MINERALOGY OF THE POLYMETALLIC ORE DEPOSIT OF PİRAZİZ, VILAYET GİRESUN, NORTHEASTERN TURKEY

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INTRODUCTION

The ore deposit with polymetallic ores, formerly mined by Piraziz Mining Company, east of the village of Piraziz near Bulancak, Giresun Vilayeti, belongs to the eastern part of the Pontid-Subbalkan metallogenetic subprovince, according to Petrascheck (1954-55). This subprovince is mainly formed by andesite, dacite, and tuffs of the Upper Cretaceous submarine volcanism series with less abundant younger dacite to rhyolite bodies and, in the central zone of the Pontus Mts., with many granitoid plutons both of Eocene age.

The narrow southern zone is characterized by effusive rocks with sediments belonging to the Eocene volcanic series (according to the Geological Map of Turkey, 1 : 500,000) and by granitoids.

Due to their geological complexity, even the ore deposits in the Pontid-Subbalkan subprovince belong to different genetic types, distinguished here by many workers, namely Wijkerslooth (1946), Petrascheck (1954-55), Kieft (1956), and in M.T.A. papers (1965, 1966). Recently Ovalıoğlu (1969) recognized here four polymetallic types, of which three belong to Cretaceous to Eocene andesite-dacite submarine volcanism or granite plutonic magmatism (in the northern and central zone) and one type to early Tertiary submarine andesite-dacite volcanism or granite plutonism (in the southern zone). According to Ovalıoğlu, Piraziz, similar to many other polymetallic vein deposits of the northern zone, belongs to the plutonic or subvolcanic deposit type.

The author of the present paper distinguished in this subprovince three hydrothermal isogenetic mineral Pb+Zn associations, indicated by the letters A, B and C.

The mineral association A corresponds to a pyrite + Cu+Zn+Pb association of the stockworks and of younger epigenetic mineralizations on exhalative-sedimentary or hydrothermal-sedimentary pyrite deposits; it is bound on Upper Cretaceous to early Tertiary dacite-rhyodacite volcanism of the northern zone of the eastern Pontus Mts. (Murgul, resp. Lahanos as examples).

The mineral association B is a Pb+Zn + Cu association of ore veins or vein zones in the effusive rocks and tuffs, bound on plutonic and subvolcanic conditions of the northern zone (Alacadağ as an example).

The mineral association C spread in the southern zone of the Pontus Mts. and continuing in a zone to the area between Çanakkale and Balıkesir, corresponds to a Pb + Zn + Cu association of hydrothermal Tertiary volcanism. The studied deposit at Piraziz belongs in this system to the mineral association B.

Unlike other deposits of this type, the Piraziz deposit is not a well-defined ore vein, but a broad zone of parallel veinlets and lenses in brecciated and very intensively altered and leached andesite and tuffs. This character of the mineralization may be observed even outside the mine in a cut of the nearby highway. The strike of mineralization may be observed as unusual approaching to N-S; the deposit Aytepe near Ulubey has similar strike. Most deposits of the association B, however, have a strike of between 80-120°.

Rich ore samples were collected by the author in 1968 and 1969 in the shaft and on dumps around the gallery on the sea beach and in the cut of the highway.

ORE STRUCTURES AND TEXTURES

The structures of the ore samples change from one place to another : predominant is the brecciated structure where the fragments of altered rocks or older hydrothermal products are cemented by younger minerals. The size of breccia may vary within wide limits. Less common are banded veinlets mostly of short length. Here, the youngest minerals often form crystals in central druse. Rhythmic segregation of pyrite and carbonates has also been observed.

The minerals both ores and gangue are mostly fine-grained or of a middle granularity, mostly not exceeding 1 cm (except for some young gangue minerals). The structure of rich ore veins is mostly massive with fine mineral intergrowth of the ore components.

MINERALS' AND THEIR CHARACTER

The altered country rocks and the chert-like hydrothermal quartz are the main components of the mineralized zone. They are followed by late carbonates. Among the ore minerals pyrite, sphalerite, and tetrahedrite predominate. On the other hand, many of the latter-mentioned minerals are in small amounts or have been observed only microscopically.

Pyrite. — The mineral is present in numerous generations which may be distinguished one from another almost only in the presence of some characteristic gangue or ore minerals. There has not been observed any habitus of pyrite crystals characteristic for a single generation: pentagonal dodekahedron crystals are known in all generations. The early pyrite generations are fine-grained, the best crystals belong to the fifth generation.

