



Orthopyroxene-rich ultramafic-mafic rocks from western Tasmania and their PGE contents

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Abstract

Ultramafic rocks from western Tasmania have been subdivided into three different successions on field criteria and/or mineral chemical data. Two of the three successions have whole-rock PGE values. Chondrite-normalised PGE plots define a negative slope distribution (Os-Pd) with an anomalous high Pt peak.

INTRODUCTION

This report combines the data used for a poster display presented at the Fifth International Platinum Symposium, Espoo, Finland (August 1–3, 1989), and a poster display to be presented at the Tenth Australian Geological Congress, Hobart, February 4–9, 1990.

Within western Tasmania there are fifteen separate areas of ultramafic-mafic rocks (fig. 1). The areas are usually fault-bounded, and consist of rocks belonging to one or more of three different ultramafic successions, which can be distinguished by field criteria and/or mineral chemical data (Brown, 1986).

The three associations are:—

- Layered Dunite-Harzburgite (LDH) succession
- Layered Pyroxenite-Dunite (LPD) succession
- Layered Pyroxenite-Peridotite and Associated Gabbro (LPG) succession

PGE Distribution

Whole-rock samples from all three of the Tasmanian ultramafic-mafic successions have detectable PGE concentrations.

A chondrite-normalised PGE diagram containing the 'average Tasmanian whole-rock sample' (average of 42 samples) shows that the plot for the Tasmanian 'sample' has a similar slope to samples from so called 'ophiolite' bodies but, in comparison to these, the Tasmanian 'sample' has anomalously high Pt values (fig. 2).

Work to date on Tasmanian samples indicates that PGE values are higher in rocks with a high chrome-spinel content. So far only Os–Ir–Ru alloy and laurite grains have been observed in polished sections. No Pt–Pd–Rh sulphide or alloy minerals have been observed, indicating that these elements are probably dispersed throughout the silicate phases and were not concentrated by a sulphide phase.

LDH SUCCESSION

The LDH succession consists of interlayered dunite, orthopyroxene-bearing dunite, and harzburgite. The rock

types depend on the amount of orthopyroxene within any specific layer. Rocks within this succession contain olivine, enstatite and chrome spinel. The chemical range of these minerals is very restricted, irrespective of which area a sample comes from. Olivine grains have the composition of Fo₉₃ to Fo₉₄; enstatite, En₉₃ and En₉₄, with a calcium content of less than 0.5 wt%, indicating an original clinoenstatite composition. Chrome spinel grains have a 100×Cr/Cr+Al ratio (Cr*) of 87–93 (fig. 4). Late-stage, coarse-grained orthopyroxenite contains enstatite crystals of En_{93–94}, chrome spinel grains with a Cr* of 92 to 94, and minor olivine of Fo_{86–89}. This succession is considered to have been formed at high temperatures and low pressures as the magma chamber product of a boninitic magma.

Areas of the LDH succession occur on the western side of the Heazlewood River Complex (No. 3, fig. 1); as the whole of the Mt Stewart Complex (No. 4); the major part of the Huskisson and Wilson River Complexes (No. 5 & 6; Plates 1 and 2); a large part of the Adamsfield and Boyes River Complexes (No. 13 & 14); and at Rocky Boat Harbour (No. 15).

PGE Contents

Os–Ir–Ru alloy grains have been mined from alluvial and eluvial deposits associated with all areas of LDH succession. Records show that between 1880 and 1980, just over 880 kg of "osmiridium" had been recovered from the four main areas — Adamsfield (No. 14); Heazlewood (No. 3); Mt Stewart (No. 4) and Wilson River (No. 5). Smaller amounts are known to have been obtained from the Boyes River (No. 13) and Rocky Boat Harbour (No. 15). Compositions of PGE minerals from the Adamsfield area are listed in Table 1a and plotted in Figure 3. Further analyses of "osmiridium" parcels from Adamsfield are given in Table 1b.

LPD SUCCESSION

The LPD succession consists of thin (<5 mm–200 mm), uniform layers of orthopyroxenite, olivine orthopyroxenite and dunite. Harzburgite layers have not been found in this succession. Orthopyroxene grains range in composition from En₈₅ to En₈₉, and have calcium contents varying between 0.6 and 2.0 wt%. Olivine grains vary between Fo₈₇ and Fo₉₀. Minor chrome-diopside has a very limited composition with an average Ca:Mg:Fe = 47:49:4. Chrome-spinel grains have an average Cr* of 64 (fig. 4).

Areas of the LPD succession occur as fault-bounded blocks intermixed with areas of the LDH succession in the northern (Harman River) and southern (Riley Knob; Plate 3) parts of the Wilson River Complex (No. 5); in the Heazlewood River and Huskisson River Complexes (No.

