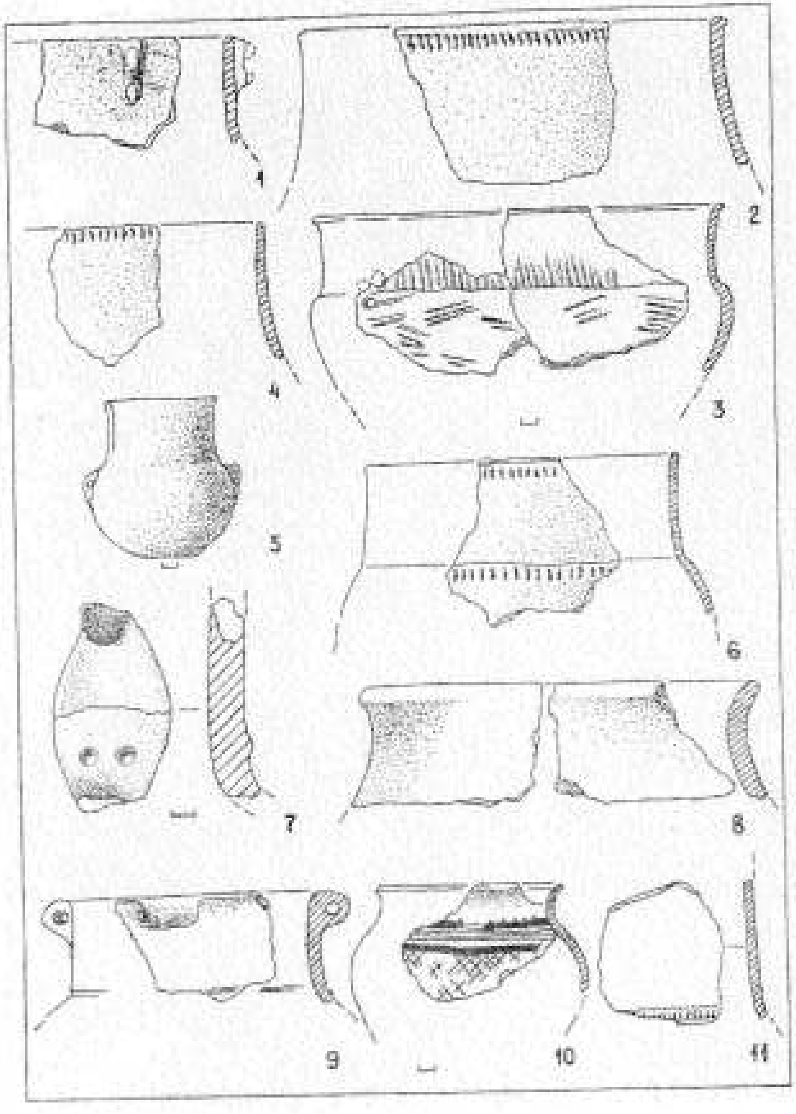

Рис.3.
Образцы энеолитической керамики из Орловки I (1 - 10) и Орловки II (11).

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(Romania)

An early bronze age axe discovered in Sălaj county (Romania)

In the last two decades the period of the Early Bronze Age of Transylvania (EBA – period framed by the ending of Coțofeni Culture and the beginning of Wietenberg culture) has been investigated by focused archaeological researches, many studies and monographs being achieved. Important research has been carried out in the south - eastern part of Transylvania (Szekely, 1997), and in the central and south - western part as well (Andrițoiu, 1989, p.35-56; 1992, p.19-26; Rotea, 1993, p.65-86; Ciugudean, 1991, s.79-114; 1996; Gogâltan, Florea, 1994, p.9-38; Popa, 1998, p.47-85; Rișcuța, 1998, p.111-139). The situation is different for other regions of Transylvania. The northern part presents as a "white stain" on a virtual map of discoveries belonging to the EBA. In Maramureș, for example, only two pieces made by bronze can be hypothetically dated to this period (Kacsó, 1999, p.56).

In this context we consider that publishing discoveries from the northern part of Transylvania is more then welcome.

In the spring of 1975, a shaft hole axe was accidentally discovered at Șasa (village Ileanda, Sălaj county, Plate I/1) Locality situated at the North - east limit of Sălajului, in the vicinity of Maramureș county. Geographically, Șasa is placed at the limit between the Someș Valley and Lăpuș Depression. The artefact was bought by the History and Art Museum of Zalău (MJIA Zalău Collection, Inventory No.18/1975). The place of discovery is called "Comorița" being a low terrace on the shore of a path with season debit.

