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Direct Age Determinations of Mineralised Quartz Veins Using the ^{40}Ar-^{39}Ar Method

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Introduction

Reliable age constraints for mineralised systems are vital for distinguishing between genetic models. A long standing problem faced by economic geologists has been that due to the major element chemistry of most ore minerals, the age of ore deposits can not be determined directly using conventional isotopic techniques. Porphyry Copper Deposits (PCD) have been constrained by age determination of genetically related host rock, but few other deposit types can be as tightly constrained by such indirect means.

Recently ore minerals have been dated directly by both the Re-Os method, and by Rb-Sr dating of sphalerite (Stein et al. 1999, Pettke and Diamond, 1996). However, these techniques can not be applied in every case so the development of new techniques is advantageous. In this study direct age determinations of the gangue mineral quartz taken from mineralised veins have been made using the ^{40}Ar-^{39}Ar method. Simultaneous analysis of Ar, Kr and Xe formed from neutron reactions on Cl, Br and I provides additional information on fluid origins and acquisition of salinity, unavailable from other chronological techniques (Böhlke and Irwin 1992).

Method

In the past ^{40}Ar-^{39}Ar dating has been made difficult by the presence of inherited $^{40}Ar_{XS}$, this is ^{40}Ar not attributable to either *in-situ* radiogenic decay of K ($^{40}Ar_R$), or from atmospheric contamination. In this study the problem has been overcome using two noble gas extraction techniques applied to neutron irradiated quartz samples and plotting data on multi component isotope correlation diagrams (Figure 1). The first extraction technique, in-vacuo crushing selectively releases noble gases from the fluid component of fluid inclusions, removing most $^{40}Ar_{XS}$. Crushed residues are step heated to release $^{39}Ar_K$ and $^{40}Ar_R$ from solid K-bearing phases such as sylvite and mica which remain inside ruptured fluid inclusions (Kelley et al.1986, Turner and Bannon 1992).

Results

The technique has been successfully applied to five PCD: Ray, Globe-Miami, Pinto Valley and Silverbell, in south west Arizona and Bingham Canyon, Utah. Ages determined at Ray (65.3±1.5), Globe-Miami (61.7±3.4) and Pinto Valley (63.2±8.0) are within error of published ages whilst the age determined at Silverbell (55.8±1.8) is significantly younger than the existing K-Ar age determination 67.1±2.0 (Livingston, 1973). The correction for $^{40}Ar_{XS}$ inherent in the method employed by this study may explain the younger age determined for Silverbell. Additional data has recently been obtained for Bingham Canyon, Utah and will be presented at the conference.

The PCD samples studied include a number from the potassic zone and although it remains to be seen if fluids less enriched in K can be dated this way, the technique clearly has potential in the study of other deposit types.

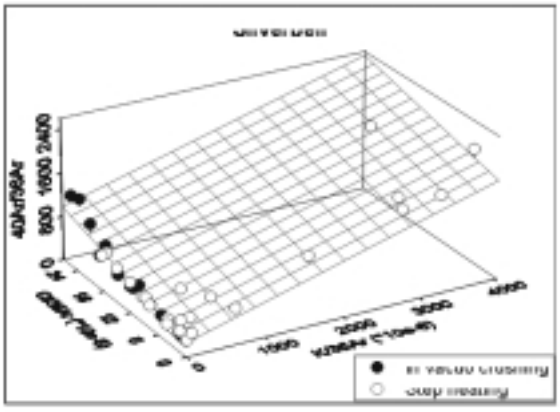

Figure 1: Multi component (K-Cl-^{40}Ar-^{36}Ar) correlation diagrams.

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