Structural setting and fluid inclusion characteristics of the polymetallic quartz-barite veins of the "Montagne de Pormenaz", Aiguilles Rouges Massif, France

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SHORT COMMUNICATION

Structural setting and fluid inclusion characteristics of the polymetallic quartz-barite veins of the "Montagne de Pormenaz", Aiguilles Rouges Massif, France*

by *Marc Polliand*[1] and *Robert Moritz*[1]

Abstract

The "Montagne de Pormenaz" consists of the pre-Stephanian A Pormenaz porphyric monzonitic Ba-rich intrusion. The quartz-barite mineralized veins are hosted by the monzonite. These mineralized veins have been emplaced during Alpine sinistral transpression as extension fractures fillings, and have been controlled by Hercynian and Alpine structures.

The microthermometric fluid inclusion study based on (1) quartz and barite crystal intergrowths from the mineralized veins, and (2) barren regional quartz veins shows that the mineralized veins correspond to a thermal anomaly with respect to the regional fluid. Homogenization temperatures indicate minimum temperatures of 200–250 °C during the ore formation process.

Keywords: polymetallic veins, structural setting, fluid inclusion, Aiguilles Rouges Massif, Western Alps.

Introduction

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". The "Mine des Baraques" is located in the Passy natural reserve, Aiguilles Rouges Massif, 7 km NW of Chamonix (Fig. 1). GYSIN and DESBAUMES (1947) report a grade of 1828 g/t of Ag and some traces of Au on an opaque mineral concentrate from the "Mine des Baraques". In this contribution we report preliminary structural, lithogeochemical and microthermometric fluid inclusion data. The aim of this study is to determine the age (Hercynian or Alpine) and the tectonic context of the ore occurrences, to define the P-T conditions during its emplacement and to characterize the ore forming fluid(s) and the hydrothermal alteration associated with the ore occurrences.

Regional geological setting

Recent studies on the geology of the "Montagne de Pormenaz" can be found in LAURENT (1968), LOX and BELLIÈRE (1993), and DOBMEIER and VON RAUMER (1995). The "Montagne de Pormenaz" is located in the southwestern part of the Aiguilles Rouges Massif. It 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 (Fig. 1). The late-Hercynian Pormenaz porphyric monzonite is part of the polymetamorphic basement of the Aiguilles Rouges Massif. Geochemical data show that the monzonitic intrusion belongs to a subalcaline high-potassic series according to the R1-R2 diagram of DE LA ROCHE et al. (1980). In particular, this rock contains typically more than 2000 ppm of Ba. The mineralized veins are hosted by the monzonite (Fig. 1).

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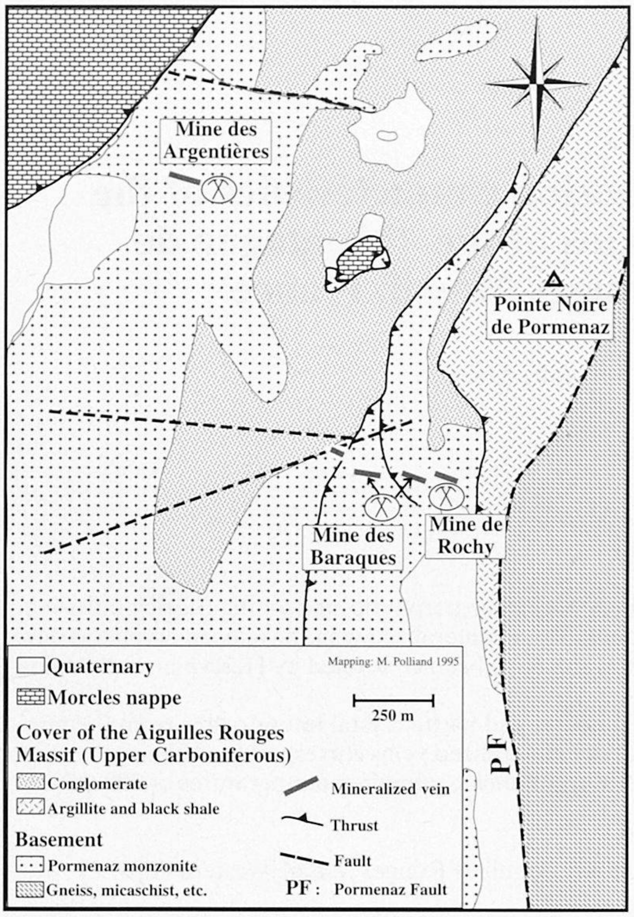

Fig. 1 Geological map of the "Montagne de Pormenaz".

Structural setting

VARISCAN CYCLE STRUCTURES

The monzonite host rock and the pre-mid Carboniferous rocks of the Pormenaz area probably underwent a late-Hercynian deformation. The N–S striking foliation of these rocks, dipping steeply to the E, may correspond to this deformation phase. DOBMEIER and VON RAUMER (1995) attribute this to an intense shearing event during a mid-Carboniferous transpression. We have also observed a diaclase network in the monzonite, probably induced by the tension during post-emplacement cooling (Fig. 2).

