The occurrence of eclogite on the Lyell Highway, Tasmania

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[Read 24 January 1963]

Summary. Eclogite occurring about 20 miles east of Queenstown, Tasmania, is the first example of this kind of rock to be described in detail from Australia. It has the chemical composition of a basic igneous rock and consists of garnet ($Al_{15\cdot8}Fe'''_{0\cdot6}Fe''_{10\cdot0}Mg_{7\cdot3}Ca_{5\cdot7}Si_{24}O_{96}$) and pyroxene ($Ca_{4\cdot5}Na_{2\cdot5}Mg_{3\cdot7}Fe''_{0\cdot7}Fe'''_{0\cdot4}Ti_{0\cdot1}Al^{vi}_{3\cdot7}Al^{iv}_{0\cdot7}Si_{15\cdot3}O_{48}$) with amphibole, muscovite, zoisite, quartz, rutile, and pyrite. The eclogite consists of lenticular bodies within Precambrian garnetiferous schists.

A ROCK from the West Coast of Tasmania previously referred to as pyroxene amphibolite (Spry, 1957) is shown to be an eclogite. Eclogites are particularly rare in Australia, having only previously been found as fragments in volcanic breccia in vents in New South Wales and Victoria (Card, 1902; Pittman, 1901, pp. 392–395; 1910, p. 178; Baker, 1945, p. 505). The Bingara eclogite (Card, 1902) is suspect as it contains plagioclase, the soda content of the pyroxene is only 1·19 %, and the garnet contains 4 % of MnO. There is no chemical evidence to support the other occurrences.

The eclogite from the Lyell Highway is coarse grained and massive and consists chiefly of red garnet and green pyroxene. It has the chemical composition of a basic igneous rock and the specific gravity of various specimens ranges from 3·19 to 3·39. It lies among Precambrian schists.

Eclogite has been found at two localities (Spry, 1957, pp. 99–101): in a quarry on the Lyell Highway, 21½ miles from Queenstown; and on a small knoll on the northern side of the Mary Creek Plains.

The field relations at both localities are uncertain because of poor outcrop. The Lyell Highway occurrence appears to be a lens about 30 ft wide and at least 100 ft long enclosed in steeply dipping schists and quartzites. The schists are coarse grained and consist mainly of quartz, muscovite, almandine, albite, and biotite with accessory rutile, tourmaline, and apatite. Kyanite occurs rarely but the rocks are placed in the quartz–albite–epidote–almandine subfacies of the Greenschist Facies of Fyfe, Turner, and Verhoogen (1958) because of the presence of ubiquitous albite.

Normal amphibolites, which are common in these schists, are composed of garnet, actinolite, albite, biotite, epidote, zoisite, and quartz. The chemical analysis (table I) of a typical specimen from the Raglan Range (2 miles away) is generally similar to that of the eclogite from the Lyell Highway and to normal basic igneous rocks. The norm of the Lyell Highway eclogite is: qu 1·9, or 6·6, ab 9·7, an 37·5, di 9·4, hyp 31·7, mt 1·6, il 1·1, ap 0·1 %.

TABLE I. Chemical analyses of eclogite and amphibolite, and of garnet and pyroxene from the eclogite

	1	2	3	4
SiO_2	50·92	44·78	39·00	53·21
Al_2O_3	16·83	13·44	21·57	12·86
Fe_2O_3	1·11	2·41	1·18	1·76
FeO	9·78	16·22	19·15	2·79
MgO	7·99	7·01	7·88	8·59
CaO	9·87	9·12	8·86	14·69
Na_2O	1·15	1·65	0·33	4·51
K_2O	1·12	0·47	0·10	0·23
H_2O^+	0·96	1·58	0·57	0·11
H_2O^-	0·14	0·07	0·08	0·25
TiO_2	0·60	2·81	0·26	0·54
MnO	0·18	0·36	0·43	0·03
P_2O_5	0·02	0·40	0·15	0·06
Sum	100·67	100·32	99·56	99·63

1. Eclogite, Lyell Highway. Anal.: W. St. C. Manson.
2. Amphibolite, Lyell Highway. Anal.: W. St. C. Manson.
3. Garnet from eclogite, Lyell Highway. Anal.: H. Asari.
4. Pyroxene from eclogite, Lyell Highway. Anal.: H. Asari.

The *garnet* is an almandine–pyrope with a considerable proportion of grossular, Al_{54} Py_{26} Gr_{20}: ($Al_{15\cdot8}$ $Fe'''_{0\cdot6}$ $Fe''_{10\cdot0}$ $Mg_{7\cdot3}$ $Ca_{5\cdot7}$ $Si_{24}O_{96}$). It is red in hand specimen and pale pink in thin section. It is commonly idioblastic with rhombic dodecahedra developed and contains inclusions of quartz and iron ores. Sp. gr. 3·569, *n* 1·765±0·001, *a* 11·51 Å.

An estimate of the chemical composition from the refractive index and cell size following Skinner (1956) and Fleischer (1937) suggests Al_{45} Py_{45} Gr_{10}, but this differs considerably from the composition indicated by the analysis. The composition is remarkably similar to that of a garnet in a rock from Ghana that may have been formed under somewhat similar metamorphic conditions (von Knorring and Kennedy, 1958).

