Platinum-Group Minerals in the Alaskan Type Mafic-Ultramafic Intrusions of the Yubdo Area, Western Ethiopia

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Introduction

The Yubdo platinum deposit is found in western Ethiopia, 540 km west of the capital Addis Ababa. Eight boreholes were drilled in the Yubdo mafic-ultramafic rocks by the Duval Corporation in 1969 to evaluate the platinum potential of the area. Two boreholes drilled at the center of the ultramafic body (Fig. 1) were selected and sampled at a 1m interval for mineralogical and geochemical study (Tables1, 2). In addition the present study describes the shape and composition of the PGM found in the borehole samples. Based on the textural and chemical data, the genesis of the platinum mineralization of Yubdo is discussed in comparison with previous studies and similar deposits. This work extends the study published by Mogessie et al. (1999).

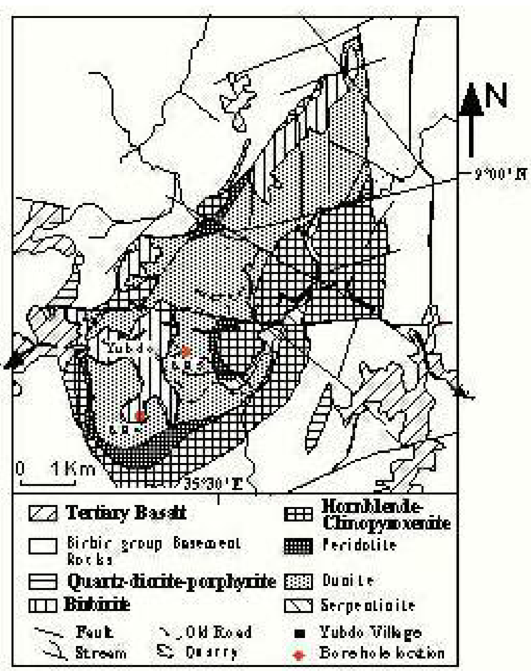

__Figure 1.__ Simplified Geological map of Yubdo mafic-ultramafic body. Modified after Kazmin and Demessie (1971).

Geology

In western Ethiopia both the low- to medium- grade metamorphism ensimatic Arabian-Nubian Shield (ANS) and the generally high-grade reworked Mozambique belt (MB) rocks occur in outcrop. Basement rocks in the ANS, commonly found associated with the mafic-ultramafic rocks, are volcano-sedimentary sequences (Kazmin et al. 1978).

Linear bodies of altered mafic-ultramafic rocks occurring from Yubdo to the Tulu-Dimtu area were thought to be part of an ophiolitic sequence by Kazmin et al., (1978). Recently Mogessie et al., (1999, 2000) have suggested that these rocks were intruded into a magmatic rift or back-arc basin. The main rock units of the Yubdo area (Fig. 1) are dunites at the core, surrounded by peridotite and hornblende-clinopyroxenite; an outcrop pattern typical of Alaskan type deposits. Birbirite appears to be a silicic alteration product overlying the dunite. Chemical analyses of core samples show a very low sulfur content (< 0.% - Belete et al., 2000). The PGM in Alaskan-type complexes are known to be sulfide poor and have affinity to oxides as clearly documented by Johan et al. (1989) and Nixon et al. (1990). These chemical data show relatively high values of Pt, Pd and Rh, which are characteristics of Alaskan type intrusions. Ru, Ir and Os in general show values below detection limits.

Sample descriptions

Silicate and oxide phases

Olivine: Relicts of olivine with a forsterite content of 88 to 92 mol. % are commonly found in serpentinized dunites and peridotites of both boreholes.Three types of olivine alteration can be found in the Yubdo ultramafic rocks forming chrysotile, antigorite and lizardite.

Clinopyroxene (Diopside) : is present in the hornblende-clinopyroxenite and peridotite of both borehole sections. Mg/(Mg+Fe) of the pyroxene ranges from 90 to 96 mol. % and this is indicative of an early appearance as a cumulate phase in the ultramafic sequence. Ca-rich amphibole (Mg-hornblende and tremolite) and Ca-poor amphibole (anthophyllite) occur in both boreholes.

Chromite: Disseminated chromite reaches up to 3 modal % in the dunites. The Cr/(Cr+Al) ratio of the chromite increases with an increase of MgO content at the center of the two borehole sections. The chromite is usually zoned showing alteration to more Fe-rich compositions around the rim.

Platinum-Group Minerals (PGM)

Several PGM are reported in the disseminated chromites and altered silicates associated with the serpentinized dunite within boreholes 4&5. The PGM in the chromites are commonly less than 5 µm across (Fig. 2A). They have euhedral shapes and in most cases are found in the cores of zoned chromites. Relatively larger grains reaching up to 15 µm PGM are found in the highly serpentinized section of the ultramafic rocks (Fig. 2B). These grains contain osmium laths, are bright white colored in reflected light and have both euhedral and anhedral shapes.

Two types of Pt-Fe compositions can be identified in the chromite and altered silicates. All the analyzed PGM in the chromite are Pt - Fe alloys. They have higher Fe contents than the PGM grains in the altered silicates (Table 1).

