

ASPECTS OF
THE EARLIEST COPPER METALLURGY IN THE
NORTHERN SUB-ALPINE AREA IN ITS
CULTURAL SETTING

VOLUME I

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EDINBURGH, 1978.



TESTIMONIAL

I declare that the research carried out for the preparation of this thesis was done entirely by myself, with the exception of the neutron activation analysis, where the specialized technique required the facilities of the Scottish Universities Research Reactor Centre.

I further testify that I wrote the thesis unaided and that none of the original material contained in it has been published. A copy of all the relevant computer listings has been deposited with the Department of Archaeology, where it may be consulted on request.

Barbara S. Ottaway,
Edinburgh, 20.9.1978.

SUMMARY

The earliest copper-based objects in Switzerland, south Germany, and Austria, were studied in their cultural contexts. The chronological and spatial distributions of the relevant Late Neolithic cultures in this area, and all available material evidence were investigated, and their relationships with one another, and with neighbouring cultures, were examined.

A first copper-using horizon was found to be followed by a discontinuity (second horizon) in which the use of copper was less frequent. This discontinuity was coeval with the considerable break in the pattern of copper-using cultures in northern Europe just before the beginning of the Corded Ware culture. The second horizon was succeeded by a third copper-using horizon which again used copper intensively. This latter horizon continued, particularly in Switzerland, without a break into the Bronze Age.

About one hundred samples of metal objects from Swiss and Austrian museums were analysed for the first time for eleven elements, mainly by neutron activation analysis and atomic absorption spectroscopy. Some samples of objects which had been previously analysed elsewhere, and three international standards, were also analysed to establish comparability of results. In addition, 330 published analyses possibly pertaining to the Late Neolithic period were considered, chosen primarily because the artifacts concerned were of types occurring in secure Late Neolithic associations.

The impurity patterns of objects containing less than 2% tin (about 360) and those containing more than 2% tin (the bronzes) were grouped

separately by cluster analysis, using a computer program. Ten main copper groups, and six bronze groups, emerged, all coherent and sharply defined. They are discussed in terms of their composition, their archaeological, chronological and geographical significance. One of the three earliest coppers contained significant amounts of arsenic, and probably came from outside the region. By the third copper-using horizon there is strong evidence for mining and smelting in several areas within the Salzach region. This mined copper was mostly used in Switzerland, suggesting that Swiss groups or individuals procured their copper from Austria.

It is concluded that the introduction of copper into the northern alpine region is due, not to a single culture, but to a complex network of multiple contacts and that this resulted not in one single culture which was the earliest to use copper, but in an entire early copper-using horizon. The start of the metal-using horizon was very soon followed by local smithing and also mining activities. The implications in terms of social structure, independent invention, and possible trade are briefly discussed.

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FU = Exact find site unknown.

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CHAPTER I. THE EUROPEAN BACKGROUND TO EARLY COPPER METALLURGYI.1 Introduction

A study of the earliest copper metallurgy in the northern subalpine area has to be viewed in the wider setting of the earliest European copper using cultures in order to understand its full meaning.

It will also be necessary to discuss the technological and metallurgical facts involved, as well as geological and, where possible, economic data to make the fullest use of all available information.

The area of study, in the first Chapter, covers most of south central and south east Europe. The second Chapter concentrates on the northern sub-alpine region - that is the entire area of the Alps between the modern towns of Vienna and Geneva and the northern areas immediately adjacent to it. The archaeological, socio-economic and chronological information of all cultures in this northern sub-alpine area is presented to provide the background to the actual metal finds themselves. These are described and grouped from their morphological, chronological and cultural point of view in Chapter III. In the fourth Chapter attention rests on the metallurgical aspect of the earliest copper artifacts and includes some 100 new metal analyses, for which a technique of measurement was adopted, developed and carried out by the writer. The grouping of the results together with results from other laboratories is also included in this part. The fifth Chapter describes the actual methods of analyses used and the final Chapter contains a summary, discussion and conclusion of all the data collected in Chapter I to V.

The period covered ranges from the early part of the fifth millenium bc to approximately 2000 bc. This is, however, mainly due to the fact that the earliest copper horizons are so much earlier in southeastern Europe than they are in the area of this study.

The latter covers a more restricted period, from approximately 3400 to 2000 bc. All dates (bc) are based on radiocarbon dates (using the conventional, uncalibrated dates calculated with the Libby half-life of 5568 years. Occasionally, corrected dates (BC) will be found in parenthesis following the uncorrected dates. The correction to calendar years will have been carried out with the aid of the MASCA correction curve (Ralph, Michael & Han, 1973).

A study of this kind, which depends upon establishing relationships between various regions requires a set of terms by which these relationships can be described. Unfortunately, there is no agreement about such terms or their conceptual content, at present, and it is therefore necessary to define them solely for the present study. Occasionally there are artifacts which are worth studying in their own right, on stylistic or artistic grounds. However, the primary interest lies mostly in the people who produced the artifacts, their development and their presumed relationships with others and with the world around them. In the study of pre-literate archeological society, a whole nexus of features, i.e. assemblages of artifacts associated with structures and economic, technological and environmental information have, of necessity, to be used as evidence for the behaviour of a limited section of the society. The difficulties in finding suitable concepts and terminology have been discussed by Piggott (1965,7), Clarke (1968,287) negatively by Hawkes (1973) briefly but lucidly by Hodders & Orton (1975,199) and very usefully by Doran and Hodson in the form of a flow-chart (1975,T.2.1). The term that causes most difficulty is 'culture'. When Childe wrote his definition of a culture as being 'distinctive artifacts regularly found associated in graves and settlements over a given geographical area..' (Childe, 1930,41) this was an excellent and useful tool for archaeologists of the time.

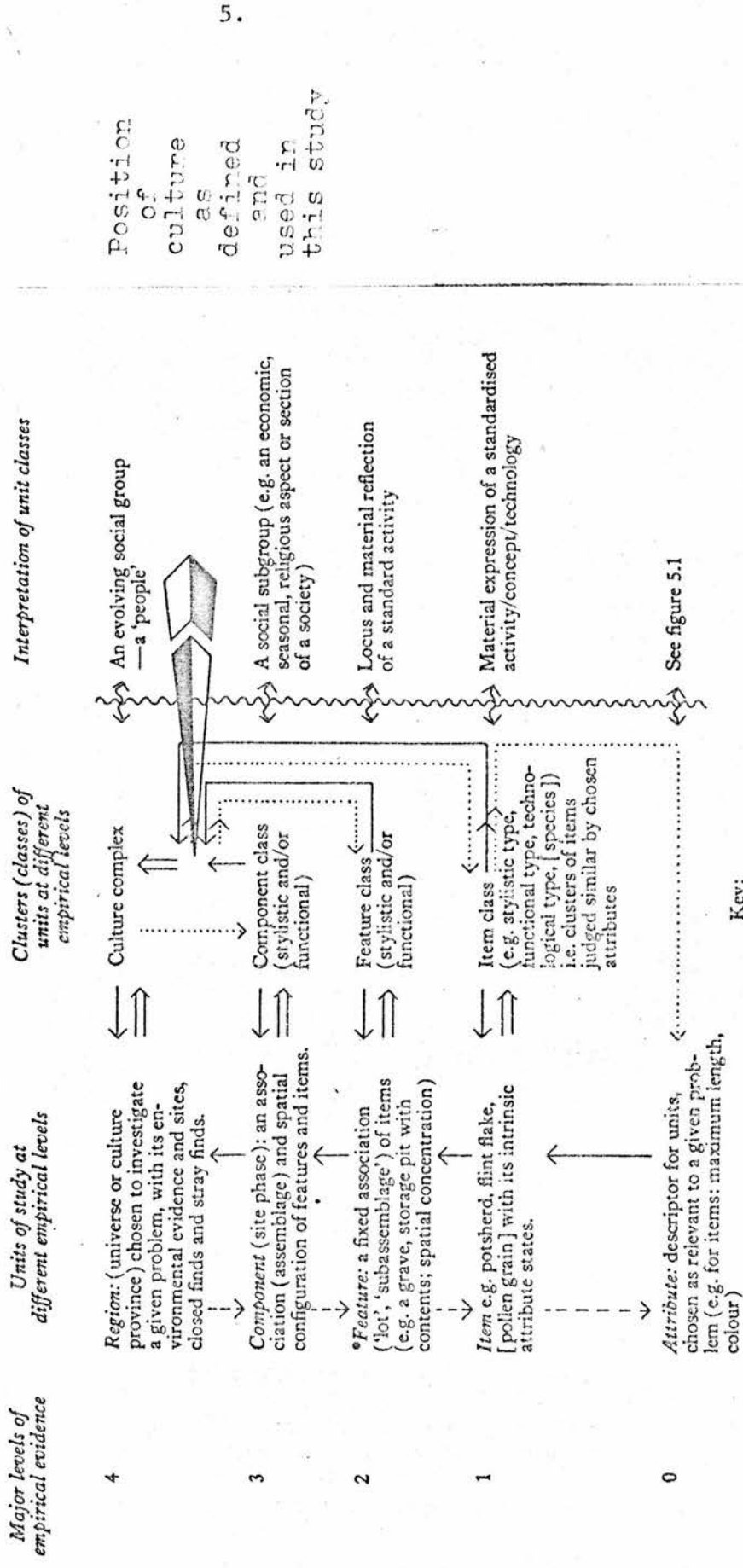
Inevitably, names used to refer to assemblages came to be used for populations or were 'assumed to have significance in human terms' (Piggott, 1965,7) and were continued to be used because 'it is an established shorthand virtually impossible to replace' (Piggott, 1965,7). However, constant extension of methods used to 'decode' the evidence - provided by constantly improving excavation methods - resulted in an increase in material from which much more detailed facts about human behaviour could be inferred. When finally anthropological and ethnographic as well as geographical concepts were included to explain archaeological data, the definition of 'culture' reached its limit and a total confusion of terms resulted. This confusion arises from the contrast between the extremely static definition used for 'culture' in Childe's sense and the desire to link it to ideas of change, development or regression, i.e. to a dynamic use of the word. This notion of change and development is, of course, implicit in the study of human populations.

The aim of Chapter two was to provide enough detailed information to make the step from a 'culture' defined in purely static or material terms to a dynamic 'culture' in the anthropological sense. This aim could not be achieved because only in one or two cases (e.g. the Cortaillod culture) was sufficient information available. Fortunately, the static definition of 'culture' in terms of a nexus of features commonly occurring together within a limited spatial and temporal horizon is perfectly adequate when dealing with a set of data such as I shall be using, provided there is a reasonable chance of dating them relatively precisely, because I am dealing with the impact and development of a single technology -metalworking- on this otherwise static horizon. Logically, if the definition of culture as I have given it is correct, phrases such as 'the dynamism of culture change'

can only be used to start a discussion of the development of a culture, within a fixed geographical area, and ideally within a limited time-horizon. Logically, the term 'spread of culture' has no meaning in the static definition of a culture, because the essential geographical element in the definition is being negated. Clearly another term is needed to define the dynamic side of a culture. Doran and Hodson (1975) constructed a hierarchy of concepts which I found most useful, because they relate closely to the stages of complexity which I found myself developing from the northern alpine material. A culture in the static sense defined above fits in between their levels 3 and 4 (cf Table 1) i.e. between their 'culture complex' (or a 'people') and a 'component class' (or a social subgroup), reserving the term 'culture complex' for entities such as 'Chasséen' or 'Vinča' or the newly defined 'Saône-Rhône', which intuitively seem too large or too long-lasting to be homogeneous cultures. It is also important to stress that a culture must be defined in terms of several traits or features, not just one or two common ones, even if as in the case of the newly defined 'Lüscherz culture' a blind eye must temporarily be turned towards the lower limit of the definition. In summary, by 'culture' I mean throughout this study a nexus of associated features - i.e. assemblages of artifacts associated with structures, economic - technological and environmental features - in a geographically and spatially defined area.

Long before Childe, archaeologists believed that anything as complex as metal objects must have come from Anatolia and maybe further east. This attitude was - and still is - very much alive, when Renfrew wrote his paper about the autonomy of southeast European Copper Age (Renfrew, 1969) advocating the independent invention of metallurgy in the Balkans. As Renfrew himself pointed out, he was not,

Table 1



* Features are often defined by the spatial patterning of item classes. If this is obliterated by successive reoccupations, erosion, bad excavation techniques, etc., this empirical level will not exist.

After Fig. 1.2, Doran and Hodson (1975).

5. Position of culture as defined and used in this study

in fact, the first to think along these lines (Hillebrandt, 1929) and has not remained alone, although most researchers have adopted a more modified 'Renfrewism' (Jovanović, 1971; Ryndina, 1971; Jovanović & Ottaway, 1976). However, Renfrew did open the way for a lively discussion between 'Diffusionists' and 'Separatists'. But no 'Diffusionist' can bring forward definite proof, partly because cultural diffusion - unlike scientific diffusion which has a measurable rate - is based on too many intangible assumptions and partly because the material from the Near East is still poorly studied. Nor can 'Separatists' uphold their idea of primitive man stumbling by chance on the discovery of smelting ores in several unconnected places independantly, because recent studies in this field and new finds have shown that places such as Sitagroi are neither in time nor space the only sites with early copper finds.

It is widely believed that copper metallurgy started with the use of native copper, i.e. copper that does not have to be smelted from the ore but can simply be cold hammered or annealed into the desired shape (Tylecote, 1962; Coghlan, 1972, 1951; Ottaway, 1971; Ryndina, 1971; Greeves, 1973; De Jesus, 1974). This native copper has, as analyses of its trace elements have shown, remarkably few impurities - often only silver (cf Ottaway, 1973, fig. 6) although, as Tylecote in a recent review of a wide variety of native copper sources has pointed out, native copper can contain Ag, As, and Fe as major impurities and there could be a considerable overlap in the impurity patterns of native and carbonate copper ores (Tylecote, personal communication). The next step in the development of copper metallurgy is believed to have been the smelting of copper from carbonate ores, such as malachite, azurite or cuprite. This would involve reduction of the ore probably achieved by a forced draught and a charcoal fire. Copper obtained from this

ore could contain several impurities each present in amounts less than 0.1%. Ag is still the most common impurity (cf Ottaway, 1973, fig. 7). The final step in the sequence would be the smelting of sulphide ore, such as chalcopyrite (CuFeS_2) or wheel ore (CuPbSbS_3). These ores require a two-stage smelting process as well as the addition of the right flux -- although this latter could sometimes be 'inbuilt' i.e. occur naturally in the ore. The resulting copper has a much more complex impurity pattern, which could contain up to 1% As or Sb (cf Ottaway, 1973, fig. 8). The impurity pattern of copper artifacts thus mirrors the raw product which has been used, provided there has been no re-use of metal or mixing of ores (Britton & Richards, 1969). It can also have a very characteristic fingerprint, for instance, a consistent combination of elements might lead one to the actual source of the ore. This was the original aim of Otto and Witter, 1952, of the Stuttgart Group (Junghans et al., 1960, 1968, 1974) of Pittioni (1959), and other groups in various European countries. The aim and their success has been very thoroughly reviewed (Härke, 1975) and it need only be pointed out here that whereas a certain amount of success has been achieved as in the case of the Russian Tripolyen raw material being tied to the SW Romanian Banat ore mountains, other results have not been as clear cut. This may however, be due to the lack of efficient grouping methods, keeping step with fast developing analytical techniques. It certainly is also due to the absence of analyses of small copper outcrops in Europe. All large and economically important copper deposits of the World have been thoroughly reviewed by Pelissonnier & Michel (1972). A more detailed discussion of these problems will be found in Chapter IV.

If this progressive and sequential hypothesis of the use of native copper, followed by carbonate ores and then by sulphide ores is correct then one would expect to find the earliest copper artifacts to be made of the pure copper characterising native copper. However, there is an indication that some of the earliest copper finds in Europe are not of native copper. Should the hypothesis outlined above be discarded and replaced by the hypothesis that the early copper industry started straight away with the smelting of copper ore, or should one carry on the search for the missing link or indeed, assume that all trace of this earliest stage has simply vanished or perhaps been destroyed by the re-use of copper? The re-cycling of metal is always a serious possibility, particularly if one bears in mind that copper simply cold hammered into shape is likely to be brittle and therefore prone to fracture. However, re-use, unless on an unlikely large scale, would not allow any clustering of analytical results. Analytical results will therefore be an important part in answering many of the questions outlined above.

1.2 The earliest European copper mines

MINES:

There are now two sites where conclusive evidence for pre-historic mining activity has been established: one is at Rudna Glava 22 km east of Majdanpek in eastern Serbia, Yugoslavia, the other is at Aibuna, near Stare Zagora in Bulgaria. At Rudna Glava a row of vertical shafts which are, in fact, empty ore veins, were discovered during modern exploitation of an open-cast iron mine (Jovanović, 1971). The shafts are 20-25 m deep and vary in width between 0.5 and 1.5 m. Finds from the shafts came from 3 main zones: the access platform, channels and cracks off the shaft and the bottom of the shafts. The majority of the finds came from the access platforms which acted as small stores and/or as preparatory workshops. Stone, bone and wooden tools all with traces

of wear (cf Jovanović & Ottaway, 1976, PL. XIIIa; Jovanović, 1976, fig. 7-11) as well as pottery had been inserted into the cracks and some of the pottery was found in small hoards either at the bottom of the shaft or at the access platforms (Jovanović & Ottaway, 1976, PL. XII & XIIIb). The typological characteristics of the pottery is very clear and it belongs to the initial phase of the Vinča-Pločnik phase or slightly earlier. The extraction of the ore seems to have been by alternative heating and cooling and subsequent breaking up of the ore by bone and wooden wedges. The ore was then further broken up by massive hammer pebbles, sorted out roughly and lifted out of the shaft. Analysis of the remainder of the ore in the bottom of the shaft showed it to consist mostly of haematite, that is iron ore, which was clearly discarded as unsuitable (Ottaway, 1975). The copper ore itself was probably malachite, but its exact trace element composition could not yet be established, because until last years' excavation in none of the veins worked by Vinča miners had any ore been found in situ. In the 1976 campaign, however, enough untouched ore from a shaft could be collected for Dr. Tylecote to carry out a smelting experiment under 'chalcolithic' conditions. It is also planned to analyse this ore.

Albuna, the Bulgarian prehistoric mine, has apparently similar tools and techniques. The shafts are wider than at Rudna Glava and analysis of the ore has shown it to be malachite and azurite. Albuna has so far been vaguely dated as belonging to the early Eneolithic (Chernych & Raduntcheva, 1972; Chernych, 1975).

Vinča-Pločnik dates cover a very long period: from 3950 to 3300 bc (4800-4100 BC) but the cultural floruit lies between 3900 & 3700 bc (4700-4500 BC) (Ottaway, 1973, 1974, 1975b). It is clear then that copper was mined in the Balkan Mountains by the early fourth millennium bc and one would expect to find a certain number of copper artifacts in

contemporary sites as a result of this activity. The evidence in the surrounding countries of Yugoslavia, Bulgaria, Northern Greece, Romania, Hungary and Czechoslovakia will therefore be briefly examined.

I.3. The earliest copper finds in Yugoslavia

Recent studies in Yugoslavia have shown that copper objects found on Vinča sites are no longer small in number. They have been found from the earliest phase of the culture at Vinča itself (Ryndina, 1971,99), but become more numerous in settlements of the earliest Vinča-Pločnik phase onwards (Jovanović & Ottaway, 1976). There are oval beads from Vinča itself; at Gornja Tuzla in northeast Bosnia layer III contained 35 beads from one deposit, one spiral ring with oval section, a fragment of thin 'wire' with circular section and 3 fragments of a copper awl with rectangular section. Early copper objects are also found in the central Danubian Morava region at Divostin (McPherron & Srejevic, 1971). At Gomolava in the Vojvodina, during the 1975 excavation, cylindrical and ring beads were found in the earliest Vinča-Pločnik layer - the Vinča Tordos phase is, incidentally not represented at Gomolava (Brukner *et al.*, 1964). The succeeding Vinča Pločnik layer contained fish hooks, and awls with square sections. (I would like to thank Dr. Brukner and his colleagues to let me study their material from Gomolava during a visit to the site in 1975).

In the second half of the Vinča-Pločnik phase (Vinča D) more developed types of copper objects such as spiral cylinders and pins were found, together with the earlier types (cylindrical beads, awls and fragments of 'wire') at Gomolava, at Gornja Tuzla and also at Velika Gradina in western Serbia (Brukner, 1964). The latter also contained a bracelet with rectangular cross section. To this phase belong the hoards from Pločnik itself: the first hoard was found in 1927 in the settlement area

near a furnace between subhumus and the archaeological layers (Grbić, 1929).

The other three hoards could not be stratigraphically determined (although the last two were found much more recently) but they are typologically very close to the first hoard. There are four massive hammer axes, 19 flat axes, four bracelets, a pin and an ingot (cf Jovanović, 1971, Pl IV, 26,27). The settlement spans the whole of the Vinča-Pločnik phase; its final phase belongs to the Bubanj-Hum group. Sixteen objects from the hoard have been analysed: they are all very pure copper and contain as only trace element Ag. Other Vinča finds await analysis.

The conclusion therefore must be that copper was certainly known in Yugoslavia from the beginning of the Vinča-Pločnik phase at least.

1.4 The earliest copper finds in Bulgaria and Greece

Turning now to Bulgaria, the second country with known pre-historic mining activity. Again one finds early scattered individual copper finds in Neolithic sites such as at Ovcarovo in the northeastern part of the country in Karanovo II contexts, or at Usce I in the southeastern part of Bulgaria (Todorova, 1973b). The latter site belongs to the Zlatarski culture which is broadly contemporary with the Vesselinovo, the Karanovo III as well as the Vinča-Tordos cultural groups. The main bulk - or floruit - of corrected radiocarbon dates for these cultures fall between 5250 and 5000 BC. The confirmation of the existence of a developed copper industry came in 1974 with the excavation of a cemetery at Varna on the Black Sea. This site, excavated by Ivanov, has produced the most astonishing collection of copper and gold finds. Only the gold finds have been preliminarily published and illustrated (cf p.8, 34 and 108, Catalogue of the Viennese exhibition 'Goldschätze der Thraker; Thrakische Kultur & Kunst auf bulgarischem Boden', Vienna, 1975). The other finds, mostly unpublished, include large copper adze-axes, hammeraxes, spearheads with barbs, small knives as well

as pins (M. Novotná, personal communication, 1975). The site has given its name to a new Varna culture and it belongs to the general Gumelnița-Karanovo VI horizon, which in turn is contemporary with the Vinča-Pločnik culture.

This is also the chronological horizon into which the small copper beads found at the end of layer II of Sitagroi in northern Greece belong (Renfrew, 1969, 1973a).

I.5 The earliest copper finds in Romania and Russia

Turning now to Romania and also to Russia, one finds that again there is one copper awl from an early Neolithic site: Balomir in Transylvania, which belongs to the Cris culture (Vlassa, 1970). This is probably contemporary with the start of the Vinča-Tordos group. The first copper in the Boian culture appears in phases III-IV (Filip, 1966) and also in the Petresti culture, which is distributed well within the highly mineralized zone of central Transylvania (Vlassa, 1967). It is interesting that both the Boian and the Petresti cultures have developed locally on early Vinča foundations (Filip, 1966).

Most of the copper finds, however, belong to the Pre-Cucuteni III and Cucuteni A-B groups, which is equivalent to the Russian Tripolye A-BI culture. They are more or less contemporary with the beginning of the Vinča-Pločnik group, and the early Gumelnița culture. Cucuteni and Tripolye finds will be treated as a homogeneous group although they are split by a modern border. This material has been very thoroughly studied in an MA Thesis at Edinburgh by T. Greeves (1973) and I would like to thank him for allowing me to include some of the main points here. The objects belonging to the earliest phase, the Pre-Cucuteni III - Tripolye A, include fish hooks, awls, beads, pins, spiral bracelets, rings, spiral cylinders, flat axes and possibly one hammer axe and anthropomorphic pendants if one includes the Karbuna hoard within this phase (Klejn, 1968).

Very detailed metallographic and microscopic study on the Tripolyen material by Russian scientists have resulted in a number of accurate observations of methods of production used in this period. Techniques such as welding two pieces of copper together were very common. Furthermore, since some of the raw material contained high Pb concentrations, the smiths had to be careful not to exceed a temperature of 327°C since any temperature above that would dissolve the Pb out. Other raw material without Pb contents were welded at higher temperatures. The technique of welding also required the use of a flux to avoid oxidation of surfaces. In spite of these advanced techniques there is no evidence of smelting or casting in this phase; other smithing techniques included beating out copper into thin plates, cutting and trimming of edges, bending on 'pigs' of necessary profile, drawing out, punching and piercing holes.

During the succeeding Cucuteni-Tripolye BI phase the copper objects resemble earlier types although the proportions have changed. The only new addition is possibly one adze-axe. However, the smithing skill has made progress in that casting of flat axes in one sided open moulds as well as the use of grooved anvils for wire production has now been developed. Otherwise, forging and the earlier techniques described above were still in use. There is one hammer axe of this period from Berezovskaya which was cast by the 'lost-wax' process in a double sided mould, which also had a 'clay pig' so that the shaft hole was cast in as well. However, Ryndina (1971) regards this, as well as other hammer axes of later periods, as imports from more developed cultures.

The copper of many of the objects has been analysed and the specific impurity patterns has led to the conclusion that much of the raw material came from Balkan-Carpathian regions. Only in the later Cucuteni A-B - Tripolye II did copper of Caucasian origin appear.

Four hoards belong to the Cucuteni-Tripolye cultures: that of Karbuna, Horodnita, Arius D and Hábasesti and although most of these have not yet been dated securely to everyone's satisfaction, the phenomena of metal hoards clearly belongs to this horizon as can also be seen at the Vinča-Pločnik hoard.

The Cucuteni A - Tripolye BI culture is contemporary with the developed Vinča-Pločnik, the Gumelnita, the Tiszapolgar and the Dniepr-Donetz cultures.

Towards the east the Tripolye culture was in contact with the Dniepr-Donetz culture: analyses of copper objects found in the Nikol'skij cemetery correspond very well with those of Tripolyen copper artifacts and show a Balkan-Carpathian origin of the raw material (Chernych, 1966; Telegin, 1971).

1.6 The earliest copper finds in Hungary

Next it will be necessary to examine the material from the Great Plain of Hungary. Again a few scattered finds such as copper beads, two awls and perhaps one embossed pendant have been found associated with the late Neolithic Herpaly group (Bognar-Kutzián, 1963, 331,333,337, 484 & Bognar-Kutzián, 1972,213). These are, however, the exception and copper in any appreciable amount appears only with the emergence of the Tiszapolgar culture. The thorough study of this culture by Bognar-Kutzián (1972) allows us to draw several conclusions: for instance, the Tiszapolgar culture should be regarded as a local development of the late Neolithic society of the same region. This assertion is based mainly on pottery but also on the absence of any foreign elements which could have caused change. Another important factor is the discontinuation of easily defensible tell settlements and a subsequent spread of unfortified settlements, particularly to sites along waterways. Together with the fact that cemeteries now appear,

as opposed to burials within settlements, this has been taken as evidence that conditions had become more peaceful. Absence of continuous or even intermittent warfare is one of the pre-requisites for expansion of trade and movement of people between tribes connected with trade. Since the Great Hungarian Plain is lacking in all major commodities such as stone, salt and metal, trade with surrounding cultural groups would be a necessity. It is therefore not surprising that the Tiszapolgár group had contact with the Slovakian Lucska culture in the north, with Romanian Cucuteni A-BI cultures, with Bulgaria's early Gumelnița and with Yugoslavian Vinča-Pločnik groups in the south. With these contacts it had access to the minerals of the surrounding mountains.

All copper finds of the early Tiszapolgár phase of Hungary come from graves, yet there are no heavy copper tools as in the cemeteries of Tibava, Velke Raškovce or Varna. It seems therefore that the population did not have unlimited goods available for exchange and was thus restricted to smaller amounts of copper in the form of bracelets, spirals and open rings, disc-shaped beads and earrings. It also imported brown flint from the Volhynia. In exchange the population of Tiszapolgár settlements had probably to rely on corn, domesticated animals and produce such as wool, hides and perhaps obsidian from Tokay.

It is perhaps not surprising that under these circumstances the Hungarian Early Copper Age started slightly later than in the surrounding areas and that it did not really 'take off' until the Middle Copper Age Bodrogkeresztur culture (Patay, 1974).

1.7 The earliest copper finds in Slovakia

The settlement and cemetery of Tibava are regarded by Bogner-Kutzian (1972) as belonging to the Hungarian Tiszapolgár culture. National feelings about this are tender, particularly since this area once did belong to the Hungarian Empire of more recent history. Although Tibava is contemporary with the Hungarian Tiszapolgár group there are numerous points of difference: the graves are richly furnished with copper tools and gold pendants and pottery include local variants not known in Hungary such as globular vessels and bell shaped pedestals which are known elsewhere in Czechoslovakia. This may be partly because Tibava is likely to have been one of the settlements in the hills acting as mediators or trading and exchange places between the Great Hungarian Plain and northern producers or between traders in Volhynian flint and perhaps Slovakian copper hammer axes. The latter appeared in the Bodrogkeresztúr cultures and their distribution would support the suggestion that they are imports from the north.

However, the difference between the Slovakian and Hungarian groups cannot entirely be explained by these facts, since the copper axes appear earlier in Tibava than in Hungary and copper in general appears earlier in Czechoslovakia than in Hungary as will be shown later. A possible explanation might be that the Slovakian cultures living in the foothills of forested regions, needed the axes more than their contemporaries who lived in the plain- for tree felling and generally for woodwork.

This explanation is probably too simplistic, particularly in view of the latest finds from an even earlier phase of the Tiszapolgár culture at Vel'ké Raškovce. It seems that Slovakia must therefore be seen as one of the strongest influences at the start of the Hungarian Copper Age. During the 1974 excavation at the east-Slovakian site of

Vel'ke Raskovce, a cemetery discovered accidentally when new gas pipes were laid (Vizdal, 1973), heavy copper tools and small gold ornaments were found. (I would like to thank Dr. Vizdal for letting me study this new material at the museum in Michalovce). The cemetery contains about 70 graves, all of them inhumations: men lying on their right side, women on their left. Gravegoods were abundant and included - in the earlier of the two phases - 4 - 6 vessels of the hollow-footed pedestal bowls, square bowls and globular bowls each with a variety of handles. The second phase had as many as 30 vessels, usually with 7 different types in each grave. Only male burials contained copper axes, and sometimes gold pendants placed around the neck, as well as unworked flint nodules of Polish (probably Volhynian) origin. Female burials were accompanied by solid copper armrings, and were on the whole more poorly furnished than male graves. Not infrequently, male burials also contained sheep bones. Sometimes a circle of graves would be arranged around a central sheep's burial.

The excavator gives the sequence of cultures in this area as follows: the Búkk culture was followed by the Stroke-ornamented pottery group, followed in turn by the Tisza-Csőszhalom-Oborin culture with its painted ware and figurines (Vizdal, 1973). This was succeeded by the first phase of the Tiszapolgár culture represented by the cemetery of Vel'ke Raskovce. The second phase of this culture is represented by finds from Tibava which contained hitherto the earliest known copper axes and gold finds from stratified finds of the ČSSR, (Šiška, 1964), which in turn is succeeded by the Bodrogkeresztúr culture.

The types of copper found at Vel'ke Raskovce include 6 cast adze-axes, hammer axes, 11 open armrings, 4 armrings with overlapping ends, 1 small knife and a fragment of a small ring (or perhaps a piece of wire). The diameter of the thick armrings was very irregular but whether this

is due to corrosion or to cold hammering can only be found out by metallographic analysis. There was one large gold disc and 8 smaller ones, usually with 4 - 6 perforations at the top. All copper finds are being analysed at present. It appears that the copper is very like that of the Tibava objects and it is likely that copper carbonate provided the raw material rather than native copper. Furthermore, the little 'copper' knife contains 4.54% Sn (the analysis was repeated three times, personal communication, Novotná, 1975). With this knife, the number of very early scattered bronze finds has been brought up to four: they are the knife from Vel'ké Raškovce, the knife from Varna, a chisel from Vidra (M. Novotná, 1975, paper given at Symposium in Pezinok, CSSR) and a bead from Gomolava (excavated 1975, analysed by neutron activation analysis; Gilmore & Ottaway paper read at the Philadelphia Archaeometry Conference, 1977). All these artifacts contain more Sn than can occur naturally in the copper; they are therefore the earliest evidence for alloying with tin in Europe.

1.8 The earliest evidence for smelting and smithing

So far evidence for mining of copper in the Balkan mountains of southern Yugoslavia and central Bulgaria has been outlined. The bulk of ready made copper artifacts has been found to occur in periods contemporary with the Yugoslavian mining activity at least and perhaps also with the Bulgarian one. What is the evidence for smelting of the ore and for the production of the artifacts from the raw material?

Evidence for smelting (and mining) is so far non-existent in Slovakia. This may seem surprising for an area which supplied $\frac{2}{3}$ of the world's copper in the 17th century. According to Točík (personal communication, 1975), who has been working in the middle Slovakian and east Slovakian ore mountains for a long time (but is now, unfortunately, forbidden to publish any more, owing to political circumstances)

all prehistoric mining activities were destroyed by the medieval mining and probably smelting activity e.g. at the Sandberg, where he was able to detect, at a depth of 20 m, an area with stone paving, of clearly pre-medieval age, which contained wooden tools and bowls and more than 300 stone axes. Another site - Spanja Dolina - also produced several stone axes all with so-called 'waisting'.

Sites where smithing and possibly smelting has been carried out have been found in Bulgaria at Useo I, in northern Greece at Sitagroi III, in Jugoslavia at Divostin, Gornja Tuzla, Velika Gradina and at Fafos I and Grivac. Furthermore in Romania at Hăbășești and finally in Russia at Luka Vrublevetskaya, at Troyanova, both belonging to Tripolye A period, and at Polivanov Yar and Nezvisko belonging to the succeeding Tripolye BI period. The evidence is mostly in form of amorphous copper lumps (Divostin) or lumps of copper oxide (Gornja Tuzla, Velika Gradina, Fafos) or copper carbonate powdered mixed up with bones and sherds (? to provide the flux, Grivac) or in the form of crucibles (Hăbășești), smith's hammers and anvils (Luka Vrublevetskaya, Troyanova, Hăbășești) and roughouts-sometimes called ingots-(Luka Vrublevetskaya, Polivanov Yar, Nezvisko). The Karbuna hoards contain 6 artifacts which had been repaired and this too must be seen as evidence for local metalworking. So far, large scale smelting sites, have not been found. It must be born in mind, however, that smelting might not have been carried out on a large scale for a long time, but rather more in the manner of primitive African smiths smelting only just enough for the present requirement. The archaeological evidence left behind from these small make-shift smelts would be very difficult to detect, indeed.

I.9 Summary and Discussion

It is now possible to distinguish three horizons:

- i) a fully neolithic period where copper objects appear haphazardly as very scattered individual finds without any evidence of local metal working. Countries in which these finds occur include Bulgaria, Romania and Yugoslavia.
- ii) a period in which cultures, forming a continuum with preceding local Neolithic groups were using copper as an extension to their normal tool kit. The types - awls, fish hooks and beads - show that the use of this material to its best advantage while it was scarce was understood. Evidence for local manufacture is numerous in this period. Techniques used can be very complex and competent as Russian investigations have shown. Finds come mostly from settlements, the only exception being the cemetery of Vel'ke Raškovce where heavy copper axes were found. The nature of a cemetery naturally excludes evidence of local smithing activities while the nearby settlement of Vel'ke Raškovce has as yet yielded no copper finds (Vizdal, 1972). Cultures and countries in which these finds occur include the earliest Tiszapolgár culture of Slovakia, the earliest Vinča-Pločnik culture of Yugoslavia, Pre-Cucuteni III - Tripolye A of Russia and Romania and the early Gumelnița culture of Bulgaria.
- iii) a wider use of copper with more raw material available - indicated by the frequent occurrence of heavy copper tools in stratified deposits - and the use of advanced techniques such as casting. This is the first true Copper Age. It is also in this horizon that the first big hoards of copper appear. Artifacts made of copper are now found both in cemeteries and in settlements. Cultures and countries in which this horizon is represented include the Tiszapolgár culture of Slovakia, the Vinča-Pločnik culture of Yugoslavia, the Cucuteni A - Tripolye B1

culture of Romania and Russia, the Dniepr-Donetz culture of White Russia, the Gumelnita and Karanovo VI culture of Bulgaria, Sitagroi layers II and III in northern Greece and the Hungarian Tiszapolgar culture which are somewhat tardier than the rest and are still without large copper tools.

The detailed study of these three horizons would almost certainly find significant variance in the proportion of the various types of copper artifacts and in their use enabling one to draw useful sociological and economical information. Tangible results can also be achieved by studying the technological evidence provided by them. It is, for instance, clear that neither the cast adze-axes nor the heavy armrings are the products of smiths involved in learning the trade; they are made by smiths who must have had a long tradition of metalworking because they knew about casting, work hardening and the addition of tin when it came to implements which needed to be sharpened continuously such as knives.

This leads to several questions, specifically, where did the metal come from? Was it worked locally and transported in the form of ingots or in their final shape? Are these sites all evidence for the independent invention of metallurgy?

In order to answer the question about the origin of the metal, each culture together with its possible local ore sources and the metal analyses of both objects and ore of this area ought to be examined separately. Unfortunately there are not enough metal analyses to do this, and the analyses that do exist provide a rather patchy knowledge. However, both prehistoric mines which we know about seem to have produced carbonate and this on the whole fits most of the analysed impurity patterns of artifacts from the earliest European copper horizon. More detailed information can be obtained from the Cucuteni-Tripolye material of which more than 100 objects have been analysed.

Chernych (1966) divided the results into 2 groups which are then further subdivided into 5 subgroups. The first group of copper has relatively high Pb, Sb, As, Ag and Bi contents but a low one of Ni. On the basis of As and Sb distribution, which is not very homogeneous within this group the further subdivision is carried out. The second group of copper is of comparatively pure copper. Most of the trace elements, except Ni and Bi, occur in significantly smaller concentrations. The subdivision of this group is carried out on the basis of the Bi content.

The copper deposits in or near the Cucuteni-Tripolye zone have been studied by Ryndina (1971, fig. 20). They are in the Dniestr valley and consist of small outcrops of oxides and sulphides of very poor copper content (0.1-6.0%). Further, in the Bukovina area of Romania there are inferior copper outcrops although rich outcrops of gold and silver also occur. The third group of ore deposits near Cimpulung Moldovenesc has outcrops of copper oxides which Ryndina deems unsuitable since the surface deposits are on a small scale and the ore-bearing lodes lie almost at a vertical angle. However, it is now quite clear that prehistoric miners were perfectly capable of exploiting just such vertical lodes (cf Rudna Glava). Chernych's first group of high Pb content copper has very good correlation to a type of copper coming from the Banat Mountains of southwest Romania. Furthermore these Banat deposits appear to have been within the area of the Vinča culture at the time of the floruit of the early Cucuteni-Tripolye culture (Ryndina, 1971; Greeves, 1973).

There are very few analysed objects in these early horizons which were made of native copper, although they do become abundant in the succeeding periods of the Tiszapolgár-Basatanya cultures in Hungary and all artifacts of the Vinča-Pločnik hoard are made of native copper. Their only impurity is Ag.

The only conclusions to be drawn at the moment therefore are: part of the raw material used for the Tripolyan artifacts came from the Romanian Banat; it is likely that the other part of the Tripolyan as well as other cultures' raw material came from the copper carbonate ores of the Balkan Mountains; and native copper if used at all cannot be assumed to be the only source of raw material for the early European copper horizon.

The second question, whether the metals were worked locally and transported in the form of ingots or in their final shape, can again be answered most conclusively for the Russian copper artifacts on which extensive metallographic and microstructural studies have been carried out. These have shown that the objects were made locally with quite uniform and advanced methods such as welding, hot forging, and slightly later, various types of casting.

Ingots as such, of roughly standard shape and size, are not known, although the Russian material does appear to have a number of differently shaped roughouts and bits and pieces of strips and sheets of copper. In Bulgaria, Romania and Jugoslavia too, as mentioned above there is evidence for smithing and possibly smelting activity, the latter particularly if one bears in mind that crucible smelting of copper carbonate ores is a possibility (Tylecote, 1974).

It seems therefore likely that a pattern of export of raw material to several smithing and possibly smelting sites had been established. This does not indicate whether or not the smiths themselves went to the ore-bearing mountains and either did their trading there or even the mining themselves. Ethnographic parallels from Iron Age tribes in Africa suggest that smiths were always also the miners (personal communication, J. Brown about the Embu and Pokot tribes). Furthermore, the raw, unsmelted ore was always transported to the smithing site

often over considerable distances of up to 100 miles. However, it seems unlikely that the European early copper smiths would carry unsmelted or even unsorted ore over the large distances involved here (for instance Tripolyan smiths were 500km away from their source) and the fact that we have left over haematite at the bottom of the mining shafts of Rudna Glava would support this. On the other hand one must not rule out the likelihood of a quite different concept of efficiency and time; for instance, it would be far more cumbersome for the African smith who wanted to smelt his ore on the spot to take women to the site to provide him with charcoal and food which he would need there, than to carry it home. The absence of any smelting site or campsite near Rudna Glava might be taken to support this hypothesis. On the whole it seems more likely that the more distant smiths would obtain their raw material in some smelted form, and the trade was either done directly or through middlemen in times of peace. The sudden disappearance of a certain type of copper could be explained by the closing of the trade route when the neighbouring tribes were at war.

Much more difficult is the answer to the question of the origin of copper metallurgy. As was shown above the metalworking skill applied to the earliest European copper objects were certainly not primitive and must therefore have developed over some length of time. At the same time there is as yet no clear cut evidence of that long experimental stage when only native copper was used.

If one would draw an isochron over the area in which the earliest European copper is found, the centre would be roughly between Varna and Rudna Glava and would enclose the whole of the Carpathians, the Tatra, the Balkans and reaching east almost to the Dniepr and west to the Dinaric Alps (Fig. 1). If the experimental stages of the

copper age are within this area, then they are not yet uncovered. It may therefore be wise to look at the evidence provided in zones outside this isochron.

The best summaries of existing early Near Eastern copper and other metal finds (Wertime, 1973; De Jesus, 1974; Mellaart, 1975) show that, even though there are simple cold-hammered trinkets (mostly beads, pins or pendants) or tools (awls) occurring from such early periods as around 7000 bc, slag and ore does not appear before about 5700 and 5300 bc (at Catal Hüyük VIA and Yarim Tepe I, respectively. I would like to thank T. Davidson, Edinburgh for drawing my attention to the ore from Yarim Tepe). Only from about 4500 bc onwards do we find an increase in the variety and size of copper objects used. They include axes and chisels (at Mersin XVI, Mellaart, 1975, 127), the contended macehead and bracelet from Can Hasan (French, 1962) as well as other cast artifacts from late Ubaid groups in southern Mesopotamia (Mellaart, 1975, 179). The Iranian Highlanders also knew crucibles for smelting (?), e.g. one was found at Iblis I and casting moulds were used at Siyalk III (Mellaart, 1975, 193). Thus, the Near East appears to have the earliest evidence for the primitive use of copper but this use lay dormant for long periods. The occurrence of slag and ore at two rather distant places is puzzling since they do not seem to have supported a larger production of metal implements. The real expansion of metal usage in the Near East, does belong to a period when metal artifacts were beginning to be seen in Europe, and soon after we even have evidence of copper mining in Europe (cf Section 2 of this Chapter).

There is no doubt that the Veselinovo culture, which had considerable influence on the formation of the Vinča^v culture, was in contact with cultural groups inhabiting the northern part of Anatolia. It is, however, important to get away from the idea of invading troupes or whole

cultures moving in, in search of the copper-rich mountains. For one thing, the Anatolian groups themselves would be coming from copper rich regions and for another one must remember that all the earliest copper-using horizons of Europe developed on local foundations and usually show no foreign influence other than the metal itself.

It is more likely to have been an acceptance of new ideas together perhaps with a few smiths and/or miners willing to teach anyone interested. For this latter case ethnographic parallels can again be found in Africa where smiths formed a closed cast within their tribe until some upheaval such as war or population explosion forced them to move out; after this they were willing to teach their skill to outsiders where before it was handed down within the families.

This leads to the question about independent invention of metallurgy. De Jesus stated that 'independent invention of smelting and use of bronze is now confirmed. We see that Southeastern European, Near Eastern and Middle Eastern cultures often went their own way in many activities as well as metallurgy and despite similarities and contacts with their neighbours' (De Jesus, 1974, 129). This may well be true for the Near Eastern and Middle Eastern evidence and only further studies will clarify the situation. It seems to me unlikely, however, that there were several places within Europe where metallurgy was invented: the fact that the sites form a definite and contemporary horizon cannot be pure coincidence. There must have been links between cultures which after all had a common predecessor in the early Vinča^V culture in places such as Yugoslavia, Bulgaria and Romania. These links are, in fact, quite obvious when one examines the trade in flint between Poland, Czechoslovakia and Hungary, similarities in pottery styles between adjacent countries (e.g. between Czechoslovakia and Hungary, between Romania and Russia, between Romania and Bulgaria and

Bulgaria and Jugoslavia) and last but not least similarities in the types of copper artifacts themselves. Maybe awls and beads and perhaps flat axes would have been an automatic first product but complex types such as hammer axes and adze axes are surely not a necessarily automatic development.

CHAPTER II. THE NORTHERN SUBALPINE-REGION

II.1 Introduction

It has become obvious in the previous chapter that many writers have concerned themselves with the possible areas of the origin of metallurgy. Many would also agree that the subsequent shift into 'Randzonen' i.e. border areas, might easily have shifted the emphasis and importance in the metallurgical centres themselves. Yet no one has treated these border areas as a unit - a study which might well enlighten us about the reasons for such a shift and hence might even bring us nearer the 'centre' - if such a single centre existed - itself.

I do not claim to provide such a huge corpus, but the material collected in this study does at least cross several national borders and presents itself, perhaps not so surprisingly, in some respects as a unit in itself. This is perhaps a useful step, because all too often county borders, let alone international borders constitute a limitation to research. In Austria, for instance, the last survey of the country as a whole was written in 1954 (Pittioni).

In Switzerland the recent appearance of Sauter's book (1975) has at least brought us up to date. But these are books covering the whole of the prehistory of that country; and whereas the former is by now out of date, the latter can only provide a framework while detailed studies of our period covering the whole of Austria or Switzerland or southern Germany are missing.

As an area of study I chose everything immediately adjacent to and north of the Alps. In practise, this includes the whole of Switzerland, Lichtenstein, Austria and part of southern Germany. The natural boundaries of this area are the mountain peaks of the Alps themselves in the south and the Danube in the north. To the West the Jura mountain range, although not as high as the Alps, is a very

effective boundary because of its ruggedness. In fact, the Rhône is probably the only 'break' in this massive during prehistory and has, as we shall see, been the gateway for successive influences. To the East the end of the alpine mountain range has been somewhat extended to include the whole of Austria.

The period studied begins with the earliest metal finds in this area. These mostly belong to Middle or Late Neolithic cultures depending on the convention of the particular country in the use of nomenclature. It ends with the appearance of the Bell Beaker culture or the EBA in areas where it did not occur. The reason for this delineation is twofold: firstly there is a renewed shift of concentrations and secondly, the inclusion of that culture would have increased the volume of this study beyond reason.

It is thus very much an intermediate phase, one where new ideas were taken up and investigated and either rejected or consolidated. This is clearly born out by its dating: periods before it, such as the Early Neolithic are well defined by radiocarbon dates. The succeeding EBA again shows an abundance of dates. Radiocarbon dates for our period, however, are very patchy indeed and reflect, above anything, the acceptance or otherwise of this method of dating by leading archaeologists in that region.

In the following section the individual cultural groups occupying the area and period outlined above will be brought together to provide as uniform a background as possible for the metal find themselves.

II.2. The Cortaillod culture

(i) Distribution, settlement - and house type

At the time of writing the Cortaillod culture is the most westerly of the earliest groups in which we find copper in the region outlined above. The Cortaillod culture is distributed in western and central

Switzerland, and it can be found as far north as lake Zürich (Fig. 2). The Jura mountains form the northern and western border (although it is often difficult to establish where the Cortaillod culture ends and the Chasséen starts). Lake Geneva is not very well studied and only a few settlements are found there. The main concentration of known settlements is around lake Neuchâtel, but this is mainly due to the active period of excavations following the 'correction of the Jura waters'. This naturally overemphasises the importance of lake Neuchâtel, a fact which must always be born in mind when discussing the distribution of this culture.

Most of the Cortaillod settlements are found on the banks of rivers and lakes - large and small ones - and in bogs. A few dwelling sites on rocky hills and rocky shelters are also known but only one settlement on the plain (Petit Chasseur) existed. It is interesting to note that the 'Höhensiedlung' of Saint Leonard for instance and the rock shelters of the Vallon des Vaux are not unequivocally accepted as belonging to the Cortaillod culture. Some classify the latter as 'related' groups (c. Strahm, 1970a), others date it to a phase between Egolzwil 3 and the beginning of the Cortaillod culture (Sitterding, 1972). In all these types of settlements - with the exception of the 'Höhensiedlungen' - copper artifacts have been found. It is also understood that all are situated on or very near rivers and lakes and were built on forest-free areas. Again Vallon des Vaux provides the only exception and it will therefore be treated separately at the end of this section.

From our present knowledge of Cortaillod villages we can say that they were usually made up of 3 to at most 8 houses. Assuming an extended family unit in each house, the village might typically house 50 people. A palisade usually surrounded the village, sometimes a fence.

The houses themselves were constructed varyingly depending on the consistency of the ground. They were always rectangular buildings with roof ridges, their walls made of wattle and daub or of thin posts placed closely to each other, sometimes covered with daub. The foundations showed the greatest variety of all, although we only know them from houses built on small lakes. Those on larger lakes were presumably above ground and hence no floors are preserved. The aim was, of course, to insulate the house from the damp ground which was done by a layer of logs supporting further layers of logs or by a mixed layers of logs and branches. The hearth, a simple layer of clay, was always situated in the centre of the house.

As a large number of cultures in this study occupied sites on or near lakes the problem of lake-side dwellings, better known as the Pfahlbauproblem has been dealt with separately (Chapter II, 3) and it is therefore not necessary to go into any further detail here.

(ii) Economy, artifacts and burial practise of the Cortailled culture

In the economy of the Cortailled culture, agriculture played an important part. The most recent well-excavated and well published site of the Cortailled culture is that of Burgäschisee-Süd and it will be from this site that most of the following observations are drawn. Cultivated plants included wheat (*Triticum aestivum* L.) and barley (*Hordeum vulgare* L.), whereas emmer (*Triticum dicoccum* Schrank) and einkorn (*Triticum monococcum* L.) were only found very rarely. Quantitatively the highest number of seeds came from the opium poppy (*Papaver somniferum*) which is clearly distinguishable from the wild form (*Papaver setigerum*). Unfortunately Villaret-von Rochow (1967) gives in her otherwise very thorough and detailed study no percentual distribution of cultivated and wild plants but concentrates rather on proof for cultivation of plants: such as cabbage (*Brassica campestris* L.)

and crab apple (*Malus silvestris* (L) MILL) as well as pea (*Pisum sativum* L.). Wild fruit, vegetables and nuts were gathered, hazel nuts being 'five times as frequent as both wheat and barley'. Sloes (*Prunus spinosa* L.), flax (*Linum usitatissimum* L.), Woody nightshade (*Solanum dulcamara* L.) and cherry (*Physalis alkekengi* L.) as well as mushrooms and berries were found to be present in Burgäschisee-Süd.

Only 10-15% of the bones found at Burgäschisee-Süd came from domestic animals, although these show evidence of coming from very highly domesticated individuals and include pig, sheep/goat, cattle and dog (Boessneck et al., 1963). The rest of the bones was made up of aurochs, bison, red and roe deer, boar, wolf, fox, wild cat, bear, birds, hedgehog, frog and 2 fish. Not all animal bones had marks of having been used as food, and were probably not of main importance for nourishment; these include dog, wolf, fox, squirrel and hare. Tree lopping and collection of herbs and grasses helped to overwinter the animals, but most of the bones are from young animals, thus reducing the winterfodder needed.

Burgäschisee-Süd is rather unlike other Cortaillod sites in its ratio of wild to domestic animals. Boessneck et al. (1963, Table 6) showed that the variation in the ratio of wild:domestic animals in 16 Cortaillod sites is very large. The mean value of these 16 sites lies at 45:55% (wild:domestic animals), but a χ^2 test indicated that this value is rather meaningless because the variation is so large that no overall ratio of wild to domestic animals can be used for all Cortaillod sites. Two of the most recently studied Cortaillod sites, Chable-Perron I and II and Yvonand III, both situated on Lake Neuchâtel, indicate the reverse proportion from that found at Burgäschisee-Süd, in their faunal evidence (Chaix, 1976, 35 & 61). Here the most predominant animal is cattle (*Bos taurus*) followed by pig (*Sus domesticus* L.).

and the ovicaprids. Wild fauna is represented by deer (*Cervus elaphus* L.), roe deer (*Capreolus capreolus*), aurochs (*Bos primigenius* Boj.) and hare (*Lepus europaeus* P.). In Châble-Perron the remains of 2 dogs were also found.

The conclusion to be drawn from these last two sites is that the Cortailled population was one of breeders on the whole rather than hunters with a preference for beef. The material from Petit Chasseur, the only land settlement, shows that there the ratio of domestic to wild animals is 97:3% (Sauter, Gallay, Chaix, 1974).

This somewhat diverse evidence can have several meanings: firstly, that each site had worked out its particular pattern of subsistence, presumably depending on the skill of animal breeding, and based on the environmental factors; or secondly, that we are missing a substantial part of the evidence since none of these sites has used sieving or flotation methods of retrieval. This second point would also explain the rather startling absence of fishbones in sites which were ideally situated for fishing and where in fact evidence of this activity is prevalent!

Turning now to the actual artifacts found on Cortailled sites we shall first look at characteristic pottery. The quality is generally good, thin walled, well smoothed and often polished and well fired. There are some sherds which can even be called black burnished. Shapes are relatively simple, usually round based and there is little variety in types. These include high storage vessels with S-shaped walls, hemispherical bowls, jugs, carinated bowls, bowls with round profile, and plates, sometimes with a wide rim. The rims are often decorated with lugs, on bowls these are usually placed on the carination. The lugs are usually vertically perforated. Decoration is rare, and consists of incised or dotted lines in simple geometric patterns

or the birchbark decoration. For the latter a pattern was cut out of white birch bark and glued on to the surface with birchbark resin. Rather unusual but well known are the so-called gynecomorphic decorations. (For a cross-section of representative pottery cf. Fig. 10 in Ottaway & Strahm, 1975).