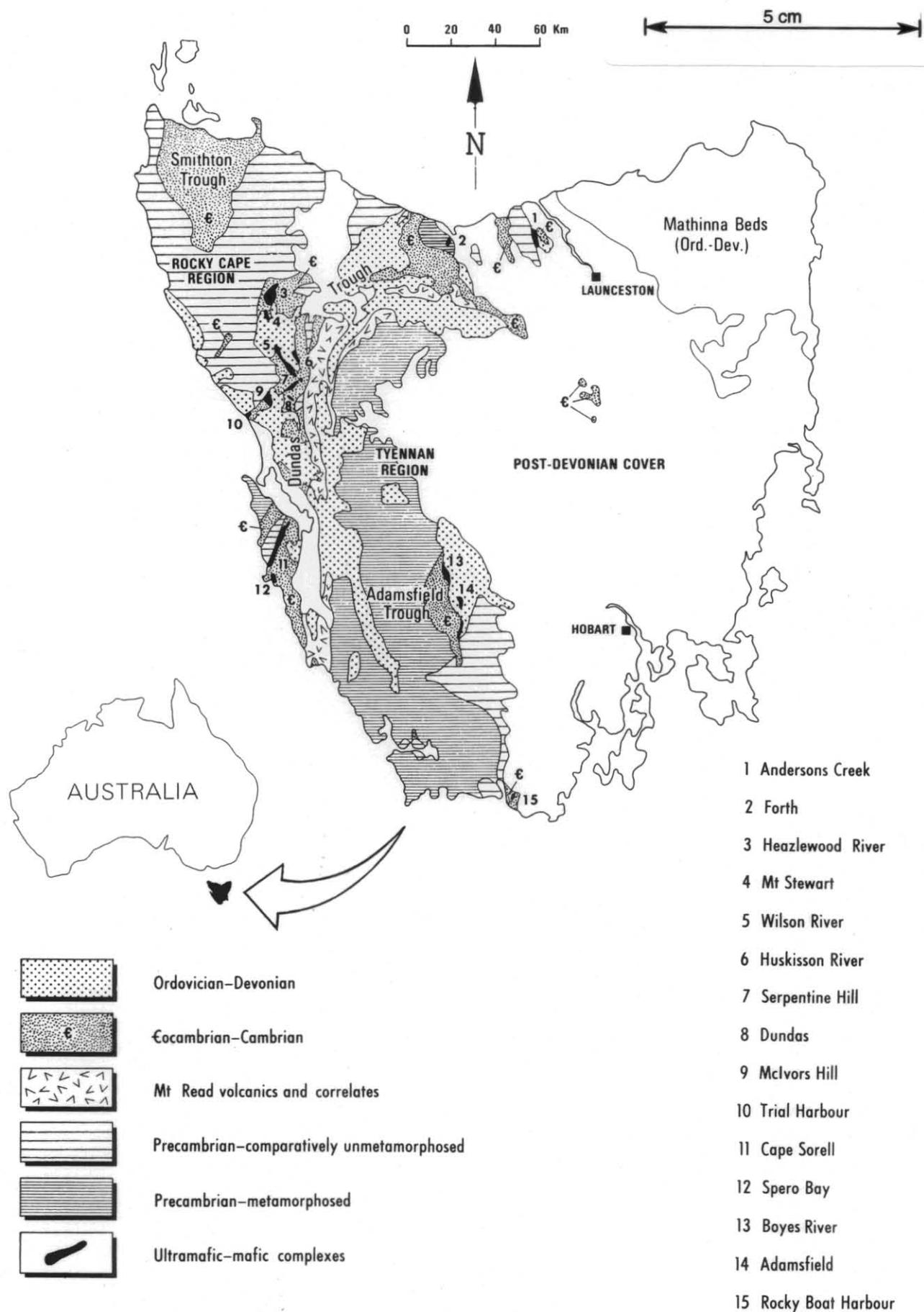
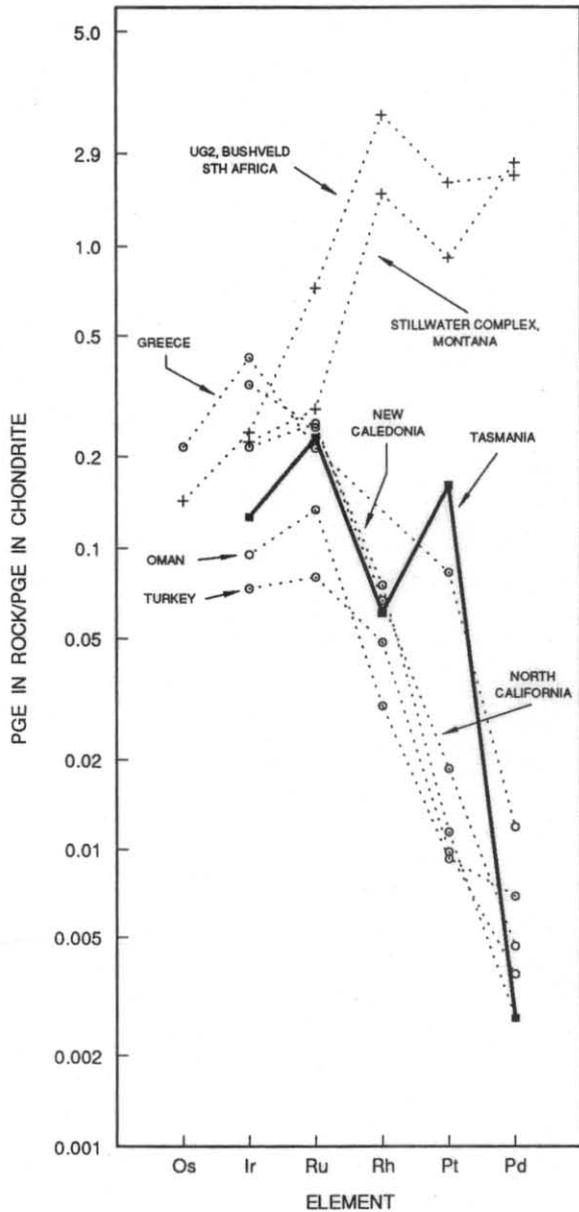


