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FLUID EVOLUTION THROUGH TIME ALONG A SHEARZONE: AN EXAMPLE FROM THE LOWER PALAEOZOIC ANGLO-BRABANT FOLD BELT, BELGIUM

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Introduction

A polysulphide mineralised shear zone occurs at the southern margin of the Anglo-Brabant Fold belt (Figure 1). The study area consists of Lower Palaeozoic greenschist metamorphosed turbidite deposits, i.e. siltstones and slates, interstratified with few volcanic rocks (De Vos et al., 1993). The mineralisation consists of quartz veins with minor amounts of sulphides, carbonates, chlorite and is associated with an envelope of extensive alteration. By ^{40}Ar-^{39}Ar dating, the main period of hydrothermal circulation, resulting in the alteration and mineralisation, has been established to be ~ 416 myrs ago (Dewaele et al. submitted). The shear zone identified forms part of a larger deformation zone at the southern margin of the Anglo-Brabant Fold belt, the Nieuwpoort-Asquempont fault zone, which has been tectonically active during later periods.

A fluid inclusion study has been carried out on vein quartz and carbonates, sampled at regular distances in a borehole transecting the shear zone. The aim of this study is to characterise the fluid types that have circulated through the shear zone.

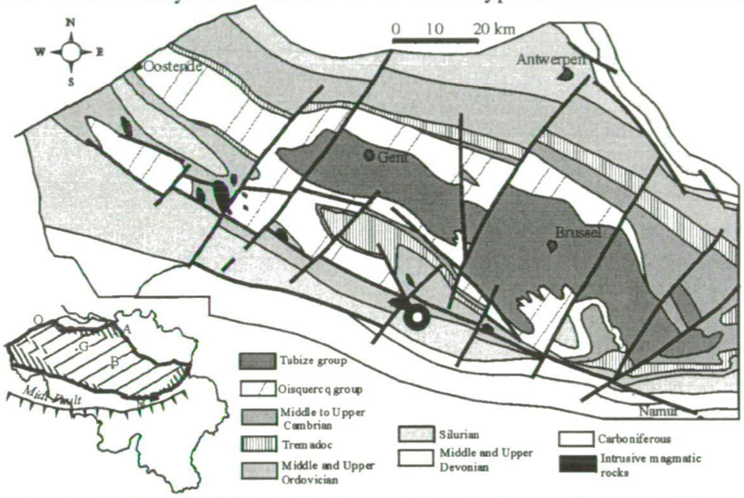

Figure 1. Geological map of the Anglo-Brabant Fold Belt, Belgium (after Devos et al, 1993). Marcq area is indicated by circle.

Fluid Inclusions paragenesis

Primary inclusions in the mesothermal quartz veins formed parallel to crystal boundaries. Secondary inclusions occur in trails towards the mineralisation or in recrystalised zones around sulphide grains. Croscutting trails are the last generation in the quartz. The secondary inclusions in trails and in the recrystallised zones in quartz around sulphide grains, are clearly related to the polysulphide mineralisation (Dewaele et al., 2001).

Carbonate precipitation clearly postdates vein quartz. Two generations of carbonates can be recognised, after staining with a potassium hexacyanoferate and Alizarin Red S solution. The iron-rich dolomite clearly formed before iron-rich calcite. The dolomite shows some minor twinning. The younger iron-rich calcites contain no indication of deformation.

Fluid types

1. Pre-mineralisation fluid inclusions

The inclusions show two phases (L+V) at room temperature, with a gas volume of 5-20 % and a size smaller than 10 μm. They have an H_2O-CO_2-CH_4-NaCl-KCl composition. The melting of CO_2 (Tm_{CO2}) is not measurable, due to the small size of the inclusions and since the formation of clathrate consumed the majority of CO_2. Raman analysis indicate the presence of CH_4 in addition to CO_2. The amount of CH_4 in the gas phase is very consistent, ~ 30%. The first melting of ice occurs at temperatures around -22.9°C. The final melting of ice (Tm_{ice}) takes place between -11.9°C and -5.5°C. The dissociation of clathrate (Tm_{clath}) occurs between 5.6°C and 10.5°C. Homogenisation temperatures vary between 189°C and 258°C (with an average of 240°C). Fluid salinities, calculated with ICE (Bakker, 1997), varies between 12 and 14 eq. wt% NaCl.

