

# Kontinentales Tiefbohrprogramm der Bundesrepublik Deutschland

## p-T-x Conditions during Formation of Sulfides, Oxides and certain Silicate-Minerals

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The objective of this study is to determine the p-T-x conditions during formation of sulfides, oxides and certain silicate minerals. In a later phase it is intended to compare the observed data of the mineral chemistry with experimental data abundant in literature. Here we report the results of the investigation of selected sulfides.

In the KTB target area Oberpfalz numerous mineral deposits are known. They are associated with the suture zone between Saxothuringikum and Moldanubikum (Erbendorfer Linie). The following investigations were carried out on samples of the geothermal well "Neusorg", Oberpfalz.

The samples acquired in this drilling consist of metavolcanics (down to 176 m), followed by phyllites (until termination of the hole at 301 m). These lithological units are typical Saxothuringian R-tectonites of the Fichtelgebirge.

The Schwarzwald samples mentioned below have been obtained from anatectic paragneisses of B-2 hole ("Schönmatz").

### METHODS

All cores have been carefully examined for macroscopically visible sulfide and/or oxide mineralization. Representative samples of different mineralization and/or lithological units occurring have been taken. Polished sections have been subject to paragenetic studies and electron microprobe analysis. Only for selected sulfide assemblages the formation conditions were deduced from phase diagrams derived from experimental data (e.g. SUGAKI et al., 1975; HUTCHISON & SCOTT, 1981).

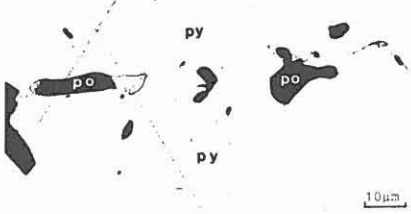


Fig. 1: Two-phase pyrrhotite (po) and chalcopyrite (cp) inclusions in pyrite (py).

### RESULTS

#### Paragenesis

In the metavolcanic sequence small pyrite lodes have been observed between 167.40 to 169.72 m. The subhedral to euhedral pyrite grains contain inclusions of chalcopyrite, pyrrhotite and galena. Chalcopyrite and pyrrhotite occur as separate and as two-phase inclusions (Fig. 1). At a depth of 169.72 m a number of different size sphalerite inclusions in pyrite have been identified. Here sphalerite occurs in three different associations:

- Paragenesis A: Sphalerite inclusions in pyrite
- Paragenesis B: Two-phase sphalerite-chalcopyrite inclusions in pyrite
- Paragenesis C: Two-phase sphalerite-pyrrhotite inclusions in pyrite (Fig. 2)

The paragenesis A and B predominate. Only paragenesis C, which is less abundant, can be used for geobarometric interpretation.

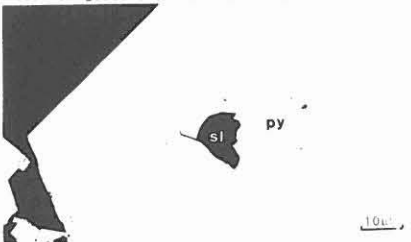


Fig. 2: Sphalerite (sl) inclusions in pyrite (py).

### Mineral chemistry

Electron microprobe analysis of sphalerite shows homogeneous Fe-distribution in most sphalerite grains. Sphalerite of the paragenesis C contains 16.77 to 17.54 mole-% FeS. These values were used for the estimation of the formation pressure (Fig. 4).

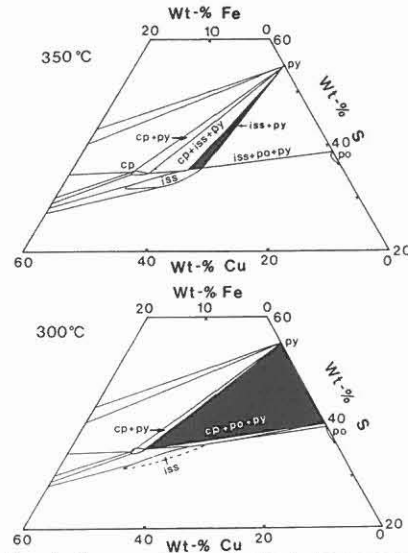
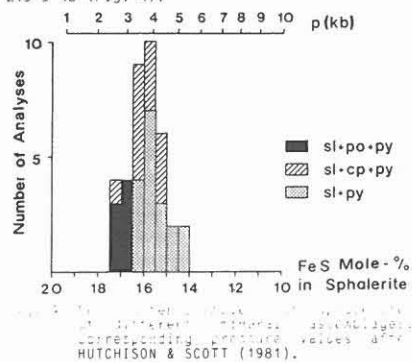


Fig. 3: Phase relations in the Cu-Fe-S-system at 350°C and 300°C after SUGAKI et al. (1975).

