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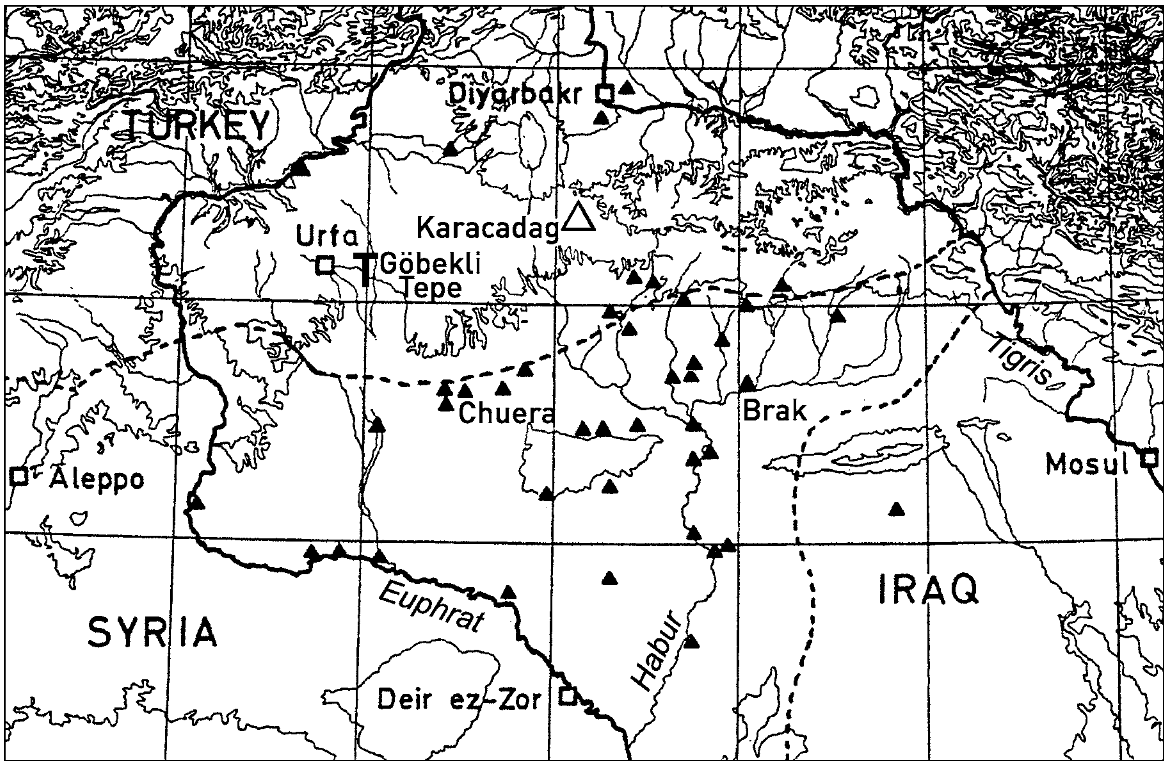
Lost knowledge today

Part 1: Metallic ceramics



ILLUSTRATION

Sites where north Mesopotamian stoneware from the 3rd-4th millennium B.C. was found in the border area between Syria and Turkey. (Border: dotted line).

Metallic ware has been found mainly at Tell Chuera (group A) and Tell Brak (group B).

In Turkey, the volcano Karacadag is situated in the foothills of the Taurus Mountains (elev. 1919 mtr.) Urfa is held to be Abraham's "birth grotto". 2 km east of Urfa is a 11,000 year-old temple complex, the oldest known to humanity, with its T-shaped stone totem poles. It is being excavated by the Berlin archaeologist, Klaus Schmidt. Agriculture originated in this area.

It may be termed the evolution of ceramics if production methods were given up in the course of its development which lost their importance with changing living conditions. Archaeologists discovered such methods during excavations in Northern Syria. What they uncovered suggests that potters in the Middle East had acquired a great store of knowledge, even three to four thousand years B.C. Hitherto their work has only been admired for its appearance. It has only been the result of recent archaeometric research that evidence has been presented of its technological inventiveness. A type of ceramic is of particular interest which in the emerging metal age was equal to metal in hardness. Today, ceramics which are based on technical and artistic characteristics as well as providing "happenings" can profit from this lost store of experience.

