acta
geologica
polonica

Vol. 30, No. 1 Warszawa 1980

EWA CHOJECKA

Fluorite origin temperatures in some barite veins in the Sudetes

ABSTRACT: The minimum crystallization temperatures of fluorite from barite veins at Boguszów and Stanisławów in the Sudetes Mts, determined by the homogenization method, permitted the recognition of this mineral as a product of the activity of moderate- to low-temperature hydrothermal solutions. The determined temperatures varied along the vertical extent of the veins, making possible the calculation of the gradient of crystallization temperature, and to suggest the gradual cooling of the mineral-forming solutions.

INTRODUCTION

The vein deposit of barite at Boguszów bearing the subordinate fluorite, occurs within the Upper Carboniferous rhyolite body in the western part of the Inner-Sudetic Depression (*cf.* Grocholski 1965). Similar deposit at Stanisławów, in the NE margin of the Kaczawa Mts, formed in the Lower Paleozoic rocks, very diversified lithologically but essentially of the intrusive and subvolcanic origin (*cf.* Wajsprych 1974).

The barite deposits at Boguszów and Stanisławów being the main sources of the barite raw material in the Sudetes (*cf.* Text-fig. 1), have been the subject of diverse economic and geochemical-mineralogical studies (Pawłowska 1970, 1973; Paulo 1972, 1973; Kowalski 1976, 1977).

THE DEPOSITS AND ORE MINERALIZATION

The main stage of the barite-fluorite mineralization at Boguszów was preceded by albitization of volcanic rocks and crystallization of illite, sometimes of dickite, kaolinite, hematite, uraninite, and disseminated pyrite with sphalerite. The final process was the silicification with a scarce sulfide mineralization. Barite, the commonest mineral in the vins, occurs in parageneses with sulfides, fluorite or quartz. The origin of those parageneses was associated with tectonic disturbances (Kowalski 1976). The deposit consists of the two veins which join each other at the depth about 160 m. Their thickness varies, achieving 2 m; the dip is about 80° NE. The veins display generally a simple structure and a tendency to pinching.