Figure 1. Schematic geological map of Tasmania showing locations of ultramafic-mafic complexes. Rock distribution after 1:500 000 Geological Map of Tasmania (1976).



3 & 6); form the Colebrook Hill and Dundas bodies (No. 8); and at Adamsfield (No. 14; Plate 4), where rafts of the succession, surrounded by serpentinitic sheaths, are fault juxtaposed against areas of the LDH succession.

PGE Contents

So far no PGE minerals have been recorded associated with areas of LPD succession rocks. The average values for whole-rock samples from three different areas of this succession, the southern parts of the Heazlewood River (No. 3), Wilson River (No. 5), and Huskisson River (No. 6) Complexes, are listed in Table 2.

LPG SUCCESSION

The LPG succession is a multi-phase ultramafic-mafic succession. It consists of two ultramafic phases and a later intrusive phase of gabbro.

At Serpentine Hill the LPG succession consists of fault-disrupted blocks of what was originally a layered, plagioclase-bearing, orthopyroxene-rich sequence of pyroxenite, olivine pyroxenite, harzburgite and dunite, with numerous sedimentary-like structures. This sequence was later intruded and dismembered by a second magma which formed a layered, plagioclase-bearing, olivine-rich succession, which incorporated blocks of the first sequence and contains zones rich in chrome-spinel. Both of the ultramafic sequences were later intruded by a magma phase, or phases, which formed a massive, two-pyroxene gabbro. Although the mineral chemistry of the constituent mineral phases of the LPG succession have a similar chemical range to those in the LPD succession, the LPG succession contains plagioclase as a pervasive post-cumulus phase, and contains different rock types and layering characteristics to the LPD and LDH successions. The LPG succession is considered to have formed as the magma chamber product of a low-titanium, tholeiite magma (Brown and Jenner, 1989).

Figure 2. Chondrite-normalised platinum-group element data (after Page et al., 1984) showing average data for 42 samples (after Brown et al., 1988)

