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Fluid Inclusion δD in Quartz Does Not Always Indicate the Source of Palaeo-Hydrothermal Fluids

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The hydrogen isotopic composition (δD) of fluid inclusion waters is routinely used to fingerprint the origins of palaeo-hydrothermal fluids in a range of geological environments. These analyses are based on the assumption that, when dealing with an anhydrous mineral such as quartz, hydrogen isotope fractionation between the host mineral and water is negligible, and thus, the isotopic signature released by decrepitated fluid inclusions accurately reflects that of the original hydrothermal fluids, particularly in low temperature environments. However, it has been shown that quartz can have hydrogen in significant quantities as a trace element (Kronenberg 1994). Simon (1997) interpreted a correlation between δD compositions and different quartz grain sizes as being the result of the sampling of hydrogen reservoirs of different compositions present in the quartz.

Low δD values are often interpreted to indicate the involvement of high latitude/altitude meteoric waters in palaeo-flow systems and, in some low temperature base metal mineralising deposits, to indicate the presence of organic waters. However, anomalous δD compositions have been reported from a range of environments e.g. Southwest England and Panasqueira W-Sn deposit, Portugal which cannot easily to attributed to the involvement of such fluids (e.g. Gleeson et al., 1999; Foxford, 1997).

This study focuses on a series of low temperature (~130 ºC) base metal mineralised veins from Cornwall. The bulk hydrogen isotopic composition of these veins has been previously analysed by the decrepitation method and several of the samples shown to have anomalously low δD signatures (Gleeson et al., 1999). When the entire dataset is considered there is a striking range in δD compositions at relatively constant oxygen isotopic compositions, which is a general feature of anomalously low δD fluids. The large grain size used (2 mm), the lack of any correlation between hydrogen yield and isotopic composition, and the abundance of fluid inclusions in the samples led Gleeson et al. (1999) to suggest that fractionation between different reservoirs in the quartz was unlikely to be responsible for the anomalous values. To rigorously test this hypothesis a micro-infrared (FTIR) spectroscopic study has been carried out to determine hydrogen reservoirs in low temperature hydrothermal quartz veins from Cornwall.

For the purpose of this study two different quartz textures (Q1 and Q3), with contrasting isotopic compositions (-39 and -103 per mil respectively), were examined. Both quartz types contain fluid inclusions. The results of the FTIR study suggest that the dominant hydrogen reservoir in Q1 is molecular (probably fluid inclusion) water. However, in Q3, interstitial hydrogen in defect sites appears to be the dominant hydrogen reservoir.

The hydrogen isotope fractionation factors for the incorporation of hydrogen into quartz interstitial sites are unknown. However, the fractionation factors between OH-bearing aluminosilicates and water are negative and are temperature dependent with greater fractionation occurring at lower temperatures (e.g. Liu & Epstein, 1984). Similarly it is likely that hydrogen with lower δD values will be produced from interstitial sites relative to molecular water. The bulk hydrogen isotope composition of these samples, therefore, is a function of the ratio of fluid inclusion water to interstitial hydrogen and, if there is a significant proportion of interstitial hydrogen present, will be lower than the true value of the hydrothermal fluids. This may explain the discrepancy of lower δD values being recorded from fluid inclusions in quartz compared to those found in co-existing hydrous minerals which appear to be co-genetic (e.g. Kelly & Rye, 1979).

These data suggest that the assumption that the isotopic composition of fluid inclusion waters accurately reflects the isotopic composition of the parent hydrothermal fluid is flawed. We conclude that δD determination from various quartz morphologies can sample distinct hydrogen reservoirs and that further analysis to determine the nature of any hydrous species present is essential if reliable isotopic data are to be produced. These preliminary data suggest that interpretations invoking the involvement of high latitude/altitude meteoric water or organic waters in hydrothermal systems based solely on low δD values may be incorrect.

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