Re/Os isotopic studies of oxide minerals in the Birch Lake PGE prospect, Duluth Complex, MN

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The Birch Lake platinum group element (PGE) prospect is located along the western edge of the South Kawishiwi Intrusion (SKI) of the 1.1 Ga Duluth Complex in northeastern Minnesota. Country rocks include the Proterozoic Biwabik Iron Formation (BIF) and Archean-aged, greenstone belt-related plutonic and volcanic rocks. In the Birch Lake area the SKI consists of a layered troctolitic series that contains layers of semi-massive to massive oxides, as well as distinct inclusions of the BIF. Strong serpentinization of the oxide-melatroctolite rocks in the area is also distinctive. Zones of enriched PGE concentrations that are associated with Cr-rich oxides were detected during early mineralogical evaluations. Based on these associations, a hypothesis emerged which related PGE enrichment to areas of BIF assimilation. Further mineralogical and isotopic studies of the oxide minerals from the SKI and the BIF have aided in evaluating this potential relationship.

Three samples of unmetamorphosed BIF have Re/Os isotopic values that fall along a chondritic 2.23 Ga reference isochron. The values suggest that seawater Os isotopic composition was controlled by either leaching of young oceanic crust, potentially in a back arc environment, or by input of hydrothermal fluids with a near chondritic isotopic ratio. One sample of BIF from the contact aureole falls near the 1.1 Ga reference isochron, suggesting exchange between magnetite and a Re-rich magmatic fluid at the time of emplacement of the Duluth Complex. Most samples of both BIF xenoliths and layered massive to semi-massive oxides in the troctolites plot above the isochron formed by the unmetamorphosed BIF samples at $^{187}Re/^{188}Os$ ratios less than 10. These values are suggestive of Re loss after a magma contamination event at 1.1 Ga. Oxygen and hydrogen isotopic values of serpentine suggest that the fluid involved in the serpentinization process was primarily of meteoric origin. Interaction with this fluid is thought to be responsible for the anomalously low Re/Os ratios of oxides in the metamorphosed BIF and melatroctolitic rocks in the Birch Lake area.

Reference

Sabelin, T., and Iwasaki, I. (1985) Minerals Resources Research Center, U-MN, Con. Report to Dept. of Nat. Res., 58 p.

PGE mobility and PGM crystallization under hydrothermal conditions

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PGE- bearing associations from non-conventional gelogical occurrences (Kupferschiefer type shales; black shales; porphiry copper ores; hydrothermal ores; metamorphozed sediment and sediment-volcanic depots, Cu-rich metamorphosed ores; metalliferrous coals; U-ores and oth.) are discussed. The list of PGM from these associations includes about 20 species with Pd, Pt, Te, S, Se, As, Sb, Au as characteristic elements of composition: Pd-Pt- sulfides, selenides, tellurides, (Pt,Fe), (Pd,Pt,Au), Pd- (Sb,As,Te,Sn) minerals etc. (Pashava J., Tarkian M., Jedwab J., Moralev G., Seredin V. and oth.).

These PGM are associated often with minerals characterized by layered structure, i.e. Fe-Mn oxides, hydroxides (goetite), “hybride” minerals (valleriite), clay minerals (halloisite, smectite), silicates (chlorite) etc. Tiny grains of PGM and “layered” mineral are closely intergrown forming specific aggregates. This is the reason of “strange” PGM compositions reported by some researchers.

According to the detail study PGM asociated with clay minerals are presented by submicro- and nanoparticles particles often located on the surface or edges of layers. PGE are transported in nature by. PGM precipitation could be reasoned by the non-equilibrated charge of structure layer surface, and by the composition of solution determining the decomposition of PGM- bearing complexes. The information on the composition of mineral- forming solution/fluids could be obtained due to the analysis of mineral composition and mineral associations as shown on some examples.

The morphology of PGM particles obtained during the hydrothermal experiments is analysed. Generally they are presented by dendrites or rounded grains. Using this fact and taking into account the composition of various complexes the mechanism of PGM crystal growth is proposed and discussed using data on PGM from other geological occurrences.