Marcasite. — This has been observed in form of fine tabular or spindle-shaped individuals in connection with calcite in some polished sections. It is visibly an anisotropic, pale brass mineral.

Sphalerite. — The color of sphalerite is mainly brown to light-brown, sometimes with yellowish or reddish tint. It occurs in individual grains in the ore filling rather than in massive or granular aggregates. Crystals in druses are rare.

On the basis of spectral analyses[1] the following chemism has been found (for results see Table 1):

Main components : Zn, S.

Isomineral[2] major and trace elements: Cd, Hg, Ga, Ge, In, most of the detected Fe, Mn, As, Bi, Sn, partly Ag, Cu, Sb.

Anisomineral[2] elements: Al, Ca, Co, Mg, Ni, Si, Ti.

When compared with the statistical data of Fleischer (1955) concerning the chemical composition of some sulphides, the content of Fe and Cd (0.5 %) in the sphalerite of Piraziz may be considered as normal; as elevated may be considered, however, the content of mercury and arsenic (0.01%) and of tin (0.01-0.05%), a combination of high- and low-temperature elements, which generally is characteristic for the chemism of this mineral in the association B.

The presence of Ag, Cu, and Sb may be explained mainly by the presence of the admixture of tetrahedrite, although some silver is present in all sphalerite samples throughout the world. The explanation of the presence of Co (0.05 %) and of nickel traces in one sample is not clear, as no Co and Ni mineral was detected during the detailed microscopic study.

Galena. — Almost only in smaller grains or intergrowths with other ore minerals, so that it is difficult to obtain pure samples of the mineral for spectral analyses (Table 2).

Main components: Pb, S.

Isomineral major and trace elements: Te, most of Ag, Bi, partly Cd, Sb, Sn.

Anisomineral elements: Al, As, Cu, Mg, Mn, Si, Ti, Zn.

Most characteristic is the rather low silver content in galena from Piraziz (about 0.1%) and, on the contrary, the very high content of tellurium (0.1-0.5%) which is a typical trace element of the Pontus mineralization, always in camouflaged form. In 50 % of the analyzed galena samples of the association B the Te content has been determined.

Tetrahedrite. — This sulphosalt belongs to the main ore components of the deposit. It forms a mostly irregular mass partly intergrown with other ore minerals. Some very pure grains of this steel-grey metallic mineral have been found forming fine crystals up to 1 cm in size in cavities. The predominant form is positive tetrahedron (111) with a striation showing the presence of narrow triakistetrahedral planes.

Spectral analyses have shown the following results (Table 3).
Main components: Cu, Sb, S.

Isomineral major and trace elements: most of Ag, As, Bi, Hg, Sn, partly Cd, Fe, In, Mn, Zn.

Anisomineral elements : Al, Ca, Mg, Pb, Si.

Relatively low is the silver content ranging between 0.1 and over 1 % and the traces of bismuth. The content of mercury (0.01-0.1 %) and of tin (0.001-0.005 %) emphasize again the relative richness of these elements in Pontus ore deposits.

Chalcopyrite. — A relatively rare mineral of this ore deposit is almost only found by use of an ore microscope to be a mineral intergrown with tetrahedrite. Sphalerite is free of chalcopyrite inclusions.

Rutile (?). — In the marginal zone of quartz III grains can be found small but abundant grains and crystals of rutile (?). In polished section its color is grey with visible low reflectivity and characteristic red to brown internal reflections. The grains are irregular, on crystals of columnar habitus often a tetragonal outline may be observed. The reflectivity measurement by Dr. Coşkun Unan in our department has given the value 22 well corresponding to rutile. However, the measured Vickers microhardness 522 is too low and the mineral must be studied even in the future.

Quartz. — Although quartz is not a very visible mineral on hand specimens, it must be considered as the main component. Very common is quartz of the first generation in the form of chert-like grey fine-grained aggregate. Both former and later quartz generations are discreetly intergrown with ore minerals and, exceptionally, form small transparent crystals in cavities. The last quartz generation which is post-ore one occurs in the form of almost big colorless crystals reaching up to 3 cm; crystals are never found freely sitting in cavities as the druses were filled up by later gangue minerals.