ALPINE CYCLE STRUCTURES

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 shown in figure 1 (DOBMEIER and VON RAUMER, 1995). Associated with

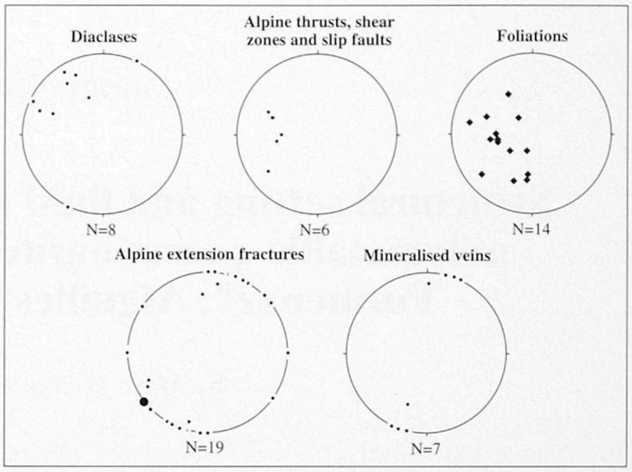

Fig. 2 Stereoplots of structural elements and mineralized veins (equal area net).

the latter, we have observed several WSW to WNW-verging thrusts, and sinistral-reverse N–S oriented shear zones and slip faults, striking N37°W to N25°E and dipping 56°E to 36°E (Fig. 2). The Pormenaz monzonite and the Westphalian D black shales are thrusted on the Upper Carboniferous conglomeratic sequence toward the WNW (Fig. 1). The foliation within these thrusts and shear zones strikes N40°W to N20°E, and is obviously Alpine in age (Fig. 2). This foliation is present in the monzonite, the black shales and the conglomerate sequence. However, it is difficult to attribute with certainty an Alpine or an Hercynian age to the foliation outside of the Alpine shear zones. Moreover, 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 (Fig. 2), and are related to the Alpine sinistral transpression. However, it is also possible that some of these fractures hosted by the pre-mid Carboniferous rocks are relic Hercynian structures.

The orientation of the mineralized veins from the "Montagne de Pormenaz", particulary the ones of the "Mine des Baraques", corresponds to the WNW–ESE strike of the Alpine extension fractures (Fig. 2). 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

Tab. 1 Characteristics of the different types of fluid inclusions.

	Composition	Phase(s) at room temperature	Th total (to the liquid)	Th CH_4	Salinity	Tm clathrate	Localization
Type Ia	H_2O–NaCl	2 phases	185–255 °C	/	6.9–12.2 wt%NaCl equ.	/	Mineralized vein
Type Ib	H_2O–NaCl	2 phases	159–202 °C	/	4.9–10.5 wt%NaCl equ.	/	Regional vein
Type II	CH_2–H_2O	1–2 phases	/	96 °C	/	+15 °C	Regional and mineralized vein

by Hercynian and Alpine structures, and have been emplaced during Alpine sinistral transpression as extension fractures fillings.

Pb–Cu–Sb–As–Ag–Au occurrences

The subvertical polymetallic veins of the "Mine des Baraques" are hosted by the porphyric monzonite of Pormenaz. They were mined along four levels among which three are still accessible: a lower gallery named "Princesse" and two upper galleries named "Duchesses". The veins are 0.5 m to 1 m thick and have a N92°E to N115°E orientation. The gangue is constitued by quartz and barite. Three different mineralization stages have been recognized. (1) The initial stage consists of quartz and barite, with in order of appearance pyrite, chalcopyrite, tetraedrite, bournonite and galena. There is a decreasing abundance to complete absence of barite during the last stages of mineral deposition. (2) A second stage is composed of quartz and stibnite. (3) Finally, a late oxydation stage with covellite and Fe-oxydes partly overprints the other assemblages (Fig. 3). Tetraedrite is suspected to contain the silver and some gold might be associated with the stibnite phase. More investigations are required to document these associations.

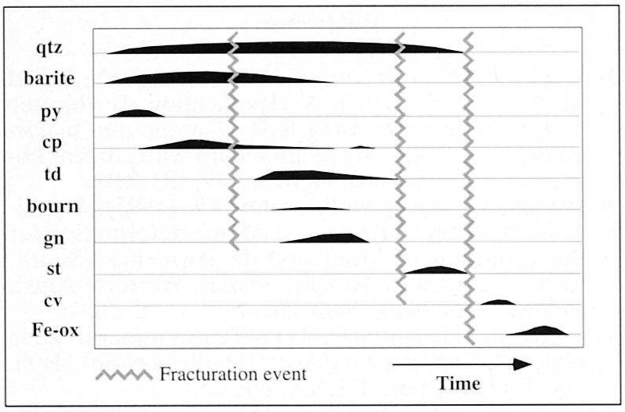

Fig. 3 Paragenesis of the "Mine des Baraques" mineralized veins.

Alteration

Two geochemical profiles along the northern and southern host rocks of the vein, including twelve and ten samples, respectively show that the monzonitic wallrock was affected by hydrothermal alteration over about a one meter range, with a significant enrichment of S, K and Rb.