In 2001 we have searched the area where the piece was discovered and we did not find any signs of a possible settlement in this point or in the surrounding area.

The artefact was firstly mentioned in 1979 in a catalogue of copper axes discovered on the territory of Sălaj (Lakó, 1979, p.44. pl.III/3) afterwards in a topographic repertory of the Neo - Eneolithic finds of Sălaj (Lakó, 1981, p.69, nr.72). In these works the axe was erroneously dated to the Eneolithic period. We considered as being opportune to re-discuss the artefact, in order to achieve a real chronological framing in correlation with the chemical and structural analysis carried out on this axe, analysis which are still rare when one consider the pieces belonging to the Bronze Age in Romania.

The shaft hole axe, discovered at Șasa (Plate II) is a piece with heavy aspect with the shaft hole a little lengthened and well marked in comparison with the blade. Apparently, the shaft hole looks fragile due to its thin walls in comparison with the weight of the body. The upper part of the blade is curved, outrunning the shaft hole and the lower part of the blade falls obliquely towards the shaft hole being separated by a small flute. The cutting edge is semicircular. The section of the blade is almost pentagonal with the bases of the pentagon at the lower part of the blade. The surface presents numerous roughness. Only the shaft hole is completely smooth. Dimensions of the axe: Length - 10 cm; Breadth - 5 cm; Breadth of the blade - 4,6 cm; Diameter of the shaft hole - 2,6 cm; Weight - 460 g.

The typological framing is not easy. In the Carpathian Basin, research carried out on moulds belonging to EBA has revealed that these were made of degreased clay and sometimes of quartzite. These moulds were used to at the most two successive operations, as researchers opined. This can explain the heterogeneity of types (Bóna, 1992, s.49-50 ; Roman et al., 1973, p.562). Thus, the typology established for these axes can be relative, in particularly some of these axes were adjusted by hammering. As a consequence, the dimensions of the piece had changed from the casting process to the final product (Hundt, 1982, s.209-211). In our case, it has been determined that the cutting edge and the margins have been smoothened by hammering.

By its first publishing the axe discovered at Şasa was attributed to Fajsz type (Lakó, 1979, p.44). It can be classified to Corbasca type as well (Vulpe, 1970, s.29-30), type which is closely related to Fajsz and both can be framed as the earliest types of shaft hole axes, besides Baniabic and Veselinovo types (Vulpe, 1970, s.27-28). Fajsz type axes are concentrated mainly in the area of the Middle Danube. Towards East, there are a few finds such as: pieces from Lipova (Arad county), Vadu Crişului (Bihor county), Şasa (Sălaj county) and Ujgorod (Ukraine) (Vulpe, 1970, Pl.44A). Corbasca type appears in the area of the Lower Danube (Serbia, Oltenia) but also in the Southern part of Transylvania (Andriţoiu, 1993, p.101; Ciugudean, 1996, p.123). The find from Corbasca (Vulpe, 1970, s.30) (Bacău county) is placed outside this area.

We believe that the initial assignment to Fajsz type made by É.Lakó is correct, but we mention that some details such as: well delimited shaft hole and its visible lengthening in the lower part suggest that we deal with an advanced version of this type.

Fajsz type axes discovered on the territory of Romania represent stray finds, fact which burden their assignment to the Romanian EBA. Based on possible cultural - chronological connections offered by pieces of the same type discovered in the Czech Republic, Al.Vulpe placed these finds into the phase of EBA corresponding to the beginning of Glina culture (1970, s.28). Another piece discovered in the North of Banat was dated by F.Gogâltan in phase II of the Early Bronze Age of Banat (Gogâltan, 1995, s.57; 1996, p.46-47), phase contemporary with Makó culture from the North - western border of Banat, followed by discoveries of German Sânpetru type which illustrate influences such as Vinkovci - Somogyvár - Roşia. In the southern part of the region it corresponds phase Glina IV (Ostrovul Corbului). An important reference point for the issue of dating the Fajsz type comes from Zók - Várhegy (Ecsedy, 1983, old.9-14; Bóna, 1992, s.49). In a pit discovered in this settlement, dated to a late phase of Vučedol culture several moulds have been discovered. These served for casting the Baniabic, Fajsz and Kömlod type axes. Besides the association of these three types in the same complex, fact which suggest that this types were cast and used in the same period,

the discovery clearly reveal that these types of axes appear at a cultural and chronological horizon which is considered by most Romanian archaeologists (and not only by them) as being earlier then the first EBA manifestations in the southern part of Hungary and in the surrounding regions.

