The occurrence of platinum-group element and gold minerals in the Bon Accord Ni-oxide body, South Africa

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ABSTRACT

Two samples from the enigmatic Ni-oxide body of Bon Accord (Barberton greenstone belt, South Africa) have been investigated with the hydroseparation technique to obtain heavy mineral concentrates. The concentrates contain abundant Pt, Pd, and gold minerals never reported before from the Bon Accord Ni-oxide body. The grains occur as: (1) minute inclusions (<3 μm) in trevorite (ideally NiFe³⁺O₆) and (2) larger (5–70 μm) free aggregates liberated from the host phase. The first group comprises several PGM compounds of Pd-Sb, Pd-Sb-As, Pd-Cu-Sb, Pt-Sb, Pt-As-S, Ru-As-S, Ru-S, along with free grains of Ni-Fe-As. The second consists of sperrylite (PtAs₂), members of the sobolevskite-kotulskite series, and electrum. These results are in good agreement with previous analyses of PGE-Au in bulk rock. Paragenetic relationships indicate that the PGM and electrum are of secondary origin, probably generated during low-temperature metamorphism of the Ni-rich mineralization. They have a terrestrial origin and are related with a low-sulfidation regime that usually accompanies hydrothermally driven serpentinitization of mafic-ultramafic bodies. The ligands in the newly formed PGM (As, Sb, Bi, Te, and O) probably proceed from the same source of the hydrothermal solutions. In this model, the metals Ni-PGE-Au were original components of the primary mineral assemblage of the Bon Accord precursor, whereas As, Sb, Bi, Te, and O might have been contributed by the metasomatizing fluids, during near-surface evolution of the ore body. The data on the high-grade heavy mineral concentrates, obtained by hydroseparation, have provided new knowledge about the mineral deportment of Pd, Pt, and Au.

Keywords: Platinum-group minerals, gold minerals, Bon Accord Ni-oxide body, hydroseparation, heavy mineral concentrate, Barberton greenstone, South Africa

INTRODUCTION

Platinum-group minerals (PGM) are the carriers of the platinum-group elements (PGE): osmium (Os), iridium (Ir), ruthenium (Ru), rhodium (Rh), platinum (Pt), and palladium (Pd). These elements, with a concentration of about 10⁻⁶ to 10⁻¹⁰% in the Earth’s crust, are numbered among the ultra-trace elements. They occur naturally as alloys, native elements or in combination with other elements, mainly S, As, Te, Bi, Sb, Hg, Se, and Sn (see Cabri 2002), and more rarely with O (Cabri et al. 1981; Garuti et al. 1997; Garuti and Zaccarini 1997; Jedwab and Cassedanne 1998; McDonald et al. 1999; Uysal et al. 2009). PGM are rare, representing less than 3% of the minerals approved by the Commission on New Minerals and Mineral Names of the International Mineralogical Association (IMA). According to Daltry and Wilson (1997), only 96 phases containing the PGE as major components were approved before 1997. These authors also listed more than 500 different chemical compositions of PGE-bearing phases that, very likely, correspond to new mineral species. However, since 1997, only 28 new PGM have been approved (Barkov et al. 2002a, 2002b; Cabri 2002; Stanley et al. 2002; Paar et al. 2004, 2005; Rudashevsky et al. 2004; Cabri et al. 2005b; McDonald et al. 2005, 2010; Botelho et al. 2006; Kojonen et al. 2007; Mochalov et al. 2007; Yu et al. 2009; Vymazalova et al. 2009, 2012a, 2012b). The failure in the identification of PGM is due mainly to their mode of occurrence as minute inclusions (usually less than 100 μm in size), which are randomly distributed in their host rocks, thus severely limiting conventional crystallographic characterization by X-ray spectrometry, as discussed below.

Traditionally the PGM are located on polished section by reflected light or electron microscope and investigated in situ. Usually, the identification of the mineral species cannot be done on a simple determination of the optical properties owing to the small size of grains, and depends on the use of electron microprobe analysis. Furthermore, although the in situ study provides useful information on paragenetical relationships of the PGM, it commonly does not allow a complete picture of their abundance and distribution throughout their host rock. Polished sections represent only a small portion of the host rocks, and it is known that two-dimensional counting of three-dimensionally distributed grains in solids may produce statistically deficient results (Oberthür et al. 2008; Cabri 2012; Shi et al. 2013). This is particularly critical when the subsidiary phases are unevenly