

## **GENESIS OF POLYMETALLIC QUARTZ-BARITE VEINS IN THE »MONTAGNE DE PORMENAZ«, AIGUILLES ROUGES MASSIF, FRANCE: STRUCTURAL , FLUID INCLUSION AND ISOTOPE (SR, S) CONSTRAINTS**

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The on-going study is essentially based on the »Mine des Baraques«, which comprises two subvertical polymetallic veins exploited 200 years ago for silver and other base metals at the »Montagne de Pormenaz«, 7 km to the NW of Chamonix. The »Montagne de Pormenaz« consists of the pre-Stephanian A Pormenaz porphyric monzonitic intrusion, which is covered by autochthonous and parautochthonous Upper Carboniferous and Triassic sedimentary rocks, and by the Morcles nappe. The late-Hercynian Pormenaz porphyric monzonite is part of the polymetamorphic basement of the Aiguilles Rouges Massif. The mineralized veins are hosted by the monzonite.

The monzonite host rock and the pre-mid Carboniferous rocks of the Pormenaz area probably underwent a late-Hercynian deformation. DOBMEIER & VON RAUMER (1995) attribute this to an intense shearing event during a mid-Carboniferous transpression. The positive flower structure of the Pormenaz area was induced by a sinistral transpression during the Alpine cycle and is rooted in the N-S oriented Pormenaz Fault (DOBMEIER & VON RAUMER, 1995). Associated with the latter, we have observed several WSW to WNW-verging thrusts, and sinistral-reverse N-S oriented shear zones and slip faults, dipping to the E. The Pormenaz monzonite and the Westphalian D black shales are thrust on the Upper Carboniferous conglomeratic sequence toward the WNW. The foliation within these thrusts and shear zones is obviously Alpine in age. However, it is difficult to attribute with certainty an Alpine or a Hercynian age to the foliation outside of the Alpine shear zones. This foliation could represent a superposition of both Alpine and Hercynian deformation.

Abundant subvertical extension fractures filled with drusic and milky quartz are associated with these WSW to WNW-verging thrusts and N-S oriented shear zones. These subvertical fractures have in general a NNW-SSE to WNW-ESE strike, and are related to the Alpine sinistral transpression. The orientation of the mineralized quartz-barite veins, particularly the ones of the »Mine des Baraques«, corresponds to the WNW-ESE strike of the Alpine extension fractures. This preferential direction of the mineralized veins is probably controlled by zones of weakness inherited from the mid-Carboniferous transpression. We conclude that the mineralized veins of the »Montagne de Pormenaz« have been controlled by Hercynian and Alpine structures, and emplaced during Alpine sinistral transpression as extension fractures fillings.

At the »Mine des Baraques«, two different mineralisation stages have been recognised. (a) The initial and main stage consists of quartz and barite, with in order of appearance pyrite, chalcopyrite, tetrahedrite, bournonite and galena. (b) A second stage is composed of quartz and stibnite. Microprobe analyses reveal that Ag is located in te-

trahedrite and galena. An opaque mineral concentrate of the initial mineralization stage indicated a grade of 312 g/t of Ag and some traces of Au. Some Au is also associated with the stibnite-quartz stage.

The monzonite host rock underwent a regional sericitic alteration. The local hydrothermal alteration due to the emplacement of the »Mine des Baraques« veins is a significant enrichment of S, K and Rb over a one meter range in the immediate wallrock which is distinct with respect to the regional sericitic alteration.