Adularia. — This feldspar forms a fine- to middle-grained aggregate of white color with an intergrowth of many small crystals of pyrite. In cavities, very fine twinned adularia crystals of a common habitus have been found.

Barite. — This is not a very common gangue mineral, but forms striking tabular aggregates (up to 2 cm long) and simple tabular colorless crystals.

Ankerite. — To this mineral belong common granular aggregate or zonal rhombohedral crystals in cavities with a yellowish color.

Calcite. — This very important component of the ore zone forms either middle-grained aggregates or simple crystals of white or rather yellowish or greenish color, with normal nacreous luster on cleavage planes. The crystals are mainly the combination of positive and small negative rhombohedrons. No specific secondary minerals have been observed here. Secondary limonitized zone in a limited area has been found in the highway cut and in boulders near the beach.

MINERAL SEQUENCE

In the ore vein filling several more or less distinct stages, partly marked by tectonic movements, have been observed. Most distinct are the tectonic actions before and after the origin of the main ore "minerals. During the crystallization of the ore minerals only indistinct and local tectonic movements took place which can be determined only by microscope.

The following mineral sequence has been determined by a combination of megascopic studies of hand specimens and of microscopic studies (Table 4):

1st mineralization period. — The oldest detectable hydrothermal mineralization is represented by chert-like grey fine-grained quartz I with a small amount of fine pyrite I. Quartz I is the most important component of fragments of breccia cemented by later minerals.

2nd mineralization period. — Adularia with pyrite II represents another important ore zone component occurring in irregular blocks or fragments in breccia. Feldspar aggregate is composed normally of grains of 1-5 mm size with rather rarer crystals in druse. Pyrite II is the younger mineral in small grains or pentagonal-dodecahedron crystals following the boundaries of adularia grains.

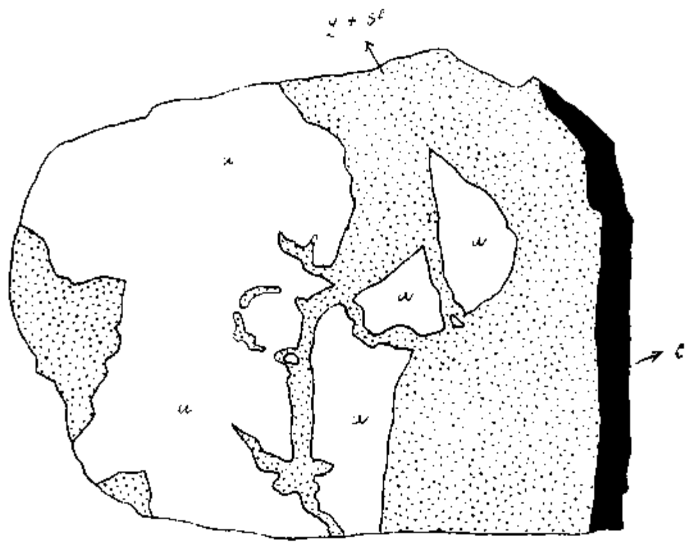

Fig. 1 - Typical structure of hand-specimen from the ore deposit of Piraziz. Adularia aggregate (a) with small pyrite II grains as breccia cemented by younger quartz II with sphalerite and other sulphides. Carbonates (c) form youngest band in the structure.

The relationship between two early mineralization periods is visible by cementation of quartz I blocks by adularia with pyrite II. The ground-mass of minerals of the 2nd period is often partly penetrated by younger minerals, especially by tetrahedrite.

3rd mineralization period. — Among numerous subperiods of this main ore-bearing period, the three earlier are represented by ore minerals with quartz and the last one by gangue minerals.

Subperiod 3/a is formed by quartx II with pyrite III and with the main sphalerite generation. Quartz II is mostly fine-grained, colorless or greyish, almost massive, accompanied by grains of pyrite III and sphalerite I. By microscope has been found either the metacrysts of sphalerite in quartz mass or a mechanical filling of formerly vacant quartz-pyrite druse where sphalerite is obviously the last mineral. No inclusions of ex-soluted chalcopyrite have been observed in the sphalerite aggregate.

