GEOCHEMICAL EXPRESSION OF SOME WEST AUSTRALIAN KIMBERLITES AND LAMPROITES

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INTRODUCTION

Geochemical analyses of soil and drill spoil samples have been used during diamond exploration in Western Australia to identify overburden-covered diatremes, dykes and sills of kimberlite, lamproite and related rocks (hereafter termed "kimberlitic" rocks where referred to collectively).

The elements chosen for analysis reflect the characteristic kimberlitic association of enrichment in elements of ultramafic affinity combined with high values for incompatible elements (Dawson, 1967). This association is as characteristic of lamproite as it is of kimberlite (Smith, 1984). Elements most widely used were chromium, cobalt and nickel as representatives of the ultramafic suite and niobium as an incompatible element. However, orientation surveys have shown that markedly anomalous values of magnesium, titanium, phosphorous, barium, strontium, lanthanum and cerium are also developed in soils over kimberlitic source rocks.

Emission spectroscopy was widely used as an analytical method and is sensitive enough for analysis of drill spoil of ultrabasic rocks and their weathering products. For soil geochemistry a combination of emission spectroscopy (Ni/Co) and XRF (Cr, Nb) has been used to increase the sensitivity, especially for niobium analysis (the detection limit for Nb was 20 ppm by emission spectroscopy and 3 ppm by XRF, whereas 15 ppm Nb can represent a soil anomaly over a lamproitic/kimberlitic body). High Ni-Co-Cr contents (hundreds of ppm) identify a soil or drill sample as derived from a basic or ultrabasic source rock. If the Nb level is also raised (15 ppm to several hundred ppm) a kimberlitic source rock is indicated. Niobium anomalies can be found in soils over siltstones and shales; Ni-Co-Cr levels then remain low.

EXAMPLES OF APPLICATION

The Skerring kimberlite (King George River area, North Kimberley) measures approximately 600m in length and 7 to 75 metres in width as defined by prospect pits and intrudes Proterozoic shale country rock. It is a micaceous peridotite body containing abundant picroilmenite megacrysts, chrome and titanian pyrope and has been likened to classical kimberlite of South African type (Atkinson et al, 1984; Jaques et al, 1986). It is lateritised and silicified at surface and forms a slight topographic ridge. Due to downslope creeping of soil and debris the width as indicated by soil geochemistry is considerably larger than the actual width of the body. The soil geochemical response in order of times background was: Cr 6, Nb more than 4, Ni 4, Co 3, Mg 2. The samples were -80# (180) and taken from a depth of 10-15 cm.

The lamproites of the West Kimberley (Prider, 1960; Jaques et al, 1984) range from basic to ultrabasic in composition, i.e. from leucite lamproite, composed essentially of leucite±phlogopite±diopside±richterite and with modal olivine content typically 5 Wt % and SiO_2 50 Wt %, to marked undersaturated olivine lamproite in which modal olivine is 20% (typically 30%). Whereas some of the leucite lamproites form fresh outcrops at surface and give rise to topographic highs, the olivine lamproites rarely do so, the olivine is frequently altered to talc and the rock rapidly weathers to form montmorillonite-rich clays. The olivine lamproites often form slight topographic depressions. The soil and weathering products are retained inside the depression if no connection to the drainage exists. At Big Spring, 5 lamproite bodies intruded Devonian limestones and Proterozoic granodiorite. The largest body has a surface area of 10 ha. The -80# (180) fraction of grid loam samples was analysed by emission spectroscopy. Anomalous values ranged from:

2 to 11 times background for Ni, average 6 times
2 to 12 times background for Cr, average 5 times

1.5 to 4 times background for Co, average 2.5 times

Niobium was not analysed for. A stream sample collected near a lamproitic breccia outcrop yielded 13, 5 and 7 times background for Ni, Co and Cr. Only 200m downstream and outside of the pipe the values had dropped to 1.7, 1.7 and 1.4 times background.

The Ellendale lamproites in the West Kimberley intrude Devonian and Permian limestones, calcarenites, siltstones and sandstones. They often form depressions, and the geochemical response occurs only immediately over the the diatreme. Values recorded from Ellendale 9 olivine lamproite were:

Soil: Background	Ni	25 ppm	Anomaly :	average 5 times background
	Nb	20 ppm		average 4 times background
Auger Drilling :	Ni	150 ppm	Anomaly :	average 5 times background
	Nb	20 ppm		average 7.5 times background

All auger holes bottomed in weathered ultrabasics or sandstone. The soil geochemistry results show the position of the boundary of the diatreme quite clearly. Values drop from as high as 10 times background to background inside 50m (i.e. 1 sample interval). The soil geochemistry values over the 81 Mile Vent leucite lamproite are virtually identical to those over the Ellendale No. 9 olivine lamproite. Soil geochemistry is effective in areas with overburden to 7m and more. At Ellendale No. 7 olivine lamproite, which is covered by 4 to 8 m (average 7m) of transported aeolian sand, nickel averages 3 times background, cobalt 1.2 times, chromium 4.5 times and niobium twice. The boundary is as sharp as at No. 9, i.e. there appears to be no "mushroom effect". At Ellendale 6 leucite lamproite where aeolian sand overburden averages 14m depth no surface geochemical anomaly could be detected.