Discussion

The degree of alteration of the dunites varies vertically. The different units of the Yubdo ultramafic sequence show relict magmatic minerals such as forsterite, diopside and Mg-hornblende. In addition, disseminated chromite and magnetite are the common oxide minerals. The PGM form magmatic euhedral grains in chromite. These PGM show compositions with PGE: Fe + Cu of 1.6 – 2.1 and differ from the Pt-Fe alloys in the altered silicates which have compositions closer to that of isoferroplatinum (Pt_3Fe). Nixon et al. (1990) suggested that during serpentinization or hydro-thermal alteration processes in the presence of chromites, tetraferroplatinum and Pt-Fe alloy could alter to isoferroplatinum and tulameenite compos-itions if copper is introduced in the fluids. The recrystallization and alteration of chrome spinels at Yubdo during the remobilization of PGM has been documented by Belete et al. (2000). It is possible that the isoferroplatinum compositions found in the silicates might be formed from Pt-Fe alloy in the chromite during one stage of the several alteration processes which have affected these rocks.

Conclusions

This paper presents the first PGE analytical data for samples of the Yubdo mafic-ultramafic rocks. The mineralogy and geochemistry of the ultramafic rocks of Yubdo area and the concentric zoning pattern clearly indicate that it is an Alaskan-Type intrusion.

The PGM in near surface rocks occur as micron-sized Pt-Fe alloys which are usually euhedral and contained in chromite. Larger, less iron-rich Pt-Fe alloys can be found in the altered silicates, especially those in the more altered rocks.

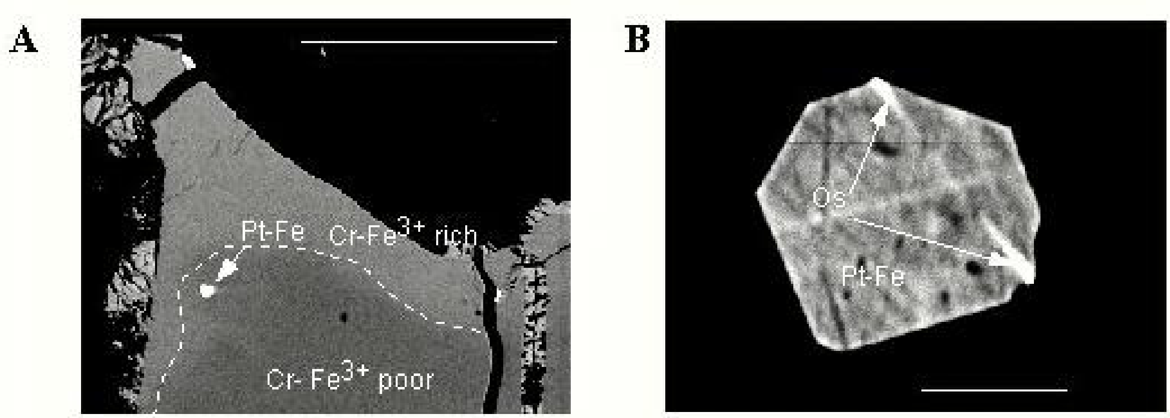

Figure 2. A) A magmatic droplet of Pt-Fe grain in a chromite. B) Osmium laths in a Pt-Fe grain within serpentinized zone. Scale bar is 50µm for A and 10 µm for B.

Table 1. Representative electron microprobe analyses of the PGM found in the chromite and altered zone in samples from two Yubdo bore holes.

		Electron microprobe analyses (wt%)							
Sample No.		**Fe**	**Cu**	**Rh**	**Pd**	**Os**	**Ir**	**Pt**	**Total**
PGM in	**4.63**	15.01	n.d.	0.83	n.d.	n.d.	2.67	81.76	100.27
Chromite	**5.33**	12.05	0.25	1.52	n.d.	7.46	2.08	75.9	99.26
PGM in	**5.19 1**	8.21	0.57	n.d.	0.91	n.d.	2.44	84.72	96.85
Altered	**5.19 2**	8.09	0.54	n.d.	0.97	n.d.	1.79	86.85	98.24
Silicates	**5.19 3**	8.25	0.72	n.d.	1.01	n.d.	1.60	84.58	96.16
	5.25	8.63	2.03	n.d.	n.d.	n.d.	1.42	87.82	99.90

		Atomic proportions (%)							
Sample No.		**Fe**	**Cu**	**Rh**	**Pd**	**Os**	**Ir**	**Pt**	**(Pt + Rh + Os + Ir) / (Fe + Cu)**
PGM in	**4.63**	38.39	0.00	0.00	0.00	0.00	1.97	59.64	1.60
Chromite	**5.33**	32.08	0.57	2.20	0.00	5.82	1.61	57.72	2.06
PGM in	**5.19 1**	24.04	1.48	0.00	1.39	0.00	2.08	71.01	2.92
Altered	**5.19 2**	23.49	1.36	0.00	1.47	0.00	1.51	72.17	3.02
Silicates	**5.19 3**	24.20	1.86	0.00	1.54	0.00	1.36	71.04	2.84
	5.25	23.99	4.97	0.00	0.00	0.00	1.15	69.89	2.45

n.d. = not detected above a detection limit of 0.1%

Several alteration processes are known to have affected the intrusion beginning with late intrusive phenomenon and veining of the intrusion. Serpentinization has occurred and there is evidence of hydrothermal processes in the area related to the mega-shear zones which bound the mafic-ultramafic bodies in Western Ethiopia. Early mining work in the area concentrated on the most accessible surface rocks that are weathered and laterized with the result that the deposit has often been described as an alluvial or lateritic deposit. The present work shows that the surface deposit is the weathered expression of a PGE-mineralized Alaskan-type ultramafic body which has suffered extensive alteration. This will greatly help future exploration work in the search for a primary platinum deposit in the area.

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