

disappears at about Chl. 3 beyond which epidote is the only Ca-Al silicate apart from actinolite. Pumpellyite is now known to be a characteristic Ca-Al silicate of semi-schists of similar metamorphic grade described by MACKIE (1936) from his traverse south of the Waitaki River, although epidote is also present. It is also common, for example, in the lower grade schists of north-west Otago (HUTTON, 1937) in the Kakanui Ranges (TURNER, in WILLIAMSON, 1939; AMIES, 1952) in South Canterbury (AMIES, 1950), and in Upper Paleozoic spilites, greywackes and tuffs of about Chl. 1 grade from northern Southland (REED, 1950).

Mutually associated minerals in the Alpine Facies greywackes include quartz, albite, prehnite, pumpellyite, chlorite, sphene and detrital orthoclase; and in typical Chl. 2 rocks from East Otago there is some combination of the following: quartz, albite, chlorite, sphene, actinolite, muscovite, stilpnomelane, pumpellyite and epidote. An extremely broad zone can thus be mapped in New Zealand characterized by prehnite and/or pumpellyite. The incoming of actinolite and stilpnomelane in rocks of appropriate composition, the conversion of orthoclase to mica, and the disappearance of prehnite represent possible isogradic markers within the zone. Beyond a zone of transition, zeolites disappear and the rocks are not to be placed in the zeolite facies. We suggest that it may prove convenient to erect a new facies or low-grade subfacies of the greenschist facies to accommodate these rocks but that further field work on their subdivision is desirable before this is done. It will be recalled that MIYASHIRO and BANNO (1958) have recently shown that pumpellyite occurs in the lowest grade schists of the Sanbagawa-Mikabu zone in Japan and that DE ROEVER (1950, 1955) has already suggested that pumpellyite-bearing assemblages belong to a special subfacies, perhaps of the greenschist facies. His further suggestion that it represents a very low-grade equivalent of the glaucophane schist facies is hardly applicable to the New Zealand occurrences in which glaucophane is almost unknown.

### 2.7. *Distribution of the lower metamorphic grades in New Zealand*

As far as is known, all Lower Mesozoic formations of the Hokonui sedimentary facies (Fig. 1) show zeolite facies alteration although, as recorded above, transitions occur to prehnite-pumpellyite assemblages. At least some of the sediments of the Later Mesozoic geosyncline are to be included and probably also some of those of the Alpine sedimentary facies, as well as part of the belt of Late Paleozoic rocks, including the Otama Igneous Complex, which separates the Lower Mesozoic rocks of Southland from the Otago schists. The remainder of this belt, a corresponding belt to the west of the higher grade schists of Marlborough and almost certainly most of the Alpine Facies rocks belong to a prehnite-pumpellyite zone as described above.

## 3. REVIEW OF OTHER ZEOLITE OCCURRENCES

(D. S. C., A. J. E.)

In the following section, the principal types of zeolite occurrence as reported in the literature will be briefly reviewed to test their bearing on the facies concept and on the conditions of zeolite formation.