matildite in arsenopyrite, which goes into the tailings.

The occurrence of both canfieldite and Te-bearing canfieldite, as well as the fact that the silver minerals reported by d'Orey (1967) from Vale da Ermida were not confirmed to be present in the ores of level 2 at Barroca Grande, indicate that conditions during the sulphide stage of mineral formation were not uniform in the different parts of the deposit.

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Diamonds from nepheline mugearite? A discussion of 'Garnet websterites and associated ultramafic inclusions from a nepheline mugearite in the Walcha area, New South Wales, Australia'

STOLZ (1984) gives a thorough description of xenoliths in this dyke and discusses their likely origins and pressure-temperature (*PT*) equilibration regimes. He also comments on the megacrysts and host rock. This site is also being investigated by the present authors and has additional features to which Stolz's study can be related.

Diamond association. Most significantly, diamonds are present at this site. This association of diamonds with basaltic volcanism, in a region generally lacking 'classical' kimberlites, is an enigmatic feature of eastern Australia (Hollis *et al.*, 1983; Jacques *et al.*, 1984). Diamonds in the Copeton area, 150 km NNW of Walcha, occur in sub-basaltic gravels and are also recorded from a dolerite dyke (MacNevin, 1977). Copeton diamonds show unusual features (exceptional 'hardness', a new 'grospyte' mineral inclusion suite and an abnormal heavy isotopic composition of carbon; Sobolev, 1984). The Brickclay Creek diamonds include pale yellow dodecahedra up to one carat weight and a stone has been submitted to Dr N. K. Sobolev, Institute of Geology and Geophysics, Novosibirsk, USSR for detailed comparison with the Copeton stones.

Seventeen diamonds were found on the southern end of the basaltic dyke by Mr G. Goodwin, the lease holder of the Brickclay Creek prospect. Here the dyke intrudes Palaeozoic basement phyllites to intersect deep lead sediments of the ancestral McDonald River. The coarse clastic sediments contain alluvial gold and are probably early Tertiary in age. Bulk testing of the dyke and adjacent deep lead sediments did not reveal further diamonds. The dyke is younger than the sediments and hence did not form a bedrock trap in the deep lead. A thin breccia intrudes basement close to, and merges with, the dyke along the diamondiferous zone. The breccia appears to pre-date the dyke.

The absence of proven diamonds in the deep lead sediments and dyke and the close confinement of the diamonds to the intrusive zone makes the breccia a suspect source for the stones.

The mantle sample. The Brickclay Creek xenoliths record mantle pressures and temperatures around 14-16 kbar and 1000-1050 °C (Ellis and Green, and Harley and Green methods; Stolz, 1984). Thus, this mantle sample records a relatively 'hot' palaeogeotherm, considered typical of the eastern Australian continental margin since the Palaeozoic (Griffin *et al.*, 1984). This mantle sample does not intersect the likely diamond stability zone in eastern Australia (Ferguson *et al.*, 1979; Sutherland *et al.*, 1984), but the anomalous hot part of the geotherm may reflect volcanism and hence may not persist to depths of diamond stability (O'Reilly, 1984).

The dyke (and inclusion palaeogeotherm) is dated at 35.5 Ma, using K-Ar dating on an anorthoclase megacryst (F. L. Sutherland, unpubl. data). There is no evidence available to link the diamonds to the presence of earlier kimberlitic intrusion (Lishmund and Oakes, 1983), when cooler geotherms and hence diamonds stable to shallower levels may have prevailed. To explain the apparent association between diamonds, higher level mantle suites and basalt, Hollis *et al.* (1983) invoked sudden mantle degassing. In this model, fracturing above a rising diapir of magma releases a surge of deeper material and initiates a volatile-charged explosive eruption. The presence of breccia, partly intruded by the Brickclay Creek dyke fits this model, but requires further examination.

Though incorporating fragments of altered country rock, the breccia also contains vesicular basalt and mineral inclusions (Cr-diopside, apatite, zircon, and opaque oxides) similar to those found in the dyke. The basalt fragments contain small pieces of sediment and closely resemble material observed in maar eruptives in the young basalt field of western Victoria. This suggests a volatile enriched phase of the basalt magma and that degassing occurred at an advanced stage during its fractionation in the mantle.

