ECLOGITE INCLUSION FROM THE CAPE PATERSON VOLCANIC NECK IN SOUTH GIPPSLAND, VICTORIA

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Abstract

True eclogite rocks are scarce in Victoria, being known only as occasional fragments that have been carried up to the surface by Tertiary volcanic eruption. The example recorded is of interest because of its simple mineral composition—garnet and omphacite, because of the fresh state of preservation of these primary constituents, and because of the occurrence of *almandine* spinel in the occasional, narrow kelyphitic zones bordering some of the garnet crystals.

Introduction

Eclogitic rocks have been recorded from many localities in other parts of the world, but detailed descriptions of them are few in number. Only rare occurrences of eclogite occur in Australia, and these are present as inclusions in volcanic necks or pipes. Those on record come principally from New South Wales; one or two have been referred to in Victoria.

E. F. Pittman (11) described volcanic breccia from Ruby Hill, Bingera in N.S.W., as consisting chiefly of angular fragments with occasional rounded pebbles of various rocks, included among which was eclogite. He also recorded lumps of eclogite from the supposed diamond-bearing volcanic pipe at Snodgrass, near Delegate in N.S.W., in material which has the characters of a volcanic breccia. Eclogite inclusions from elsewhere in New South Wales were recorded from Bundundah, from ten miles east of Warialda, from 3 miles north of Allyn Brook, and from four and a half miles north of Kandie Peak (12).

G. W. Card (3) described the eclogite from Ruby Hill, Bingera, as being abundant in pieces of all sizes and as being readily recognised by its constituent garnet and pyroxene. Card (4) also placed on record the occurrence of eclogite from Mullimbibby, N.S.W.

H. J. Grayson and D. J. Mahony (9) described an ejected block of pyroxenite from the Western District of Victoria as consisting of dark green pyroxene and pale pink garnets. They regarded this rock as being allied to eclogite. An additional occurrence of eclogite in Victoria occurs among the collection of rocks at the Victorian Mines Department Geological Museum. This rock (section no. 2234 and sample no. 7593 in the Mines Dept. Collection) is referred to as eclogite, labelled as coming from Benambra, and said to be from a pipe on the Snowy River in the Benambra District. It is described as a coarse-grained mixture of pyroxene, amphibole and garnet. Another example in this collection (section no. 690) is labelled "Basic Concretion?" from the Old Landing Place, Cape Paterson. It is a rock type comparable with the eclogites, consisting of greenish-brown garnet, pyroxene and an indeterminate, brownish coloured alteration product. It is one of the "basic concretions" referred to by A. E. Kitson (10) in his work on the Volcanic Necks from South Gippsland.

The eclogite from the volcanic neck at Cape Paterson, South Gippsland, is apparently the first record of true eclogite from such a source in Victoria. Only one small specimen, weighing approximately 10 grams before sectioning, was found at Cape Paterson. It was collected by Mr. C. Norris, Chief Surveyor at the State Coal Mine, Wonthaggi. The volcanic neck from which the eclogite specimen was obtained, has been described in some detail by A. E. Kitson (10), W. F. Ferguson (7) and A. B. Edwards (6).

The neck is a pear-shaped outcrop of $\frac{3}{4}$ acre in extent that intrudes Jurassic sediments. Kitson (10) referred to pebbles contained in the neck as having the same general shape as those in the adjacent Jurassic rocks, and as being broken in a similar way. Ferguson (7) showed, on a plan of the neck (7, plate VI), the positions of coarse agglomerate and tuff, dense basalt, sandstone, mudstone, masses of olivine, indurated shale and ferruginous veins. Edwards stated (6) that the greater part of the plug was occupied by a dense, blue-black tuff composed of fragments of basic igneous rock. Inclusions of Jurassic rock were recorded as numerous. A dunite xenolith in roughly columnar monchiquite found in parts of the neck, was noted as consisting almost entirely of olivine and picotite.