The *pyroxene* is apple green in hand specimen and colourless to faintly green in thin section. It has the usual prismatic cleavages and an irregular (001) parting. α 1·664±0·001, β 1·670, γ 1·685, γ–α 0·021; $2V_{\gamma}$ 66° and γ:[001] 35°. Sp. gr. 3·401.

The chemical analysis in table I shows that it is omphacite with more than 30 % of the jadeite molecule: $(Ca_{4\cdot5}Na_{2\cdot5})$ $(Mg_{3\cdot7}Fe''_{\cdot7}Fe'''_{0\cdot4}Ti_{0\cdot1}Al_{3\cdot7})$ $(Al_{0\cdot7}Si_{15\cdot3})O_{48}$. Soda (4·51 %) is higher than in normal pyroxenes, which do not exceed about 0·7 % (Hess, 1949; Muir and Tilley, 1958), and is higher than in the omphacite of Alderman (1936) or of Yoder and Tilley (1958). Alumina is very high (12·86 %), although this is characteristic of omphacite.

The *amphibole* is dark green in hand specimen but in thin section is pleochroic with α colourless, β light green, and γ light greenish-brown. The mineral has $2V_{\alpha}$80°, γ:[001] 20° and sp. gr. 3·168. The highest interference colours are second order blues. It is probably a hastingsitic type.

Muscovite. Mica is abundant in some specimens. It is white in hand specimen and colourless in thin section. Refractive indices are α 1·563 (±0·001), β 1·596, γ 1·600, γ–α 0·037. A partial analysis by Dr. J. R. Richards gave 7·20 % K_2O on a bulk sample, but values of $2V_{\alpha}$ ranged from 4° to 44°, with most values at 34°. The X-ray pattern resembles that of muscovite, but the exact nature of the mica is not clear.

Petrology

The rocks are medium grained, massive, and granular. Slight segregation produces weak colour-banding and parallel flakes of mica and prisms of pyroxene and amphibole give the rock a weak preferred orientation. Thin sections show that the bands differ in grain size and mineral constituents. The bulk of the rock is of eclogite with garnet 38 % (by volume), pyroxene 25 %, muscovite 18 %, amphibole 10 %, quartz 6 %, zoisite 0 to 3 %, and accessory rutile. The finer-grained bands contain much more quartz (up to 38 %) and zoisite (up to 13 %), with garnet 21 %, pyroxene 14 %, amphibole 9 %, muscovite 3 %, and pyrite up to 2 %.

Garnet forms idioblastic porphyroblasts up to 1 mm across, with scattered large (2·5 mm) poikiloblastic amphiboles, ragged flakes of muscovite, and smaller pyroxenes in an even-grained mosaic of pyroxene, muscovite, zoisite, and interstitial quartz with an average diameter of about 0·4 mm.

There is no evidence that the large amphiboles are not in equilibrium with the other minerals. Some interfaces between quartz and muscovite have a thin reaction rim of spongy brown biotite and some pyroxene has a rim of fibrous brown amphibole. This alteration is most strongly developed along parallel, widely spaced fractures through the rock.

Conclusions

The high density, mineralogy, and chemical composition indicate that the rock can be included in the eclogites. The presence of hydrous minerals such as amphibole, muscovite, and zoisite suggests that it may be related to a group of rocks said to be transitional between the eclogite and the amphibolite facies but the validity of this transition group is questionable and criteria are lacking to make a distinction. The garnet is identical with one from a garnet–hornblende–scapolite gneiss from Ghana (von Knorring and Kennedy, 1958), which was considered to belong to this transitional group. A garnet–hornblende–pyroxene rock from Glenelg, Inverness-shire, (O'Hara, 1961) is possibly also related.

Most of O'Hara's conclusions about the mineralogy of rocks in the eclogite facies are supported by this study: the garnet has a higher iron to magnesium ratio than the pyroxene; the garnet in this orthopyroxene-free assemblage is high in lime; and amphibole appears to be a primary stable mineral. The presence of amphibole, muscovite, and zoisite suggests that metamorphism took place under a small but real partial pressure of water.

The analyses show that the Lyell Highway eclogite has the chemical characteristics of a basic igneous rock and is generally similar in composition to the nearby amphibolite, which is the common form for metamorphosed basic rocks in the schists of this region. The difference in mineralogy suggests that the eclogite is out of place in its present environment and might be a tectonic inclusion brought up from considerable depths. The eastern side of the eclogite is exposed in the quarry; the contact is sharp and the foliation in the schists wraps around the lenticular body. The enclosing schists, quartzites, and amphibolites contain a number of foliations, and other evidence attests to multiple stage deformation during metamorphism, but the eclogite is massive and granular with a weak banding and its texture is different from that of any of the enclosing rocks. The potash content of the eclogite is higher than that of the neighbouring amphibolite and also of other eclogites, suggesting some accession of potash, perhaps from the surrounding mica schists.

Acknowledgements. My thanks are due to Mr. D. Gee for carrying out the mineral separations, the X-ray analyses, and the determination of the optical properties of most of the minerals, and to Dr. J. Lovering for discussion of the manuscript.

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