For stone tools, local material from glacial moraines was made into barrel-shaped axes (fig. 3a) mostly of oval cross-section, either with straight or pointed butt (fig. 3b) or of rectangular cross-section. Some very small axes do occur (fig. 3c).

For flint tools white or honey coloured material from the nearby Jura was used. Points, scrapers and 'knives' were all made on blades (figs. 3d,e,f) and arrowheads can have either a concave or a straight base (figs. 3g,h).

The wooden tools from the settlement at Burgäschisee-Süd have been studied in extreme detail and thus provide us with a very valuable insight into techniques, skill and material used by the population. Since other Cortaillod sites, although not as well studied have similar material of wood it is assumed that the conclusions arrived at might apply to the Cortaillod population as a whole. I shall give some of the most important examples of the total 26 tool categories present at Burgäschisee-Süd, but for further detail readers are referred to the original study (Müller-Beck, 1965).

Of all the tools studied the axe handles with winged head and the harvesting knives with stalk catchers (fig. 4Aa) seem to be characteristic of the Cortaillod culture in particular. Other tools including chisels, wooden awls in holders, adzes and wedges, mallets and hammers were all used for wood working. The hammers are shafted vertebrae and are not exclusively used for wood work, but also for hitting (probably piles). Knives can have long (fig. 4Ab) or short handles.

Agricultural tools include simple hoes, hand-ards (Furchenstöcke) (fig.4Bc) and possibly wooden spades (gestielte Blätter) usually referred to in older literature as paddles (fig.4Bd), although they may have been multifunctional tools. Weapons are represented by clubs, bows probably with an average length of 1.60 m, arrow shafts, lances and projectile points. Finally, household items include bowls, cups, mugs, beakers, ladles, spoons and bark rolls perhaps used as candles. Combs are somewhat unusual (fig.4Be) but should not be excluded. The technological standard of this wood work is of a very high degree and allows us to catch a glimpse of the skill and knowledge with which the Cortaillod craftsman choose and worked his raw material.

In contrast to this, bone tools are rather plain and have not been studied in such great detail. There are for instance awls, chisels and points (figs.4Cf-i). Antler was used to produce sleeves for stone axes (fig.4Ck) but also for axes, often with shaftholes. Harpoons (fig.4Cl) and beakers also made of antler belong to the assemblage of the Cortaillod culture. The extremely high recovery rate of wood, bone and antler artifacts is due to the favourable condition in the waterlogged and therefore anaerobic soil. These same conditions have also preserved a large number of woven baskets, and cloth made of flax.

The variety of ornaments show that people of the Cortaillod were very fond of decoration and this has been contrasted by Gonzenbach (1949) and others with the Horgen and the Michelsberg cultures which are very poor in ornaments. Pendants are the most popular form of ornament; they are made of either boar's tusk and bone (fig. 5a) decorated with grooves (fig. 5b), of polished single- or multiple segmented antler (fig. 5c) of perforated polished bones (fig. 5d). Flat antler rods (fig. 5e) plain or decorated (fig. 5f) small antler spoons with a

perforation (fig. 5g) and stone beads (fig. 5h) are found but perhaps the most popular are the perforated animal teeth (figs. 5i,k). Small animal sculptures of clay (figs. 5l,m) also belong to the Cortaillod culture. Copper occurs mostly in the form of beads and flat axes (cf. Chapter III).

Evidence for the burial practise in the Cortaillod culture is not unambiguous. On the whole, the Chamblande type of graves are taken to belong to the Cortaillod period (Sauter & Gallay, 1969). The only clear-cut evidence comes from Petit Chasseur, Sion where several Chamblande-type burials occur at the same level as the Cortaillod settlement (Bocksberger, 1971). Other evidence is based on the few gravegoods which accompany burials of this type. At Colombey Barmaz (Sauter, 1955) sherds of Cortaillod type were found and the same is true for a Chamblande-type grave at Montaglien, France which belongs to the closely related Chassey culture. A segmented antler bead of the type described above (fig. 5c) was found at the grave at Allamande (Sauter, 1975) - the evidence is thus very scarce. Another serious reason for caution is the area in which the Chamblande burials are found. Comparison of the maps of Wyss (1969, 155) and of Sauter and Gallay (1969, 65) show that the distribution of the Cortaillod and that of the Chamblande burials is almost exclusive of each other. Certainly the areas of their highest respective concentration do not overlap: the Chamblande type graves are concentrated around Lake Geneva and along the Rhône, whereas the Cortaillod culture is distributed along the 'Swiss corridor'. It is also significant that one of the northern outliers of this group, the cemetery at Lenzburg does not have all the characteristics of the Chamblande group of graves and has apart from some clear Cortaillod indicators also evidence of influence of the Pfyn culture. Wyss, (1969) in a thorough study of all Neolithic graves in

Switzerland was not able to find another group of burials more likely to belong to the Cortaillod culture than the stone cists with crouched inhumations which include those of the Chamblande type. I shall therefore briefly outline their most characteristic features: they are stone cists, of size approximately one meter square, built into the ground, with a capstone, and usually grouped together in cemeteries. The chambers are usually orientated on a north south axis. The crouched skeletons normally lie on the left, facing east. Of the grave goods - if present at all - crescents made of boar's tusk, shell, ornaments or necklaces of stone beads might accompany the dead. There is not enough material to draw sex-related conclusions of the grave goods. In several of the stone cists of the Chamblande type couples were buried together (cf. Sauter & Gallay, 1969, 62), but mostly they contain just one skeleton, although occasionally 3, 4 and once even 5 have been found. This is in strong contrast to the stone cists of the Lenzburg cemetery (Wyss, 1967a) where each cist contained between 5 and 17 skeletons. The skeletons were not deposited at the same time, but at intervals, sometimes a new floor was created by throwing soil on top of earlier burials, sometimes room was made by moving older burials aside. The strongly crouched position was probably achieved by wrapping the corpse into skin or cloth or by tying it with rope, although no clear evidence for either of these methods could be found. The proportion of men/women/children in each grave was such that it led anthropologists (e.g. Scheffrahn, 1967) and excavator alike to suggest that we are dealing in each case with the smallest unit of society: the family, buried in one cist over several generations. Infant mortality was very high. The life expectancy of this particular group of people (21 years) was extremely low, lower than for some of the other cemeteries of the Chamblande type as

can be seen in Scheffrahn's table (1967, Abb. 1, p.36), and, in fact, lower than for Palaeolithic populations, (cf. Wobst, 1974) where life expectancy was on average 28. One would expect an improvement with more settled way of life, but evidently other detrimental factors took a heavy toll. One of these could well have been malaria - the disease was still endemic in the 19th. century A.D. in Switzerland. This can be seen from Murray's 'Handbook for travellers in Switzerland' (1938 p.XXIII) where travellers are advised:

'... Avoid, sedulously, stopping for the night near the embouchure of a river, where it empties itself into a lake. The morasses and flat land, created by the deposits of the river, are the hotbeds of malaria, and inevitably teem with disease. To stop in such situations for the night will probably be followed by a fever ... Should, however, any accident compel the traveller to take up his night-quarters in such a spot, let him choose the highest house in the village, and the loftiest room in the house: the malaria does not rise above a certain height ... Such morasses are most dangerous in autumn and spring.'

It has for some time been worrying me, how the population in lake-side settlements was able to survive in these marshy conditions which were likely to have been just as infested in prehistory with malaria as they were up till last century. One possible explanation could be 'balanced polymorphism'. This is a genetic adaptation in which an inheritable disadvantage is linked to an

advantages, such as resistance to a prevailing disease, in such a way that population density remains stable. The best-known example of this is sickle-cell polymorphism (Cavalli-Sforza et al, 1971, Alison. 1971, Harris, 1970, 219, Lehmann et al, 1966), in which an inherited defect in the red blood cells confers protection against falciparum malaria. It is unlikely that this most virulent form of malaria ever reached Switzerland, but the quotation on the previous page proves, that one or more other forms certainly did, and possibly long ago. Certainly, endemic malaria - if it existed in prehistoric periods - is a possible choice to explain the high mortality rates of Neolithic populations.

iii. CONTACTS, ORIGIN AND DATING

Although it has become clear that caution should be used when applying the name Cortaillod-Chassey-Lagozza culture (Bailloud, 1974; Phillips, 1975; Guerreschi, 1967), to many researchers this expression is still a convenient - and if defined, useful - shorthand. The connection between the Cortaillod culture of Switzerland, the material from the Camp de Chassey in France and the Lagozza culture in Northern Italy was first pointed out by Laviosa-Zambotti (1939). Since then many papers on the subject, too numerous to be discussed here, have appeared. There is no doubt that a strong resemblance between the Chasséen assemblages of France and those from Cortaillod sites exists. The same can be said for the finds from the lake-side settlement of Lagozza di Besnata itself. However, too often this connection is made only on the basis of pottery types alone and while there is no doubt that this basic unity of pottery types exists and has led to correct formulation of interconnected cultures - which is now supported by radiocarbon dates - there is no excuse for present time studies to continue this trend. On the other hand, general studies of economy and settlement forms cannot be used alone to define links since the former is usually a combination of pastoralism agriculture spreading throughout the whole of Europe at this time and has large internal fluctuations, and the latter is dependent to a considerable extent on the given geographical situations, such as soil, presence or absence of caves, lakesides etc., to which man could adapt himself. However, if there is a pattern underlying all those activities of man the only way in which we can get near to it is to survey a good cross-section of all

aspects of society, taking into account environmental factors as much as possible. This, of course, depends largely on existing up-to-date studies and while these are available for most of Switzerland and other parts of Europe such as Italy (Barfield, 1969, 1971; Barker, 1974) and France (Phillips, 1971 & 1975) they are practically non-existent in south Germany and Austria.

Coming back to the pottery we can see why comparisons were made for instance in the Chasséen culture where the same main shapes of jars, flasks, globular and carinated bowl and plates occur as in the Cortaillod. Devices for handling are more varied in the Chasséen, there are lugs with multiple perforations (cf. Bailloud, 1974, figs. 5.1 - 2,4,7), but these lugs are more like plastic decoration and an extreme form is the 'flute de pan' (cf. Phillips, 1975, Fig. 3.3). These do not occur in the Cortaillod culture but are known in the Lagozza site and elsewhere in the Po valley, (cf. Barker, 1974). The lithic industry includes numerous small blades, burins and borers mostly of honey coloured flint. Arrowheads include transverse, lozenge, leaf and tanged - and barbed ones. Although most of the raw material came probably from river beds, some was perhaps mined at local outcrops; and obsidian was certainly imported (Phillips, 1975, 84). Bone, antler and stone were utilized in a similar fashion to that described for the Cortaillod culture, although some of the artifacts, such as antler beaker, and, of course, the multitude of wooden tools, are missing. The faunal evidence suggests that domesticated animals, predominantly sheep/goat or cattle, provided at least 50% of the meat requirements. Emmer, wheat and barley, beans and possibly vetches were grown and acorns were collected (Phillips, 1972). The site of Lagozza di

Besnate was in prehistoric times situated on a lake and surrounded by heath and forest predominantly of oak. Remains of wheat, barley, lentils and flax represent the cultivated plants; wild nuts, beech masts, acorns and cherries, the collected wild species. Animal bones were strangely absent (Barfield, 1971, 52). The pottery consists of carinated cups, globular vessels with pierced lugs, and brimmed plates (cf. Phillips, 1975, Fig. 18,1,4). Other types of vessels occur such as the flat based bowls with decorated lids (cf. Barfield & Fasani, 1972, Pl.II,3,9,7,8,11) which have no parallel in the Cortaillod culture. In fact, the Lagozza assemblage is rather unique to the type-site, although some similar artifacts are known from other sites, some belonging to the final square-mouthed phase (e.g. Rivoli-Castelnuovo), others belonging to the Po-valley-late-Neolithic. This latter is the name used by Guerreschi (1967) and should now be used instead of Lagozza to avoid confusion (cf. also Phillips, 1975). Another possible link between those three cultural groups is their somewhat common burial practice. The Chasséen evidence is rather diverse and scanty for a culture occupying such a large area over a long period, but it does include flexed inhumations with or without cists amongst them. No burials have been found at or near Lagozza itself, but there is a group of crouched inhumation cemeteries in the upper Aosta valley just below the Great St. Bernard Pass, one of them at Villeneuve with approximately 25 inhumations in one cist (Barfield, 1971, 53), reminding us strongly of the northern outlier of this group of burials at Lenzburg. Contacts and relations of the Cortaillod culture to the northern and north-eastern area with the Pfyn culture are well attested. Many of the Pfyn objects were actually produced in Cortaillod settlements and conversely, artifacts

- some of these copper - were most probably made in Pfyn sites and exchanged with the Cortaillod (cf. Ottaway and Strahm, 1975) as will be discussed in the succeeding chapter.

Radiocarbon dates for the Cortaillod culture come mainly from Burgäschisee-Sud, where there is a whole series of 17 dates (Bandi & Oeschger, 1967) ranging from between 3000 and 2440 bc. Other Cortaillod dates come from Petit Chasseur (Galley, 1972c) and from St. Léonard (Sauter, Gallay & Chaix, 1971). The range of all these dates lies between 3200 and 2440 bc as can be seen on Fig. 6. The interquartile range indicates between 3000 and 2650 bc for the probable floruit of this culture. (For detailed radiocarbon dates, their standard deviation, their laboratory numbers and place of publication, cf. Appendix I.) The Chasséen has now been extremely well dated and covers a period from 3810 for the earliest date from Église Supérieure cave in the south of France, to the mid-third millenium bc (Phillips, 1975, 81). It is now believed that the origin of the Chasséen lies in areas of France west of the Rhône (Phillips, 1971 & 1975). The culture is then thought to have expanded rapidly up the Rhône and this is clearly when contact with the Cortaillod culture was established; when examing the range of the Chasséen dates it is evident that a chronological overlap exists. Some wooden posts from a recent excavation at Lagozza itself have been dated by various laboratories in Italy and lie between 3030 and 2630 bc. These dates tie in very neatly with the Cortaillod dates.

Stratigraphically the Cortaillod has repeatedly been found above the Egolzwil III culture and below the Lüscherz group (cf. Ch. II, 96).

A number of authors subdivide the Cortaillod into two phases: the early and late phase (Gonzenbach, 1949; Sauter, 1975; Sauter & Gallay, 1969, and Sitterding, 1972), but this is often based entirely on pottery styles (Gonzenbach, 1949) and a progress from an unknown starting phase to one rich in forms and techniques is put forward. There is, however, no obvious break; subdivision seems artificial and unnecessary. Kaenel (1976) in fact, rejects a subdivision, and Strahm (1977) outlines a continual development from the Cortaillod to the Lüscherz culture.

There remains to be mentioned a further group so far represented at one site only: Vallon des Vaux. The excavator, Sitterding (1972) places it stratigraphically between Egolzwil III and Cortaillod; the only radiocarbon date would seem to support this (3200) bc). However, one date is not a very reliable measurement (cf. Ottaway, 1972). Furthermore, the material has been shown by Sitterding to have parallels (based almost entirely on pottery) with a large number of Cortaillod sites as well as with early Chasséen sites in France and with the Lagozza assemblage (for comparison of bowls, globular bowls, plates with wide rims, carinated bowls, globular jars and baggy jars c f. Sitterding, 1972, Pl. 18,2; 16,11; 19,15; 23,8; 29,1 & 39,4 respectively. But cf. also spindle whorls, flint arrowheads, blades, sickles, scrapers, bone and antler tools and pendants). Perhaps the most similar material comes from St. Léonard (A. & G. Gallay, 1966) and from Abri de la Cure, Baulmes (Leroi-Gourham & Girard, 1971) which is not very surprising, since these sites too are situated on rocky hills.

All finds from Vallon des Vaux come from 14 pits. These were found in the eastern part of a terrace, 50 m above the river Chêne. The

terrace was overhung by a rock, thus effectively creating a shelter. Several of these pits contained corn, others sand, silt and small finds such as sherds, flint, bone objects and one fragment of a copper spiral. The bone remains were examined and found to be 66% from domestic and 34% from wild animals. Of the domestic ones, 29% alone came from pigs. It is not clear where their fields were, where they herded their animals or even whether they occupied the terrace all year round. There was no evidence of a workshop or particular hunting activity - although the site had been rather badly dug twice previously - rather the evidence has all signs of a longer stay during which animals and stored grain was brought along. Could this be a site where the population from a lake site took refuge? It is, after all only 5 km away from lake Neuchâtel.

In any case it seems more likely that this site should be fitted into the Cortailod horizon and the assumption made that the differences occurred because of adaptation to the environment.

II.3 LAKE SIDE SETTLEMENTS

As pointed out in Chapter II.2 (i), a large number of settlements in this study occupy sites on or near lakes. The problem of interpreting all available evidence will be discussed here briefly. In 1955 Vogt, reviewing all available evidence for and against the existence of Pfahlbauten or pile dwellings, came to the conclusion that the popular image of villages built on stilts never existed. He based his conclusion on new excavations at Egolzwil and found that all evidence pointed to settlements built on level ground. He was correct except that all evidence then available came from small lakes and bogs. Excavation of settlements on large lakes e.g. lake Neuchâtel, lake Constance, etc. became only possible with advances in modern excavation methods. One of these is the 'caisson technique' which enables excavations to be carried out at 2 to 4 m below ground water level. As a result we now have to reckon with the distinct possibility that houses - on large lakes - were after all built on stilts (Strahm, 1972a, and Strahm lecture in Edinburgh 1974). Using this technique Strahm was able to excavate settlements at Auvernier and Yverdon in lake Neuchâtel and found clear evidence that on these two sites the individual houses were standing on platforms supported by stilts. This, he suggested, explains a great number of otherwise puzzling facts, such as evidence of constant water activity and water sedimentation in between cultural layers, and the fact that the majority of faunal remains come from animals which can only exist in water. Other excavations have since supported these findings (Egloff, 1972; Ruoff, 1976). We should therefore distinguish

between settlements on small lakes, which were less liable to seasonal flooding and were built on level ground, and settlements on large lakes where seasonal water level fluctuation can be as much as 2 m and was probably much more before the correction of the Jura water levels.

Houses in the latter settlements were built on stilts to counter the water fluctuations. The land around them, was nevertheless probably boggy or even dry part of the year as can be seen on working platforms which were used on level ground but were seasonally flooded.

The big quarrel about Pfahlbauten, it seems need never have taken place, since both level ground houses and those on stilts were used. Only the idea that whole villages were erected on platforms has to be discarded.

II,4 The Pfyn culture

(i) Distribution, settlement and house type

The main distribution of the Pfyn culture is not neatly separated from that of the Cortaillod culture. There is about as much overlap of the Pfyn culture in the south of its area with the Cortaillod culture as there is in the north with the Michelsberg culture (fig. 7).

This is, of course, only natural, since we know that both cultures were in contact with the Pfyn group, and that they exchanged certain regenerating products, probably intermarried, thus not only the gene-pool but also bringing in a few new pottery styles - assuming that the generally held opinion, of women potters is correct. This latter idea has been illustrated on ethnographic studies which showed that women would at first try to imitate the particular style of pottery of their new surroundings, but would later go back to their accustomed style continuing with this for a considerable period of time (David & David-Hennig, 1971). This is not to suggest that marriage patterns can explain overlap in ceramic distribution, merely to point out a possible alternative explanation of some of the phenomena encountered.

The main concentration of settlement sites belonging to the Pfyn culture is found around lake Zürich and on the upper arms of the Bodensee (lake Constance), with a few sites scattered in between those two lakes and three possible sites in Lichtenstein. As before, the favoured situation for settlements was along lake sides, on riverbanks and bogs but there are some sites on hills (e.g. Lutzengüttele) and the type site itself Pfyn, Breitenloo lies in a valley only 2 km away from the lake-side settlement of Niederwil. This latter site and that of the Weier, south of Thayngen are the only two sites that have been excavated and published reasonably well (Waterbolk & Zeist, 1966; Harsema, 1973; Wininger, 1971). The Niederwil settlement was erected 40 m away from the lake, the Egelsee (the full name of this site is Egelsee near Niederwil-Gachnang) and could at the time of excavation be seen in outline as a roughly circular island covering 200 square metres in the moor. The area is now used as a waste-water basin of the nearby sugar factory. There are numerous other recent excavations, but they are mainly rescue excavations which have to be carried out hastily on sites that are usually already half-destroyed (cf. Ruoff, 1976). Most elements from other Pfyn sites can be fitted into the material from Weier and Niederwil and it is therefore those two sites which will provide most of our information.

Houses at the Weier I have recently been schematized by Guyan (1976). His plan (fig. 8) shows how at first 2 houses with a hearth and 1 Wirtschaftsgebäude (fig. 8,a), probably an animal shed without a hearth, had been built. To this was added after an interval of 17 years, a second shed (fig. 8,b). After a further 13 years a fence was built (fig. 8c). The second shed had a large number of bones scattered around it. Five years after the fence was built, the site was abandoned. The entire occupation lasted only 35 years. All houses were directed

SW to NE, their sizes varied between 4X8 and 6X8 m. A shift in the economy is indicated in the second settlement, Weier II, by smaller house sizes, but more (10-15) houses, and a larger proportion of houses without hearths (5 of the 8 excavated). The third settlement, Weier III, uses a different house type - Stelzbauten, houses built on stilts, made of halved tree trunks had either 7 x 3.5 m or half that size. Although none of the houses had a hearth, the whole village gives a well planned and "orderly" (Guyan, 1976) impression with paths running at right angles to each other and a strong fence surrounding it, reaching right out into the moor. There were probably 30 houses in all. In contrast to this type of house, excavation at Niederwil found sufficient evidence to show the existence of long houses. These houses measured 37-30 m (possibly even up to 70 m) (Waterbolk & Zeist, 1966) by 4 m (Harsema, 1973, 223) and had internal partition walls with square fireplaces in each room. There were six parallel rows of these buildings and footpaths between them ran along the whole length (cf. Waterbolk and Zeist, 1966, fig. 2). Harsema suggested that the long houses were subdivided into 10 m long subunits each with at least one hearth or a more substantial oven, which was often renewed, and another less permanent fireplace. He suggests this type of house would be occupied by an extended family. This type of long-house has been very startling, and comparisons have been made to the only known coeval similar types of houses in the Tripolye and the northern TRB cultures. But recently Guyan (1976) indicated that the excavator seems to have been wrong in his interpretation and we will have to await final results, before drawing any further conclusions.

II,4 ii) Economy, artifacts and burial

Most of the Pfyn's population's protein demand was satisfied by domestic animals and by agricultural products. The percentage at Niederwil of 82% domesticated animals is strikingly high compared to other Neolithic domestic sites in this area (cf. Boessneck, 1963, T.6). In the nearby settlement of Pfyn, 36% of faunal remains came from domestic animals (Clason, 1966). Cattle and pig were the most important of the domestic animals followed by sheep/goat and dog. At Weier the presence of remains of several young dogs seem to point to their inclusion in the diet (Guyan, 1976). An important discovery both at Niedwil and at Thayngen-Weier, was excreta of goat/sheep and now also cattle in and around the houses, which led to the conclusion that these animals were kept within the settlements, in the case of cattle perhaps only during the winter. From Weier I we now have evidence that 70-80% of all butchered animals were calves, sheep ^{were} too ^{more} generally butchered young. The meat was probably conserved by smoking, possibly with the addition of herbs (Guyan, 1976), because it is unlikely that salt was available in this autochthon economy. The problem of providing winter fodder was thus neatly solved, since only a low stock of animals overwintered in that period. However, generalizations must be avoided, because the situation even at Weier II is different again: fewer young animals were butchered and although sheds for both cattle and sheep/goat were found the concentration was on cattle breeding; consequently, more cattle must have overwintered and Guyan (1976) found evidence for tree lopping of oak, ivy, lime, ash and elm as well as collection of wild garlic (*Allium ursinum*) for fodder. The list of wild animals present in Pfyn settlements is similar to that found in the Cortaillod culture. It includes at Niederwil red deer, roe deer, boar, aurochs, beaver, badger, fox and hedgehog, possibly also elk and European bison,

although the latter two cannot be determined with certainty in the modern excavation (Clason, 1966). Several birds such as duck, bird of prey, pidgeon, and carrion crow were caught. Evidence for fishing - either in the form of fish, bones, scales, nets, harpoons or fish hooks - is completely missing at Niederwil. The list of wild species from Thayngen-Weier can be completed by hare, squirrel, mouse (*Microtus ratticeps*, and *Microtus oeconomus*), bear, iltis, otter, wildcat, wild horse, aurochs (*Bos primigenius*), tortoise and frog (Guyan, 1976). Also the following birds were captured at Weier: swan, caper, crane and other fowl. Finally, there is, at last, some evidence at the Weier for fishing: bones of 2 pikes as well as antler harpoons have been found.

Agriculture was carried out on fields cleared by the slash - and burn method, which is indicated by the large number of stone axes and their shafts (for which most commonly the wood of ash was used) as well as by the presence of airborne charcoal in old fields, the reduction in tree pollen coupled with an increase in pollen of grasses and weeds.

Cultivated plants represented at the Weier are dwarf-, or club-wheat (*Triticum compactum*) and common bread wheat (*Triticum vulgare*), emmer and barley; the former two being the most common. Also cultivated were poppy and flax. Flax was probably crushed with a pestel and mortar to oil and poppy most likely provided narcotica (Guyan, 1976).

The material from Niederwil is at the moment being prepared for a detailed report by Jørgensen, Kopenhagen, and so far only millet (*Panicum miliaceum* L) can be added to our list (Clason, 1966).

The material from Horgen gave very similar results (Pawlik & Schweingruber, 1976).

Collection of wild fruit and berries is attested by a large variety of remains, which is very similar to that from the Cortaillod settlements. To this list can be added beechnuts, elder, blackberries, raspberries,

fat hen, blueberry and water chestnut (*Trapa natans* L). Caraway seeds and wild garlic served as spices. Herbs for medicinal purposes are quite numerous and include vervain (*Verbena officinalis* L.) yarrow (*Achillea millifolium*) and mugwort (*Artemis vulgaris*), just to mention a few (Clason, 1966).

The impression is obtained that the economy of Pfyn villages was diverse and well organised. There is, for instance, a special clay-covered area where wheat and barley was threshed with a threshing stick (cf. Guyan, 1976, Abb.27), there are quernstones to grind the grain (Wininger, 1971, Fig. 48,9), and spindlewhorls, loam weights, flax combs and numerous remains of woven and plaited textiles. All available resources were used, e.g. honey was collected and the presence of a wooden milkbowl in Weier might suggest the start of dairy production.

The characteristic pottery of the Pfyn culture is well fired but usually very thick walled. There are Trichtertöpfe, i.e. vessels with S-shaped profile, in varying sizes. They have either a smoothed surface, or one roughened by incisions or by fingertip impression, or they can be covered with a rough mud cover (Schlickauftrag). This kind of surface is used mostly for covering large vessels. Their rims are round and undecorated or thickened and decorated with Arkadenleisten (reminiscent of Romanesque arches) or with fingertip decoration. Further, there are conical pots, flasks, vessels with perforated lugs and Henkelkrüge, i.e. jugs with handles. Hemispherical and carinated bowls, sometimes with perforated or conical lugs also occur. (For illustrations of representative Pfyn pottery cf. Ottaway & Strahm (1975) fig. 11). There are a few plain beakers and some 'Tulpenbecher' (i.e. tulip-shaped beakers). The latter are so similar to those from Michelsberg sites that all 6 found at the Weier could easily be fitted into Lüning's classification (1968). There are also ladles, spoons,

numerous miniature vessels and Backteller (i.e. baking plates). These latter are typical for the Michelsberg culture, but their large number suggests local production rather than import from Michelsberg.

Niederwil's pottery is very similar and includes for instance the Backteller, not however, Tulpenbecher. On the other hand a clay crucible was found here as on other Pfyn sites.

Part of the clay used at the Weier could be traced to a source 4,5 km away: it contained very recognizable iron inclusions (Bohnerz). Another type of clay was used, e.g. for the floors and hearths and this clay occurred at a distance (by air) of 1 km. Guyan (1976) calculated that the material transported from this source to the Weier II settlement alone weighed roughly 1.5 tons.

Flint implements were made of 2 kinds of flint: a light brown one found in the nearby Schaffhausen Jura Plateau, and a better quality grey clear flint, which is not found in the neighbourhood and was used only for more demanding tools, such as arrowheads. Arrowheads can have a straight or concave base (fig. 9a,b) but a few barbed arrowheads also occur (fig. 9c). Points and scrapers (fig. 9d,e) are very numerous and a few nuclei were retouched indicating that the local flint at least was worked on the site (fig. 9f). The rich flint material from Thayngen Weier is at the moment under study (Winiger, 1971, 38) and we hope to gain more insight into this rich material in the future.

Stone tools, as in the Cortaillod culture, include hammers, sometimes worked to have a better grip but more often just recognizable by their fractured base. Axes have cross sections varying from almost rectangular (fig. 9g) to oval and with thin butts (fig. 9h). Some of the small ones may be adzes. Another typical tool is the Knaufhammeraxt or battleaxe (fig. 9i) and also the hammeraxe, or so-called X-axe (fig. 9k).

Bone and antler tools again are rather similar to those from Cortaillod sites, although possibly bone spatula (fig. 10a), scapers (fig. 10b) and flax combs (fig. 10c) should be added. Similarly, weapons and tools of wood are all comparable to those used by the Cortaillod population with the exception of the sickle, which has not been identified at Pfyn sites.

Ornaments are rather scarce; none were found during the excavation at Niederwil. Those found at Weier are almost all pendants mostly teeth, perforated at the root (fig. 10d) and very occasionally of antler.

An unusual type of find, which is nevertheless very characteristic of Pfyn sites is the crucible. They are made of clay usually 10-20 cm long, thick walled and are either rectangular without a handle (fig. 10e) or oval and with a handle (fig. 10f). A whole group of them, collected by Dr. Wyss awaits full publication. Some of these still have traces of metal on their insides, and we hope that permission for analysis will be given soon.

Copper occurs mostly in the form of flat axes (cf. Chapter III).

We now come to the problematic question of burial practise of the Pfyn culture. The last comprehensive study of Wyss (1969) came to the conclusion that burials with extended inhumations could be coeval with the crouched burials in stone cists, which as discussed earlier, probably belong to the Cortaillod culture. The distribution of these extended inhumation graves (fig. 7) is roughly suitable for Pfyn culture, although there are some startling gaps, notably in the areas of highest concentration of settlements, i.e. at the Zürich- and Boden-see. Should we assume that the lake-side population had other ways of disposing their dead e.g. in the water? Or that we have not yet found any of their cemeteries? The latter is hardly likely in such densely populated country as modern Switzerland. The graves with extended

inhumations have no unifying orientation but the skeletons are all lying on their back. The graves themselves are usually dug into the subsoil and sometimes surrounded by a circle of stones. This kind of burial is found predominantly under overhanging rocks or in caves. It is therefore not surprising to find a concentration around Schaffhausen, where the type of rock provides ample and ideally suited sites.

A few burials have grave goods, usually flint implements, axe blades and a few ornaments e.g. serpulæ beads (which have a south alpine origin) and a large number of perforated stone buttons found not only around the neck, but also on the chest and stomach.

The most southerly situated grave (Opfikon) is particularly interesting: it is a stonecist, of the type that usually has crouched inhumations, only here it contains 2 extended inhumations with rather rich grave goods (Wyss, 1969, fig. 2,1-9), including a beautiful dagger, a knife, a whole set of arrowheads all of flint, and a miniature stone axe. Opfikon is not very far away from Lenzburg, the Cortaillod cemetery, mentioned earlier, where Pfyn contacts have been demonstrated. These two grave sites give a good picture of reciprocal influences.

II,4 iii) Contacts, origin and dating

Many of the contacts of the Pfyn culture with neighbouring groups have already been mentioned. It could be seen that contacts, were quite frequent with the contemporary Cortaillod culture. This can be further illustrated by an antler beaker, (typical of Cortaillod), found at the Pfyn site of Wetzikon-Robenhausen; or by some birch-bark decorated vessels from Weier. Conversely, a vessel with Schlickauftrag, a typical surface treatment of the Pfyn culture, was found in the Cortaillod settlement of Seematte and a Henkelkrug of Pfyn-type found its way to Egolzwil 2. Another contact was through the copper axes which were used by the Cortaillod, but probably manufactured on Pfyn sites

(cf. Ottaway & Strahm, 1975). As was just discussed, contact is illustrated by the Lenzburg and Opfikon graves. These 2 cultures also shared a very similar inventory of flint, bone, stone and wood, they were also both predominantly situated on lake sides. Yet one has very strong ties with a southern orientated cultural circle, the other with a northern and central European one.

In the north, contacts of the Pfyn with the Michelsberg culture have been expressed by the pottery.

It is interesting that the Munzinger culture, which is regarded as a regional group of the Michelsberg culture and has a distribution covering southern Baden and the Alsace, has according to Winiger (1971,104) more in common with the Pfyn culture than with the Michelsberg culture. However, there is a gap in the distribution just in the area - Kanton Basel - where the groups would have been in contact and no studies examining material other than the pottery exist.

The Altheim and the Pfyn cultures both said to be united in their shared lack of typical Michelsberg elements presumably other than the Backteller and the occasional Tulpenbecher. Their pottery certainly share a number of common factors, such as flat bases and the Schlickauftrag, this will become apparent when dealing with the Altheim culture itself. There are, however, factors which could have prevented direct contact one of them being the occupants of the large area in between those two cultures. This will be discussed in the next section.

So far various outside influences on the Pfyn culture have been mentioned, but the impression is that this culture should not be regarded as intrusive. It has strong ties with local earlier groups, in particular with the Lutzengletle group. This has been shown clearly at the type-site itself. Vogt (1967) suggested that the Pfyn and Lutzengletle cultures probably form one ethnic group. The later Pfyn group developed by taking in selectively some of the elements mentioned above.

A subdivision of an early, middle and late Pfyn phase was suggested by Lüning (1968) and Wininger (1971) and has been used by Guyan (1976). The criteria on which these subdivisions were undertaken are not very satisfactory: Wininger was unable to subdivide the finds from the 3 successive settlements at Weier (I-III), using the Pfyn finds as a whole he called elements such as crucibles and battleaxes and handled jugs 'late'; based the 'early' phase entirely on pottery styles, and treated the vast material left over as belonging to a 'middle phase'. However, it is much more important to stress the strong continuity throughout its entire duration and this should after all not be too difficult to accept considering the rather compact area occupied by the Pfyn culture.

The interquartile range of all available Pfyn radiocarbon dates lies between 3100 and 2740 bc. This is slightly earlier than the interquartile range for the Cortaillod culture which lies between 3000 and 2650 bc (fig. 6). This precedence of the Pfyn culture over the Cortaillod has not been accepted by Swiss archaeologists and is not supported by dendrochronological measurements. These latter indicate an almost coeval building period of the Pfyn settlement at Thayngen and the Cortaillod settlement at Burgäschisee-Süd (Huber & Merz, 1963). It is clear, at any rate that there is a considerable temporal overlap between these two cultures.

A further date comes from the Egelsee but is not directly connected to the Pfyn settlement there. Since it comes from a grain pollen and gives a very early date (4200 bc; Guyan, 1976) it might be an indication that agriculturalists had settled near the Weier before the Pfyn culture. (For radiocarbon dates, laboratory number and reference cf. Appendix I).

II,5 The Altheim culturei) Distribution, settlement and house type

Advancing in a north-easterly direction and remaining in the same time-horizon the next copper-using culture is the Altheim. This culture has been accepted as an entity since 1960, when Driehaus published his thesis. He separated the Altheim group off the Michelsberg culture at the same time suggesting Pfyn to be a parallel culture in Switzerland. Since then there has been no new comprehensive study of this area or period and on the whole Driehaus' culture has been completely accepted with only a few exceptions (e.g. Maier, 1964). There have been no planned excavations of Neolithic sites in Bavaria since the second World War (the only excavation is a Dutch one at Hienheim, which promises to unravel several problems around the area, Moddermann, 1971, and has provided the only two radiocarbon dates). Therefore, the entire evidence rests on old material (Altheim was excavated by Reinecke in 1914 and again by Wagner in 1938), to which a few odd chance finds have been added (Maier, 1965b, Schneider, 1968). Often, studies are based entirely on stylistic differences in the pottery (Mauser-Goller, 1969).

The situation is further complicated by the fact that - unlike its SW German counterpart - Bavaria's earlier periods are by no means satisfactorily worked out. One group's chronological position, the Münchshöfener culture, although itself studied well and shown to be an entity (Süss, 1967) is still the subject of vehement discussion (Mauser-Goller, 1969; Siegroth, 1972). Added to these difficulties is the resistance of scholars in this area to the use of radiocarbon dating.

Maier (1964) has suggested a return from the Pfyn and Altheim terminology back to the term Michelsberg culture and has put forward a differentiation between 'See-Michelsberg' and 'Land-Michelsberg'. However, this suggestion has not been accepted and although many

fundamental gaps remain to be filled I shall briefly outline what is known to belong to the Altheim culture:

The main distribution of this group (fig. 11) as outlined by Driehaus occupies modern South Bavaria; the eastern and western borders are the rivers Saalach (the modern boundary with Austria) and the Lech.

The modern border is the Bayerische Wald; the southern border is ill defined, due to large gaps in the distribution of find sites.

Driehaus suggested it ran along a line between the modern towns of Landsberg and München and the lake Chiemsee.

It was not possible in 1960 to detect a uniform settlement pattern and the situation has not improved since, for reasons outlined above. In lower Bavaria the preferred areas of settlement on the whole were edges of loess, in dry high valleys. In the border zones they lived on Höhensiedlungen, e.g. at Auhögl, which might indicate the necessity for defence (cf. Ritter, 1963).

Houses were not found at Altheim itself, just pits but since they lack postholes and any other evidence of occupation they should be discounted as possible dwellings. Reinecke (1924) and Driehaus (1960) suggested that there had been only 1 farmstead in the inner area, enclosed by 3 ditches at Altheim, and that the buildings must be in the unexcavated quarter of the site. It is probable that the outer two ditches are later than the inner one. The area surrounded by the inner palisade measured 35 x 60 m. The inner ditch contained 15 human skulls as well as other disarticulated human bones. Most of these bones were fairly close to the entrances as were 174 flint arrowheads. This suggested to Reinecke a fierce battle. During the 1938 excavation more skeletal remains were found this time in all three ditches, although most again in the inner ditch. There are no exact figures, but an estimate brings us to at least 30 individuals. Maier (1962c) reviewing the evidence from

Altheim and comparing it with a similar but perhaps slightly earlier site at Kothingeichendorf (Landkreis Landau on the Isar) pointed out that both sites although planned carefully by man are not situated in a defensive position (fig. 12). On both sites no evidence of structure above ground remained, and both are constructed of discontinuing ditches which were filled with human skeletal and cultural material.

Kothingeichendorf was used over a long period of time (attested by the presence of sherds from the Rössen to the Münchshöfener period) and in one separately dug ditch 2 infant inhumations (crouched) were found closely associated with vessels, stone axes and animal jawbones.

The parallels to some features of the interrupted ditch system at Hambledon Hill (GB) are striking (I would like to thank R. Mercer, Edinburgh for the information on Hambledon Hill) particularly when bearing in mind that we know of practically no graves belonging to the Altheim culture.

At the Fuchsberg 2 houses were partly unearthed in 1949/51. They were 5 m apart, parallel to each other and had foundations about 30 cm deep. Large amounts of burnt and charred beams and planks as well as daub were found, not, however, postholes. Unfortunately, only the length of the houses - 6.5 m - was excavated but not the width, so that we have no information of their exact size. A year later one hearth was found: a burnt floor area surrounded by a stone circle. Although nothing else has been excavated on this tantalizing site, it provided the largest amount, quantitatively, of any Altheim site so far.

At other sites similarly incomplete evidence has been found: a row of postholes without any recognisable pattern here (Klosterberg, nr. Mailingen), remains of a wooden floor and large amounts of daub there, usually associated with Altheim bone, stone and pottery artifacts.

A tantalizingly under-explored site is a field at Merching nr. Friedberg, known only from numerous surface finds and 3 drilling samples (Schneider, 1968). The fact that this site is on a moory subsoil would provide ideal research conditions and would yield information about faunal floral and economic circumstances as well as house structures. However, the only information available indicates that there is a layer of loessy soil with daub, charcoal and other settlement evidence including sherds at a depth of 58-80 cm.

All this patchy evidence allows us only to talk in the vagest sense of wooden houses, probably with wattle and daub walls, built perhaps above hollowed-out foundations (Gruben) on dry land, and on posts on marshy ground.

ii) Economy, artifacts and burial

The economy of the Altheim group must - without a single thoroughly excavated site - of necessity be equally poorly known. There is no hope of finding detailed faunal and floral evidence. We can only give a list of species of animals and plants whose presence has been attested on Altheim sites. From Altheim itself there are 13 sherds with plant imprints: Emmer, einkorn, barley and apple (*Malus communis* L.) are thus represented. Numerous quernstones as well as flint sickles support the impression that agriculture was of importance. Boessneck (1956 & 1958) has studied all available animal bones from Altheim sites and from this we know that cattle dominated and was followed by sheep/goat, pig, and dog. On 2 sites horsebones were found. Boessneck, expressing himself very carefully stated that very probably these were domesticated animals, either herded freely or not yet fully domesticated and probably - like all other animals - kept initially just for their meat value.

Wild animals are represented by red deer, roe deer and boar, in that order of frequency, although one has to be particularly careful here since these bones were often preferred for tools because of their greater toughness (Boessneck, 1956) and could therefore be over-represented.

We can only assume that weaving was known and flax was used for textiles because ^aflax comb at Altheim, and a spindle whorl at Merching were found (Schneider, 1968, fig. 7.5).

Turning our attention to the actual artifacts one is immediately struck by the predominance of two groups of material: pottery and flint. Again, until one site has been fully excavated one cannot know whether this is significant or merely a reflection of the fact that these two materials are the most easily recognizable as surface finds and by amateurs.

The pottery can be equally divided into fine and coarse ware. The latter is well smoothed and burnished. The coarse ware is often covered with Tonschlicker i.e. the same method of roughening as in the Pfyne culture was applied. It has been suggested that it was applied to equalize tension during heating and that these vessels were cooking pots. The fine ware is subdivided by Driehaus into four-handled flasks (fig. 13a) of nearly biconical shape; barrels (fig. 13b) Henkelkrüge with Bandhenkel i.e. ribboned handles, which can either start below (fig. 13c) or at the rim and go slightly higher than it. There are further Henkeltassen (fig. 13d) vessels with 4 lugs or with only 2 lugs, and bowls either with carinated or soft profile. The coarse ware is subdivided into Trichtertöpfe with fingertip or 'Arkaden' decoration (fig. 13e) or with a plain rim but with knobs (fig. 13f), and Trichtertöpfe with a wide mouth or smaller undecorated ones. There are also sieves usually with hemispherical but now also with flat bottoms (fig. 13g) (Schneider, 1968). The percentage of each type (cf. Driehaus, p. 25) using the 600 vessels from Altheim showed that the Trichtertöpfe

with arcaded rim decoration appear most frequently, followed by bowls, Henkelkrüge and other Trichtertöpfe. This domination of one type seems to be supported by the latest Altheim finds from Merching (Schneider, 1968).

Flint artifacts from Altheim can be recognized easily: they are mostly made of local flint found in an area between Heman (Bavaria) and Altmühl, in the form of flat slabs Plattensilex, of about 1 cm thickness and up to 20 cm long. Large implements can therefore be produced relatively easily and often only the edges had to be retouched. This type of flint, on the other hand, cannot be subjected to techniques that were used on blades. For the latter, banded jasper from the Jura was used. This material was sometimes found unworked in Altheim sites, whereas the flint was never found in its raw form on the sites. Most common are arrowheads - there are 174 from Altheim alone and they are almost all of triangular form, retouched on both sides with a concave base (fig. 14,a). More than 2/3 have lost their tips, some have denticulated sides (fig. 14,b). The sickle is a typically large flint implement, from Altheim itself there are only fragments but elsewhere intact samples have been found. Driehaus distinguished between the narrow crescent shaped ones (fig. 14,c) and the short stubby ones with a straight inner cutting edge (fig. 14,d). On a very few, sickle gloss has been detected, but otherwise a technological study of wear and use patterns has not been carried out. It would be particularly useful for all so-called knives, which show no uniformity in shape and size and are often just fragments with well-used cutting edges. The impression is that the shape of the raw material influenced to a large extent the final shape. Scrapers are almost always made from flint nodules; the point of percussion, even though sometimes retouched, can still be seen clearly. On many scrapers the original weathered surface has been left untouched (fig. 14,e). No functional studies have been made on

these implements which vary considerably in size and shape. Blades, as mentioned earlier were made of banded jasper and have either round (fig. 14,f) or straight end (fig. 14,g) with steep or flat retouch.

Stone tools and weapons belonging to the Altheim group were all made of locally available alpine rocks, such as diorite, serpentine, gneiss and granite. The nearer the site to the Alps, (e.g. Auhögl) the larger is the variety in rock types used. Along the Danube, on the other hand, almost all stone artifacts were made of diorite; again all identifications of rock and stone tools are cursory and a more scientifically study is badly needed. Driehaus gave the axe hammer as a typical Altheim tool (it has the same shape as those found in the Pfyn culture, cf. fig. 9,i). Yet only fragments of 9 such axes have been found altogether (fig. 15,a) and it seems somewhat questionable whether it should be called a "typical" type of axe and not rather a rare element, as it was in the Pfyn culture.

There are quite a number of stray finds of axe hammers either of the so-called X-type or a more elongated form. Some of the fragments found in Altheim context could be similar to these axe hammers.

Unperforated stone axes are very numerous and are divided into round ones with more or less pointed butt (fig. 15,b) of about 9-30 cm length and similar to axes of the Pfyn culture. Flatter ones with a straight butt are usually smaller (7-12 cm long, fig. 15,c) and mostly polished. This subdivision would be somewhat hazy, were it not for the very large number of axes found at Auhögl (96 axes).

Other stone tools are similar to those mentioned earlier and include hammer stones, whet stones and 'waisted' stone hammers.

Bone and antler tools have only been found on 4 Altheim sites but this is hardly surprising bearing in mind the poor excavation record of this group. As Boessneck (1956) pointed out most of the tools were made

of bones of wild animals; amongst these the rib bones of red and roe deer are most common, but bones of cattle and of pigs were also used. All perforated tools are made of antler, but again one cannot at the moment be sure, whether wooden tools may not have played as important a part as they did at Switzerland. Tools made of antler are mostly axes or hammers (fig. 16,a); their perforation is almost always near the burr. But there are also numerous antler chisels, awls and points with either single or double working ends (figs. 16,b-f).

There is one flax comb found at Altheim made of rib bone (fig. 16,d).

Driehaus suggested that 2 smoothed and perforated antler points (fig. 16,g) were used like halberds. This is supported by the wear pattern which show that the haft, about 5 cm in width, was lying parallel to and between the (dotted) lines and was probably held in place by the rivet.

Ornaments are, as in the Pfyn culture, very scarce. They are of perforated boar's or pig's teeth (fig. 17,a) but stone beads (fig. 17,b) and stone pendants, imitating teeth (fig. 17,c) are also known.

Copper is represented in the Altheim group by very few, but nevertheless significant finds - these are flat axes, one pendant, an awl and a piece or fragment of copper.

There are no cemeteries, burial sites or graves which can with certainty be tied to the Altheim group. The disarticulated skeletons found at Altheim itself, as mentioned earlier, are the nearest we come to burials. The only other evidence comes from the western area, where contact with the Michelsberg culture was possible. At Inningen, near Augsburg, a crouched inhumation was accidentally cut open and a round shaft was, at 1.40 m depth, found to contain 6 skeletons together with a few Michelsberg or Altheim sherds and several animal and bird bones. Three further such shafts, probably of similar date, were found.

Maier (1965b) discussing this find, compares it with an extreme example of shaft burials at Nitriansky Hradok (in SW Slovakia) belonging to the Baden-Pécel group. In that group, however, such highly ritual burials always go together with perfectly ordinary mass and settlement burials. These are not all known in the Altheim nor, indeed in the Michelsberg culture.

iii) Contacts, origin and dating

In the description of the patchy material of the Altheim culture several contacts have been mentioned. Many more wide ranging ones have been pointed out (cf. Müller-Karpe, 1974) and as so often, the low number of radiocarbon dates is inversely proportional to the number of publications on this subject. Under these circumstances and bearing in mind how radically the picture can change with one modern excavation, it is perhaps wisest to adhere to the immediate geographical neighbours and to the most obvious parallels.

The connection between the Altheim and the Pfyn cultures is made almost automatically, yet there are as many stylistic and other differences as there are similarities. The similarities are found in the proportion of Trichtertöpfe with 'arcaded rims' to bowls and Henkelkrüge, as well as in the Schlickauftrag on coarse ware, and the stone axes. Yet the differences must not be overlooked: they are most obvious in the flint working techniques, the lack of some of the most typical Altheim vessels (barrels and lugged flasks) and the lack of graves in the Altheim group.

Another major consideration is the fact that both cultural groups have fairly well defined borders towards the west and east respectively which do not meet, but leave rather a wide area in between. The country between the rivers Lech and Iller is remarkably poor in finds of all periods, but further west around the Federsee and in Baden-Württemberg

and upper Swabia, lake-side dwellings and other sites belonging to the Schussenried culture are quite numerous and have been relatively well studied (Zürn, 1965 & 1968). Both Driehaus (1961) and Lüning (1968) put forward the suggestion that Altheim and Schussenried are roughly coeval and the only Altheim date has supported this. The interquartile ranges of the Schussenried site Ehrenstein lie between 3400 and 3200 bc with outer limits of 3570 and 3080 bc (total numbers of dates: 27). Its floruit is therefore considerably earlier than that of the Pfyn culture and only their outer quartiles overlap (making a concentrated contact between those two cultures rather unlikely, if Ehrenstein is representative for the whole culture. The Schussenried settlement at Ehrenstein was very well established and in every aspect - such as housebuilding on moors, and agriculture - as developed and successful as the Pfyn culture. In many ways it was perhaps even more advanced, e.g. it had two-roomed houses with wooden fore-courts and wide streets and baking ovens as well as hearths in every house, yet after 200 years it was abandoned for no obvious reason.

Driehaus was puzzled not to find any stylistic (pottery) parallels between the Altheim and Schussenried cultures and therefore did not include it into his alpine 'Kreis', indeed only the Henkelkrug is found in both cultures.

The Henkelkrug and a common habit of building on wet subsoil and near lakes is shared by the Pfyn, the Schussenried, the Mondsee and the Altheim (?) cultures. One wonders whether the Schussenried culture as a whole did not perhaps last longer than indicated by the Ehrenstein dates alone thus allowing a genuine overlap. These wider cultural connections have also been made on the basis of the decorated and white incrustated ware found in Schussenried (Maier, 1964) and also on lake Constance (Maier, 1962b) and the Upper Austrian Mondsee culture, but this will be discussed later.

It may well be that the Pollinger group which, according to Driehaus, was later than the Altheim culture but has been shown by Müller-Karpe (1961) to be late Neolithic and put parallel to Michelsberg II by Lüning (1968), followed the Schüssenried culture, thus filling at least part of the gap. The site Polling now near the Starnberg lake was in prehistoric periods situated on the lake. The settlement extended over an area 80 x 300 m and the pottery included arcaded vessels, Henkelkrüge, and flasks often deeply incised. These incisions were probably filled in with white material (Müller-Karpe, 1974, 469). Numerous flint tools were made of imported flint-Plattensilex-and worked at the site. Limestone beads are similar to those manufactured at the workshop in Bodman at lake Constance (Maier, 1962a). Surprisingly, the analysis of bones from this site indicated a dominance of wild over domesticated animals (Müller-Karpe, 1974, 940) which does differentiate this culture in economic terms from its neighbours. A typical Michelsberg Tulpenbecher was found at this site recently pointing to contact between those two cultures (Maier, 1975).

Until 1960 the Altheim group was part of the Michelsberg culture but Driehaus has stated quite clearly that Altheim can not be a 'subgroup' nor can it have developed from the Michelsberg culture (1960, 141). He conceded that there is a general agreement in the overall pottery shapes, such as the coarse Trichtertopf with fingertip-decoration on the rim or the lugged bowl although there the lugs are usually on the neck of the vessel and perforated horizontally. Large flasks with funnel necks might perhaps be compared to Altheim's flasks, but again the Michelsberg vessels often have lugs near the base. More important, perhaps, is the total lack of 'classical' Michelsberg pottery such as the Tulpenbecher, and the Backteller. There are, a few individual Michelsberg finds in the Altheim area but the most important point in the

argument about relationships between the Michelsberg and the Altheim culture is the Altheim Erdwerk itself. If, as suggested by Driehaus (1960) it is a defensive site then parallels to the Michelsberg culture would be excellent and Altheim could even be dated as belonging to one or two of Lüning's five phases (to phase II). If, on the other hand, we accept Maiers' suggestion (1962c, 1965b) of a ritual monument without defensive character, then the difference between the two cultures is highlighted even further. The question will not be resolved until new light is shed on it by further excavation.

It is interesting that the Pfyn settlement at Thayngen was suggested by Lüning (1968) to be parallel to Michelsberg phase III. This was accepted by Wininger (1971). Michelsberg sites along the Bodensee, on the other hand, are grouped under Michelsberg phases IV and V. These are sites such as Sipplingen and Bodman, where Pfyn material also occurs. Michelsberg finds of the Salzburg area of the Saale and of Bohemia all belong to phase II, IV and V or the late Michelsberg culture (cf. Lüning, 1968, Pl. 98, 799). Tendencies to push the Michelsberg culture even further east have been checked by Hechmann (1973) who categorically stated that there is no Michelsberg material in eastern central Europe. He pointed out that what we do have to decide is whether there are Michelsberg imports of pottery, presumably with their contents, or whether they are forms of the local TRB cultures. Scientific studies of the trace elements in the clay by neutron activation could solve this problem.

One further culture, the Baalberg culture, must be mentioned here briefly: because it is at the Altheim's northern border. The comparison is usually based on their pottery alone - the Trichtertöpfe with rim decorations of either arcades or fingertip impressions. However, although the Baalberg culture also makes use of copper (cf. Ottaway, 1973)

almost all copper finds come from graves and we are dealing therefore with groups with very differing habits.

Müller-Karpe's supra-regional Arkadenrand-Keramik might at best constitute a very coarse framework which can serve as a useful starting point, but only if it is filled in by close studies of regional variations and socio-economic information.