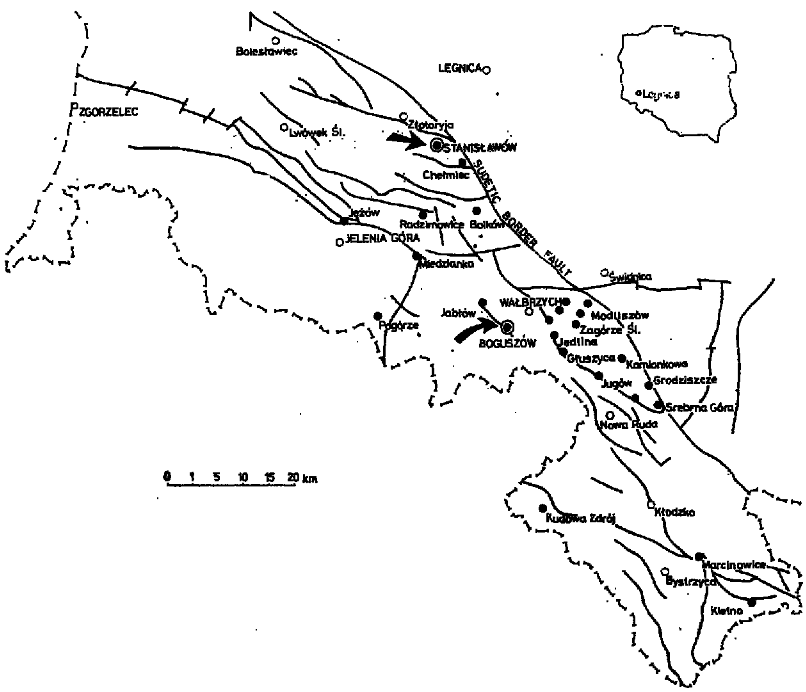
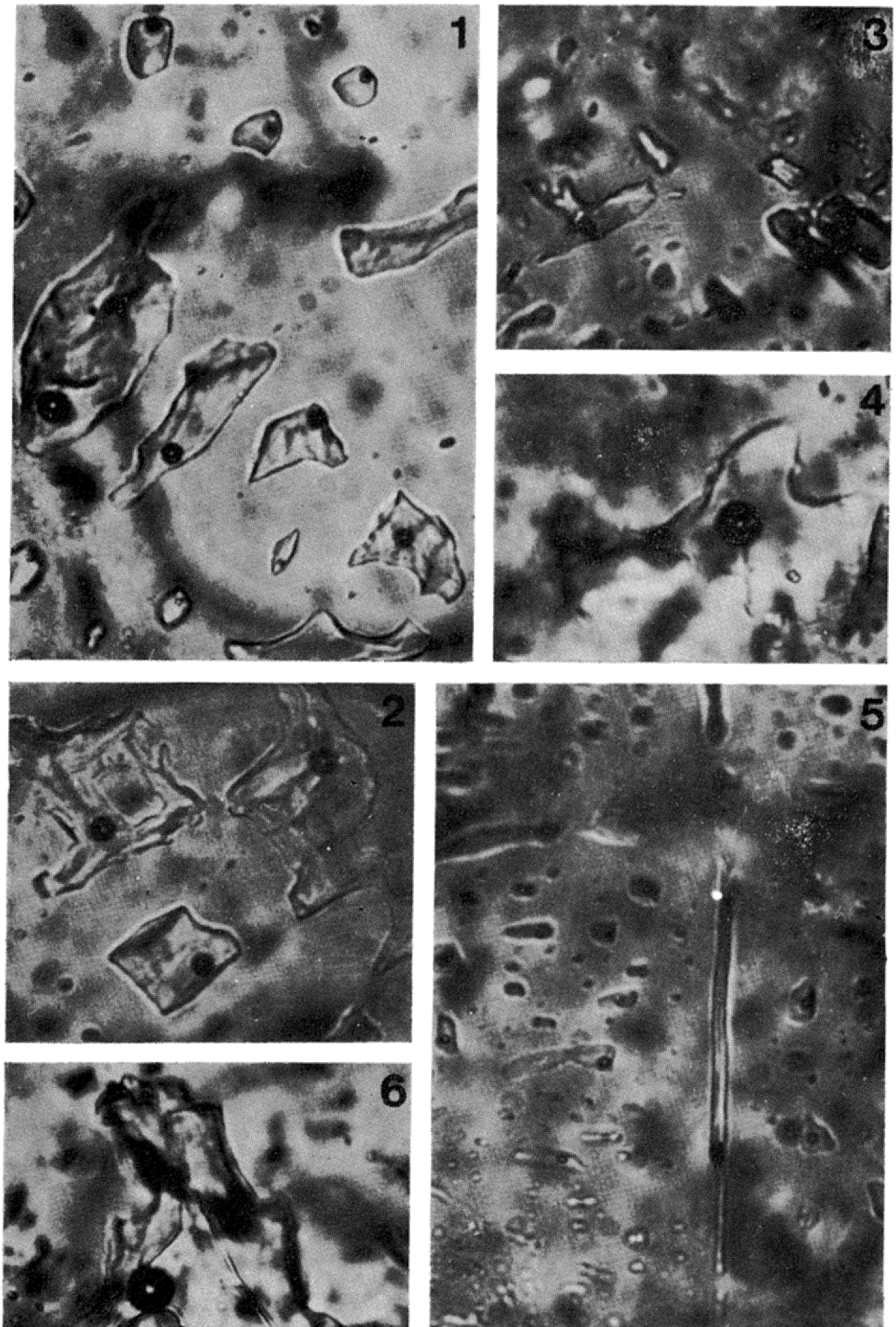


Fig. 1. Occurrence sites of the barite mineralization in the Sudetes (*after* Jerzmański & Kornaś 1970; simplified); solid lines denote the more important faults

In the Stanisławów region, the two ore-bearing veins are known (Stanisławów and Wilcza). The vein Stanisławów formed in the NW-SE dislocation zone, consists essentially of barite, which appears in parageneses with iron and manganese oxides (the latter of psilomelane-hollandite group), fluorite plus sulfides plus carbonates. This vein of strike 140° and SW dip, revealing small local variations, was investigated along the distance 990 m and down to the depth 642 m (borehole *St 18/S*). Thickness of the vein ranges from 1 to 3 m, but sometimes to as much as 6 or 8 m. The average thickness at the depth 100 m exceeds a little the thickness at the surface, and individual apophyses are short and thin.



