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Predicting Base Metal Concentrations in Crustal Fluids

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Crustal fluids are significant agents of element transfer through the Earth system and play a fundamental role in the formation of hydrothermal ore deposits. In particular, sedimentary brines are responsible for the formation of extensive low-temperature Pb, Zn and Cu mineralization and temperature and chlorinity are widely considered to impose first-order controls on crustal fluid metal contents. Through the development of a database of crustal fluid P-T-X characteristics, the relationship between temperature, chlorinity and base metal concentrations can be explored and order-of-magnitude estimations of the Fe, Mn, Pb and Zn concentrations in chloride-dominated aqueous crustal fluids established. In order to test the veracity of predicted metal concentrations, two data sets with combined LA-ICP-MS major and trace element analysis and corresponding microthermometry of individual fluid inclusions were investigated from three different metallogenic systems [1,2]. While some variation from predicted fluid metal concentrations is apparent, the measured fluid inclusion data broadly conforms to predicted metal concentrations.

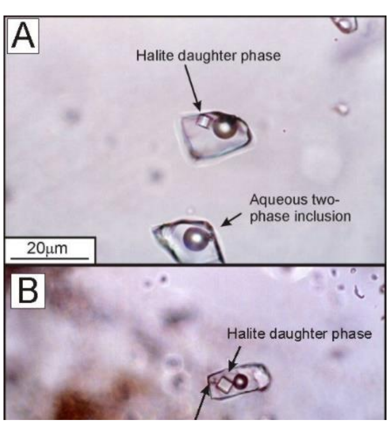

Figure 1: Fluid inclusions from Nchanga Mine [5].

Using this approach we have estimated the base metal concentrations of brines present in the Zambian Basin which hosts one of the largest and richest metallogenic provinces in the world. Previous studies have suggested the presence of two generations of Zambian Copperbelt fluids, distinguished by their halogen systematics and host vein chronology [3]. These fluids are anomalously hot and saline relative to most sedimentary waters, with elevated Fe, Mn, Pb and Zn predictions. However, copper solubility in crustal fluids is less well constrained by fluid temperature and chlorinity alone, implying a more significant role for one or more other physiochemical parameters such as the fluid redox state or post-entrapment modification through diffusion processes [4]. The predicted metal concentrations of the Zambian basin fluids are compared with recently acquired fluid inclusion LA-ICP-MS data to assess the primary controls on the composition and temporal evolution of the fluids responsible for the formation of this world-class metallogenic province.

References:

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