The actual date of the Altheim group can be deduced from contacts outlined above. The Schüssenried site Ehrenstein has its interquartile range between 3400 and 3200 bc, the median of the Michelsberg dates lies around 2900 bc, the Pfyn culture has interquartile ranges between 3100 and 2750 bc and the only Altheim date now available lies at 3290 \pm 40 bc. (I would like to thank I. Berger for her kind information about this vital date.) A date lying in the later fourth or early third millenium seems to be indicated for the Altheim culture.

The origin of this culture is rather obscure. Driehaus discounted the Michelsberg culture, but similarly saw no reason to extend the duration of the Münchshöfener group which preceeded the Altheim group in this area. This, would create a discontinuity leaving, as Lüning pointed out, Bavaria in a vacuum, while the Michelsberg culture phases I and II spread into more northern parts of Europe.

However, recent finds such as at Penning, near Griesbach, (Uenze, 1964) and at Wallerfing-Bachling, near Vilshofen (Siegroth, 1972) indicate that there was in fact, contact between the Münchshöfener and the Altheim cultures. At Pennig, two pits - one of them with purely Münchshöfener ceramic, was overlaid by a layer containing Münchshöfener and Altheim sherds. At Wallerfingen, a trial trench revealed 'Rössen-Münchshöfener - and Altheim sherds together with bone spatulae and a copper awl' (cf. Chapter III), unfortunately not at all in a stratified context (Siegroth, 1972). Technically it is possible that the copper

find is associated with the Münchshöfener culture which opens up interesting parallels in Austria (cf. Chapter II, 6 & 7). Maier (1972) not surprisingly, finds the Wallerfing phase of the Münchshöfener culture quite different from the Münchshöfener culture itself, and associates it more closely with the Altheim culture. He also finds that it shows some Baden-Boleraz traits. This, however, would mean that the 'Wallerfing phase' lasts as long or longer than the Altheim culture or, alternatively, that it pushes the Altheim culture into a much later horizon, which in view of the radiocarbon dating outlined above is rather unlikely.

One can only hope that some time one of these 'trial trenches' will expand into a proper excavation, solving many of the fundamental problems of the Altheim culture.

II,6 The Mondsee culture

1) Distribution, settlement and house type

The rivers Enns and Salzach from Bischofshofen to Salzburg form the east, south- and western border of this culture; the northern border is less clear and reaches just north of the Danube (fig. 18). The distribution within this area is by no means even: the concentration of known sites is highest around the Mond- and the Attersee, where lake-side dwellings cluster together. Another cluster is around Salzburg, where we are dealing exclusively with Höhensiedlungen. The concentration in this area is due mostly to the activities of one archaeologist (Hell) rather than as a reflection of the real distribution. (Hell's numerous rescue excavations, publications between 1916 and 1975 and his large collection should now be studied in detail.) A few domestic sites just east of the Enns around Laussa (e.g. Prücklermauer and Langensteiner Wand), on the Enns around Garsten (e.g. Rebensteiner Mauer and Sonnbichl) and an important site in the valley on the river Traun (Paura) have assemblages similar to those from Mondsee sites.

Yet for the former two groups of sites the excavator-collector (Mitterkalkgruber, 1954) claims that they are an independent local development with 'Danubian' roots. However, since the material is still awaiting its promised publication (Reitinger, 1968, 107) judgement has to be withheld until then. Finds at Gerlham, discovered during peat cutting, indicates occupation of bog areas by the Mondsee culture, since this site was a dried up lake by about 5000 bc (Willvonseder, 1968, 112).

The preservation of the large number of settlements around the Mondsee and the Attersee is due - as in Switzerland - to the waterlogged conditions, creating possibly the same distortion of real distribution of sites as in Switzerland. All those sites situated in higher mountain areas (e.g. Mühlbach-Bischhofshofen) are connected either with mining - or with stone - and flint-working or with both (e.g. the Göttschenberg) activities (Pittioni, 1954, 228). On the whole, the culture occupied a territory much closer to the Alps than any group before.

It is practically impossible to present a comprehensive picture of house types. None of the lake-side dwellings have been excavated as well as in Switzerland. This is partly due to the fact that the Austrian sites are up to 6 m under the present water surface, but partly due to the lack of application of modern (expensive) excavation techniques because some of the sites are quite near the edges of lakes. A great deal of damage had also been done at the end of the last and the beginning of this century when enthusiastic amateurs dredged up the areas between the piles with mechanical aid, thus destroying all possible intact layers. More detailed information is now available through the diving activities of Kunze (Mondsee) and Offenberger (Attersee). At Miesling II for instance 600 m covered by piles were charted and this represents probably one quarter of the total site

(Offenberger, 1974). Piles were set most densely in the middle (15-20 piles/m²) and less densely at the edge of the settlement (5-10/m²). The thickness of the piles varied between 2-30 cm. At Scharfling (Attersee, Offenberger, 1973) a crumbly clay floor indicates the presence of a hearth. The cultural layer at this site was covered by coarse rubble up to 30 cm thick and this held the layers of branches, twigs and bark in situ under water. Amongst these decorated and undecorated fine and coarse ware was found: battleaxes, copper, flint implements and animal bones were also recovered. All these finds are at the moment being studied and we have to await the publication. At the Mondsee Kunze found that piles between 10-25 cm were used for the settlements (1973) and that these piles show the clear traces of having been cut by stone tools at their points. Wattle and daub was also found in the cultural layers. A major advance in the question of whether these settlements had been on a dry or wet foundation came with the discovery of an ancient landslide which had blocked the exit of the river Seeache from the Mondsee, raising its level by several meters. Janik (1969) could show that during the periods when the settlements were in use, the lake had a level below that of the sites, they were thus on dry land. Offenberger has come to similar conclusions for the Attersee, by evidence from the wooden piles at Scharfling (Offenberger, 1974), but it is not yet known what could have caused the rise of the water level there.

The settlement size around the Attersee varies a great deal: sites can be as small as 40 x 10 m (Misling 1) or as large as 200 x 15 m (Aufham), but even these figures will probably need revision when more exact measurements on all sites have been made.

The Höhensiedlungen are of necessity of quite a different character. This and the fact that the proportion of coarse to fine and decorated ware on Höhensiedlungen is quite different from that on lakes made Hell suggest that they belong to the Altheim rather than to the Mondsee culture. However, when reading reports of rescue activities on the two lakes we frequently come across statements indicating that the coarse, undecorated, fragmented or just uninteresting pottery was thrown back into the water, (cf. also Willvonseder, 1968, 354), thus indicating one reason for the contorted ratio. No new Höhensiedlungen have been excavated. The Grillberg near Elsbethen can be used as an example (Hell, 1919). It occupied a plateau of 46 x 35 m surrounded by natural defences in the form of steep rock walls. Two rectangular huts were excavated (fig. 19) measuring 3 x 5.5 m and 3.8 x 5.9 m respectively. Both had the same east-west orientation, sunken floor levels (50-60 cm) and a patio running along the whole length of each house. One of the houses had a hearth and within both house-areas flint stone and ceramic artifacts were recovered as well as wattle and daub. The daub was on average 7 cm thick and the round branches used for the wattle were 3-7 cm in diameter. Other sites such as Hellbrunner Berg (Hell, 1921), Schlossberg bei Mattsee (Pittioni, 1954) and the Rainberg in Salzburg (Kyrle & Klose, 1918; Hell, 1952a) are similar.

Inland settlements in valleys are typified by Paura which lies on a hillock in a bend of the river Traun (Beninger, 1961), and Etsdorf near the Mühl (Theuer, 1925; Reitinger, 1968, 65). Although Beninger's excavation has provided a great number of settlement remains no house structures or postholes were found in the trenches which contained most of the Neolithic finds.

ii) Economy, artifacts and burials

The faunal evidence of the Mondsee group is in such a poor state of research that we can do little more than list the animal species represented at various sites: domesticated animals include cattle, pig, sheep and goat and dog. Wild animals are represented by red deer, roe deer, bear, fox, marder and boar (Kunze, 1973). According to Franz & Wininger (1927) the wolf and elk should be added to the list. Apart from those bones which were used for tools, most were smashed and partly burnt and were thus included in the diet (Willvonseder, 1968, 276). Boessneck, in the most recent published study of bone material from this general area (1958) did not take Mondsee fauna into account at all and Amschler (1949) studied only the few finds from Attersee which are in the museum in Wels although the entire material - scattered over several museums in Austria - would have been far more significant. The bone material from Kunze's Mondsee excavation is at the moment being studied and we hope publication will follow soon. Until then most of the information given above comes from studies of Wurmbrand (1875). The same is true for floral evidence which has been summarized by Willvonseder (1968, 277-279): domesticated plants include emmer, wheat, 6-row barley (*Hordeum haxstichum* var. *sanetum*) apple and possibly pea. Beach-nuts, hazelnuts, cherries and sloes were collected.

Bast was used to prepare coarse material and ropes; spinning and weaving was known as can be seen by the presence of weaving forks and spindle whorls. The corn was ground in quernstones. Thus, although we have no detailed ratio of wild to domesticated fauna and flora we can perhaps assume an economy, not too different from that found at the Swiss lake side dwellings, but a confirmation of this will have to await the detailed forthcoming reports.

The finds themselves are best known in the typical form of the Mondsee pottery: this is somewhat misleading, since by that most workers mean decorated, and white incrustated ware. As pointed out, far more weight and attention should be given to the plain and coarse ware. This may not be easy with older finds, because as Willvonseder (1968, 256) pointed out: 'separation into fine and coarse ware as done in Altheim can be done up to a certain degree with the Mondsee pottery, but it is difficult: there are masses of fragments of coarse thick-walled vessels none of them giving an indication for reliable reconstruction of shapes. It may be better not to talk of coarse and fine ware but to separate out storage and household vessels - according to their presumed function - and to compare these with fine ware which is mostly decorated'.

It has also become clear that Pittioni's suggestion of early decorated and later undecorated Mondsee ware (Pittioni, 1954, 212) does not hold true: both types have been found together e.g. at the Paura (Beninger, 1961).

Household and storage vessels have S-shaped profiles and are usually grouped together as Pfahlbautöpfe, or are large deep bowls with 2 or 4 small perforated lugs on the carination (fig. 20,a) or straight-sided containers with lugs (fig. 20,b) and sometimes with arched rims. They also include large-2-handled vessels, small straight sided beakers (fig. 20,c) and wide mouthed bowls with smooth or carinated profile (fig. 20,d).

The fine ware is characterised by the so-called Mondseekrug a jug with a wide handle, decorated (fig. 20,e) or undecorated (fig. 20,f). Some jugs have almost globular bodies (fig. 20,g). Other jugs have higher necks and there are handled cups. The handle is always slightly higher than the rim and almost always start from the rim.

This is taken as one of the major differences to the Altheim jugs where the handle often starts from below the rim and only rarely rises above it.

Characteristic decorations are incrustated white ornaments in the form of bands, spirals, triangles filled with parallel rows and the so-called 'sun-motive'. The pattern was usually pressed into the soft clay by the stab-and-drag technique (Furchenstich) before firing and the impressions were filled after firing with a white chalky paste. This paste was analysed by Sauter and Rossmannith (1967) and found to consist of calcium carbonate i.e. of calcite, thus disproving the suggested use of crushed up shells (Pittioni, 1954, 218). Franz and Winingler (1927) suggested that chalk-quarries at Mitterweissbach, near the Attersee might have been already in use during prehistoric times.

It is interesting that the white incrustation can survive prolonged submerging in lake water (which admittedly is very alkaline and has a pH of 2-3!) yet it cannot stand heat. It cracks, crumbles and eventually falls under heating. We can therefore safely assume that no incrustated ware from this group was used for cooking purposes.

Other characteristic ware is the miniature pottery, which is alternatively interpreted as toys or as ceremonial or sacrificial vessels (Maier, 1964), and clay crucibles.

Small animal sculptures of clay (fig. 24,h,i) have been interpreted as either Bandkeramik or TRB influences, but it seems much more likely that a group which had a taste for artistic style wanted to express valued and precious things around them.

For flint tools 2 basic techniques were used: careful retouch on blades - producing bilaterally retouched narrow blades, with parallel cutting edges (fig. 21,a), pointed awls, arrowheads with concave basis (fig. 21,b) round scrapers and double ended scrapers and 'daggers'

(fig. 21,c). The alternative method, and the more common one, made tools on flat slabs of flint (Plattensilex) of 0.5-1 cm thickness of grey/black colour which is probably of local origin and was certainly worked locally. Tools made by this method and material include sickle knives, of either narrow (fig. 21,d) or broad form or with parallel cutting edges (fig. 21,e), always retouched on both sides. Some with straight cutting edge and a strongly arched back (fig. 21,f) were probably used as knives for lopping which required stronger tools than cereal cutting. On none of these sickles has a sickle-shine been found. A few points or 'daggers' of either broad shape with careless retouching or slimmer and all-over retouch, and numerous arrowheads with either straight or - more common - concave basis or with serrated edges are also included in the toolkit.

Stone artifacts, although very numerous have not been studied since 1871 (Wurmbrand). He suggested that most of them are of serpentine, coming probably from around Vöcklabruck. Tool fabrication sites - indicated by the presence of large quantities of waste material - were found at the Langensteiner Wand (Kyrle, 1918), at the Göttschenberg and the Rainberg. These probably supplied part or all of the Mondsee and Attersee population with stone tools (Willvonseder, 1968, 122), but until we have a scientific investigation of this material much remains informed guesswork.

The main types are rectangular axes, of either small (fig. 22,a) or elongated shape with parallel sides (fig. 22,b); so-called Walzenbeile with flat to round cross-section (fig. 22,c), often with a pointed butt; perforated axes include those with round butts of varying shapes and sizes (22, d), Knaufhammeraxes or battleaxes of the well-known shape (22,e) and axe hammers similar to Plyn's axe hammers (fig. 9,k) (called in Austria 'Michelsberg Axt').

There are also some

miniature axes of sandstone, which cannot have served a useful purpose and fall again into the categories of 'toys' or 'sacrificial object'. Other stone weapons include hammers and waisted stone hammers (fig. 22,f). These latter two occur on land-, lake- and mining sites.

As in the cultures treated earlier, both bone and antler were used as raw material for tool production. There are double-pointed awls, pins (fig. 23,a), chisels (fig. 23,b) for smoothing or cutting (fig. 23,c) and flax combs (fig. 23,d). The burr of antler was used for hammers (fig. 23,e), picks and sometimes small stone axes were still found in situ in their antler sleeves. There are also several grooved antler points (fig. 23,f) whose function is not clear. Again a detailed study of this rich material would be very welcome.

Ornaments are quite numerous; there are beads of white alpine limestone, and of pebbles (fig. 24,a) made on the sites; there are disc beads, biconical beads (fig. 24,b,c), thin limestone discs with 1 or 2 perforations (fig. 24,d), as well as numerous v-perforated buttons of limestone also with a diameter of up to 6 cm (fig. 24,e) and serrated pendants of limestone (fig. 24,f). Teeth, mostly of pig, but also of bear and boar and perforated at the roots, were very popular (fig. 24,g) but claws were also used and sometimes both teeth and claws were imitated in limestone. Rings of bone and coal were probably also used as beads and perhaps the small perforated axe and the grooved antler point can also be seen as amulets.

Copper finds from the Mondsee group are numerous and include types such as flat axes, knives, daggers, spirals and awls. Most numerous are the finds dragged up from the Mondsee and the Attersee but copper finds from land settlements such as the Paura leave no doubt that the use of copper is not restricted to the lake district. Copper finds in and around Salzburg as well as evidence for smelting (melting) in the

form of crucibles (fig. 20,h) and droplets of copper are quite numerous but all of them were rescue excavated by Hell who often was unable to do more than just group finds into 'late Neolithic' or 'Bronze Age' according to their characteristic appearance. Pottery found in association with these metal finds are named by Hell as belonging to great variety of cultures such as the Mⁿichshöfener-, Michelsberg-, Altheim and the Cham.

Evidence of burials of the Mondsee culture is entirely lacking. One part of skull has been the only human bone found so far in any of the lake side settlements (Willvonseder, 1968, 280). The large number of personal metal finds might, according to Willvonseder (1968, 317), indicate burials near the settlement which with rising water levels got washed away or lie undetected at the bottom of the lake. This, however, is too tentative evidence to be of any use and we have to assume as for all the other cultures that some other method of deposition or funeral rite was used.

iii) Contacts, origin and dating

There are now 13 radiocarbon dates from the Mondsee and the Attersee. Their interquartile range lies between 2880 and 2460 bc (cf. fig. 6) with outlying dates reaching back to 3000 bc and down to 2300 bc. This should provide a fairly accurate picture of the true duration of this group (Ottaway, 1973) whose floruit in calendar years is thus in the late fourth millennium BC. It is partly coeval with the Cortaillod and Pfyn cultures in Switzerland, its interquartile range overlaps with the Michelsberg and the TRB groups, and perhaps the Altheim culture lasted until this horizon too. In principle the Mondsee group could have had contacts with a number of groups and discussion on this topic is not lacking (for a most complete recent review of this discussion cf. Willvonseder, 1968, 313-388).

Stratigraphic sequences of inland settlements of the Mondsee culture have shown that there is a basic continuum of sites and of raw material. This is demonstrated at Paura where Münchshöfener sherds were found below those of the Mondsee culture (Beninger, 1961) and the Prücklermauer and Garsten (Mitterkalkgruber, 1954, 1971).

The similarity to the Altheim group has often been pointed out (Driehaus, 1960; Pittioni, 1954). The same kind of raw material for their flint implements was used, several common flint tools (sickles) and similar types of stone tools (Walzenbeil and axe hammer) and Höhensiedlungen occur in both cultures. The typical ceramic ware - the Henkelkrug - was known in the Altheim culture, although in a slightly different version as pointed out earlier. One copper flat axe and the awls from Altheim are similar to Mondsee copper finds. Yet all these common factors could be explained by related economic needs and the presence of the same raw materials in the area. More convincing evidence for contact are the border settlements around Salzburg themselves. Some of these, (Rainberg, Ainring, Auhögl) are alternatively grouped with the Altheim culture (Driehaus, 1961; Hell, 1943) and to the Mondsee culture (Willvonseder, 1968; Reitinger, 1968) with equally valid arguments. This is the best indication of a true cultural overlap with strong contacts. The chronological position of the entire Altheim culture is, of course, still uncertain; it is, however, certain that it did not last as long as did the Mondsee culture.

The latter is surprisingly uniform throughout its duration and must have been a closely knit ethnic group towards its end: although quite a few of the metal artifacts are made of bronze, i.e. it had contacts with technologically more advanced people or centres, none of these are found on sites where Mondsee and EBA groups mixed (Reitinger, 1968, 61). It is probably ^{due to} the seclusion of these areas in the mountains,

which have shown a trend for individuality until quite recently, for instance, the last dug-out canoe, was made and used on the Mondsee only a few decades ago.

It is not clear where the origin of the Mondsee culture lies. The preceding culture in Upper Austria and around Salzburg was the Münchshöfener culture of which 6 certain sites are known. Maxglan and Rainberg, both near Salzburg, and both excavated by Hell (1954) are included in this group by Ruttkay (I would like to thank E. Ruttkay for allowing me to use this material prior to publication). Both sites contained copper finds and the proposal is therefore highly interesting. The Münchshöfener culture - according to Ruttkay - is part of the large Epi-Lengyel complex to which Belaton-I, Jordanov- and the Lasinja culture belong. This again would be a highly interesting horizon since copper was well known in graves of the Jordanov culture (Ottaway, 1973).

II,7 Burgenland, Styria and Carinthia

The transition of the middle to late Neolithic period is not very clear in Burgenland, Styria and Carinthia. Here relations to the Münchshöfener culture have recently been shown to exist (Süss, 1969) and E. Ruttkay (in press) has included it in her Epi-Langyel-complex. It is represented by the type 'Kanzianberg' which is known from Höhensiedlungen (e.g. Judenberg-Pölschals) and lake-side settlements (e.g. at lake Keutschach) in Carinthia. However, there are as yet no closed finds and although several copper flat and shaft-hole axes could belong to this horizon, their associations are too uncertain to be included here. The 'type Kanzianberg' has strong links with the norther Yugoslavian (Slovenian) Lasinja culture. This latter has to be distinguished from the more eastern, Croatian Lasinja culture which, though related has differing traits. The whole area would merit a thorough study of its rich material.

II,8a Lower Austria

In Lower Austria the type 'Bisamberg' and 'Oberpullendorf' belong to the Epi-Lengyel-complex. Only the former is of interest to us since a crucible was found at the site Bisamberg, near Vienna (Ruttkay, in press). It is a vital link and constitutes the third instance for the use of copper in the Epi-Lengyel-complex - the other two possible ones were at Wallerfingen, Bavaria and at the Rainberg and Maxglan near Salzburg. These three finds do not justify talking about a copper-using horizon, but parallels to early scattered copper finds preceding the Copper Age cultures of south-eastern Europe (Chapter I) are self-evident. In the northern part of Lower Austria at the same time influences of the northern TRB culture made themselves felt (Ruttkay, 1975). This is mainly manifested in the pottery, which takes up the arcaded rim, the Baalberg jug, the Trichterbecher and also the Furchenstich (stab-and-drag) decoration.

II.8b The Baden culture

We have thus a very complex substratum from which finally the clear picture of the Baden culture emerges. This is now subdivided into an early Boleráz group (Němejcová-Pavúková, 1964; Ruttkay, 1971a, 1973) and the mature Ossarn group. This subdivision, although well worked out for Slovakia and now supported by stratigraphic evidence from the site Iža (Němejceva-Pavúková, 1968) has not been accepted by all (cf. Müller-Karpe, 1974, p. 207), or further subdivided by Neustupný (1973a) whose phases A and B are Pavúková's early Boleráz, and whose phases C and D are the mature, classical or Ossarn culture. There is also in Slovakia, and elsewhere a third group, the late Baden Kostalac group, but it is not represented in Austria. In Austria the subdivision relies heavily on pottery sequences and information about graves, settlement sites etc., are still lacking.

i) Distribution, settlement - and house type

The distribution of the Boleráz group is mainly in the eastern part of Lower Austria concentrating on the hills around Vienna e.g. at MÖdling, Jennyberg, Frauenstein and Anninger (Ruttkay, 1975) but also appearing in more northern parts such as Baiersdorf (cf. fig. 25) and the Burgenland. The Austrian Boleráz group is only a very small part of the entire group whose main concentration is in the surrounding areas of Hungary, Slovakia, Moravia and Bohemia (for the entire distribution cf. folding map Chropovsky, 1973).

The Ossarn group's distribution is roughly similar to that of the Boleráz (Ruttkay, 1973) with a concentration along the Traisen valley, along the Danube and around Baden, south of Vienna. Again the Austrian is only part of the whole Baden group whose distribution can be seen in Banner (1956). Preferred settlement sites for both groups were hilly plateaus.

The most important site of the Boleráz group is MÖdling-Jennyberg. It is situated at the eastern slope of the mountain and is protected at its south side by an earthen wall. Surface collection and several excavations were undertaken, a total publication of all the material was planned but never carried out because 'the finds and the excavation notes are scattered in an unusually large number of places' (Ruttkay, 1973). This leaves us with just a few sherds from this important site. At Schwechat discolouration of the soil and a few sherds were noticed during the building activities of an oil refinery. A rescue excavation retrieved amongst other Neolithic artifacts, the contents of two pits with Boleráz material. At Gemeinlebarn near Vienna, on a steeply rising hillock a settlement was found to cover the whole of the northern side. Several older excavations revealed square hut foundations, 4-5 m long (Fischer, 1898). In Burgenland the site of Stinkenbrunn was rescued in

1933. The domestic site had a stone paved floor of 1.8 m diameter, with a hearth in one corner.

The remaining 10 Boleraž sites in Austria are identified solely by their ceramic finds, although three, possibly four of them are potential domestic sites as indicated by the presence of rubbish pits. Research in respect to settlements and economy has been similarly neglected elsewhere, e.g. the entire volume dedicated to the 'origin and chronology of the Baden culture' (Chropovsky, 1973) has in its 537 pages not a single paper dealing with the economic information of any of the sub-groups belonging to the Baden culture.

The most important find of the Ossarn group in Austria is the recent excavation of a trapezoidal house foundation in Pottenbrunn near St. Pölten (Friesinger, 1972). It was accidentally uncovered during the excavation of an early medieval cemetery in 1965 and 1966 during which soil discolouring drew attention to its outline (fig. 26). It is orientated on a NW to SE axis, is 5.5 m wide and probably 14 m long. Most of the finds came from postholes, a narrow ditch running along the outside of the house and from the single hearth. Several pits nearby contained similar finds. Caves too were used as domestic sites e.g. Königshöhle, in one part of which a grey layer of ash of 30-1.20 m thickness contained a large assemblage including flint waste material, stone, antler and bone tools and shells as well as 3 typical Baden Henkelkrüge, a fragment of a metal spiral and a metal ring (Kyrle, 1924; Ladenbauer-Orel, 1954).

ii) Artifacts and burial

Of the finds, the pottery is the best studied material, almost to the exclusion of all the other evidence. The main wares of the Boleráz group are: jugs with a short neck, round based cups, both with handles which start at the rim (fig. 27a,b), large amphora with 3 handles on the widest part of the vessel and a smooth high neck (fig. 27,c) or smaller shorter necked ones or those without necks; carinated bowls with Trichterrand and deep bowls with round profile and short cylindrical neck (fig. 27,d) whose surface is smooth at the neck and roughened at the body. There are further hemispherical bowls and clay spoons (fig. 27,e) and spoons (fig. 27,f). The jugs cups and amphoras and the insides of the bowls are often channeled which led to the name Kannelierte Keramik. Another characteristic decoration is the so-called wolfs' tooth pattern but plastic decoration on neck or rim, flat lugs or incised lines of dots, as well as incised herring-bone patterns also appear regularly. The latter is often a way to roughen the surface of coarse ware but this applies only to the body of the vessel; the neck always remains smooth.

The main ceramic ware of the Ossarn groups are: the jug with cylindrical neck and very high Bandhenkel (fig. 27,g), small high-handled bowls with biconical body and round base (27,h) and slightly funnel shaped neck, conical, straightwalled ladles with high handles, high-necked conical bowls with vertically or horizontally perforated lugs (27,i), high necked amphoras with 4 handles on the body, the well-known bipartite bowls and the so-called Ossarn plate (fig. 27,k) with a conical shallow body and a very broad handle.

The decoration on these vessels is again the channeling, and also bands of triangles formed of incised dots. The coarse ware and the storage vessels often have a thickened rim decorated with incisions

or with arcaded rims. Bowls with Trichterrand and inside decoration are known to both Ossarn and Boleráz groups.

Stone tools found at or near Baden sites include flat axes and perforated axe hammers similar to those found at Mondsee sites (cf. fig. 22, a, d) but also perforated axe hammers with a concave neck and shafthole axes (for best illustrations, but unfortunately photographs only, cf. Pittioni, 1954, fig. 133).

It is futile to try and describe characteristic bone, flint or wooden tools and other artifacts of this culture, since only a thorough re-examination of existing total assemblages or, better still, a new excavation will give information about its economy and technology.

Even the Slovakian material includes only small flint bladelets, several stone axes and oval 'waisted' stone implements and an antler tool from the settlement of Iža (Němejcová Pavuková, 1968, Abb 21 & 24). We are therefore left to assume that these materials were also used by the Austrian culture, but have as yet little evidence for it.

Burials belonging to the Boleráz group are not yet known in Austria, but using again [✓]Czech and Hungarian parallels we could expect to find cremation burials below mounds: where the burnt calcinated bones were put into a shallow pit and covered with layers of stone and soil on top of which a few, usually 1-9 vessels, were put to mark the grave (Torma, 1973). In Moravian cemeteries e.g. Chrozim, which gives its name to a whole group of similar cemeteries, graves containing cremations of oval or round shape were under small mounds, sometimes covering more than one such burial. Here bones were put into various kinds of vessels of typical Boleráz character; the pottery was sometimes so badly fired that it can only have been intended for funerary uses.

The Ossarn group abandoned cremation and went back to inhumations - at Lichtenwörth the skeletons of eight individuals - 3 of them children - were found in a pit 2.25 x 1.65 m, surrounded by stones. Grave goods included 5 flint arrowheads, near the skulls 2 stone axes and on six of the skeletons Osenhalsringe, i.e. ingot torcs (Willvonseder, 1937). Another inhumation with Ossarn pottery was found in 1876 at Leobersdorf (v. Sacken, 1887, 393). This time the pit was paved with stones and skeletons crouched, lying on the left with head towards west, on a WE axis. Near its feet were the skulls of 5 children. Grave goods included a complete channeled jug with high handle, 1 flint arrowhead and 20 perforated animal teeth and 1 Osenhalsring as well as several snails. A burial site at Vösendorf contained in an oval stone encircled pit 3 crouched inhumations (WE orientation). It contained a scraper, a flint or stone knife, a 'stone saw' and a perforated boar's tooth (Seewald, 1966). It was excavated during the war and all the finds are lost - we only know that a nearby settlement was occupied by Boleráz-pottery using groups (Ruttkay, 1975) and Seewald's suggestions that it belonged to the general Baden horizon is therefore probably correct.

Although in itself probably not very meaningful, the change from cremation to inhumation does mark the distinction between the two phases, and between the changover to the Baden phase. In this context it is very interesting to note, that the Lažný group in E. Slovakia - which precedes the Boleráz group but is according to Šiška (1972) partly coeval with it - has bi-ritual burial practice, that is both cremation and inhumation were used.

At Ossarn circular pits contained 'several hundreds of kg of pottery' (Bayer, 1928). Some of these vessels were intact and sometimes contained grain. Bayer (1930) interpreted this as neither a dwelling

site nor as rubbish pits but as a site used probably for religious rites. This idea was taken up by Makkay (1965) and accepted by Ruttkay (1975) but as Pittioni already pointed out in 1954, only further excavation at this site will solve the question of ritual or domestic site.

iii) Contacts, origin and dating

The contacts of this culture, which is distributed over a large area, will of necessity be of great variety. In Bohemia contacts of the early Baden culture with the Salzmünde phase of the TRB culture are very strong, so strong indeed, that Neustupný put forward the TRB as origin for the Baden culture (cf. 1973a, 333).

In Slovakia the early Baden-Boleráz group followed the Ludanice, which is one of the last Lengyel groups. Recently, however, this clear succession has been put to doubt. The possibility that another group - the Retz-type, characterised by the typical Furchenstich (stab-and-drag) decoration - might have occupied time and space in between the Baden Boleráz and the late Lengyel groups, has to be taken into account. (Nemejcová-Pavúková, 1973). In Austria the situation between Retz and Boleráz groups is similarly unclarified and it is possible that here they are coeval. This might, of course, also be true for Slovakia and the direct contact between Ludanice and Boleráz as seems to be indicated by several common ceramic traits, e.g. Milchtöpfe, bowls with drawn-in rims, and plastic lugs on carinations as well as the general surface treatment of the pottery, could thus be explained.

In Hungary east of the Danube only developed Baden groups settled - probably even after an interval - on sites previously occupied by the Bodrogkeresztúr culture, e.g. at Tiszapolgár Basatanya and other sites (Bognár-Kutzián, 1973). Patay (1973) stressed how "typologically unlikely" it is that the Bodrogkeresztúr had any contact with the Baden culture (cf. also Patay, 1974).

A completely new culture seems to be the key to a number of questions. It is the Balaton group - centred around lake Balaton in western Hungary. Kalicz (1973) has very convincingly argued that this culture, which settled on small hills surrounding the lake and which can be subdivided into 2 to 3 phases, has in its earliest phase I, close contacts with the south, e.g. parallels can be found in the Vinča Pločnik culture. This early phase is coeval with early Bodrogkeresztúr and also the Ludanice culture of Slovakia as well as with the early Lasinja culture. Phases II and III cannot yet readily be distinguished from each other, but they are contemporary with late Bodrogkeresztúr, and have Furchenstich pottery which shows very close parallels to the Retz-type and also to the Mondsee type of pottery cf. incrustation and spiral decoration, similar metal industry as seen on spirals and copper bands as well as crucibles. Kalicz (1973) suggested a reverse influence, i.e. an alpine influence into Hungary at this period. One radiocarbon date of 2940 ± 80 bc (Quitta & Kohl, 1969, 242) indicates that mutual contact between the Mondsee and Balaton II-III cultures was as feasible, as with an earlier phase (Epi-Lengyel-complex) in Upper and Lower Austria. The Boleráz group only developed after the end of the Balaton culture and has then the same characteristics as elsewhere.

The Boleráz group has also been shown to have remarkable ties with the Cernavoda culture of Romania again illustrated by ceramic ware. The intermediate area of northern Yugoslavia is still under investigation. Several sites from the latter are known to have possible Boleráz material but certainly the later Baden Kostalac group is represented e.g. at Gomolava.

This finally brings us to the dating of the Baden groups: the Kostalac layer at Gomolava was dated to 2410 ± 60 bc (personal communication Mook, 1976; Brukner, 1977). The date corresponds well to the only other direct radiocarbon date of a Baden site of 2570 bc (Ruttkay, 1975).

Using Neustupný's dating of the various Baden phases as put forward in 1973, we obtain an interquartile range between 2700 and 2475 bc (fig. 6).

The sequence of the Baden phases has now been shown stratigraphically at the settlement site of Iza on the Danube in Slovakia. Here we have clear evidence that the Boleráz was followed by the classical (called Ossarn in Austria) and then by the Kostalac group (Němejcová-Pavuková, 1968).

It is, as yet, clearly too early to have any evidence of the origin of this culture. All we can say at present is that its main concentration corresponds roughly to that of the original Lengyel area before the latter entered its final phase.

II,9 Lower Bavaria, the Cham culture

Let us now return our attention westward from Lower Austria to southern Bavaria, remembering that the Mondsee culture is at this time still strongly established in Upper Austria. The Altheim culture is succeeded by the Cham culture which is also found in western Bohemia (I would like to thank I. Burger, who is at present engaged in research on the Cham material, for her valuable information). In Austria, material similar to that from the Bavarian Cham is found in Ruttkay's MÖdling-Zöblin-group (1973) which according to I. Burger is equal to Moravia's Jevišovice culture, and also coeval to Laibach-Vučedol, i.e. the late Eneolithic horizon. Since there are no secure copper finds in the entire Cham culture (and only one insecurely associated fragment)

we need not go into further detail and only point out that the most westerly point of the Cham's culture distribution is at Goldberg III and that it is probably coeval to Switzerland's Horgen and Auvèrnier cultures.

II,10 The Horgen culture

i) Distribution, settlement and house types

The Horgen culture will be dealt with only relatively briefly because it like the Cham culture is regarded as a metal-rejecting one. The only certain copper find is a dagger blade and it has been suggested that this is in reflection of the real situation rather than another gap in the archaeological research (Strahm, 1975).

The culture occupies areas which were previously settled by either the Pfyn or the Cortaillod population, as well as some new areas in between, in particular around lake Zug. The main concentrations are found around lake Zürich, lake Zug, and Lake Neuchâtel (cf. fig. 28) (Itten, 1969; Schwab, 1971a; Kimmig, 1966). The most northerly sites are Dullenried (in the Federsee moor) and Fridingen on the Danube (Kimmig, 1966). This has been taken as evidence for the culture's spread over the entire area between the Black Forest, the river Iller, the Danube and lake Constance (Lüning, 1968). The most south-eastern site, is the Petrushügel, near Cazis.

The situation of the sites is predominantly on lake-sides, but there are a number of inland settlements and sites on hills. Several settlement sites e.g. Zürich-Utoquai, and Z. Kleiner Hafner have shown evidence for repeated occupation and abandoning by Horgen groups, but it has not yet been established why this happened.

House shapes are extremely difficult to ascertain as yet. At Utoquai the lowest of three Horgen layers contained mainly charcoal, ash, charred piles and no plan could be deduced from this, except that

4 hearths of clay, which did not rest on a wooden floor indicate that houses were not built on stilts (Ruoff, 1963). At Zürich-Enge, Breitingersstrasse (also called 'Rentenanstalt') a very complicated stratification hastily excavated revealed two cultural layers: one belonging to the Horgen culture and a lower one to the Pfyn culture. Both these layers have been radiocarbon dated as will be discussed later. The Horgen layer consisted of a compact conglomerate of peat, clay, stone and burnt material and did not allow any reconstructions; wooden remains in form of planks were also found (Drack, 1961).

ii) Economy, artifacts and burials

Little detail of the economy of the Horgen culture is known and only from 2 sites do we have detailed information about domesticated animals: in Zürich-Utoquai the wild to domesticated ratio was 40:60% and pig was the most common, followed by cattle, sheep and goat (Higham, 1968a). At Lutzengütli the wild to domestic animal ratio was similar (45:55%) but here cattle made up almost 50% of the domestic animals, followed by pig, goat/sheep. Dogs were present in both settlements (Hartmann-Frick, 1969).

The extraordinary large number of stone flat axes, allows us to assume that tree felling (or slash-and-burn agriculture) was practised.

Woven textiles from Utoquai and the 'Kleiner Hafner', near Zürich allow us a glimpse of an advanced craftsman's skill. Its delicacy comes rather unexpectedly when one considers the extraordinary coarse pottery of this culture. This reminds one of modern nomadic groups (e.g. the Baktuari) who have a highly developed skill in producing beautiful textiles but who value permanent settlements very little. It could also explain the coarseness of the pottery, if one may think of it as a waste product. The fact that they are the only group which has occupied the same sites several times after intervals, that they

have an unusually large number of stone axes (to cultivate new land), that they spread into new areas - and that they have no copper, would all fit into the picture of an ethnic group different from previous and succeeding ones. This would also explain, the partial contemporaneity with the Plyn and the Cortailled cultures as expressed in the radiocarbon date (see below).

No study has as yet been published of plant remains of this culture.

The pottery is easily recognized: it is extremely coarse, and thick-walled (between 2-4 cm thick walls are the norm). Plain shapes - mostly cylindrical - and flat bases prevail. The few decorative elements include grooves below the rim, knobs and lugs (fig. 29,a-e). The pottery is not made by addition of coils but by adding patches of clay - a method easily recognisable on fractured vessels. Quite a few vessels do have charred remains of cereal stuck to the inside of the walls.

Flint implements are not very specific - or they have not been studied in full yet. There are arrowheads, usually bifacially retouched, of triangular shape with convex or straight bases (fig. 30,a,b), a few beautifully worked dagger blades (fig. 30,c), knives sometimes still in their wooden holders (fig. 30,d), scrapers and blades.

The most numerous stone implements are axes. They are flat and of almost rectangular shape and cross section (fig. 31,a). Axe hammers are mostly short, broad with a round shafthole and with a round (fig. 31,b), pointed (fig. 31,c) or straight butt (fig. 31,d). Double axes (fig. 31,e) also called "Horgen battleaxes" are said to be a typical Horgen axe type, but not enough have yet been found in secure Horgen stratification. A large number of stone slabs, which were used as stone saws, probably for the production of stone axes, have been recovered in Horgen levels, e.g. at Petrushtügel, near Cazis 150 such slabs were found (Itten, 1969) and probably indicate a fabrication site near the source of raw material.

Horgen groups used antler as a so-called Zwischenfutter i.e. sleeves which allowed them to haft the stone axe firmly in the antler and the latter in turn was hafted in some larger wooden shaft. They were found in the Cortaillod culture (cf. fig. 3,a) but there they were not quite so common. Schwab (1971a, 67-87) has studied these sleeves in great detail and 3 of her 5 types are illustrated in fig. 32a-c together with her suggested wooden hafting methods (fig. 32,d,e).

Wooden tools have not been studied in great detail; there are shafts which would hold the antler sleeves (with their stone axes), awls, and pins.

Ornaments, almost entirely in the shape of pendants, are made of white pebbles, or polished stone discs and of antler (fig. 33,a,b), or more unusually in the shape of a miniature axe (fig. 33,c).

Perforated bear's and dog's teeth were also popular.

Burials, belonging clearly to the Horgen culture have not yet been found. Sauter (1975, 60) assigns a few Dolmen to this culture, but burials in or near settlements are a possible explanation (Rucff, 1963).

iii) Contacts, origin and dating

There is only one radiocarbon date (3330 ± 120 bc) available for the Horgen culture from the excavation at the Breitingers[^]strasse in Zürich mentioned earlier (Drack, 1971b). The lower Pfyn layer from the same site gave a date of 3210 ± 120 bc, both dates therefore lie within 1 standard deviation of each other, indicating a fairly rapid succession of one occupation after the other. The evidence is somewhat conflicting, because the sediments between the 2 cultural layers at the site were sometimes only 2-3 cm thick and separation therefore difficult (Drack, 1961b) yet the geologist at the site implied a separation in time of the 2 cultural occupation by about 100-200 years, basing this on a yearly sedimentation rate of 0.8 mm/p.a. We need to await more radiocarbon

dates for the Horgen culture before deciding on an absolute time (cf. fig. 6). Horgen levels have been found clearly stratified below Corded Ware and above either Cortaillod or Pfyn layers (cf. Itten, 1969, Abb 1) at a number of sites.

Both Itten (1969) and Vogt (1965) saw the origin of the Horgen group in the French SOM (Seine-Oise-Marne) culture of the Paris basin: both groups have ceramic ware with firm basis and straight walls and the SOM uses grooves under the rims. Although a possible SOM-influence is not denied, the relationship is perhaps not close enough to postulate the Horgen's origin there. It is much more likely to have developed locally, under influences from both Pfyn and SOM, taking up a somewhat different livelihood, such as possible nomadism. This is indicated by the repeated occupation of the same sites, and by the further penetration into the mountainous alpine areas (e.g. Petrushügel). A waste production of heavy, not easily transportable ceramic ware, but stress on textiles and stone axe manufacture supports this hypothesis. At the same time contacts to copper using or producing cultures was not maintained constantly or never sought after, thus differentiating this culture from the others as an ethnic entity.

II,11 The Lüscherz culture

1) Distribution, settlement and house type

In 1938 Vogt placed the 'Neolithique moyen' of western Switzerland within the Horgen culture. He had, however, by 1967 enough doubts about this grouping to contradict his own proposal and suggested that further results should be awaited before re-naming the culture again.

The excavation at Vinelz provided enough clear stratification to allow Strahm (1966a) to separate the Lüscherz culture out of the late Neolithic material. This has since been substantiated by excavations at Yverdon (Strahm, 1973 and 1975), at Yvonand (Strahm, 1975) and at

Chabl[^]e Perron (Kaenel, 1976). Material very similar to Strahm's Lüscherz culture has been excavated by Schwab at Portalban (Schwab, 1971a and 1971b), and at Ponte-de-Theille (Schwab & Müller, 1973). Although the sites are on or near lake Neuchâtel[^] - as are those of the Lüscherz culture - they were published under the names 'Horgen' (Schwab, 1971a) or 'neolithique moyen' and later under 'neolithique lacustre moyen' (Schwab & Müller, 1973). This latter name was put forward by Schwab to stress the fact that both Horgen and Lüscherz were no separate cultures in western Switzerland but are part of the 'neolithique lacustre moyen'. This is a phase leading from the 'neolithique ancien' (known to us as Cortaillod) to the 'neolithique lacustre récent' (known to us as Auvernier) and to the Corded Ware culture. The finds will be outlined below and although they show a strong relation to those of the Horgen culture, it will become evident that there is little justification in continuing the use of both 'Lüscherz' and 'neolithique lacustre moyen' and that it would be desirable and less confusing if a compromise would be reached by the contestants. This is particularly necessary in view of the fact that 'neolithique moyen' is used in French archaeological literature to denote the Cortaillod culture (Gallay, 1970); the latter in some of the Swiss literature is 'neolithique ancien'.

The main distribution of the Lüscherz culture lies around lakes Neuchâtel[^] and Biel (= Bienne) (fig. 34). So-called Horgen sites such as Chevroux, Concise, St. Aubin and Port Conty will have to be studied closely - to see if they really do contain Horgen material (Itten, 1969) and therefore possibly ^{could be} a genuine overlap and contact area, or if they should really be grouped as sites belonging to the Lüscherz group.

All sites are - or were in prehistoric times - near or on lakes. House types belonging to this group are better known than those of the Horgen culture, due to recent excavations. At Portabian two houses were excavated: a stone foundation of rectangular outline was found 20-50 cm below a Corded Ware house. Each house had a fireplace of red burnt clay on top of the stone paving; below the paving piles reached down for 1 m into the sand. Fifty centimetres below the Horgen layer a Cortailled level was found. At Vinelz the excavation allowed a possible reconstruction of a house (Strahm, 1966, fig. 17 & 16); a layer of small trunks suggested that the floor was probably not lifted above the ground on stilts. Here too, a certain concentration of stones in the area of the house suggests a paving and several large strips of (water repellent) bark were either used as floor or roof covering.

At Ponte-de-Thielle two house plans each with a line of central roof supports and a hearth were found. In the first house the collapsed roof-beams were found roughly in situ (Schwab & Müller, 1973, Abb. 17). This again suggests a house construction at ground level. The site contained a large amount of charcoal, indicating possible destruction by fire. Towards north the houses were protected by a closely set pallisade. The clay of the hearths had been renewed three times.

ii) Economy, artifacts and burial

There is as yet no detailed analysis nor enough material to draw conclusions about the exact nature of Lüscherz economy. Domesticated animals were mainly cattle, followed by pig, goat/sheep and dog. Bones belonging to dogs, were on the whole well preserved; it is therefore unlikely that dog served as a meat supplier. The occupants of Pont-de-Thielle were hunters, fishermen and farmers (Schwab & Müller, 1973, 36). Wild animals at this site included bear, deer, roe deer, boar, biber, frog, waterbirds and fish.

Apart from cereal growing, evidence for the collection of berries and hazelnuts is also present.

Amongst the finds themselves, the pottery again occupies first place, indeed it is the main basis for a definition of the Lüscherz culture. During the excavation at Vinelz a remarkably restricted number of shapes in the pottery was noted: the cylindrical high vessel with straight or barrel-shaped walls and a slightly drawn in rim were prevalent (fig. 35,a). In Yverdon, avenue des Sport the Lüscherz pottery was well preserved: there were small round based bowls (fig. 35,b) and pots with small, lenticular lugs (Strahm, 1973), Schwab's excavation produced pottery which fell entirely within this type (cf. Strahm, 1966, 1973, 1975). There are also flat-based vessels (fig. 35,c) indicating a relationship with the Horgen culture.

The most common decorative elements are the lugs which are usually added on not far below the rim. They can also be larger, rounder lugs (fig. Schwab & Müller, 1973, 33) as are found in the Cortaillod culture. Other characteristic decorations are plastic cords (fig. 35,d) and rows of incisions just below the rim (Strahm, 1977).

Clay used for the pottery is coarse, with largish quartz inclusions. The walls are fairly thick and the pottery is badly fired. The condition of the sherds, is of course, not improved by constant change between submerging in water and exposure to air and frost as caused by the fluctuations of the sealevel. Other finds of clay include spindle whorls (Strahm, 1966, Abb. 11,5) and daub with impression of wooden trunks about 5 cm thick.

Flint implements are not yet very numerous and are mostly of the white flint obtained from nearby Jura deposits (Strahm, 1973) although yellow, brown or black flint also occurs (Schwab & Müller, 1973, 35).

Arrowheads have a new form: in Vinelz the only one found during the 1966 excavation is rhombic, i.e. it has a small not very pronounced tang (fig. 36,a). Of the arrowheads from Pont-de-Thielle two are leaf-shaped, 3 rhombic, 3 have a more pronounced tang and barbs and only one is of the previously mentioned common triangular shape with a concave base (fig. 36,b-d). Knives, are flat and broad and have a steep retouch (fig. 36,e). Blades of Pressigny flint from the Loire region in France, have now been found in Lüscherz context at Pont-de-Thielle (Schwab, 1971). This flint was thought to have entered Switzerland only from the beginning of the Corded Ware culture onwards, a hypothesis which has to be reviewed in the light of these new finds.

Other tools, e.g. scrapers and points were made of quartzite and are often steeply retouched.

Stone implements in the form of axes, some of them still in their antler shafts, occur in large numbers. Those from Pont-de-Thielle are carefully worked in serpentine and usually have thin pointed butts and an oval cross-section (fig. 37,a). At Vinelz only one whole axe was found during the 1960 excavation (fig. 37,b). It was shaped only at the cutting edge and gave more the impression of a rough-out. Other fragments indicate the presence of small oval or perhaps rectangular axes (fig. 37,c). A hammer with traces of use as a hitting tool was also found at Vinelz and there are limestone spindle whorls (fig. 37,d).

Beautifully worked bone tools from Pont-de-Thielle give us an idea of the variety of bone implements: there are awls, chisels and arrowheads (cf. Schwab & Müller, 1973, T.24) all highly polished. At Vinelz the chisels (fig. 38,a,b) outnumber other bone tools but they are less highly polished, whereas at Pont the points outnumber the chisels (Schwab & Müller, 1973, T.24).

Antler implements in the form of Zwischenfutter and sleeves, mentioned in the Cortaillod and the Horgen cultures, were found (Schwab, 1973) to appear in 2 types. One is the so-called Tüllenfassung (fig. 38,c) the other the winged type (fig. 38,d). Perforated sleeves (fig. 38,e) are also known. At Vinelz several pieces of partly worked antler were found.

From Pont we further have flat antler harpoons (fig. 38,f) and so-called Netznadeln, crescent shaped pins with a small perforation at the side which occur in quite a variety (fig. 38,g,h) on other Lüscherz sites (cf. Schwab, 1971, fig. 27). They might have been used as hairpins (Schwab, 1973, 35) and the use as ornaments might be true for so-called Kopfstäbchen i.e. round headed pins. The latter have for the first time been found in a clearly stratified context at Vinelz (fig. 38,i).

Other ornaments are in the form of small pendants made of serpentine, or small limestone beads and perforated animal teeth.

Copper is now ascertained for the Lüscherz group: at the excavation at Yvonand-Geillinger - also called Yvonand IV - 2 Rollennadeln were excavated together with typical winged antler sleeves, with flint arrowheads of rhombic shape and typical pottery.

The similarities of Lüscherz and Horgen material has been evident. Recently C. Strahm has found continual development in two sites - (Auvernier and Twann) expressed in the pottery - of late Cortaillod - and succeeding Lüscherz layers (Strahm, in press). He is, nevertheless convinced that Lüscherz is an independent group and not a transitional phase because other sites in western Switzerland (e.g. Auvernier-Brise-Lame and Yvonand) all have settlements containing Lüscherz material only. Burials belonging to this group have not yet been identified.

iii) Contacts, origin and dating

There are two radiocarbon dates, both from the 1960 Vinelz excavation (Strahm, 1966) they are 2220 ± 250 and 2510 ± 250 bc. The dates correspond to their stratigraphic position above Cortailod layers and would also seem to indicate that the Horgen preceded the Lüscherz culture (cf. fig. 6).

II,12 The Auvernier culturei) Distribution, settlement and house type

Only in 1969 did Strahm describe a cultural complex which had - due to insufficient clearly stratified finds - been grouped by Vouga (1929) to the 'neolithique recent' where it was mixed up with finds belonging to the Corded Ware groups. Strahm's excavation in Auvernier during 1964/1965 enabled him to distinguish a group of finds which did not fit into any known cultural group; he named it after the site Auvernier, and put it forward as a culture (1969). Since then more recent excavations e.g. at Yverdon; Yvonand, La Peuplerie; at Auvernier, La Saunerie, have justified the treatment of these finds as an entity.

Moreover, during a Symposium, held at Neuchâtel in 1974, which brought together archaeologists from Switzerland and France who work on late Neolithic material, it became clear that the Auvernier culture is only part of a much larger culture-complex which was given the name "Saône-Rhône-Kultur" (Strahm, 1975). This name indicates for one thing the geographical distribution and for another a relationship to the Rhône culture. Names used previously, such as Auvernier culture, Chalain-group, and Groupe de la Saône will be continued as regional sub-groups indicating regional and perhaps chronological variations within the larger complex. This Saône-Rhône culture complex cannot be seen as a traditional culture, but rather as an expression of the

polythetic nature of large groups where not single attributes or type-fossils are used as criterion for group membership but where groups are defined as a range of variations between defined limits (Clarke, 1968, 37). The distribution of the Saône-Rhône culture complex is limited in the north and west by the Saône, the eastern border takes in the three lakes of the Swiss Jura: Neuchâtel, Biel, and Murten. It has been found as far south as the Dauphine, and could therefore have occupied the areas around lake Geneva, too. There are even some comparative forms at Isolino di Varese, and a transitional border with the 'Pasteurs des Plateaux-complex' also seems indicated. At the present state of research, however, only the areas in fig. 39 belong with certainty to the culture complex. The Auvernier group occupies the three Swiss Jura lakes mentioned above and is thus the north-easterly tip of the culture complex's distribution.

All settlements belonging to this culture found so far are situated on lake-sides; houses are relatively large. At Auvernier only the vertical posts - mostly of split oak trunks - were found (Suess & Strahm, 1970), and similarly at Yverdon only vertical piles were found in situ.

ii) Economy, artifacts and burial

Little is as yet known of the economy. The only examination of bone material - from Auvernier, La Saunerie- has led to surprising results: pig predominates amongst domesticated animals, and horse is represented amongst the wild animal bones. Other specialised studies such as pollen, bone, botanical and sedimentation analyses are apparently under way (Egloff, 1972/73), and should give us a better insight into the socio-economic circumstances of this culture.

The finds are characterised mostly by their pottery: large barrel shaped vessels with straight, rarely curved, walls predominate to such an extent that they can almost be called a type-fossil.

Their rim is usually slightly turned in and the base can be either flat or round (fig. 40,a). Mostly these vessels have very typical broad lugs below the rim which can be perforated (fig. 40,b). Less common are plastic cords (fig. 40,c) which can be combined with lugs; both plastic cords and lugs can have finger tip impressions (fig. 40,d), and the only other form of decoration, simple engraved patterns, is quite rare (cf. Strahm, 1969, fig. 1,3). Small vessels also occur (fig. 40,e). The clay used for this pottery is coarse, with relatively large quartz inclusions, and they were not very well fired. In some regions of the Saône-Rhône culture, but not in that of the Auvèrnier group, a fine black burnished ware usually in hemispherical forms, is found.

Tools made of flint occur in only three basic shapes: there are scrapers (so-called Querschaber) which can be waisted (fig. 41,a) daggerblades (fig. 41,b) and arrowheads which can be leaf shaped, rhombic or with a pronounced tang (fig. 41,c). These latter arrowheads are rather unusual and are not found anywhere else in Switzerland; the closest are those from Pont-de-Thielle, although there the tang is less pronounced. Strahm compares tanged arrowheads from the Auvèrnier to similar arrowheads from the upper Italian Remedello culture (Strahm, 1973). At Auvèrnier, no waste material was found and most of the flint artifacts were made of Pressigny flint. It is therefore natural to assume that most of it arrived in ready-made forms at the site indicating trade rather than local production (Strahm, 1969). At other Saône-Rhône sites, the raw flint material varies to a greater extent and sometimes local Jura flint was used (Strahm, 1975). Flint implements from Yverdon have been studied in relationship to other Neolithic flint artifacts in a Freiburg dissertation (Uerpmann, 1975).