The next subperiod 3/b is introduced by crystallization of quartz III which is mostly accompanied by irregular aggregate or crystal groups of microscopic rutile (?). Quartz III forms often imperfect metacrysts into sphalerite mass. Rutile (?) forming small aggregate or crystals, as described above, is always found in the marginal zone of quartz III crystals. Pyrite IV forms groups of small pentagonal dodecahedral metacrysts dispersed in the mass of quartz III or, in cavities, on its crystals.

The next mineral in the sequence is galena forming irregular grains or isometric metacrysts in the quartz mass. Complicated are the relations between galena and tetrahedrite as the mutual boundaries permit a contradictory sequence explanation. Most common are cases where tetrahedrite forms thin veinlets or tongue-like peninsulas into galena grains following the cleavage planes of galena, which are marked by characteristic triangle figures due to selective cleavage breaking. In such cases tetrahedrite is naturally younger. Less reliable are concave-convex mutual boundaries between both minerals, but here galena seems to be younger. A partial mutual overlapping of both minerals is the most probable. Tetrahedrite builds fine crystals in druses growing on crystals of adularia, quartz II and III or pyrite III and IV.

Fig. 2 - Pyrite crystals (p) forming crystalline aggregate cemented by quartz III (q) with dispersed rutile (?) grains (r); no metasomatism of pyrite by quartz has been observed here. Tetrahedrite (t) cements also the pyrite aggregate with selective metasomatism of some internal pyrite zones. Magn. 120 ×.

Insignificant but under the microscope often very striking textures are formed by minerals of the next subperiod 3/c: rare sphalerite II, pyrite V and chalcopyrite. They form nets of fine veinlets composed of crystals or grains which cut the main mass of tetrahedrite and quartz II and III and crystals of pyrite III and IV. On the other hand, galena is only exceptionally cut by chalcopyrite. The mutual relation between the three minerals is as follows: sphalerite II in very small irregular grains is cut by younger components in veinlets—pyrite V and chalcopyrite. Pyrite V seems to be older than chalcopyrite which sometimes cuts or cements its grains. In cavities no crystals of sphalerite II or chalcopyrite have been observed; pyrite V, however, often forms nice pentagonal dodecahedrons on the surface of tetrahedrite crystals.

In the cavities of all the above-named minerals many younger gangue components have crystallized. They belong to three sequence units the oldest of which

Fig. 3 - Sphalerite I aggregate (sf) with visible triangle pattern due to breaking up along cleavage planes, during polishing is metasomatically replaced by tetrahedrite (t) following the sphalerite grains boundaries. Magn. 120 ×.

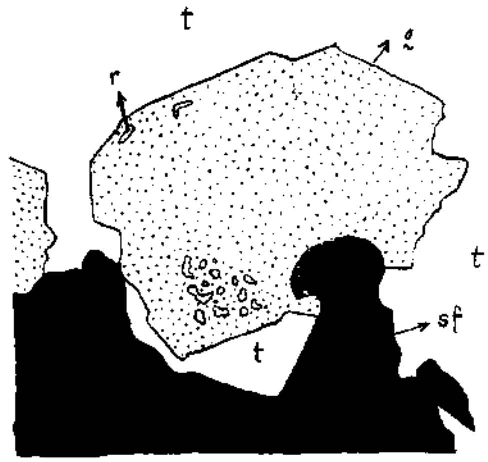

Fig. 4 - On the surface of the sphalerite aggregate (sf) grow crystals of quartz (q) with rutile (?) inclusions (r). Younger tetrahedrite (t) follows the mutual boundaries between sphalerite and quartz. Magn. 160 ×.

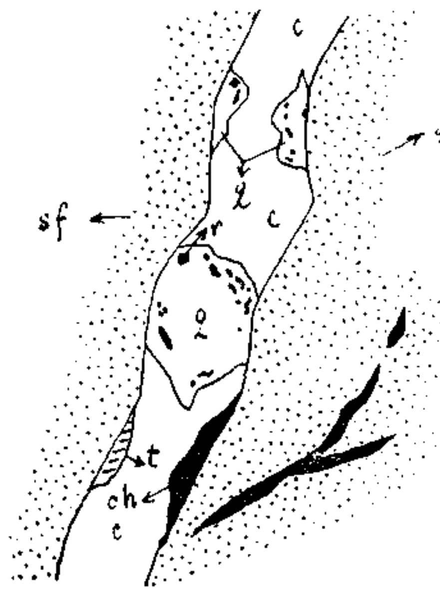

Fig. 5 - Fissure in sphalerite aggregate (sf) with various mineralization: oldest are grains of quartz III (q+r) with rutile (?) and tetrahedrite (t) as well as chalcopyrite (ch), younger is the carbonate infilling (c). Magn. 120 ×.

belongs to the subperiod 3/d : quartz IV and barite. Quartz IV forms big crystals in druse cavities. The base of its crystals is often tetrahedrite crystal or their group. Barite forms coarse-grained tabular aggregates growing over crystals of sulphides or quartz IV. Fine crystals of barite occur in some druses.

