Primary and related diamond occurrences within a Phanerozoic subduction regime in eastern New South Wales, Australia

Barron, L.M.[1], Lishmund, S.R.[1], Oakes, G.M.[1], and Barron, B.J.[2]

1. New South Wales Department of Mineral Resources, 29-57 Christie Street, St. Leonards, NSW 2065, Australia.
2. Consulting Petrologist, 7 Fairview Avenue, St. Ives, NSW 2075, Australia.

Within eastern New South Wales, exploration companies and prospectors have found small numbers of diamonds (mostly macros) in intrusives at 17 locations (A-R on Table 1), and in fluvial material draining adjacent intrusives at another 7 locations (S-Y), see Figure 1. The intrusions range from Permian to Tertiary age. Macrodiamonds have been recovered from similar intrusives in southern Queensland. High sodium garnet occurs at 7 primary, 2 adjacent and 5 other alluvial diamond localities, confirming that diamond facies rocks have been sampled (McCandless and Gurney, 1989). Alluvial deposits near these primary locations have produced close to two million diamonds, mostly from Tertiary deep leads in the Copeton (near J on Fig. 1)- Bingara (50km west of J) area in the north of the state, with smaller production elsewhere. Current small scale production from mining and exploration indicates >90% gem quality.

Together with diamond occurrences in Victoria and Queensland, these occurrences define an eastern Australia diamond province 3000 km long and up to 800km wide (Sutherland et al., 1994). Most diamond explorers have searched for kimberlite/lamproite or assumed that the alluvial diamonds were derived from an ancient cratonic source. However, the nearest craton is over 1000km to the west, and kimberlite/ lamproite have not been found. A local derivation from a high grade source is indicated by the distinct tribal character of the alluvial diamonds and by their low levels of surface damage (MacNevin, 1977).

The eastern New South Wales tectonic setting is unlike that for conventional diamond deposits, involving a Phanerozoic sequence of accreted subduction terranes, with relatively thin crust, high heat flow and a maximum age of 550Ma for the basement (Scheibner, 1996). The diamonds have unusual features including rounded shapes, extreme durability (Joris 1986), heavy carbon isotopic composition/ calcsilicate mineral inclusions/ low and very high levels of nitrogen (Sobolev 1984; Meyer et al. 1994, 1995), seams, euhedral macro-indentations (Barron et al., 1996), strange markings and fine 'bubble' scars on the surface. Such features are commonly encountered for diamonds from the eastern Australia diamond province.

Barron et al. (1996) proposed that these diamonds formed with increasing pressure in the descending slab within a low temperature window into the diamond stability field during cold Phanerozoic subduction, at half the depth required by conventional models. The diamonds are trapped and preserved at depth by termination of subduction, and brought to the surface by obduction or by entrainment in the post-subduction magmas indicated in Table 1. In New South Wales, the ages of 520, 435, 380, 315, and 254 Ma represent the known major terminations of subduction (Scheibner, 1996), representing potential crystallisation ages of subduction diamonds. Many authors have invoked subduction in the formation of diamond, but mostly the role of subduction is restricted to that of *supply* of carbon, with diamond formation at conventional pressures and temperatures. In contrast, Robinson (1978), Sobolev (1984) and O'Reilly (1989) offer brief suggestions that diamonds can form during actual subduction (depth unspecified) while

Kesson and Ringwood (1989) and Sutherland *et al.* (1994) favour a depth of 170-450 km. These previous subduction diamond models cannot explain the presence of diamond in eastern Australia because their diamond crystallisation depths mean that only kimberlite/lamproite can carry such diamonds to the surface, yet such rocks appear to be absent in eastern NSW.

The subduction diamond model of Barron et al (1996) predicts: diamond ages and geographic distribution relate to New South Wales tectonic provinces (younger age eastwards); diamond types and grades depend on the original source rocks (trench sediments, ocean floor basalt, oceanic lithosphere); micro diamonds will be scarce while solid state growth from graphitic sediments produces close packed unzoned diamonds with growth shapes that include large euhedral indentations; nitrogen aggregation states will be anomalous; alkali basaltic magmas carry diamonds to the surface; the association of certain types of sapphire with diamond in alluvial deposits in eastern Australia (Lishmund & Oakes 1983; Oakes *et al.* 1996). There are implications for diamond exploration within all Phanerozoic terranes that have alluvial diamonds.