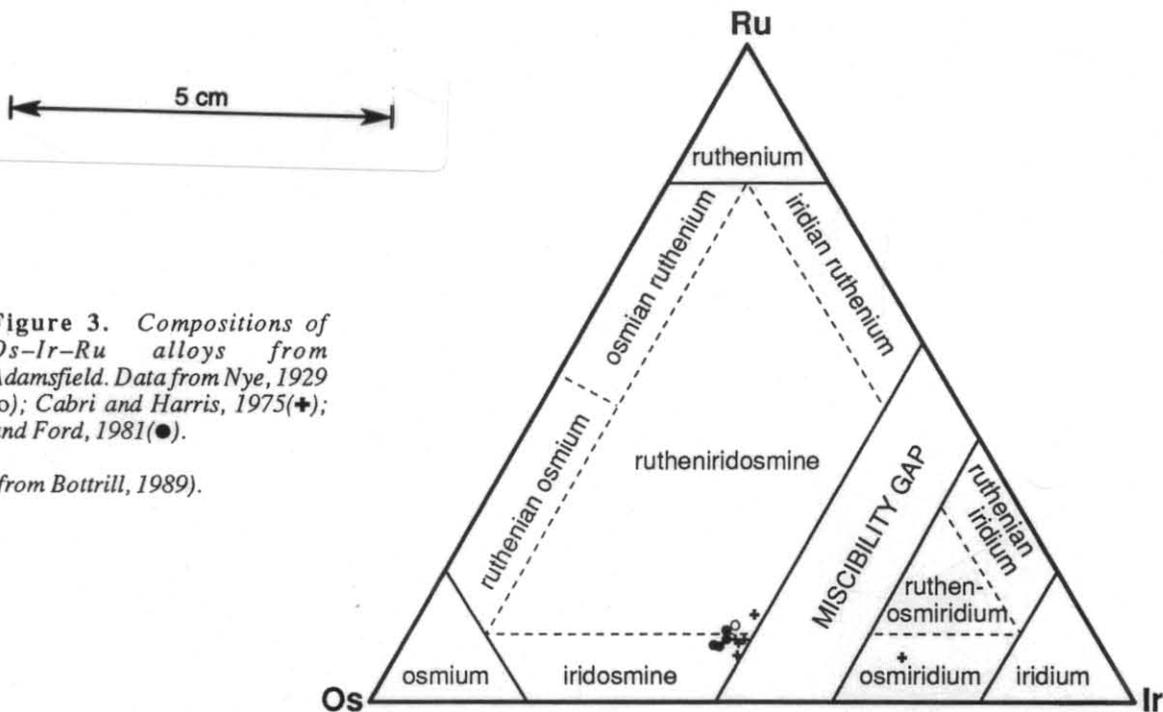


Figure 3. Compositions of Os-Ir-Ru alloys from Adamsfield. Data from Nye, 1929 (o); Cabri and Harris, 1975(+); and Ford, 1981(●).

(from Bottrill, 1989).

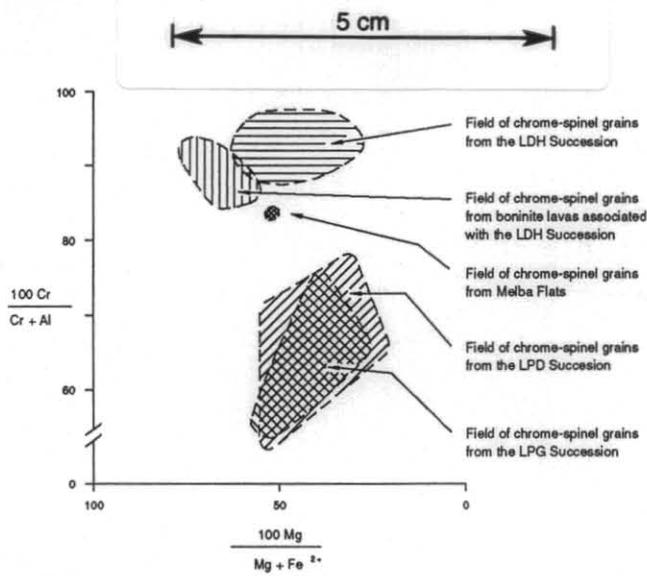


Figure 4. Fields of chrome-spinel grains from Tasmanian ultramafic rocks.

Areas of the LPG succession occur at Serpentine Hill (No. 7; Plates 5 and 6); McIvors Hill (No. 9); and as part of the Heazlewood River Complex (No. 3).

PGE Contents

A study of the LPG succession at Serpentine Hill (Brown *et al.*, 1988) showed that all the different parts of the succession contained whole-rock PGE values. Surface whole-rock samples were analysed by fire-assay / atomic absorption for Pt, Pd and Rh, and by fire-assay / spectographic technique for Ir and Ru, at the USGS Laboratories, Lakewood, Colorado, USA. Average values for these samples for the various sequences within the LPG succession at Serpentine Hill are listed in Table 3.

Because of the results obtained in the surface sampling programme, a follow-up programme of six, 100 m drill holes was undertaken on the different lithologies of the LPG succession at Serpentine Hill. The purpose of the holes was to obtain the distribution of PGE values across a stratigraphic distance in areas where PGE values had previously been obtained. Five samples were taken from each drill hole, at approximately 20 m spacings, for analysis.

Three holes were placed in the olivine-rich layered sequence to intersect the chromite-rich zone which had been defined by surface mapping in the original study. The dominant rock type intersected in these holes was serpentinite, after pyroxene-bearing dunite. The serpentinite has a high percentage of disseminated chrome-spinel which has a Cr* around 66. Chromitite lenses were not intersected by any of the drill holes, indicating that the zone defined by surface mapping is discontinuous down dip.

The fourth hole was drilled at Melba Flats, at the site of the sample which gave the Pt reading of 1244 ppb in the earlier study. The resultant core was dominantly sheared serpentinite with disseminated chrome spinel. The top ten metres of the drill hole, and the zone between 75 and 85 m, contained chrome-spinel with a Cr* around 84, whereas the rest of the core contained chrome-spinel with a Cr* around 60 (fig. 4). The fifth hole was drilled into the associated two-pyroxene gabbro, and the sixth into the low-titanium basalt.

Samples obtained from drill core were prepared by fire assay-NiS collection and analysed by INAA techniques at Becquerel Laboratories, Lucas Heights, Sydney, Australia.

The analyses obtained from the drill hole samples do not reflect the results obtained from grab samples of surface outcrop. At Melba Flats, with the exception of one 50 mm thick chromitite band encountered at 18 m, none of the samples gave PGE values greater than detection limit values.

