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Osmium isotope systematics of Os-rich alloys and Ru-Os sulfides from oceanic mantle: evidence from Proterozoic and Paleozoic ophiolite-type complexes

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This study presents a substantial data set of Os-isotope compositions of Os-rich alloys and Ru-Os sulfides from deep portions of ophiolite sections from oceanic mantle. These are represented by samples from different in age ophiolite-type massifs (i.e., Neoproterozoic Kunar in Northern Taimyr, Russia, and Hochgrossen in Eastern Alps, Austria, Paleozoic Verkh-Neivinsk in Middle Urals, Russia, and Shetland in northern Scotland). The investigation employed a number of analytical techniques, including electron microprobe analysis, ID ICP-MS after high pressure acid digestion, and laser ablation attached to multiple collector-inductively coupled plasma mass-spectrometry (LA MC-ICP-MS).

Two distinct platinum-group mineral (PGM) assemblages have been recognized at the Shetland and Verkh-Neivinsk localities: a 'primary' euhedral PGM assemblage, which occur as inclusions in chromite, and a modified 'secondary' subeuhedral to anhedral PGM assemblage observed in cracks filled by chlorite or serpentine, interstitially to chromite grains [1]. A 'primary' PGM assemblage at Shetland is represented by solitary grains of laurite or iridian osmium and composite grains of laurite + osmian iridium ± iridian osmium that display well defined phase boundaries between two or three distinct PGMs. A 'primary' PGM assemblage at Verkh-Neivinsk is represented by Ru-Os-Ir alloy grains that frequently mantled by 'secondary' Ru-Os sulfide and/or Ru-Os sulfarsenide overgrowths.

The osmium isotope results identify (1) a restricted range of 'unradiogenic' $^{187}Os/^{188}Os$ values for coexisting laurite and Os-rich alloy pairs that form 'primary' PGM assemblages at Hochgrossen and Shetland (0.11860–0.11866 and 0.12473–0.12488, respectively); (2) similar 'unradiogenic' $^{187}Os/^{188}Os$ values for both 'primary' and 'secondary' PGM assemblages at Shetland (with mean $^{187}Os/^{188}Os$ 0.12419 and 0.12464, respectively) and Verkh-Neivinsk (with distinct mean $^{187}Os/^{188}Os$ values), and (3) a wide scatter of subchondritic $^{187}Os/^{188}Os$ values for 'primary' PGM assemblages at Kunar (i.e., $^{187}Os/^{188}Os$ 0.11848–0.11239), Verkh-Neivinsk (0.11619–0.12565), and Hochgrossen (0.11860–0.12450).

The whole-rock Os-isotope budget of chromitite at Shetland (0.1240±0.0006) is largely controlled by laurite-dominant assemblages. In this case, the 'secondary' PGM assemblage inherited the 'unradiogenic' Os-isotope signature of the 'primary' PGMs. No evidence for other source contributions during later thermal events has been observed here. However, the wide range of subchondritic $^{187}Os/^{188}Os$ values has been found in the 'primary' PGM assemblages (e.g., laurite and Os-rich alloys) from the ophiolite-type complexes worldwide [2 and references cited therein]. This wide range would be consistent with a model, in which a prolonged history of melting events of parent ultramafic source rocks took place in the mantle. This variability is in agreement with the conclusion that the Os-isotope system of PGMs records multiple events during the chemical differentiation history of the mantle [3] and could have been controlled by deep-geodynamic processes [4]. On the other hand, the observed Os-isotope heterogeneity may be also attributed to the presence of subcontinental lithospheric mantle (SCLM), characterized by highly unradiogenic $^{187}Os/^{188}Os$ values (i.e., $<$0.1220 [5]), that has lately been incorporated into asthenospheric mantle with more radiogenic $^{187}Os/^{188}Os$ values (0.1220-0.1230 [6]).

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