4th mineralization period. — The last hypogene mineralization at Piraziz also may be named carbonate period due to the absolute predominance of different carbonates unusually common on this deposit. This mineralization follows after intensive tectonic movement an brecciation of all older filling.

Yellowish ankerite is the oldest of all carbonates. It often forms thin covers on the surface of previous minerals or simple rhombohedral crystalst oward the open cavity space. It also cements the brecciated older filling. On some ankerite crystals sit fine pentagonal dodecahedral crystals of pyrite VI.

Much more widespread is the occurrence of calcite I in druses. Granular calcite I fills up the rest of the cavities, so that recent open spaces in the ore vein filling are not very common. Calcite I forms also fine druse with rhombohedral crystals, mainly, however, it cements the brecciated older minerals and of these chiefly the sulphidic ones. Rare fine-grained pyrite VII or spindle-shaped marcasite grow over calcite I crytals or penetrate by means of metacrysts the older minerals (tetrahedrite, quartz II and III, etc.). The youngest of all known minerals is calcite II in form of fine veinlets cutting older filling incl. marcasite aggregates.

Fig. 6 - Frontal metasomatism of tetrahedrite (t) by galena (g). Magn. 75 ×.

CONCLUSION

The mineral assemblage on the Piraziz deposit belonging to polymetallic mineral association B in the sense of Bernard classification (in print) is rather rich. When compared with other localities of this association, the content of tetrahedrite and carbonates is distinctly higher. Characteristic also is the abundant adularia. In the mineral sequence four mineralization periods can be recognized, three of them mainly of gangue character (1st, 2nd, 4th), the third containing quartz with ore minerals.

Fig. 7 - Shaft and dumps in Piraziz. (Photograph by Ayhan Erler.)

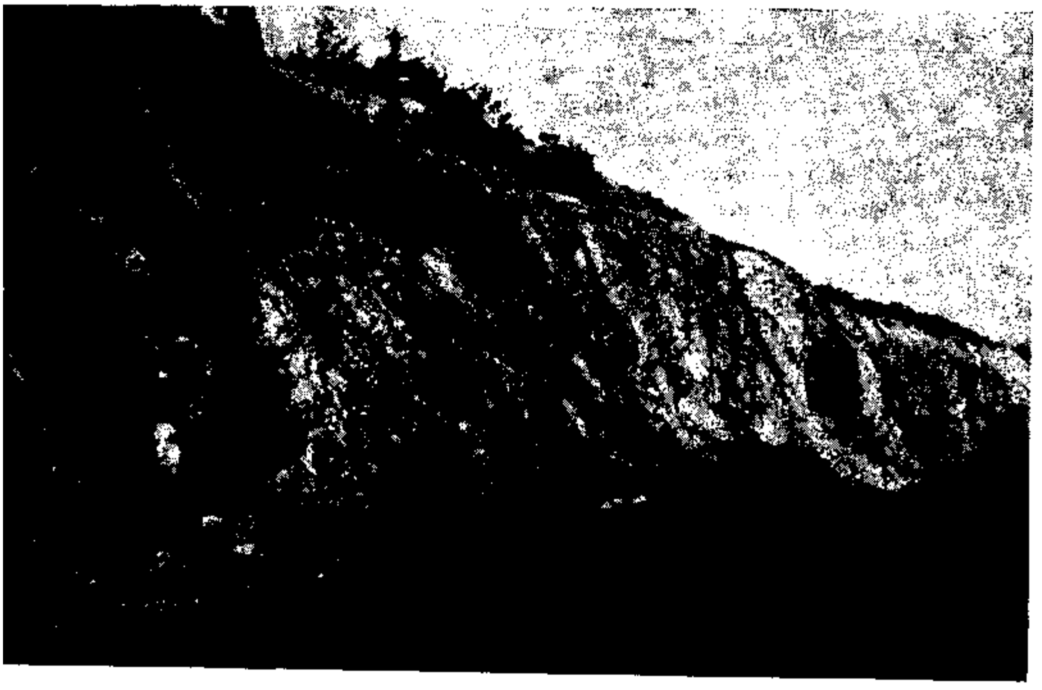

Fig. 8 - Higway cut near Piraziz mine; altered andesite-dacite and tuffs contain a system of ore veinlets. (Photograph by Ayhan Erler.)

