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THE INVESTIGATION OF THE IRON - SPONGE FRAGMENTS FROM BURGENLAND

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The archaeological excavations of the ancient sites provide sometimes, many interesting materials. Historical documents become here not only ready semi-products usually accompanied abundantly by slag but also small slag — like pieces which react to magnet. These small magnetic pieces of slag containing magnetic iron, are known in Poland als »grompy« and this word has its historical justification. It has been introduced to commemorate the seventeenth century poet and metallurgist Walenty Rozdzienski and is connected with his poem entitled »Officina Ferraria«.

The word »grompy« appeared in the poem in its original form but in other literature no specific term is being used and it is usually refererred to as »pieces of iron sponge«.

However, in order to distinguish them from larger bloomery products or its fragments we should use this term in archeological papers.

Until magnet was used in archaeological excavation and research gromps excaped the attention of archaeologists.

Gromps are also visible and drawn by S m i t h in the Japanese picture scroll ot the Sumija Iron Mine at Geishu Kake.

The investigation of Holy Cross ancient metallurgy in Poland demonstrated for the first time, owing to the introduction of magnet, the appearence of magnetic (metalic) fragments and so called magnetic powder among the slag.[1)] The powder turned out to be maghemite while gromps provided valuable pieces of information for both archaeologists and metallurgists.[2)]

Since that time magnet has become simple but basic tool in examination of smelting sites.

In archaeological excavation of smelting sites in Burgenland[3)] the introduction of magnet allowed the selection of gromps among layers of the slag. They reacted to magnet and seemed to be slag-like material. A number of these were found at Unterpullendorf (site 1 and site 2) and a dozen were later sent to the Research Laboratory of the Archaeology Museum in Krakow.

The Burgenland's gromps were irregular in shape and polluted by earth and sand on the outside (Fig. 1). Their colour was usually brownish, sometimes rusty on the surface.

After removing the outside layer, porous surface was revealed. In some instances small fragments of charcoal were detected, in others there were cavities with distinct imprints inside.

The smallest gromps weighed about 1 g and measured 10 mm in diametre while the largest one came up to 12 g and 80 mm. Their magnet sensitivity was varied which undoubtably depended on their iron content.

