

## APPENDIX.

*Whangarei Heads Xenoliths and Their Comparison with Rocks of Southern New Zealand.*

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*Origin of the Rocks.*

Although the classification of the metamorphic xenoliths from Whangarei Heads set out in the paper above includes suggestions as to the derivation of the various types, the well-known similarity of end-products of high-grade metamorphism of rocks so diverse as basic igneous rocks and tuffs, impure calcareous sediments and greywackes makes it impossible to be certain of the origin of rocks in Class III of that classification. Similarly individual rocks of Class II may well be derivatives of sediments, although the general small content of quartz and lack of mica and garnet are somewhat against this possibility.

All appear to be products of metamorphism of the highest grade, for minerals such as diopside, pleonaste, and basic plagioclase indicate high temperature. The almost universal schistose structure indicates, however, that shearing stress was in operation. There are thus two alternatives:—

1. Contact metamorphism with accompanying shearing stress.
2. Regional metamorphism of highest grade. Even in this case, however, some contact action is necessary to account for scapolite in one rock and pleonaste in another.

The preferable alternative is that which regards the series of rocks as essentially the product of contact metamorphism.

*Comparison with Rocks of Southern New Zealand.*

There is seldom any approach to identity of individual rocks between the Whangarei Heads rocks and those of southern New Zealand. Considerable similarity exists, however, without actual identity in the following examples in which the Whangarei rocks are mentioned first:—

1. The noritic hornblende-gabbros parallel those of the Bluff, Orepuki and other Southland intrusions (cf. Service, 1937).
2. Quartz-biotite-norite: the occurrence of this type recalls the biotite-norites of Fiordland, although the resemblance is not close.
3. Hornblende-plagioclase-gneisses are more or less matched by somewhat similar rocks at Manapouri; these latter, however, have more sodic plagioclase and usually biotite and epidote.
4. The hornblende-diopside-plagioclase-gneisses recall similar rocks with green diopside near Anita Bay, Milford Sound, which were shown the writer by Dr. P. Marshall.
5. The hornblende-epidote-schist compares closely with some Manapouri gneisses.

6. The hornblende- and hornblende-diopside-schists may be compared with similar rocks associated with the Bluff norite which are described by Service (1937).

The following generalisations are perhaps significant:—

- (a) In Fiordland (e.g. Manapouri) there are hornblendic gneisses which probably represent altered sediments and interstratified basic tuffs or lavas, which have been invaded by gneissic granites. There followed a later injection of noritic gabbros, which in turn was succeeded by the local intrusion of smaller masses of granite and local conversion of norites to epidiorites. Thus there are areas, as, for example, Holmwood Island in Lake Manapouri, where hornblendic gneisses (of the "sedimentary" series) are cut by epidiorite that represents original hornblende-gabbro. There are other large areas, such as the Darran Range, where biotite-norites are extensively developed together with hornblendic dyke rocks.
- (b) The Bluff complex, described by Wild in 1912, and recently re-investigated by Service (1937), consists of a series of norites and gabbros (with insignificant later injections of quartz-diorite and granite) which invade a series of spilitic tuffs, lavas, keratophyres, etc., which probably represent a local development of the Te Anau Series.

Towards the contact with the norite, these invaded rocks have been converted to schists, granulites and sometimes hornfelses of high metamorphic grade, for they consist largely of plagioclase, green hornblende, quartz, garnet, etc., in different varieties. A most unusual feature is that, as a legacy of the spilitic origin of the rocks, the feldspar is often albite even in high-grade pyroxene-granulites. Service agrees with the writer's conclusion in his paper on the Manapouri rocks (Turner, 1937) that the Bluff complex is probably to be correlated with the "norites invading hornblende-gneisses" in Fiordland. The main difference is that, at the Bluff, the original rocks had been affected only by very low-grade metamorphism prior to their injection by norite, whereas in Fiordland intense regional metamorphism preceded such invasion. At the Bluff, therefore, the present condition of the granulites and associated rocks is the direct result of contact metamorphism induced by the intrusion of norite.

- (c) The Whangarei Heads xenoliths also represent material from a complex of basic plutonic rocks and high-grade essentially contact-schists derived mainly from basic igneous rocks, but including also true sediments. The whole association appears to be comparable with the associations at the Bluff and in Fiordland that have been mentioned above, although there are of course differences of detail.

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