Chemically, sphalerite is characterized by a high content of mercury, arsenic, and tin, tetrahedrite by a high content of arsenic and mercury and tin traces and galena by a high tellurium content. On the other hand, the silver content is anomalously low in all of these three minerals.

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Table - 1

Semiquantitative spectral analyses of sphalerite from Piraziz

Sphalerite	*Ag* (%)	*As* (%)	*Bi* (%)	*Cd* (%)	*Co* (%)	*Cu* (%)	*Fe* (%)	*Ga* (%)	*Ge* (%)	*Hg* (%)	*In* (%)	*Mn* (%)	*Ni* (%)	*Sb* (%)	*Sn* (%)	*Zn* (%)
Main shaft	0.001	0.01	0.001	0.5	—	0.01	0.1	0.001	—	0.01	0.001	0.01	—	0.005	0.05	> 10
Main shaft............	0.005	0.01	0.001	0.5	0.05	0.05	1	0.005	0.001	0.01	0.001	0.01	0.005	0.05	0.05	> 10
Highway cut..........	0.005	0.01	0.005	0.5	—	0.05	0.5	0.001	0.005	0.01	0.001	0.01	—	0.01	0.01	> 10

Table - 2

Semiquantitative spectral analyses of galena from Piraziz

Galena	*Ag* (%)	*As* (%)	*Bi* (%)	*Cd* (%)	*Cu* (%)	*Pb* (%)	*Sb* (%)	*Sn* (%)	*Te* (%)	*Zn* (%)
Main shaft..................	0.1	0.05	0.05	0.001	0.1	> 10	0.05	0.005	0.5	0.01
Highway cut	0.1	0.01	0.01	0.001	0.05	> 10	0.05	—	0.1	0.05

Table - 3

Semiquantitative spectral analyses of tetrahedrite from Piraziz

Tetrahedrite	*Ag* (%)	*As* (%)	*Bi* (%)	*Cd* (%)	*Cu* (%)	*Fe* (%)	*Ga* (%)	*Hg* (%)	*In* (%)	*Mn* (%)	*Pb* (%)	*Sb* (%)	*Sn* (%)	*Te* (%)
Beach gallery	0.1	5	0.001	0.01	> 10	5	0.001	0.1	—	0.5	0.05	> 10	0.001	—
Beach gallery	0.1	5	0.005	0.05	> 10	5	0.005	0.5	—	1	0.05	> 10	0.005	—
Main shaft	1-5	> 5	?	0.1	> 10	1	—	0.01	0.001	0.5	0.5	> 10	0.005	?