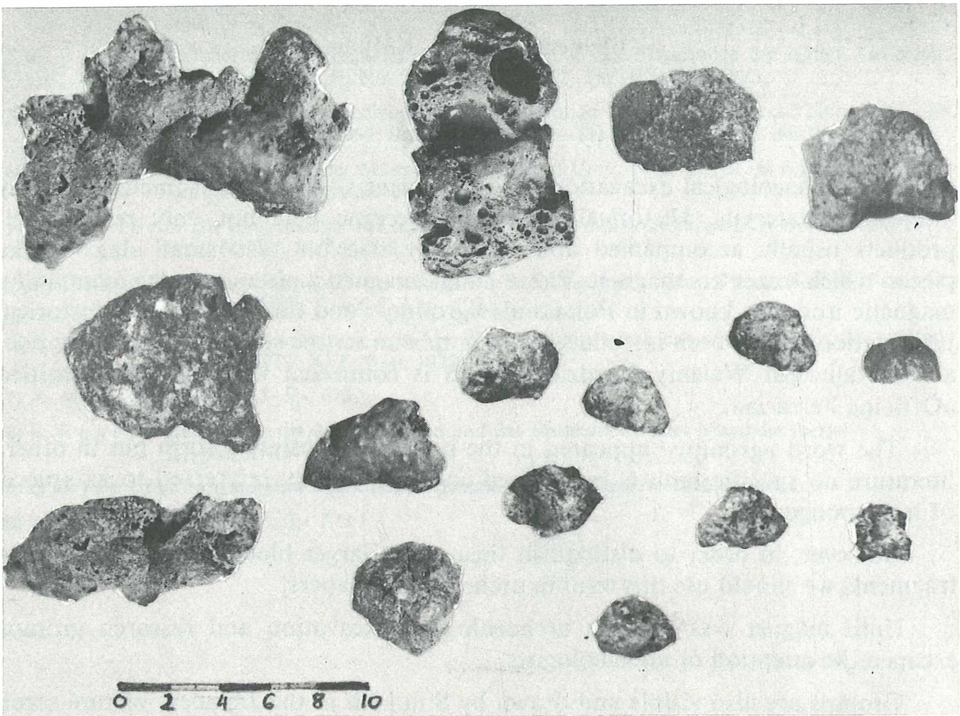

Fig. 1 The fragments of the iron sponge »gromps from Burgenland«

For gromps examination the following technique was used: After cleaning off the outside surface the gromps were cut along the layer of maximal iron content and cross section photograph was made. Microscope examination followed before and after etching with 4 % nital or pychrine acid. Special attention was devoted not only to the metallic surface but also to the surrounding oxideslag area. Afterwards the metal was extracted and chemical examination followed.

The non metallic content was examined separetly. The gromps with separately metal content were investigated by means of Cameca microprobe.

The constituents of iron oxide were determined (hemetite and magnetite) as well as those of silicon oxide, manganese, aluminium, magnese, calcium, phoshorus and sulphur.

Thus all the gromps were examined no matter how varied their metallic content. At this stage I shall try to illustrate our research reffering only to specific, representative examples.

Gromp No 1

It was found at Unterpullendorf site 1 in the layer of slag site. Outside surface has rusty colour. Slag structure largely porous without any charcoal. Sample weighed 2,5 g, measurment 2,1 x 1,4 cm. Cross section detected minimal content of metalic iron, invisible to the naked eye (Fig. 2).

Chemical analysis of the non metallic part produced the following results:

24,03 % FeO	38,32 % Fe_2O_3	20,32 % SiO_2	1,5 % CaO
5,98 % Al_2O_3	0.44 % P_2O_5	3,64 % MnO	0,42 % S

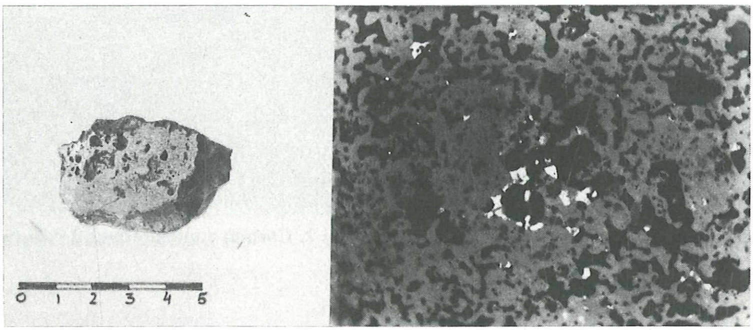

Fig. 2 Unterpullendorf site 1. Structure of the gromp No 1 (magnification 200 : 1)

The overall iron content as well as that of manganese and silica was very high. The iron in metallic part has ferritic structure and reveals no traces of carbonisation. A high content of hematite (Fe_2O_3) might be the result of partial reduction, undergone by the iron ore passing through all the stages of the bloomery furnace.

Slag with similar Fe_2O_3 content is commonly found in the finery forges.

Our recent analyses of several dozen specimens of finery slags confirmed similar proportion in the iron oxides content. The appearence of a great number of ferric oxides may also be accounted for by the process of gromp's oxidation over centuries (also the high content of the sulphur may be the result of the corrosion processes). Examples of partly corroded metal will be visible in other specimens from Unterpullendorf.

Gromp No 2

It was found like the first one at Unterpullendorf stite 1 in a layer of slag.

Its weight was 13 g, dimension 4 x 3 cm. This gromp contains more metal surrounded and submerged in layers of oxides. It has relatively uniform perlitic structure and corresponding carbon 0,7 % C (Fig. 3). The upper part of the sample on the interface between metallic and non metallic zone discloses smaller carbon content and its ferrite perlite arrangements form the Widmannstättens structure (Fig. 4).