Published with the permission of the Director General of the New South Wales Department of Mineral Resources.

References

Barron, L.M., Lishmund, S.R, Oakes, G.M., Barron, B.J., and Sutherland, F.L., 1996, Subduction model for the origin of some diamonds in the Phanerozoic of eastern new South Wales. *In* Sutherland, F. L., ed., Nick Rock Symposium on Alkaline Rocks and Mineralisation, Austral. J. of Earth Sci., v. 43, p. 289-298.

Joris, A., 1986, A Destiny in Diamonds. Boolarong Publications, Brisbane.

Kesson, S.E., and Ringwood, A.E., 1989, Slab-mantle interaction: 2 The formation of diamonds: Chem. Geol., v. 78, p. 97-118.

Lishmund, S.R., and Oakes, G.M,. 1983, Diamonds, sapphires and Cretaceous /Tertiary diatremes in New South Wales: Quart. Notes Geol. Surv. New South Wales, v. 53, p. 23-27.

MacNevin, A.A., 1977, Diamonds in New South Wales: Geol. Surv. New South Wales, Min. Res. 42.

McCandless, T.E., and Gurney, J.J., 1989, Sodium in garnet and potassium in clinopyroxene: criteria for classifying mantle eclogites, *in* Ross, J., ed., Kimberlites and Related Rocks: Volume 2. Their Mantle/Crust Setting, Diamond and Diamond Exploration, Geol. Soc. Austral., Spec. Pub., v. 14, p. 827-832.

Meyer, H.O.A., Milledge, H.J., and Sutherland, F.L., 1994, Unusual diamonds and inclusions from S. E. Australia [abs.]: Geol. Soc. America, Seattle, Abstracts, p. 417.

Meyer, H.O.A., Milledge, H.J., and Sutherland, F.L., 1995, Unusual diamonds and unique inclusions from New South Wales, Australia[abs.]: 6th Int. Kimb. Conf., Nova Sibirsk, Abstracts, p. 379-381.

Oakes, G.M., Barron, L.M., and Lishmund,S.R., 1996, Alkali basalts and associated volcaniclastic rocks as a source of sapphire in Eastern Australia, *in* Sutherland, F. L., ed., Nick Rock Symposium on Alkaline Rocks and Mineralisation, Austral. J. Earth Sci., v. 43, p. 289-298.

O'Reilly, S., 1989, Nature of the east Australian lithosphere, *in* Johnson, R.W., ed., Intraplate Volcanism in Eastern Australia and New Zealand, Cambridge University Press, Cambridge, p.290-297.

Robinson, D.N., 1978,The characteristics of natural diamond and their interpretation: Min. Sci. Eng.,v. 10,p.55-72.

Scheibner, E., 1996, Geology of New South Wales-Synthesis. Volume 1. Structural Framework: Geol. Surv. New South Wales, Mem. 13 (1).

Sobolev, N.V., 1984, Crystalline inclusions in diamonds from New South Wales, Australia, *in* Glover, J.E., and Harris, P.G., eds., Kimberlite Occurrences and Origin: A Basis for Conceptual Models in Exploration, Geol. Dept. Univ. Ext., Univ. Western Australia, Pub. 8, p. 213-226.

Sutherland, F.L., Temby, P., Raynor, L.R., and Hollis, J.D., 1994, A review of the East Australian Diamond Province, *in* Meyer, H.O.A., and Leonardos, O.H., eds., Diamonds: Characterisation Genesis and Exploration,Compahia Pesquisa Recursos Minerais Spec. Pub. 1B/92, Brasilia, p.170-184.