Element	Au	Ir	Os	Pd	Pt	Ru
Detection limit (ppb)	1	0.5	5	10	20	20
Melba Flats chromitite sample	20	51	58	<10	32	320

Samples from the three holes drilled into the olivine-rich sequence Pt, Pd, Os and Ru were all below detection limits. Ir values ranged between 0.9 and 5.0 ppb, with an average of 2.3 ppb for ten samples. However the fifteen samples from the three holes averaged 25 ppb gold, and small Ni-Fe-Co sulphide grains were ubiquitous throughout the samples.

All PGE were below detection limits for the samples of two-pyroxene gabbro. Gold averaged 28 ppb across the section. The low-titanium basalt recorded an average of 21.5 ppb for Pd, and below detection limits for other PGE. Gold averaged 86 ppb across the 100 m section.

Individual grains of PGE alloys or PGM are rarely found in polished sections. Two PGM grains which were found occurred within chrome spinel grains which were obtained from areas of high spinel concentration within the olivine-rich sequence. The first grain (Plate 7) was an Os-Ir-Ru alloy with subsidiary amounts of Cr, Fe, As and S. The amount of PGE's in the analysis was 80.81 wt% in the proportions Os_{0.554}:Ir_{0.322}:Ru_{0.124}. The grain is 10 µm long by 9 µm wide. The second grain (Plate 8) is a rectangular grain of laurite, 15 µm long by 7 µm wide. The analysis, with a total of 100.81 wt%, gave a formula of (Ru_{1.003}, Os_{0.055}, Ir_{0.032})_{1.09} S₂.

This follow-up study to Brown *et al.* (1988), shows that

- Platinum Group Elements and/or minerals are not distributed evenly over stratigraphic depth;
- the chromitite zone defined by surface mapping is discontinuous at depth as well as along strike;
- grab samples from surface outcrop are not necessarily representative of a continuous section through a specific unit;
- when dealing with low level PGE contents, different parts of a specific whole-rock sample do not necessarily give repeatable PGE values.

REFERENCES

BOTTRILL, R. S. 1989. Economic Geology, in: BROWN, A. V. *et al.* Geological atlas 1:50 000 series. Sheet 73 (8112N). Huntley. *Expl. Rep. geol. Surv. Tasm.*

BROWN, A. V. 1986. Geology of the Dundas-Mt Lindsay-Mt Youngbuck region. *Bull. geol. Surv. Tasm.* 62.

BROWN, A. V.; PAGE, N. J.; LOVE, A. H. 1988. Geology and Platinum-Group-Element geochemistry of the Serpentine Hill Complex, Dundas Trough, Western Tasmania. *Can. Mineral.* 26:161-175.

BROWN, A. V.; JENNER, G. A. 1989. Geological setting, petrology and chemistry of Cambrian boninite and low-Ti tholeiite lavas in western Tasmania, in: CRAWFORD, A. J. (ed). *Boninites and related rocks*. Allen & Unwin: London.

CABRI, L. J.; HARRIS, D. C. 1975. Zoning in Os-Ir alloys and the relation of the geological and tectonic environment of the source rocks to the bulkPt:Pt+Ir+Co ratio for placers. *Can. Mineral.* 13:266-274.

FORD, R. J. 1981. Platinum-group minerals in Tasmania. *Econ. Geol.* 76:408-186.

NYE, P. B. 1929. The osmiridium deposits of the Adamsfield district. *Bull. geol. Surv. Tasm.* 39.

PAGE, N. J.; ENGIN, T.; SINGER, D. A.; HAFFTY J. 1984. Distribution of Platinum-Group Elements in the Bati Kef chromite deposit, Guleman-Elazig areas, Eastern Turkey. *Econ. Geol.* 79:177-184.

REID, A. M. 1921. Osmiridium in Tasmania. *Bull. geol. Surv. Tas.* 32.

[3 November 1989]

Table 1 (a)