Fig. 3 Unterpullendorf site 1. Structure of the gromp No 2. Carbon content about 0.7 % (300 : 1)

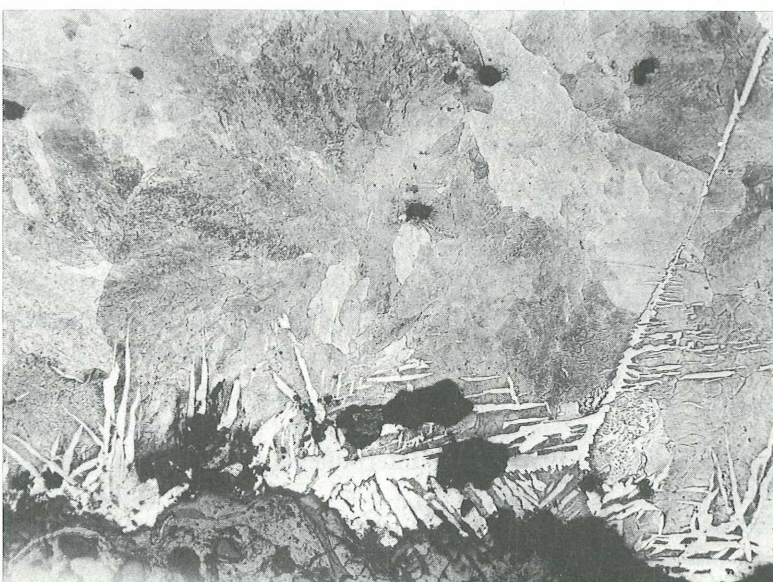

Fig. 4 Unterpullendorf site 1. Structure of the gromp No 2. Interface between non metallic and metallic part. Ferrite and perlite arrangement forms the Widmannstätten structure (100 : 1)

Chemical analysis gives the following results:

In the metallic part we found
P — 0,10 %
Mn — 0,01 %

In the mass of oxide slag we found

18,03 % FeO	48,32 % Fe_2O_3	19,44 % SiO_2	5,98 % Al_2O_3
1,80 % CaO	0,98 % MgO	3,64 % MnO	0,68 % P_2O_5

It seems that the smaller content of carbon in metal is caused by its oxidation in the presence of slag.

Gromp No 3

It was found at the same place (site 1), weighed 11 g, measured 6,5 x 2,3 cm. It contained a certain amount of ferritic iron which was considerably carbonised and its structure approximated that of hypoeutectoidal steel with 1,1 % of carbon content (Fig. 5). Insignificant area was carbonized to a smaller degree (Fig. 6). Corrosion processes produce a great number of iron oxides. One can also observe needles of secondary cementite against the background of oxides with perlite in a completely corroded state.

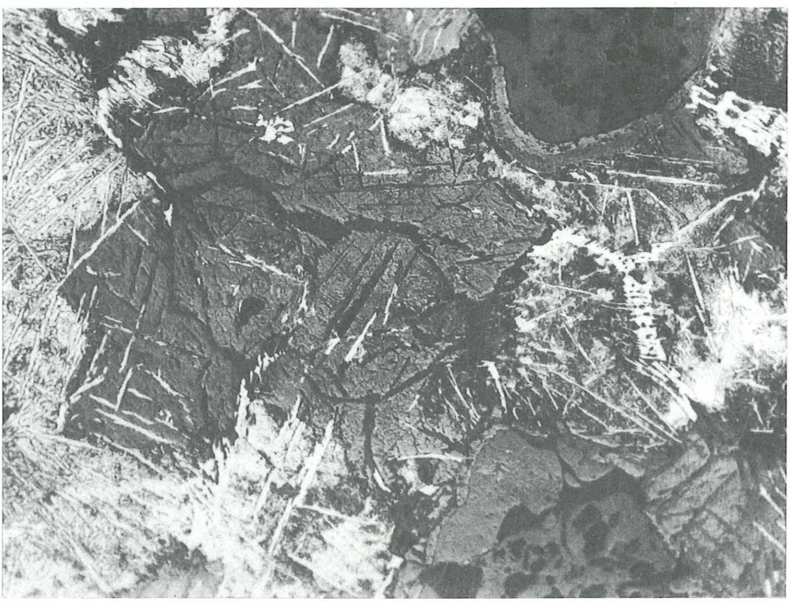

Fig. 5 Unterpullendorf sit 1. Structure of the gromp No 3. Hypoeutectoidal steel partly corroded. Needles of secondary cementite on the background of corrosion products. (100 : 1).