2. Fluid inclusions associated with the sulphide mineralisation

The inclusions investigated are two phase (L+V) at room temperature with a gas volume of 10-50 % and a size varying between 10 and 50 μm. They belong to the H_2O-CO_2-CH_4-NaCl-KCl (Dewaele et al. 2001). The melting of CO_2 (Tm_{CO2}) is measurable in a limited number of inclusions and the values vary between -65.9°C and -56.6°C. Raman analysis shows that the amount of CH_4 varies between 30% and 100%. The first melting of ice also occurs at temperatures around -22.9°C. The Tm_{ice} is between -15.3°C and -5.5°C. The dissociation of clathrate (Tm_{clath}) occurs between -2°C and 14.8°C. Homogenisation of the fluid inclusions occurs between 262°C and 305°C with an average of 290°C. Fluid salinities, calculated with ICE (Bakker, 1997), are between 6 and 18 eq. wt% NaCl.

3. Post-mineralisation fluids

In quartz a distinction can be made between two types of aqueous fluids: an H_2O-NaCl-KCl and an H_2O-NaCl-$CaCl_2$ fluid. The former inclusions show two phases (L+V) at room temperature with a gas volume of 5-10 % and a size up to 25 μm. The first melting of ice often occurs around -22.9°C. A range between -1.8°C and -4.9°C of the melting temperatures of ice (Tm_{ice}) can be observed. The inclusions homogenise between 160 and 200 °C. Fluid salinities, calculated with Flincor (Brown, 1989), are between 1.8 and 8.3 eq. wt% NaCl. The H_2O-NaCl-KCl type fluid inclusions are also present in the ferroan dolomites, confirming their post-mineralisation origin. In the dolomites, the final melting of ice takes place between -10.9°C and -6.5°C. The inclusions homogenise around 220°C. The calculated salinities vary between 10.7 and 15.2 eq. wt % NaCl.

The inclusions, belonging to the H_2O-NaCl-$CaCl_2$ system, show two phases (L+V) at room temperature with a gas volume of 5 % and can be larger than 40 μm. The first melting seems to occur at a temperature $\leq$ -50°C. Tm_{ice} occurs between -15.3 °C and -10.6°C. T_h is between 133°C and 150°C. Fluid salinities in the H_2O-NaCl system, calculated with Flincor (Brown, 1989), are between 16.6 and 22.2 eq. wt% NaCl. This fluid type is also recognised in the iron-rich calcites. In the calcites, Tm_{ice} is between -7°C and -6.3°C. Inclusions have a homogenisation temperature between 189 and 225 °C. The calculated salinities are between 10.2 and 11.2 eq. wt% NaCl.

Discussion and conclusion

Different types of fluids can be recognised in the quartz-carbonate veins in the shear zone in the Lower Palaeozoic of the Anglo-Brabant Fold Belt in Belgium. The earliest fluids in quartz have an H_2O-CO_2-CH_4-NaCl-KCl composition. This fluid type is interpreted as metamorphic, released during the main deformation event in the Anglo-Brabant Fold belt (Piessens et al., 2002), and is responsible for the local formation of polysulphide mineralisation.

The quartz veins in the shear zone formed the migration pathway for later fluids. Firstly, fluids with an H_2O-NaCl-KCl composition circulated through the fractures. These fluids were recognised both in quartz and in iron-rich dolomite. A comparable fluid has been recognised at the Variscan deformation front, south of the study area (Muchez et al., 1998). This fluid has been considered as released during the late stages of metamorphism (Darimont, 1986).

The youngest fluid generation identified has an H_2O-NaCl-$CaCl_2$ composition. Fluids with a similar composition, salinity and homogenisation temperature have been identified throughout the Variscan belt (Muchez et al., 1998). These fluids are thought to be responsible for the development of the Mesozoic Mississippi Valley-type Zn-Pb mineralisation in southern and eastern Belgium (Muchez et al., 1994). The H_2O-NaCl-$CaCl_2$ fluid in the iron-rich calcite has a lower salinity and higher average homogenisation temperature. However, fluids with a similar composition and salinity have also been described from Mesozoic calcite veins in Upper Palaeozoic rocks at the Variscan thrust front (Muchez et al., 1997).

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