### CONCLUSIONS

According to data of SUGAKI et al. (1975) the inclusions of coexisting chalcopyrite and pyrrhotite can be used for an estimate of the formation temperature. In the Cu-Fe-S-system above 350°C and 1 kb pyrite coexists with an ISS (Intermediate Solid Solution). This metastable phase segregates below 334°C +/- 17°C to form pyrrhotite and chalcopyrite (Fig. 3). After HUTCHISON & SCOTT (1981), a shift to a temperature between 353°C and 400°C appears at 5 kb. The two-phase inclusions of chalcopyrite and pyrrhotite imply that the enclosing rock has been heated to at least these temperatures. After KISSIN and SCOTT (1982) pyrrhotite has a hexagonal structure above 254°C. In case pyrrhotite still shows this structure, an estimate of the formation pressure is possible (sphalerite geobarometer; HUTCHISON & SCOTT, 1981; SCOTT, 1983). Sphalerite coexisting with pyrrhotite (paragenesis C) contains 16.77 to 17.54 mole-% FeS. The formula deduced from experimental data  $p(\text{kb}) = 42.3 - 32.1 \log \text{mole-\% FeS}$  yields formation pressure for sphalerite of 2.3-3 kb (Fig. 4).



### Correlation with the results of the fluid inclusion studies at Göttingen University

Two generations of fluid inclusions have been identified. Small quartz veinlets have homogenization temperatures of about 230°C (REUTEL, 1987, pers. com.). The fluid inclusions are NaCl-dominated, of low salinities. The formation temperatures were determined using the p/T-diagram for the H<sub>2</sub>O-system (FISHER, 1976). Considering the sphalerite pressure estimate of 2 to 3 kb the homogenization temperature of 230°C is adjusted to a formation temperature of 350°C - 425°C (Fig. 5) for quartz veinlets. This corresponds with the results derived from sulfide geobarometry and geothermometry.

The combination of microthermometric and geobarometric results suggest a postmetamorphic mineralization with formation pressures and formation temperatures of the diathoreses in the p/T-diagram (Fig. 6) of KLEEMANN (1986).

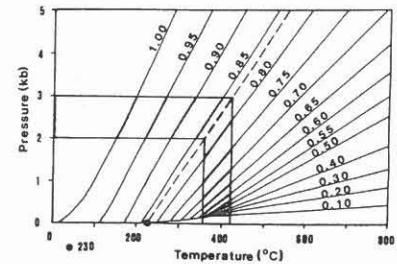


Fig. 5: P/T-diagram after FISHER (1976) for the pure H<sub>2</sub>O-system. Pressure estimate from sphalerite geobarometry is used for pressure correction of the 230°C homogenization temperature of coexisting quartz.

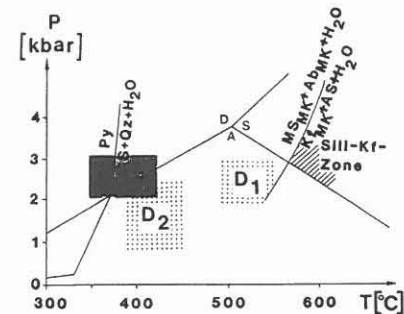


Fig. 6: Combined microthermometric and geobarometric results (black area), marked in the p/T-diagram of KLEEMANN (1986).

The two-phase chalcopyrite-pyrrhotite inclusions in pyrite are also present in the B-2 hole "Schönmatz"/Schwarzwald from 171.60 m to 232.90 m. The mineralization occurs disseminated in anatectic paragneisses. Peak metamorphic condition for this paragenesis probably has also been above 334°C +/- 17°C.

### Literature

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