A magmatic end-member fluid at Sudbury, Canada?

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Veins and patches of granophyre are common in the brecciated/partially-melted footwall, and igneous sublayer of the Sudbury Igneous Complex. Cross-cutting relationships demonstrate that the granophyre veins in the footwall post-date the impact event and formation of massive sulfide ore along the footwall contact of the Sudbury Igneous Complex (SIC), but crystallized *prior* to the emplacement of Cu-PGE-enriched sulfide veins in the footwall. The granophyre veins are comprised of a sympletic intergrowth of quartz + orthoclase ± hornblende and preserve a primary, high temperature fluid inclusion assemblage derived from entrapment of an exsolved fluid phase. Trace element composition and structural considerations do not support the granophyre veins as forming in-situ (e.g., by host-rock melting). Rather, the granophyre may represent a K-enriched residua which was mobilized during the late stages of crystallization of the SIC. Brine inclusions within the granophyre phase homogenize at 543±55°C (n=82, 1σ), corresponding to a salinity of 66±8 wt% NaCl eq.

Microanalytical data (by LA-ICP-MS) show that the highest temperature, highest salinity brine inclusions contain a Na-Fe-K-Ca-Cl-rich fluid (up to 28 wt% K). All other brine compositions identified in the footwall environment fall on a mixing line between the high-temperature, Na-Fe-K-rich end-member and regional saline groundwaters. The range in brine inclusion compositions observed at Sudbury requires up to 90% (by mass) groundwater in the mixture. Base and precious metals (Cu – up to 1 wt%, Pt, Bi, Ag all in the 1-10 ppm range) were only detected in brine inclusions from granophyres occurring in close proximity to, or overprinted (replaced) by massive sulfide veins; this, along with cross-cutting relationships suggest that brines were in contact with sulfide liquids prior to the final crystallization of the sulfides in the footwall ore zones. Late secondary inclusions contain a saline fluid that is comparable in composition to the primary brine but contains much lower overall concentrations of major and trace elements. The late fluid may represent a cooled, diluted form of the primary, high-temperature brine. Ore metals were lost from the brine prior to entrapment of the secondary inclusions as the metal contents of the secondary inclusions are unremarkable.

High resolution LA-ICP-MS analyses of PGMs and sulphides, Marathon Pd-Cu deposit, Ontario

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The Marathon platinum group element (PGE)-Cu deposit is hosted by the 1108 Ma Coldwell intrusive complex. Three styles of mineralization occur in the deposit: (1) massive to net-textured Fe-rich sulphides in a massive, fine-grained gabbro (the Basal Zone); (2) disseminated, Cu-rich sulphides within variably-textured (medium-grained to pegmatitic) gabbroic rocks (the Lower Zone); and (3) magnetitite layers in layered olivine gabbro (the Upper Zone). PGE mineralization is Pd-rich and is principally associated with Cu-rich intervals in the Lower Zone, which generally occur several tens of metres stratigraphically above the sulphide-bearing, Basal Zone rocks. The magnetitites of the Upper Zone also host Cu-PGE mineralization.

Magmatic and hydrothermal sulphide textures exist within the different mineralized zones. LA-ICP-MS analyses of sulphides and platinum group minerals (PGMs) demonstrate stratigraphic chemical and mineralogical zonation. Basal Zone sulphides are As-rich and PGMs are Pb-poor, varying from arsenides to bismuth-tellurides to antimonides. The Lower Zone has As-poor and Te- rich sulphides and PGMs of extreme chemical variability. Upper Zone sulphides are Pb-rich as are the PGMs which are As-poor bismuth-tellurides and more Au-rich than PGMs in the other zones.

Strong zonation and a wide variety of PGMs is not unusual for PGE-rich mineral districts but this usually relates to lateral changes in footwall compositions while at Marathon it occurs within a single stratigraphic section of a few hundred meters.