PROSPECTIVE RELATIONSHIPS BETWEEN DIAMONDS, VOLCANISM AND TECTONISM IN AUSTRALIA

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There are several regional occurrences of diamonds across Australia (Jaques et al. 1984). These include:-

a) an eastern highlands Palaeozoic-orogenic belt, where there was considerable Mesozoic-Cainozoic volcanism.

b) central epicratonic belts, associated with Mesozoic kimberlites and kimberlitic lamprophyres.

c) western-northern cratons, characterised by leucite lamproites and kimberlitic lamproites of several ages (Precambrian-Tertiary).

Other occurrences, mostly detrital, have unproven provenance (e.g. in Tertiary gravels, Nullagine, W.A.; Triassic conglomerates, S.A. and fields strewn across northern Australia).

HOSTS AND SOURCES

Confirmed diamond hosts are diverse and some are unusual. Direct evidence for the eastern hosts is scarce,but diamonds are known from Mesozoic (?)tholeiitic dykes (Copeton) and also appear to be derived from a Tertiary nepheline mugearite intrusion near Walcha (Sutherland et al. 1985). Alluvial 'kimberlitic' zircons (low U, 21ppm) giving early Tertiary-late Cretaceous fission track ages (41-66 Ma) are present in some eastern gemfields (New England, Anakie).

Diamond distribution in eastern Australia can be viewed as a 'background' of low concentrations on which is superimposed some restricted regions of 'anomalous' higher concentrations. Some of the background diamonds may be recycled from Palaeozoic sediments of the Lachlan Fold Belt, as studies show a dominance of northerly current directions in these beds, with possible derivation of large amounts of sediments from Antarctica. If these diamonds came from Antarctica or other adjacent cratons, they should be able to survive to or beyond upper greenschist facies (c.400° C, 2-10kb) typical of this fold belt. However, this model is incapable of accounting for the more concentrated diamond 'anomalies' whose specific features and preservation of detail suggest local sources (Copeton, Bingara, Cudgegong, Beechworth).

The Copeton and Walcha diamonds are unusual in their inclusions (grossular garnet, abundant coesite) and anomalously heavy C isotope compositions (Sobolev 1984 and pers.comm.), in keeping with an orogenic 'subduction' source.

REGIONAL SETTING

The occurrences of Australian diamonds can be examined in relation to intraplate volcanism and tectonism (Sutherland, 1985). Migration patterns appear to characterise much of the late Mesozoic-Cainozoic and possibly late Palaeozoic-early Mesozoic volcanism. This migration offers important clues in targetting potential diamondiferous areas; its features are:-

1) migrations are irregularly spaced in place and time,

2) they seem to originate from rift-spreading zones,

3) episodes within them tend to be localised on structural weaknesses,

4) individually they commonly show an overall decay in volcanic intensity with time,

5) regions of multiple migrations typically record high palaeogeotherms in mantle/lower crustal xenoliths,

6) migrations show variations in parental alkaline magmas which reflect underlying mantle heterogeneity,

7) migrations seems to add metasomatic elements to the mantle,

8) peaks in the migrational activity appear to coincide with periods of maximal regional tension.

Certain combinations of these factors may generate deep undersaturated volatile-rich magmas capable of transporting diamonds from 'diamond windows' (Nickel and Green, 1985) or from 'kimberlitic' material introduced into higher mantle levels. Conditions favouring diamond transport in one region, may be unfavourable in another region at any one time.

PROSPECTIVE CONDITIONS

The rift-spreading hot spot model proposed for much of the late Palaeo- zoic to Cainozoic volcanism in Australia would favour ascent of diamondiferous under-saturated magmas,

a) over small weak hot spots,

b) during initial or dying stages of stronger hot spots,

c) within periods of cooler geotherms between migrations over hot spots,

d) in later migrations, over mantle metasomatised by earlier migrations,

e) in traverses of mantle metasomatised by old events, including subduction.

Hot spot traces, sometimes changing direction, can be traced on the Australian continent for periods of up to 65-150 Ma. These provide a variability of conditions, which could yield some discrete diamondiferous eruptions. Changes in Australia's plate speed over hot spots may also play a role in production of kimberlitic magmas and diamond transport.

Indications are that particular periods in the cratonic areas provide better prospects for economic diamond deposits than in the younger orogenic belts. Certain periods of activity and places that offer more potential for diamond exploration can be suggested. These would avoid peaks of multiple volcanic/ intrusive episodes, which maintain hot geotherms for extended periods (Griffin et al. 1986).

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Figure

Typical geotherm for eastern Australia (Griffin et al. 1986), constructed from P,T data derived from lower crustal-upper mantle xenoliths in regions of multiple basaltic volcanism (35-55 Ma to present). The geotherm is based on garnet granulites (squares) and garnet websterites (dots) and the histograms (boxes) represent T determinations on granulites and spinel lherzolites. The seismic crust-mantle profile (verticle rectangle) is scaled to a depth of 48 km, in equivalence to the pressure scale. The relationships of the hot Australian geotherm to the Lesotho African geotherm and diamond/graphite stability fields is shown in inset.

Note that time-space domain associated with such a geotherm has little potential for diamond transport, but that domains of restricted volcanism interspersed with or outside them have potential.