Unlike the Far East, where in northern latitudes nature favoured the development of ceramics with suitable clay deposits and firing temperatures, the potters in the Middle East had to make use of the predominantly calcareous clays at low firing temperatures. The clays would have melted to a shapeless lump even at only 1200°C, but they would not have been able to fire so high because they did not have the forests the Chinese did.

Ceramics of great hardness

In the course of excavations in Northern Syria conducted by the Deutsches Archäologisches Institut, shards and vessels made from a metallic ware were discovered, which were archaeometrically examined at the

Freie Universität Berlin by Gerwulf Schneider. They revealed unusual properties, which experts considered to be a sensation. In the age when metals were coming into use, potters had produced a type of ceramic that was impermeable and of similar hardness to copper. Even tools were made from it. This type of ceramic, which was fired to 1,000-1,100°C, corresponded in hardness and impermeability to high-fired stoneware that was only developed some thousands of years later in China (at the end of the Shang dynasty, 1500 – 1000 B.C.).

Stoneware as we know it requires a clay with a wide maturing range. It must be almost free of lime because lime reduces the range between vitrifying and melting. As a result of the uniform geology of the Arabian Plate between the Taurus Mountains and the Arabian Gulf, the clays are lime rich (approx. 6-8% CaO) to very lime rich (exceeding approx. 30%), and no ceramics of stoneware type could be made from them. At the vertex of the Fertile Crescent, the present border region between Turkey and Syria (fig. 1) there are however a number of young volcanoes, which have changed the composition of the soil. In contrast to China and Europe at a later date, the early potters produced a hard impermeable ware, which produces a clear ringing tone when struck, at low temperatures, in which iron is the principal flux, thus in a sense anticipating the Iron Age.

In this type of ceramic, known by archaeologists as Metallic Ware, two groups may be distinguished. In Group A, where the findings were centred on Tell Chuera, the clay body contained (average from 54 samples):

5.21% Fe_2O_3,
1.59% CaO (+0.88 MgO)
and
2.29% K_2O (+0.08% Na_2O)

and in Group B centring on Tell Brak (average from 95 samples):

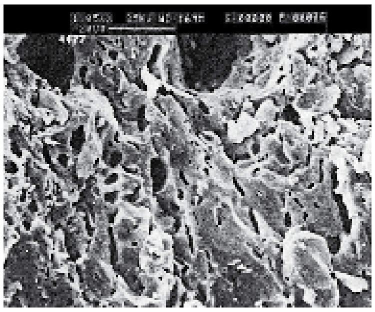
6.84% Fe_2O_3,
1.67% CaO (+1.16 MgO)

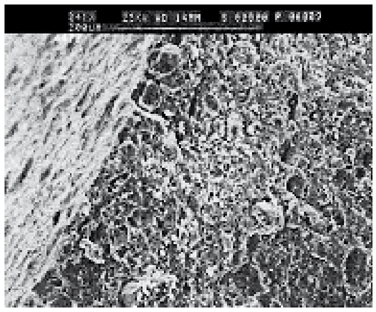
4.01% K_2O and
0.11% Na_2O

In some of the samples from group B, the potassium oxide content reached a level well above 5%, the most significant distinguishing feature compared with group A. Both groups contained large quantities of trace elements such as vanadium, chromium, nickel, zirconium and others, as is typical of volcanic ash. The raw materials are thus local, they remained the same for thousands of years. This exceptional position with regard to raw material resources in the Middle East may have contributed to the fact that this type of ceramic was restricted to such a small area and that it did not gain further significance.

