MITT.ÖSTERR.MINER.GES. 146 (2001)

UNUSUAL PGE-, REE-, AU- AND U-RICH MINERAL ASSEMBLAGE IN MANTLE-DERIVED CHROMITITES FROM THE EASTERN ALPS, AUSTRIA: A COMBINED MULTI-DISCIPLINARY STUDY

by

K. N. Malitch

Institute of Geological Sciences
University of Leoben, Peter-Tunner Strasse 5, A-8700 Leoben, Austria

Highly unusual assemblages of platinum-group minerals (PGM), rare earth-, gold- and uranium-rich accessory minerals from geologically and compositionally distinct chromitites (podiform and banded types) at Kraubath and podiform chromitite at Hochgrössen have been evaluated during FWF-Projects M505 and M601-CHE "Platinum-group element geochemistry and mineralogy in Eastern Alpine ultramafic massifs" Parts of these results have been summarized recently [1, 2].

The Kraubath and Hochgrössen dunite-harzburgite massifs, two large mantle relicts in the Eastern Alps, have been interpreted as part of a dismembered Precambrian to Early Paleozoic, strongly deformed and metamorphosed ophiolite complex, which originated in a supra-subduction setting [3-6, etc.]. However, the age of ultramafic protoliths is unknown. Preliminary data on Os-isotope composition of laurite, presented for the first time, help constrain the age of protolith(s) formation.

The predominant chromitite type at Kraubath and Hochgrössen is schlieren, deformed stringers and streaks of massive chromite not more than a few centimeters thick. These are considered to be typical of podiform chromitite. However, at Kraubath another, less abundant type of chromitite (i.e. sheet-like orebodies, banded type) is present as layers in a stratigraphically higher level of the massif (the Sommergraben area). Various accessory minerals from 3 different bedrock chromitites have been investigated by several techniques, including highly effective hydro-separation method and electron-microprobe analysis (EMPA). However, negative thermal ionization mass-spectrometry (NTIMS), to date, has only been applied to monophase Ru-Os sulfides in the size range of 45 - 100 μm from the podiform chromitite of the Kraubath massif.

Mineralogy and PGE-geochemistry

Chemical composition of chromite varies from Cr# [100*Cr/(Cr+Al)] = 73 - 77 in the banded-type to Cr# = 81 - 86 in the podiform chromitite at Kraubath and Hochgrössen.

About 15 different PGM, one gold-rich mineral (tetrauricupride AuCu) and uraninite are firstly observed in the banded chromitite with pronounced enrichment of Pt and Pd relative to more refractory platinum-group elements (PGE) of IPGE-group (Os, Ir, Ru) like in those characteristic of crustal section of ophiolites. On the contrary, the podiform chromitites at Kraubath and Hochgrössen display a negatively sloping chondrite-normalized PGE pattern. This pattern is similar to typical ophiolitic-podiform chromitite. Twenty-one different PGM are recorded in the podiform chromitite from Kraubath, compared to 3 PGM and 2 unnamed rare earth minerals in the podiform chromitite at Hochgrössen. Distinct PGE distribution patterns of different chromitites correspond well to variable PGM assemblages.

Banded chromitite is dominated by sperrylite (53 % of all PGM), which occurs in polyphase assemblages with an unnamed Pt-base metal (BM) alloy and Pd-rich minerals such as stibiopalladinite, mayakite, mertieite II, palladoarsenide, unnamed Pd-Rh-As and Pd(Pt)-(As,Sb) minerals. Banded type also contains PGE-sulfides (about 7 %), which are represented by a wide compositional range of the laurite-erlichmanite series and irarsite (8 %). Iridian osmium, geversite, unnamed Pt-Pd-Bi-Cu, tetrauricupride and Pb-Th-rich uraninite are present in minor amounts. Uraninite is characterised by high contents of PbO (13.63 17.04 wt.%) and ThO_2 (9.54 - 11.44 wt.%), yielding model ages between 1520 and 1780 Ma.
In contrast, podiform chromitite is dominated by laurite, which occurs in complex polyphase assemblages with PGE-alloys (Ir-Os, Os-Ir, Pt-Fe), PGE-sulfides (kashinite, bowieite, cuproiridsite, cuprorhodsite, unnamed Ir-rich variety of ferrorhodsite, braggite, unnamed Ni-Fe-Cu-Rh- and Ni-Fe-Cu-Ir sulfides) and Pd telluride (keithconnite). A variety of PGE-sulfarsenides (33 %) including irarsite, hollingworthite, platarsite, ruarsite and a number of intermediate species have been identified, while sperrylite and stibiopalladinite are subordinate (2 %). Unnamed rare earth minerals are present as mono- and polyphase grains. Their composition is dominated by Ce_2O_3 (51.15 - 52.85 wt.%), La_2O_3 (25.32 - 26.32 wt.%), Nd_2O_3 (14.89 - 15.83 wt.%) and Gd_2O_3 (6.19 - 7.6 wt.%).