In Sălaj county there are a few finds which can be dated to the EBA. With two exceptions namely, Şimleu Silvaniei "Observator" and "str. G.Bariţiu" one can talk about only older, uncertain mentions (Roska, 1942, old.272, nr.208) and materials proceeded during surveys. Some of the Early Bronze Age materials from Şimleu Silvaniei (unpublished) present relationships with those finds from Upper Tisa region (Nyirség culture), and some others present common elements with finds belonging to the Early Bronze Age I and II from Central Transylvania. Although the axe from Şasa is situated at the eastern limit of Fajsz type axes, being far away from the area of maximal concentration, we believe that it's dating can not exceed the chronological frame of the evolution of these type of axes. Theoretically the artefact should be assigned in general lines, to a period being synchronic to the EBA I- beginning of the EBA II from Central Transylvania (Ciugudean, 1991, s.142-144).

On the bases of the moulds discovered in clearly delimited archaeological contexts it is supposed that these type of axes initially appeared in late Vučedol environment and have been produced later on, in the period of the Makó culture (Kalicz, 1968, s.48; 1984, s.97-98; Bóna, 1992, s.49). The Makó type finds from the Romanian territory, grouped in the western and North - western part of Banat (Gogâltan, 1995, pl.16; Kulcsár, 1998, p.44) and on a narrow band on the North - western border with Hungary, seams to show the eastern and South - eastern limit of this culture (Kulcsár, 1998, p.44; Boná, 1993, old.74-77; Kacsó, 1997, p.430-431). From the three Fajsz type axes discovered on the Romanian territory only the axe from Lipova could hypothetically belong to the Makó culture (Lipova is placed on an important communication lane-the Mures valley), the other two can be dated to other contemporary cultures (Roman, 1984, p.266-274; Roman, Németi, 1986, p.229-230). All three axes have been discovered on the shores of important rivers (Mureş, Criş, Someş), all oriented towards the Tisa basin, fact which indicates possible communication lanes in the period of the Early Bronze Age.

In order to completely describe the artefact, complex investigations have been carried out in the laboratories of University of Bristol, UK and University of Gelsenkirchen, Germany. The axe was included into a group of 100 pieces analysed by Manuella Kadar in the framework of Research Grant HPRI-CT-1999-00008 financed by the European Committee in the Program : Access to Research Infrastructure at the Geochemical Facility of the University of Bristol, UK. X ray difractometry and microscopic investigations were achieved at Fachhochschule Gelsenkirchen Germany, Department of Materials Sciences. Investigations focused both on chemical composition and microstructure analysis. Major and trace elements have been detected by Inductively Coupled Plasma – Mass Spectrometry (ICP-MS) and Inductively Coupled Plasma - Atomic Emission Spectrometry (ICP-AES). In order to determine the chemical composition, 50 mg of material was sampled with 1 mm borer. The sample was digested in 1,25 ml of HCl + H NO_3 (3 : 1 Aqua Regia). Digestion was achieved in a microwave oven, at the temperature of 100^{0}C during 12 hours. The purpose was to maintain in solution volatile elements such as mercury. After complete digestion the solution was added up to 25 ml with deionized water. In the first stage, supposed major elements (Cu, Fe, As, Sn) have been detected on Jobin-Yvonne 24 equipment by ICP-AES. Results have been checked by ICP-MS on a Plasma Quad equipment (Kadar, 2002, p.11-14).

Trace elements such as: Cr, Co, Ni, Zn, Sn, Au, Hg, Ag, Pb, Sb have been determined by ICP-MS (ppb detection limits). It was used Cu_{254} for detection of copper, error limit of ±1-2 % for copper and for trace elements standard deviation was considered between 10 and 15 %. Chemical composition is given in table 1.