G r o m p N o 4

From Unterpullendorf site 2 test — trench 4. The outside surface of this specimen is similar to gromp No 1. It weighted 4 g and was 4 cm in diameter. Cross section disclosed insignificant amount of ferritic metal in the shape of small particles suspended in the surrounding oxide — slag mass (Fig. 1). No traces of carbonisation were detected in the metal.

Chemical analysis produced the following date.

20,85 % FeO	47,92 % Fe_2O_3	18,67 % SiO_2	1,87 % Al_2O_3
0,21 % CaO	0,68 % MgO	1,37 % MnO	0,56 % P_2O_5
0,21 % S			

This conglomerate has higher content of Fe_2O_3 which leads us to believe that like sample 1 it underwent oxidation. Comparison with slag analysis of the same site shows that it has less SiO_2, CaO, MnO, Al_2O_3 but higher Fe_2O_3 of content.

And here, for purpose of comparison are the results of chemical analysis of slag from the same test trench.

52,44 % FeO	6,77 % Fe_2O_3	30,48 % SiO_2	0,34 % CaO
0,68 % MgO	6,26 % Al_2O_3	2,71 % MnO	0,40 % P_2O_5
0,1 % TiO_2	0,17 % S		

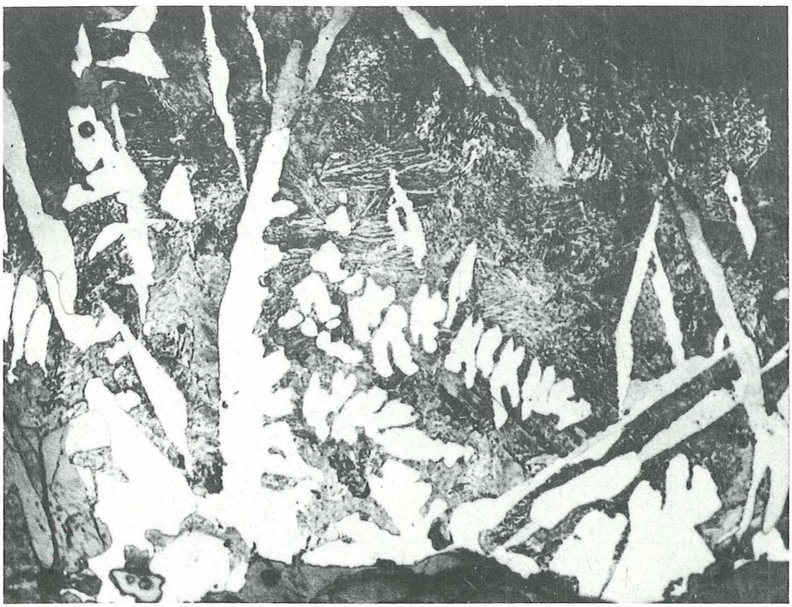

Fig. 6 Unterpullendorf site 1. Structure of the gromp No 3. Metal carbonized to a smaller degree (100 : 1)

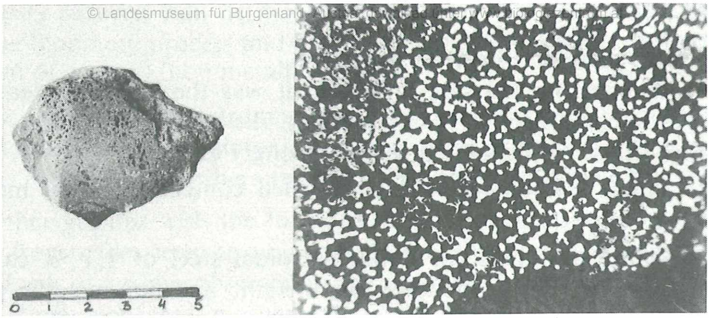

Fig. 7 Unterpullendorf site 2. Structure of the gromp No 4. Ferritic iron in the shape of small particles suspended in the surrounding oxide-slag mass. (200 : 1)