Host fractionation. The host dyke structure extends north beyond the present exposures (magnetometer survey, R. E. Pogson, unpubl. data). Some lateral lobate bodies show accumulations of lherzolite xenoliths which may comprise up to 90 % of the rock and indicate significant settling of these dense xenoliths. This abundance suggest rapid initial transport and a highly fractionated host magma before xenolith entrainment.

Small discontinuities and variation in petrology and chemistry along the dyke may indicate the presence of several separate magma pulses. Material from the north end (authors' unpublished data) differs from that described by Stolz (1984) in lacking sodic plagioclase in the nepheline-rich groundmass, in having lower CO_2/H_2O and in showing a significant depletion in Ba (984 cf. 1313 ppm). Ba can be depleted by biotite crystallization in evolved basalt magmas (Irving and Frey, 1984) and the rock is transitional towards nepheline benmoreite. Sparse titan-biotite megacrysts (100 $Mg/(Mg+\Sigma Fe) = 33$; TiO_2 5.3 %) are found in the more southern parts of the dyke. Apatite and zircon are also megacrysts found in the biotite-bearing rock, these phases typically crystallizing in evolved end members of basaltic lineages (Irving and Frey, 1984).

Anorthoclase is an abundant megacryst in parts of the Brickclay Creek dyke and one specimen includes apatite. Its role in fractionation was considered unlikely by Stolz (1984), as it is not a near-liquidus phase in most experimental runs on natural basaltic compositions above 10 kbar. However, Arculus *et al.* (1977), found it up to 15 kbar in the presence of CO_2 in the basaltic-basanitic system. Thus, anorthoclase is a potential crystallization product in magmas within the pressure range indicated by the Brickclay Creek xenoliths.

The high Na_2O/K_2O (3.6) of the Brickclay Creek host rocks can be explained by extraction of biotite (9 % K_2O) from a parental magma with a lower Na_2O/K_2O ratio. Later crystallization of anorthoclase (Na_2O/K_2O 3.7) would leave the modified Na_2O/K_2O ratio relatively unchanged. Mantle-fractionated sodic nepheline mugearite and benmoreites of Brickclay Creek compositions contrast with K-rich examples from the Tasmanian Province which generally lack such megacrysts (Sutherland *et al.*, 1984). They also contrast with

K-rich nepheline mugearites and benmoreites in eastern Australia that contain anorthoclase megacrysts, but also carry kaersutite as a probable fractionating phase (Green *et al.*, 1974; Sutherland, 1980).

Kaersutite is recorded at Brickclay Creek with TiO_2 4.8 % (Stolz, 1984). This suggests its possible crystallization around 14–17 kbar based on the geobarometer of Oba *et al.* (1982) as used by Hollis *et al.* (1983). However, its rarity suggests it was not significant in mantle fractionation of the nepheline mugearite.

Mantle involvement. Stolz (1984) divided Brickclay Creek xenoliths into Group I and II types representing Cr and Ti–Al enriched series in the classification of Wilshire and Shervais (1975). The spinel–amphibole websterites were included with Group II, but are transitional between the two extremes and indicate hydrous crystallization in the mantle assemblage. Secondary veining by hydrous minerals was also noted in pyroxenites (pargasite and phlogopite, Stolz, 1984) and we have identified vermiculite (altered phlogopite) in lherzolite xenoliths.

Such hydrous phases in mantle sources would introduce greater variations of incompatible elements into primary basanitic melts (Wass, 1980) and significant melting of phlogopite would give lower Na_2O/K_2O before fractionation to nepheline mugearite. Higher Mg, Ni, Cr, and H_2O^+, coupled with some enrichment of Zr, Y, Sr, Rb, La, and Ce, of the northern dyke rock (authors' unpublished data) compared to Stolz's analyses (Table I) suggests a greater proportion of hydrous mineral phases contributed to that melt.

The primary basanitic magmas presumably evolved by crystallizing subcalcic augite and spinel as they ascended from pressure regimes exceeding 13–20 kbar (Stolz, 1984). Olivine probably participated at some stage in the mantle fractionation as we have identified grains of composition Fo_{84}, in the coarse heavy mineral concentrates of the dyke rock, lying between mantle xenolith Fo_{87-91} and host rock (Fo_{76-63}) olivine compositions.