COMPOSITIONS OF PGE MINERALS FROM ADAMSFIELD

No.	mass %									Totals	atomic %						Mineral
	Os	Ir	Ru	Rh	Pt	Pd	Fe	Ni	Os		Ir	Ru	Rh	Pt	Fe		
1	45.51	41.65	6.40	0.29	1.12	tr	na	na	94.97	46.08	41.73	12.19	...	...	...	Bulk sample
2	48.40	44.70	5.60	0.61	0.67	0.05	1.40	0.27	101.70	46.91	42.88	10.21	...	...	...	Rutheniridosmine
3	49.10	46.50	5.30	0.60	0.75	nd	0.07	0.01	102.33	46.72	43.79	9.49	...	...	...	Iridosmine
4	47.90	46.50	5.40	0.66	0.96	nd	0.29	0.04	101.75	46.02	44.21	9.76	...	...	...	Iridosmine
5	26.50	65.30	3.70	0.53	5.00	nd	0.45	0.10	101.58	27.02	65.88	7.10	...	...	...	Osmiridium
6	44.70	46.40	7.60	0.49	1.00	0.05	0.56	0.09	100.89	42.61	43.77	13.63	...	...	...	Rutheniridosmine
7	49.80	46.30	4.20	0.49	0.67	nd	0.28	0.05	101.79	48.11	44.26	7.63	...	...	...	Iridosmine
8	50.46	42.97	6.42	0.00	0.00	na	0.49	na	100.34	48.03	40.47	11.50	...	...	...	Rutheniridosmine
9	51.41	43.13	5.44	0.43	0.00	na	0.54	na	100.95	49.28	40.91	9.81	...	...	...	Iridosmine
10	52.24	42.52	5.18	0.42	0.00	na	0.56	na	100.92	50.20	40.43	9.36	...	...	...	Iridosmine
11	50.81	42.54	4.95	0.67	0.00	na	0.43	na	99.40	49.71	41.18	9.11	...	...	...	Iridosmine
12	50.09	43.03	5.60	0.00	0.00	na	0.58	na	99.30	48.53	41.26	10.21	...	...	...	Rutheniridosmine
13	2.96	7.41	6.10	8.36	72.24	na	3.81	na	100.88	2.45	6.08	9.51	12.81	58.39	10.75	Rhodium iron platinum	
14	0.00	1.29	0.00	4.94	86.35	na	7.07	na	99.65	0.00	1.08	0.00	7.70	70.95	20.28	Iron platinum	

Analyses: 1 - from Nye, 1929 (the average of 31 concentrates); 2-7 - from; Cabri and Harris, 1975; 8-14 - from Ford, 1981.

tr = trace, nd = not detected, na = no analysis given

Table 1 (b)

ANALYSES OF OSMIRIDIUM FROM ADAMSFIELD (from Nye, 1929)

No.	mass %							Remarks
	Ir	Os	Ru	Pt	Rh	Pd	Au	
1	40.80	46.10	8.00	2.00	0.80	tr	...	From Eames and Scoles' Claim
2	39.20	50.20	6.50	2.00	1.00	tr	...	Hansen's Claim
3	38.40	47.00	9.80	1.60	1.60	tr	...	H. Tudor's Claim
4	36.30	47.25	10.60	2.20	1.60	tr	...	General sample
5	40.12	44.89	6.50	1.02	0.18	...	...	} From 60 oz parcels
6	40.48	44.14	6.54	1.00	0.20	...	...
7	40.02	43.96	6.67	1.16	0.20	...	...
8	44.35	45.74	6.46	...	tr	...	tr	} Samples from 50 oz parcels
9	41.43	43.50	5.35	1.10	0.16	...	0.007	
10	42.33	43.86	5.97	1.06	0.17	...	0.03	
11	42.70	46.28	5.54	1.04	0.18	...	0.003	
12	41.37	46.84	5.29	1.01	0.16	...	0.005	
13	42.80	47.10	5.52	0.48	0.14	...	0.002	
14	42.22	46.30	6.03	0.92	0.14	...	0.005	
15	43.21	45.88	5.81	1.04	0.14	...	0.003	} Samples from 75 oz parcels
16	42.39	44.96	6.75	1.25	0.17	...	nil	
17	41.25	43.92	6.59	1.27	0.21	...	nil	
18	42.85	44.10	6.47	1.21	0.19	...	0.007	
19	42.82	44.30	6.12	1.36	0.22	...	nil	
20	43.58	44.36	5.81	0.50	0.14	...	nil	
21	42.11	45.70	6.16	0.56	0.10	...	nil	
22	42.03	45.92	5.73	0.52	0.16	...	nil	50 oz parcel
23	42.62	43.31	6.43	1.14	0.14	...	nil	75 oz parcel
24	41.45	46.80	6.13	1.12	0.16	...	nil	75 oz parcel
25	42.53	44.36	6.02	1.24	0.18	...	nil	50 oz parcel
26	41.66	43.35	6.48	1.34	0.12	...	nil	75 oz parcel
27	42.02	46.22	5.30	1.21	0.11	...	nil	75 oz parcel
28	41.85	46.64	5.49	0.92	0.12	...	nil	50 oz parcel
29	41.76	45.74	6.79	1.14	0.19	...	nil	75 oz parcel
30	42.20	45.83	6.35	1.26	0.18	...	nil	75 oz parcel
31	42.28	46.50	6.31	1.20	0.18	...	nil	50 oz parcel
Average	41.65	45.51	6.40	1.12	0.29	...	0.002	

Analysts:

- Samples 1-4. Department of Mines Laboratory, Launceston
 Samples 5-7. Daniel C. Griffith & Co., London
 Sample 8. Mathey's, London
 Samples 9-31. Daniel C. Griffith & Co., London

Table 2

*AVERAGE PGE VALUES FOR SAMPLES FROM THE LPD SUCCESSION
(from Brown et al., 1988)*