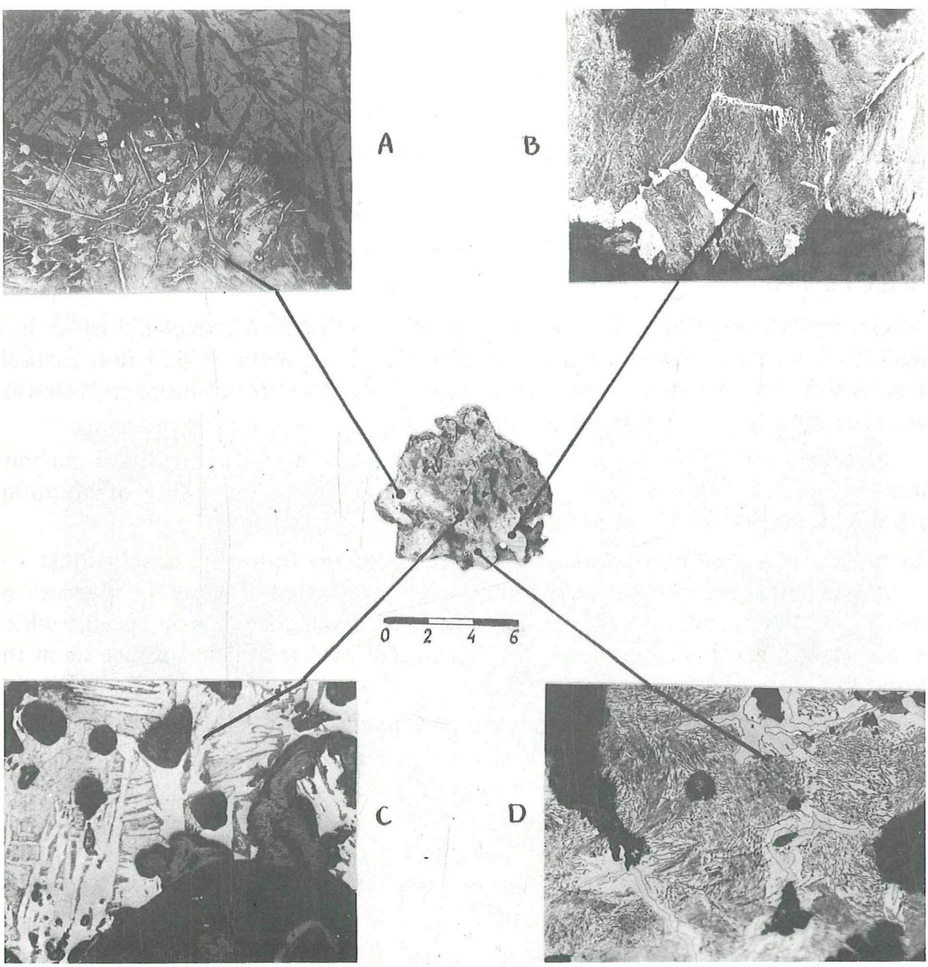

Fig. 8 Unterpullendorf site 2. Structure of the gromp No 5.

G r o m p N o 5

From Unterpullendorf site 2 test-trench 4.

It was found among the slag layer and it was the largest tested gromp. It weighed 12 g, diametre 8 cm. It was porous on the surface and there were empty cavities formely filled with charcoal. It was strongly magnetic.

After cleaning, rectangular section revealed content of metal mostly along one edge.

Metal structure is typical for hypoeutectoidal steel of 1,1 % carbon. Products of corrosion are visible between the metallic and non-metallic part of the gromp (Fig. 8). Perlite was the first to undergo corrosion. Then secondary cementite followed. Against the background of corrosion products one may notice needles and nets of cementite, partly corroded. Small part of the metal near the interface of metallic and non metallic zone contains smaller percentage of carbon (Fig. 8 b, c).

Chemical analysis

Non metallic zone

22,50 % FeO	56,01 % Fe_2O_3	7,05 % SiO_2	0,55 % CaO
0,75 % MgO	1,82 % Al_2O_3	0,55 % MnO	0,21 % P_2O_5
0,08 % S			

C o n c l u s i o n s

Gromp investigations are of considerable significance especially when it is possible to determine their chemical analyses of both metallic and non metallic parts as well as the structure of metal. This allowed us to get more information about the kind of ore used for iron production.