Primary and secondary inclusions in the investigated fluorites
1 and **2** — secondary from Stanisławów (sample *St 18/S*), ×448; **3** — primary and secondary from Boguszów (level *XIX*), ×512; **4** — secondary from the Rottleberode mine in GDR, ×480; **5** — primary and secondary from the Rottleberode mine in GDR, ×500; **6** — secondary from Boguszów (level *XIX*), ×466

Table 1

Crystallization temperatures of fluorite from Boguszów and Stanisławów, determined by the method of homogenization of inclusions

Location and No. of sample	Level and depth, m	Temperature of homogenization, °C minimum	maximum	primary inclusions	secondary inclusions	Colour of fluorite
BOGUSZÓW						
B3/77-1	XII SE region 240	104	134	75-134 average 113	74-104	colourless
B3/77-2		74	113			bluish-green
B9/77		79	113			pale yellow
BXIX-1	XIX SE region 380	66	144	95-219 average 157	66-110	yellow
BXIX-2		71	219			greenish
STANISŁAWÓW						
St7/77	VIIA NW 160	58	170	108-170 av. 144	58-104	colourless and pale bluish
St10/77	IX SE 200	70	210	112-210 av. 173	70-108	greenish
St17 - 19/77	XI NW 240	88	221	118-221 av. 174	88-114	bluish-white

Table 2

Crystallization temperatures of fluorite from the comparative localites in GDR, determined by the method of homogenization of inclusions

Location	Temperature of homogenization °C minimum	maximum	average of the primary inclusions	Colour of fluorite
HARZ MTS				
Strassberg mine				
Sample No. 1	78	128	110	white-greenish
Sample No. 7	76	164	135	blue, green
Glasebach mine	72	206	148	greenish
Rotleberode mine	70	146	123	bluish-green
THURINGIAN FOREST				
Steinbach mine	66	112	110	greenish

Table 3

Gradients of the temperature of fluorite origin in the barite-fluorite deposits at Boguszów and Stanisławów

Location and depth range: mining levels	metres	Temperature gradient °C/m
BOGUSZÓW		
XII-XIX	240-380	0.31
STANISŁAWÓW		
VIIA-IX	160-200	1.0
VIIA-XI	160-240	0.38
VIIA-drilling	160-640	0.21
XI-drilling	240-640	0.35

LOCATION OF SAMPLES AND METHODS OF INVESTIGATIONS

The samples of barite and fluorite were taken at Boguszów in the mining levels from No. *XII* down to No. *XIX* and at the dump near the shafts *B* and *C*, moreover in the levels Nos. *XII*, *XIII* and *XV* — from the SE section in the third region, and in the level XIX — from the prospecting exploitation wall, about 2,000 m to SE from the shaft *B*.

The samples from Stanisławów come from the levels No. *VII* — *XI* and from the dump. In the levels *VII*, *VIIA*, *VIII* and *XI* they were collected in the NW (central) part, whereas in the level *IX*-both in the NW and SE parts.

The above samples were supplemented by those from the drilling Stanisławów *St. 18/S* from the depth interval 620 to 642 m, and by the specimens kept in the collection of the Institute of Geochemistry, Mineralogy and Petrography, and coming from the Harz Mts and the Thuringian Forest (*see* Pl. 1, Figs 1—6).

The minimum temperatures of crystallization of fluorite were determined by method of homogenization of inclusions. The polished preparations were of thickness 0.2 to 1.0 mm, and the measurements were performed in the microscope heating stage constructed by A. Kozłowski and Ł. Karwowski (*see* Kozłowski 1978), with Pt-PtRh thermocouple calibrated at melting points of salts. The types of inclusions were distinguished using criteria described elsewhere (*e.g.* Ermakov 1948, Pawłowska 1975). The studied samples represented all types of fluorite known from the area; total number of measurements achieved 600.

CRYSTALLIZATION TEMPERATURES OF FLUORITE

Measurements of the homogenization temperatures were made both for primary and secondary inclusions, all of two-phase type homogenizing in liquid. Rarely, inclusions with large gas bubble in fluorite from Stanisławów (levels *IXSE*, *XINW*) have homogenized in gaseous phase. However, this fact does not prove the existence of pneumatolytic solution, but it was caused by leakage of those peculiar inclusions. In the smallest studied inclusions, the migration of gas bubble in the thermal gradient and Brownian movements were observed.

The obtained homogenization temperatures (T_H) of inclusions in fluorite (Table 1) yielded the mean temperatures of the origin of this mineral. at Boguszów as equal 113°C and 157°C for the levels *XII* (upper) and *XIX* (lower), respectively. The data permit the conclusion that temperatures decreased gradually upwards within the deposit limits. The similar tendency was revealed at the Stanisławów deposit. The measurements gave the mean minimum temperatures from 144°C for the level *VIIA* (upper) to 174°C for the level *XI* (lower). Temperatures of the origin of fluorite at the depth 620—642 m (borehole *St18/S*) equal 160°C—245°C, being the highest ones found for the mineral under study. The results (Table 1) prove that fluorite from Stanisławów have crystallized at higher temperature than that one from Boguszów.