Description of the Cape Paterson Eclogite

Prior to sectioning, the specimen was a small, rounded nodular sample with an irregular surface. It is a fresh basic rock having a green coloured base of omphacite, and is studded with pink to deep reddish coloured grains of garnet. Chemical work on eclogites from other localities where samples were abundant enough for analytical purposes, has shown that they have compositions like basic igneous rocks or basic derivatives of magmas, mainly gabbros. Some have chemical affinities with peridotites and pyroxenites (2).

The chief interest in the Victorian specimen centres around the fact that it is a true eclogite of simple mineral composition, conforming with A. R. Alderman's statement (1) that the term "eclogite" should be used to denote a rock consisting essentially of omphacite and garnet, the garnet having the almandite and pyrope molecules generally dominant, in agreement with Haüy's original definition.

Examples of eclogite from other parts of the world, contain in addition such primary minerals as cyanite, hornblende, glaucophane, various kinds of mica, epidote, zoisite, olivine, clinozoisite and rhombic pyroxene; also accessory quartz, rutile, ilmenite, apatite and pyrrhotite. Perhaps these are not seen in the Cape Paterson eclogite, because of the small amount of rock available, which may not therefore be entirely representative of the eclogite as it occurs in depth.

The rock has a granular texture, is medium grained and tends to be inequigranular with a few of the grains of garnet ranging up to 7 mm. across, and so forming occasional porphyritic individuals. The specific gravity of the rock is 3.31.

The essential minerals, consisting of primary pink garnet belonging to the almandite—pyrope group, and green augite of the variety known as omphacite, are of xenoblastic habit, the garnets being granular and rarely showing crystal faces. Numerous irregular cracks traverse the grains of the garnet (Fig. 1). The omphacite, which is bright green in the hand specimen, is colourless to pale green in thin section, with occasional well-marked cleavages, extinction angles up to 41°, R.I. = 1.675, 2V variable from 60° to 80°, and optically positive. It shows an occasional tendency towards the development of crystal faces and is mainly of smaller grain size than the garnet. Some of the omphacite grains measure as much as 4 mm. in length.

The only accessory mineral present is the violet coloured variety of spinel known as *almandine* ($MgO.Al_2O_3$). It occurs as small, irregular crystals, seldom displaying crystal faces and commonly appearing in the nature of angular fragments. Spinel is apparently a rare mineral in eclogites; G. W. Card refers to a yellowish-brown spinel with a broad black margin, a variety which he determined as pleonaste, in the eclogite from Ruby Hill, Bingera. Apart from this, the author has seen no other record of the occurrence of spinel in eclogites.

Secondary minerals are uncommon in the eclogite from Cape Paterson, principally because of the freshness of the rock. Narrow, brownish-green, kelyphitic reaction borders, as in the Mullimbibby (4) and Ruby Hill (3) eclogites from New South Wales, and other extra-Australian examples (1 and 2), occur in places around several of the garnet grains, and appear to consist of fibrous hornblende with a very small amount of basic plagioclase and occasional grains of diopside; these constituent minerals in the kelyphitic borders, are of microscopic dimensions.

The violet coloured, microscopically small spinel grains are mainly confined to the outer portions of the alteration zones (Fig. 1), but a few occur enclosed in the omphacite; even in the omphacite, however, they are always very close to the reaction borders of the garnets.

The association of spinel with the reaction zones in this rock, suggests development by the same process which formed the kelyphitic zones. MgO would be available from the pyrope molecule in the garnet, while sufficient Al_2O_3 would be available from both the almandite and pyrope molecules. The FeO present would go to form the small amounts of hornblende in the kelyphitic borders. Lime for the production of minute amounts of the basic feldspar would be derived partly from the garnet

FIG. 1. Sketch of micro-section of eclogite (×9) showing garnet with kelyphitic reaction zones. Opaque areas represent *almandine spinel* in the outer regions of the reaction borders. Omphacite forms the groundmass.

and partly from the omphacite, as the garnet constituent of eclogites is usually, to use Fermor's terminology (8), "a calc-pyralmandite variety with 70% to 86% of pyrope and almandite, the remainder being lime garnet."