Metallographical research allows the determination of the degree of carbonisation in metal and thus we can reach conclusion about the possibility of obtaining carbonized steel in the bloomery furnace.

Our research on the Burgenlands gromps prompted the following conclusions:

All gromps are primary products which originated during the process of smelting in bloomeries and maybe considered as fragments of iron sponge which desintegrated into smaller pieces either during removal from the furnace or in the second phase of smelting and processing.

The results of excavation and research allowed us the reconstruction of the furnace at Unterpullendorf as a large copule bloomery furnace with varied conditions of reduction.

In some zone inside the furnace carbonized steel was obtainable and gromps Nos 2, 3, 5 seem to indicate that possibility. Metal of these gromps with its eutectoidal and hypoeutectoidal structure would also point to the fact of getting the steel with up to 1 % carbon content.

Chemical analyses of non metallic parts of the gromps as well as previous investigations of the slag from Unterpullendorf smelting places proved that the ore was easily reduced with its manganese content. Manganese did not pass into metal in the bloomery process and its presence in the ore could be detected by the examination of gromps (non metallic parts).

Decarbonisation in the gromps probably resulted from the contact of highly carbonized metal with strongly oxidizing slag especilally as it was observed in the upper areas of the gromps where the metal interfaced with the oxide slag mass.

The other gromps with the low iron content were also bloomery products. Numerous iron oxides seem to point to the fact that the metal was oxidized over centuries. Lack of carbon observed in the other oxidized metal particles seems to indicate that they appeared in other zone of the bloomery furnace.

The high content of sulphur detected in non metallic part of the gromp No 1 is probably due to corrosion processes. It appears locally as shown by microprobe testing.

In order to reach a general conclusion about sulphur content in the ore extended analysis would have to be carried out.

The results of investigations over Burgenland gromps overlap with those carried out on the Magdalensberg sites led by Straube, Tarmann and Plöckinger.[4)]

Concluding my paper, I wish to present the results of gromps examination from the region of Holy Cross Mountains. Both the Burgenland and this center date back to ancient times and different types of furnaces were exploited there. That is one reason why it may be worth while examining their waste products which happen to be several hundred kilometres distant from each other.

The Polish gromps are usually found in the vicinity of the smelting site. Some of them constitued conglomerate of slag -oxide with small quantity of ferric metal and no traces of carbonisation (Fig. 9).

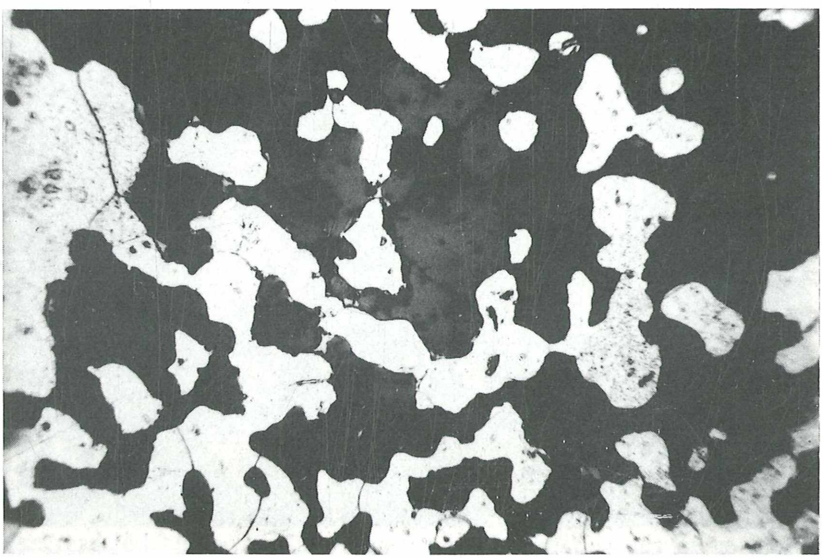

Fig. 9 Osiny (Poland). Structure of the gromp with small amount of metallic iron (100 : 1)