Different from other late neolithic groups is the stone industry of the Saône-Rhône culture. Axes, oval in cross section, were made by 'retouching', i.e. by taking off blades and slivers, in the fashion of flint working; only the edge was cut (fig. 42,a). Other stone tools include hammer stones, grind stones, wet-stones and flat spindle whorls of stone (fig. 42,b-c).

Bone tools are not different in any way from those of earlier cultures described; they include awls, chisels, 'daggers' and points. Antler was very important as raw material: numerous Zwischenfutter i.e. antler sleeves as described earlier were found and they are usually of the winged type (fig. 43,a) or have an almost square haft (fig. 43,b) but another type is the forked one (fig. 43,c) which seems to be specific to the Auvernier culture. Antler was also used to make hammers, axes and so-called retoucheures (fig. 43,d). These latter are simply pieces of antler whose ends are work-smoothed. It is doubtful whether they are really used as a flint-working tool.

Wooden tools are fairly numerous but they vary within the regions of the Saône-Rhône culture complex, and those of the Auvernier group have to await a thorough analysis.

Ornaments seem to be rather rare, there are occasionally beads of stone or antler and pins of the Plattenkopf-type (Strahm, 1969).

Copper has now been found in a clear stratigraphic context at Yvonand in the form of flat a triangular riveted dagger and a few awls. But this applies only to the Auvernier culture; in none of the other groups of the Saône-Rhône culture complex have any metal finds been made.

Burials are extremely rare in this area, and the Saône-Rhône culture complex is no exception. Strahm (1975), however, considered the possibility that the megalithic graves which are sometimes brought into connection with the Horgen culture could belong to that culture,

and bases this suggestion on the correlation between the distribution of these 'Dolmen' with that of the Saône-Rhône culture complex.

It is possible that one of the graves at Petit Chasseur (monument VI) belongs to this culture: it has grave goods which are very closely related to finds usually assigned to the Saône-Rhône culture complex (Strahm, 1969; Bocksberger, 1967).

iii) Contacts, origin and dating

At the end of the last section a continuum between the Lüscherz and Cortaillod cultures was indicated (Chapter II, 11, iii). A similar continuum can be found between the Lüscherz and the Auvernier cultures. This has recently been demonstrated at Yverdon, Avenue des Sports where the lowest layers contain pure Lüscherz material and the succeeding ones show a slow infiltration of Auvernier elements (Strahm, 1977). A similar continuum, but lasting right into the Early Bronze Age, has also been shown to exist at Sion, Petit Chasseur (Gallay, 1976).

The origin of the Saône-Rhône culture-complex is thought to lie in the south of France, but the Swiss Auvernier culture has a local development with very strong roots in the Lüscherz culture thus stressing the autochthon element. To these developments outside influences were added, as can clearly be seen by the Corded Ware elements which after a certain time infiltrate all younger layers at Auvernier and at Yvonand, Av. des Sports. This infiltration was dated by a series of radiocarbon dates of the Bern and La Jolla laboratories. As fig. 44 a shows we can clearly distinguish an earlier settlement phase where only Auvernier traits are manifested in the pottery; a later settlement (probably occupied after an inundation of the first site) shows that the layers with Corded Ware elements date to about 150 years later than the 'pure' Auvernier layers. This trend can be seen from a series of dates from

Auvernier (Suess and Strahm, 1970) and from another series from Yverdon (unpublished, personal communication, Strahm, 1973). At Yverdon, the Auvernier culture without Corded Ware contacts, had its floruit between 2350 and 2150 bc. The settlement with Corded Ware influences had a floruit between 2200 and 2050 bc. The dates published by Suess (Suess and Strahm, 1970) are corrected to allow for isotope fractionation and cannot be compared with other dates as they are. In order to use them for comparison with all other dates they would have to be re-corrected to align them with the standard radiocarbon publication convention, which luckily has remained constant to avoid precisely this kind of re-correction. Tree rings from the two settlements at Auvernier (I and II) ^{indicate that the} medians of both Yverdon settlements lie 165 years apart and this is a very good agreement. (Calibrated to calendar years the Auvernier II settlement was built around 2690 BC and Auvernier I about 2450 BC.)

We can thus confirm the stratigraphic evidence from the excavations by radiocarbon dates and state that a culture, not influenced by Corded Ware culture lived in Switzerland about 150-250 years before those groups who had contact with the Corded Ware populations. The latter contact seems to have reached Auvernier slightly earlier than Yverdon but the occupation of the site at Auvernier did not last as long as that at Yverdon.

There is now a further series of radiocarbon dates available for the Auvernier culture. These have been compared with dendrochronological measurements (personal communication, Strahm, 1977). The dates agree very well with earlier measurements (cf. fig. 44,b).

II, 13 Cultures belonging to the Corded Ware Culture-Complexi) Switzerland: Distribution, settlement and house type

From material belonging to the Auvernier group in Switzerland discussed in the last chapter, it has become clear that the Corded Ware elements started to penetrate Auvernier settlement sites very gradually, that there then followed a time when both Auvernier and Corded Ware seem to have lived side by side - e.g. Yverdon (Strahm, 1973) and at Auvernier (Suess and Strahm, 1970) and that only then the Corded Ware became the dominating part and established itself. But not until recently (Strahm, 1971) had the Swiss Corded Ware group been treated as an individual group; only passing references, pointing out that the Corded Ware did exist in Switzerland had been made (Vogt, 1933; Sangmeister, 1951; Vogt, 1953).

It is probably the stage at which Bavarian and Austrian archaeology is at the moment: numerous references to the existence of Corded Ware elements - in particular axes, a few sherds with cord-impressions and burials under mounds - have been made (Maier, 1963, 1965c, 1967a,b; Stroh, 1940; Pittioni, 1954; Hell, 1950) but only Reitinger (1969) has made any attempt at drawing some of the evidence together for Austria since Pittioni's first attempt (1954).

In Switzerland, Strahm was able to put forward evidence of the existence of 2 or 3 phases of the Corded Ware cultural groups - and this without newly excavated material. After working through Corded Ware material in Swiss museums, he selected 3 complexes, each representing approximately a typical stage in the Corded Ware development in Switzerland. The expression Einheitshorizont - unitary horizon - is used as a way of indicating an early phase of the Corded Ware complex which can be recognized over wide parts of Europe by one or more of its typical components - the A-axe

(as defined by Glob (1944)), the corded beaker with a rim diameter to width of mouth of about 2:3, and Strichbündel amphora (decorated with groups of incisions) the coarse-ware pot with fingertip impressions on its neck and single graves under burial mounds (Strahm, 1971,132). In Switzerland its presence is attested by A-axes from settlements in the western part and as stray finds in arable areas of eastern Switzerland (fig. 45). Furthermore, the corded beaker appears all over Switzerland but this object by itself is not of such high chronological significance as the A-axe, since it appears almost throughout the entire Corded Ware period (cf. Strahm, 1971, Table 7). The same is true for amphoras and coarse ware: they too, appear throughout Switzerland. The burials under mounds also appear throughout Switzerland for the first time (Wyss, 1969). This in itself is significant, since these are the first burials definitely connected with one of our cultures. However, they are somewhat different from the ordinary Corded Ware burials in that they are cremations and not crouched inhumations.

All these elements together are taken as evidence for the intrusion of small Corded Ware groups into Switzerland during the early Einheitshorizont, probably coming from the Neckar valley in south-west Germany (Strahm, 1971,134), although they had to cross an area which is remarkably poor in Corded Ware finds (Gallay, 1970). According to Strahm the Sutz phase follows this Einheitshorizont very soon in Switzerland. The most widely distributed of the Corded Ware groups in Switzerland is however, the late Utoquai phase. Another group - represented by the Schöfflistorf cemetery should chronologically fit in between the Sutz and Utoquai phases: its parallels, in e.g. decorative elements are found in both phases. Yet it should be treated as an independent phase and this in spite of the differences one would

expect to find when comparing finds from settlements with those from burials (Strahm, 1971, 113). The late Utoquai phase, represented by sites such as Vinelz and Chevroux, with numerous copper finds, is partly contemporaneous with the EBA and this is why contrary to the praxis of the previous chapters, early and late phases of a cultural group have been discussed here.

The distribution of the entire Corded Ware group taken as a whole covers the entire Swiss central area - from lake Constance to lake Neuchâtel probably including lake Geneva, where a few individual Corded Ware finds are known, but not much research into this period has been done.

The settlements, judging by the large number of finds, were concentrated around the lakes, but individual finds and burials indicate that other areas - usually arable land - had also been used. Again the fact, that the correction of the Jura waters gave rise to the discovery of more sites than anywhere else, has to be born in mind when looking at these distribution maps. The settlement of Zürich Utoquai was situated at the southern edge of a wide bay of lake Zürich, an area which had already been occupied by the Pfyn and the Horgen cultures (Strahm, 1971, Fig. 1). The Pfyn site was furthest away from the lake, Horgen closer to the lake than the Corded Ware site, which is a good reflection of the fluctuation of the water level. The Corded Ware settlement had a thick pallisade; no house forms could be reconstructed from the old excavation reports but hearths of red burnt fractured stones, mixed with charcoal layers were found. In one corner a layer of thin round branches seem to indicate a housefloor and coarsly interwoven branches formed the walls of some of the houses. It is assumed from these few indicators that the house was built on ground level.

ii) Economy, artifacts and burial

Very little is known about the economy of the Swiss Corded Ware groups, mostly due to the lack of modern excavations. This is particularly regrettable because Switzerland is one of the few areas where Corded Ware settlements are known (Schlette, 1969), and because research dealing with Corded Ware economy has always been too ready - quite wrongly (Neustupný, 1969a) to assume pastoralism for these groups, since mostly only burials are known. Even indirect evidence such as used by Schultze-Motel (1969) would be useful to find out if the Swiss Corded Ware groups fall into the exclusively barley-growing northern European - or the more varied cereal growing (incl. emmer, einkorn and barley) Saale Corded Ware groups.

Higham, studying animals bones at Utoquai (1968) found that domesticated animal bones made up 82% of all the bones. Within these, cattle were with 60% the most preferred animal followed by pig (30%) and goat/sheep (15%). A few dogs were also represented. Results from the Corded Ware site Egolzwil 2/1 published by Aeschler and Rüeger should according to Clason (1969) be treated with caution, since it is likely that they were mixed with earlier (Cortailled) layers. It is possible that domesticated horse is represented at a new site at Wootel, Oberborgen (Guyan, 1972). A more general study taking a number of Corded Ware groups into account (Clason, 1969) showed that certainly western Corded Ware groups were settled farmers who also practised animal husbandry, but that the ratio of domesticated to wild animals varied considerably between individual local groups (cf. also Neustupný, 1969a). Therefore without a detailed study we cannot deduce the exact economy practiced by the Swiss Corded Ware groups.

Almost the entire ceramic material of the Swiss Corded Ware groups falls into 3 basic shapes: beaker, amphora and coarse ware pot.

The base is always flat and the body usually hemispherical. Strahm defines these 3 basic shapes as follows (1971,29): the beaker: a vessel which is always higher than wide and whose width of rim and body are roughly equal size. Amphora: a two handled vessel with hemispherical body and a narrow neck. Coarse pot: a wide-mouthed vessel whose width at the neck is only slightly smaller than its body circumference and with a characteristic plastic decoration on the neck. All 3 types have their own characteristic decorative elements and it is these patterns that distinguish the 3 Swiss Corded Ware groups most clearly. The earliest Einheitshorizont has compact beakers as e.g. those from Vinelz (fig. 46,a). Beakers of the Sutz phase have regular rows of cord impression, combined with stabbed impressions (fig. 46,b), usually covering the whole neck and part of the body.

The late Utoquai phase beakers have a more constricted neck (fig. 46,c). Amphora from the Sutz phase can be decorated with fir-tree decoration (fig. 46,d); those from the Utoquai phase have short necks and are decorated with typical wave-line pattern made by cord impression and the fields are then often filled in by stab-impressions. The coarse ware pots make up most of the material at Sutz and at numerous later Corded Ware sites. It was mostly used for storage and cooking (cf. thick burnt layers of food inside) and it is hardly surprising that it was not known from Corded Ware groups known only by their burials. They have a relatively small straight base and a wide body and narrow neck and wide mouth. The outside is often roughened either by a Schlickauftrag or by brush marks, and the interior has been smoothed. Decoration is always plastic and is usually on the neck or the rim of both (fig. 46,e).

Other objects of clay are net-sinkers or loomweights and spindle whorls.

Flint tools are very much like those from the Auvernier group, perhaps with a larger variety of types (Strahm, 1969) although this does not apply to flint implements from Utoquai, where both variety and quality is poorer. There are points (Fig. 47,a) large and small scrapers (fig. 47,b), blades (fig. 47,c) and a dagger blade (fig. 47,d). The latter is of imported material. Tanged arrowheads are missing.

Stone tools are represented by A-axes (fig. 48,a) and by so-called degenerated A-axes (fig. 48,b). An interesting find is a roughout from Utoquai (fig. 48,c) which Strahm groups as a K-axe (Strahm, 1971). There are numerous unperforated stone axes, some still in their antler sleeves. At Utoquai Strahm found (1971,39) that the axes as well as the antler sleeves fall into 2 groups. Small mostly flat axes, were hafted in small long sleeves (fig. 48,d) larger axes fitted into winged or large sleeves (fig. 48,e). There are also hammerstones and whetstones.

Bone tools are like those mentioned in previous groups and consist of awls (fig. 49,a), whose unworked ends were probably shafted, one-sided (fig. 49,b) or two-sided chisels (fig. 49,c), and points made of rib bones which are always highly polished (fig. 49,d) sometimes forked (fig. 49,e) and were most probably used in working flax.

Antler was used in great amounts for tool production. At Utoquai, judging by the amount of raw and waste material a 'workshop' was found. It seems likely that the antler was softened in water before it was worked: most of the cut edges are extremely clean-cut and sharp and such a sharp working of normally hard material cannot be explained any other way. Antler sleeves were most numerous and as explained earlier, small stone axes were hafted in small or sometimes forked (fig. 50,a) sleeves. Larger axes were hafted in larger, heavier sleeves (fig. 50,b) and these are sometimes/winged shape (cf. fig. 48,e)

as known from the Horgen groups. For a more detailed typological subdivision of these sleeves see Strahm (1971, p. 42-47). Antler axes of various forms as well as harpoons (fig. 50,c) are other tool forms. Numerous sharpened antler points and antler forked axes (fig. 50,d) show traces of wear, without giving clear indication of their function. Probably more of an ornament than tool were the antler rings and so called Kopfst bchen (fig. 50,e) - these too were found in Horgen groups.

Wooden vessels and tools from Swiss Corded Ware sites are quite numerous. At Utoquai they occurred in particularly large numbers and again it is possible that this is an indication of the presence of a workshop, since there were many roughouts and half-finished products. Most of the vessels are made of thick uneven wood. There are cups, and large and small bowls (fig. 51,a), and all with round bases. This led Strahm to suggest that the production of wooden vessels lay in the hands of a substratum of the population which carried on old traditions whereas the production of ceramic vessels was in the hands of the intrusive groups - they used flat bases only (1971, 36). It is however, also possible that the distinction is due to the difference in the material.

Wooden tools include shafts for the antler-sleeves, axe-hammers, bows, (fig. 51,b), net-swimmers (fig. 51,c), mixers and kitchen utensils e.g. spoons (fig. 51,d). There are also small woven mats of branches held together by bast.

Ornaments are very numerous and this is in general agreement with other European Corded Ware groups. They can be made of stone as in the form of the black slate pendant (fig. 52,a) or of bone e.g. as a crescent (fig. 52,b) (of bovine rib bone which must have been bent in steam or more likely in dungheaps to obtain its unnatural curvature) or of perforated animal's teeth (fig. 52,c) or of antler. The latter material was also used to make pins with crotchet heads (fig. 52,d) flat headed

pins (fig. 52,e) and ring headed pins (fig. 52,f). These pins will be mentioned again later since they are very interesting examples of metal copies. Similar examples are found in German Corded Ware graves their position indicating their use as hair or dress pins for women.

The use of copper is now well established and the variety of tools and ornaments of this material is much larger than in any of the previous groups. These will be discussed in Chapter III.

Burial rites of the Corded Ware groups normally involved crouched inhumations beneath a burial mound, with relatively few grave goods which do, however, differentiate between men, women and children (Fischer, 1956; Buchvaldek, 1966; Behrens and Schlette, 1969). In Switzerland, a different form of burial rite seems to have been practised: the dead were cremated and then buried under a flat mound. According to Strahm (1969) the finds are too inaccurate to decide whether cremation took place on the site of the burial mound or whether a special cremation site was used.

The cemetery at Schöfflisdorf is regarded by Strahm (1971) as the only Corded Ware cemetery in Switzerland apart from individual burials at Sarmenstord, and Schleinikon. The burial mounds there are flat (height to diameter = 1:10). As far as could be reconstructed from old excavation reports the dead had been cremated, the ashes then buried at ground level with or without grave goods (pottery). It is possible that a small wooden structure was erected over the ashes, and in some cases they were covered by stones. Over this a flat barrow of earth was erected which was covered by stones. It is not clear whether another cover of earth was put on top. Some of these burial mounds were used after a short time for secondary burials (Strahm, 1971, Abb. 6-19).

iii) Contacts, origin, dating

The contacts of the Swiss Corded Ware groups were, as we have seen, of a very complex nature. The earliest group clearly had strong links with central and northern Europe; this is expressed by the Einheitshorizont in eastern Switzerland and by infiltration of Corded Ware elements into the Auvernier groups in western Switzerland. Further waves of infiltration reached Switzerland in some but not all parts, until the widest distribution of Corded Ware was reached in the late Utoquai phase, to which sites like Vinelz belong.

Of further importance is the cultures' contemporaneity with the earlier phases of the Bronze Age. There are a number of good examples showing how those 2 cultures influenced each other, i.e. how Corded Ware groups imitated EBA forms and vice versa. This has been well documented in recent papers by Strahm (1974, 1977) and examples include for instance a copper axe with slightly flanged sides from purely late Neolithic material which must be an imitation of an EBA form (unless one wants to propose independent invention for this form at Vinelz).

There are also EBA metal pins with their exact counterpart in bone and antler the latter often imitating details which have no functional purpose (cf. Strahm, 1974, fig. Abb. 6,7,8). On the other hand, EBA groups copied attractive Corded Ware designs. The distribution map of Corded Ware and EBA groups in Switzerland (Strahm, 1971, map 4) gives an indication how those 2 groups could live side by side. The Corded Ware settled in the central Swiss corridor, including lake Geneva, the EBA groups on the other hand, formed small enclaves in the Wallis, on the eastern side of lake Geneva, around Thun and Singen. All the EBA areas are well situated for traffic, on trading routes and in areas where simple mining activities were worth while e.g. at the so-called Berner Oberland, where up to the last century a small copper mine was

still worked (Strahm, 1974). It is even possible, that the economy of both EBA and Corded Ware groups did not conflict, as the Corded Ware was probably extensively agriculturalist whereas the Early Bronze Age groups seem to have been small agriculturalists using terraced fields and keeping sheep and goats, and living on the proceeds of their trading and mining activities. This form of economy was still common until recently in many of the Swiss mountain valleys.

The origin of the Swiss Corded Ware groups has to be sought in one of the central European groups, with which they have such close contacts. Different waves seem to have come from different centres; such as northern Germany and Jutland. Parallels to the Schöflisdorf phase pointed to the direction of the west and south west German Corded Ware groups. A study of the origin of the Corded Ware complex as such would be very illuminating, but research concentrating entirely on these problems has not come up with an answer and it would go beyond the framework of this work to deal with it here.

When discussing the dating of the Auvernier culture it was pointed out that on many sites the radiocarbon dates and the stratigraphic evidence reflected a gradual change-over from Auvernier to Corded Ware elements (fig. 44). We have also just discussed the contemporaneity of the late Corded Ware phase with Early Bronze Age cultures in Switzerland. It is evident therefore, that the early Corded Ware culture in Switzerland was partly coeval with the Auvernier culture, whereas the late Corded Ware phase was contemporary with the EBA in Switzerland. The interquartile ranges of Swiss Corded Ware radiocarbon dates bear this out very clearly (fig. 44). The floruit of the whole culture lies between 2350 and 1900 bc (fig. 6).

iv) Bavaria

The presence of Corded Ware cultures in Bavaria is represented mainly by faceted stone axes, by trapezoidal and rectangular stone axes and by beakers which sometimes have cord impressions and at other times rows of stamp impressions (Maier, 1964). There are also leaf-shaped flint daggers (Müller-Karpe, 1974, 233) and a few graves under burial mounds. At Straubing (Hundt, 1952) the burial mound contained a typical Corded Ware crouched inhumation with a dagger of imported flint, a beaker with rows of circular impressions (Müller-Karpe, 1974, T. 105), two stone axes, animal bones, and a disc made of boars tusk. Single finds of stone axes (Maier, 1965c) and flint daggers (e.g. two of them in beautifully worked Pressigny flint, Maier, 1967b), as well as occasional Corded Ware material amongst settlement finds (e.g. from the Roseninsel in lake Starnberg (Müller-Karpe, 1974, 233) support the suggestion made earlier that there is more Corded Ware material in Bavaria than has hitherto been believed. Nevertheless, it will probably always be one of the peripheral areas of settlement of the Corded Ware groups. The basic counting method employed by Buchvaldek (1966 & 1975a) which uses the number of vessels and stone-axes per local group, perhaps gives a good indication of the main concentrations of this culture complex: the Saale area:3000 vessels, several hundred hammeraxes; Bohemia 1500 vessels and more than 400 axes; Moravia: 400 vessels and several 100 axes; Silesia about 50 vessels and several 10s of axes, south Germany including Hesse, Bavaria and Austria have only 150 vessels and several tens of axes between them.

v) Austria

In Austria, which we left at the end of the discussion on the Mondsee and Baden cultural groups, there is again just enough material

to make one wonder how far the Corded Ware groups really penetrated into Austria. An early infiltration is indicated by the presence of quite a number of axes belonging to the single grave culture (Reitinger, 1969; Abb. 64 also Pittioni, 1954, 240,242). The grave at Linz-Scharlinz (Stroh, 1940) which contained a beaker with corded decoration (fig. 53,b) and a crouched inhumation is evidence that this group penetrated probably through the Mühlviertel down to the Danube. Unfortunately this grave contained no stone axe, but numerous single finds generally of late neolithic character e.g. the beautifully worked double axes from Linz-Lusenau and Natternbach Gaisbuchen (Reitinger, 1969, Abb. 45) could belong to this period, and could be an expression of a local development of the Corded Ware complex, as was indicated by Maier (1964).

The fact, that one of these axes was found near the lake side settlement at See (Mondsee) indicates contact between these groups and would support the long duration of the Mondsee group. Corded Ware elements also appear around Salzburg (Hell, 1950). Another Corded Ware grave from Wien Leopoldau contained a typical amphora beside a crouched inhumation (cf. Pittioni, 1954, Abb. 166). Both the settlement at Guntramsdorf and Drassburg contained Corded Ware elements according to Pittioni (1954, 239).

The double grave from Füllik shows that elements of the Corded Ware, i.e. crouched inhumation under a burial mound with gravegoods including animals bones - in the case of Füllik pairs of cattle, horse and sheep - reached as far south as the Burgenland.

A new study of this material is badly needed and would throw light on a highly interesting phase in which many elements came into contact with each other such as the Laibach Vucedol groups in the south, and the newly emerging Kosihi-Caka and Mödling-Zöbbling groups in Lower Austria.

It will have become obvious how devoid in finds the area of Tirol is. A few finds e.g. stone axes (Pittioni, 1954, 247) and now a heavy copper flat axe from Lana-Gaulschlucht and a menhir or stele with engraved designs of a triangular dagger and necklace and belt (Lunz, 1973) very similar to finds from Petit Chasseur in Switzerland, are clear evidence that this is an area which, with further research, will bring to light more material containing vital clues to links between cultural groups discussed above.

The dating of the entire Corded Ware group is not easy, nor can one assume absolute contemporaneity for groups over such a wide area.

The radiocarbon dates which exist have a very wide spread, even of their interquartile range and this is probably a reflection of the real situation. In any case, they fit fairly well into the general pattern of the cultural groups under discussion.

II,14 Summary

In summary, the analysis of all archaeological material available for the cultures in this study allows certain conclusions:

The Cortaillod, Pfyn, Mondsee, Horgen and Corded Ware cultures are found predominantly on or near lake sides, in bogs or on riverbanks, but always with a few outposts on hills or rocky shelters.

Vice versa, the Altheim and Austrian Baden cultures occupy mostly hills but settlement sites were also found on lakes, rivers and in bogs.

The Lüscherz and Auvernier cultures are known from lakesides only but this may be due to the fact that they have only recently been identified.

Cultures belonging to the Epi-Lengyel culture complex in the north of Austria are known from hill sites only. Again this culture-complex has only recently been worked out and the fact that lakeside settlements belonging to it are known in southern Austria may be taken in support for the assumption that the whole settlement pattern has not yet emerged.

Too little exact information is available to draw any but the most general conclusions about house types and the situation is not very different for the economic pattern in our area. Only the Cortaillod and Pfyn cultures are well studied. Both practised a mixed agricultural - animal husbandry economy but with widely varying ratios between wild: domesticated species in both fauna and flora. In both these cultures cattle, closely followed by pig constituted the main animal protein in the diet. The little information we have about the Altheim, Mondsee, Lüscherz, and Corded Ware cultures also suggest preference for cattle and perhaps only the Horgen and Auvernier cultures preferred pig.

Close contacts between several of our cultures were found to exist. This has been demonstrated most thoroughly by numerous typological studies on pottery. However, it could also be shown to be true for several of the small finds such as the typical antler sleeves, occurring with certainty in the Cortaillod, Pfyn, Lüscherz, Auvernier and Swiss Corded Ware cultures and for stone Knaufhammeraxe occurring in the Pfyn, Altheim, Mondsee and the simpler stone axehammer occurring in a larger number of cultures (Pfyn, possibly Altheim e.g. at Auhögl, Mondsee, Horgen, Auvernier and Corded Ware). Flint arrowheads with a concave base are also widely used and occur in the Cortaillod, Pfyn, Altheim, Mondsee, Horgen and Lüscherz, but not in the Auvernier and Corded Ware cultures. A specific type of flint - Plattensilex - was found in the Altheim and Mondsee cultures, and other contacts can be demonstrated by the presence of limestone beads, segmented antler pendants and last but not least by the copper finds themselves and the paucity of them in Horgen-Cham horizon. With all these contacts and with the aid of radiocarbon dates we are able to work out the following distinct chronological horizons: (of which only those with copper finds have been discussed in the preceding pages): proceeding from western to eastern Switzerland, thence to southern Germany, western Austria and finally to eastern Austria the first horizon comprises the Cortaillod, Pfyn,

Altheim, Mondsee and Retz cultures. The second horizon contains the Lüscherz, Horgen, probably still the Altheim or Cham, the Mondsee and the Baden-Boleráz cultures. The third horizon comprises the Auvernier, Early Corded Ware, Cham, Baden Ossarn and perhaps still the Mondsee cultures. Before the first horizon we have found the Epi-Lengyel-culture-complex and the Münchshöfener culture in Austria and southern Bavaria respectively, which provided the first scattered evidence of the use of copper. This, in short, is the northern alpine cultural setting between 3400 to about 1900 bc.

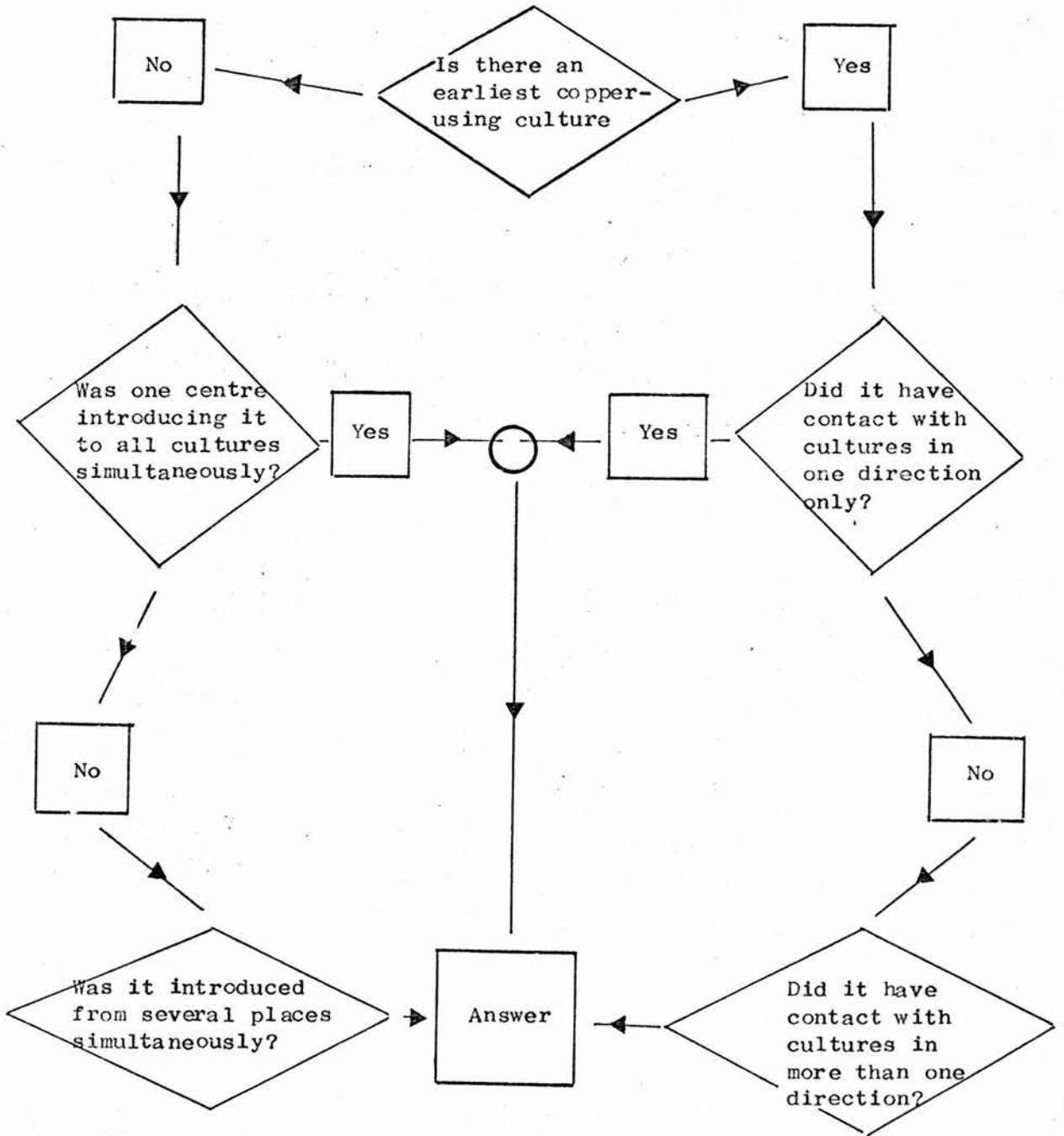
CHAPTER III. THE EARLIEST COPPER FINDS IN THE NORTHERN ALPINE REGIONIII.1 INTRODUCTION

Having outlined the archaeological background from which all the copper finds stem, it is now necessary to outline clearly the objectives of the detailed study of these finds.

In the last chapter the conclusion was reached that three copper-using horizons existed. Figures 54 and 55 show the spatial distributions of the two copper-rich, i.e. the first and third horizons. Of course, there are overlaps: cultures do not simply die out. The distribution maps are a necessary simplification of a three-dimensional time-space development which provides the basis for the following fundamental questions: can one distinguish any one of the cultures to be earliest to use copper? If the answer is 'yes': was there a later linear development throughout the area and was it one - or two-directional? If the answer is 'no': was the use of copper introduced from some centre to all cultures simultaneously, or was it introduced simultaneously from different places? This can perhaps be better illustrated in the form of a flow-chart (p.124) where each question has a yes/no alternative.

There are ideal situations which would enable one to answer all these questions quite clearly. These would be that 1) each copper artifact had been found under controlled conditions, i.e. that its exact provenance and cultural affinity was known, 2) that each culture had a precisely known time-distribution, and 3) that each metal object had been examined metallurgically. This last

Table 2



specification is in order that one would be informed about the exact techniques employed in its production, both analytically, so that each had a known 'fingerprint' and could perhaps be traced to its source of raw material, and also typologically. This list of ideal conditions could, of course, be extended considerably, e.g. it could include the precondition that all analyses had been executed by one laboratory, that all excavations had been led with the same meticulous care, etc.. It is self-evident, that nowhere and probably never can all these ideal conditions be satisfied and that as usual when dealing with archaeological material we shall have to content ourselves with partial information.

It is proposed to use those copper artifacts which are securely associated to a known cultural assemblage and for whose time-distribution we have a good approximation, as a 'hard core'. This hard core of securely associated finds will also be referred to as 'first-order associated finds'. Since this hard core is mostly very small, the circle has to be widened by including artifacts which come from sites where Neolithic material only has been found. These will be referred to as 'second-order associated finds'. Swiss and Lake Constance sites from which only Neolithic finds are known are such a case. These include Burgäschisee-Süd, Dietikon-Senne, Egolswil, Hagnau, Lorze, Niderwil-Gachnang (Egelsee), Nussbach-Maurach, Thayngen-Weier, Vallon-des-Vaux, Vinelz, Wetzikon-Robenhausen, Yverdon, Yvonand and Zürich-Grosser Haffner. In Austria most of the material does not allow such a clear-cut division.

This chapter is devoted to the typological aspects of the metal finds of first and second order associations. I shall also group

other single metal finds found in the northern sub-alpine region around this core on purely typological grounds - and include a brief study of coeval material from surrounding cultures in Italy, France, Germany, Czechoslovakia and Hungary. Only the briefest of references to other material evidence accompanying any of the metal finds will be made, since this has been fully dealt with in the previous chapter.

Unfortunately, the circumstances in which most of the metal finds have been recovered are far from ideal: over 90% are single or stray finds. This is mainly due to the fact that both Swiss and Austrian lake-side settlements provide the bulk of the material, which in both countries was obtained by indiscriminate treasure hunting during the end of the last and the beginning of this century. Many of these settlement sites were occupied for long periods either continuously e.g. at Mondsee: or with intervals of non-occupation in between (Egolzwil), and only rarely were they occupied for a well defined short period as at Burgäschisee-Süd. The development of modern techniques has enabled Swiss archaeologists to excavate sites up to 4m below water level (Egloff, 1972; Strahm, 1971c). They were thus able to ascertain at some of the lake-sites which groups were represented and which were not. In Austria the situation is made more difficult by the greater depth of the lakes, and consequently a greater depth of water above some of the lake-side settlements. However, there are sites which are not under deeper water than in Switzerland (e.g. Seewalchen: 2m depth), which could be excavated with the same care and rich results as in Switzerland, but this has not so far been attempted. Fortunately there are also some settlements on dry land in Switzerland, south Germany and Austria, all of them providing us with vital, securely stratified metal finds.

First and second order associated copper finds include the following types: flat axes, flat daggers, knives and daggers with midrib, awls, spirals, beads, small Ösenhalsringe, pendants, chisels, sickles, a spiral cylinder, a fish hook and several droplets of copper as well as crucibles. The cultures which produce most of these associated copper finds are the Pfyn, the Cortaillod, the Altheim, the Mondsee and the Baden-Ossarn cultures. The interquartile ranges of their uncorrected radiocarbon dates lie between 3100 and 2450 bc (cf. also Fig. 6, Volume II). Based on this information, the Pfyn and possibly the Altheim cultures are the earliest, followed closely by the Cortaillod and the Mondsee cultures.

In the following sections of this chapter the individual types of copper artifacts found in association to the late Neolithic cultures will be discussed. Although the sample size in this and the following chapters may be criticised as being too small to allow valid conclusions to be drawn from them, it is the only extant material of its kind available to us. Valuable studies such as locational analysis have been carried out on very small samples (cf. Hodder and Orton 1976, 211-223).

III.2 AXES

1. Flat axes securely associated to the Pfyn culture were found at Cham-St. Andreas, at Risch-Schwarzbach and at Zürich-Wollishofen. The former two were associated with typical Pfyn stone axes (i.e. 'Michelsberg' stone axes in the old terminology), the latter with a crucible which is now in Dr. Wyss' study collection at the Schweizerische Landesmuseum, Zürich.

Second-order associated flat axes were found at Egolzwil 4 and at

Hitzkirch-Seematte: both are Cortaillod sites. To these a few others with less reliable association but a high probability of belonging to the Pfyn horizon were added. A typical example is the axe from Wetzikon Robenhausen, which was not found during the excavation of the Pfyn settlement site itself but on their rubbish heap in 1882. However, this site contains Neolithic material only and the flat axe can therefore be included. A 'hard core' of 18 flat axes was thus established. (They are marked by an asterisk (*) in Appendix II.) Seventeen of these axes occur in a typological study by Sangmeister and Strahm (1974); fifteen were of their type Thayngen (cf. Appendix II under 'old grouping: T') and two of their type Bevaix (cf. Appendix II under 'old grouping: B'). Because my criteria were more stringent than those of Sangmeister and Strahm, twelve of their Bevaix-type axes are not included in my hard core of associated finds. Sangmeister and Strahm (1974) suggested that the Thayngen type axes were synonymous with the Pfyn culture: their distribution is almost exclusively in eastern Switzerland, i.e. the distribution of the Pfyn culture itself. The definition of this type was somewhat vague, sometimes even conflicting, thus indicating that perhaps it was not such a homogeneous group as suggested. I tried to define this group more precisely by taking measurements of the length, the widths at the butt, half way down and at the cutting edge, and the maximum thickness, (Fig. 56) as well as the weight. All these measurements for all flat axes in Switzerland were put into a datafile (cf. Appendix III).

The attempt to define the Thayngen group used cluster analysis (see Chapter IV, p.191). The objects used numbered twenty-eight; they included all my hard core of eighteen, and ten of the twelve

Bevaix-type axes defined by Sangmeister and Strahm; the two axes from Greng were left out because they are too corroded to provide reasonably accurate measurements. The numerical data was first converted into a similarity matrix (Pearson Product-Moment correlation coefficient) and then clustered with Olivier's option 7 (Nature's Group). Three major groups appeared and stayed relatively constant even when other clustering methods in the Bieber-Olivier package were tried. These three clusters (R,T,B in Fig. 57) raised some interesting points. Above all: the three most securely associated axes, all of Pfynd association, fell within two well defined separate groups; they are axe numbers 01, 03 and 12 and are illustrated in Fig. 59a, 58b and 58e respectively. (The axe numbers are those used for discriminant and cluster analysis in Figs. 57, 63, 64 and 65, and correspond to those in Appendix II and IVa.) The results of the cluster analysis thus indicates that the old Thayngen type should be subdivided, but that both sub-divisions belong firmly to the Pfynd culture. Professor Strahm, in a discussion on the new group formed by the sub-division, suggested that it should perhaps be called 'Robenhausen type', after the axe from Wetzikon Robenhausen (Fig. 58a). The distribution of this group is entirely in eastern Switzerland, i.e. a typically Pfynd distribution. Some axes formerly grouped under the Bevaix type now clearly belong to the new Robenhausen type, such as e.g. the axe from Risch-Schwarzbach (no: 12, Fig. 58e, PL.1). Others, such as the axes from St. Blaise (no. 46, Fig. 62a), Estavayer (no. 59, Fig. 62b) and Pr efargier (no. 62, Fig. 62c) form a sub-cluster within this new group.

Axes of Robenhausen type (total number: 10) are small, with a mean length of 7.7 cm, a mean width at the butt (w_i) of 2.2 cm, mean width half way down (w_{ii}) of 2.8 cm, mean width at cutting edge (w_{iii})

of 3.7 cm and mean thickness of 6.5 mm and can be seen on Fig. 58. They were cast (Sangmeister and Strahm (1974) suggested in bipartite moulds since their outline is very precise) - but not always very skilfully - as one axe from Zürich-Wollishofen, Haumesser shows. It has several tears across both sides, probably indicating too rapid cooling.

The Thayngen type, comprising now twelve axes, still forms the largest group. The mean length is larger (11 cm, the other mean measurements are w_i 1.8 cm, w_{ii} 2.6 cm, w_{iii} 4.1 cm, T 11.9 mm) and the outline is more concave, as can be seen in Figs. 59 and 60, and PL.2.

The Bevaix type (now only containing six axes) is broader than the Thayngen type and at the same time is slimmer in profile (Fig. 61A, 61B and PL.3). The mean measurements are length: 10.5 cm, w_i 2.7 cm, w_{ii} 3.9 cm, w_{iii} 5.1 cm and thickness 10.6 mm.

The grouping achieved by the clustering method was corroborated by discriminant analysis (cf. Chapter IV, p.200), the percentage probability with which each of the axes is allocated to the 3 groups was very high. It is therefore clear that the Pfyn culture used two types of axes: the Thayngen and Robenhausen types - and these will provide the firm basis for further studies on flat axes.

Grouping of all Swiss flat axes was attempted next, and the result can be seen in Fig. 63. (All measurements used for the clustering are in Appendix III.) Again three big groups appear. The first (upper) group (T), contains all of the securely associated Thayngen finds, defined from clustering the hard core. Added to these have been seven further axes, which can therefore tentatively be assumed to belong to the Pfyn culture. Two of these (Nos. 37 and 38)

are from the lake-side dwelling Nussdorf-Maurach on Lake Constance, which contains almost certainly only Neolithic material. The Robenhausen group (R) remains a tight cluster, with several other axes clearly closely related to it. The third cluster includes all Bevaix-type axes, as well as all those not assigned by Sangmeister and Strahm (1974). The Robenhausen-Bevaix subgroup (p.129) has moved back to the third group, but as Fig. 64 shows, is not very closely associated with it. This third cluster is indeed a rather heterogeneous cluster of axes; it includes some of the axes from Greng, which all have a very thick layer of patina attached to them (Schwab, 1970), and should probably have been excluded from the clustering. Bevaix-type axes cannot be firmly associated with any one culture in Switzerland but are most probably later than Pfynd-type axes.

None of the Austrian flat axes were found in secure association, even though some of them are quite recent finds, e.g. one at Lana-Gaulschlucht in Tyrol (Lunz, 1973), and one found during the extension of Linz harbour on the Danube (Pittioni, 1957). Nevertheless, all Austrian flat axes are compiled in Appendix IV; their numbers are all prefixed with 'A'. Their measurements are in the datafile in Appendix V. Cluster analyses of the data showed that there are basically four big groups, (D-G; Fig. 64). Examination of the axes in cluster F and G showed that they are large massive axes, mostly from Carinthia, Tyrol and the eastern Danube region.

Group D (Fig. 64), on the other hand, contains small axes of an appearance so strikingly reminiscent of the Robenhausen type that the similarity was tested by combining the data files of the Swiss axes of

Robenhausen type and of Thayngen type (groups R and T of Fig. 63) with groups D and also E of Fig. 64. The combined data (62 objects) was clustered. Fig. 65 shows that three major clusters emerged. Cluster H is in effect the Swiss type Robenhausen, together with six of the small Austrian axes - no. A23 from Pölshals (Fig. 66a), no. A17 (P1.4) and A15 from the Mondsee, nos. A10 and A22, also one from Altheim (no. A52). The similarity both visual and statistical, between the Austrian and Swiss axes in this cluster is considerable.

Cluster K contains all the Swiss axes of the type Thayngen, and three Austrian axes, whose similarity to the former is not, however, overwhelming.

Cluster L is basically the nineteen Austrian axes not so far mentioned, together with three Swiss axes. Almost all the Austrian group E (Fig. 64) are in this group, still tightly clustered; characteristic examples of this group come from the Attersee (Fig. 66b) and are more elongated than the Robenhausen type, but broader than the Thayngen type.

Thus the effect of clustering was to show that most small Austrian axes are more similar to each other than to any Swiss ones, but a minority relate closely to types Thayngen and Robenhausen, especially the latter.

In order to achieve completeness, clustering was performed on the combined data formed from the large Austrian axes (groups F and G, Fig. 64) and the Swiss Bevaix axes, but no meaningful re-grouping emerged. This is perhaps not surprising, since group G in Fig. 64 includes such axes as that for instance shown in Fig. 67a and 67b. Group F should indeed perhaps have been excluded from the study

altogether, since four of the six axes - from the Austro-Hungarian Empire - might in fact, be of Hungarian or Slovakian origin.

Thus clustering, on a purely morphological basis, has helped to distinguish clearly between two types of Swiss flat axes, the types Robenhausen and Thayngen, both belonging to the Pfyn culture. The hope to attach unassociated flat axes, i.e. stray finds, to an associated type has, however, been only successful on a limited scale. Several stray finds from Switzerland could be grouped to the type Robenhausen. A close typological relationship between one group of Austrian flat axes and the Swiss type Robenhausen could also be shown to exist. Whether this is coincidental or constitutes a real contact can only be decided after further study in particular with the aid of metal analysis.

It also seems significant that the large heavy axes are from the southern and eastern and most accessible Danubian part of Austria, where contact with the neighbours and accumulation by trade might be assumed. The more one goes into less accessible regions and the further west one goes, the more uniform the groups become so that it was relatively easy to group the Swiss flat axes typologically. The homogeneity begins to appear in the Austrian lake district.

One might expect such a reduction in variability on geographical grounds if the underlying hypothesis assumes contact by trade and other social means with cultures more advanced, and richer in copper metallurgy, in the east and the south. Further away from these contacts, i.e. further west, cultures with access to copper might have made their own axes as copies of the larger ones, but with a more economical use of metal. This hypothesis seems to be supported by the uniformity of axes in the Mondsee and the Pfyn cultures. The

distribution of the flat axes is shown in Fig. 68.

ii) Copper axes with shaftholes are not known in Switzerland or southern Germany and only a couple come from second order securely associated finds in Austria. One axe hammer comes from Zwerndorf and was found in 1931 with sherds of the Baden culture, other Neolithic sherds and wattle and daub (Willvonseder, 1937b). Its sides are faceted (Fig. 69a) and it has alternatively been grouped to Garasanin's type I,2 (Garasanin, 1954) or to Schubert's type III (Schubert, 1965). Another axe hammer from Linz St. Peter (Fig. 69b), was found close to the copper flat axe (cf. App. IVb) during the building of Linz harbour. This type of axe hammer is well known from the Hungarian Tiszapolgár culture and from Slovakia e.g. Vel'ke Raškovce or Tibava (cf. Chapter 1).

Two further axe hammers are thought to belong to the Baden culture. One was found at Puch and is unlike any found in south-east Europe. It is however, very similar to stone axe hammers found in Austria and is thought to be a copy of them (Pittioni, 1954; Fig. 136). The other axe hammer is very massive and large and was found in the small museum at Mödling, near Vienna (Pl. 6). It has again parallels in the Hungarian Copper Age culture of Tiszapolgár.

These axe hammers are listed in Appendix IVb and their distribution is shown on Fig. 68.

iii) There are no securely associated pronounced flanged axes in the area of study belonging to a late Neolithic horizon. The only possible exception is an axe from Vinelz which shows very slight flanges on one side (cf. Strahm, 1971a; Fig. 25,2). Pronounced flanges are thus clearly an EBA development.

III.3 DAGGERS AND KNIVES

The next type to be discussed is daggers, and knives. Of the former usually only the dagger blades are preserved, their hafts only very rarely. The hafts were probably made of wood; rivetted daggers requiring, of course, a different type of hafting from tanged daggers. One example of how the latter type was hafted is provided by the dagger from St. Blaise which has fragments of the wooden handle still attached to the blade by tar and both secured by a cord wound round tightly (Fig. 70a). A flint dagger from Vinelz of exactly the same shape and type of hafting (Fig. 70b, cf. also Strahm, 1962 Abb. 10,10) gives us an example of the appearance of the whole dagger. Wooden hafts of this kind and similar ones have been studied by Strahm, who came to the conclusion that tanged flint daggers - mostly made of Pressigny flint, were an imitation of tanged copper daggers (cf. Fig. Strahm, 1962 Abb. 7-10). Pressigny flint is close in colour and probably value to the copper implements. Rivetted daggers were probably hafted in the manner suggested by the steles of Sion; on two of these steles a triangular dagger has a crescent-shaped pommel (Fig. Gallay & Spindler, 1972, p.63 and p.51). Since these steles were re-used by Beaker people for some of their graves, and neolithic occupation of this site has been proven (Gallay, 1972c), it is clear that this kind of hafting was well known in our period.

Daggers in Switzerland as well as in Austria are often very small and their application as a stabbing tool is rather dubious, they were more likely used as knives. It is therefore often quite difficult to draw the line between small daggers and knives.

Basically the daggers fall into the following 3 groups:

i) flat rivetted daggers; ii) rivetted daggers with a midrib on one

or both sides, and iii) tanged daggers, which are all flat. Both types i) and ii) could be subdivided again into small and large and into those with round, straight or trapezoidal hafting plates. However, very often the graduation between these sizes is so imprecise that grouping based on those criteria would be quite artificial, particularly if one bears in mind that different castings even in the same mould could produce different sized objects (Tylecote, 1973), and that each time a dagger is re-sharpened it changes its shape somewhat.

The midrib is a more important distinction: Flat daggers could be manufactured by hammering - unfortunately, there are no metallurgical examinations to prove this, although the appearance of some of these daggers and knives would support such an assumption. Daggers with a midrib on one side only, were cast in open moulds, but those with midribs on either side were cast in a bi-valve mould and are therefore a more advanced type than the others.

(i) One securely associated find is a large flat rivetted dagger-blade (Fig. 71a). It was excavated in 1973, just a week prior to my visit to that area, at the site of Yvonand-La Peupleraie (Yvonand I) in Switzerland, together with a vessel belonging to the Auvernier group (Strahm, 1975a, 17). The dagger blade is elongated but still triangular, its point slightly rounded and its hafting plate straight. Its cutting edges were hammered to sharpen them; three square rivets forming a straight line are still in their rivet holes and Strahm suggested a shafting like those mentioned for the Petit Chasseur, Sion daggers. He also pointed out that one of the cutting edges is slightly convex, indicating its use as a knife i.e. a cutting implement than a stabbing tool.

At Vinelz, a site with Corded Ware material only, a dagger very similar in appearance and size was found (Fig. 71b). Morphologically similar, but smaller flat daggers also occur at Vinelz (Strahm, 1971a, Abb.25). This indicates clearly that this type is typical for the late Neol. Auvernier/Corded Ware groups. A list of typologically similar ones, e.g. those from Onnens (Plate 7), but also including small daggers with a straight hafting plate (cf. Plate 8 and 9) can be found in Appendix VIa and their distribution (Fig. 72) shows them to be an entirely Swiss development.

It is not clear whether round hafting plates merit a distinction from daggers with a straight one. Certainly the size of the dagger from Sutz, Lattrigen (Fig. 73) is very similar to that from Yvonand. A small riveted flat dagger with rounded hafting plates (Kyrle, 1918. Fig. 9.1; Kneidinger, 1942, T. IV, 52) was excavated between 1914-1917 at the Langensteiner Wand in the Laussa valley in Austria. This site has, like several others in the area, produced Late Neolithic finds only (Kyrle, 1918; Mitterkalkgruber, 1954; Reitinger, 1968) but has not been fully published. However, it seems justifiable to include this small type of dagger blade with rounded hafting plate and two or three rivets parallel to the hafting plate (Fig. 74) in the late Neolithic assemblages. A group of morphologically similar daggers (PL. 10, 11 and 12) are all single finds from Austria and Switzerland (App. VIc and d), and their distribution (Fig. 72) shows that they occur widely scattered over the northern alpine area.

(ii) Both small and medium sized daggers with midrib occur at Vinelz (Fig. 75 a-c), so that we cannot automatically rule out the existence of midribbed daggers from the late Neolithic period. This is also supported by the presence of a dagger with a very pronounced midrib

in the Bygholm hoard (Sylvest and Sylvest, 1960) in Denmark which belongs to the TRB:C cultures (Ottaway, 1973d). Small daggers with midrib and round hafting plate (Fig. 75d), and large daggers with midrib and with trapezoidal hafting plates (Fig. 75e) and also smaller ones (PL.13) are fairly frequent in Austrian lakeside settlements of the Mondsee culture. Similar ones to those can only be found in secure association outside our area; in the Slovakian Ludanice group which is contemporary to the Hungarian Bodrogkeresztúr culture. A list of daggers with midrib can be found in Appendix VIIa-c and their distribution in Fig. 72.

(iii) Tanged daggers, belonging to the late Corded Ware phase of Utoquai (Strahm, 1971a, 153) in Switzerland, occur at Lüscherz (Fig. 76a), Colombier (Fig. 76b) and at St. Blaise (Fig. 76c,d). At this latter site the large tanged dagger (Fig. 70a) mentioned earlier was also found. Very similar daggers to those (in Fig. 76 a-c) have been found in the late Fontbousse culture of southern France, which belongs to the very end of the Neolithic there (Strahm, 1971a, 153). The larger dagger from St. Blaise is so far the only one of its kind, and its context is problematic although the exact copy in flint at Vinelz suggests a Corded Ware date. In Austria at Wien; XXII-Aspern, a flat tanged dagger (Fig. 77) of similar size to that in St. Blaise has been found in a double burial of the Baden cultural group. Its shape, however, is not triangular, but has been broadened at the tip and then sharpened at the edges (Plate 14). It appears therefore that large as well as small tanged daggers occur relatively late in Switzerland and Austria, yet they are well known from the Bodrogkeresztur culture of Hungary (Fig. Hillebrandt, 1929, T. IV.5) and the Lažnany group of Czechoslovakia (Šiška, 1972, Abb. 35,3). Tanged daggers are not very

numerous but their list is given in App. VIIId and their distribution is found in Fig. 72.