Table 1

Cu %	Fe ppm	As Ppm	Sn ppm	Cr Ppm	Co ppm	Ni ppm	Sb Ppm	Pb ppm	Hg ppm	Au Ppm	Ag ppm
95,5	62	7114	123	5	2	186	863	247	n.d.	n.d.	720

The chemical composition has disclosed that the main element and impurity is copper and arsenic, respectively. One can see that this axe is situated at the limit between low arsenic copper - arsenic alloys and arsenic bronzes.

In the scholarly literature (Lechtman, 1996, p.481) the terminology used in the case of copper – arsenic alloys can be distinguished on the bases of the amount of arsenic in the composition: arsenic copper (less than 0,1 % As), low arsenic copper – arsenic alloy (between 0,1 % - 0,5 % As) and arsenic bronze (between 0,5 % - 7 % As). This terminology is based on the relationship which exists between the concentration of arsenic in the composition and the modifications occurred into the mechanical properties of alloys related to the composition. Arsenic copper is impure copper with diminished electrical properties but with similar mechanical properties as of high purity copper (over 99 % Cu). Mechanical properties of low arsenic copper - arsenic alloys such as hardness and malleability visibly change starting at 0,5 % As. At concentrations higher than 0,5 % arsenic the alloys can be considered bronzes. Alloys with concentration of 7 – 8 % As are arsenic bronzes, very brittle in case of cold working.

Analysis achieved on pieces belonging to the Romanian Eneolithic and EBA have shown both high and low levels of arsenic, depending of the region which was taken into consideration. Thus, the dagger discovered at Băile Herculane, at level (c_1) dated to phase Coţofeni I has 6 % arsenic in the composition (Roman, 1976, p.16). Spiral pendants discovered in a tumuli at Cheile Aiudului have more than 0,5 % arsenic in composition (Beşliu et al., 1992, Annex 3). Neck rings discovered in the deposit at Deva, analysed by the Stuttgart (Junghaus et al., 1974, Analyses NR.9130- 9139) group indicate variable contents of arsenic – 1,3 % to 1,7 % in eight neck ring bars and other two have 0,26 % and 0,67 % arsenic, respectively.

In the case of the shaft hole axe from Şasa, beside the high level of arsenic one can notice also significant amount of antimony (863 ppm). The same situation

has been noticed in some other cases (Altheim type flat axe) discovered at Dragu (Sălaj county), locality situated in the basin of Almaş river, southern tributary of Someşului river (Beşliu et al., 1992, Annex 2, p.121, piece L14).

The relationship between the hardness of copper - arsenic alloys and reducing in thickness by cold hammering is presented in Plate I/2. Micro - hardness of this axe was determined for the cutting edge (130 HV). This value is much higher then of the cast copper – 50 HV – and can be obtained by cold hammering reduction in thickness of 50 %.

As concerns the raw material our discussion focuses on the concept of intended alloy, when arsenic was added in order to improve mechanical and casting properties versus impure copper obtained by co-smelting of copper ores and arsenic bearing ores such as: domeykit, ennargite, algodonite etc. Analysis carried out on the hoard from Nahal Mishmar from the Judea Desert dated to the Chalcolithic have revealed ternary chemical composition: copper – antimony – arsenic. In some pieces the alloy elements exceed 20 % (Shalev, Northover, 1993, p.35-47). Without speculating on the type of ores used for obtaining the raw material, the authors suggest tetrahedrite Cu_{12} (AS, Sb)$_4$ S_{13} as source for the majority of analysed objects belonging to this hoard. Analysis carried out on exploited ores in a Chalcolithic context from Norsun Tepe (Turkey) (3500 - 2800 BC) have disclosed that this type of ore can easily weather into malachite, azurite and complex minerals of copper, arsenic and antimony (Zwicker, 1980, p.13-26).

In the Western Carpathians such complex ores with high content of arsenic exist (Rădulescu, Dimitrescu, 1966), they could be a possible sources for the analysed artefact. The presentation of the complex ores from the Carpathians has been achieved in a database which summarises geo - morphological, physical - chemical and technological properties of copper ores (Kadar, 1999, p.345-348). In our case, the high level of arsenic (7114 ppm) and antimony (863 ppm), significantly higher then of other impurities suggest as possible source tetrahedrite type ore.

Metallographical considerations complete the investigations of this artefact. The axe was investigated by optical microscopy and X ray diffractometer. Before etching were evidenced inclusions, porosities and other metallographical constituents with specific colour. Copper oxide (Cu_2O) was uniformly distributed on the surface (Plate III).