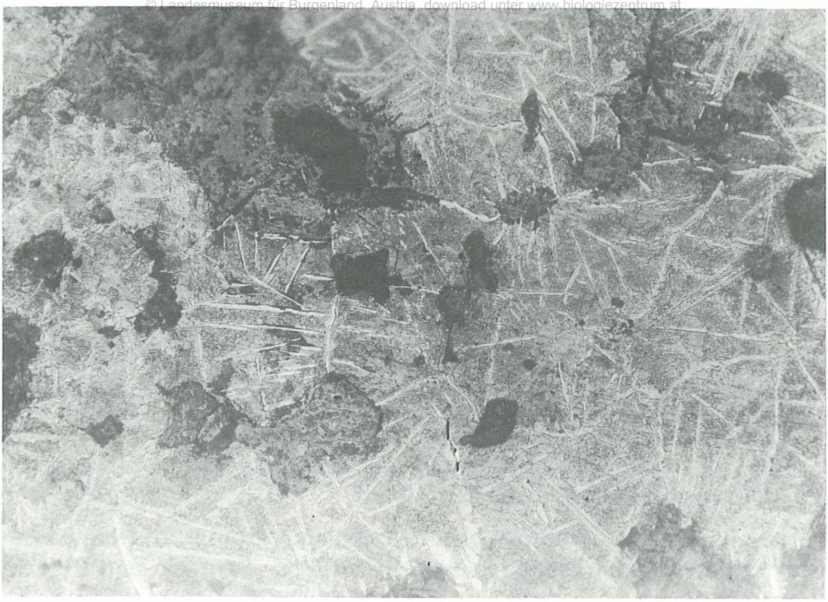

Fig. 10 Wieloborowice (Poland). Structure of the gromp with carbonized iron (100 : 1)

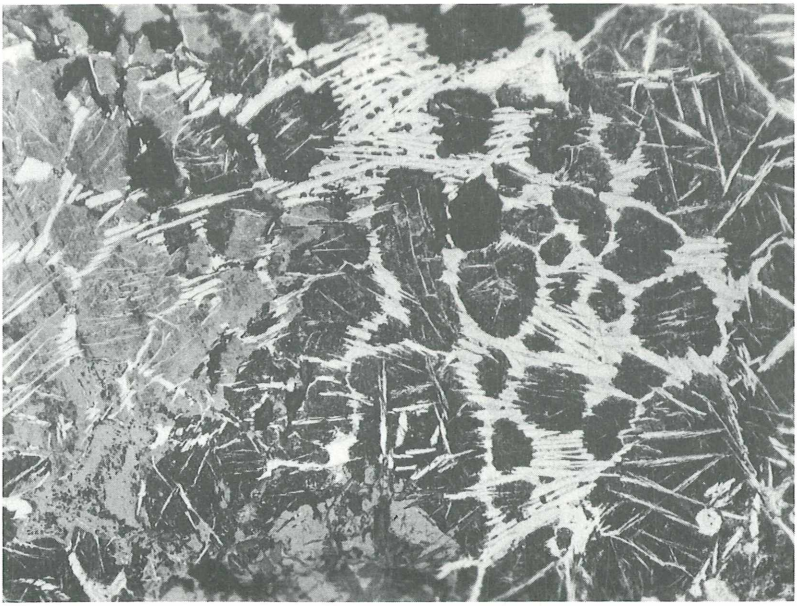

Fig. 11 Wieloborowice (Poland). Structure of the gromp No 2. High carbonized iron partly corroded. Ledeburite on the background of the corroision products (150 : 1)