Rock type	No. of samples	Pt	Pd	Rh	Ru	Ir
		(ppb)				
Pyroxenite	6	25	1	<1	<100	<20
Peridotite	6	20	<1	<1	<100	<20

Table 3

*AVERAGE PGE VALUES FOR SAMPLES FROM VARIOUS PARTS OF THE LPG
SUCCESSION AT SERPENTINE HILL (from Brown et al., 1988)*

Rock type and sequence	Pt	Pd	Rh	Ru	Ir
	(ppb)				
Orthopyroxene-rich layered sequence	36.0 (4)	1.7 (3)	2.0 (3)	<100	<20
Olivine-rich layered sequence					
a) Dunite with a high chrome spinel content	22.3 (6)	1.0 (3)	<1	<100	<20
b) Chromitite lenses in dunite	44.5 (6)	3.4 (5)	6.2 (6)	270 (6)	68.3 (6)
Melba Flats—chromitite lense	1240	4	54	180	70
Two-pyroxene gabbro	36.0 (4)	10.3 (4)	<1	<100	<20
Low-titanium tholeiite	37	25	<1	<100	<20

(number of samples, if greater than one, in parentheses)

(Surface whole-rock samples analysed by fire-assay/atomic absorption for Pt, Pd and Rh, and by fire assay/spectrographic technique for Ir and Ru, at the USGS Laboratories, Lakewood, Colorado, USA. See Brown *et al.* (1988)



Plate 1.

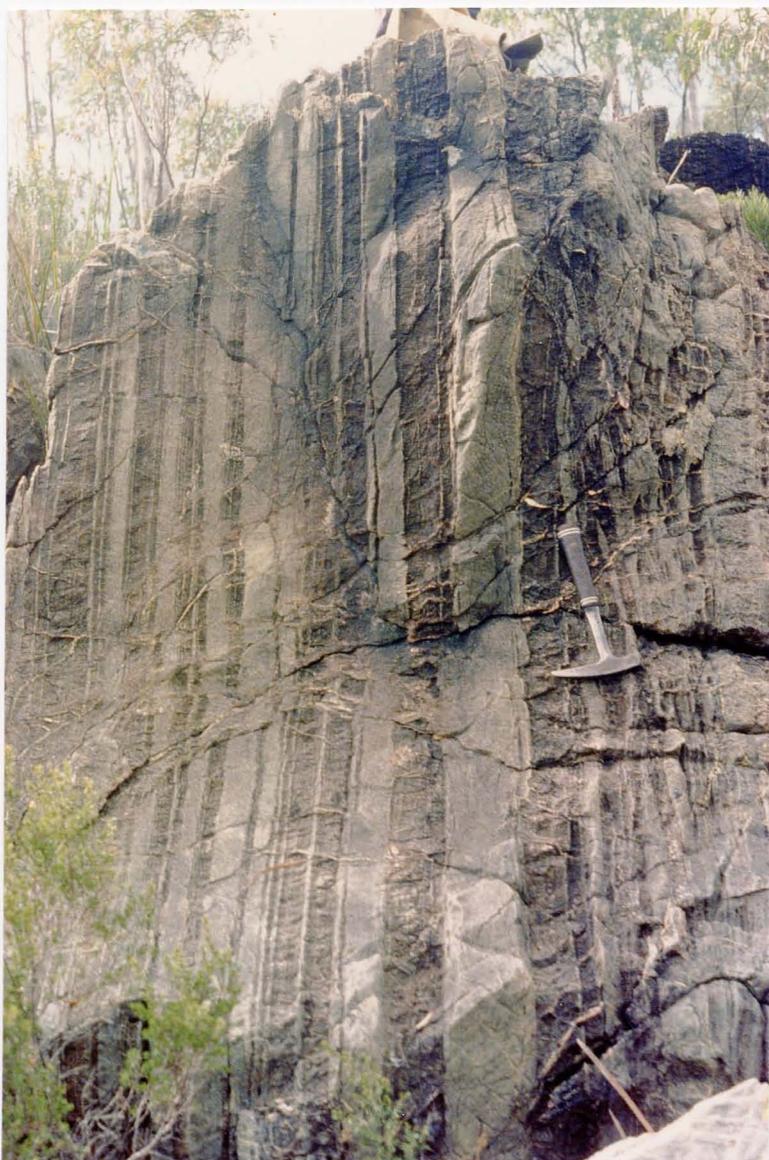


Plate 2.

Plates 1 and 2. Typical layering within the LDH succession. The smooth textured layers are dunite, and the 'pock-marked' textured layers either orthopyroxene-bearing dunite or harzburgite. Location: Harman River area.



Plate 3.



Plates 3 and 4. Typical layering within the LPD Succession. The smooth-textured, light grey layers are dunite; the relatively smooth light brown layers are olivine-bearing orthopyroxenite; and the rough-textured, brown layers are orthopyroxenite.