As pointed out above, daggers were often used as knives and it is particularly difficult to distinguish between some tanged daggers and knives. This can be illustrated by the knife-daggers from St. Blaise or Monruz (Fig. 78 a,b). There is one securely stratified knife in Switzerland from Erlenhölzli, lake Halwil, near Meisterschwanden. It is not symmetrical, less slim in outline than a tanged dagger and has a slight midrib (Fig. 78c). It was found in 1947 and belongs to the Horgen group (Itten, 1970). In Austria one knife and a fragment from another were found at Paura (Beninger, 1961), and one at the Langensteiner Wand; both sites, as discussed in the previous chapter, belong to the Mondsee horizon. Twelve small knives were found in Seewalchen alone, (Willvonseder, 1968) but most of them are now lost. They were on the whole a rather heterogeneous group and less defined than those from Switzerland (Fig. 78 d,e). Several of the knives could have been cast in an open mould, since they have a midrib on one side only, but again without metallurgical examination it is impossible to be sure. One of the ends of the knife was probably hafted. There are several very similar knives at the cemetery of ^YSebastovce, belonging to the ^{VV}Lazňany group in ^YČSSR (Fig. (^YŠiška, 1972, Abb. 35, 1,2). The knife is therefore a fully Neolithic artifact and a list (App. VIII a,b) as well as their distribution (Fig. 72) can be found in Vol. II.

In summary, it can be said that the knives are the earliest representatives amongst the stabbing - cutting implements - they are known from the Horgen and Mondsee cultures onwards. Next in chronological order appears the flat dagger with a round hafting plate which occurs on Mondsee land settlements and onwards in Austria and Switzerland.

Then follows the flat dagger with a straight hafting plate which is represented at the Auvernier culture and later, as well as tanged daggers which are known in Austria from the Baden period and in Switzerland from the Corded Ware period. Finally, midribbed daggers appear at Corded Ware sites in Switzerland and probably belong also to a similar time period in Austria.

III.4 AWLS AND PINS

The next artifact type to be discussed is awls and pins. The latter should really be discussed separately but since there are only two, perhaps three, pins in our entire area they will be included with awls. One pin, a Rollennadel, was found in Switzerland at Yvonand/Geilinger in 1974 in clear stratigraphic association with finds of the Horgen and the Lüscherz groups, such as pottery, antler axes, winged antler sleeves and rhombic arrowheads of flint (Strahm, 1975a). The pin consists of a long irregular square shaft which is pointed at one end and hammered flat and then bent over at the other (Fig. 79a). Microscopic examination showed that it had several grooves running along its shaft and that it was probably hammered together from several pieces of metal.

In 1975 another similar Rollennadel - with square shaft, grooves and a slightly more bent head - was found at an excavation at Auvernier/Brise-Lame, and Strahm (1975a) suggested that we are dealing here with a specific type of pin of the Lüscherz group. This is a rather interesting suggestion since hitherto the Rollennadel was thought to be a typical BA object, and coeval parallels to the Swiss Neolithic pins cannot be found nearer than in the Ukraine. It seems likely therefore and indeed most plausible that this simple type of

ornament was 'invented' in Switzerland. Whether we agree with Strahm's suggestion that it could have led to the BA Rollennadel or whether such a simple type could have been thought of several times is a matter of taste and cannot at the present be decided.

At Yvonand/Geilingen another smaller pin or awl (Fig. 79b) was excavated under precisely similar circumstances and associations as the previous pin. It too shows traces of having been hammered together from several pieces of metal. One end is pointed, the other flattened but it is only half the size of the Rollennadel. It has an almost exact counterpart in Austria at Seewalchen (Fig. 79c). A Rollennadel of similar size was found at Corcelle, Switzerland, (PL. 15) but is a single find. Another stratified square awl was excavated at the settlement of Auvernier/La Saunerie (Strahm, 1965).

The four Swiss finds are the only securely associated ones. There are, however, quite a few second-order associated awls in Switzerland, South Germany and Austria. They can be divided morphologically into those with i) a square shaft and a rounded tip and those with ii) a round shaft. The first sub-type (i) has very good parallels in the Hungarian Bodrogkeresztur group, and a recent find of a small, thick awl with square shaft and oval tip was excavated at Schernau, Lower Franconia, Germany (Lüning, 1973). This awl had been cold-hammered and was found in late Rössen contexts (layer 6) in the south eastern part of a house floor together with a small spiral finger ring. Charcoal from layer 6 gave a radiocarbon date of 3260 ± 65 bc (KN 726). Awls with round shafts (ii) occur in the Slovakian Lažňany^{yy} group. We can therefore be sure that both sub-types can occur from Neolithic contexts onwards.

In Bavaria an awl was found during the excavation of a trial

trench at Wallerfing-Bachling (Siegroth, 1972). This trench also produced a conglomerate of hitherto unsorted Rössen-Münchshöfener-Altheim elements and could therefore belong to either of those three groups. It is quite likely to belong to the Münchshöfener Wallerfing phase (Maier, 1972), which I would suggest - disagreeing with Maier - is coeval with the Austrian Bisamberg-Oberpullendorf group recently worked out by Ruttkay (1976), since they have several elements, amongst them the handled jugs and enlarged herringbone patterns of incised lines, in common. The awl - or is it a pin? - is 12.6 cm long and has a similar pitted and hammered appearance to the pin from Yvonand. Its shaft is round at one end - just as that from Yvonand - and is otherwise square.

In Austria, at the Neolithic settlement site of Prücklermauer both a copper awl and a copper pin were found (Mitterkalkgruber, 1954) but the only illustrations (both finds are in private hands) are so poor and without scale that it is impossible to decide whether they really are an awl and pin. In Switzerland, at the site Zürich/Grosser Hafner, which contains Neolithic material of the Cortaillod and the Horgen culture only, an awl with a square shaft but pointed and round on both ends was found in the last century (Antiqua, 1885). It belongs therefore to the Neolithic period, although it is not clear to which cultural group.

At the south German site of Altheim three 'awls' were found (Driehaus, 1960, T. 34, 3-5). They are very small (2.8, 2.7 and 1.4 cm, Fig. 79h) and of irregular, rectangular cross-section. They are more like rivets than awls and are listed in the Munich Staatssammlung as '2 Kupferstifte and 2 Fragmente' (one of the latter is now missing).

Finally, at the Corded Ware site of Vinelz, several awls with round, and half round and half square, shafts were found. The most common type is a basically square shaft which has been smoothed and thereby rounded at the tip (Fig. 79d and PL. 16). It is also common in Austria e.g. at Seewalchen (Fig. 79e and PL. 17). It is possible that the one end was deliberately left square to facilitate fastening into a bone, wood or antler handle with the aid of tar, in a manner demonstrated by one of the Vinelz awls (Fig. 79f). The manufacture of these awls can be followed closely by the very rough awl (Fig. 79g) which has several sheets (up to 5) folded inside each other. Their seams are hardly worked over and only the tip has been smoothed. There are also some very small awls and these can have either square or round shafts.

Thus, there is evidence that the square, roughly hammered awl with a rounded tip was the earliest type - belonging to the Münchshöfener culture. A similar type - only rounded at both ends - could belong either to the Cortailod or the Horgen group. It was followed by small round awls in the Mondsee culture. Both types were carried through to the Corded Ware period when they are represented at Vinelz. By then the awl with a square shaft and round tip is worked with more care and - presumably understanding of the raw material - and there is little evidence of the rough hammering found earlier. This latter handling of the material was still practised in the Lüscherz group from which we know the Rollennadeln.

A list of the two types of awls including the securely associated and the single finds (Appendix IX a-c) and their distribution (Fig. 80) can be found in Vol. II.

III.5 CHISELS

The type to be discussed next is the chisel. None were found in Austria. In Germany a few occur around lake Constance but in Switzerland they are numerous and several come from second-order secure contexts: one is the chisel from Burgäschisee-Süd (Fig. 81a), found at the start of the excavation in 1952 during cutting the surface humus. It was treated as a stray find at the time but later the cultural layer was found to reach up to the surface in this field, and there is therefore no reason to doubt that it belongs to the Cortailod culture as all other finds from this site do (Sangmeister and Strahm, 1974, 191).

The others all come from the Corded Ware site of Vinelz and are of varying size and shape (Fig. 81 b-d). All chisels that could be compared to those mentioned above as well as all smaller ones (e.g. PL. 18) are listed (App. X) and their distribution is shown in Fig. 80.

III.6 BEADS

The next type to be discussed is beads. These occur in our period in Switzerland only and can be divided into two clear groups: ring-beads and biconical beads. The former occur in an absolutely secure stratified context, the latter in a (second-order) secure association. The ring-beads from Burgäschisee-Süd were found in the Cortailod settlement during the 1967 excavation. A total of 56 beads belonging to 2 strings, some still on a cord, were excavated from a shallow pit, where they had been carefully deposited. A detailed study (Sangmeister & Strahm, 1974) proved that they were made from 5 rods, four of them about 30 cm long, the fifth somewhat shorter. These rods had evidently been cut and the short pieces then been bent until their ends met. Each bar can be clearly separated from the other (Ottaway &

Strahm, 1975, cf. Fig. 12) and the suggestion was made by the latter authors that the beads were currency rather than ornaments.

Biconical beads are known from the Corded Ware site of Vinelz (Fig. 82g) but also from a few other sites (Fig. 82 h-1). The 46 beads from Vinelz were first mentioned in Antiqua (1885), but the site also produced some ring-beads of the type known from Burgäschisee-Süd. It seems then that ring-beads were known from the Cortaillod through to the Corded Ware period (Fig. 82 a-f), but they are rare. In areas outside Switzerland parallels are just as scarce (cf. Ottaway & Strahm, 1975), Brešc^{VV} Kujawski being the only site where they occur in any larger number. In Southern France there are about 8 beads which could be called ring-beads (Sangmeister, 1971, Fig. 4) belonging to the French Chalcolithic, which according to Sangmeister is roughly coeval with the Horgen in Switzerland. In 1975 a few very small ring-beads were found at the excavation of Gomolava in Jugoslavia in levels 15 and 16 during my stay, they are therefore also known from the Baden-Kostalac period, radiocarbon dated to 2410 ± 60 bc (GrN7371, personal communication, Mook, Groningen).

Biconical beads do find some parallels; in Kelsterbach, for instance, belonging to the south-German Corded Ware period. Sangmeister (1971) found that the biconical, faceted type of bead found in the Chalcolithic of France was another very local development of the type.

A list of all ring-beads and biconical beads can be found in App. XI and their distribution in Fig. 83.

III.7 i) TUBES OF SHEET COPPER

Beads made of sheet copper, also called tubes of sheet copper, are very numerous in northern Europe, particularly in Germany during

the Neolithic period prior to the Corded Ware (cf. Ottaway, 1973, Fig. 12) yet in the northern alpine area they are exceedingly rare and only one was found in a relatively secure (second-order) association. It is the tube of sheet copper from Vinelz (Fig. 84a) which, therefore belongs to the Corded Ware culture. It seems that this type of copper artifact was not at all popular before this period, and only started to be used at the changeover from late Neolithic to the EBA.

A list of tubes of sheet copper (App. XII) and their distribution (Fig. 83) can be found in Vol. II.

III.7 ii) SPIRAL CYLINDERS

A similar lack of securely associated finds is true for spiral cylinders of copper. They are often called beads, or salta leoni. Again they are quite frequent in northern Europe in various Neolithic periods (cf. Ottaway, 1973, Fig. 11), i.e. the late Lengyel, the northern TRB:C, the Salzmünde, Baalberg and Walternienberg-Bernburg as well as in the Corded Ware cultures. The only secure find (of the second-order) comes from the Corded Ware site of Vinelz (Fig. 84b). The band width of the Swiss spiral cylinders varies between 1-3 mm and the band used for these spirals was usually flat. Those from the lake-side settlement of Sumpf, Zug and from Chevroux have a triangular profile (PL.19) which gives the spiral cylinders a biconical appearance reminiscent of the Corded Ware beads at Vinelz and elsewhere. In Austria most of the spiral cylinders come from the Stollhof hoard and are of quite a different type (PL. 20). They are much larger, much more regularly executed and have a very constant band width within each individual spiral cylinder. In fact, they look like a luxury edition of the other cylinders, which can also be said for the other artifacts

of the Stollhof hoard. The method of production for spiral cylinders has been briefly touched on before (Ottaway, 1973) and nothing new can be added to this.

A list of all probable spiral cylinders (App. XIII) and their distribution (Fig. 83) can be found in Vol. II.

III.8 i) SINGLE SPIRALS

The next type to be discussed is a very intriguing one: Until quite recently it had always been assumed that the many single spirals which had been found in lake-side dwellings were fragments of spectacle spirals. However, when Kalicz excavated a spiral earring at Zalavar (Kalicz, 1969, Abb. 2), a site belonging to the Balaton culture of Hungary, and when a similar one was 'excavated' in the Vienna museum and found to belong to the excavation of Wien-Jirawetz, (PL. 21), a dwelling pit which contained sherds with elements of the Lengyel and Tiefstich-Ware (Ruttkay, personal communication), I re-examined all objects which I had previously classified as spiral spectacles or fragments thereof. It was found that all those that come from relatively secure (second-order) associations in Switzerland as well as in Austria were, in fact, single spirals. This is true for one found at the Pfyf site Niederwil Gachnang on the Egelsee (PL. 22a) of which there is a copy in the Zürich Landesmuseum. Unfortunately, the spiral was not found during the Dutch excavation but afterwards on the rubbish dump. It is still with the finder, who wears it - set in gold - as a necklace (I am much indebted to Professor Waterbolk and Dr. Butler for their information and illustrations of this important find). The enlarged illustration (PL. 22b) shows that we are not dealing with a cast wire of smooth cross-section, but one which was probably made of several

strands of metal wound and rolled together.

Another 'spiral' is mentioned by Sitterding (1972, p.32 and 86). It was ... 'a tiny piece of a spiral, which was the only metal found at this site ...'. The site is Vallon des Vaux and as discussed in the previous Chapter, it contained Cortaillod material only. Unfortunately no illustration is available, and the 'spiral' might even be a spiral cylinder.

All these three single spirals came from our earliest horizon, to which phases 2-3 of the Balaton culture also belong. There are two radiocarbon dates for the Balaton culture from Keszthely-Fenekpuszta of 2830±80 bc and 2940±80 bc (B1n 500 and 501) (Quitta & Kohl, 1969) which fits in very well with Pfyn and Cortaillod ¹⁴C dates. Other single spirals from Austria, e.g. from the Mondsee (PL. 23) are similar.

Two further relatively securely associated spirals come from our next horizon: one was found at the Corded Ware site of Vinelz (Fig. 85a) the other at Baden-Königshöhle, together with late Neolithic pottery (Ladenbauer-Orel, 1954), for which Kyrle (1924) just noted that a 'fragment of a spiral' was found. The Vinelz spiral is somewhat larger than those of the earlier horizon, and made of a flatter broader band. It finds its exact counterpart in a single find from Lüscherz (Fig. 85b). App. XIV lists all single spirals known to me and their distribution is shown on Fig. 87. Once one accepts the idea of spiral earrings one could include pieces of 'wire' which have been found occasionally as part of this artifact type. One such 'wire' was found at Ossarn (PL. 24), together with typical Ossarn pottery (forthcoming publication, Ruttkay & Ottaway); another at Seewalchen, Attersee, which might well have had a spiral attached to it.

It is also interesting that a single spiral of lead is exhibited in the museum at Zug (Inv. No. 400).

III.8 ii) SPECTACLE SPIRALS

Spectacle spirals create quite a different problem. There is not a single (even second - order) securely associated example in the whole of our area, yet for the first time we are assisted by their depiction within Switzerland on two steles at Petit-Chasseur, Sion (Gallay, 1972c, PL. 50 & 51). These two steles are still somewhat of an enigma but we can be certain that they were re-used in Bell Beaker times for graves when they were roughly be-headed - whether for purely functional or superstitious reasons is, of course, not known. They had originally been made in pre-Beaker periods (Bocksberger, 1971; Gallay, G. & Spindler, K. 1972; Gallay, A. 1972c).

We have further proof for the early date of spectacle spirals by their presence at the graves in Breš^{VV}č Kujawski and elsewhere in northern Europe (cf. Ottaway, 1973, Fig. 12), e.g. at sites on the Oder and the Bohemian part of the river Elbe, as well as in graves of the Bodrogkeresztúr culture. But the northern European examples are made mostly of flat copper ribbon (cf. Ottaway, 1973, PL. 31 a & b), whereas the Swiss ones are all mostly of rounded or oval 'wire' (PL. 25 & 26). One spectacle spiral, from Font in Switzerland (Fig. 86a) is made of such perfect round wire that it might be a forgery, because no true wire has been found in secure association in northern Europe or in our alpine area (cf. also Section 14, this Chapter). However, Schwab does not consider it to be a forgery, although circumstances under which it was found are somewhat obscure (personal communication; I would like to thank Dr. Schwab for her kind help and the drawing of this

interesting find). Other Swiss and lake Constance spectacle spirals are less carefully executed (Fig. 86b) as is one made of gold from Mörigen. In Austria, the only spectacle spirals - of much larger size and made of even, hexagonal wire (PL.27) come from Stollhof. There are six of them and they have been compared to those found at Malé Leváre (Spindler, 1971), although the latter's loop is different. It is bent over to form a hook.

The entire question of spectacle spirals will have to be reviewed again when more securely stratified examples are found. Nevertheless, a list (Appendix XV) and their distribution (Fig. 87) can be found in Vol. II.

III.9 PENDANTS

The next type - pendants - includes all those objects which were worn on a string. This is indicated either by a perforation or a turned-over end. One found at the settlement site of Altheim (Fig. 88a) is very similar to the copper sheets with turned-over ends from Preussnitz, belonging to the Baalberg culture (cf. Ottaway, 1973, Fig. 5). It is the only intact one of its kind known to me in the northern alpine region and might indicate contacts of the Altheim with its northern neighbours. Fragments of flat sheet copper have been found at Vinelz as well as 6 triangular pendants (Fig. 88 b-d). Unless one wants to make a rather far-fetched comparison to very similar pendants at Inowroclaw in Poland belonging to the late Lengyel period, one has to assume that this type is an independent development. Considering its simple shape I find it not so unlikely.

A very interesting shape of pendant comes from St. Blaise; and is a metal copy of an animal tooth (Fig. 88e) (Munro, 1890, Fig. 8,11,

12) mentions two of these pendants, but only one is left in the Neuchâtel museum). Another pendant, from Gemeindeberg, Vienna, is in the shape of a slim flat axe but the material used is a banded slate and is perforated in the centre.

A list (Appendix XVI) of these few pendants and their distribution (Fig. 87) can be found in Vol. II.

III.10 ÖSENHALSRINGE

The next type to be discussed is ingot torcs, commonly also called Ösenhalsring or Ösenhalsreif. They are a well known BA artifact and therefore, particular care was taken to include only those whose secure association was undisputed. Nine examples belong to the Austrian Baden culture, eight out of these nine come from burials. They are different from the well known Bronze Age torcs: they are smaller and thinner and, as will be discussed in Chapter IV, their impurity pattern is totally different from the very characteristic so-called Ösenhalsring-copper. Moreover, all the sites on which they were found (Fig. 89) are very close to each other so that we can be sure to have found the centre of a local development.

One from Baden-Königshöhle (Fig. 90a) was found in a settlement deposit in a cave together with 3 jugs with handles of typical Baden appearance, flint and other material, including the spiral which was mentioned previously (Ladenbauer-Orel, 1954; Kyrle, 1924).

One Ösenhalsring and a fragment of another (PL. 28) was found at Leobersdorf during the building of the water mains into Vienna in 1876. Two graves were accidentally uncovered; grave 1 was found to contain one crouched inhumation. At his foot were the skulls of 5 children. As grave goods a channeled jug, fragments of a further

four jugs, and 20 animal teeth, a flint arrowhead as well as the Ösenhalsring and the fragment were found. Unfortunately we do not know for certain the exact position of the Ösenhalsring on the body (Willvonseder, 1937a).

In 1933 a mass burial containing 8 skeletons (3 youths and 5 adults) was uncovered in Lichtenwörth. They were accompanied by 5 arrowheads of flint, and 2 shafthole axes of serpentine. Near 6 of the skulls, close to the neck, one Ösenhalsring each was found (Willvonseder, 1937a). Pittioni illustrated four of these still intact (1954, Fig. 137). However, in 1973 only three intact objects (Fig. 90b and PL. 29) were found in the museum at Asparn an der Zaya. The three intact examples are remarkably similar to each other as well as being similar to those from Baden-Königshöhle and Leobersdorf: they are made of round irregular 'wire' which has been flattened at both ends and then bent-over to form the hook - or Öse. One of the Lichtenwörth rings has split open near the end and reveals that they - like the pins and awls in Switzerland, had most probably also been rolled together from several strips of metal and then smoothed.

A similar, but smaller, Ösenring was found in the Denk collection at Wieselburg. It had been found in a grave with a crouched inhumation which had automatically been labelled 'Early Bronze Age', presumably because of the presence of this artifact. Unfortunately, no other circumstances of the Ösenring could be found.

Two Ösenhalsringe were found at Maxglan, but since this site contains EBA as well as Neolithic material we have to treat these finds with caution (Hell, 1952b; Hell, 1975), although as we shall see in Chapter IV metal analysis will be able to help us somewhat further here.

Seven Ösenhalsringe from the Mondsee which were supposed to be in the Museum in Vienna but were found to be missing in 1973 were analysed by the Stuttgart group (Junghans et al., 1968) and by Otto & Witter (1952). Their analyses suggest a different type of metal - they are made of the typical Ösenhaltring-metal - and they are of the typical later, heavier EBA type.

Nothing exactly like this early type is known in Switzerland and the only artifact approaching it is the so-called Ösenband of which two are known. One, from Concise (cf. Strahm, 1971a, Abb.35,2), is made of a flat ribbon of copper with bend-over ends. Strahm suggested that this is a Corded Ware imitation of coeval bronze 'diadems' which was first of all copied in bone then later, when metal was more easily obtainable, in metal (Strahm, 1971a, 156). The other is from the museum at Neuchâtel (Fig. 91a) but its exact location is unknown.

A few less circular crescent-shaped sheets of copper are known from northern Europe (cf. Ottaway, 1973, Fig. 12) and the Swiss Ösenband is really more like those than the Austrian early Ösenhalsringe.

As before a list (Appendix XVII a & b) and the distribution of Ösenringe and Ösenbänder (Fig. 89) will be found in Vol. II.

III.11 SICKLES

Of our next type - the sickle-knives - only one has a secure stratification. It was excavated by Beninger (1961) at the Paura on the river Traun, Austria. In field $\alpha 1$ and $\gamma 1$ a sickle and a fragment thereof, were excavated in layer M (Fig. 91b). This layer M is below a firm stone paving which separates the Bronze Age finds from late Neolithic and Neolithic (layer T) finds (Beninger, 1961, 55). Together with the first sickle in field $\alpha 1$ the following artifacts were found:

a triangular flint arrowhead, a bladelet of rock crystal, a copper fish hook, 2 spindle whorls with deeply incised decorations, and a serpentine axe. The other field in which a sickle was found, $\gamma 1$, again contained serpentine axe fragments, sherds decorated with deeply incised circular patterns, typical of the Mondsee group and 'a piece of crude metal' (Beninger, 1971, 73). (Several such pieces of crude metal are mentioned in Beninger, but they are not illustrated, nor, to my knowledge, analysed metallurgically.) It seems then that there is no doubt about the correctness of including sickles in the inventory of late Neolithic finds, and several others from Austria are listed in Appendix XVIII. All of them seem to have been cast in an open mould, but no metallurgical examination is available.

Those from Micheldorf (e.g. Fig. 91c) come from a limestone quarry where late Neolithic finds also occurred; and the Rainberg has already been mentioned as a likely candidate for late Neolithic settlement.

This distribution of these sickles (Fig. 89) shows it to be of local importance - another local development - which only became more wide-spread with the Bronze Age.

III.12 FISH HOOKS AND UNIDENTIFIABLE METAL PIECES

There now remains one securely associated artifact: a fish hook (Fig. 91d) from the Paura, Austria (Beninger, 1961). It was found together with the sickle just discussed. One would expect this type of artifact to be very numerous indeed on settlements near water, yet it is extremely rare. One fish-hook from Cortailod is mentioned in Munro's guide to lake-side settlement material (Munro, 1890, Fig. 10,2). Others are also illustrated (e.g. Fig. 32,13 and 19). None of these

could, however, be found in any of the museums visited, but they are listed (Appendix XIXa) and plotted on Fig. 89.

The only other securely associated copper objects found in the area of this study are pieces of metal, unidentifiable bits of sheet-copper, or fragments of objects whose shape is long lost. Sometimes, particularly from those four notorious sites - Langensteiner Wand, Mühlbachgraben, Rebensteiner Mauer and Sonnleichl, (cf. Chapter II, p.71) - we have only the excavators' remarks that '... a few unimportant metal objects...' had been found, and have to await a further publication patiently (personal communication, Reisinger). All these objects are - for completeness' sake - listed in Appendix XIXb and their distribution too can be found on the map (Fig. 89).

III.13 CRUCIBLES, (BUN) INGOTS

Having discussed all the artifacts which with some probability belong to the northern alpine earliest horizons of metal-using groups, we shall now turn our attention to some of the other evidence left behind of smithing and smelting activities. These are in the form of crucibles and similar containers of clay, and pieces of raw material or 'ingots'. The German terms are often confusing and not always correctly used. For instance Gusskuchen is a bun ingot but Schmelzgut can mean anything from a rough piece of metal to the typical early type of 'bun-ingot' which is just a lump of raw material usually with one semicircular and one flat surface (Fig. 92a). This is the form obtained when the copper melted out of the ore during smelting into a shallow pit of sand or similar material. As the discussion in the next Chapter will show these pieces of raw material can be quite pure or they can still contain quite a large amount of iron and other bits

of slag so that we are not always justified in calling them 'ingot'. Two other terms in German usage are Guslöffel and Gusstiegel. The latter is our crucible, the former is really also a crucible, but with a perforated handle into which a (wooden) rod was inserted to act as a convenient way of holding the hot container (PL. 30). This by implication means that the ordinary crucible was held by some sort of tongs - perhaps of green wood as used by the primitive smelters in Africa (personal communication, J. Brown) - whereas the handled version was better adapted to pouring the molten metal into some kind of mould and they do, in fact, sometimes have spouts. By implication the handled version is the later type, but we cannot be sure of this until Dr. Wyss publishes all of the 20 crucibles from Switzerland which he has in his collection. Further evidence of the smelting or melting activities on a site can sometimes be in the form of a droplet of metal, as for instance the one from the Mondsee (PL. 31).

The oldest material of this kind comes probably from the settlement at the Bisamberg, near Vienna. Unfortunately, the Bisamberg assemblage, which belongs to the Epi-Lengyel Complex (cf. Chapter II, p.83), has not yet produced any metal finds. There are, however, several fragments of a crucible (Ruttkey, 1976 and in press).

The Pfyn culture of Switzerland has - as mentioned above - quite a number of crucibles; 5 of them are securely associated and come from Wetzikon-Robenhausen, Niederwil Gachnang (cf. Waterbolk & Zeist, 1966), Zürich-Breitinger Strasse and two from Horgen (Drack, 1969, Abb. 8).

At Prücklermauer, Austria, a fragment of a crucible and a droplet of raw copper were found. At Paura, Beninger found at least 8 pieces of Schmelzgut (Beninger, 1961). The piece of metal from Altheim,

mentioned before, could also be some raw material. At any rate it is clear that melting if not smelting, that is local manufacture but not necessarily local smelting, was carried out at several sites belonging to our first and second horizons of alpine early metal work.

A list containing bun ingots, crucibles etc. will be found in Appendix XX a and b, and their distribution (Fig. 93) shows that all sites are close to the northern alpine edge.

III.14 DISCUSSION

We have now discussed all the metal artifacts in the northern alpine region for which securely stratified parallels within the area could be found. It was possible to group most of the objects, with a few notable exceptions: neither for arm rings, nor spiral arm rings could securely associated parallels within our area be found. I do not think that this is accidental; it means that we have come to the limits of the metal smith's ability in the late Neolithic period. This might at first sight seem rather astonishing, after all the smiths were capable of casting objects like flat axes, possibly starting in the Corded Ware period to cast flanged axes, daggers with and without midribs, knives, and possibly, again at the Corded Ware horizon, awls. Yet all these objects are more solid, shorter or less vulnerable than the length of 'wire', which would be required to manufacture a spiral armring. This 'wire' would undergo further stress and tension when being wound. The production of real wire has always been regarded as a difficult and late process (cf. discussion of this point in Ottaway, 1973) and although very primitive methods of wire-drawing are known (personal communication, J. Brown) they usually involve iron and not copper (Lindblom, 1939). The reason why 'wire' has always been used

in quotation marks in this study, is that the northern alpine area did not know the method of true wire-production, nor did most of the rest of northern Europe in Neolithic and late Neolithic periods know it. Areas where copper had a much longer tradition of being worked (cf. Chapter I) probably provided the few scattered single finds and hoards, such as those found at Stollhof (PL. 32) and Bygholm, all of which contain wire of round, half-round or oval cross-section. There are some spiral arm rings and ordinary arm rings which are made of flat copper ribbons, belonging to the Late Lengyel and the Salzmünde cultures of northern Europe (Ottaway, 1973, Fig. 11). It is possible that the spiral arm ring from Lichtenwörth (Fig. 92b) as well as rings from the Rainberg (Hell, 1943) do belong to our Neolithic horizon. The Lichtenwörth spiral ring, although coming from the same site as the Ösenhalssringe, was found in a different pit during gravel digging, i.e. it is a single find. It was not mentioned by Willvonseder (1933, 1937). In Hungary, these flat ribboned spiral arm rings occur in the Tiszapolgár culture and in Czechoslovakia, they are known in the Lažňany culture (Šiška, 1972, Fig. 34).

Foreign to our area, are also the bars with triangular cross-section which provided the material for the Burgäschisee-Süd beads. It is not surprising that no parallels for similar beads could be found - they are clearly a manifestation of a short-lived import.

Other artifacts for which no parallels with secure associations within our area exist are axes with a semicircular cross-section and double axes. With one exception the former are finds from unknown sites, in the museum in Vienna, which had - as so many other museums - bought from a wide circle of people and places. The axe from Spitz on the Danube (PL. 33) - is said to have come from a hoard (museum

catalogue) but all the other axes have disappeared. Three double axes are known from Switzerland, but neither in Austria nor in south Germany have any been found. None of the three Swiss examples were found in securely associated circumstances, although the one from Küssnacht (Fig. 94) was found as recently as 1970. Their function and distribution in central Europe - mainly on the Saale/Elbe and the Rhine - have been well discussed, and since they cannot be included in this study under the stringent pre-conditions laid down in Chapter III, (p.125) I shall refer the reader to Wyss' publication (1974).

At the end of this Chapter we have thus come to a realization of the remarkably broad variety of types which were in use during what is commonly called the 'Late Neolithic' period. We have been able to distinguish three copper-using horizons. Before these there are a few stray copper finds from the Münchshöfener and the Bisamberg-Oberpullendorf cultures of southern Germany and Austria, respectively. The types include awls, pieces of copper and crucible fragments. The first copper-using horizon is represented by copper finds from the Pfyn, the Cortaillod, the Retz, the Altheim and Mondsee cultures. Types in these cultures were flat axes, spirals, beads, knives, chisels, and crucibles. It was possible to increase the variety of finds belonging to the Mondsee culture by a very large extent after analysing the land settlement sites belonging to it. Thus the following types are known to be represented in the Mondsee-culture: flat daggers with rivets, knives, awls, fish hooks, sickles, pieces of metal and crucibles.

In the second copper-using horizon - represented by copper finds of the Lüscherz and the Horgen cultures - the amount of metal used

decreased and only pins, awls and knives are known. However, only a few years ago these two groups were thought to be 'metal-repelling'. This judgement has now been slightly altered but the fact remains that there is very little metal in our second horizon.

The third horizon is again very rich in metal types. Flat daggers and those with midribs, both rivetted, as well as beads, pendants, spiral cylinders, flat axes, spirals, Ösenringe and pieces of 'wire', other fragments and crucibles are known to belong to it.

It is very interesting to compare these three metal-using horizons of the northern alpine region with their neighbours. The horizon where the first scattered copper artifacts appear, finds its coeval eastern neighbours in the fully fledged Copper Age. The Ludanice culture of western Czechoslovakia has daggers; at the slightly earlier eastern Czech site at Vel'ké Raškovce heavy shafthole axes and massive rings were in use which is also true for the Hungarian Bodrogkeresztur culture, where smaller objects such as awls, knives, pins, beads were also made in copper.

South-eastern neighbours in Yugoslavia represented by the Lasinja group in Slovenia (N. Yugoslavia) do not seem to have used copper, although earlier further south-eastern groups (Vinča) in Yugoslavia did. But then the Lasinja group has only very recently been outlined (Leben, 1973) and it might still be too early to make positive statements about it. In the south the only coeval group which has any use of copper at all is the last phase of the Bocca Quadrata group; the Rivoli-Castelnovo site at Bocca Lorenza at which 3 trapezoidal axes were found (Barfield, 1971, 49).

Our first horizon, which is in every respect the richest of the

early groups, finds coeval neighbours such as the Lažňany group of Czechoslovakia using knives, daggers, arm rings made of broad ribbons with a midrib, flat axes and awls. The coeval western Hungarian Balaton II group has spirals, and is also smelting or at least melting its copper since a crucible has been found in this only recently defined culture. In the southern Po-valley - late Neolithic (Lagozza) culture several copper objects have been found at Attiggio, and a hoard of flat axes from Isolino might also belong to it (Barfield, 1971, 52).

To this horizon also belongs the Brjuni-Skocjan group around Trieste, which used copper in the form of flat axes and daggers. Further south-east, in Jugoslavia, there is as yet no group which would exactly correspond to our horizon.

Our second horizon is a highly interesting one; there is a general impoverishment in the use of copper. This is felt in Hungary, (in the Boleráz culture) as well as right across our alpine region into Switzerland; but it witnesses the first appearance of copper in France: the late Chasséan in the Rhône area is now beginning to use awls, blades and slag (Phillips, 1975, 125). The 'Chalcolithic' period of southern France begins.

The third horizon witnesses another change: the northern alpine region again begins to use a great deal of copper; Switzerland as much as in Austria. The eastern neighbours, during the period of the classical Baden culture, are still poorer in copper than our region. On the other hand, France and Italy, the former represented by the Saône-Rhône culture complex, the latter by the Remedello complex, are now fully copper-using cultures.

We have thus traced a complete reverse of a situation in which

cultures that were familiar with the use of metal and had obviously rich supplies of it at hand - note the heavy type of tools e.g. shafthole axes - gradually came to be without the metal. On the other hand, cultures who had been very slow and hesitant in taking up this new raw material made increasingly more use of it until a time arrived when they became independent of its original suppliers and produced their own supplies. This change-over can, of course, be explained in several terms, such as exhaustion of ore supply, or transfer of power to control the exploitation of the ore sources. But in view of the closeness of local alpine supplies which - as we now collect more and more evidence - the northern alpine population knew well how to exploit, the latter explanation is rather unlikely. The early copper users in the south east may have lost control over their supplies but not to the northern alpine region.

This change-over began to make itself felt at the end of the first and during the second horizon, which expressed in terms of uncorrected ^{14}C dates is around 2400 bc.

CHAPTER IV. METAL ANALYSIS OF THE EARLIEST NORTHERN SUB-ALPINE FINDSMETHODS

The next two chapters deal with the analysis of trace elements in the earliest copper finds. This Chapter describes the methods used on samples obtained from museums in Austria and Switzerland, whereas the next Chapter deals with the problem of grouping these and other available results in a meaningful way.

This Chapter has been divided into two main Sections, one on physico-chemical methods, and one on the techniques of classification and statistical treatment of the data that were used. Since basic criticisms, both of metal analysis and of statistical classification of the analyses, have been voiced from time to time, both Sections are prefaced by a short introduction. Neither of these is intended to be exhaustive, since this Thesis is not being submitted in the discipline either of metallurgy or statistics.

IV.1 PHYSICO-CHEMICAL METHODSi) INTRODUCTION

This Thesis is concerned with all the metal artifacts from a defined region and a limited time domain, and therefore has to deal with the artifacts that exist. I could not afford to be selective. This point is made because I had originally intended to use micro-graphical examination as an adjunct to my study, but was unsuccessful in obtaining funds to purchase a petrographical microscope. Examination of the crystal structure of metal artifacts can give valuable information about the manufacturing techniques used (Allen et al, 1970; Slater, 1972, 21), but attempts to distinguish metallographic features

that unambiguously identify objects made of native copper have failed to stand up to rigorous testing (cf. Maddin, 1978). In the event, to have put great emphasis (Coghlan, 1962) on this technique would have been useless, since only one of the museums I approached to take samples for analysis would have been ready to allow the surface of any object to be prepared for micrographical examination. Even permission to drill holes for sample material was only given after assurances as to the smallness of the sample, which is understandable since all the early artifacts are rare, and usually extremely fragile and thin (other than axes).

Thus the data which I have collected is of impurity patterns only. The impurities measured could have included sulphide, which in theory could give an indication of the type of ore used for making the raw copper (Tylecote, 1962, 27 ff).

The quantitative analysis of metal objects, particularly those based on copper, has a long history. It began about 1860, at first with the limited object of distinguishing bronze, brass and copper from one another by analyses of tin, zinc and later lead, but before the turn of the century a considerable corpus of analyses had been published. Early work, notably by Hampel, Helm, Montelius and Much, has been well reviewed by Otto & Witter (1952, 1 ff).

Analyses continued to accumulate throughout this century, but the rate of growth has increased enormously since the beginning of the systematic study of the composition of European copper and bronze objects by Junghans et al (1960, 1968, 1974), (hereafter also referred to as JSS) which at the beginning also included tables of data published by Otto & Witter (1952), of Coghlan and Case (1957), of Briard and Maréchal (1958) and Novotná (1955b).

The number of multi-element analyses of copper and bronze objects extant must now be of the order of 40,000 (probably more, if the multitude of unpublished Russian analyses were to be included). It is therefore rather startling to read, as recently as 1975, that '... while thousands of analyses of archaeological bronzes have been reported in the literature, the basis for comparing them, especially those from different laboratories, is shaky' (Chase, 1975, 148). The underlying causes of these doubts seem to me to be three, and I propose to discuss them in order.

ii) THE SENSITIVITY OF THE ANALYSIS

It is only to be expected that the lower limits of detection for the various elements have been lowered during the century in which archaeological metal analysis has been in existence, sometimes perhaps by 100-fold. The spark spectrograph uses an image of a spectrum on a photographic plate as the basis for measurement. When the existence of a spectral line can be detected, but is too faint to be quantitatively compared with the standard, most authors use a qualitative symbol: JSS actually use seven symbols - 'less than' (<), much less than (<<), trace (Spur), ++ and +, more than (>) and much more than (>>). Although it is troublesome to convert these and other symbols into reasonable quantitative equivalents (cf. Appendix XXIII), the objection that lower limits are not concordant is not, in the present work, a serious one. The lower limit stated in the earlier work of Otto and Witter (1952) was, for several elements, lower than that of JSS, and more like my own, while JSS have re-determined arsenic, antimony and bismuth (for samples 1-10,040) by more sensitive techniques and published them as an Addendum to Volume 2,4 (1974). The differences in the lower limits between the three sets of analyses is therefore not

great.

The more important reason for thinking this objection a minor one is the very wide range of analytical values encountered; for example for cobalt, values range from 0.0002% (my analyses, Appendix XXI) to 'much greater than 0.5%' (cf. Gemeinleborn coppers, in JSS). In consequence, whether an analysis is 0.0002%, or 0.002%, it still means that the element in question is present only as a tiny trace of impurity. Furthermore, the raw data is normalized before cluster analysis as is discussed in section 2.iv of this Chapter. One would only need to worry seriously if one were trying to use earlier analyses which consistently showed an indicative element to be absent when it was, in fact, present in traces.

iii) REPRODUCIBILITY OF THE ANALYSES

This question has two facets: the index of precision for a single laboratory - that is, the likely range within which an estimate of a single sample would be likely to fall if it were repeated - and the consistency between analyses of the same sample made by different laboratories.

I was not well placed to form an estimate of the index of precision for most of my own analyses, because the method used was neutron activation analysis, and there was no way of getting replicate analyses done, although each estimate is already the mean of a number of intensity peaks of that element (see below). The reproducibility of estimates of standard solutions by atomic absorption spectroscopy was in general, very good, perhaps $\pm 10\%$, but I was more interested in the consistency between estimates made by different methods on the same sample, and this is discussed in Section 1.x of this Chapter.

Other laboratories have hardly been more forthcoming about their index of precision. A range of 8-16% as the mean percentage error for the five elements used by JSS for classification purposes is quoted by Junghans, Klein & Scheufele (1954, Table 2 & 3). No other statement has been made in later publications from this laboratory, to my knowledge.

When Chase made the remark quoted above, he had in mind chiefly the lack of agreement between estimates of the same element in the same sample, made by different laboratories specializing in metal analysis, which led him to set up the 'Comparative Analysis of Archaeological Bronzes Programme' to improve the inter-laboratory consistency. It should be remarked that poor consistency between results from different laboratories is a general phenomenon in chemical analysis. When accuracy is a matter of life and death, as in clinical chemistry, quality control may be established by sending unknown samples every month to hundreds of laboratories all around the world.

Comparison of my own results with the inter-laboratory standards is dealt with in Section 1.xi of this Chapter.

iv) INHOMOGENEITY OF THE ARTIFACTS

This is probably the source of error in metal analysis that has caused most discussion among archaeologists. For reasons which are fairly obvious, but described more fully in Section 1.v of this Chapter, it is rarely possible to take more than one sample from an artifact. Unless the composition of the copper is absolutely uniform throughout, the result given from analysis of a second sample would not be identical with the first. How, then, can the results from a single sample be relied upon as an indicator of the composition of an artifact?

It seems that no one has ever thought this problem through to its logical conclusion. I have deliberately avoided using the word 'error' in the previous paragraph. If the artifact is genuinely inhomogeneous, then both sets of analyses might be correct for their local region of the artifact, but neither would be 'correct' for the object as a whole. How many samples would one have to take to get an average that was 'correct', or is the only satisfactory procedure to reduce the whole artifact to fine turnings, mix these to ensure homogeneity, and analyse samples of this mixture?

There are good reasons for expecting some inhomogeneity in copper artifacts of any size. These reasons range from segregation of bismuth and lead, which have a very limited solubility in copper (Slater and Charles 1970), to differential solidification, i.e. micro- or macrosegregation during cooling (Richards & Blin-Stoyle, 1961 ; Charles, 1973), mechanical displacement or squeezing out of a lower melting point phase during hot working (Slater, 1972 , Charles, 1973), and enrichment - or depletion - of surface layers, whether due to leaching (Hall, 1961) or inverse segregation (Werner, 1970; Charles, 1973). Quantitative figures are hard to come by, but Richards and Blyn Stoyle reported differences of 10% for several elements between butt and tip of an Irish axe. Charles (1973, Fig. 7) found enrichment of about 6% in tin in the surface layers of a chill-cast slab with an average tin content of 5.09%.

In the following argument I shall try to prove that the element of error due to causes outlined in Sections iii and iv, although real, is not a cause for alarm. Let us suppose that we have 30 artifacts (say axes) coming in equal numbers from each of three sites, and that we are trying to establish whether the axes differ from site to site

on the basis of an analysis of one element only (say nickel). The best way to proceed would be to use a statistical technique known as the One-Way Analysis of Variance.

To do this one would first calculate the mean nickel content of all the axes, and then the sum of the squares of all the deviations of the individual analyses from this mean. This sum of squares is then divided, by algebra that need not concern us here (see Colquhoun, 1971, 182) into a component assigned to the variation between the three groups of axes, and one assigned to the variation within each group. The significance of the differences between the groups would be estimated by dividing the mean sum of squares for between groups, by the mean sum of squares for within groups. The ratio ought to be about four for significance.

It is the word mean that is important here. The mean is calculated by dividing each component of the total sum of squares by the degrees of freedom (cf. Section 2.vii of this Chapter). For between groups the number is $(3-1) = 2$, but within groups (between axes) it is $(10-1) = 9$. Thus the total sum of squares could be partitioned into two components of equal size, and the difference between groups would still be significant.

Further the component assigned to 'between axes' can obviously in principle be broken down into sub-components related to experimental error (including non-comparability between laboratories), inhomogeneity of each axe, and real differences between the composition of each axe within one group. Of these three, the last would be expected to be by far the largest, because until the EBA, it is unlikely that objects which have been retrieved and analysed come from anything but small-scale smelting operations. All those who have analysed the composition

of ore samples even from a single vein have commented on the large variability in their composition (Pittioni 1957, 1959, 1971). Pittioni indeed was so impressed by this that he refused to express the results of his analysis in quantitative terms, which unfortunately makes it impossible to compare his results with anyone else's. This difference in ore composition must undoubtedly be reflected in the composition of individual artifacts. For the present purpose the point to be taken is that, because one is not assigning individual objects, even quite large variations in comparability between laboratories, and inhomogeneity of artifacts, are likely to make up only a small fraction of the 'within groups' sum of squares. Providing the number of groups is not too great, and the number of objects within each group is quite large, we need not fear that errors due to causes listed under iii. and iv. will give rise to a failure to classify objects into separate groups - what statisticians call 'an error of the first kind'. Of course, one should take every care that errors due to causes ii. indicated under iii. and iv. are minimized wherever possible.

What statisticians call 'an error of the second kind' is misclassification into a wrong group. This could happen if one were using a limit value of a single element as a guide to classification. This is the basis of the criticisms that have been levelled at the classification used by JSS, but here I am on safer ground, because the method of classification that I used makes simultaneous use of all 11 elements that were analysed. It was my experience that even when one or two important elements were left out of the classification (i.e. were masked), the groupings usually did not change significantly. Moreover, in the first analyses of the data that I collected, I used the original values quoted by Junghans et al (1960, 1968), whereas

those which are now in this Thesis have been corrected by reference to the supplement (Junghans et al, 1974, p.362-382), already referred to. The corrections are in many cases substantial, but I have been astonished to find how little the classification has been affected. Thus one may say that providing a sufficient number of objects is being studied, and providing the analyses are being used for a suitable purpose, errors perhaps inherent in any large-scale analytical investigation need not deter us from making use of the results. The question 'what is a suitable purpose?' needs a brief discussion.

Doran and Hodson (1975, 251) wrote ...'It should be possible to distinguish clusters that represent common, natural and widely distributed combinations of elements from those that have at least some regional significance. Within the latter it might then be possible to distinguish highly distinctive workshop clusters from more general ore-clusters that reflect no more than well-known major ore-types...'. This quotation puts forward a hierarchy of significance levels for groupings based on metal analysis, but two major, and different, aims stand out clearly: to obtain clusters (or groups) that have 'some regional significance' for their own sake, and the relationship of copper objects to ore-types. The latter aim has been frequently stated as a major aim for metal analysis, but it has on the whole been tacitly abandoned for the present, since many more years of research are needed. In particular the ore analysis programme still has to be widened (Tylecote 1970), and the monumental survey being prepared at the moment by Rapp at the University of Minnesota (1977) should be an important step in this direction. Other workers are studying the behaviour of various elements during experimental smelting and are thus providing valuable information. For instance, Tylecote

& Boydell (1978) have found that recovery of silver during smelting is 100% and that of nickel nearly so, i.e. silver and nickel are copper-related, whereas manganese and cobalt, for instance, are iron-related. It is to be hoped that more studies of this kind are forthcoming.

It has been shown that relationships between ore and artifact can be achieved; Coghlan: (1958, Coghlan et al, 1963) related Irish halberds to ores analysed by Biek (1957). There will, however, always be serious drawbacks, because there are considerable variations of composition within an ore body and thus within the artifacts, as pointed out earlier, and also because there is the strong possibility that prehistoric metal was often obtained from sources which are now exhausted. In order to distinguish the output of a workshop, on the other hand, one might well have to concentrate on a particular type of artifact. In an earlier study of ornaments (Ottaway, 1973), I was in fact able by using the methods of manufacture - ranging from simple sheet-copper pendants to spectacle spirals made of 'wire', in conjunction with impurity patterns - to establish cluster types which are of general usefulness, at least in Denmark (Randsborg, 1978). The present study, however, is concerned with all artifacts; the only simple distinguishing mark of a workshop (if physical examination is ruled out) would seem to be a characteristic alloy. This is easier to establish for tin-bronzes than for coppers. The rather widespread use of lead in bronzes in western Switzerland, which is not characteristic in EBA bronzes of Austria (e.g. Gemeinlebarn cemetery) is one such example. The possibility that arsenic was used for alloying during the time studied here, is a complex matter which will be discussed in detail in the next Chapter.

v) PREPARATION OF SAMPLES

Having thus established that analysis of metal artifacts is still a very useful approach to certain problems concerning early metallurgy, I found that several of the important early Austrian and Swiss metal finds had not been analysed. I therefore undertook the task of analysing these, since the Stuttgart team has stopped its programme of analyses. Over 100 artifacts were sampled and several Bronze Age objects were included, partly because the typological/chronological study of Chapter III had not then been carried out, and partly because a few museums wanted to have as many artifacts analysed as possible.

The main methods used for analysis were neutron activation and atomic absorption spectroscopy. Neither of these methods are new in themselves, but they have here been used for the first time for such a wide range of elements and on such small samples, and this necessitated several alterations in the commonly used methods (Shaw and Ottaway, 1974; Chase, 1975; Hughes et al., 1976). Copper was analysed by a method developed by Felsenfeld (1960). On some of the samples Sn and Zn were analysed both by neutron activation and atomic absorption spectroscopy. In about 25% of the samples Sn was measured by a recently developed method using catechol violet (Corbin, 1973). All these methods are described in Sections vi-ix below. Inter-laboratory comparisons as well as measurements of standards are also outlined.

All samples were in the form of fine powder and had been obtained by drillings taken from prehistoric copper or copper-based artifacts. For this purpose, a portable dental drill with high-grade, nickel-free

drills was used. The purity of the drills was examined by passing samples over a magnet and comparing the result with samples which had not been passed over a magnet. Before the drilling was started the corroded surface was removed on a small area with special attachment to the drill. The drilling was then carried out to a reasonable depth which depended on the size of the object. In this way the samples were, if at all possible, free from corrosion products and possible surface enrichments (Werner, 1970). The drillings were collected on clean filter paper and transferred into tared polypropylene microcentrifuge tubes, with attached lids (purchased from Sarstedt). These lids were covered by zinc-oxide plaster and the tubes then labelled. Permission to sample the artifacts was sometimes only obtained when assurance was given that a hole of not more than 1 mm in diameter would be drilled and that only one side would be 'defaced'. This is sometimes quite difficult since many of the earlier finds are small, very thin and fragile. On other occasions there was no such restriction on sample size and it would have been desirable to have had a stronger drill.

The samples were weighed and then subjected to neutron activation analysis (Section vi). After sufficient time had elapsed for the radioactivity to reach an acceptably low level - this time depends mainly on the activity of copper and antimony, and was usually 4 to 6 months - the samples were dissolved in a solution of 4 M fluoroboric acid and 3 N lead-free nitric acid (1:1, V/V) (Hwang and Sandonato, 1970). This mixture was found to dissolve 60 mg/ml copper or bronze readily and hold it in solution indefinitely. Above 15% Sn,

however, a small volume of concentrated hydrochloric acid had to be added to redissolve the metastannate. The samples were kept in the polypropylene tubes mentioned above which have the added advantage that they are not attacked by hydrofluoric acid, which attacks glass. Moreover, unlike glass, polypropylene hardly adsorbs metal ions (Struempfer, 1973). It is also convenient to weigh the samples into polypropylene centrifuge tubes, because the powdered sample concentrates at the point of the tube, which does not contain impurities. Milar containers, which were used at East Kilbride, were found to contain 214 ppm (0.214 mg/g) Sb. It is also important that the plastic containers should survive exposure to high temperature because temperature in the neutron flux apparatus is about 100°C (Gilmore, personal communication). Polypropylene survives exposure to 130°C. Most tubes survived the exposure to high temperature in the neutron flux but some became brittle, and it was necessary to put the samples into new polypropylene containers after irradiation, and before atomic absorption analysis. Re-weighing then resulted in a slight loss of sample.

The dissolution of the samples was aided by an automatic test tube shaker and after complete solution part of the sample was diluted, mostly 1:1000 times, and was then ready for atomic absorption spectroscopy.

vi) NEUTRON ACTIVATION ANALYSIS

In neutron activation analysis the weight of the required element in a sample is determined by measuring the intensity of induced radioactivity. This intensity is directly proportional to the weight of the required element and is independent of its state of chemical

combination. Most elements can be converted into artificially radioactive isotopes by appropriate neutron bombardment or 'activation'. The process of neutron bombardment of a weighed sample, normally together with a standard, followed by measurement of the intensity of the induced radiation, constitutes neutron activation analysis. The mass of the required constituent, Y, in the sample is finally calculated by the equation:

$$\text{Mass of Y in sample} = \text{mass of Y in standard} \times \frac{R_Y \text{ sample}}{R_Y \text{ standard}}$$

where R = Radiation intensity (Jenkins & Smales, 1956).

Optimisation of a multi-element neutron activation analysis involves a compromise between the conflicting requirements of the various isotopes produced. The problem is even more severe when, as in my case, the sample matrix itself is activated. Table 3 shows some of the typical impurities contained in copper, as well as the tin and copper itself, all with their radioactive isotopes and their half-lives. The effect of activation of the sample matrix is to raise the lower limit of measurement of the minor activities in the sample. Sensitivities of detection of all elements can be improved by increasing the neutron flux of the irradiation, but this is ultimately limited by the reactor facilities available. The optimum irradiation and decay times will be different for each isotope, depending upon their respective half-lives and the half-lives of the matrix activities, but in practice the irradiation time is limited by the high ^{64}Cu and ^{66}Cu activity produced by the copper matrix. Ideally, an irradiation time of less than two minutes should be used if short-life trace isotopes are to be measured, but longer irradiations are necessary to determine longer-lived

TABLE 3

ELEMENT	ISOTOPE(S)	ENERGY	INTENSITY OF PEAK	HALF-LIFE				
				YEARS	DAYS	HOURS	MINS.	
Fe	^{59}Fe	1099.27	5600	45				
		1291.58	4400					
Co	^{60}Co	1173.23	9988	5.2				
		1332.48	10000					
Cu	^{64}Cu	1345.50 β^+511	10000			12.8		
Zn	^{65}Zn	1115.51	50000	243.8			13.9	
		438.7	10000					
As	^{76}As	55.1	10000				26.5	
		657.04	1500					
		1216.25	1000					
Ag	$^{110\text{m}}\text{Ag}$	657.6	10000	253				
		884.5	7400					
In	$^{113\text{m}}\text{In}$	391.7	65400				99.99	
		417.0	3000					
	$^{116\text{m}}\text{In}$	1097.1 1293.4	5300 8000					54
Sn	$^{113}\text{Sn}/^{113\text{m}}\text{In}$	391.688	60000	115				
		^{117}Sn	158.4	83000	14			
		^{123}Sn	160.2	10000			42	
		^{125}Sn	1070	10000	9.4			
		$^{125\text{m}}\text{Sn}$	331.7	10000				9.7
Sb	^{122}Sb	564.0	66300	2.8				
		692.5	3300					
	^{124}Sb	602.7	10000	603				
		1691.0	5100					
Au	^{198}Au	411.8	99000	2.7				
		675.88	1000					
		1087.68	200					

Typical impurities which can occur in copper with their isotopes, energy (KeV), intensity of peaks (where the intensity is the number of γ rays emitted per 10,000 disintegrations) and half-lives.

isotopes adequately. In this case, a delay of 4-5 days is needed to allow the ^{64}Cu matrix activity to decay sufficiently to prevent overloading the detector.