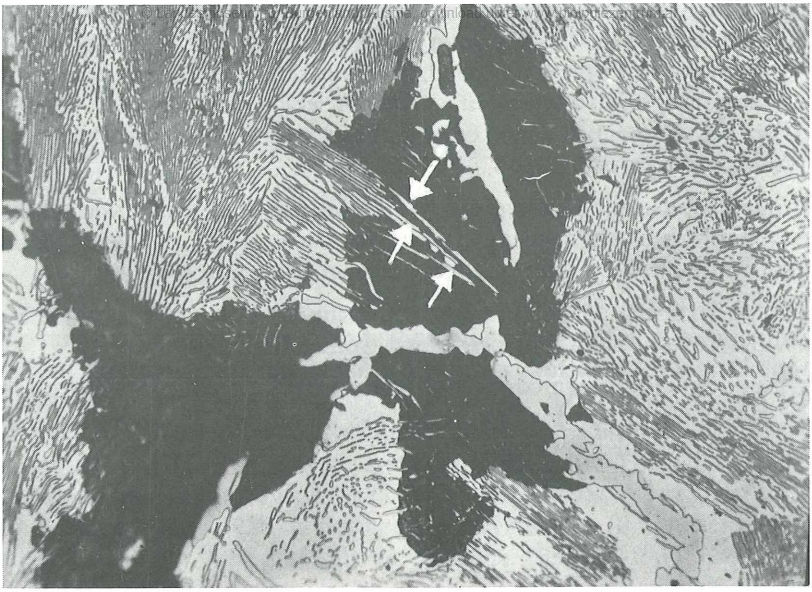

Fig. 12 Wieloborowice (Poland). Gromp No 2. Partly corroded metal with smaller content of carbon. Uncorroded cementite on the background of corrosion products (300 : 1).

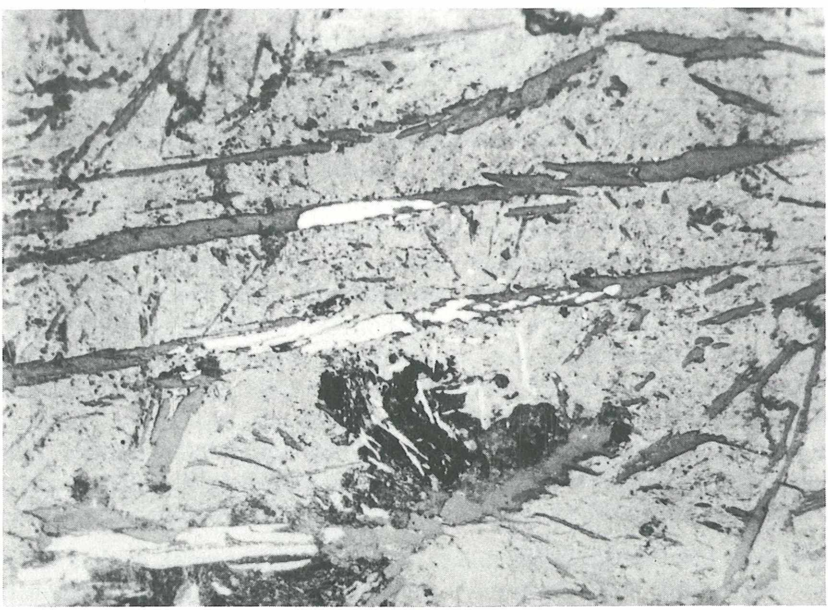

Fig. 13 Wieloborowice — gromp No 3. Interesting case of corrosion. The large needles of cementite against the background of the corrosion products (300 : 1)

Others revealed higher metallic content in different stages of carbonisation. Typical structures were observed for the eutectoidal and hypoeutectoidal steel

(Fig. 10). Sometimes the carbonization comes up to 3 % and the structure discloses ledeburite (Fig. 11). Very interesting structure has been observed in the gromp from Wieloborowice (test-trench 2). Its perlite structure is clearly visible in the microphotograph with traces of corrosion which first affected the ferrite to perlite (Fig. 12). Cementite is not corroded and is visible against the background of the products of corrosion.

An interesting case of corrosion of the strucural elements was observed in sample 2 from Wieloborowice. Against the background of dark products of corrosion (iron oxides) one may see large cementite needles (Fig. 13).

This short survey of the gromps appearing in Poland reveals their similar structural picture allthough they originated from different furnaces.

This, undoubtably, is in connection with the direct reduction of iron in those furnaces. No matter what type of furnace was used it was characterized by similar processes both physical and chemical.

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