Copper oxide is stable at high temperature but at the temperature of 430^{0}C decomposes into Cu and CuO. Observed at the microscope before etching these separations have a grey-bluish colour and in polarised light they turn into red. After etching with a solution of 3 % Fe Cl_3 in HCl, the Cu_2 O separations became dark coloured being easy to distinguish between this type of inclusions and sulphides, for examples.

The metallographic structure of this axe is constituted by polyhedric crystals, arsenic - copper eutectic was noticed at the grain limits. This structure can result after casting or after a plastic deformation (hammering) followed by annealing. Copper can be hardly cast due to its reduced fluidity, high superficial tensile strength (edges and corners are not filled and the surface presents porosity).

The margins are rounded, the cutting edge is semicircular and roughness cover the entire surface, therefore we believe that the axe was initially cast then the edge and margins were smoothened by hammering.

The complex analysis achieved on the axe from Şasa is added to other analysis carried out on pieces discovered in Sălaj county by colleagues from MNIT Cluj Napoca (Beşliu et al., 1992, p.97-128; Topan et al., 1996, p.635-646). Two other pieces were discovered at Dragu (Hida village, Sălaj county), one of them was referred to in this discussion and belongs to the same category of arsenic bronze. Even if the first use of arsenic in alloys was not intended, being the result of using ores reach in arsenic, the advantages of the new alloy were noticed by the craftsmen of the EBA. These advantages are obvious for the cutting tools, especially. In some opinions the first pieces made by copper - arsenic alloys appeared in the Balkans in the first part of the IV millennium BC (Pernicka et al., 1997, p.56-57).

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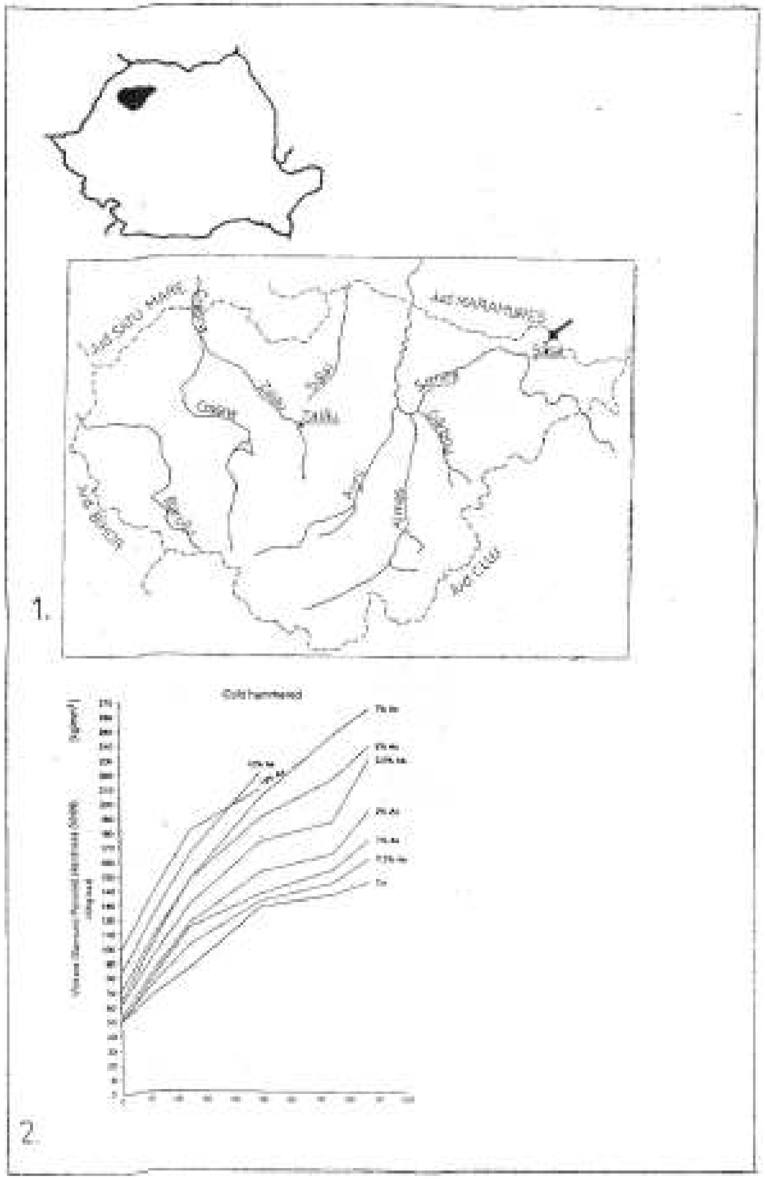


Plate 1: 1. Map of Sălaj county. 2. Variation of hardness versus reduction in thickness depending on the percentage of As in the conposition (after Lechmann, 1996).