In recent times the value of epithermal neutron activation as a means of improving selectivity in instrumental neutron activation analysis has been realized (Gilmore, 1976). Unfortunately, the research reactor centre at East Kilbride, Glasgow, where most of my neutron activation analyses were carried out, has not yet adopted this improvement. Thus, when planning analyses, certain practical considerations had to be taken into account. They involved availability of the irradiation facilities and of time to use the high resolution gamma spectrometer necessary for instrumental activation analysis.

The determination of relevant elements had to be considered in the light of these factors, and the conditions were as follows:
Irradiation: 6 hours in a high-flux mixed neutron spectrum. Decay period: 3-5 days; Count period: 10 minutes. The elements so determined were As, Sb, Au and Sn. After a long decay period of 1-3 months, the sample was counted again for 60 minutes and the elements determined in this count were Ag, Co, Zn and again Sn and Sb. The long decay period allowed the radioactivity of the copper to decay, but any trace of the short lived isotopes had vanished. Peaks belonging to ^{76}As , ^{198}Au , or ^{122}Sb cannot be expected, but peaks belonging to the isotopes ^{124}Sb , $^{110\text{m}}\text{Ag}$, ^{60}Co , ^{65}Zn and ^{113}Sn may be identified more clearly. Figure 95 shows the γ -spectra of a 10 mg sample after short (a) and after long (b) decay.

The amount of the trace elements in the sample is calculated

from the ratios of the peak areas to those of the standard. The latter is always irradiated along with the sample so that conditions are exactly comparable. At first all 8 elements were included in one standard, but it was found that the identification of all the peaks in the trace from one standard is rather difficult. Two standards were used instead, one containing Au, Sb and Fe; the other As, Sn, Ag, Co and Zn. Identification was also aided by including a radium calibration count, because under the particular conditions at East Kilbride Reactor Centre, the multichannel analyser was used by several people for different projects and the setting of the analyser was therefore changed frequently. The peaks shown in Fig. 95 are the visual output, the actual counts were punched on paper tapes. These tapes were brought to Edinburgh, where I transferred them to the computer. There were a total of 228 tapes each with 2000 channels on it. Several computer programs were written for peak search, calculation of peak areas, subtraction of background, decay period and correction factors. Most of these programs were written by J.H. Ottaway and I would like to express my deep gratitude for his help here. Without these purpose-built programs the evaluation of the data would have taken up an unreasonable amount of time. I had hoped that the computer-aided evaluation, which is well established at Manchester where I had first studied the method, would be implemented at East Kilbridge, but this did not happen.

The elements measured by me are shown in Table 4, where a) shows the elements estimated after a short decay period and b) those estimated after long decay periods. For elements such as Sb and Sn, where peaks after short and long decay periods may both be used, the result is the mean of all measurements.

TABLE 4a: ELEMENTS USED FOR COUNTS AFTER SHORT DECAY PERIOD

ELEMENTS	GOOD PEAK (KeV)	MEDIOCRE PEAK (KeV)	COMMENTS
^{65}Zn	-	1115	-
^{76}As	559	657	Interference from $^{110\text{m}}\text{Ag}$ /peak at 657 KeV.
$^{110\text{m}}\text{Ag}$	884	(937)	Interference from ^{76}As peak at 657 KeV.
$^{117\text{m}}\text{Sn}$	-	158	Interference from copper matrix.
^{124}Sb	603	1691 (723)	-
^{198}Au	676 412	1087	-

TABLE 4b: ELEMENTS USED FOR COUNTS AFTER LONG DECAY PERIOD

ELEMENTS	GOOD PEAK (KeV)	MEDIOCRE PEAK (KeV)
^{60}Co	1173 1332	-
^{65}Zn	1115	-
$^{110\text{m}}\text{Ag}$	885	(1504) (1384)
^{113}Sn	-	391
^{124}Sb	603 1691	(1436) (1367) (713) (706)

Figures in parenthesis were used only for identification, not for counts.

vii) ATOMIC ABSORPTION SPECTROSCOPY

The elements Pb, Bi and Ni cannot be determined by neutron activation analysis, and determination of Fe may not always be feasible, depending on the conditions and instruments available. All these elements can be estimated by atomic absorption spectroscopy.

In atomic absorption, atoms of the element to be measured are caused to emit light (nowadays a hollow cathode lamp is used). This incident beam is passed through an air space containing atoms of the element. These atoms absorb light of the characteristic wavelength of the incident beam and in so doing reduce its intensity, but no other element will absorb light of precisely this wavelength. Therefore the element in question can be measured in the presence of any other element, and the method is absolutely specific, although there can be matrix effects (see below).

The intensity of the light source, measured with a photomultiplier, is set at some arbitrary point on a scale. The diminution in intensity caused by the presence of atoms of the element in the sample space can be measured for various concentrations of the element, and from this a calibration curve can be drawn, which enables the concentration of the element in samples of unknown composition to be estimated.

The only technical difficulty in the method is to get the sample vaporized, so that the atoms of the element are not in chemical combination. If they are, excitation by the incident beam will not take place, and the method does not work. Originally a solution of the sample was sucked into a gas flame by a Venturi tube, but in the last few years it has been found that greater sensitivity can be

obtained if the sample is vaporized by being placed in a depression in a graphite rod or block, which is heated to a white heat for a second or two by a large electric current passed through it. This is the so-called 'graphite furnace' or 'flameless atomization'. With the use of this device, concentrations as low as 10 nanograms/ml (0.01 ppm or 0.00001 mg/ml) can be estimated, and the sample volumes can be as low as 5 μ l. I was fortunate that such an apparatus is in the possession of the Biochemistry Department of Edinburgh University, and I was enabled to use it through the kindness of Professors Fisher and Boyd, during the Christmas vacation 1975-76. Furthermore, the Chemistry Department of Strathclyde University is a recognized centre for the development of atomic absorption analysis, and I was able to spend several days there learning techniques at the kind invitation of Dr. John Ottaway.

Although the technique is simple in principle, attention to detail is important. The precautions to be observed will only be briefly mentioned here. The graphite rod must be surrounded by a stream of nitrogen gas, to prevent it burning when the current is passed through. A rigid schedule of waiting for the rod to cool down must be observed between each analysis. Even so, each rod only lasts for 60-100 vaporizations. Each new rod, which is fragile and easily broken, must be accurately positioned in the incident light path, and 'purged' of contaminating salts before it is ready for use. The optimum temperature and duration of the vaporization flash have to be worked out empirically for each element, and although these conditions usually hold for all the rods in a batch, they tend to vary from batch to batch. Nevertheless it was found to be possible to measure the concentration of one element in about 20 samples, in duplicate,

together with the intercalated standards and blanks (bidistilled water) in a working day.

There are also certain difficulties that arise from the nature of the sample. Copper itself readily dissolves in dilute nitric acid, but many impurities, particularly tin, do not, and the standard solvent for bronze is aqua regia. However, the halides of many metals vaporize only at very high temperatures, and even then the atoms of the salt may not be dissociated in the vapour phase. Thus it is best to avoid hydrochloric acid whenever possible. This was achieved by the use of the solvent described in Section iv.2. Another problem is that at the very low concentrations used, the ions readily precipitate or are adsorbed on the walls of the container in which they are stored. Glass is particularly bad in this respect, and all containers used both for standards and samples were made of polythene. Although there is a finite adsorbance of some metals (notably Pb) on this material (Struempfer, 1973) it is very much better than glass.

The most serious difficulty, however, is the 'matrix effect' referred to above. While atoms vaporized from a standard solution may stay isolated for some time, or at worst recombine with the counter-ions of the salt from which the solution was made, an unknown solution will probably contain a high concentration of another element - copper, in the case of bronzes, or iron in the case of steels. The atoms of this base or matrix element have a great tendency to form lattices, or in some cases chemical compounds, with the element to be measured. This is to be expected, since the latter was at least in solid solution in the matrix before the sample was vaporized. The 'matrix effect' varies not only with the element being measured but also with

the proportionate relationship between it and the main component of the metal. This can be seen in Fig. 96, where Ni in concentrations between one and five $\mu\text{g/ml}$ (Fig. 96a) and between 0.1 and 0.5 $\mu\text{g/ml}$ (Fig. 96b) was measured at varying concentrations of copper. No general relationship can be found from these graphs, and this is also true for the other four elements measured by atomic absorption spectroscopy. For the best results, a series of standards ought to be made up for each sample, each standard containing the same concentration of copper that there is in the sample solution. This would have been altogether too time-consuming, and in practice, three or four sets of standards, each containing differing concentrations of copper, were run for each element. An empirical algebraic relationship between the inhibition of absorption and the copper concentration was found by manipulation of the calibration graphs, and this was used for evaluation of the data.

It may be mentioned that the Absorption Spectrometer manufactured by Perkin-Elmer has a different design of graphite furnace with a larger block. In this apparatus the atoms of the sample remain separate within the vapour phase for several seconds, and the matrix effect does not occur. As against this, the sample volume has to be greater (50 μl). Nevertheless, if this work were being undertaken again, I would make every attempt to get the use of a Perkin-Elmer apparatus.

viii) DETERMINATION OF COPPER

Copper was determined by a method developed by Felsenfeld (1960). For this method test tubes had to be cleaned consecutively in hydrochloric acid, EDTA-solution and distilled water. To 20 μl of the

sample and 2 ml water were added 50 μ l hydroxylammoniumchloride solution (5% weight per volume) and the solutions were gently mixed. 2 ml of 2'2'-biquinoline in glacial acetic acid (50 mg 2'2'-biquinoline in 100 ml glacial acetic acid) was added from a burette and the solution was shaken vigorously. It was then put into a waterbath at 30°C for 10 minutes. After leaving overnight, the depth of colour was read in a photometer at a wavelength of 545 nm against a reagent blank. A series of standard solutions, containing 4,8,12,16 and 20 μ g/ml of copper, was treated in the same way, and gave a perfectly straight calibration curve (Fig. 97) from which the readings of the samples were evaluated.

ix) DETERMINATION OF TIN

Tin was determined by neutron activation analysis (cf. Section 1, vi) and in some of the samples also by atomic absorption with a Perkin Elmer apparatus (cf. Section 1, x). However, some of the results were so high that it was thought wise to check the results by yet another method. For this purpose a recently developed colorimetric method which uses the pH indicator pyrocatechol violet was employed (Corbin, 1973). The method depends on the colour change (from blue to red) which takes place when Sn^{4+} complexes with the indicator. The concentration of the sulphuric/citric acid mixture necessary to prevent precipitation of metastannate, and to keep the pH constant, has to be carefully watched. Moreover, it is possible to use up almost all the indicator in the reagent mixture by adding too much Sn^{4+} , and the curve relating Sn to absorbance will then no longer be linear. However, by careful choice of catechol violet concentration it is possible to find a range in which the calibration curve is perfectly

linear (Fig. 98). The reproducibility is good, and the analysis itself is very simple. The absence of interference from Cu^{2+} in the sample, even in concentrations 1000 times those of Sn^{4+} , was checked by direct experiment. Fig. 99 shows that the results obtained by the catechol violet method (CV) and by neutron activation (NAA) show very good correlation. The scatter around the lower part of the graph is not as serious as it looks, since this is a double logarithmic scale, and the absolute deviations are not great.

x) SOME COMPARISONS OF RESULTS OBTAINED BY ATOMIC ABSORPTION AND NEUTRON ACTIVATION ANALYSIS

Figure 99 also shows, that the results obtained by atomic absorption, for tin, represented by open squares (AA) are in good agreement with both the methods mentioned in the previous Section. It is clear therefore, that the high Sn values obtained in some samples - sometimes as high as 34% Sn - are correct.

As mentioned earlier (Section 1, vii), I was able to use a Perkin Elmer apparatus to carry out atomic absorption spectroscopy in Glasgow. This was done to check results obtained on an EEL apparatus where the 'matrix effect' was very marked. Preparation and dilution of the samples was exactly the same as for the atomic absorption measurements outlined earlier and the only difference is the sample size of 50 μl . Besides Sn (Fig. 99) a few of the Ni, Bi and Zn results were checked and found to be in generally good agreement with previous estimations (cf. Fig. 100 for Zn).

xi) COMPARISON WITH 'WASHINGTON STANDARDS' AND WITH STUTTGART ANALYSES

To check my own results, I included the 'Washington Standards' in my analytical programme. These are the basis for a comparative analysis

programme instigated by Gettens in 1965 and supervised by Chase (1975). For this purpose two ancient bronze objects of different composition have been taken, half of each object has been reduced to homogeneous filings and samples drawn from these filings have been circulated to various laboratories which have routinely analysed archaeological bronzes or who have wanted to participate in the programme.

The results have been tabulated and reported (Chase, 1975). The goal was to test the comparability of the results from each laboratory using its usual method under routine conditions. (I would like to thank Dr. Carriveau, Metropolitan Museum of Art, New York, for pointing out the existence of this project to me, and Dr. Chase, Smithsonian Institution, Washington, for sending me samples, internal reports and offprints.) A third sample which was included in the Chase project was from the National Bureau of Standards, Washington (NBS). Figs. 101 and 102 give an indication of the large standard deviation of these interlaboratory comparisons (blank bars represent results published by Chase, diagonally hatched bars are my results from neutron activation analysis and squares those from atomic absorption analysis). They show that my results lie comfortably within this standard deviation on the whole, although antimony values are somewhat low and nickel values slightly high. For atomic absorption results only two values were available and therefore no standard deviation could be calculated.

Direct comparison was also achieved by including 5 samples of bronze objects which had previously been analysed by the Stuttgart team. These samples were obtained from the Museum at Elgin, Scotland. Fig. 103 shows that the correlation between analyses from Stuttgart and my own is very good, and integration of the two sets of results is therefore possible.

IV.2 CLASSIFICATION AND STATISTICAL TREATMENT OF THE DATAi) INTRODUCTION

Having outlined the methods by which the analytical results were obtained, and checked that comparison of my own results with those of other laboratories is possible, this section deals with the treatment of the data so obtained. The raw data of my own analyses can be found in Appendix XXI, the combined data in Appendices XXIV and XXV.

About 60% of all the metal objects associated to late Neolithic cultures in Austria or Switzerland or included on typological grounds (cf. Chapter III) have been analysed, either by the Stuttgart team (Junghans et al., 1960, 1968, 1974) by Otto and Witter (1952), by myself (cf. Appendix XXI) or (in one instance) by Angeli (1953). The analysed objects are broadly representative of the whole, although ornaments, apart from beads, are under-represented. For instance of a total of about 400 tools, 240 were analysed; of the total of just over 300 ornaments, about 150 were analysed, although 90 of these were beads. The associations within these analysed artifacts, purely in terms of their chemical components, were explored by a statistical technique that must be briefly discussed.

There is no doubt that much information can be picked out by the eye of an experienced metallurgist, without sophisticated mathematical techniques, as can be seen very clearly in the 'Handbuch der ältesten vorgeschichtlichen Metallurgie in Mitteleuropa' (Otto and Witter, 1952). It is unfortunately not possible that many archaeologists should be experienced practical metallurgists and it is also true that few metallurgists have a really sound archaeological background.

For the rest of us, a method of grouping which does not rely on subjective judgement is highly desirable.

Three statistical techniques have been used within the last 15 years to detect groups in collections of analytical data. The first is the statistical frequency analysis developed by Klein (Junghans, Klein & Scheufele, 1954) in which an object is assigned to a group on the basis of whether an analytical result is larger or smaller than a particular value for a single element.

This division was based on Klein's observation, originally on 400 analyses, that the frequency distributions within four basic groups (A-D) were normal. He checked this by plotting the frequencies against the concentrations of the 'most important elements' (Ag, Ni, Sn, As, Sb, Bi and Pb), on log/log paper, on which normality appears as a straight line (cf. Section 2, viii). Deviation from a straight line was taken as evidence that a sub-division within the group was necessary (e.g. group D was sub-divided into one with low and one with high Sn contents). After each of the groups contained only normally distributed (Gaussian) components, checked by the graphical method, a Table with the border values of each element in each of the groups was constructed (cf. Table 4, Klein, 1954). This led to the now famous Stammbaum in Junghans et al (1960, 210).

The method has been severely criticised (Butler and van der Waals, 1964, Waterbolk and Butler, 1965, Slater and Charles, 1970). The chief grounds are the possibility of error in analysis, which could put an object irretrievably in one major group with no possibility of re-assignment, on the basis of the result for a single element; and the fact that the element chosen for the first division into two groups was

bismuth. This element has only a low solubility in copper, and segregates badly (Slater and Charles, 1970), and was therefore a very unfortunate choice. This method of grouping has now been abandoned (Sangmeister, personal communication, 1977) but this does not detract from the value of the analyses themselves.

In 1965 Waterbolk and Butler, in the course of a review criticising Klein's grouping technique, proposed a method which depends essentially on visual display. It has the advantage that it uses all the elements for which analysis are available, and there are no preconceived cut-off values. A series of histograms is constructed, one for each element, in which the number of objects with analyses falling between certain limits, is plotted against the concentration of the element. Waterbolk and Butler used a logarithmic scale in which the common logarithm of the concentration spanned a range of 0.25 for each block of the histogram, or in the terms which they used, the concentration rose by $(10)^{\frac{1}{4}}$ from one boundary to the next. A separate convention was used for zero and trace values.

The limit for each block was probably set too narrowly, because an object can move from one block of the histogram to the next if the error in analysis is as low as 10%, but this does not affect the validity of the method, because for each element the values tend to be distributed within 3 or 4 blocks, rather than a single one, in a pseudo-Gaussian fashion. The sorting of objects into groups is done by eye, removing objects which give outlying values for any element, until a characteristic pattern results, for a group of analyses, which can be visually distinguished from all others.

I used this method - or rather a computer program sorting objects on the basis of this method - for my M.A. Thesis, which was a study of

copper ornaments of the Neolithic period in northern Europe (Ottaway, 1971). The program sorted the objects on the basis of four elements - arsenic, antimony, silver and nickel - although histograms were drawn by hand for all the other elements. I found that the method worked satisfactorily provided that the number of clusters was not too large, and the pattern of elements was not too complex. For the topic mentioned above, this was so, and a useful grouping was obtained, which has proved to be of more general usefulness (cf. Randsborg, 1978). However, when I later came to look at more complex material - the Wessex bronzes analysed by four different laboratories (as compiled in Ottaway, 1974, Appendix A), I found that the Waterbolk-Butler method was not sufficiently powerful, and seems hardly suitable for inter-regional studies (cf. also Doran and Hodson, 1975, 247).

If a grouping method is to keep pace with fast developing and improving techniques of analysis it needs the following attributes:

a) it should be reasonably easy to handle the data, b) it should be able to take account of all measured trace elements so that no information is wasted, c) it should be able to deal with missing values and d) it should stand up to testing by an independent grouping method. The method to be described fulfills these criteria.

ii) CLUSTER ANALYSIS

This fast developing method of analysing multivariate data has been applied in a wide range of studies, including zoology, biology, sociology, language and many others.

Ball (1971) has given seven possible uses of clustering techniques and of those two or three are of particular interest to archaeologists: namely, 1) finding a true typology, b) data reduction,

c) data exploration. Everitt, in his useful Social Science Research Council review on cluster analysis (1974, p.4) puts it very lucidly: '... in many fields the research worker is faced with a great bulk of observations which are quite intractable unless classified into manageable groups, which in some sense can be treated as units. Clustering techniques can be used to perform this data reduction, reducing the information on the whole set of say N individuals to information about say g groups (where hopefully g is very much smaller than N). In this way it may be possible to give a more concise and understandable account of the observations under consideration. In other words simplification with minimal loss of information is sought...'

By using cluster analysis on two kinds of data - i.e. on physical measurements of flat axes (cf. Chapter III, p.127) and on chemical composition of metal artifacts - I found the resulting clusters provided me with a basic framework from which I could start the interpretation of the data.

In 1969 Hodson published the first experiments with a clustering technique for copper objects, based on the construction of a similarity matrix for all the objects, using all results for all the elements. My own experience with this technique has been very satisfactory, but the choice of clustering method used in this study needs to be justified.

It goes without saying that all cluster analysis techniques depend on computer programs both for establishment of the similarity or dissimilarity matrix, and for the 'nearest neighbour' comparisons, which produce the actual dendrogram. Since I am not capable of writing such a program, and would think it a waste of time to try to do so, I must necessarily depend on those available to me. The first clustering program that I used was part of a suite of programs written by Wishart

(CLUSTAN, E.R.C.C. Manual 1973). The program worked satisfactorily, producing the clusters used for the Wessex bronzes. It has the great advantage that it produces an estimate of the coherence, or density, of each cluster, and a measure of the distance of the centroid of each cluster from all the other clusters. From these numerical values a diagram can be constructed, showing graphically the relationship of the clusters to one another (Ottaway, 1974, Fig. 3). However, the Wishart program had two grave defects from my point of view, one local and one basic. The local defect was that the graphics subroutine of the suite has never been implemented in Edinburgh, so that it is impossible to get the computer to print out a dendrogram. The basic defect (which is in many ways a virtue) is that the program is both hierarchical and relocatory, i.e. iterative. Left to itself, it starts with a large number of small clusters, and successively relocates objects until all end up in one single cluster. In order to get the details of intermediate clusters printed out, the user has to specify a minimum number of clusters that should remain when the program stops itself. There is no way of identifying 'natural clusters'. This introduces an element of subjective judgement that I found unsatisfactory. I was therefore interested to try out a non-relocatory program written by Olivier of the National Bureau of Economic Research in Boston, Massachusetts which had been used by Bieber et al (1976) (and also by Hammond, Harbottle and Gazzard, 1975). The program is called ACCLUS and offers seven options for the clustering method, each of which can work with any similarity matrix (Olivier, 1973). In practice I used a program for calculating similarity matrices written by Bieber of the Department of Nuclear Energy, Brookhaven National Laboratory, Upton, New York, U.S.A. who very kindly gave me permission to include the source code for this program (NADIST), since it has not

been published anywhere. The program was written under the auspices of the US Atomic Energy Commission and should be credited to the Brookhaven National Laboratory. It provides seven different formulae for calculating similarities, and has been used by Bieber et al (1976).

Unfortunately, Oliver's documentation of the clustering program is fairly brief, and has not been published other than in the preliminary version (1973). No reply has been obtained to a request for permission to include the source file in this Thesis.

I tested the program exhaustively by using all seven similarity matrices, and all clustering options (49 variants in all) on the Wessex bronzes, and comparing the results with those I had already obtained by using Wishart's suite of programs. Both methods were compared with a completely different technique, Discriminant Analysis (see Section vi of this Chapter). The results of these studies were presented to the Archaeometry Symposium at Oxford in March 1975; there was no adverse comment. Briefly, the clustering method which gave results most in agreement with both Wishart's suite and Discriminant Analysis was one called by Olivier 'Nature's Clusters' (cf. Fig. 104). Unfortunately, there is no reference to the details of the method, but from the program it appears to have something in common with a method available in Wishart's suite, called 'Ward's method', which is quite well-known, and which I had found to give good results. I also found that the method of forming the similarity matrix had a much more decisive effect on the success of the clustering, than the clustering method itself. The similarity method that was far superior to the other options, for my data, was Pearsons's Product-Moment correlation. This is referred to in more detail in a subsequent paragraph. Bieber et al (1976), who were clustering analytical data from Aegean ceramic

material, used the more common General Euclidean Distance matrix. Although they discussed the clustering technique in some detail the authors did not make it plain whether they had tested all possible alternatives.

The terms 'success', 'good results', and 'satisfactory', when applied to clustering of metal analyses, are hard to define objectively. The most desirable results are that the data should not split up into a large number of very small groups; that the groups, once selected, should be stable - that is, objects should not move from one to another group if the system is perturbed either by corrections to the analyses or by the addition or deletion of a few objects; and that objects whose similarity can be detected by the Waterbolk-Butler method should end up in the same group. That the clustering should make 'archaeological sense' is an added bonus, because if the archaeological meaning of the objects could be extracted without metal analysis and subsequent statistical treatment, one might spare oneself the labour. However, in the case of the Wessex bronzes, the results of cluster analysis did agree reasonably well with the relationships expected on typological grounds.

By the purely scientific criteria enumerated in the previous paragraph, ACCLUS behaved very well when used with the data in Appendices XXIV and XXV. A stringent test was the correction of the values for As, Sb, and Bi for about 20% of the data, when new determinations of these elements for objects 1-10,040 in the Stuttgart analysis catalogue became available (Junghans et al, 1974, 363). The corrections were in some instances substantial, but they affected the clustering remarkably little, although they did, of course, change the mean values within the clusters.

Fortunately, I was also able to test the cluster analysis on some numerical data involving archaeological relationships. This test was the clustering of the Swiss flat axes on the basis of physical measurements, already described in Chapter III. Not only did the cluster conform extraordinarily closely to the purely typological grouping previously established by the traditional archaeologists (Sangmeister and Strahm, 1974), the results indicated the existence of a new group (type Robenhausen) which had not been previously recognized, although suspected.

The following paragraphs deal with some technical points of cluster analysis which are important.

iii) SIMILARITY MATRIX

This is the lower triangular matrix which records the similarities between each pair of objects in the file of data. For the Pearson Product - Moment coefficient the normalized data (see below) are used as follows. For objects i and j , with k being the number of elements (in the study: 11) for which analyses are available:

$$II = \sum_1^k (C_i)^2 \quad (\text{the sum of squares of values for all elements for object } i).$$

$$JJ = \sum_1^k (C_j)^2 \quad (\text{the sum of squares of values for all elements for object } j).$$

$$IJ = \sum_1^k [(C_i) \times (C_j)] \quad (\text{the cross-correlation}).$$

$$\text{Distance } (i \rightarrow j) = \frac{IJ}{[II \times JJ]^{\frac{1}{2}}}$$

Only one unforeseen catastrophe was found to occur during the running of the program. If any of the analyses for an object are missing, the value C_i for that element is replaced by zero. It is possible for missing values to be so distributed among the analyses for two objects, that either C_i or C_j is zero, for all 11 elements. If this is the case, the sum IJ will be zero, and this will cause the program to crash during the calculation of the distance, since division of zero by a finite value is not permissible on a computer. To avoid this, IJ was tested before the division step, and if it was zero, a message was printed out. One object was found to cause this condition with several other objects; when it was omitted from the data file, the problem disappeared.

iv) NORMALIZATION OF DATA

The program written by Bieber for calculating the product moment coefficient automatically normalizes the data beforehand. That is, for each element, it calculates the mean for all the objects in the data file, and then subtracts this value from the raw data. Next it calculates the standard deviation for each element, and then multiplies the corrected raw data by a fraction which ensures that the standard deviation will have a value of unity. In statistician's jargon, 'the data are normalized to a mean of zero and standard deviation of 1.0'. This procedure has two advantages:

- i. It ensures that all elements have equal weight in the computation of the distance. This is important when it is remembered that the maximum value, e.g. for lead, as measured was >10%, for bismuth the maximum value was 0.01%.
- ii. It rendered unimportant a problem that otherwise could have been

embarrassing and practically insoluble, namely, the difference in the limits of detection between one laboratory and the next. The problem was most acute with the SAM analyses, because the limits of detection changed as the work proceeded. Sometimes this was clear even within the limits of a single volume. Appendix XXIII shows my attempt to attach a precise numerical value to the various quantitative symbols used by authors other than myself. The difference between a value of 0.002 and 0.005 which represent the limit of detection at various times for the element arsenic, for example, represent a difference of 150%, and apparently makes it impossible for results from different laboratories to be compared. However, when the results are normalized, both 0.002 and 0.005 come at one end of the Gaussian curve, and the difference between them is vastly reduced. In other words, both values were transformed to mean 'very little arsenic indeed', which is precisely what the symbol originally meant.

The effect of taking logarithms of the analytical values, before constructing a similarity matrix, was tried for several options but the result was not so satisfactory, and this was not pursued.

v) IDENTIFICATION OF CLUSTERS

In the dendrogram printed out by the ACCLUS program, each object is accompanied by a 'value'. The method of calculating this number is not precisely explained in Olivier's manual (1973), and I have been unable to elucidate it completely from a study of the program, but basically its meaning is as follows. The program works by running through the similarity matrix to find two objects with a high similarity

for each other. These form the nucleus of a cluster; if the similarity is absolute, the 'value' attached to the second object is zero, in other words the 'distance' between the objects is zero. This aggregative process goes on until the 'distance' between the object next to be added in and the centroid of the cluster is greater than that between the object, and the object most similar to it, remaining in the similarity matrix. These latter two form the nucleus of a new cluster, and the 'value' opposite the first of the two objects records the distance between the first cluster and the beginning of the second. An advantage of the clustering option and similarity matrix used was that the numerical size of the 'values' varied greatly. In the major cluster of 362 objects, the values varied from 0.000 to 84, and it was possible using a series of arbitrary limits for the 'values', to break the dendrogram up into a series of clusters. The details are shown in Table 5, p.217. The practical limit to this dissection was easily ascertained, because the less coherent clusters eventually began to break up into more and more numerous sub-clusters, while the major clusters remained unaffected. The limit was therefore set at a point just before this occurred, except as described in the next paragraph.

Doran and Hodson (1975, 246) have pointed out that all cluster methods have difficulties in dealing with objects which are relatively pure, because their similarity coefficients in the method are not very distinctive. The ACCLUS program is no exception to this generalization, and the clustering produced one large cluster - about one-third of the total objects - with very similar 'values', separated by a very distinct break from all the other clusters. It was, nevertheless, very important to subdivide this cluster: in particular to try and separate objects possibly made of native copper. There seemed to be two ways

of achieving this. One was to re-cluster, using as raw data only the objects in the large cluster of 'pure' objects. When this was done, the cluster sub-divided, with breaks indicated by satisfactorily large values. The other method, which was adopted here, was to retain the complete dendrogram, but to use very much lower values to indicate breaks in the 'pure' cluster than for the other clusters. Table 5 (at the bottom) shows how this was done. Both methods gave essentially the same results, but the advantage of retaining all the objects in one single dendrogram - apart from that of space - is that it was possible in a second run to mask an element, e.g. arsenic, (that is to omit analyses for arsenic when forming the similarity matrix), and thus to study the effects of this one element in the distribution of artifacts within the clusters.

vi) TESTING THE COHERENCE OF THE CLUSTERS (DISCRIMINANT ANALYSIS)

For this purpose, and also to check the validity of the clusters themselves, the Discriminant Function routines of the IBM Scientific Subroutines Package (SSP) were used. Discriminant analysis is a mathematical technique, the purpose of which is to examine how far it is possible to distinguish between members of various groups on the basis of observations made upon them. It is really an extension to multivariate observations of the ordinary analysis of variance within and between groups. It has been adequately described by Marriott (1974, 32). Here it is only necessary to say that the IBM routine contains an algorithm for calculating the probability that any object belongs to any of the groups that have been fed into the program, on the basis of the discriminant functions that may be calculated for it. It was therefore only necessary to run the appropriate subroutines, using as groups those

provided by breaking up the dendrogram as described in the previous paragraph, and to study the 'Most Probable Groups' and the 'Percentage Probability' columns of the output (cf. Print-out D in pocket at back of Vol. II). Objects which were not assigned a high probability of belonging to the cluster in which they were found were provisionally re-assigned. These were very few, and in general it was found that their adherence to the new cluster was not greater than to that from which they had been transferred. In the interpretation of the individual clusters, objects which had only a low probability of belonging to that cluster were not used for archaeological evaluation.

In the course of investigating the validity of the clustering techniques described in Sections 2, ii-v of this Chapter (p.191 ff), discriminant analysis was used in a slightly different way. The results of the investigation were reported at the Archaeometry Symposium at Oxford (Ottaway, 1975a) but as only the abstracts from these meetings are published, it has been thought desirable to reproduce the substance of the argument here.

In its orthodox use discriminant analysis is used to find the measurements that are most significant in discriminating between a number of pre-defined groups. These measurements are then used to allocate fresh objects to one or other of the existing groups. However, if the algorithm mentioned at the beginning of the Section, is used to relocate objects, discriminant analysis can be used actually to find groups (or clusters). For this purpose the objects are first fed in in a series of clusters formed at random, and the program is run iteratively, relocating the objects to their most probable groups each time, until the largest Mahalanobis D^2 is achieved. Clusters which

become very small (≤ 2) are eliminated. It was of course necessary to start the process several times with different initial random grouping; however, it was found that the iteration converged reproducibly to almost identical groups each time. It is a limitation of the method that the number of groups cannot be greater than the number of measurements.

When the groups obtained by discriminant analysis are compared with the clusters obtained by Wishart's cluster analysis - using the Wessex bronze analyses (as in Ottaway, 1974) as test data - it can be seen (Fig. 105) that there is very good correlation between all groups, particularly when account is taken of the fact that discriminant analysis converged to six rather than to seven groups. The same excellent agreement can be seen in Fig. 106 where tin was masked in both cluster analyses and discriminant analyses. On the basis of the good agreement between cluster analysis, using either Wishart or Bieber's programs, and discriminant analysis, I became confident that clustering could be used for grouping analytical results. It may be recalled here that cluster analysis and discriminant analysis were also used to group Swiss flat axes discussed in Chapter III, p.130. In this instance it was possible to use a third independent method of checking the techniques, namely that of comparing the typological allocation to groups made by an experienced archaeologist by visual inspection, with the grouping methods. Correlation was again extremely good.

vii) CONTINGENCY TABLES, THE CHI-SQUARED TEST,
AND THE EXTENSION OF THE MEDIAN TEST.

Very considerable use is made in the next Chapter of contingency tables. These are tables which may be drawn up to discriminate between

objects on the basis of two different attributes which each object may simultaneously possess, for example, one may draw up a Table in which the nature of the object - dagger, bead, etc. - is used as one criterion, while the cultural group to which it may be assigned is the other. The object of drawing up such tables, which are not unfamiliar to archaeologists, is to assess whether there is any correlation between the two sets of attributes. This may be done by statistical testing. Since the only numerical information available is the number of objects in each cell (row x column), i.e. the frequency distribution, the chi-square test is the only one that can be used (Siegel, 1956, 175). Chi-square (χ^2) is a measure of dispersion, it estimates the extent to which the observed frequencies of distribution among the cells differ from the expected frequencies. The null hypothesis (H_0) is that there is no difference between observed and expected frequencies; it is not usually possible to construct, in advance of testing, an alternative hypothesis about the distribution. The formula by which chi-square is calculated is as follows:

$$\chi^2 = \sum_1^k \frac{(O-E)^2}{E}$$

where k is the number of cells, O is the observed value, and E the expected value, for each cell. Clearly if $O=E$ for every cell, χ^2 will be zero. Conversely, the larger χ^2 , the more likely it is that the null hypothesis - that the frequency distribution is the expected one - is untrue. The critical value is looked up in Tables for the appropriate degrees of freedom (see below).

The calculation of the expected frequency for each cell is usually done from probability theory. If the total number of objects

is N , and the total number of objects in a single row of the contingency table is p , then the expected frequency with which an object will turn up in that row is p/N . Similarly, the expected frequency for an object to turn up within one column is q/N , where q is the total number of objects in that column. The probability that an object will be placed within one cell, at the intersection of a row and a column, is

$$p/N \times q/N, \text{ or } \frac{pq}{N^2}$$

This is the expected value that is calculated for each cell.

The chi-square distribution is an approximation that is true for large numbers. If the expected frequency in a cell is small, χ^2 may over-estimate the probability that the null hypothesis is untrue. To guard against this, rows or columns may be amalgamated, to arrive at a minimum value for the expected frequency. The traditional advice is that the expected frequency should not be less than 5 for more than 20% of cells (Siegel, 1956, 178), but later research (Snedecor and Cochran, 1967, 235) has suggested that this is too restrictive, and that the minimum value for the expected frequency should be 1. Again, this should not occur more frequently than one in five cells. This less conservative view was certainly of great help in this study, where it would have been impossible to study the expected distribution of infrequently analysed finds, such as chisels and awls, if an expected frequency of 5 for each cell had been obligatory.

The only other point to consider is the calculation of the number of degrees of freedom. For each row (or column) of the contingency table the total number of objects is fixed (that is, it

is an observation). The objects can be distributed among the cells belonging to the row or column in any way, except for the last cell, where there is no freedom of choice, because the total for all cells must be equal to the observed value. Therefore the number of degrees of freedom for each row is (n_p-1) , and for each column is (n_q-1) . The total number of degrees of freedom, used for looking up the critical value of chi-square, is $(n_p-1)(n_q-1)$.

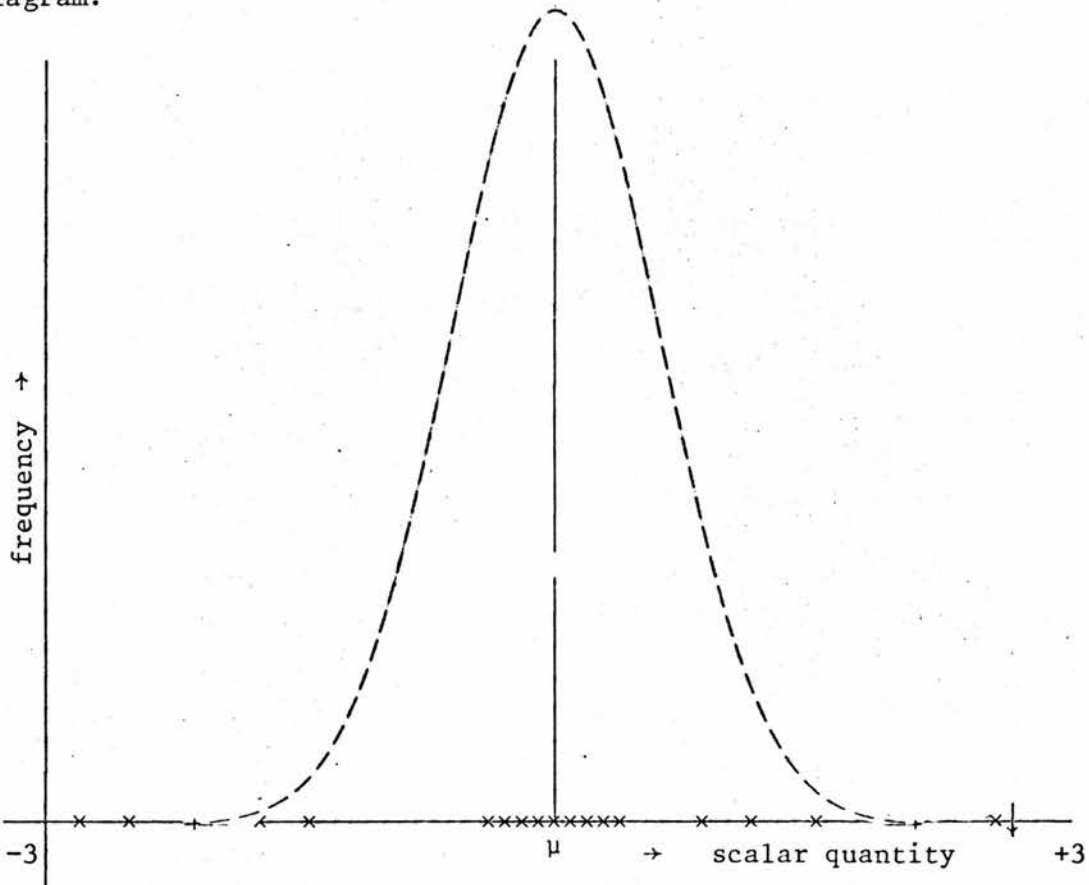
The rule is also true for the Extension of the Median Test (Siegel, 1956, 179), which was used for testing whether the geographical distribution of three clusters was uniform. This is a 'ranking' test, which involves finding the median rank for all the objects to be tested, on a suitable scale (in this case the E-W distribution of the find-sites within the region). For each cluster, the number of objects with ranks below, and above, the median is counted, and the results for all the clusters to be tested are entered in a $2 \times n$ contingency table. The correct number of degrees of freedom is $(2-1)(n-1)$, or one less than the number of clusters to be tested.

The extension of the Median Test was found to be better than the Kruskal-Wallis test (Siegel, 1956, 184), for the case where one of the clusters was much smaller than the others.

viii) THE RANKIT TEST

It is sometimes very difficult to decide whether a distribution is normal, i.e. Gaussian, or not, and various statistical methods exist to test this. One used by Klein (in Junghans, Klein & Scheufele, 1954, 106), has already been mentioned. Another is the Rankit test (Colquhoun, 1971, 80), which uses 'expected normal order statistics'.

The principle of this may be most easily explained by the following diagram:



The normal (Gaussian) distribution curve is a plot of frequency against some scalar quantity. If the latter is normalized, to zero mean and unit standard deviation, the curve shown above will result. Any sample of finite size from a normal population will tend to be distributed along the scalar abscissa in the way shown in the diagram, bunched more closely around the mean (μ). It is possible to calculate, by statistical formulae, a precise numerical value for any member of the sample in terms of the normalized mean and standard deviation. Tables for sample sizes up to 60 are given by Colquhoun (1971), and for samples up to 400 by Harter (1961).

To make use of the Tables, the sample to be tested is ranked in order of size of the scalar variable whose distribution is in

question. Each member of the sample is then plotted on a graph, using ordinary graph paper. On one ordinate is the variable to be tested, and on the other is the normalized statistic. If the sample is normally distributed, a straight line will result, because all that is done in normalization is to subtract a constant from the value for each member of the sample, and then to multiply each value by a constant term to scale it. Deviation from a straight line indicates a non-normal distribution (cf. for instance, Fig. 116, Cluster 10).

CHAPTER V. METAL ANALYSIS OF THE EARLIEST NORTHERN
SUB-ALPINE FINDS: INTERPRETATION

V.1 INTRODUCTION

Using the grouping method described in Chapter IV, most analytical results obtained by the methods described in that Chapter were clustered, together with all the relevant analyses carried out by the Stuttgart team (Junghans et al, 1960, 1968, 1974), and by Otto and Witter (1952). It has been shown that comparison of analytical results of these teams is possible (cf. Chapter IV, p.186). It remained to decide which analysed objects should be included. First of all, artifacts which are securely associated with any of the cultures discussed in Chapter II were included. These were very few in number, and consequently artifacts which on typological grounds (cf. Chapter III) could be assumed to belong to the period under discussion, were also included. In addition, certain artifacts have been considered which either have a typological or a temporal association. For example, certain daggers have been included which have some typological similarity to late Neolithic types. Also considered are spiral cylinders which as a type are not found in association in the late Neolithic period of the region studied here, but do occur in the Stollhof hoard. In general, however, the artifacts included are limited to those discussed in Chapter III.

In this way some 450 analyses - including most of my own 100 - were collected, and stored in data files on the ERCC computer. The data had been amended by inserting the re-analysed values of the elements arsenic, antimony and bismuth for Stuttgart analyses numbers 1-10,040 (Junghans et al, 1974, p.362-382) when appropriate. Incidentally,

great care had to be taken in correcting the old values, i.e. when inserting the new results, because the new analysis numbers up to 860 are not the same as the old ones.

Elements merely presented as trace or by other non-numerical symbols such as larger than, smaller than, etc., pose a problem in quantification. Appendix XXIII shows which values have been used to replace these non-numerical symbols.

The first step in handling this set of 440 analyses, each with 11 element determinations, was to remove those that contained a significant amount of tin. This was taken to be larger than 2% of the element (Witter, 1938, 121, Forbes, 1964, 144). In this way, 80 analyses of artifacts which were certainly alloyed with tin were removed (cf. data file, Appendix XXIV). The data file for the remaining 362 copper analyses can be found in Appendix XXV.

The representation of the results of clustering in the form of figures, tables, appendices, and inserts in the pocket at the end of Volume II, is somewhat involved and I am providing here a guide to facilitate cross-reference.

FIGURES (IN VOLUME II)

- 107 : Impurity patterns of copper subclusters 1.1 - 1.4.
- 108 : Impurity patterns of copper clusters 2, 1.5 and 10.
- 109 : Impurity patterns of copper clusters 3, 5 and 6.
- 110 : Impurity patterns of copper clusters 4 and 7.
- 111 : Impurity patterns of copper clusters 8 and 9.
- 112 : Copper clusters plotted against cultures (cultural association diagram).
- 113 : Distribution of copper clusters 2, 1.5 and 10.
- 114 : Impurity pattern of large copper cluster containing early arsenic-containing clusters 2, 1.5 and 10; after clustering with masked arsenic values.
- 115 : Histograms of arsenic contents of copper clusters 2 and 10.
- 116 : Rankit test on arsenic values of copper clusters 2, 1.5 and 10.
- 117 : Rankit test on silver values of copper cluster 10.
- 118 : Linear distribution of copper clusters 2, 1.5 and 10 for Extension of the Median Test.
- 119 : Distribution of copper sub-clusters 1.1 - 1.4.
- 120 : Distribution of copper clusters 5,6,8 and 9.
- 121 : Distribution of copper cluster 7.
- 122 : Distribution of copper cluster 3.
- 123 : Distribution of copper cluster 4.
- 124 : Impurity patterns of copper ore types (after Pelissonnier and Michel, 1972).
- 125 : Impurity patterns of Pittioni's 'East-alpine, 'Bertha Grube' and 'East-Copper' types.
- 126 : Impurity patterns of bronze clusters A-C.
- 127 : Impurity patterns of bronze clusters D-F.
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APPENDICES (IN VOLUME II)

- XXIII : Conversion of non-numerical symbols used by SAM and Otto & Witter to numerical values.
- XXIV : Data file of 81 bronze analyses with identification of artifacts.
- XXV : Data file of 362 copper analyses with identification of artifacts.
- XXVI : List of analysis (i.e. laboratory) numbers (e.g. SAM 2776) contained in each of the copper clusters 1.1-1.5 and 2-10.
- XXVII : List of analysis numbers contained in each of the bronze clusters A-F.
- XXVIII : Identification of codes used for the graphic display of the impurity patterns in figures 107-111, 114 and 125-127.

PRINT-OUTS (POCKET IN BACK OF VOLUME II)

- A : Dendrogram of copper clusters 1-10.
- B : Dendrogram of bronze clusters, A-F, where tin was masked before clustering.
- C : Dendrogram of bronze clusters a-f.
- D : Results of discriminant analysis on copper clusters.

V.2 THE COPPER CLUSTERS: GENERAL DISCUSSIONi) CLUSTERING AND REPRESENTATION OF RESULTS

The 362 copper objects, i.e. those containing less than 2% tin, were clustered using the clustering programs NADIST and AGCLUS which were described in Chapter IV, p.191. Ten basic clusters can be discerned from the dendrogram (Print-out A, in pocket of Vol. II), using a boundary value of -6.1. Table 5 gives an insight into the hierarchical breakdown of the one large, initial cluster into smaller ones, and makes it clear that a number of clusters are stable from boundary value -16 onwards, and the last cluster is stable until breakdown was stopped. It is therefore only a minority of analyses which form denser clusters as the boundary constraints are increased.

Discriminant analyses performed on these clusters showed which of the analysed objects do not fit so well into each of the clusters. On the whole, the probability that each of the individual analyses belong to the cluster assigned to them by the cluster analyses is very high (cf. Print-out D, in pocket of Vol. II). Only cluster 1 was less homogeneous. This is the largest cluster (136 artifact analyses are contained in it) and it does contain objects made of relatively pure copper, which do not readily form clusters. It was decided, therefore, to break up this cluster 1 into smaller sub-groups, by decreasing the boundary value further, in fact, down to -0.5 (cf. Table 5). Five sub-clusters resulted and I named them 1.1-1.5, to help in remembering the fact that they are all sub-groups of the 'purest copper' cluster.

Since the aim of using cluster analysis is to reduce the data to manageable groups, it is desirable to use the smallest number of

clusters which makes sense archaeologically and geographically. Preliminary checks showed that no information was lost, and no more detailed information could be gained, by either reducing or increasing the number of clusters from those shown in Table 5. It was therefore decided to use the nine basic clusters of copper objects and the five sub-clusters of the first cluster for final evaluation.

A list of the analysis (i.e. laboratory) numbers, contained in each of these clusters can be found in Appendix XXVI.

For each cluster the mean concentration for each element was worked out by computer together with the percentage coefficient of variation, referred to also as V. These values can be found in Table 6 (for sub-clusters 1.1-1.5) and in Table 7 (for the remaining clusters 2-10). The coefficient of variation is used here rather than the standard deviation because the absolute values for each element are so very different. To keep this in proper perspective the standard deviation (SD) is transformed to be a proportion of the mean. V, which is dimensionless, is calculated as follows (Hodge and Seed, 1972, p.77):

$$V = \frac{100 \text{ SD}}{\text{mean}}$$

Thus the coefficient of variation can be used as a measure of relative importance for each element in the formation of a cluster. In Tables 6 and 7 those elements which have a significantly low value of V, i.e. a low standard deviation of that element within that cluster, are stressed visually by heavy outlines.

A graphical representation of these mean values of the impurities contained in each of the copper clusters can be found in

Figures 107-111. Here the mean values were coded on a logarithmic scale, i.e. the ordinates represent logarithmic concentrations starting from an arbitrary base for each element. For instance, code 1 means that the element is present only in trace amounts. Code 3 for the elements lead, arsenic, antimony, silver, nickel, zinc and iron, for instance, is less than 0.03% whereas code 4 for these same elements is less than 0.1%. A complete key to the codes is given in Appendix XXVIII. The importance of the coefficient of variation is represented in the Figures by shading: the darker the shading, the lower the value of V, and consequently the lower the standard deviation of that element within the cluster. Two diamonds show that the value of V equals zero, that is, all measurements of that element have the same value within the cluster. This absolute agreement only occurs when the element in question is completely absent.

TABLE 5: ILLUSTRATION OF HIERARCHICAL FORMATION OF COPPER CLUSTERS WITH INCREASING BOUNDARY CONSTRAINTS.

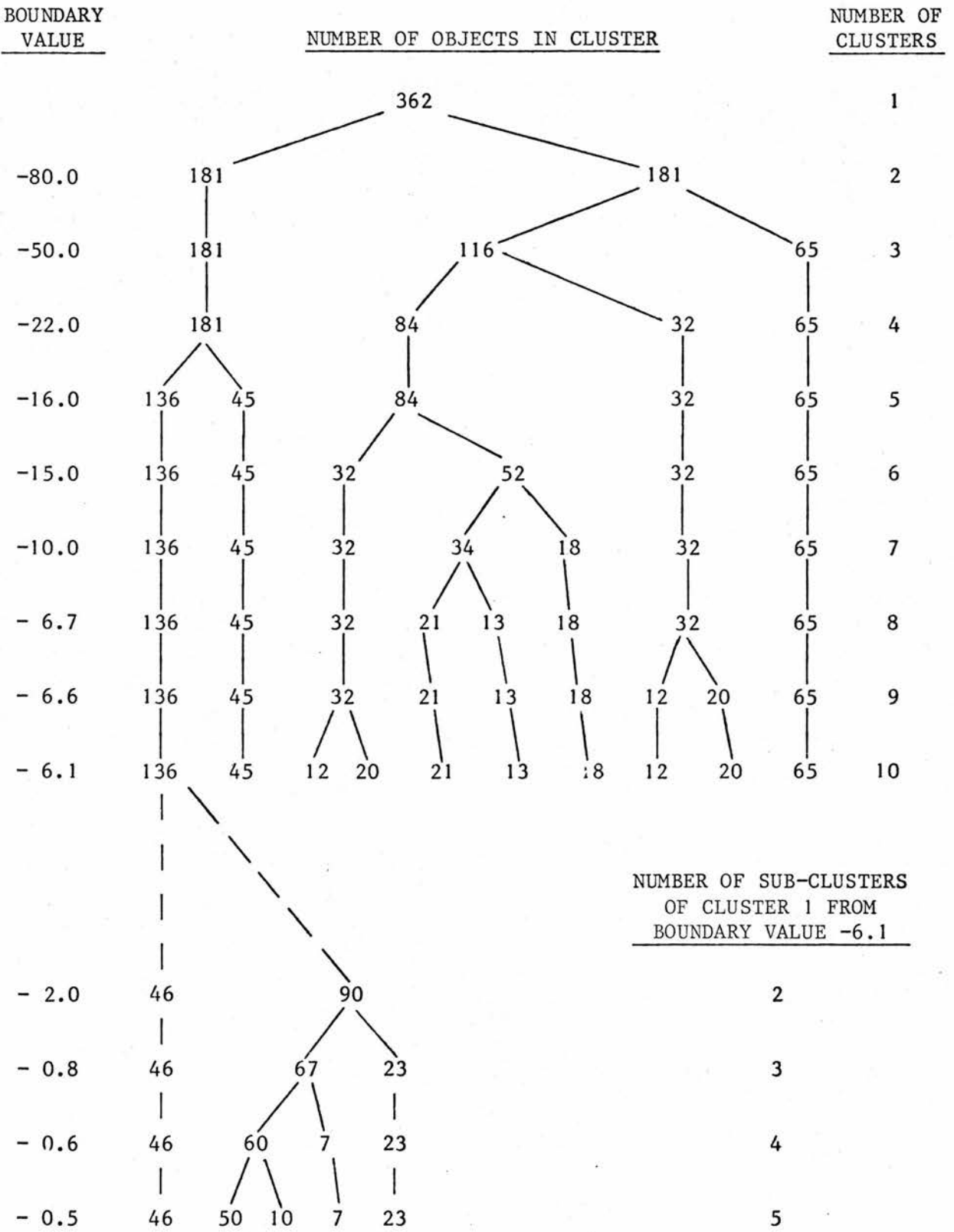


TABLE 6:
 MEAN VALUES AND THEIR PERCENTAGE COEFFICIENT OF VARIATION (V)
 FOR EACH ELEMENT IN COPPER CLUSTERS 1.1 - 1.5

CLUSTER NO.	IM-PURITY	Sn	Pb	As	Sb	Ag	Ni	Bi	Au	Zn	Co	Fe	NO. OF OBJECTS IN CLUSTER
1.1	Mean V	0.0002 678	0.0001 678	0.007 553	0.002 587	0.003 410	0.1 28	0.0002 432	0 0	0 0	0 0	0.001 665	46
1.2	Mean V	0.001 495	0.0003 400	0.011 407	0.007 324	0.013 165	0.003 344	0.0001 295	0 0	0 0	0.0002 511	0.004 356	50
1.3	Mean V	0 0	0.01 143	0.003 238	0.014 110	0.022 146	0.016 112	0.0066 40	0.0004 165	0.007 211	0.0006 148	0.022 166	10
1.4	Mean V	0 0	0.001 192	0.114 113	0.01 150	0.139 25	0.006 90	0.004 63	0.0001 265	0 0	0 0	0.001 218	7
1.5	Mean V	0.0004 480	0.001 203	0.212 21	0.020 78	0.021 89	0.002 141	0.001 97	0 343	0 0	0 0	0.0002 480	23

Mean values are given as per cent by weight.