The differences in the temperature of crystallization were found for coloured varieties of fluorite from Boguszów. Colourless or yellowish fluorite from the level *XII* yielded T_H about 110°C, pale green — 135°C, similar feature was ascertained for the level *XIX*, where T_H equal 130°C, and 170°C respectively. The comparative samples from the Harz Mts and the Thuringian Forest have yielded similar values (Table 2).

The obtained T_H of secondary inclusions in fluorites of the two studied Sudetic deposits were generally lower than T_H of the primary inclusions (Table 1) and they are connected with later alterations involving the formerly precipitated mineral.

GRADIENTS OF THE TEMPERATURE DECREASE

The results yielded by the inclusion studies alter regularly along the vertical extent of the mineralized body. That fact was the basis of calculation of the gradients in temperature decrease for the fluorite origin within the ranges of the barite-fluorite formation. At the Boguszów deposit the gradient calculated for two extreme mining levels (*XII* and *XIX*) was determined for 0.31°C/m.

At the Stanisławów deposit, certain variations of the gradient were revealed (Table 3). The longest section of the deposit that might be recently studied having 482 m, i.e. borehole *St18/S*, submitting samples from the mining level *XIIIA* to the depth 642 m, was characterized in general by the gradient 0.21°C/m. The interval between the mining levels *VIIA* and *XI* (80 m) has higher value of the gradient exceeding 0.3°C/m, whereas the distance between the topmost mining levels *VIIA* and *IX* (40 m) gave the value of the gradient as high as 1.0°C/m.

Consequently the above result suggest the tendency for a more rapid temperature decrease in the shallow, subsurface parts of the deposit. This phenomenon may be explained either by a simple cooling of the hydrothermal solutions due to wall-rock thermal conductivity during crystallization in opened and just opening fractures, or by a mixing of the ascending (hot) and descending (cool) waters.

DISCUSSION OF THE RESULTS

The presented results include fluorite from Boguszów and Stanisławów into group of hydrothermal minerals of low- to moderate-temperature origin. These results agree in general with determinations performed by the same method by A. Kozłowski (published *in:* Kowalski 1977) but they represent T_H distribution in the deposit by more detailed manner, especially taking into account the depth of the fluorite origin. The results of decrepitation of fluorite from the same deposits presented by Pawłowska (1973) are different and the estimated temperatures of crystallization are higher than T_H given in the present paper. However, temperatures obtained by the two methods, homogenization and decrepitation of inclusions, cannot be compared due to low accuracy, ambiguity and other uncertainties of the decrepitation method.

Fluorites from the comparative samples may be also included into the same temperature group (Table 2), since the obtained minimum crystallization temperatures 110—166°C fall into epithermal stage of the hydrothermal process after Fersman.

The discussed deposits of barite-fluorite type from the Sudetes and similar comparative locations in GDR occur in the area of the Middle-European metallogenic province, and structurally they belong to one geological unit of the Bohemian massif. Its development was of polymagmatic and multistage nature, as the massif is cut by numerous deep-seated faults ascertained by seismic studies. A number of the faults expand below the Moho discontinuity reaching the upper mantle, the others disappear at various depths in the Earth's crust (Zeman 1973). According to Zeman, these faults had an extremely important influence upon the magmatic events, since they were also the ways of migration of the mineralizing solutions. It is noteworthy that similar assumptions were already expressed by Grushkin (1964) who presented evidences that origin of the majority of the world's barite-fluorite deposits, mostly low-and moderate-temperature ones, is connected with migration of the potentially mineral-forming substance from the deep-seated magmatic chambers.

On the basis of the referred opinions and the writer's own results, the conclusion may be expressed on the hydrothermal origin of the studied deposits in the Sudetes. However, neither the present paper, nor any hitherto published data determine unambiguously the place of generation of the mineral-forming solutions. Thus, one may conclude again that the barite-fluorite deposits under study have formed due to activity of the deep-seated magmatic chambers but unfortunately still of unknown location.

Institute of Geochemistry, Mineralogy and Petrography
of the Warsaw University,
Al. Żwirki i Wigury 93,
02-089 Warszawa, Poland

REFERENCES

ERMAKOW N. P. 1948. Proiskhozhdenie i klasifikatsija zhidkikh vkluchenij v mineralakh. *Miner. Sbornik*, No. 2, 53—73. Lvov.

