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Magmatogene fluids of metal bearing reefs

in the bushveld complex, South Africa: based on research data on fluid Inclusions in quartz

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Abstract

Fluid inclusions in the Merensky Reef quartz and later pegmatite veins crosscutting the Platreef rocks of the Bushveld Complex are studied by a suite of advanced high-precision methods. Based on the conducted studies, we identify a few types of fluids, some having been separated during the crystallization of volatile matter-rich residual melt of original basic magma, while others are derivatives of later felsic (granite) melts that formed crosscutting veins in fully devitrified ultrabasic and basic rocks. The earliest fluid is captured by quartz in symplectitic intergrowths with intercumulus plagioclase from the Merensky Reef pyroxenite occurs as a homogenous dense dry reduced gas (CH_4–N_2 ± CO_2) mixture separated from the aluminosilicate melt at 800–900°C and 3050 bar. The following heterophase highly concentrated fluids (60–80 wt % NaCl eq.) separated at over 550°C and below 3050 bar transport a large number of metals. Major saline components of such fluids included Na, K, Fe, Ca, and Mn chlorides, Ca and Na sulphates and carbonates. According to LA ICP-MS analysis data, inclusions of these fluids contain high concentrations of Fe, Cr, K, and Na at the level of a few wt % and also significant contents of Cu, Sn, Sb, Mo, Au, Ag, Bi, and Ni in a concentration range from a few to thousands of ppm. Relatively lower-temperature (much higher than 450°C) fluids accompanying the crystallization of crosscutting quartz–feldspar pegmatite veins at the Platreef are also highly concentrated (from 70–80% to 40–14 wt % NaCl eq.), oxidized and metal-bearing. High concentrations of metals such as Na, K, Ca, Mn, Fe, and Pb at the level of wt % and also Ni, Co, Cu, As, Mo, Sn, Sb, and Bi (1–500 ppm) in inclusions in quartz of later pegmatite veins suggest the possible participation of magmatogene fluids related to later felsic intrusions in the redistribution of primary magmatic concentrations of metals. The oxidation of reduced heterophase fluids may be the most important geochemical barrier invoking the crystallization of solid mineral phases from heterophase fluids.