Microthermometric fluid inclusion study

The microthermometric fluid inclusion study was carried out on: (1) quartz and barite crystal intergrowths from the mineralized veins and intimately associated with the sulfide and sulfosalt mineralization, and (2) barren regional quartz veins, unrelated to the mineralization. Three types of fluid inclusions have been observed (Tab. 1).

Type Ia are liquid-rich NaCl–H_2O inclusions from the mineralized veins, with two phases at room temperature. Salinities based on ice melting temperatures range between 6.9 and 12.2 wt% NaCl equivalent, with a mode at 8.9 wt%. Total homogenization temperatures fall between 185 and 255 °C with a mode at 206 °C.

Type Ib are liquid-rich NaCl–H_2O inclusions from the regional quartz veins, with two phases at

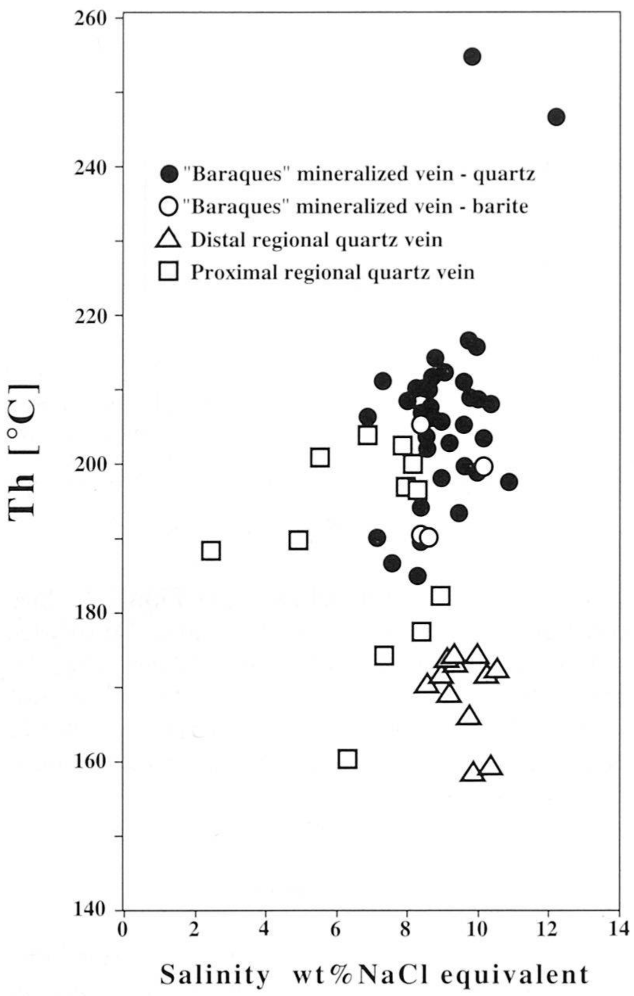

Fig. 4 Total homogenization temperature vs salinity of *type Ia* and *type Ib* fluid inclusions.

room temperature. The ice melting temperatures indicate salinities between 4.9 and 10.5 wt% NaCl equivalent with a mode at 8.2 wt%. Total homogenization temperatures are lower than in the type Ia fluid inclusions, and range between 159 and 202 °C with a mode at 179 °C.

Type II are fluid inclusions from both regional and mineralized veins. They contain one to two phases at room temperature. These inclusions, containing CH_4, are dark in aspect, and yield a clathrate melting temperature around 15 °C. The CH_4 homogenization temperature is about –96 °C.

The microthermometric characteristics of the studied fluid inclusions are similar to those described by MULLIS et al. (1994) in the anchizone of the Central Alps. Quartz and barite from the "Mine des Baraques" ore-bearing veins yield similar microthermometric data (Fig. 4). Thus, the mineralized veins probably did not suffer an important deformation phase post-dating their emplacement. In addition, some CO_2-rich fluid inclusions have been observed in quartz from the quartz-stibnite mineralization stage. They are currently under study.

Conclusions

The fluid inclusion data show that the mineralized veins correspond to a thermal anomaly with respect to the regional fluid (Fig. 4). For the time being, the fluid inclusion data do not allow us to define the mechanism of ore deposition (cooling, mixing,...?). The mineralized veins of the "Mine des Baraques" and all the other quartz-barite mineralized veins of the "Montagne de Pormenaz" have been controlled by Hercynian and Alpine structures, and have been emplaced during the Alpine sinistral transpression event, as extension fracture fillings. The fluid inclusions indicate minimum temperatures, i.e. homogenization temperatures, of 200–250 °C. Ba is likely derived from the monzonitic host rocks, while some of the base metals may come from the Upper Carboniferous sediments.

Sulfur isotope analyses on barite, galena and chalcopyrite, strontium isotope analyses on barite, and a more detailed fluid inclusion study are in progress. These additional data will allow us to gain a better understanding of the depositional mechanism and of the nature of the fluids involved in the ore formation process.

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