GROCHOLSKI A. 1965. The volcanic rocks in the Wałbrzych basin in the light of structural studies. *Biul. Inst. Geol.*, **191**, 5—67. Warszawa.

GRUSHKIN G. G. 1964. Nekotorye osobennosti formirovanija fluoritovykh mestorozhdenij. *Geol. Rudnykh Mestorozhd.*, **6** (1), 15—32. Moskva.

JERZMAŃSKI J. & KORNAŚ J. 1970. The minerals of the barite deposit at Stanisławów, Lower Silesia. *Prace Inst. Geol.*, **59**, 85—96. Warszawa.

KOWALSKI W. 1976. Geochemistry, mineralogy and origin of the Lower Silesian barite deposits and occurrences. Part I: Introduction, investigation methods, barite mineralization in the Intra-Sudetic synclinorium and in the Owl Mountains. *Arch. Miner.*, **32** (2), 5—88. Warszawa.

— 1977. Geochemistry, mineralogy and origin of the Lower Silesian barite deposits and occurrences. Part II: Barite mineralization in the Kaczawa Mountains, geochemical results, and remarks on the age and origin of barite mineralization in the Sudetes Mountains. *Arch. Miner.*, **33** (1), 107—167. Warszawa.

KOZŁOWSKI A. 1978. Pneumatolytic and hydrotermal activity in the Karkonosze-Izera block. *Acta Geol. Polon.*, **28** (2), 171—221. Warszawa.

PAULO A. 1972. Mineralogy of the barite deposit at Stanisławów *Prace Min. Kom. Nauk Min. PAN, Oddział w Krakowie*, **29**, 1—77. Warszawa.

— 1973. The barite deposit at Stanisławów against the background of metalogeny of the Kaczawa Mountains. *Prace Geol. Kom. Nauk Geol. PAN, Oddział w Krakowie*, **76**, 1—72. Warszawa.

PAWŁOWSKA J. 1970. The barite mineralization in the northern part of the Intra-Sudetic trough. *Prace Inst. Geol.*, **59**, 97—123. Warszawa.

— 1973. Physico-chemical condition of formation of Lower Silesian barite deposits. *Biul. Inst. Geol.*, **267**, 1—113. Warszawa.

— 1975. Thermobarogeochemistry: application and methods. *Kwart. Geol.*, **19** (2), 371—388. Warszawa.

WAJPRYCH B. 1974. Tectonics of the Chełmiec unit (north-western part of the Kaczawa Mountains). *Geol. Sud.*, **9** (1), 101—123. Warszawa.

ZEMAN J. 1973. Variscan tectogenesis of the Bohemian massif and its relation to deep zones. *Przegl. Geol.*, **7**, 378—382. Warszawa.

E. CHOJECKA

TEMPERATURY POWSTANIA FLUORYTU W NIEKTÓRYCH ZŁOŻACH BARYTOWYCH SUDETÓW

(Streszczenie)

Przedmiotem pracy jest rozpoznanie temperatur powstania fluorytu występującego w złożach barytu w Boguszowie i Stanisławowie w Sudetach. Temperatury krystalizacji wyznaczone metodą homogenizacji inkluzji (*patrz* pl. 1) wskazują, że fluoryt jest tutaj produktem średnio- i niskotemperaturowych roztworów hydrotermalnych. Stwierdzono także zmienność temperatur powstania tego minerału w profilach pionowych obu kopalń: w Boguszowie od 113°C (poziom *XII*, głębokość 240 m) do 157°C (poziom *XIX*, gł. 380 m), oraz w Stanisławowie od 144°C (poziom *VIIA*, gł. 160 m) do 245°C (wiercenie, gł. 620—642 m). Ze zmiennością tych temperatur krystalizacji związane jest zabarwienie fluorytu: odmiany bezbarwne i żółte powstawały w temperaturach 130—110°C, natomiast zielone (Boguszów) — w temperaturach 170—135°C. Gradienty spadku temperatury w obrębie obu złóż są generalnie coraz wyższe w strefach przypowierzchniowych; wartość ich dla złoża w Boguszowie wynosi 0,31°C/m, zaś dla Stanisławowa — od kilku dziesiątych do 1°C/m. Spadek temperatury był tutaj rezultatem bądź normalnego ochładzania roztworów hydrotermalnych, bądź mieszania się ich z wodami descensyjnymi.