Surface transformations of platinum grains from Fifield, New South Wales, Australia

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ABSTRACT

A growing literature is demonstrating that platinum (Pt) is transformed under surface conditions; yet (bio)geochemical processes at the nugget-soil-solution interface are incompletely understood. The reactivity of Pt exposed to Earth-surface weathering conditions, highlighted by this study, may improve our ability to track its movement in natural systems, e.g., focusing on nanoparticles as a strategy for searching for new, undiscovered sources of this precious metal. To study dissolution/re-precipitation processes of Pt and associated elements, grains of Pt-Fe alloy were collected from a soil placer deposit at the Fifield Pt-field, Australia. Optical- and electron-microscopy revealed morphologies indicative of physical transport as well as chemical weathering. Dissolution “pits,” cavities, striations, colloidal nano-particles, and aggregates of secondary Pt platelets as well as acicular, iron (Fe) hydroxide coatings were observed. FIB-SEM-(EBSD) combined with S-μ-XRF of a sectioned grain showed a fine layer of up to 5 μm thick composed of refined, aggregates of 0.2 to 2 μm sized crystalline secondary Pt overlying more coarsely crystalline Pt-Fe-alloy of primary magmatic origin. These results confirm that Pt is affected by geochemical transformations in superegene environments; structural and chemical signatures of grains surfaces, rims, and cores are linked to the grains’ primary and secondary (trans)formational histories; and Pt mobility can occur under Earth surface conditions. Intuitively, this nanophase-Pt can disperse much further from primary sources of ore than previously thought. This considerable mineral reactivity demonstrates that the formation and/or release of Pt nanoparticles needs to be measured and incorporated into exploration geochemistry programs.

Keywords: Platinum, weathering, Fifield Pt-Province, secondary mineralization, Australia

INTRODUCTION

Platinum is a highly prized noble metal; its resistance to oxidation and corrosion in combination with its unique surface properties makes it an important catalyst in industrial processes and automobile catalytic converters (MacDonald 1987). With ca. 90% of the world’s production of Pt coming from the Republic of South Africa and the Russian Federation, Pt is a highly strategic resource, important to resource security (Koek et al. 2010). To enhance exploration success, a fundamental understanding of (bio)geochemo processes leading to Pt dispersion in surface environments needs to be developed. Understanding Pt-Fe alloy weathering is one component that will improve our ability to recover Pt from soils and track its movement in nature. This could potentially lead to new, undiscovered sources of this precious metal and to an improved understanding of the cycling of industrial Pt-nanoparticles in the environment.

Schneiderhöhn and Moritz (1939) described native Pt that was entirely porous from the oxidized zone of the Merensky Reef, Bushveld Complex, Republic of South Africa, that they interpreted as a dissolution feature of a pre-existing mineral, such as sperrylite or cooperite. Native Pt as rims was subsequently observed on both sperrylite (Oberthür et al. 2003, 2013; Melcher et al. 2005) and on cooperite (Oberthür 2002; Oberthür et al. 2004). Platinum mobility can occur in eluvial, alluvial, and lateritic environments in tropical and possibly also semi-arid to arctic climates (Bowles 1986; Gornostayev et al. 1999; Barkov et al. 2005; Freyssinet et al. 2005). Under superegene conditions Pt may be oxidized, dissolved, complexed by inorganic- and organic-ligands, transported, re-precipitated, and deposited, yet these processes are incompletely understood (Fuchs and Rose 1974; Bowles 1986; Hanley 2005). The reactivity of platinoids to secondary processing appears to vary based on the reactivity of the starting material. Placer Pt grains are often larger than the primary sources they are derived from (Cousins 1973; Cousins and Kinloch 1976) suggesting that secondary processes contribute to growth or aggregation of these materials. Conversely, other studies indicate that Pt-Fe alloy is susceptible to dissolution and will “shrink” in weathering environments (Cabral et al. 2007;