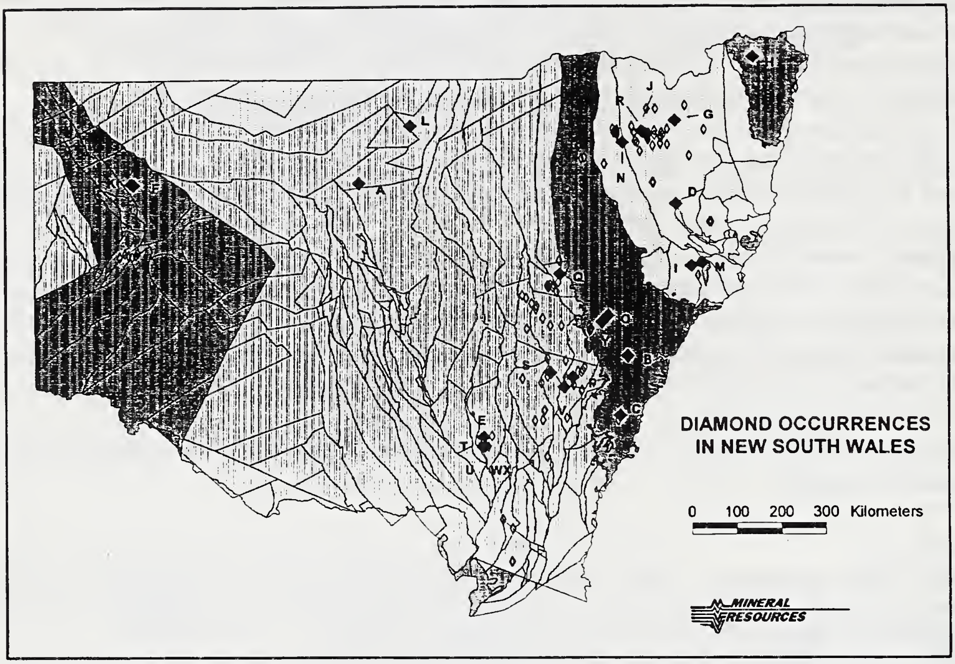

Fig. 1 New South Wales diamond provinces, based on major tectonic units of Scheibner (1996). The solid symbols refer to Table 1; open diamonds mark alluvial occurrences. These localities were found by Australian Selection (Y), CRA (AKLO), Frazer Mining (P), PlatSearch (Q), prospectors (BCDJNR), Selection Trust (G), Stellar(V), and Stockdale (EFHIMSTUWX).

Table 1. New South Wales localities where diamonds occur in intrusives

	Locality * = high sodium garnet	Form	Number Of Stones	Size (m = Micro) (M = Macro)	Confidence (1 Low) (10 High)	Rock Type
A.	Byrock	Lava/Plug	1	m	9	Leucitite
B.	Diamond Hill	Diatreme	1	m	1	Alkali Basalt
C.	Diggers Creek	Diatreme	Several	M	8	Alkali Basalt
D.	Goodwins (Walcha)	Plug/Diatreme	Several	M	8	Nephelinite
E.	Jugiong*	Diatreme	Several	M	8	Nephelinite
F.	Kayrunnera*	Diatreme	1 or >1	unknown	8	Basanite
G.	Kings Plains*	Volcaniclastic	Several	m	5	Basalitc Tuff
H.	Mt Brown*	Diatreme/Plug	1	m	9	Basanite
I.	Oaky - Watsons Ck	Diatremes	1	M	5	Alkali Basalt
J.	Oaky Creek (Pikes)	Dyke	Several	M	10	Teschenite
K.	P2 (Kayrunnera)	Diatreme/Plug	2	M	10	Basanite (?)
L.	Penarie*	Diatreme	3	M	10	Nephelinite
M.	Prince Charlie Ck	Diatreme	1	m	10	Basanite
N.	Ruby Hill*	Diatreme	Several	M	5	Basanite
O.	The Ovens*	Diatreme	1	m	8	Basanite
P.	Vulcan	Regolith	Several	M	6	Unknown
Q.	Winona	Diatreme	1	M	1	Alkali Basalt
R.	Wonderland	Volcaniclastics	>1	M	6	Basaltic Tuff
S.	Carrawa	Fluvial	1	m	10	Basanite
T.	Gobarralong 1	Fluvial	Several	M	10	Alkali Basalt
U.	Gobarralong 2	Fluvial	1	m	8	Minette
V.	Isabella Bridge*	Fluvial	1	M	10	Basanite
W.	Red Hill 2	Fluvial	1	m	8	Unknown
X.	Red Hill Creek	Fluvial	1	m	8	Unknown
Y.	Umbiella*	Fluvial	1	M	10	Basanite