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FLUID INCLUSION MAPPING AND CATHODOLUMINESCENCE OF VEIN QUARTZ FROM THE CINERA-MATALLANA COAL BASIN (NW SPAIN)

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Introduction

The interpretation of fluid inclusion data requires knowledge about the relative time of trapping in order to define the fluid systems during rock evolution. In the present study information obtained from fluid inclusions and various textures preserved in natural vein quartz observed by cathodoluminescence (CL) microscopy have been combined. Zoning and veining observed in CL reveal a complex crystallisation history which has not been outlined by previous fluid and petrographic studies (e.g. Ayllón, 2003). Vein samples were collected in the Ciñera Matallana coal basin, a pull-apart Stephanian clastic sequence characterised by a transition from high diagenesis to upper anchizonal metamorphic grade. Mineral content, fluid evolution and P-T conditions are characterised in detail in Ayllón et al. (2003). The cm-wide polymineralic fissures formed synchronously with folding and faulting in sandstone and conglomerate beds alternating with shales, pelites that are rich in organic material, and coal-bearing strata. The mineral growth sequence preserved in the filled fractures is defined by early calcite, euhedral quartz, saddle dolomite, ferroan blocky calcite, minor sulphides and authigenic kaolinite.

CL microscopy

Optical 'hot' (high-intensity) CL microscopy (HC3-LM; Neuser, 1995) has been applied in order to assign the fluid inclusions to different quartz generations, which cannot be distinguished by observation in transmitted light. The CL of quartz is basically caused by point defect structures, which in part are related with trace elements in the crystal lattice and in part are intrinsic. The quartz in the present veins shows highly variable CL colours ranging from blue, brown, orange-red, and white, whereas some of the quartz is non-luminescent. Photographs were taken with a conventional camera using 1600 ASA films (Kodak P1600 EPH 135-36), taking double automatic exposure times and utilise pushed developing with a factor 2. CL is essentially a surface phenomenon, but the information obtained by CL can be used for the interpretation of fluid inclusions at depth in the sample by estimating the three-dimensional extension of the textures (Van den Kerkhof, Hein, 2001). Another complication is the fact that both applied study methods (CL microscopy and microthermometry) require different sample preparation. We successfully compared doublets of carbon-coated polished thin sections (CL microscopy) and thick fluid inclusion sections (microthermometry). In this way fluid inclusion 'maps' could be drawn which show the textural relationship between fluid inclusions and the host quartz.

Correspondence of CL zones and fluid inclusion generations

The CL photographs show evidence for at least 3 sequential generations of quartz. The earliest generation (Q1) constitutes the core of the studied crystals. It is represented by euhedral quartz with brown and occasionally blue CL and typical growth lamellae. A second generation of quartz (Q2), generally disposed along the outer part of the crystals, shows blue CL or is non-luminescent and has been interpreted as quartz cement and overgrowths. A banded structure can often be recognised. The earliest quartz of this generation is characterised by white CL, this colour being probably the result of trace element diffusion. The latest quartz phase (Q3) is disposed in small crosscutting healed microfractures and shows deep blue CL.

An example of detailed mapping of the fluid inclusion generations in relation to CL textures, undertaken for one sample, is outlined in Fig. 1. The earliest quartz generation (Q1) appears to be virtually free of inclusions, whereas the second quartz phase (Q2) contains H_2O-CH_4 ($\pm CO_2$) inclusions. These are distributed in clusters paralleling the banded structure (growth zones) and in pseudosecondary trails cutting the Q1 quartz. Short trails containing secondary H_2O-$NaCl$-$CaCl_2$-CH_4 inclusions are present within the latest quartz generation (Q3).

Growth history of the vein quartz

From the textural relations at least three different quartz crystallisation events can be distinguished in the studied crystals (Fig. 2): The initial stage of quartz crystallisation (Q1) was characterised by regular growth rates, which inhibited the formation of fluid inclusions. Therefore, fluid composition and T-P conditions could not be determined. Subsequently, a second quartz phase (Q2) crystallised from an immiscible fluid mixture composed of a low-salinity aqueous solution and a CH_4-rich ($\pm CO_2$) vapour phase, at temperatures of about 110-120°C and pressures ranging from 15 to 56 MPa. This fluid system is associated to the thermal maturation of organic matter (coal) in the basinal rocks. In a later stage, euhedral crystals suffered brittle deformation and the latest quartz generation (Q3) precipitated as a consequence of healing processes in the micro-cracks formed. A H_2O-$NaCl$-$CaCl_2$-CH_4 fluid system, with homogenisation temperatures of 40 to 98°C and molar volumes of 16.9 to 17.2 cm^3, is preserved in the trails of secondary inclusions within the micro-cracks. This late quartz crystallisation event is associated with vein reactivation and the precipitation of blocky calcite.