Os-isotope constraints

The $^{187}Os/^{188}Os$ ratio was used to identify the substantial source and model (mantle-derived) osmium-isotope age of PGM. The $^{187}Os/^{188}Os$ value, measured by NTIMS, in single Os-rich laurite grains from podiform chromitite at Kraubath was found to range from 0.1158 to 0.1162. Therefore, first age estimates on the formation of the ultramafic protoliths, based on osmium isotopic composition of Ru-Os sulfides, yield model ages in the range of 1630 - 1685 Ma, assuming chondritic mantle reservoir. The model ages obtained indicate that the matter source for PGE-mineralization had been the Proterozoic mantle. The Rb-Sr isotope-geochemical system identifies several younger metamorphic events that occured in the vicinity of the Kraubath and Hochgrössen massifs at c. 400 and 100 Ma [6, FARYAD et al. unpublished data]. In this context, the model Os-isotope ages obtained (1630 - 1685 Ma) indicate the high stability of the Os-isotope system within PGM, despite the occurrence of later thermal events. Os-isotope stability has also been demonstrated for detrital 3.1 Ga Os-rich alloys from the Evander goldfield, Eastern Witwatersrand, South Africa [7]. This feature is considered a promising sign in the evaluation of Os-isotope composition of various PGM (e.g., Os-rich alloys, sulfides and sulfarsenides) from geologically and compositionally distinct chromitites at Kraubath as well as from podiform chromitite at Hochgrössen.

Conclusions

The occurrence of about 30 PGM, two rare earth minerals, tetrauricupride and Pb-Th-rich uraninite from only three bedrock chromitite samples is highly unusual for an ophiolitic environment. Such unusual diversity, firstly observed in or close to the mantle section of an ophiolite, is due to the novel investigation approach undertaken in this study. Consequently, geologically, geochemically and mineralogically distinct banded chromitite from Kraubath might be considered as indicative for the transition zone of an ophiolite, closely above the mantle section with podiform chromitite, rather than representative of the crustal cumulate pile. Model ages of Ru-Os sulfides vary from 1630 to 1685 Ma. Therefore, they indicate the existence of Precambrian parent ultramafic protolith originated at the PR2-PR3 boundary.

Acknowledgements

Financial support by the Austrian Science Fund and productive atmosphere in the Institute of Geological Sciences is gratefully acknowledged.

References

[1] MALITCH, K. N., MELCHER, F. & MÜHLHANS, H. (2001): Palladium and gold mineralization in podiform chromitite at Kraubath, Austria. - Mineral. Petrol. 73 (In press).

[2] MALITCH, K. N., THALHAMMER, O. A. R, KNAUF, V. V. & MELCHER, F. (in press): Diversity of platinum-group mineral assemblages in banded and podiform chromitites from the Kraubath ultramafic massif, Austria: evidence for an ophiolitic transition zone? - Mineral. Deposita.

[3] STUMPFL, E. F. & EL AGEED, A. (1981): Hochgrössen and Kraubath - Teile eines paläozoischen Ophiolit-Komplexes. - Mitt. Abt. Geol. Paläont. Bergr. Landesmuseum Joanneum 42: 161-169.

[4] NEUBAUER, F. (1988): Bau und Entwicklungsgeschichte des Rennfeld-Mugel- und des Gleinalm-Kristallins (Ostalpen). - Abh Geol B-A. 42: 1-137.

[5] MELCHER, F. (2000): Chromite and platinum-group elements as indicators of mantle petrogenesis. - Unpubl. Habil. thesis. Mining University Leoben, 202 pp.

[6] PUHI, J. (2000): Vergleichende Petrologie und Geochemie von ultramafischen Massiven der Ostalpen. - Unpubl. PhD thesis, Mining University Leoben, 332 pp.

[7] MALITCH, K. N., KOSTOYANOV, A. I. & MERKLE, R. K. W. (2000): Mineral composition and osmium isotopes of PGE-mineralization of Eastern Witwatersrand, South Africa. - Geology of Ore Deposits 42: 253-266.