Regional setting. The Brickclay Creek intrusion lies within the older sequence of the Walcha Province (largely Palaeocene–Eocene, 58–45 Ma; Wellman and McDougall, 1974), and is early Oligocene age (36 Ma). Such remnants of lherzolite-bearing, fractionated undersaturated basalts also disconformably overlie the older sequence nearby, north at Ruby Hills and above Congi Creek.

The megacryst suites of these later magmas can be compared with the suite described from a mantle-derived hawaiite near the base of the older flow sequence at Ruby Hills (Binns *et al.*, 1970). The latter contains abundant to common clinopyroxene and orthopyroxene, and sparse to rare spinel and anorthoclase. Their compositions can be extrapolated back to a hypothetical parent magma of transitional, mildly alkaline (Hy-normative) basaltic affinities. This suggests partial melting of the mantle source rock to at least 11 % during the main formation of the Province (cf. similar Walcha and Mt. Widderin, Victoria parent basalts: Binns *et al.*, 1970; Frey *et al.*, 1978). It compares with 6–7 % partial melting in the mantle source for more undersaturated compositions of the later Brickclay Creek dyke episodes.

Thus the Brickclay Creek xenolith suite is mantle affected by a cycle of melting which produced a range of basalt compositions. The detailed mineralogical and chemical characteristics of this mantle may be significant with respect to the proposed alkali basalt/diamond association (Hollis *et al.*, 1983).

Significance. Brickclay Creek is similar to other examples in Eastern Australia where rare deeper mantle material or diamonds occur with fractionated, volatile-bearing, basaltic eruptions (Bow Hill garnet lherzolite occurrence, Sutherland *et al.*, 1984; Proston breccia pipes, Hollis *et al.*, 1983; A. D. Robertson, F. L. Sutherland, and J. D. Hollis, unpublished data).

The Bow Hill K-rich nepheline hawaiite is of particular interest, being much less fractionated than Brickclay Creek and Proston nepheline mugearites (M 61 cf. 44), but having comparable *LREE* enrichment (La 105, Ce 191 cf. La 99–117 ppm, Ce 183–208 ppm: F. L. Sutherland, unpubl. data; Stolz, 1984). Its *LREE* enrichment also exceeds those of the Kiama basanite–nepheline hawaiite

TABLE I. *Comparison of chemical analyses, Brickclay Creek Dyke*

Analysis	MgO wt. %	H_2O^+ wt. %	Ni ppm	Cr ppm	Zr ppm	Y ppm	Sr ppm	Rb ppm	La ppm	Ce ppm
N. end, authors' analysis	5.8	5.0	156	218	448	31	2068	41	141	242
Centre of dyke; Stolz, 1984	4.3	2.2	131	178	326	22	1954	29	117	208

dyke (La 62–76 ppm, Ce 144–165 ppm, Wass and Rogers, 1980), which isotopically resembles lherzolitic mantle modified by 'kimberlitic' metasomatism (Menzies and Wass, 1983). The *LREE* are much higher than for K-rich nepheline hawaiite of comparable major element chemistry in the Victorian basalts (Mt. Leura, M 63, La 53, and Ce 108 ppm; Frey *et al.*, 1978).

Clearly, more comprehensive comparisons are needed to resolve the respective roles of mantle metasomatism, melting, fractionation, and degassing in entrainment of high-pressure inclusions in eastern Australia basalts. Detailed description of the Brickclay Creek site is in preparation.

The association of diamonds with non-kimberlitic rocks such as alkali basalts and ultrabasic intrusions is reaffirmed from world-wide examples (Kaminski, 1980). Brickclay Creek is another example. Apart from mantle magmatic degassing to explain this association, possible alternatives include: (*a*) entrainment of diamonds from older, higher level ultrabasic intrusions (these are mapped in the general area; Tamworth): 250 000 Sheet, Geological Survey of New South Wales; (*b*) entrainment of diamonds, previously introduced into the spinel lherzolite mantle zone with 'metasomatic kimberlitic' melts and fluids such as described from Kiama (Wass and Rogers, 1980).

Both these require diamond stability preserved at lower *PT* than needed in the mantle degassing model.

If the diamonds are fortuitously derived only from the deep lead gravels immediately along the narrow dyke zone, they could come from erosion of early kimberlites, as yet unseen. A final solution to the perplexing origin of eastern Australian diamonds awaits further investigations.

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