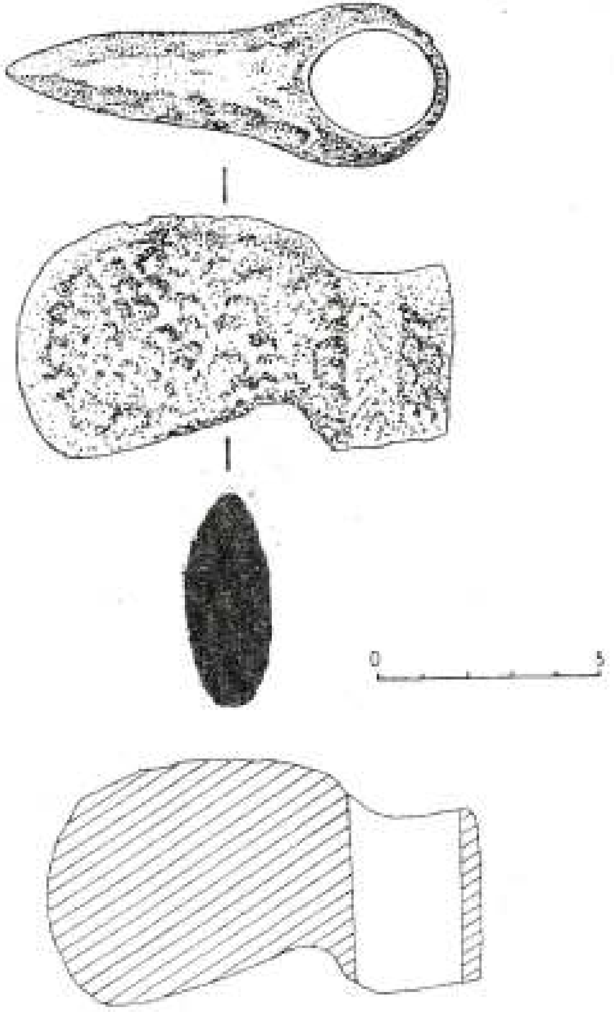
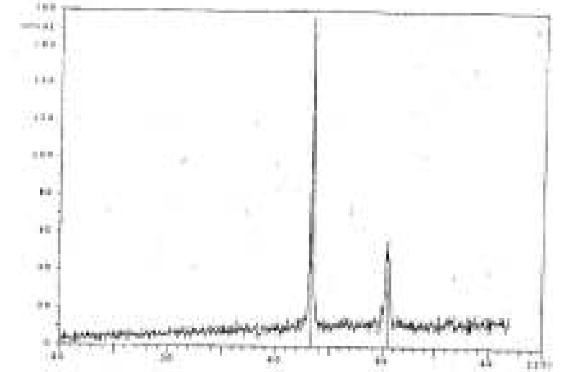


Plate II: The shatf - hole axe from Şasa.

1.



2.

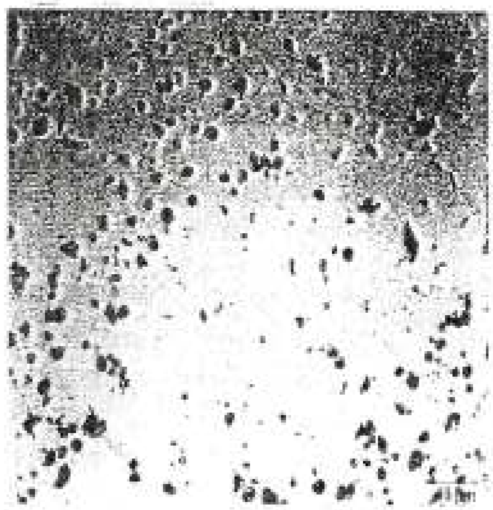


Plate III: 1. Diagram impurities in the shaft - hole axe from Şasa. 2. Copper - oxide inclusions in the shaft - hole axe from Şasa.