J. A. Dunn (5) has also described the development of occasional examples of spinel within and close to garnet, by reaction in a garnet-cordierite gneiss from Mogok in India. Dunn pictured the garnet as supplying some of the constituents for the reaction, and he regarded garnet molecules as diffusing through, or being carried by, cordierite to sillimanite where reaction produced a secondary intergrowth of spinel and cordierite. According to Dunn, the presence of cordierite was necessary before the action could take place, but in the reaction zones of the garnet in the eclogite from Cape Paterson, there is no evidence that either cordierite or sillimanite played any part in the reaction which produced spinel.

The occurrence of the kelyphitic rims of plagioclase and hornblende around garnets, is regarded by Alderman (2) as developing at quite an early stage in the retrograde changes undergone by eclogites. The dark rings thus formed around the garnet are attributed to reaction between iron-rich garnet and omphacite (1). The changes in the Cape Paterson eclogite seem to represent an even earlier stage of alteration, as some of the garnets are entirely unaffected, while those with the alteration rims only have incomplete kelyphitic borders; in addition, the omphacite is entirely unaffected, being quite fresh and clear. Nevertheless, the evidence, however slight, exists to show that retrogressive mineral change had begun.

The small inclusion of eclogite from the Cape Paterson volcanic neck, is not necessarily co-magmatic with the basaltic material of the volcanic neck. It was most probably derived from a deep-seated source of consolidated basic rock, and was torn off from the walls of the vent up which the basaltic lava rose; it was carried up to the surface among other types of country rock gathered up during the ascent of the lava. At the surface, the eclogite has become subject to minor amounts of retrogressive mineral changes, consequent upon the eclogite-minerals becoming unstable on arriving in regions of lower temperature and lower pressure, where they are out of harmony with the changed physical conditions. The minerals retained their original form by virtue of the rapid process, i.e. volcanic eruption and explosion, by which they were carried up from regions of high temperature and high pressure.

References

1. Alderman, A. R., Eclogites in the neighbourhood of Glenelg, Inverness-shire: *Quart. Journ. Geol. Soc.*, **92**, 488–530 (1936).
2. Alderman, A. R., Eclogites: A review. *Igneous Rocks Research Committee, A.N.Z.A.A.S.*, April (**1940**).
3. Card, G. W., An eclogite-bearing breccia from the Bingera diamond field: *Rec. Geol. Surv., N.S.W.*, **7**, part 2, 29–39 (1902).
4. Card, G. W., Mineralogical and petrological notes, No. 9: *Rec. Geol. Surv., N.S.W.*, **8**, 153 (1905).
5. Dunn, J. A., Reaction minerals in a garnet-cordierite gneiss from Mogok: *Rec. Geol. Surv. India*, **65**, part 4, 445–456 (1932).
6. Edwards, A. B., Tertiary dykes and volcanic necks of South Gippsland, Victoria: *Proc. Roy. Soc. Vic.*, **47** (1), n.s., 112–132 (1934).
7. Ferguson, W. H., Report on the Lower Powlett, Cape Paterson and Inverloch Quarter Sheets: *Mem. Geol. Surv. Vic.*, no. **8** (1909).
8. Fermor, L. L., Garnets and their rôle in nature: *Ind. Assoc. Cult. Sci., Special Publication*, **6** (1938).
9. Grayson, H. J., and Mahony, D. J., The geology of the Camperdown and Mt. Elephant Districts: *Mem. Geol. Surv. Vic.*, **9**, 19 (1910).
10. Kitson, A. E., Volcanic necks at Anderson's Inlet, South Gippsland, Victoria: *Proc. Roy. Soc. Vic.*, **16** (1), n.s., 154–176 (1903).
11. Pittman, E. F., *The Mineral Resources of New South Wales*, 392–395 (**1901**).
12. Pittman, E. F., Annual Report, *Dept. of Mines. N.S.W.*, 178 (**1909**).