After chemical analyses (i.e. according to main components), they may be presented as follows:

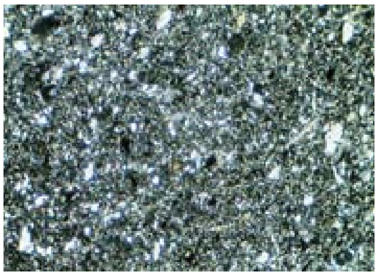
However, if we look for an explanation of the fluxing properties of the iron, these approximate reconstructions will not suffice. If we take the total of all the fluxes including alkalis, earth alkalis and iron (II) oxide (FeO), the total quantity of fluxes in the metallic ware comes to approx. 10%, for the comparable Böttger stoneware it is 15%, and in spite of the lower flux content, metallic ware is fired much lower, viz. at 1,000°C compared with the stoneware, which was fired to around 1,300°C. The alumina and silica content are the same in both





ILLUSTRATIONS
Optoelectronic images of a shard of metallic ware from group A. The high resolution illustration on the left with quartz and feldspar grains and mullite and hercynite fully melted at around 1,050°C. The image to the right from the same sample at lower resolution shows a ridge with a sinter skin (left of the image).

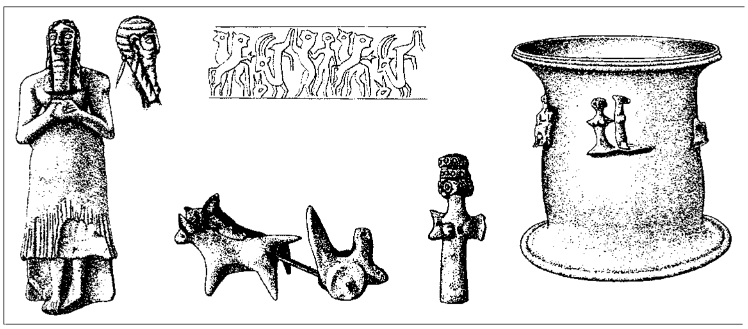
Group A
57.42 powdered white clay no.1501 from Goerg&Schneider
22.07 powdered quartz
14.32 alkaline frit M 1233
6.22 red iron oxide.



Thin section of metallic ware from Tall Bi'a under a polarising microscope. Undecomposed inclusions of quartz and feldspar (white and grey) as well as ore and mica (black). The height of the image correspods to 1 mm.
image: G.Schneider.

Group B
47.26 powdered red clay 311 from Goerg & Schneider
31.50 Lavalit or basalt
4.06 powdered quartz
15.20 calcite
1.98 red iron oxide

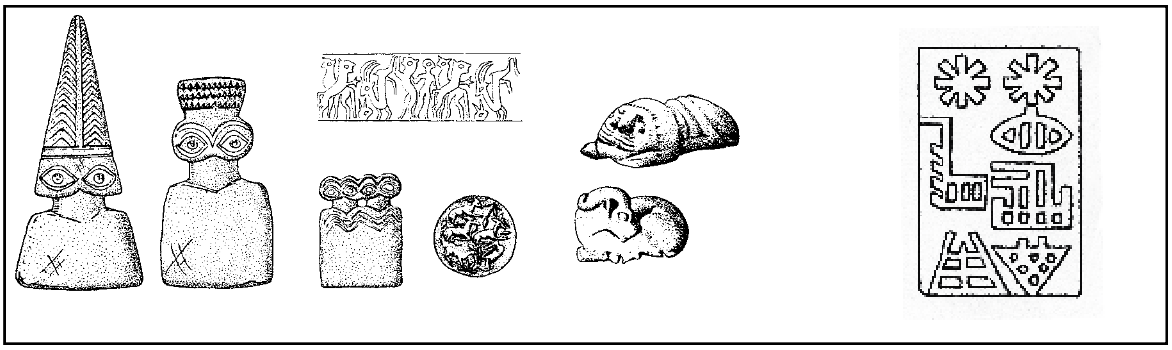
Piercing and cutting tools made of metallic ware from Tell Brak, length 9.6cm.