TABLE 7: MEAN VALUES AND THEIR % COEFFICIENT OF VARIATION (V) FOR EACH ELEMENT IN COPPER CLUSTERS 2-10.

CLUSTER NO.	IM-PURITY →	Sn	Pb	As	Sb	Ag	Ni	Bi	Au	Zn	Co	Fe	NO. OF OBJECTS IN CLUSTER
2	MEAN V	0.0002 671	0.004 288	0.566 23	0.024 131	0.02 117	0.004 325	0.0047 172	0 387	0.001 671	0 473	0.004 495	45
3	MEAN V	0.003 181	0.001 235	0.046 229	0.009 307	0.009 125	0.447 21	0.0006 226	0.0002 167	0 0	0.0018 182	0.004 223	12
4	MEAN V	0.003 190	0.015 166	1.322 80	0.197 124	0.151 138	1.453 50	0.0087 201	0.0004 233	0.007 447	0.0062 164	0.469 182	20
5	MEAN V	0.11 395	0.089 128	0.317 119	0.587 124	0.126 195	0.198 161	0.0086 84	0.0155 166	0.284 145	0.0249 179	0.122 122	21
6	MEAN V	0.64 100	0.368 198	0.162 122	0.215 124	0.089 123	0.041 99	0.005 132	0.0006 341	0.0208 361	0.003 306	0.005 218	13
7	MEAN V	0.006 114	0.013 191	0.130 163	0.022 180	0.024 166	0.25 172	0.008 169	0.0002 271	0.007 326	0.0032 96	1.075 97	18
8	MEAN V	0.0008 346	0.0004 346	1.200 64	1.493 47	0.736 66	0.004 298	0.1131 75	0 0	0 0	0 0	0.0001 346	12
9	MEAN V	0.003 315	0.023 185	0.266 196	0.615 89	1.399 72	0.083 199	0.011 140	0.0005 268	0.0025 447	0.004 282	0.026 331	20
10	MEAN V	0.001 290	0.022 220	1.693 54	0.019 157	0.034 129	0.019 233	0.008 338	0.0003 606	0.004 480	0.0002 408	0.016 516	65

ii) CHRONOLOGICAL CONSIDERATIONS

Before the metal composition of each of these copper clusters is discussed in detail, the cultural affinities of the artifacts contained in the clusters will be examined, since they provide chronological information which is relevant to the discussion on the clusters.

In Table 8 the copper clusters are plotted against the cultures to which the securely associated artifacts in each cluster can be assigned. The chronological basis for the culture sequence was provided in Chapter II (see especially Fig. 6), where the existence of three distinct horizons of coeval cultures in the region under study was deduced (cf. p.121-122). Only first- and second-order associated finds (as assigned in Chapter III) are included in the Table, which is therefore a good indication of the relatedness of these copper types to the cultures. Artifacts which were included in the main cluster analysis only on the basis of their typological similarity to securely associated finds, are not included in this Table. The number of beads was divided by ten - on the assumption that one bar of copper provided enough material for about 10 beads (cf. Ottaway and Strahm, 1975) - to avoid overweighting the results (as a result of this, not all numbers in the Table are integers). The number of associated artifacts in each cluster (in the column headed Σcol), the number of all artifacts - associated and un-associated - in each cluster and the percent of associated objects in each copper cluster are also given. Thirty-one percent of all analysed artifacts are associated finds, although the percentage was very variable for individual clusters, e.g. 100% for cluster 1.5, but only 5% for cluster 5.

This variability made inference slightly hazardous.

Nevertheless, in view of the fact that almost all the artifacts of cluster 1.5 are associated with the first copper-using horizon, i.e. to the Altheim, Pfyn, Cortaillod and Mondsee cultures, it appeared to be worth while to test statistically the probability that the copper types identified by the clusters are, in fact, related to the cultures. In Fig. 112 the clusters are re-arranged in what appears to be the chronological order. A distinct association between copper of clusters 2, 1.5 and 10 and the Altheim, Pfyn, Cortaillod and Mondsee cultures, i.e. the earliest copper-using horizon, is visually suggested. On the other hand, copper of clusters 1.3, 3, 4 and 1.1 does not seem to have been used until the later Auvernier, Baden and Corded Ware cultures. It is impossible to test statistically Table 8 or Fig. 112 as they stand, because the expected frequency is too low in too many of the cells (cf. Chapter IV, p.204). By merging several cultures into an early horizon and a late horizon (the early corresponding to the first - the later corresponding to the third copper-using horizon) as well as by grouping two related copper clusters together and leaving out altogether groups with too low values, I was able to test the relatedness of copper clusters to cultural groups statistically (Table 9). It would have been desirable to keep the Lüscherz culture as a separate middle period, but the numbers of associated finds in it are too small.

The χ^2 test (cf. Chapter IV, p.202) tests the goodness of fit to the model, which assumes that there is no relationship between copper clusters and cultures, i.e. that the copper clusters had the same chance of having been used by either early or late cultures. This model, or null hypothesis, is tested against the alternative hypothesis

TABLE 8: COPPER CLUSTERS 1-10 PLOTTED AGAINST THE CULTURES

		NUMBERS OF COPPER CLUSTERS										TOTAL				
		1.1	1.2	1.3	1.4	1.5	2	3	4	5	6	7	8	9	10	TOTAL
C U L T U R E S	Altheim					1									2	3
	Pfyn	1	1		3		1							1	1	8
	Cortailloed					1	3								2.7	6.7
	Mondsee		2		1	9	8								14	34
	Lüscherz						1					1				2
	Auvernier									1				1		2
	Baden		3						1						1	8
	Corded Ware	9.4	1	0.1					4					1	1	19.5
Ecol.	10.4	7	2.1	4	12	13	4	4	1	0	1	0	3	21.7	83.2	
No. of objects in each cluster (beads 1/10)	15.4	41	9.1	7	12	27	12	20	13	18	20	12	20	49.7	276.2	
% of associated objects in each cluster.	68	17	23	57	100	48	33	20	5	0	6	0	15	44	31.14	

that there is a probability of certain kinds of copper being used by certain cultures. The values in parenthesis in Table 9 are the expected frequencies, the degrees of freedom are 5 and the significance level of 1% was chosen, i.e. the probability under the null hypothesis that $\chi^2 \geq 15.09$ is 0.01. Since the computed value for χ^2 is 45.32, the null hypothesis is rejected and the alternative hypothesis is accepted, that is, there is a better than 99% probability that copper types are related to cultures. Thus the probability that some of the copper types were used in the early copper-using horizon - as suggested visually by Fig. 112 - whereas other copper types have a tendency to have been used by later copper-using cultures, is high. Most outstanding is the observation, that the three earliest copper types 2, 1.5 and 10, are all arsenical coppers. This will be discussed in detail later. Most of the sub-groups of cluster 1, i.e. 1.2, 1.3 and 1.1, and to some extent cluster 2 and 10, have an early/late pattern of occurrence; i.e. they occur in the early as well as in the late copper-using horizon. The remaining clusters, in particular 5, 3 and 4, appear in the late copper-using horizon only. Unfortunately, the proportion of securely-associated finds which were analysed and which belong to the later copper-using horizon is very small, but I think the general trend is clear.

I propose to deal with the copper clusters not in numerical order but in terms of the order shown in Fig. 112 and thus follow, as far as possible, its chronological indications.

Since the arguments are involved, I shall briefly outline the major conclusions of this Section here. They are:

- i) The earliest types - or clusters - of copper contain arsenic in varying amounts.

TABLE 9 : TWO-WAY CONTINGENCY TABLE FOR TESTING THE RELATEDNESS OF CULTURES TO COPPER GROUPS

		NUMBERS OF COPPER CLUSTERS						Σrow
		2	10	1.5	1.2	1.1	3&4	
C L I P S	Early copper- using groups.	12 (8.4)	19.7 (14.3)	11 (7.8)	3 (4.5)	1 (6.5)	0 (5.2)	46.7
	Late copper- using groups.	1 (4.6)	2 (7.8)	1 (4.2)	4 (2.5)	9.4 (3.5)	8 (2.8)	25.4
Σcol.		13	21.7	12	7	10.4	8	72.1

Degrees of freedom : $(r-1)(c-1) = 5$

Probability under H_0 that $\chi^2 \geq 15.09$ is 0.01

computed $\chi^2 = 45.32$

- ii) There are two, possibly three groups of ingots from the region under study. Their distribution as well as their composition suggest that several copper sources in the Salzach region of Austria were worked, probably at slightly different periods.
- iii) Some artifact types, in particular daggers, correlate with certain copper types, but others were made of any type of copper.
- iv) Native copper is notably absent from the early copper-using contexts.
- v) The types of copper used for tin bronzes are completely different from any of the types not alloyed with tin. (This conclusion is mentioned here, although it is arrived at in Section 4 and 5 of this Chapter.)

All these conclusions refer, of course, only to the northern alpine region during the period under study.

V.3 DISCUSSION OF THE INDIVIDUAL COPPER CLUSTERS (IN SEQUENCE AS LAID OUT IN FIGURE 112)

i) CLUSTER 2

This is a rather large cluster, containing 45 artifacts which stayed constant from an early stage onward in the clustering (cf. Table 5). The artifacts in it were made from a metal which contained appreciable amounts of arsenic. The average arsenic value (Table 7) is slightly over 0.5% - code 6 in Fig. 108 - with a very low coefficient of variation of 23%. This remarkably low value of V indicates a very coherent cluster (cf. section 2, of this Chapter p.215). Relatively low coefficients of variation are also found for antimony

and silver which are present in low concentration. Bismuth is also present, but has a rather high coefficient of variation of 172% which means that the scatter is too large for the element to be of indicative value for this cluster. In general, tin, gold, zinc and cobalt are not present - the positive values for tin and zinc reflect a very few analyses. Nickel has a wide scatter but occurs more frequently than the four previous elements.

Table 8 and Figure 112 show that this copper cluster has a tendency to appear in the earliest copper-using horizon in the northern alpine region. Almost 50% of the artifacts in this cluster are securely associated finds. This is largely due to the number of beads from Burgäschisee-Süd (SAM 2977-3020, App. XXV), belonging to the Cortaillod culture. However, the cluster also contains ten flat axes, two of which belong to type Robenhausen, which, as we saw in Chapter III (p.129) belongs to the Pfyn culture. The other axes come mainly from the Mondsee and Attersee. The distribution of this type of copper is therefore, not surprisingly, mainly around the Swiss and Austrian lakes (Fig. 113).

All three early arsenical copper clusters on Fig. 108 will be discussed in more detail on p.229.

(ii) CLUSTER 10

This large cluster (65 artifacts) was again very stable from an early stage in the clustering (cf. Table 5). It includes all artifacts made from metal with the highest arsenic content of all the copper objects studied here. The average value for arsenic is 1.7% with a low coefficient of variation of 54%. Of the other elements only silver, and to a lesser extent antimony, have low coefficients of variation (cf. Table 7 and Fig. 108). Most of the other elements are present in very low amounts with a fairly large

scatter, indicated by the large values of V.

The chronological indication of this cluster is, like cluster 2, early, i.e. the artifacts which are securely associated and are made from metal of type cluster 10 (44% of the total in the cluster), come from the early Altheim, Pfyn, Cortaillod and Mondsee cultures (cf. Table 8 and Fig. 112). Two analyses, securely associated to the later Baden and Corded Ware cultures, suggest that this copper was also in use in later periods.

Again ten of the Burgäschisee-Süd beads are included in this cluster (SAM 2990-3026, Appendix XXV) as is a bead from Baulmes, also belonging to the Cortaillod culture (SAM 21674). The inclusion of a further six beads from Gerolfingen (SAM 3092-3100, Appendix XXV) means that almost a quarter of objects in the cluster are beads from Switzerland. However, an equally high number of flat axes (22) and daggers (13) are made of this copper, and the finds are almost equally distributed between Austria (28) and Switzerland (35). Perhaps significantly, two of the south German finds are also included in this cluster (cf. distribution map Fig. 113). Quite a large number of the Burgäschisee-Süd beads could almost equally well fit into cluster 2, as suggested by discriminant analysis (cf. Print-out D in pocket in Vol. II) and this stresses the fact that these clusters are closely related.

iii) CLUSTER 1.5

This is the smallest (23 artifacts) of the early arsenical copper clusters. When cluster 1 was further sub-divided, cluster 1.5 separated out at an early stage and stayed constant in size (cf. bottom of Table 5). Incidentally, sub-cluster 1.1 was also constant from an

early stage in the sub-division (cf. Table 5) and only sub-clusters 1.2, 1.3 and 1.4 were less stable. This is particularly interesting in view of the fact that each of these three main sub-groups (i.e. 1.1, 1.2-1.4, and 1.5) have different chronological implications (cf. Table 8 and Fig. 112). This will be discussed in more detail at a later stage (p.239).

Cluster 1.5 has the lowest average arsenic content, about 0.2%, of the early arsenical copper clusters, with a very low coefficient of variation of 21%. This is not particularly surprising, since it is a sub-group of the 'purest copper', cluster 1. The elements antimony, silver and bismuth are present at very low concentration with a low coefficient of variation (cf. Table 6) and the concentration of nickel is even lower. The absence of zinc and cobalt is highly indicative; (cf. Table 8), no object in this cluster contains either of these two elements. Tin, gold and iron have too wide a scatter to be indicative.

All artifacts in this cluster either come from excavated sites or can be linked typologically to artifact types discussed in Chapter III, i.e. they can be considered associated finds (Table 8), either of the first or the second order (Chapter III, p.125). Thus the correlation of this type of copper with the early copper-using horizon is highly significant and particularly interesting from the archaeological point of view (cf. Fig. 112).

The remaining beads from Burgäschisee-Süd are included in this cluster (SAM 2988-3025). Thus all beads from this site were made of one of the three arsenical copper types discussed so far, and this will be commented on later. Copper of cluster 1.5 was also used to produce 8 flat axes, some of definite Robenhausen type (e.g. SAM 4345

and 14465). The cluster also includes the flat axe from Altheim itself, again of type Robenhausen (cf. No. A52 in the typological study in Figure 65). This axe has been analysed both by Otto & Witter (1952, An. No. O & W 278) and by Stuttgart (SAM 8) and since the results differed slightly (cf. Appendix XXV) they were both included here as a check. Both stayed together in cluster 1.5. This underlines a point made at an earlier stage (cf. Chapter IV, p.170), that slight individual differences in the analyses need not distort the overall result, if an appropriate grouping method is used.

Artifacts of this cluster are mainly found in Austria (cf. Figure 113); only Altheim and Burgäschisee-Süd are sites at which copper of this type was found outside Austria.

There is only one object which does not belong to the early horizon: it is a small torc from Leobersdorf (SAM 3731, Appendix XXV), belonging to the Baden culture (cf. Chapter III, p.151).

iv) DISCUSSION OF THE THREE EARLY, ARSENICAL
COPPER CLUSTERS 2, 1.5 and 10.

Cluster analysis was repeated on the data with the arsenic values masked. It was interesting to note that all three early arsenical clusters merged into one big cluster which contained a few other artifacts as well, and which had the impurity pattern shown in Figure 114. This suggests that basically one similar type of copper - or copper ore - was used in the early horizon.

In two of the clusters - those with low arsenical contents, cluster 1.5 and cluster 2 - the arsenic was normally distributed. In cluster 10, however, this is not the case, as can be seen on

Figure 115, where the arsenical contents of cluster 2 and 10 are shown in histogram form. It is always difficult to decide whether a distribution is normal or not, and the Rankit test (cf. Chapter IV, p. 205 for description of this test) was used to test the normality of arsenic values in these three clusters. Figure 116 shows that the individual arsenic values of clusters 1.5 and 2 are normally distributed (i.e. on average they lie on a straight line) with a low standard deviation, indicated by the slope. The arsenic of cluster 10, on the other hand, is normally distributed up to about 1%, but then has a sharp break after which it again forms a straight line, but with a much steeper slope, i.e. a much larger standard deviation.

It is, to my mind, significant, that this break occurs at an arsenic value just above 1%, the value most often associated with arsenical alloying (Otto and Witter, 1952, 47; Tylecote, 1962, 39; Sangmeister and Strahm, 1974; Doran and Hodson, 1975, 250, Eaton and McKerrel, 1976). It is therefore possible that arsenic was added deliberately to those objects which contain more than 1% of it. This is supported by the silver values in cluster 10 which, when subjected to the Rankit test (Figure 117) are seen to be normally distributed.

Alloying might have been achieved by smelting arsenic sulphides in conjunction with the copper ores, as suggested by Slater (1972, 101), although there is no way of proving that early alloying was done by this method. Another possible source of arsenic is indicated by two bun ingots from Zihl, Switzerland, one of which contains 10% tin, the other 3% arsenic and 2% nickel, suggesting the use of a metal arsenide (nickel arsenide) for alloying, at least by the Bronze Age. This source of arsenic could not have been used for the three early arsenic clusters 2, 1.5 and 10, since they hardly

contain any nickel at all (cf. Tables 6 and 7 and Figure 108), but the use of other arsenides might have been feasible.

On the other hand, arsenic can occur naturally in some copper ores, although it is not always present in quite such high amounts as in the well publicised Azerbaijan ores (Selimchanov, 1962). The wide variation in the high arsenic contents of cluster 10 could be due to varying smelting conditions and to the original content in the ore. For instance, arsenical copper can be the result of retention of arsenic from the ore. This has been demonstrated by Tylecote (1977) by smelting experiments with artificial oxide ores, where arsenic contents of 4.4% in the ore produced a raw smelted metal with an arsenic content of 4.2%. Experiments with naturally containing arsenic oxide ores have yet to be carried out. On the other hand, experiments with smelting of sulphide ores showed a severe loss of arsenic: an arsenic content of 1.4% in the ore gave an arsenic content of only 0.26% in the matte. The loss of arsenic into the fumes was 82% of the original content of arsenic. Further experiments with different ores under differing conditions will be needed to show whether this is a general phenomenon.

Looking again at the distribution of the three arsenical copper clusters (Figure 113) one finds that they reflect reasonably accurately the settlement pattern of the period involved. I wanted to test whether the artifacts clustered in these three groups geographically belong to one population and used for this purpose the Extension of the Median Test (cf. Chapter IV, p.205 for description of this test). The sites were plotted on a linear distribution (Figure 118) and ranked in order of their west to east distribution. From the ranks a two-way contingency table about the median rank (Table 10)

was made and the test carried out as described in Chapter IV (p.202). The null hypothesis (H_0), that there is no difference in the distribution of these three clusters, was tested against the alternative hypothesis, that there is a difference in the distribution. The degrees of freedom are 2 and a significance level of 5% was chosen, i.e. the probability under H_0 that $\chi^2 \geq 5.99$ is 0.05. Since the computed value for χ^2 is 6.27 the null hypothesis is rejected and the alternative hypothesis is accepted.

The contingency table (Table 10) shows that the expected values (in parenthesis) are roughly equal to the observed values for clusters 2 and 10, but that those for cluster 1.5 differ markedly. We can thus deduce that there is a strong possibility that copper of cluster 1.5 came from a different population (used here in the statistical sense) than those of clusters 2 and 10. This very limited distribution of copper cluster 1.5 in Austria - which consists of associated finds only, as shown earlier, and contains on average about 0.2% arsenic - could suggest exploitation of a local source and might help to explain why there are two different clusters of low arsenical coppers, which have nonetheless normally distributed arsenic contents within themselves.

To suggest a possible local source of copper of cluster type 1.5 is one thing. To say, however, that clusters 2 and 10 are coppers from similar local sources is somewhat speculative at the moment. Only if it could be shown by future research that there is no similar copper outside the artificial boundaries of this study, might one be justified in assuming a source within this area. In the west the boundary has been found to be a true one, because there are few copper artifacts

TABLE 10: CONTINGENCY TABLE FOR 'EXTENSION OF MEDIAN TEST' FOR THE GEOGRAPHICAL DISTRIBUTION OF COPPER CLUSTER 2, 10 & 1.5

	COPPER CLUSTERS		
	2	10	1.5
-	14 (13)	26 (23)	2 (6)
+	12 (13)	20 (23)	10 (6)
Σ_{col}	26	46	12

computed $\chi^2 = 6.27$

Degrees of freedom = 2

Probability under H_0 that $\chi^2 \geq 5.99$ is 0.05

belonging to French cultures coeval with our early copper-using horizon. None of these French artifacts which have been analysed have similar impurity patterns to those in our region.

There are Slovakian copper artifacts which typologically and chronologically have excellent parallels to the first- and second copper-using horizons of the northern alpine region, namely the knives mentioned in Chapter III (p.138), which belong to the Lažňany culture of Slovakia (Šiška, 1972). Later periods in Switzerland, such as the Corded Ware culture, continued to use this particular type of dagger/knife. However, the copper of these Slovakian artifacts - if one can take the seven analyses published in Šiška's paper (1972, Table II) and carried out by Selimchanov, as a representative sample - is rather variable. When these analyses were added to the data file and re-clustered together with the northern alpine analyses, they grouped with several copper clusters (e.g. with clusters 4,6,7,8 and 10) rather than with a particular one. No direct connection between the copper types of the two regions can thus be found, at the moment. A detailed study of the Slovakian material is envisaged and would be highly interesting, but would go beyond the scope of this thesis.

In the south, typological links between Italy and Switzerland belong to a later period, e.g. Remedello type daggers were found in the Corded Ware site of Vinelz. Twenty-two analyses of Remedello artifacts were added to the data file and re-clustered with the northern alpine data (the analyses were those of Junghans *et al*, 1960 and of Otto and Witter, 1952). Half the Italian analyses clustered with copper cluster 8, a further seven with the 'pure copper' (sub-

clusters 1.2-1.4) and the remaining ones with copper clusters 6 and 10. As will be shown later, cluster 8 probably belongs to the EBA and is very atypical for the copper-using horizon of the region, and clusters 1.2 to 1.4 have a mixed early-late chronological association. None of the Italian analyses were found in cluster 1.5. The clustering suggests that Remedello artifacts were made either from a fahlerz - or of a pure type of copper, without, in all probability, sharing sources with the northern alpine region.

In the east, particularly in south-east Austria and northern Yugoslavia, the state of research is too patchy at the moment to allow any definite statements to be made, and further research is needed before final conclusions can be reached.

A further interesting observation was made when all artifacts of cluster 10 containing arsenic values higher than 1.5% were studied. Of the 27 objects so abstracted from the cluster, nine were associated finds, belonging to the Altheim (SAM 10), Pfyn (SAM 7293), Cortailod (SAM 3090, 3095), Mondsee (SAM 4351, 14466 & O & W 256) and Corded Ware cultures (SAM 2842), i.e. they are not exclusively early, a fact born out by some of the unassociated artifacts, particularly daggers, in this group, typologically belonging to the late horizon. Table 11 shows the types of artifacts with arsenic present in amounts larger than 1.5% (under column 'Observed'). The expected values (under the middle column), i.e. assuming that artifacts were indiscriminantly made of either of the three arsenical types of copper, were calculated as a proportion of all artifacts of this type in the three arsenical clusters (shown in the last column). These expected values show quite clearly that there are twice as many daggers as expected made from copper with more than 1.5% arsenic. Flat axes seem to have been

made in equal numbers of high and low arsenical copper. On the other hand, only one tenth of the expected number of beads were made of the high arsenical copper. It seems that the properties of arsenical copper, for instance its increased strength after cold hammering (Tylecote, 1962, 42; 1976, 8) might well have been recognized and utilized, whatever its mode of production from the ore. It is unfortunate, that this observation cannot be supported at the moment by metallographic studies of the artifacts involved.

Summarizing, one can be reasonably certain that one or more types of copper containing arsenic as dominant element were used in the northern alpine area before any other type of copper was used in any appreciable amount.

It must be pointed out that the proviso 'dominant element' is important. Arsenic is a very usual contaminant of copper, and occurs to some extent in almost all the clusters. However, only in clusters 2, 1.5 and 10 is it both the impurity present in highest concentration, and also the impurity with the lowest coefficient of variation (only cluster 4 (cf. below, Section xi) has arsenic with a similarly low coefficient of variation). The term 'arsenical copper' seems justified, since it has already been used by Otto (1973) and also by Sangmeister and Strahm (1974), who pointed out the early occurrence of arsenic-containing copper artifacts in Switzerland. One of the reasons for the confidence that I placed in the clustering method was the coincidence between their conclusions, obtained by visual inspection of SAM data, and my own.

It is likely, although it cannot be proven, that at least some of the objects in cluster 10, containing the highest amounts of arsenic,

were alloyed. This inference is based mainly on the fact that the silver contents of this cluster are normally distributed, whereas the arsenic contents have a bimodal distribution, and that this copper was preferentially used for the production of daggers where the properties of the alloy were particularly useful.

It is likely, that the arsenical copper was at first imported into the region, which after all had no previous experience in the use of metal. At a slightly later time, copper ores containing some arsenic were perhaps also found and exploited locally. The localized distribution of cluster 1.5 suggests one possible source.

In general the notion of a local development - after an initial contact with fully metal-using groups - is supported by the fact that the bars with plano-convex cross-section of which the Cortaillod beads were made, and indeed the beads themselves (cf. p.145) are totally foreign to any other coeval culture not only in the region studied but also outside (cf. Ottaway and Strahm, 1975). As was shown earlier (p. 232) it is very difficult to find, in the immediately neighbouring regions, an arsenical copper that matches that used in the northern alpine areas, implying that the initial import came from much further afield. More detailed research will have to be carried out to confirm the implications of this.

TABLE 11: CONTINGENCY TABLE RELATING ARTIFACTS OCCURRING IN CLUSTER 10 WITH ARSENIC CONTENTS HIGHER THAN 1.5% TO ARTIFACT TYPES.

ARTIFACTS	OBSERVED NO.	EXPECTED NO.	TOTAL NO. OF ARTIFACTS IN CLUSTERS 1.5, 2 & 10
FLAT AXES	10	8.9	40
DAGGERS	10	4.9	22
CHISELS	2	2.0	9
BEADS	1	10.4	47
PENDANT/RING /INGOT	4	0.9	4
TOTAL	27	27.1	122

v) SUB-CLUSTERS 1.2-1.4

As mentioned earlier, these three sub-groups of cluster 1 were the least stable of that cluster (cf. Table 5). The sub-division of cluster 1 could have been stopped at a boundary value of -0.8 , but it was felt that since none of the coefficients of variation was lower than 165 at this stage in the proto-cluster 1.2-1.4, a further sub-division would be beneficial. In fact, as can be seen in Table 6, the coefficients of variation had dropped drastically at a boundary value of -0.5 , so that we find that sub-cluster 1.2 has zero coefficient of variation for both gold and zinc which are absent, sub-cluster 1.3 has no tin, and a low V for antimony, silver, nickel and bismuth. Sub-cluster 1.4, the smallest of them all, with only 7 artifacts, has a low value of V for practically all elements except for gold and iron (cf. also impurity patterns Figure 107), with notable absence of tin, zinc and cobalt. As the actual average values in Table 6 show, all elements in all three sub-clusters, if present at all, are there only in traces, only nickel, arsenic and silver, with average values of about 0.1%, being present at slightly higher amounts (in sub-cluster 1.4).

Sub-cluster 1.4 has the best cultural association (cf. Table 8), almost 60% of objects being associated. From Figure 112 it can be deduced that all associated finds in this cluster belong to the earliest copper-using horizon. However, since this cluster has such a small number of artifacts (7), this can only be a tentative conclusion.

Of sub-cluster 1.2, which contains 50 artifacts, only about 20% are associated finds (Table 8). These few associated finds are almost equally distributed between the early and the late copper-using horizons (cf. Figure 112). This means that small amounts of this

type of copper, which is not too dissimilar from that of sub-clusters 1.4 and 1.5 (cf. Table 6), reached the early copper-using Pfyn culture of Switzerland (e.g. at Schwarzbach, Hüneberg, (SAM 2845), but it was also used in the later Corded Ware site at Vinelz as well as at sites near Vienna. At Vinelz, this type of copper was used to produce ten biconical beads. In Austria, three artifacts of this type of copper belong to the Baden culture (SAM 3730, 4638 and 6080). In view of the fact that so few of the small number of Baden metal finds are analysed, this must be important. The fact that all of the artifacts of the Stollhof hoard are included in this cluster, suggests that the Baden culture either had access to copper resources similar to those available to the producers of the objects in the hoard, or that the Baden population re-used some of the huge artifacts of the hoard, which still has not been satisfactorily dated (for a review on this problem see Angeli, 1967).

Mention of the Stollhof hoard brings up the point that the controlled disintegration of basic cluster 1 did not bring to light the expected sub-cluster of 'native' copper, of the type so frequently found in Copper Age artifacts from Hungary (Bognár-Kutzian, 1963, 500; 1972, 164). The question of native copper is a rather complex one. Tylecote (1976, 1) has shown that copper known to be native can contain one of a number of impurities; on the other hand, by collating all the then extant analyses, I was able to show (Ottaway, 1973, Figure 6) that the most frequent impurity in native copper was silver, present in low concentration and not usually accompanied by any other impurity. It therefore seems reasonable to assume, as do for instance, Otto and Witter (1952, 45), and also Tylecote (1976, 1) that copper artifacts containing only a trace of silver as impurity have been made from

native copper.

The majority of objects from the Stollhof hoard have this composition, and it would have been very satisfactory if they had been found in a sub-cluster of objects which could have been identified as being made of native copper. The fact is, however, that by visual inspection of the datafile (cf. Appendix XXIV and XXV) one can see that there are practically no objects, other than those from the Stollhof hoard, which contain only silver as an impurity, whether alloyed or not with tin. Native copper is remarkable for its absence from copper-using contexts in Austria and Switzerland, which contrasts strongly with its appearance in Early Bronze Age bronzes in the Gemeinlebarn group of cemeteries (Boomert, 1975).

In order to have produced a sub-cluster containing only the Stollhof objects, one would have had to break down cluster 1 to a much greater extent, which would have been generally unwelcome. This explains the 'masking' of the Stollhof hoard in sub-cluster 1.2 and indicates that the hoard should not really have been included. (Inclusion was done on typological grounds, although rather hesitantly, since all its objects are so much bigger than those known from the copper-using horizons of the region).

Sub-cluster 1.3, which has only 10 artifacts, is distinct from the others by its slightly higher average values for bismuth (0.006%) and the presence of zinc, gold and cobalt (cf. Table 6). Again only 20% of the artifacts are associated finds and these belong to the late copper-using horizon (Figure 112, Table 8), such as the small torcs from Lichtenwörth (SAM 4636, 4637). One biconical bead from Vinelz was also grouped with this cluster (SAM 2881) as well as one of the

two flat axes from the Stollhof hoard (SAM 4926).

vi) SUB-CLUSTER 1.1

As Table 5 shows, sub-division of cluster 1 produced sub-cluster 1.1 at a very early stage, and this sub-cluster remained stable down to the final sub-division. Its relatively large number (46) and its high percentage of associated finds (about 70%, cf. Table 8) makes this an important sub-group. The impurity pattern (Figure 107 and Table 6) shows that absence of gold, zinc and cobalt, the presence of nickel (at about 0.1%) are the indicative elements in this cluster.

Such a copper, containing only nickel, is quite probably a native copper of an unusual kind, and it is interesting to see that most of the associated finds in this cluster belong to the Corded Ware culture (cf. Figure 112) which is largely due to 37 beads, awls, daggers and pendants from Vinelz. It seems that this site used this very specific type of copper which is only found in a very few other settlements nearby, such as Lüscherz, Granson and Estavayer, but not anywhere else (cf. Figure 119).

The distribution of the sub-clusters discussed in the last two sections (Figure 119) shows that, whereas at Lake Constance only one type of pure copper - sub-cluster 1.4 - was used, at Vinelz three of the sub-clusters were known. Apart from cluster 1.1, with its very local western occurrence, the distribution of sub-clusters 1.2-1.4 is approximately even throughout Austria and Switzerland.

The question arises, whether a sub-division of the first basic cluster was justified. In my opinion, the fact that the different

sub-clusters coincided with different chronological, geographical and possible metallurgical implications is important, and fully justifies the procedure.

vii) CLUSTER 9

With this cluster, comprising 20 artifacts, we enter a different phase of the metal-using era: the impurity pattern indicates that a more complex copper ore was used, the concentration of the impurities present rise, and the chronological indications are that coppers of the types to be discussed from now on were used at later periods than the purer ones discussed above.

Table 7 and Figure 1'1 show that the indicative elements of copper cluster 9 are antimony (with an average value of about 0.6% and a coefficient of variation of 89%), silver (which is present on average at about 1.4%) and bismuth (present on average at about 0.01%). Gold and zinc are present in trace amounts, other elements slightly higher, but all of these latter elements have a large scatter within this cluster and are not indicative.

Only 15% of the artifacts in this cluster are associated finds, and they fall either into early or later copper-using cultures without giving an indication for any preferred association. Since these few associated finds (SAM 2787, 22223 and O & W 120) do not fit with 100% probability into this cluster, as indicated by the discriminant analysis (cf. Print-out D in pocket at back of Volume II), but could possibly belong to cluster 1, this cluster is virtually unassociated to any particular period within this study and the information that can be obtained from it is very limited. The inclusion in this cluster of one of the two double axes (AXX1) might indicate that this

type of copper belongs to an early BA period and has perhaps a more north central European distribution (cf. distribution map of double axes, Wyss, 1974, 7).

The predominantly Swiss distribution of this cluster could be explained in this way. Another possible indication for a BA date for this cluster comes from the inclusion of two heavy ingot torcs from Lake Mondsee and of an unassociated find from the Rainberg near Salzburg.

viii) CLUSTER 7

This cluster is the result of an experiment in which I included all the bun ingots and metal pieces of this area in the cluster analysis. One group of bun ingots (cluster 7) remained almost unassociated with other artifacts.

Table 7 shows that the most characteristic elements of this cluster (which contains 18 objects) are iron, cobalt and a very low concentration of tin, all with coefficients of variation of around 100%. The high iron content (cf. Figure 110) of this cluster (around 1%) is characteristic for smelted ores which either had contained iron which was removed by the addition of silica, or conversely which had contained silica which was later removed by slagging with iron (cf. Tylecote, 1976, 6 and 1978). The presence of cobalt should help to identify a source of this copper since it is a somewhat unusual marker. This type of copper also contains on average some arsenic (0.13%) and nickel (about 0.25%), but the value of V is slightly high for them to be used as indicative elements.

There are only three artifacts - two awls and one axe - in this cluster, apart from the bun ingots. Figure 112 and Table 8 show that

one of these was an associated artifact (BAR 90) which, however, did not fit very well into this cluster, as shown by discriminant analysis (cf. Print-out D in pocket of Volume II). The fact that it belonged to the middle copper-using horizon is therefore too tentative evidence to be taken any further. The cluster remained unassociated with others, even when cobalt and iron were (separately) masked, which suggests that it does not relate to any of the other copper types in this study.

The distribution of this copper type is a very interesting one: most of the bun ingots (Figure 121) come from the area along the Salzach valley, but also along the Enns, and several were found at the point where the Enns debouches into the Danube. The occurrence of some bun ingots of the same type of copper in Switzerland might suggest that the metal in the form of bun ingots was transported down the rivers Salzach or Enns, and thence along established 'flow patterns' (Chang 1975), into Switzerland. It is in Switzerland, close to where some of these ingots were found, that the three artifacts of this type of copper were found.

In this connection it may be interesting to point out that in the early copper-using horizon, the Pfyn culture had occupied the area in which two of the Swiss bun ingots were found and that this is the culture for which there is evidence of metal working, in the form of crucibles (cf. Figure 93). The culture was known to pass its products on to the Cortailod culture which occupied territory immediately adjacent to it in the south-west (cf. Figures 2 and 7). This established flow pattern may well still have been operative during later periods.

ix) CLUSTER 5

This cluster, which contains 20 objects, is characterized by a large number of indicative elements (cf. Figure 109 and Table 7), all present in higher amounts than hitherto found. For instance, lead (average 0.09%), arsenic (average 0.32%), antimony (average 0.6%), silver (average 0.13%), nickel (average 0.19%), bismuth (average 0.009%), gold (average 0.016%), zinc (average 0.28%) and iron (average 0.12%) all have a coefficient of variation around 100%. Bismuth has the lowest coefficient of variation (84%).

Unfortunately, only one artifact, a dagger from Yvonand, belonging to the Auvernier culture of Switzerland, (BAR 88, cf. App. XXV) was found in secure association, and it is only loosely attached to the cluster as shown by the discriminant analysis (cf. print-out D, Volume II).

Most of the other artifacts in this cluster also come from Switzerland (cf. Figure 120), and the larger proportion of finds on Lake Geneva might indicate a new influence from the West.

Two analyses (BAR 86 and 93) are from the same flat dagger from Auvernier; they were samples from differently coloured zones of the artifact. The two flat axes from Hungary (BAR 43 and 44) should not really have been included in the cluster analysis, but had originally been incorporated because a number of finds in the Vienna museum came from the 'Austro-Hungarian Empire'.

Fifty percent of this cluster are daggers, which are of three types (early - flat daggers with round hafting plate, middle - flat daggers with straight hafting plates, or late - midribbed daggers). A spectacle spiral from Concise, unfortunately without clear

association, was also included in this cluster.

x) CLUSTER 3

This cluster, which was the last to separate from the dendrogram (cf. Table 5), is also one of the smallest clusters (it contains 12 artifacts). It is characterized by the absence of zinc and by a very low value of V for nickel, whose average concentration is 0.5%. Silver (average 0.009%) and trace amounts of tin and cobalt are also present (cf. Figure 109 and Table 7).

The chronological indications for this type of copper are slightly more secure than for the last three clusters which have been discussed: it clearly has a predominant association for the late copper-using horizon. It was used in the Baden and the Corded Ware periods in the region under study. At the Swiss Corded Ware site of Vinelz, awls and a dagger were of this copper (SAM 2835, 2837, 2839), as was one of the small ingot torcs of the Baden culture found at Lichtenwörth in Austria, (cf. Chapter III, p.152). The second analysed double axe from the region is also included in this cluster and the probable EBA date of these artifacts has been mentioned under cluster 9.

Two Austrian bun ingots, one from the Salzach and the other from the Mondsee (cf. Figure 122) which segregated in this cluster could indicate that the east alpine copper zone supplied this type of copper to Switzerland too, as was suggested for copper of cluster 7.

xi) CLUSTER 4

This cluster, which contains 20 objects, is differentiated from cluster 3 by higher arsenic (about 1.3%, with a value of V of

80%) and higher nickel (average 1.5% with a V of 50%). The other indicator elements in this cluster are antimony and silver (with average values of 0.2 and 0.5% respectively) which both have relatively low coefficients of variation. Iron is high (on average about 0.5%) but not as high as in cluster 7 (cf. Table 7 and Figure 110). Cluster 4 contains almost all those bun ingots added to the data file before clustering which did not end up in clusters 7 or 3. It is very interesting to see that although there are slight differences between the composition of the bun ingots and the artifacts, they were similar enough to come together in one cluster. For instance, it is particularly interesting to note that only the ingots, but not the artifacts, contain traces of tin (cf. Table 12). Also arsenic, bismuth and iron are higher in the ingots, yet the basic composition is similar enough for them to be in the same cluster, and the cluster as a whole is quite dense, as can be seen in the discriminant analysis (cf. Print-out D, in back pocket of Vol. II). This print-out also shows that only one dagger (SAM 2834) might be closer to cluster 3 than to cluster 4.

Three of the ingots (SAM 2939, 3027, and 3063) were found in Switzerland and three in Austria (O & W 1269, 1296, 1297); yet the composition of all six is remarkably similar (cf. Table 12). All artifacts except one were found in Switzerland around Lake Neuchâtel and Lake Biel (cf. Figure 123).

Looking at the mean values of the ingots and of the artifacts in this cluster (cf. Table 12) an interesting question arises: Loss of iron, bismuth, arsenic and lead during the manufacture of the artifacts from the ingots can be explained by hot working and melting prior to casting (cf. Slater, 1972, 38), but can the concentration of

TABLE 12: RELATIONSHIP BETWEEN MEAN VALUES OF INGOTS AND ARTIFACTS IN CLUSTER 4

	Sn	Pb	As	Sb	As	Ni	Bi	Au	Zn	Co	Fe
ARTIFACTS	0	0.012	1.35	1.96	0.191	1.5	0.0037	0.0005	0.0093	0.0067	0.09
SD	-	±0.02	±0.91	±0.19	±0.22	±0.73	±0.004	±0.0009	±0.03	±0.01	±0.16
BUN INGOTS	0.01	0.022	1.25	0.19	0.058	1.355	0.0195	0.00003	0	0.0075	1.3
SD	±0.006	±0.04	±1.27	±0.32	±0.1	±0.64	±0.03	±0.00007	-	±0.0018	±1.06

silver and nickel be increased during this process? Tylecote, in recent smelting experiments (1978) has shown that recovery of silver is 100% and recovery of nickel is nearly as high. It is therefore a possibility, but so far we have not enough data, since metallurgists are only beginning to carry out the extensive experiments that are needed. It is, of course, also possible that the rather low number of ingots which survived and which were analysed, and included in this study, may not be representative for the entire population of ingots used. But one thing seems clear: that the Swiss population had access to metal mined, and probably also smelted, in the Austrian Salzach region.

The proportion of daggers made of the copper of cluster 4 is extremely high (cf. Table 13, p.258), so that it can be deduced that this type of copper was preferentially used for daggers. It may well be that the relatively high amount of arsenic was the determinant factor, as we have seen in cluster 10 that twice as many daggers than expected were made of copper containing more than 1.5% arsenic (Table 11). Presumably the improved properties of arsenic-containing copper, such as increased hardness, mentioned earlier, and easier working without cracking, greater strength and rigidity than pure copper, and possibly the recognition that this material could more easily be hardened under hot forging (Böhne, 1965 and Slater 1972, 30) than pure copper, had been recognized and utilized.

In view of the high amount of nickel in the copper of this cluster, it must be pointed out that nickel is also an element which increases the hardness of copper; the possibility of an addition of nickel, or of nickel arsenide, must not be forgotten.

Four of the artifacts (20% of the total) in this cluster belong

to the Corded Ware site of Vinelz (SAM 2834,2838,2843 and 3088) although as was mentioned above, the first of these does not fit as closely into this cluster as the others. Nevertheless, the chronological implication is clear: this type of copper belongs to the late copper-using horizon and not a single artifact comes from an earlier period (cf. Table 8 and Figure 112).

There is an even stronger case than that made out for cluster 7, for a direct link - by whatever means - between the Austrian copper mines in the Salzach valley and the Swiss copper-using population, this time belonging with rather higher probability to a known pre-historic period - the Corded Ware. In other words, it is possible that some of the copper of the Salzach valley (Figure 121) was mined by a group belonging either to the Swiss Corded Ware population or one in close contact with it. This would be procurement. Alternatively, it is possible that copper mined in certain parts of the ore deposits along the Salzach valley, and presumably smelted nearby, was traded along earlier established flow patterns directly to Switzerland.

Considering all three clusters which contain bun ingots (clusters 7, 3 and 4), it is striking that hardly any artifacts made of this type of copper occur in Austria, the probable source area of the ore. Of course, later (that is, BA) artifacts may well have been made of it, and would not have been included in this study. At any rate, it seems likely that at a period during which the Corded Ware and Baden cultures flourished, and possibly earlier, ingots were transported to Switzerland and worked there into artifacts. It is, of course, not known whether the smiths travelled to Austria or the miners travelled to Switzerland, or whether an indirect trade was involved. All three variants are possible, but the very localized

distribution of the three copper clusters, and their absence in intermediate regions, would to me suggest a direct contact between smiths and miners. The absence of hoards during this period suggests that these were not travelling smiths but local metal fabricators who collected their own supply.

xii) CLUSTER 6

We finally come to two small clusters (6 and 8) which contain no securely associated artifacts (cf. Table 8), and are therefore somewhat floating in this present study, and seemed better not represented in Figure 112. The impurity pattern of cluster 6 (cf. Figure 109 and Table 7) shows that this is the first cluster which contains appreciable amounts of tin (average value of 0.6% with a coefficient of variation of 100%). The other indicative elements are arsenic (average 0.16%), antimony (average 0.2%), silver (average 0.09%) nickel (average 0.04%) and bismuth (average 0.005%) all with coefficients of variation around 100%. The high level of lead (average 0.37%) might be characteristic, but since the group has no chronological indications, and has only 13 objects of which several are not very closely connected to the cluster (cf. Print-out D, pocket in Volume II) as indicated by the discriminant analysis, it has no great value for archaeological interpretation.

Its distribution, mainly around Lake Neuchâtel, can be seen in Figure 120.

xiii) CLUSTER 8

This, in contrast is quite a dense cluster, and only two flat axes, which do not seem to belong to the area under study anyway (SAM

3633 and 6373), do not relate closely to it, as indicated by discriminant analysis (cf. Print-out D, Volume II). This leaves us with 10 objects. The impurity pattern (cf. Figure 111 and Table 7) has a striking similarity to the well-known 2:2:1 proportion of arsenic to antimony to silver (on average 1.2 : 1.5 : 0.7 % respectively), which is, characteristic of a copper smelted from the fahlerz type of ores. The absence of gold, zinc and cobalt all with a coefficient of variation of zero, is also characteristic for this cluster. It contains analyses with the highest bismuth values (on average 0.11%, with a value of V of 75%) in all the 362 copper artifacts included in the cluster analyses.

Waterbolk and Butler (1965, Figure 7) give a diagram of 51 Ösenringe whose composition they regard as characteristic. The composition is identical to that of cluster 8, and we may thus regard the objects made of this type of copper as fabricated from 'Ösenhalsring' copper, which is widely distributed throughout Austria, Bohemia and Moravia at the beginning of the EBA. (It is distinguished by the absence of nickel from the otherwise similar fahlerz copper found at Singen, which the Dutch call 'Singen metal'). The fact that so few objects in my group of 362 were fabricated from this type of copper increases confidence in the original choice of objects, whether securely associated, or included only on typological grounds.

Cluster 8 includes seven heavy ingot torcs of the type well-known for the EBA, mostly from Lake Mondsee (SAM 3772-6, and 4439), and two spiral bracelets, which were only included because they were similar to those of the Stollhof hoard. It seems therefore that copper of this cluster really belongs in the EBA and is yet another

demonstration of how well the cluster analysis has worked on the data.

Only the flat axe from Cham St. Andrea (SAM 2844) is somewhat puzzlingly included in this cluster. It is an axe of type Thayngen and belongs to the Pfyn culture. Its presence here can, however, be explained when the actual analysis of the axe is inspected: it is made of virtually pure copper containing only a high concentration of antimony (2.7%), and silver (0.086%). No other artifact with a similar analysis has been found in the region studied here and those in cluster 8 are clearly the most similar. We must therefore consider the possibility that during the early copper-using period not only arsenic-alloyed, but also antimony-alloyed artifacts, or metal, came into the northern alpine region, but so far this axe is the only evidence for this hypothesis. We should perhaps regard it as a sporadic, somewhat precocious occurrence, just as tin bronzes have been found to appear sporadically in the Copper Age of central Europe. Artifacts containing very high concentrations of antimony (about 5%), but also containing several percent of nickel and arsenic are known from Switzerland, e.g. from Salez (cf. analyses BAR 80,81, Appendix XXI, and also SAM 2768,2779-2784,3761-3762). They are flanged axes and are usually taken to belong to the EBA.

The distribution of cluster 8 is almost exclusively Austrian (cf. Figure 120) but it is clear that if artifacts of EBA types had been included, this cluster would be far larger in size than it is now. It should also be remarked that the most homogeneous group of the Remedello analyses (cf. Section iv, of this Chapter, p.234) segregated with this cluster.

xiv) CORRELATION BETWEEN ARTIFACT AND COPPER TYPE

It has already been shown that several of the types of copper were used preferentially for the fabrication of daggers. This was found to be particularly true for cluster 4 and for artifacts in cluster 10 with arsenic values larger than 1.5%. In an attempt to find out whether there is a general correlation between types of copper and types of artifacts, a contingency table was constructed (Table 13), and the χ^2 test was carried out (cf. Chapter IV, p.202). The null hypothesis, H_0 , that there is an equal chance for any type of artifact to be made of any type of copper was tested for significance. The degrees of freedom are 21 and the significance level of 1% was chosen, i.e. the probability (of random association) under H_0 that $\chi^2 \geq 38.9$ is 0.01. Since the computed value for χ^2 is 130.03, the null hypothesis is rejected and the alternative hypothesis, that copper types do correlate with certain types of artifacts, is accepted. The expected values (in parenthesis) in Table 13 give a clear indication where the correlations are to be found. For instance, it is apparent, when comparing the observed with the expected values, that far fewer flat axes than expected were made of copper of type 1.1 (observed 1; expected 12.1) whereas this type of copper was preferentially used for beads (observed 34; expected 17.8). On the other hand, daggers were made preferentially from copper of types 3, 4 and 5 (observed values for both 12 and 10 respectively, expected values 3.8 and 2.6 respectively) and not of copper type 1.2 (observed 0; expected 5.2). The earlier observation, that the number of daggers with arsenical contents higher than 1.5% within cluster 10 tended to be twice as high as expected, does not come out in Table 13, since all artifacts in the clusters are considered here. Clearly, more detailed

information can at times be extracted when single elements within a cluster are studied, e.g. as in Section iv of this Chapter, by the Rankit test. Cluster analysis, which deals with the distribution of all eleven elements in space - or better in hyper-space - cannot, and indeed should not, focus attention on one element alone, and has difficulty in distinguishing very impure, as well as very pure, analyses.

Table 13 shows that beads were preferentially made of copper types 2 and 1.1 (observed 20 and 34 respectively; expected 15.8 and 17.8 respectively) but not of copper types 5 and 3/4.

Awls and chisels tended to be made of copper types 3/4 (observed 7; expected 2.3). Other, but less significant differences can be seen on inspection of the contingency table.

xv) CORRELATION BETWEEN ARTIFACT TYPES AND CULTURES

Having established that there is a correlation between the copper types and the cultures and also between the copper types and the artifacts, it is hardly surprising to find that there is an implied correlation between the artifact types and the cultures (Table 14). This contingency table was constructed - of necessity using only associated finds - to test the null hypothesis, H_0 , that there was a random association between artifact types and the cultures which used them, against the alternative hypothesis, H_1 , that certain types of artifacts were preferred by certain cultures. The degrees of freedom are 4 and the significance level of 1% was chosen i.e. the probability under H_0 that the $\chi^2 \geq 13.28$ is 0.01. The value computed for χ^2 is 39.57 and therefore we must reject the null hypothesis and accept the alternative hypothesis. In other words, there is an association between

certain cultures and certain types of artifacts. This, of course, is one of the basic principles of archaeology, but not always easy to prove. In this instance we may note that the early copper-using cultures preferred flat axes (observed 35; expected 19.3), whereas the later ones did not (observed 1; expected 4.7). On the other hand, early copper-using cultures did not have ingot torcs, whereas the later ones did. Beads occur in both early and late horizons; but no distinction was made in Table 14 between cylindrical and ring beads on the one hand - as known from the Cortailod settlements, and biconical beads on the other - as occur at the Corded Ware site of Vinelz.

This raises the question of the meaningfulness of testing association between copper types and artifact types. I would say that in the early horizons the association between artifacts and copper types is secondary - that is, artifact types known to an early culture (e.g. flat axes) can only be made of one (or a few) kinds of copper, because that culture only had access to one (or at most a few) types of copper. On the other hand, in the late horizons the association is probably primary, because these cultures had access to several different types of copper, and if artifacts were made preferentially from one type, the presumption is that this was a deliberate choice.

TABLE 13 : CONTINGENCY TABLE; ARTIFACTS AGAINST COPPER CLUSTERS

ARTIFACT TYPES		COPPER CLUSTERS										Σ row
		2	10	1.5	1.2	1.1	9	5	3&4			
Flat axes	10 (10.8)	22 (15.2)	8 (5.2)	13 (7.2)	1 (12.1)	6 (2.8)	2 (3.6)	0 (5.2)	62			
Daggers	5 (7.8)	13 (11)	0 (3.8)	0 (5.2)	3 (8.8)	2 (2)	10 (2.6)	12 (3.8)	45			
Awls & Chisels	4 (4.7)	3 (6.6)	1 (2.3)	3 (3.1)	6 (5.3)	2 (1.2)	1 (1.6)	7 (2.3)	27			
Beads	20 (15.8)	17 (22.2)	10 (7.7)	10 (10.5)	34 (17.8)	0 (4)	0 (5.3)	0 (7.7)	91			
Σ col.	39	55	19	26	44	10	13	19	225			

computed $\chi^2 = 130.03$

Degrees of freedom = 21

Probability under H_0 that $\chi^2 \geq 38.9 = 0.01$

TABLE 14: CONTINGENCY TABLE OF ARTIFACT TYPES AGAINST CULTURES

CULTURES	ARTIFACT TYPES						Σ row
	FLAT AXES	DAGGERS/ KNIVES	AWLS	BEADS	INGOT TORCS		
Early copper-using cultures.	33 (19.3)	7 (7.4)	2 (6.2)	47 (52.2)	0 (4.0)		89
Late copper-using cultures.	1 (14.7)	6 (5.6)	9 (4.8)	45 (39.9)	7 (3.0)		68
Σ col.	34	13	11	92	7		157

Degrees of freedom: 4

Probability under H_0 that $\chi^2 \geq 13.28$ is 0.01computed $\chi^2 = 39.57$.

V.4 THE BRONZE CLUSTERS

The analyses of the eighty artifacts which were detached from the main data file, because they contained more than 2% tin, were clustered using the same clustering programs as those used for the copper objects. It was felt that by masking tin, the underlying types of copper would emerge, and this would indicate whether they were similar to the copper clusters discussed in the previous Sections. This was done first. Six main clusters, A-F, can be discerned from the dendrogram (Print-out B in pocket at back of Vol. II), using a boundary value of -5.1. The number of objects in each of these clusters is of necessity smaller than when 360 objects were grouped, and inferences drawn from them may not hold true if more data were to be included. The mean values for each element together with their percent coefficient of variation, for each of these six clusters, can be seen in Table 15, and their visual representation is shown in Figures 126 and 127. A list of the analysis (i.e. laboratory) numbers contained in each of these six clusters is given in Appendix XXVII.