Future work comprises the trace element compositional characterisation of the CL textures, which may enable to relate fluid events with the transport and precipitation of different cations.

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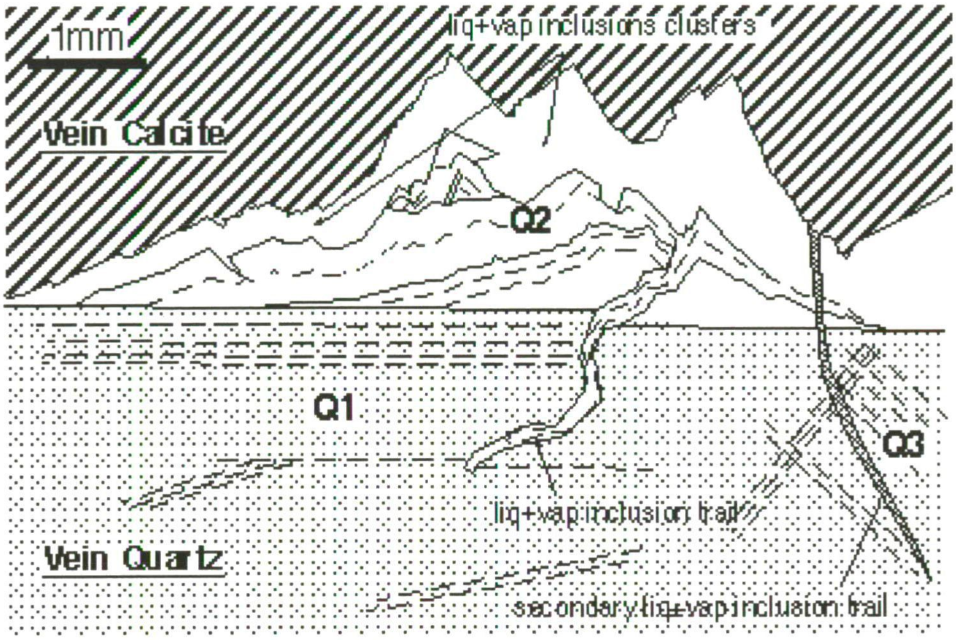

Figure 1. Textural relationship between fluid inclusions and quartz generations as differentiated by CL microscopy.

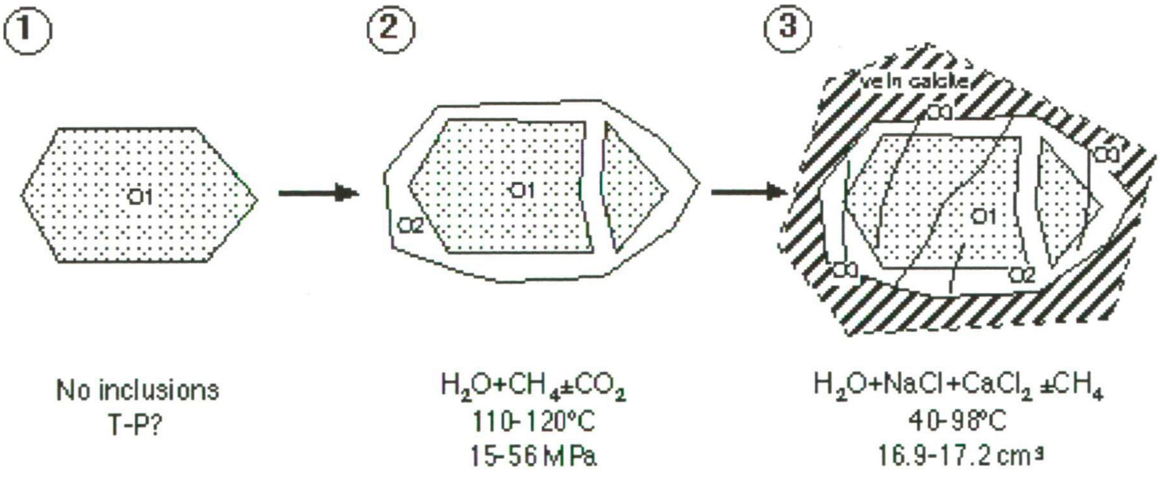

Figure 2. Stages of vein quartz growth established from CL microscopy and fluid inclusion studies.