În Tell Chuera a number of alabaster statues were found in an annexe to a temple, together with the clay model of a chariot, female clay figures and vessels, roller stamps, 70 pieces of silver jewellery and bronze articles from the 3rd millennium B.C. (after Moortgat)

ILLUSTRATIONS

Typical eye figures from the "Eye Temple" in Tell Brack from the Djemet Nasr period (3rd-4th millennium B.C.). Several hundred votive objects of this kind made of alabaster with eye grooves filled with black or green paint were found. Also animal figures, roller stamps and interesting circular stamps. Beside the temple a palace was excavated from the Akkad period (3rd millennium B.C.), made of dried mud bricks, which were stamped with the mark of the builder, "Naramsin" (right of the illustration). (After M. Mallowan)



cases: metallic ware A has 10% flux, 22% alumina (Al_2O_3) and 68% silica (SiO_2), whereas Böttger stoneware has 15% flux, 21% alumina and 64% silica. The relationship among the oxides in the flux group must therefore be different to explain the differences in the firing temperatures. Indeed, iron (II) oxide predominates in the metallic ware. The proportions of the other ingredients in the natural volcanic compounds must also be so favourable that we have a mixture that melts at the lowest possible temperatures (eutectic). This may be deduced with the assistance of the siliceous multi-compound systems described by the American Ceramic Society in three weighty volumes. It reveals that the iron-rich three compound system consisting of the three ingredients FeO (1380°C), SiO_2 (1713°C) and Al_2O_3 (2050°C), which forms the basis, reveals a eutectic point of 1083°C when it the proportions are 48% FeO, 40% SiO_2 and 12% Al_2O_3, which indicates a heavy fluxing influence of the iron. The eutectic temperatures are regularly lowered even further if small quantities of other oxides are added. In the present case, this would be lime, which would reduce the temperature to 1,070°C, but it is the alkalis that have the greatest effect. The lowest eutectic temperature for the system $FeO\text{-}Na_2O\text{-}SiO_2$ is as low as 667°C, with K_2O it is 767°C. Analyses of shards also reveal the presence of approx. 0.1% phosphor (P_2O_5) and several hundred millionth percent of various trace elements that are typical of volcanic ash. These include vanadium (V_2O_5), which in a certain eutectic relationship with iron (II) oxide even melts at 625°C. This means that in a reduction atmosphere and in the presence of small quantities of alkalis and other traces, in a complex multi-component system, iron can reach the composition discovered in the analyses. For this to happen, the alkalis and earth alkalis must come from feldspars to raise the alumina and silica levels. The particularly heavy influence of sodium has made some archaeologists draw the conclusion that the clay body was made up with salt water.

As regards firing, it is believed that two-chamber kilns, which were known in Mesopotamia at an early stage, were used. It is possible that straw and iron were used as fuel, as is still traditionally the case in Iraq. It is however certain, that firings took place in reduction.

Only in reduction is the very hard iron-aluminium spinel, hercynite ($FeO \cdot Al_2O_3$), formed. This does not necessarily mean that the hardness of the body derives from this material: even under oxidation in an electric kiln, a hard, impermeable body was created, in experiments to reproduce this ware, although this was only achieved at 1,100°C. The flux effect of the iron occurs at an earlier stage in reduction than in oxidation. The firing temperature can be determined by the mineral content of the body because up to 1,000°C mica and feldspar do not change, and above 850°C the calcium-magnesium silicate, diopside, and the calcium-aluminium silicate, anorthite are formed - if too a lot of lime is present, gehlenite is also formed. At around 950°C, mullite is formed in kaolin rich clays with the proportion increasing at higher temperatures. The higher the temperature, the more quartz and feldspar melts. Thin sections under the microscope reveal a fine grain in metallic ware (fig. 2). The white or grey inclusions are quartz and in part feldspar. There are also black particles of ores and mica. A firing temperature not significantly above 1,000°C reveals the remains of undecomposed feldspar and mica.

Metallic ware resembles in its appearance Chinese Yixing stoneware and jaspis porcelain by Böttger and the so-called "mulatto porcelain" from the 19th century. It is known that this consisted of:

1 pt. by weight Bavarian basalt
+2 pts Kaolin
+3 pts red clay

All of these European stonewares were fired at the high temperature of hard past porcelain.

below - first excavations at the temple complex of Göbekli Tepe from c. 9,000 B.C.

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