Origin of Mixed Brine-Sulphide Inclusion Trails from Broken Hill New South Wales Investigated by LA-ICP-MS

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Complex assemblages of secondary inclusions occur in quartz from Western A Lode which is part of the giant Pb-Zn-Ag deposit at Broken Hill. They are of interest in the light of recent speculation that sulphide melts and aqueous fluids evolved from them could have been generated during the transitional amphibolite-granulite conditions of peak metamorphism.

Most inclusion trails consist exclusively of either sulphides galena±pyrrhotite or moderate to high salinity aqueous brine. However, composite trails are also present containing both aqueous and sulphide types, along with mixed inclusions in which sulphides are eneveloped by aqueous liquid ± salts in varying proportions. The brine inclusions have variable salinities (28-48 wt% $NaCl_{equiv.}$) and homogenisation temperatures (>150° C). Those with salinities >33 wt% $NaCl_{equiv}$. typically decrepitate without total homogenisation at temperatures up to 480° C.

LA-ICP-MS data indicate that the aqueous brine inclusions have K ≥ Na, Mn≈Fe, high Pb and Zn, and Pb/Zn ratios approximately an order of magnitude higher than published data for high temperature crustal brines. Sulphide inclusions have Pb/Zn and Pb/Fe ratios much higher than those of the brines, and Pb:Zn:Cu:Fe ratios that are much more variable than their Pb:Ag:Sb ratios. Most of the sulphide inclusions are strongly Fe- and Zn-depleted compared to published experimental sulphide eutectic compositions.

The best explanation of these data is that the sulphide inclusions do not represent melts but were precipitated from aqueous solution, possibly through a mixing process involving brines with different salinities and temperatures. Final sulphide emplacement in this particular quartz-rich lode type is interpreted to have been a retrograde hydrothermal process. The distinctive Pb- and Zn- rich and very high Pb/Zn aqueous brine signature could ultimately be related to synmetamorphic sulphide melting. However, such a fluid would have had to have been retained in the system until it were able to interact with cool external fluids at temperatures well below those of the metamorphic peak.