The microthermometric fluid inclusion study was carried out on: (1) quartz and barite crystal intergrowths from the mineralized veins and intimately associated with the sulfides and sulfosalts, (2) quartz intimately associated with the stibnite mineralization, (3) barren regional quartz veins, unrelated to the mineralization, and (4) quartz from a WNW verging thrust. Fluid inclusions in the quartz-barite mineralized veins (1) are liquid-rich NaCl-H<sub>2</sub>O inclusions, with two phases at room temperature. They yield a constant salinity around 9 wt% NaCl equivalent and total homogenisation temperatures ranging from 240° to 180°C. This indicates that cooling was the main mechanism responsible for the formation of the mineralized veins. Barren regional quartz veins (3) and quartz from a WNW-verging thrust (4) also contain liquid-rich NaCl-H<sub>2</sub>O inclusions, however with a larger range of salinities and total homogenisation temperatures: 4.9 to 11.6 wt% NaCl equivalent and 156° to 243°C, respectively. These data suggest that following precipitation of the mineralized quartz-barite veins, the hydrothermal system was opened resulting in mixing of the saline, high temperature NaCl-H<sub>2</sub>O fluid with an in-coming dilute, low temperature fluid, possibly of meteoric origin. The quartz-stibnite veins (2) contain H<sub>2</sub>O-CO<sub>2</sub>-NaCl fluid inclusions, with two phases at room temperature. Salinities based on clathrate melting temperatures range between 2.4 and 8.2 wt% NaCl equivalent, and total homogenisation temperatures fall between 210° and 300°C with a mode at 273°C. Late-stage dilute (0.7 to 3.8 wt% NaCl equivalent) secondary fluid inclusions with homogenisation temperature of 172° to 190°C crosscut the stibnite-bearing quartz. Thus, the hydrothermal fluid which formed the quartz-stibnite mineralization is different from the one responsible for the quartz-barite veins, and occurred at late stages, just before the NaCl-H<sub>2</sub>O system ceased to function.

The  $\delta^{34}\text{S}$  values of barite samples range between 18.1 and 27.1‰, of galena samples between -0.2 and 1.8‰, and of chalcopyrite samples between 1.9 and 3‰. Thermometers based on fractionation of sulfur between sulfate and sulfide indicate a temperature of 260° to 320°C for the emplacement of the quartz-barite veins. Diagrams with  $\delta^{34}\text{S}$  values of pairs of sulfide and sulfate plotted against the corresponding  $\Delta_{\text{sulfate-sulfide}}$  values yield a  $\delta^{34}\text{S}$  of the ore-forming fluid of about 2.5‰. This indicates that the S in the mineralized veins was leached from a magmatic rock, most likely the monzonite host rock. Furthermore, the latter contains Ba-rich phenocrysts of K-feldspar with up to 1.2 wt% Ba. Thus, the Ba in the barite veins was also derived from the host monzonite.

Barite is enriched in <sup>87</sup>Sr with respect to the weakly and moderately altered monzonite host rock and their included K-feldspars. <sup>87</sup>Sr/<sup>86</sup>Sr values of twelve barite samples fall between 0.71474 and 0.71510, of three little to moderately altered monzonite samples between 0.71259 and 0.71448, and of three very weakly altered K-feldspars from the

corresponding three monzonite samples between 0.71100 and 0.71196. Thus, Sr in the barite was at least partly derived from another source. Further isotope analyses are in progress to test whether the Upper Carboniferous conglomeratic and arenitic sequence overlying the Pormenaz monzonite, or more strongly altered monzonite host rocks may have provided Sr enriched in  $^{87}\text{Sr}$  to the mineralization. We can rule out any derivation of Sr from overlying Triassic to Cretaceous carbonates (and evaporites?) since such Sr would be fairly non-radiogenic ( $^{87}\text{Sr}/^{86}\text{Sr}$  between 0.707 and 0.708).

We conclude that the quartz-barite veins of the »Montagne de Pormenaz« have been controlled by Hercynian and Alpine structures, and have been emplaced during cooling of a moderately saline aqueous fluid between 320° and 260°C during the Alpine sinistral transpression event, as extension fractures filling. Ba and S were likely derived from the monzonite host rock. The source of Sr is still open to question and must be partly derived from a source other than the weakly altered monzonite host (its more altered sericitic counterparts or the Carboniferous cover?). The base metals are likely also derived from the same rocks. Quartz-stibnite veins were emplaced at late stages from a distinct  $\text{CO}_2$ -bearing  $\text{H}_2\text{O}$ -NaCl fluid.

DOBMEIER, C. & VON RAUMER, J.F. (1995): *Ecolgae geol. Helv.*, 96/2, 267–279.