The clustering was then repeated, using un-masked data for all elements. The resulting dendrogram (cf. Print-out C in pocket of Vol. II) shows that the number of clusters, and indeed the objects in most of the clusters, remain the same, regardless of whether tin was masked or not. The mean values for each element and the percent coefficient of variation for these six clusters (a-f) are given in Table 16, where again the low values of V are stressed by heavy outlines. It can be seen when comparing the two tables (15 and 16) that the compositions of clusters A-D and F, and of a-d and f, are very similar, in fact, clusters B and b are identical. Only cluster e, which now contains all analyses with tin values larger than 10%

(which had been assigned the value of 15%) has changed.

Only very few of the bronze artifacts in all these clusters come from securely associated finds. One of them is the awl from Sion, Switzerland, which I was allowed to sample (analysis BAR 50, Appendix XXI) and which could either belong to the Bell Beaker (so-called 'Neolithique final') or to the Early Bronze Age I phase (Galley 1972c). The other is an awl or rivet from Altheim (SAM 7) which must be assumed to have been found together with the other metal finds from Altheim itself (Driehaus, 1960, Figure 35). The ring from Unterwölbling (O & W 177) comes from an EBA type site and should perhaps have been excluded from the study. None of the other finds are associated to any of the copper-using cultures studied here, yet they were included, as pointed out earlier, on the basis of their typology. There are 4 awls and 2 daggers made of bronze from Seewalchen, Attersee and it is not clear whether they belong to the Neolithic Mondsee culture or to a later BA occupation of the site. Their copper does contain relatively high arsenic contents (cf. Appendix XXIV) as did most of the analysed Neolithic Mondsee artifacts, but at least one of the daggers (SAM3616) is of totally different copper and contains lead and high amount of iron.

Some of the copper clusters discussed in the previous sections had shown a tendency to occur in late copper-using horizons only, and others a very tentative tendency to be linked to EBA, such as copper cluster 8. It now appears that none of the bronze clusters can be securely linked to the earlier horizons, and when the impurity patterns of the copper clusters (Figures 107-111) and those of the bronze clusters (Figures 126 & 127) are compared, it becomes clear that they are totally dissimilar. The bronze clusters have much

TABLE 15: MEAN VALUES AND THEIR % COEFFICIENT OF VARIATION (V) OF EACH ELEMENT IN BRONZE CLUSTERS A-F (WHEN TIN IS MASKED).

BRONZE CLUSTER NO.	IM-PURITY →	Sn	Pb	As	Sb	Ag	Ni	Bi	Au	Zn	Co	Fe	NO. OF OBJECTS IN CLUSTER
A	MEAN V	(9.08) (48)	0.097 207	0.773 38	0.237 82	0.076 102	0.505 96	0.0035 161	0 424	0.001 424	0.0011 253	0.1 148	18
B	MEAN V	(6.41) (53)	3.898 129	1.055 36	1.759 47	0.692 64	0.878 80	0.0435 218	0 316	0 0	0.0145 209	0.003 156	10
C	MEAN V	(8.96) (26)	0.744 57	0.876 79	0.457 55	0.107 85	0.436 56	0.015 85	0.0106 39	0.037 265	0.2414 54	0.067 62	7
D	MEAN V	(10.26) (76)	0.288 181	0.162 92	0.228 127	0.082 112	0.137 116	0.0088 143	0.0156 419	0.001 566	0.01 234	0.034 172	32
E	MEAN V	(12.83) (42.5)	0.219 108	0.291 73	0.23 112	0.043 124	0.295 91	0.0084 87	0.0025 166	0.02 245	0.0127 81	1.477 62	6
F	MEAN V	(12.81) (81)	0.19 113	0.348 112	0.161 110	0.052 133	0.082 88	0.033 172	0.0021 112	0.435 63	0.012 135	0.127 159	8

TABLE 16: MEAN VALUES AND THEIR % COEFFICIENT OF VARIATION (V)
OF EACH ELEMENT IN BRONZE CLUSTERS a-f.

BRONZE CLUSTER NO.	IM-PURITY	Sn	Pb	As	Sb	Ag	Ni	Bi	Au	Zn	Co	Fe	NO. OF OBJECTS IN CLUSTER
a	Mean V	8.43 48	0.087 183	0.833 29	0.23 90	0.051 103	0.246 45	0.0047 150	0 0	0 0	0.0008 252	0.092 139	12
b	Mean V	6.41 53	3.898 129	1.055 36	1.759 47	0.692 64	0.878 80	0.0435 218	0 316	0 0	0.0145 209	0.003 156	10
c	Mean V	8.31 34	0.776 52	0.766 93	0.55 64	0.125 79	0.431 53	0.0189 85	0.0543 228	0.033 283	0.2204 61	0.063 65	8
d	Mean V	8.52 45	0.282 194	0.172 91	0.216 112	0.066 103	0.108 109	0.0062 123	0.001 271	0.001 520	0.0059 318	0.022 201	27
e	Mean V	15.99 63	0.185 126	0.334 66	0.199 95	0.098 106	0.505 102	0.008 150	0.0074 315	0.021 223	0.0129 142	0.565 148	18
f	Mean V	8.08 68	0.134 145	0.372 123	0.144 143	0.043 185	0.092 89	0.0415 154	0.0019 115	0.538 43	0.006 99	0.147 159	6

higher contents of impurities and one of the clusters, cluster B, indeed seems to have had lead added to it. I shall therefore only briefly discuss the individual bronze clusters in the following Section.

V.5 DISCUSSION OF THE INDIVIDUAL BRONZE CLUSTERS
(A-F, CLUSTERED WITH MASKED TIN)

i) CLUSTER A

Table 15 and Figure 126 show that this second largest cluster contains moderately high amounts of arsenic (average about 0.8%) with a low coefficient of variation, and high amounts of nickel (average of 0.5%) again with a low value of V. Other indicative elements in this cluster (expressed by their low values of coefficient of variation are antimony, silver and iron (present at about 0.2, 0.08 and 0.1% respectively). This cluster apart from containing the Alheim artifact mentioned in the previous section, also contains 9 daggers, i.e. 50% of the cluster are daggers. The distribution of this, and all the other bronze clusters, can be seen in Figure 128.

ii) CLUSTER B

This cluster contains on average almost 4% lead, an amount of this element too high to occur naturally in the ore, and the metal was therefore alloyed with lead - a characteristic occurrence in LBA of, e.g., Britain (cf. Tylecote, 1968, 48). The basic copper in this cluster is of the fahlerz type with high arsenic, antimony and silver (average values of 1.06, 1.7 and 0.7% respectively, all with low values of V), but also with a high content of nickel (on average about 0.9%, coefficient of variation of 80%). Zinc is absent

with a coefficient of variation of zero. The distribution of this cluster is entirely around the area of Lake Neuchâtel and would suggest that either a source of copper with nickel was locally exploited, or that this area had now contact with an eastern supply of this distinct type of metal.

iii) CLUSTER C

In this cluster - the second smallest, containing only 7 artifacts - almost all elements have a low coefficient of variation (cf. Table 15) the only exception being zinc. The concentration of lead is quite high (average of 0.7%) and so are the concentrations of arsenic and nickel (on average 0.9 and 0.4% respectively). Again its distribution is confined entirely to the area around Lake Neuchâtel (Figure 128).

iv) CLUSTER D

This is the largest of the bronze clusters and contains 32 analysed artifacts. It has considerably lower contents of arsenic, silver and nickel than those mentioned above (0.16, 0.08, and 0.14% on average respectively, all with a low value of V). Further indicative elements are antimony and bismuth (present on average at 0.23 and 0.009% respectively). This type of bronze can, like that of clusters A and E, be found in Austria as well as in Switzerland.

v) CLUSTER E

This is the smallest cluster, containing only 6 analyses. It is not surprising that it is very coherent, with low coefficient of variations for all but one element (cf. Table 15). The high amount

of iron (on average 1.5%) is indicative for this cluster.

vi) CLUSTER F

This again is a rather small cluster, containing only 8 analyses and the coefficient variation is small for most elements (cf. Table 15 and Figure 127). The high amount of zinc (on average 0.4%), together with the very localized distribution, partly in the Vallais and partly on Lake Neuchâtel, might indicate again exploitation of a small local source (Figure 128), but the number of the artifacts included in this cluster is too small to allow more than tentative conclusions.

It has been shown that none of the bronze clusters resembled any of the copper clusters discussed earlier. This indicates that entirely different types of copper were used in the region under study for bronzes. The indications are that most of them come from the west rather than from the east, with a possible start of exploitation of small local nickel-containing sources in the south-western parts of Switzerland. Alloying with tin was not in use in the early copper-using horizon. In Switzerland typological and settlement evidence points to an overlap of the EBA and the latest copper-using horizon, and it is possible that the use of tin bronzes and the use of copper went on side by side for some time. At the least then one is justified in concluding that the artifacts containing tin belong to the latest copper-using horizon, and maybe to a later period still.

V.6 SOURCES OF THE COPPER ORE

It is of great interest for the tracing of patterns of movement, contact and trade, to find the sources of ores from which the raw materials were made (Lamberg-Karlovsky, 1975). Basically, three

approaches are possible:

- i) the distribution of objects of a particular copper type in geographical areas;
- ii) the empirical approach, i.e. detailed analysis of a large number of ores and artifacts from a restricted area; and
- iii) the geological approach.

Since both of the first two approaches have hitherto not been entirely successful, I shall discuss the last one first.

Pelissonnier and Michel (1972) have studied the distribution of existing and perhaps undiscovered copper ores throughout the world. In doing so they discussed exhaustively the previously published classifications of these ores and produced a relatively simple classification of their own, which relates ore types to the surrounding rocks. This work should enable one to introduce a new conceptual idea of basing groups on geomorphological evidence. Although Pelissonnier and Michel's interests lean heavily toward industrial exploitation of copper resources, their division of the majority of all deposits into 13 groups might well prove suitable as a theoretical basis for grouping of prehistoric copper analyses, when more work on the exact relation between the ore and the smelted metal has been carried out. Their classification shows up strong correlations between certain types of copper deposits and the type of rock in which they are usually found (Table 17). It is also flexible enough to allow for variation within the vertical layers of one deposit, thus eliminating one of the basic criticisms of other grouping methods. It may bring us ultimately closer to the original aim of all metal analyses, i.e. to try and trace the metal back to the

original source of raw material. It will probably also enable us to view prehistoric centres of metallurgy with a critical eye by inspecting the surrounding geology and allowing us to make 'informed guesses' as to whether copper deposits, which are now exhausted, might have been present in prehistoric periods.

It would go beyond the scope of this study to do more than outline briefly the 13 types put forward by Pelissonnier and Michel (1972, 129-223). They were obtained by distinguishing three domains for the major elements iron, sulphur and oxygen, and by using the minor elements as sub-characteristic markers. There are a number of types which can be excluded for early prehistoric use in Europe, leaving us with the types represented in Figure 124. Both types 7 and 11 occur in Austria, type 11 also in restricted locations in Switzerland. Type 7 is of particular interest in that it is a possible source of a natural alloy of copper and arsenic. It is not, however, at all widely distributed in Europe, and it is not known whether the only major deposits there (at Bor in Eastern Serbia) were worked before modern times. Types 11 and 12 can according to Pelissonnier and Michel often not be clearly distinguished from one another. They are characteristically found in shallow, quickly exhausted deposits near the surface (Mitterberg with its deep layer being the exception). In spite of the small proportion of the total world copper ore deposits which they form, they are widely distributed throughout Europe, particularly in the Eastern Alps, and in the Carpathians. The best known deposit is at Mitterberg but there are several other deposits in Austria.

The large scale experimental study by Rapp (see Chapter IV, p.171) and also further experiments by Tylecote on smelting native

TABLE 17

TYPE	MAJOR ELEMENTS	MARKER ELEMENTS	TYPICAL ASSOCIATED ROCKS	PER CENT OF TOTAL WORLD Cu DEPOSITS
1	S, Fe	Zn, Pb, Ag, Au, Se, Fe, Ba.	Massive pyrite deposits in volcanic tuffs and agglomerates.	10
2	[S]	Ag, Zn	Lavas and tuffs (no pyrite).	~1
3	(native Cu)	Ag	Basalt lavas	2
4	-	Ag, Co	Sedimentaries - sandstones, clays (some native Cu).	27
5	[S]	[Sn] Bi, W, Ag	Cu-bearing tin deposits in subvolcanic granites	<1
6	[S]	[Mo] Au, Re	Porphyry, subvolcanic granodiorites.	48
7	S, [Fe]	[As] Ag, Pb, Zn	Enargite in subvolcanic granodiorites	4
8	Fe, O	Co, Ni, Au	Basic intrusive rocks; diorite, gabbro, diabase sills.	2.5
9	S, Fe	[Ni] Pb, Co	Basic and ultrabasic intrusions.	2
10	[S]	Co, Au	Quartz veins in schists and carbonates.	0.05
11	[Fe] [S]	[Co] [Fe] [Sb] Ni, Ag, Bi, Hg Ba.	Siderite - no typical country rock. Tetrahedrite veins.	<0.1
12	Fe, S	[As] Au, Ag, Bi.	Schist, sandstone, sometimes lava. Mispickel.	~1
13	-	[Ge] [As] Pb, Co, U, V, Mo, Ag, Cd, Zn.	Tennantite in carbonate rocks.	<1

copper, copper carbonate and sulphide ores, coupled with the determination of their impurity patterns, may also bring us a large step nearer to the provenancing of copper ores.

The second approach has been followed by Otto and Witter (1952) and by Pittioni (1957, 1959, 1964, 1965, 1966, 1967, 1971). Since it has been established in this Thesis that the Salzach region in Austria supplied the northern alpine area with some of its raw metal, possibly even during the middle copper-using horizon in Switzerland, it seemed desirable to make use of the studies of Pittioni. He has repeatedly pointed out that the reason why he cannot accept Witter's results is that no allowances were made for the variations in composition of differing lodes of the same mineral deposit (Pittioni, 1957, 3). This is perhaps a reason why Otto and Witter's work has not been followed more closely by later workers, because basically their grouping method was more meaningful than that of Junghans *et al* (1960, 1968, 1974) which was purely statistical. However, Pittioni's semi-quantitative analyses, which - though perhaps more sensitive in detecting the lower concentrations of impurity than Stuttgart's quantitative method - do not facilitate objective comparison with other analyses. Pittioni's results are subdivided into 7 arbitrary, unequally large subgroups (not detected, not certainly detected, trace, + and ++ and +++ and main component).

Neuninger & Pittioni (1962a) compared 37 artifacts which had been analysed by both Pittioni's and Stuttgart's methods. From this work it is evident that there is a considerable degree of overlap in Pittioni's groups. This is particularly noticeable for the elements lead, silver, arsenic and bismuth (cf. Neuninger and Pittioni 1962a, Figure 1) where for instance, a value of bismuth of 0.01 (according to

Stuttgart's determination) could belong to any of three groups (trace, + or ++) in Pittioni's scale; an arsenic value of ca 5% could belong to either + or ++, and a silver value of 0.01% could be either trace or +, whereas a silver value of 0.02 could be + or ++. The authors say that '... a slight overlap cannot be avoided, because the eye cannot measure as accurately as the photometer' (1962a, p.99). They propose a reasonable agreement for the two laboratories for the four main elements tin, silver, arsenic and nickel (cf. 1962a Table 16), but suggest that one cannot compare the results of the two methods without due consideration.

Bearing these restraints in mind, I have nevertheless attempted to give quantitative values to Pittioni's three basic types of copper ore: the east-alpine type, the Bertha Grube type (Tyrolean) and the East copper (Ostkupfer), and have shown this in Table 18 and Figure 125, because it seems a great pity to leave such valuable material unused. However, the variations within each element - indicated in Figure 125 by the vertical bars - in each of the groups are so big that only a very rough approximation indeed can be obtained.

Nevertheless, none of the copper clusters described in the previous pages agree with any of Pittioni's alpine groups of copper, which is very unexpected in view of the distribution maps (cf. Figures 121-3). Only copper cluster 8, which has, as pointed out earlier, a typical Fahlerz composition, resembles at all closely Pittioni's East copper (Ostkupfer). The high amounts of arsenic, antimony and silver, and also of bismuth are found in both the Ostkupfer and cluster 8; the absence of lead in cluster 8 could also lie within Pittioni's East copper group with its range of lead from zero to 0.02%. Pittioni thought that the east copper was probably of Slovakian origin, and it

TABLE 18: CONVERSION OF NON-NUMERICAL SYMBOLS USED BY PITTIONI TO NUMERICAL SYMBOLS: USING 37 ANALYSES CARRIED OUT BY BOTH PITTIONI'S SEMI-QUANTITATIVE AND BY STUTTGART'S QUANTITATIVE METHOD (NEUNINGER & PITTIONI, 1962a)

	Sn	Pb	As	Sb	Ag	Ni	Bi	Au	Co	Zn
++	1-10	0.08-5	0.5-3	0.08-1.15	0.01-1.0	-	0.004-0.051	?	?	whole %
+	0.05-1	0.008 -0.02	0.01-0.07	0.06-0.69	<0.01-0.05	0.05-1	0.004-0.021	?	?	tenth and % hundredth
trace	-	0.008 -0.02	-	<0.03-0.03	<0.01	<0.01-0.09	0.003-0.004	?	?	?

TABLE 19: ATTEMPTED CHARACTERIZATION OF PITTONI'S 'EAST-ALPINE',
'BERTHA GRUBE' AND 'EAST-COPPER'.

PITTONI'S COPPER TYPES										
	Sn	Pb	As	Sb	Ag	Ni	Bi	Au	Co	Zn
East alpine	trace -	0-trace 0-0.02	0-trace 0-0.7	- -	trace - + <0.01-0.05	trace - + <0.01-1.0	- -	- -	trace -	- -
Bertha Grube	trace -	+ - ++ 0.008-5	+ 0.01-0.7	trace <0.03-0.03	+ - ++ <0.01-1.0	trace - + <0.01-1.0	trace - + 0.003-0.021	0-trace -	trace -	0-trace <0.01
East copper (Ostkupfer)	0-trace -	0-trace 0-0.02	+ 0.01-0.7	trace - + <0.03-0.69	++ 0.01-1.0	- -	+ 0.004-0.021	- -	- -	- -

is interesting to note the almost entirely eastern distribution - within the region studied in the thesis - of cluster 8 (cf. Figure 120). The typological indications of this cluster pointed towards the Bronze Age rather than earlier periods, although none of the finds were associated to the Bronze Age, and this could agree with Pittioni's finding of this type of copper. He pointed out that the bulk of Early Bronze Age material was not supplied by the east alpine mines, but came from further east. He showed that in 37 Ringbarren hoards, which were usually taken as an indication of EBA east alpine copper mining activities, 87% of the 1053 analysed artifacts were made of his 'East Copper' (Ostkupfer), and only 3% were made of east alpine and Tyrolean copper (Pittioni, 1964). As a source for his 'East Copper' Pittioni suggested Slovakian or Hungarian copper ores. So far, however, ancient Slovakian copper mines have not been found, although the area is rich in copper-bearing minerals.

According to Pittioni, a few artifacts from the Attersee and Rainberg near Salzburg are made of 'East Copper'. I found his distinctions sometimes difficult to follow, but have been able to trace the analyses of some 10 artifacts which were specified by Pittioni to have been made of Ostkupfer, but which had also been analysed by Stuttgart. The resulting average impurity pattern is depicted in Figure 125d.

In general it is remarkable how few associated early artifacts of this type of copper there are. This suggests that it is a later appearance in the northern alpine area, which was what Pittioni had suggested in the first place.

Returning now to the first approach, that of tracing a pattern

of movements of the metal, and finding possible sources of ores from which the raw material might have come; this was the approach adopted by the Stuttgart team (Junghans, et al, 1960, 1968, 1974), in their ambitious attempt to provide a system embracing the Eneolithic and Early Bronze Age of Europe as a whole, using statistical methods to provide groups which were obtained without taking archaeological judgements into account. This method was rightly criticised by Waterbolk and Butler (1965), who suggested using a graphical method for classification of analyses, starting with archaeologically homogeneous groupings. Their method which has been discussed in Chapter IV (p.190) worked well for small groups but is extremely tedious for large numbers of analyses, as has been pointed out by Doran and Hodson (1975, 247).

By using basically a combination of these two approaches, i.e. by confining myself to a very precise time and space horizon and applying statistical methods to provide the groupings, I have been able to obtain information on some of the sources. However, the difficulties I found in tying more than a few of the copper types to any particular source area indicates how futile this attempt would be if undertaken on too large a scale, geographically and chronologically. This difficulty is furthermore increased by the probability that raw material was re-used after the onset of the full Bronze Age. However, a deep insight into the pattern of movements and contacts of the copper-using populations was obtained, and this in itself is a considerable achievement.

V.7 CONCLUSIONS

A complex pattern has thus been elucidated for the period immediately preceding the Early Bronze Age in the northern alpine region. The pattern is more complicated than can be covered by a simplistic explanation or model.

The early copper-using horizon - which included the Altheim, Pfyn, Cortaillod and Mondsee cultures - had a few very distinct types of copper, mostly containing arsenic, and some possibly alloyed with it. Sites like the Cortaillod settlement of Burgäschisee-Süd have a particularly clear pattern: no types of copper other than of clusters 1.5, 2 and 10 were used (cf. Figure 112) for the production of their tools and ornaments. Similarly, for Altheim implements, only copper types 1.5 and 10 were used. But here the situation is made less clear by the fact that one of the small awls or rivets from Altheim is made of bronze, whose copper is totally unlike that of the copper clusters.

Considering the Pfyn culture as a whole, a study of the analysed artifacts indicates that far more than just one or two basic types of copper were used. They can be made of copper clusters 1.1, 1.2, 1.4, 2 and 10. This, together with the large number of crucibles found exclusively at Pfyn sites in Switzerland (cf. Figure 93), some of which have traces of metal still inside, is, to my mind, a clear indication that a part of the Pfyn population were metal workers who obtained their raw, but perhaps smelted, material from various sources, whereas the inhabitants of settlements such as Burgäschisee-Süd were recipients of finished and semi-finished objects which they perhaps fashioned themselves into some of the final products - e.g. such as the ring and

cylinder beads known at that period nowhere outside the Cortaillod culture - but who did not have contact with as many metal-using or producing centres as the Pfyn culture did.

The very localized distribution of copper cluster 1.5 has been taken to suggest, tentatively, that this type of copper was mined or worked in the Mondsee and Attersee area and that trade or exchange patterns of this type were on a limited scale only.

Moving to the middle copper-using horizon, which included the Horgen and Lüscherz cultures, and which was, as shown in Chapter II, much poorer with regard to copper finds, only one of the copper types used on the earlier horizon continued to be used: cluster type 2. Other types such as cluster 5, 7 and 9 also began to be used at this time.

The late copper-using horizon - which included the Baden, Auvernier and Corded Ware cultures - presents quite a different, and wider, spectrum of types of copper used. The population at the Corded Ware site of Vinelz, for instance, used cluster types 1.1, 1.2, 1.3, 3, 4, 9 and 10 for their implements. Further east, at the Baden site of Lichtenwörth, copper types 1.2, 1.3 and 3 were used.

We have thus in this late horizon a predominance of types of copper which were rarely, if at all used in the early horizon (cf. Figure 112). Moreover, copper of cluster 4 can be safely assumed to have been mined in the Salzach region as was shown by the analyses of bun ingots from this region (cf. Figure 123).

It has been explained that the bun ingots, although they are commonly taken to be of Bronze Age date, were included as an experiment. The results, in my view, justify the venture. It is significant, that

only for copper types used in the later copper-using horizons are there bun ingots of comparable composition (i.e. clusters 3 and 4). A number of bun ingots remained in a group by themselves (cluster 7) indicating that this type of copper was not in use during the period studied here. The absence of any ingots of the early arsenical copper of clusters 2 and 10 could indicate that this material came from outside the region, although a search for similar copper has so far failed to find areas in which artifacts made of this type of copper are concentrated, in the coeval cultures of the immediate neighbourhood to the south, west and north-east.

Thus a combined study of the possible ores, the bun ingots and the distribution of the copper clusters in the region under study has shown that the Austrian Alps were very likely sources of some of the raw material for artifacts of this thesis. This was particularly marked for copper of the types of cluster 1.5, 3 and 4. Of these clusters 1.5 and 4 could be linked to a definite period - to the Mondsee and the Corded Ware periods respectively. The former link was based on the very limited distribution of artifacts of this type, whereas the latter is more definitely linked to the actual mining area by the occurrence of ingots of very similar composition as artifacts in Swiss Corded Ware sites. The complex impurity pattern of cluster 4 suggests that a sulphide ore was mined.

None of Pittioni's Austrian copper types were found to occur in the region during the period under study. This implies that Mitterberg itself, and the Bertha Grube, were exploited after the period under study here. Pittioni had at first (1957,56) put forward the idea that mining activity began at Mitterberg and related mines in the area before the EBA, but in 1964 he changed this to the beginning of the

EBA. It seems from the work reported here, that there are strong indications that some of the mines of the area around Mitterberg, but not Mitterberg itself, were worked before the EBA, particularly during the Baden and Corded Ware periods.

Pittioni's 'East Copper' (Ostkupfer) was represented by my cluster 8 which had, however, no secure links to any pre-Bronze Age period in this region. According to Pittioni this Ostkupfer probably had a Slovakian origin, and this might indicate a flow pattern from Slovakia to Austria. Contact with Slovakia in an earlier period has been suggested on typological grounds (cf. Chapter III, 138) but there is no evidence that this contact existed with regard to copper.

It could be shown that a correlation between copper types and artifacts existed. This was particularly marked for daggers, which were made preferentially of a type of copper containing relatively high amounts of arsenic, particularly clusters 3, 4, 5 and 10.

The bronze clusters, which were formed from analysed artifacts which had been included on a typological basis only, were found to be totally different in composition from any of the copper clusters, even when the tin contents were masked before clustering. Nor did they resemble any of Pittioni's copper types. Their distribution is predominantly a western one and could indicate the beginning of local exploitation of small copper sources in Switzerland during the EBA, or alternatively, mark the beginning of influence and contact with France.

The continuation of a few types of artifacts, foremost among

them daggers, awls and chisels, from the copper-using phases into the EBA, is marked in Switzerland, whereas in Austria only the Attersee site Seewalchen has a similar trend. This supports the hypothesis of a discontinuity of a large number of settlement sites of the Mondsee cultures in the Austrian lake district (Reitinger, 1968, 61) on the one hand, and the continuum of lake site settlements (cf. Strahm, 1977) in Switzerland, on the other hand.

CHAPTER VI. CONCLUSIONS1. TECHNICAL CONSIDERATIONS

The investigations which I have reported in this Thesis required a good deal of purely scientific research, as well as the archaeological studies which have been discussed in Chapter I-III. It does not seem appropriate to discuss this technical work in greater detail than has been done in Chapter IV. Most of it will be published, or has been briefly reported elsewhere (Ottaway, Archaeometry Conference, Oxford, 1975; Gilmore & Ottaway, Archaeometry Symposium, Philadelphia, 1977). It is nevertheless necessary to recapitulate briefly the work that I accomplished. This can be dealt with under three headings.

i) Analytical Methods. The techniques of neutron activation and atomic absorption spectroscopy are already well established, but they have, in the main, only been applied in archaeological research for the determination of a few individual elements, not for the whole range of elements determined by Otto and Witter (1952) or by the Stuttgart team (Junghans et al., 1960, 1968, 1974). Furthermore, in a number of instances, the complete objects weighed only a few grams, and it was difficult to obtain more than a few milligrams of sample. Neutron activation analysis had therefore to be scaled down to micro-level and all possible measurements had to be obtained from the irradiation of a single sample. Epithermal neutron activation, which minimizes the inference of the copper matrix, improves tremendously the sensitivity and certainty with which traces of some elements can be determined (Gilmore, 1976). It was unfortunate that this

method was not available at the Scottish Universities Research Reactor Centre. For the elements which cannot be determined by neutron activation, namely, lead, bismuth, nickel (and iron only with difficulty) flameless atomic absorption spectroscopy was the method of choice, but many technical problems had to be solved, such as the choice of solvent, and allowing for the effects of the copper matrix on the shapes and gradients of the calibration curves for each element. Most of these problems again were connected with the smallness of the sample size.

ii) DETECTION OF SIMILARITIES BETWEEN ANALYSES

Although the hundred or more sets of analyses which I made took me a great deal of time, and in some instances filled important gaps in our knowledge, they represent only a small fraction of the metal analyses now in existence. The latest volume of Junghans et al. (1974) carries the number of ~~of~~ analyses of copper and bronze objects, primarily from Europe, beyond 22,000 and there are more analyses to be published. How can similarities be detected within this vast mass of material?

Very occasionally this can be done by simple inspection. For example, Professor Müller, of the Institute of Egyptology, Munich, provided me with a copy of analyses of Egyptian copper and bronze objects from pre-dynastic to Roman times. Even a superficial glance showed that, allowing apart, the copper source was very unlike any with which I have become familiar from European sources, and moreover, that the impurity pattern remained amazingly constant over the whole period of several millenia.

This kind of conclusion is, however, exceptional. Figs. 107-110 show that the impurity patterns of the copper objects found in the northern alpine region do not show this homogeneity, and that the patterns for the bronzes are not only just as bewildering, they are also completely different from the coppers.

When the number of analyses was no more than a thousand or so, as for Otto and Witter (1952), it was possible for a trained metallurgist to come to some valuable conclusions by visual inspection of impurity patterns. I do not think that this is any longer possible. Certainly, when I tried to find similarities by eye in analyses which arrived too late to go into the computer, I found myself making the most subjective and non-repeatable distributions. Some kind of automated sorting, based on statistical probabilities, is a necessity.

I have found cluster analysis to be a very reliable technique for the following reasons: a) it ~~uses~~ similarity coefficients between objects which are obtained from all impurities simultaneously, in contrast to sequential sorting, which is the basis of the sorting technique employed by the Stuttgart team. b) both in the present work and in a previous study (Ottaway, 1974) analyses which were entered into the computer more or less blindly were sorted into groups which mostly made archaeological sense in terms of location or typology. c) Cluster analysis of Swiss axes purely in terms of size and shape produced clusters which not only agreed almost exactly with the visual sorting of an experienced archaeologist, but also indicated a new and important group (flat axe of type Robenhausen).

It is probably as well that the size of computer at Edinburgh limits the number of objects which can be clustered to something over

300, or one would probably also be tempted to be over-ambitious. I feel that progress can be made in interpreting metal analyses, but only by taking relatively small groups of analyses from an area restricted in time and space, and analysing them in detail. This has already been done for the Early Bronze Age material from Gemeinlebarn (Boomert, 1975). Eventually, the groupings relevant to each area will be linked up to give regional patterns, but probably not on a pan-European scale. The problem of controlling the time-scale, which is discussed briefly in the next paragraph, will always remain important.

iii) DATING

The interpretation of the analyses which have been collected can only sensibly be done in terms of a firm chronological framework of the cultures, and this must mean radiocarbon dating, for the period of the northern alpine region with which we are concerned. For defining the relationships between the cultures more precisely the interquartile method (Ottaway, 1973a) was used (Figs. 6,44). In certain instances this method shows up the present lack of a necessary minimum number of radiocarbon dates. This is particularly true of the Altheim culture, the essential link between the western and eastern halves of the northern alpine region. This is especially sad, because the evidence from numerous stray and chance finds (Maier, 1965a), as well as unpublished field surveys and surface finds in the region of Lower Bavaria, shows that settlement of this culture must be much more densely distributed than indicated by the distribution map of Driehaus (1960). The lack of detailed chronological information is entirely due to the fact that no site belonging to this culture has

been excavated since before the Second World War. It is to be hoped that the German archaeological authorities remedy this defect at a not too distant time in the future.

VI.2 LOCATIONAL CONSIDERATIONS

In an area where natural geographical constraints such as the Alps play such an important role, one has to be careful to make allowances for their existence in the interpretation of one's findings. This is why the lack of recent excavations of Altheim sites has been stressed repeatedly. On the other hand, the correction of the Jura waters in Switzerland must also be borne in mind, and must not be allowed to overweight results in that area. However, there is a part of southern Germany which seems genuinely to have been sparsely populated during the whole of the Neolithic period. This is the area between the rivers Lech and Iller, and one asks oneself why this gap exists. One of the possibilities is that, as with the Inn valley, sedimentation could be a very late and slow process, so that there was not enough suitable soil for sizeable settlement sites much before the Bronze Age (Paschinger, 1957). However, it is equally possible that the area was very inhospitable, because it was covered either by bog and swamp vegetation or consisted of barren glacial debris, which even today will only support sparse growth, unless heavily fertilized.

VI.3 GENERAL CONCLUSIONS

In the northern alpine region the first copper-using horizon was preceded by some evidence of earlier use of copper (see below). This is a repetition of the process as seen in south-eastern Europe

where the true Metal Age was also preceded by individual finds of copper consisting of no more than a bead or a small trinket. The interquartile range of the first copper-using horizon in the northern alpine region lies between 3200 and 2600 bc, that of the south-east European Metal Age, e.g., in Yugoslavia, the Pločnik culture, between 3900 and 3700 bc. The priority of south-east Europe over the northern alpine region cannot be denied with respect to the development of metallurgy. Nobody disputes that development in the former preceded and influenced the northern alpine area, which later became independent.

The question arises, as an offshoot of the study proper, can one conclude from a similar chronological priority, in terms of copper finds, of the Near East with respect to south-east Europe, that the former area influenced the latter? This question is more complicated, because in the Near East there is no evidence to support the suggestion that the true Metal Age there, with large-scale mining and smithing activities, started at a period very noticeably earlier than in south eastern Europe. It is possible that a few copper artifacts came from the Near East into south-east Europe where the new material imparted information which aroused the curiosity of the receivers and prompted them to start to experiment. This is, of course, only another - and more clumsy - way of expressing the phenomenon in terms of a flow of ideas. Whether or not one should call the subsequent local developments 'independent invention' is still open to discussion.

At any rate, in the northern alpine area, as in south-east Europe, the start of the true metal-using horizon is very soon followed by local mining and smithing activities.

The earliest evidence of the use of copper in the northern

alpine area comes from the Münchshöfener and the Epi-Lengyel cultures. It consists of one awl and pieces of crucibles. The time at which they occur is roughly coeval with the Italian Bocca Quadrata culture, in which copper also occurs (Chapter III). None of the northern alpine copper of this period has been analysed and we cannot say where it came from.

The next period at which copper finds occur, and which I have called the first copper-using horizon, since only then the real use of this material started, is the Pfyn, the Cortailod, the Altheim and the Mondsee horizon. This is coeval with the Po-Valley-late-Neolithic of Italy, from which there is copper in small amounts. It is also approximately coeval with the northern European TRB:C, SE Polish TRB, Salzmünde and Baalberg cultures, which are known to have used copper (cf. Ottaway, 1973d). In the east, the La^{VV}znany culture of Slovakia, the Balaton 2-3 culture of western Hungary, and the Bodrogkeresztúr-B culture of eastern Hungary are all coeval. All these eastern cultures use copper and this is, indeed, a very rich copper-using horizon in south-eastern Europe as well as in the northern alpine region. It is, however, also coeval with the Chasséan culture of France which did not use copper until later. The copper types which were used in the northern alpine area are mostly arsenical copper of types 2 and 10, and of the type 1.5 which has a very localized distribution around the Attersee and Mondsee (cf. Chapter V, p.232). Some pure copper (types 1.1 and 1.2) also occurs. The artifacts include types such as flat axes, beads, flat daggers, knives, chisels, awls, spirals, fish hooks, metal pieces and crucibles. Techniques employed were cutting, hammering and probably also annealing (but metallographic analysis has still not been employed on any of the

objects), hammering together of several pieces or strands of copper, rolling and casting, and, of course, smelting and melting. The objects were largely for use and not for display or decoration, but the absence of graves may distort the interpretation here.

The following (second) horizon in which the use of copper is attested in the northern alpine region, is a very interesting one, because neither the Lüscherz, the Horgen, nor the Boleráz cultures used very much copper and the only types known to belong with certainty to this period are simple, roughly hammered awls, pins and knives. The coeval Boleráz culture of the ČSSR shows a similar absence of copper, yet the late Chasséan culture of France for the first time has a few copper artifacts. At the same time, new types of copper - 5,7 and 9 - are used in the northern alpine region. The early arsenical copper (type 2) is represented by only one analysis (Fig. 112).

The third copper-using horizon, however, witnesses a return to a rich copper-using phase. The Auvernier, the Early Corded Ware and the Baden cultures have the same types of artifacts as the first copper-using horizon, i.e. flat axes, daggers (but now these daggers can be either flat or have a midrib), biconical beads and crucibles. A few new types also appear, namely pendants, spiral cylinders and Ösenringe.

The types of copper used for these objects are rarely those used in the earlier horizons (cf. Table 8 & 9 and Fig. 112) and represent a much wider spectrum. The pure copper types 1.1-1.3, but also copper types 3,4, and occasionally types 9 and 10, were used in the western area, whereas the eastern area of the region under study

only used types 1.2, 1.3 and 3. Copper of type 4 and possibly 3 can be safely assumed to have been mined in the Salzach region (cf. Fig. 123) but most of it was used in the western area (cf. Fig. 122 and 123).

At this time eastern (Baden) as well as western (Saône-Rhône culture complex of France) and southern cultures (Remedello-Rinaldone cultures of Italy) all use copper, but interestingly, of different impurity patterns from those of the northern alpine region. The latter remains a unit in this sense. The techniques with which these copper artifacts were produced did not change greatly from those used in the first horizon, except perhaps that casting became more commonplace. This can be seen in the fact that awls from this horizon are now cast and not rolled together from different strands of copper as before, and that perhaps the bivalve mould is beginning to be used as can be seen from the appearance of daggers with midribs on both sides.

The Mondsee culture is often thought to form a continuum right through to the Early Bronze Age, yet neither the interquartile range of all its ^{14}C dates (Fig. 6) nor the types of copper found in the Mondsee area support this idea: of the 40 analysed Mondsee artifacts 31 are made of the early arsenical copper types 2, 10 or 1.5 and only 6 are of bronze. Since most of the Early Bronze Age sites seem to be differently situated from the late Neolithic ones in the Austrian lake district (Reitinger, 1968), a discontinuity between late Neolithic and Early Bronze Age occupation is suggested by the available evidence. The fact that so very little of the copper from its immediate neighbourhood resources (i.e. of types 4, 3 and 7) was used suggests that this discontinuity happened during the second and third copper-using horizon when the exploitation of these types of copper started. The

Neolithic Mondsee population used mostly arsenic containing copper of types 2, 10 and 1.5, of which there is suspicion of local origin, but not yet cogent proof.

It seems that bronze was not used to any great extent in the northern alpine region until after the period studied here: of the 80 artifacts which contained more than 2% tin and which were included in this study purely on their typological relation to Neolithic finds, only those six from the Attersee mentioned above and one from Altheim were associated Neolithic finds.

Thus we are now in the position to answer at least some of the questions posed at the beginning of the third Chapter and in the flow chart (Table 2, p.124). We can say that there was not one single culture which was the earliest to use copper in the northern alpine area, but an entire 'early copper-using horizon'. We also know that this early horizon used a few very distinct types of copper, mostly containing arsenic and some possibly alloyed with it. Local copper production cannot be proven conclusively for this early horizon, although it may be suggested for at least one type of copper (type 1.5). Evidence for metal working and smithing activities however can be found in this horizon, namely in the Pfyn and Mondsee cultures and possibly also in the Cortaillod culture.

It does not seem likely that metal or metallurgy was introduced from one metallurgical centre alone either simultaneously or successively, since the types of copper used in the second and third copper-using horizons change considerably. In these later horizons there is a predominance of types of copper rarely, if at all, used in the early horizon. Moreover, several types of copper used in the

later horizon can be assumed to have been mined locally in the copper-rich eastern Alps and were used predominantly in the western area, i.e. in modern Switzerland.

Thus we find a rather complex flow pattern of material which could not have been suspected from the typological or purely archaeological study alone.

However small the quantities of metal used may seem to someone who is accustomed to dealing with the vast quantities of the Bronze Age, they are not the results of stumbling efforts of people who did not really know what they were doing. Although the copper artifacts were in my opinion largely produced in local smithing centres and the ore was mined in local mining centres, at least by the third copper - using horizon, and although these centres were probably independent of their more developed (eastern) neighbours as suggested by their less complex casting methods, the technological knowledge of the craftsmen was considerable. This becomes the clearer the more one tries to unravel the history of metallurgy. Is it not true that some of the processes involved are still incompletely understood? Is it not true that some of the empirical knowledge that these craftsmen had, has been lost completely to modern man? I am thinking in particular about the ability of distinguishing the different kinds of ore. Witter suggested that softer and harder coppers (presumably pure and impurity-containing copper) could be distinguished by the sound they made (Witter, 1938, 30). Similarly, Tylecote demonstrated recently the 'cry' of tin which is due to deformation of the crystal structure when bending the metal (Archaeometry Symposium, 1977), and Otto (1973) suggested recognition of arsenic-containing ores by the characteristic garlic smell given off during

roasting. It is also striking that the quantity of arsenic added to copper was extremely well controlled and depended on the type of artifact for which it was going to be used.

It is difficult to ascertain whether copper, or the possession of copper, carried any social status. This kind of question is usually most easily answered from a detailed examination of grave goods. Hardly any of the cultures involved in the northern alpine region have securely associated burials, before the Corded Ware and Baden periods. Consequently, it is impossible to answer this question. It is, however, likely, although by no means proven, that there was some social stratification within the cultures where mining and smelting was carried out, as suggested by Chernych (1975). One would expect to find professional miners, smelters and perhaps smiths coming into existence a few generations after the start of local exploitation, in particular, since these occupations could not just be carried out in seasons when the fields needed no tending, because the severe winters in the Alps would have made work of any kind impossible at that time of year.

In retrospect, the choice used to delineate the period discussed in this study may seem somewhat arbitrary. It was done as a result of the observation that in northern Europe there is a considerable break in the pattern of metallurgy just before the beginning of the Corded Ware culture (Ottaway, 1973). I expected this - rightly, as it appeared - to be true also for the northern alpine region. The break occurred in the northern alpine area during the second of the copper-using horizons, that is during the Lüscherz, Horgen and Boleráz periods, i.e. again just before the start of the Corded Ware and coeval cultures. At the same time, one must stress that there is no

break - at any rate in Switzerland - at all, between the third horizon and the Early Bronze Age. This is particularly clear from the partial contemporaneity of the Swiss late Corded Ware and the Early Bronze Age, where an exchange of ideas and patterns has been clearly demonstrated (cf. Chapter II, p.110). From then on there is a rapid increase in technological innovation as well as in the sheer amount of copper used. Some of the Early Bronze Age cultures, e.g. Singen, do continue to use more copper than bronze, presumably because of supply problems with tin, and perhaps the terminology should be revised. This rise in technological innovation was accompanied by an increase in the variety of metal artifacts produced, and by increasing evidence of sophisticated smelting and mining methods (Neuninger et al., 1969a, 1970a, 1970b; Preuschen & Pittioni, 1956; Pittioni, 1965a, 1967). For instance, the prehistoric mining area at the Kelchalpe, near Kitzbühel in the Tyrol, was found to have running water, i.e. water was collected from a nearby spring and guided along wooden troughs; it was found to have areas which were reserved for the separation of the ore, others for the smelting and yet others for living (Preuschen & Pittioni, 1939). Later again, in Lower Austria, there is evidence for sophisticated double smelting pits (e.g. Pühr, 1972, Fig. 12). Numerous moulds (e.g. Hell, 1943, Fig. 19) give us a good insight into the casting procedure used. The social structure of Bronze Age populations became differentiated as can be witnessed by their graves, by their dress, and weapons. The whole attitude to metal changed - it was now often used for fabricating showpieces, whereas before it was mostly used for day-to-day tools. Much later again, dealings in metal became very complex indeed and trading, quite apart from mining and working of metal, was a specialized activity. Also supply and

demand patterns changed seasonally, for instance, at the Magdalenensberg in Austria, clients from the south came in the summer, using sea transport, whereas the locals came in the winter, using sledge transport (cf. Egger, 1961). The appearance of numerous hoards, mostly of uniform shapes, indicates an entirely different approach and supply pattern than in preceding periods. This also implies true trade, in the sense of balanced exchange of materials.

On examining the cultures that inhabited the northern alpine region and which were using the first copper artifacts, it was clear that most of them had a highly organised way of life (Chapter II). They were accustomed to obtain certain raw materials from outside their immediate neighbourhood. The Cortaillod culture, for instance, obtained cattle for breeding purposes from outside their own settlements. The Pfyn culture obtained antler beakers and perhaps birch-bark decorated vessels, presumably with their contents, from their neighbours. The Altheim culture was in contact with its western and eastern neighbours, and exchange of ideas and artifacts makes it sometimes difficult to decide whether we are dealing with the Altheim or the Mondsee culture (as for example at Auhögl). The Swiss Auvernier culture is part of a larger culture - the Saône-Rhône-culture complex - with which it shares many traits. Both the Auvernier and the Lüscherz cultures imported Pressigny flint from the Loire region of France. Thus, flow patterns of goods are known from this period but they tend, on the whole, not to cover very long distances, but rather to exploit the resources of the surrounding neighbourhood. The notable exceptions are copper and Pressigny flint. It follows that different flow patterns existed for the former types of goods and the latter two.

In terms of final interpretation we must ask ourselves whether we are right in focussing attention on the spatial distribution of natural resources. A common interpretation of the spatial distribution of a material, such as has been studied in the preceding Chapters, is the existence of trade. In the following brief discussion I acknowledge a heavy debt to the Symposium on 'Ancient Civilization and Trade' (Sabloff & Lamberg-Karlovsky, 1975) and in particular to a paper by Chang, which I found most stimulating, perhaps because he expressed lucidly concepts towards which I had been struggling during my attempts to interpret the data for the northern alpine region. Chang wrote (and I quote here extensively, because I cannot express it any better):

'Archaeological ecosystemists often seem to assume that the population as a whole, or its procuring segments, act in concert, according to survival needs. The homogeneity of the population in terms of its survival interest as a whole is also implicitly assumed. ... in the short run, at the operation level, an ecosystemic interpretation must take due account of the way in which individuals are organized into populations, and it is more often than not these human organisations that determine what natural resources are to be exploited, processed and distributed, and in what way'. I also subscribe to Chang's view that '... trade can be studied only in the total context of the distribution of raw and processed natural resources within a societal framework' and that 'archaeological data pertaining to the identification and distribution of natural resources through space merely pose the problem'. This author also advances the view that the solution to the problem can only begin with a knowledge about the social units involved, about the reciprocity in the flow of resources

between the units and the means by which transactions were effected, i.e. whether the flow was bilateral, redistributive, etc..

It seems to me that for none of the cultures treated here in as much detail as is available - save perhaps for the Cortailod and the Pfyn cultures - do we have enough information to fulfil some of these basic requirements. This is partly because hierarchical structures within the societies are not yet visible, but it is also due to the fact that studies of natural resources, apart from the copper, are incomplete or non-existent. Renfrew (1975) has pointed out how important is the study of internal trade, yet we can only infer this internal trade for domestic animals and possibly also for seeds of cultivated plants, and for some of the goods mentioned earlier. How insecure and ill-defined trade is at the period in the region under study can be seen by the example of the Backteller and Tulpenbecher which occur sporadically outside the Michelsberg culture for which they are synonymous. Tulpenbecher are taken to be imports because only a few of them occur in the Pfyn culture. Backteller, on the other hand, are supposed to be local copies of Michelsberg prototypes, because they occur in greater numbers than the Tulpenbecher in the Pfyn culture.

If not trade, what other pattern can we offer which would fit the data collected in this thesis? The answer, as usual, must surely be as manifold as the patterns themselves and of these the most unusual and outstandingly clear-cut one is that of the Swiss smiths who - as suggested - obtained their raw material from Austrian mining areas. Of all the modes of transport suggested by Chang (1975) - part of a tribute, part of a raid, purchased at a local market by barter, as

part of a 'gift', part of a tax from the farmer to the landlord - none seems applicable other than the gift, and even that is not totally suited. This is in general agreement with Lamberg-Karlovsky (1975), who found that 'the concepts of reciprocity and redistribution are totally insufficient' - for his late fourth-early third millenium situation in Mesopotamia, which indicated for him a far more complex economic system than previously conceived. Of course, we are dealing with a period prior to 'civilization' and it is therefore necessary to be even more cautious when using words such as 'trade', 'exchange' and 'gift'. I would suggest repeated individual procurement as a means by which the Austrian copper arrived in Switzerland and was used there. There was thus a flow of goods but it was not necessarily a balanced one, even in non-material terms.

All flow patterns are partly determined by geographical facts, but partly they must be expressions of the different ways in which different populations reacted to them, and are thus one of the keys to the organisation and behaviour of the cultures studied here. Thus the northern alpine area can, in terms of fluctuations in the use of copper and the general types of artifacts which it used, be regarded as an ecological unit over a long period of time, but it was far from being a homogeneous set of consumer units when studied in detail.

List of Abbreviations

- AAC = Acta Archaeologica Carpathica
- ABB = Archives of Biochemistry and Biophysics
- Acta Arch. = Acta Archaeologica
- Acta Bern. = Acta Bernensia
- ADJ = Arheolosko Drustvo Jugoslavije
- AIPF = Atti della XV Riunione Scientifica dell'Istituto Italiano
di Preistoria et Protostria Firenze
- AJ = Antiquaries (The) Journal
- AJA = American Journal of Antiquities
- AMN = Acta Musei Napocensis
- Am. Ant. = American Antiquity
- Anal. Chem. = Analytical Chemistry
- Arb.& Forschgem.SB = Arbeits- & und Forschungsgemeinschaft zur
sächsischen Bodendenkmalspflege
- Arch.Austr. = Archaeologica Austriaca
- Arch.Ert. = Archeologica Értésitő
- Arch. Geo. = Archaeologia Geographica
- Arch. Hung. = Archaeologica Hungarica
- Arch. Korrb. = Archäologisches Korrespondenzblatt
- Arch. Pol. = Archaeologia Polona.
- Arch. Roz. = Archeologické Rozhledy
- ASA = Anzeiger für schweizerische Altertumskunde
- ASAG = Archives Suisse d'Anthropologie Générale, Genève.
- ASpectr. = Applied Spectroscopy
- Bad.Fund. = Badische Fundberichte.
- Bay.Vorg. = Bayerische Vorgeschichtsblätter

- BPI = Bulletino di Paleontologia Italiana
- BRGK= Berichte der Römisch-Germanischen Kommission.
- Bull.SPF = Bulletin de la Société Préhistorique Française
- Congres de l'UISSP = Actes du Congrès International des Sciences Préhistorique et Protohistorique
- FAP = Fontes Archaeologici Pragenses.
- FB = Fundberichte Schwaben.
- FBW = Fundberichte aus Baden-Württemberg
- Fundber.O. = Fundberichte Österreich
- GP = Gallia Préhistoire
- Helv.Arch. = Helvetia Archaeologica
- ISAAP = International Symposium on Archaeometry and Archaeological Prospection
- JAWL = Jahrbuch der akademischen Wissenschaft und Literatur
- JBB = Jahresberichte der Bayerischen Bodendenkmalspflege
- JBHM= Jahrbuch des Bernischen Historischen Museum
- JFA = Journal of Field Archaeology
- JGK = Journal of Geophysical Research
- JHMS = Journal of the Historical Metallurgy Society
- JIF = Jahresbericht des Instituts für Vorgeschichte der Universität Frankfurt/Main
- JKKZW = Jahrbuch der Kaiserlich-Königlichen Zentralkommission, Wien.
- JMV = Jahresschrift für Mitteldeutsche Vorgeschichte
- JOOM= Jahrbuch des Oberösterreichischen Musealvereines.
- JSGU = Jahrbuch der Schweizerischen Gesellschaft für Urgeschichte.
- JVSTL = Jahresschrift der Vorgeschichte Sächsisch Thüringischer Länder.
- MAGW = Mitteilungen der anthropologischen Gesellschaft Wien.
- MAGZ = Mitteilungen der Antiquarischen Gesellschaft, Zürich
- Mem. et Doc. = Mémoires et Documents publiés par la Société

D'Histoire de la Suisse Romande

- MIA = Materialy i Issledovaniya po Aekheologii SSSR
- MMKV = Mitteilungen der Museen des Komitates Veszprém
- MNZ = Mitteilungen der Naturforschenden Gesellschaft, Zürich
- MOAG = Mitteilungen der Österreichischen Arbeitsgemeinschaft für Ur- und Frühgeschichte, Wien.
- MPK = Mitteilungen der prähistorischen Kommission der Akademie der Wissenschaften, Wien
- MZBV = Materialhefte zur bayerischen Vorgeschichte
- OKT= Österreichische Kunsttopographie.
- PA= Problemy Archeologii, Leningrad.
- PAO = Prähistorische Archäologie in Oberösterreich
- Pam. Arch. = Památky Archaeologické.
- Phil. Trans. Roy. Soc. = Philosophical Transactions of the Royal Society, London
- PM= Prace i Materiały.
- PPS = Proceedings of the Prehistoric Society, London
- Przeglad A.= Przegląd Archeologiczny.
- PZ = Prähistorische Zeitschrift.
- RAPC = Rivista Archeologica, Provinciae Diocesi di Como
- RGZ = Römisch-Germanisches Zentralmuseum
- SAM I = Junghans, S., Sangmeister, E. & Schröder, 1968
- SAM II = Junghans, S., Sangmeister, E. & Schröder, 1968 & 1974
- Slov. Arch. = Slovenská Archéologia
- SMbl = Salzburger Museumsblätter
- SNMP = Sborník Národního Muzea v Praze
- Sov. Ark. = Sovetskaya Arkheoloiya
- Symp. Baden = Symposium über die Entstehung und Chronologie der Badener Kultur. Chropovsky, B. (ed), Verlag der Slowakischen Akademie der Wissenschaften, Bratislava 1973.
- SZ = Študijné Zvesti

UFAS = Ur- und frühgeschichtliche Archäologie der Schweiz,
Drack, W. (ed)

UISPP = Union International des Sciences Prehistoriques et
Protohistoriques

VLMH = Veröffentlichungen des Landesmuseums für Vorgeschichte,
Halle

VNGZ = Vierteljahrschrift der naturforschenden
Gesellschaft, Zürich

World Arch. = World Archaeology.

WPZ = Wiener Prähistorische Zeitschrift.

ZA = Zeitschrift für Archäologie

ZD = Züricher Denkmalspflege

ZSAK = Zeitschrift für Schweizer Archäologie und Kunstgeschichte.

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