Table - 4

Mineral sequence on the polymetallic ore deposit of Piraziz

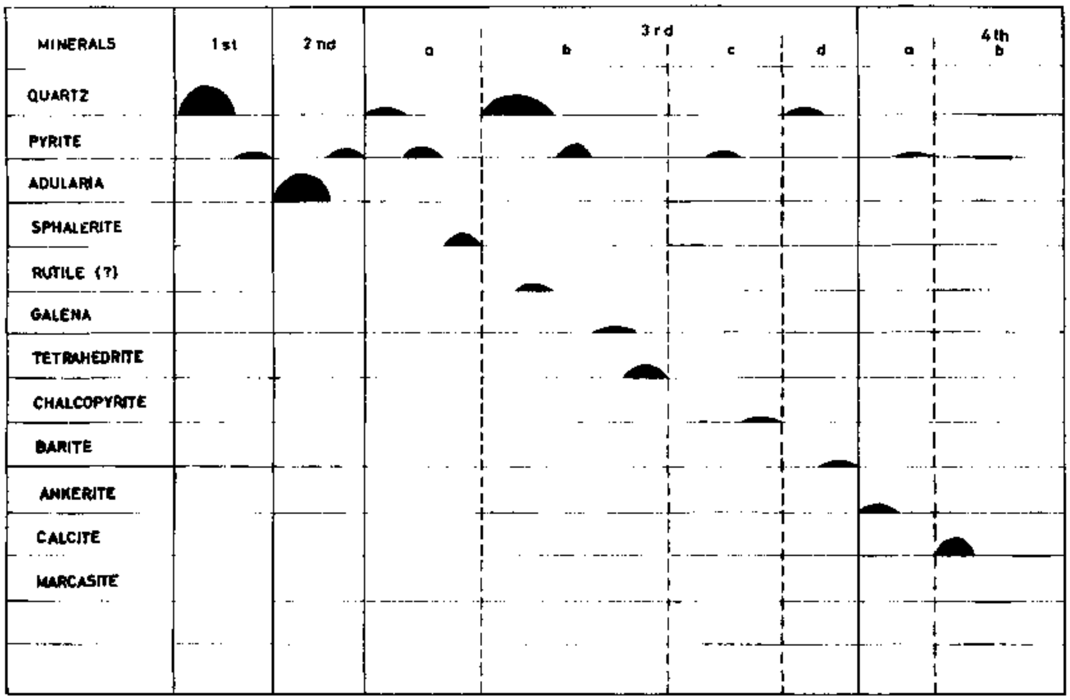
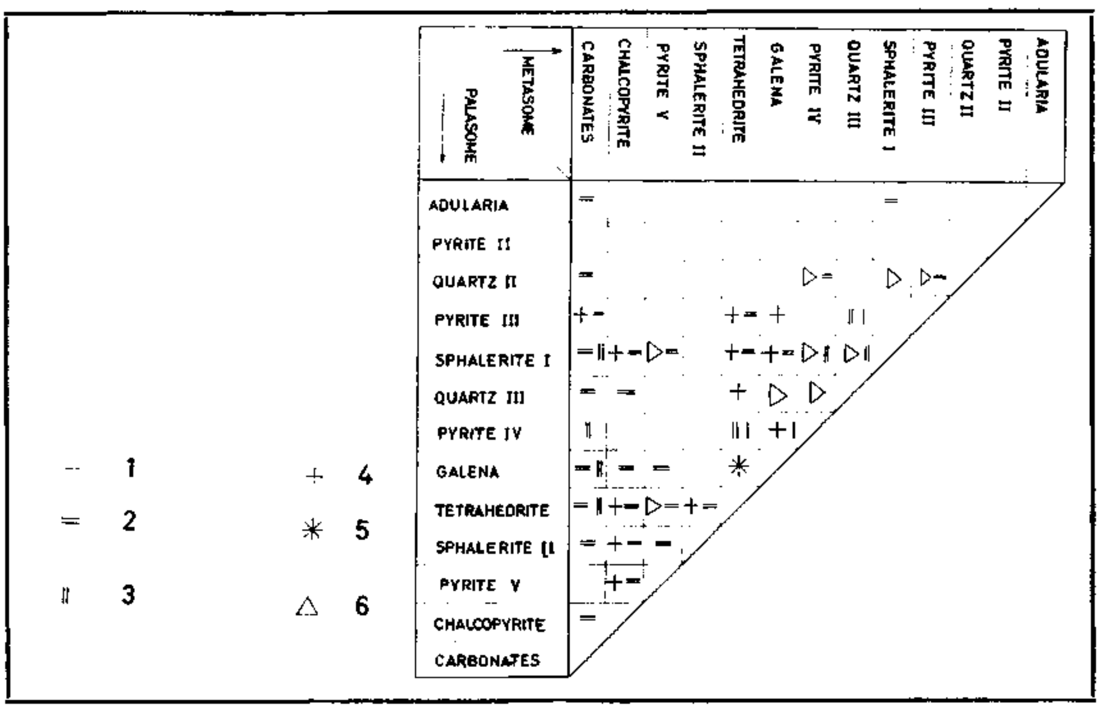


Table - 5

Schema showing the observed character of mutual boundaries between minerals
(according to Bernard, 1953)



1 - Mutual contact without obvious sequence criteria; 2 - Mutual contact as pure filling up of veinlets or cementation of brecciated older minerals, etc., without metasomatism; 3 - Partial metasomatism along fissures walls, along grain or cleavage boundaries, etc.; 4 - Frontal replacement; 5 - Mutual frontal replacement; 6 - Origin of metacrysts.