Locations: Plate 3 Rileys Knob; Plate 4 Adamsfield.

Plate 4.



Plate 5. Layer types in orthopyroxenite-rich sequence. Smooth areas are olivine-rich, rough areas are orthopyroxene-rich. In the middle of the plate is a typical dunite → harzburgite → orthopyroxenite graded layer.



Plate 6. Unconformity in orthopyroxenite-rich sequence. Mineralogy is the same as Plate 5.

Plates 5 and 6. Typical layering within the LPG Succession, Serpentine Hill.

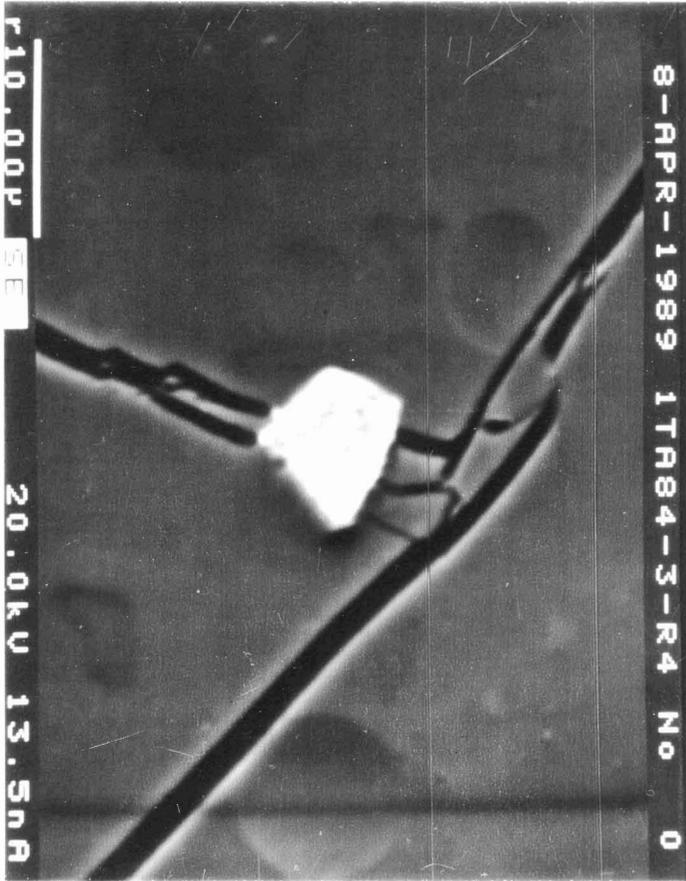


Plate 7. A grain of *Os-Ir-Ru* alloy in a chrome-spinel crystal from a chromitite lense in LPG succession rocks, Serpentine Hill.

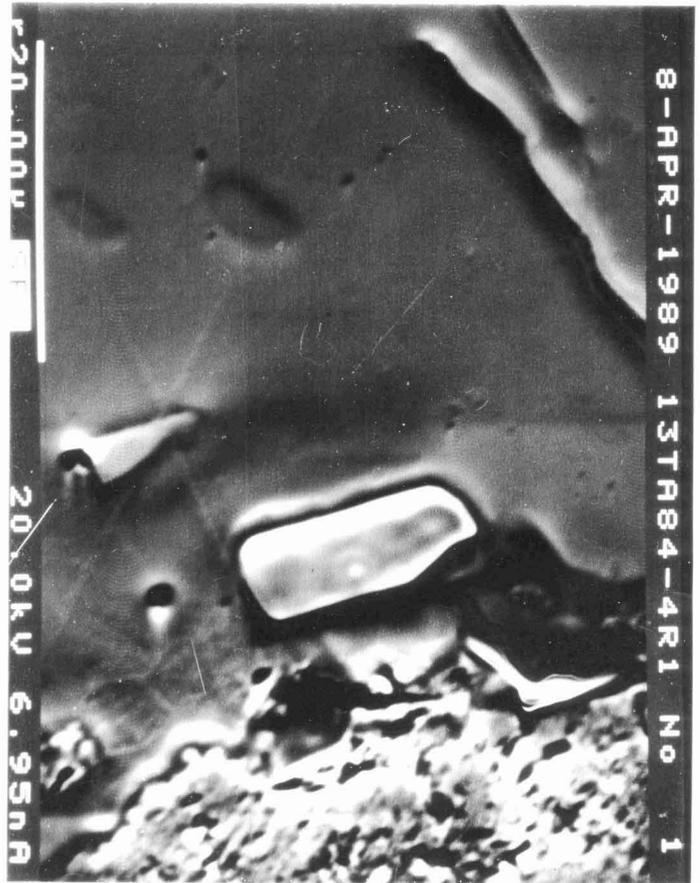


Plate 8. A laurite grain in a chrome spinel crystal from a chromitite lense in LPG succession rocks, Serpentine Hill.