At Wandagee in the Carnarvon Basin, breccia diatremes with kimberlitic affinities are associated with olivine picrite sills (Atkinson et al, 1984). The diatremes carry chrome pyrope, chrome diopside, rare picroilmenite macrocrysts, and very rare microdiamond. Juvenile clasts in the diatremes are olivine-rich, sometimes contain phlogopite, but are too altered to determine their full petrographic affinities. Geochemically the diatremes are generally similar to kimberlite, but niobium values are noticeably low. During exploration at Wandagee the -40# size fraction of grid loam samples was analysed by AAS and XRF for Ni, Co, Mg, Cr and Nb. For pipe M89 nickel and magnesium anomalies occur over the pipe and to the west. Chromium is centred on the pipe, niobium and cobalt do not show any correlation with the pipe. Nb anomalies of 2.5 times background occur to the NW and SW of the pipe, Co shows 2 depletion anomalies to the E and W of the pipe.

DISCUSSION

Geochemical analysis of samples of soil and sand overburden over West Australian kimberlitic pipes has shown that anomalous values of ultramafic-association elements and of incompatible elements occur immediately above the pipes. Where the pipes are marked by a topographic hollow at surface, or where the ground is flat, there is little lateral dispersion of the geochemical anomaly and the pipe contacts are sharply defined. Where there is sloping ground the anomaly will extend downslope, but only for distances less than the diameter of the pipe. These results parallel those obtained overseas, e.g. Yakutia (Litinskiy, 1964), Mali (Alcard, 1959), even to the magnitude of the anomalies, i.e. typically some 2 to 7 times background values for Cr, Ni, Co, Nb.

The Western Australian results show that similar geochemical anomalies characterise leucite and olivine lamproite as well as kimberlite. Even where transported sand overburden as thick as 7 metres covers the pipe, a geochemical anomaly can be found at surface. However, the limited lateral dispersion of the soil geochemical anomalies has meant that the method has not been as effective as an exploration method for kimberlite as have heavy mineral indicator or geophysical techniques, although the characteristic geochemical signature helps to identify weathered rock samples from outcrop or borehole spoil.

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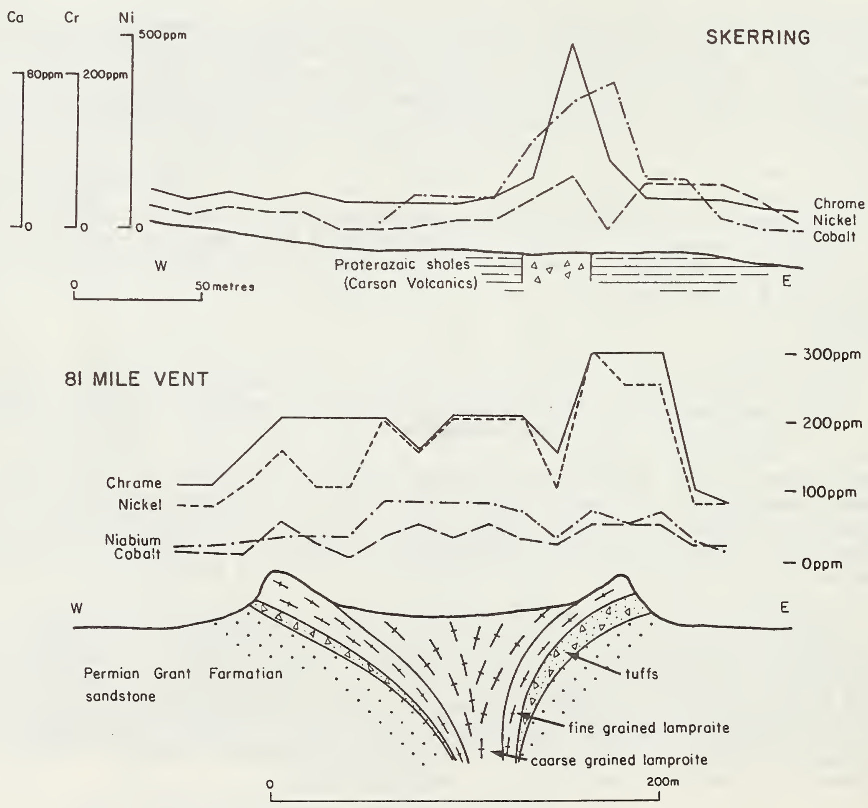

Fig. 1 Cross sections and geochemical profiles for Skerring Pipe and 81 Mile Vent