

or epidote, together with chlorite and sphene derived from the ferromagnesian.

- (2b) In a few cases in these rocks the prehnite and pumpellyite appear to replace earlier laumontite.
- (3a) In the most basic noritic gabbros thomsonite is the characteristic zeolitic alteration product, and in some cases is itself in process of replacement by prehnite.
- (3b) In the less basic gabbros, thomsonite is accompanied by varying amounts of analcime and laumontite, also sometimes partially replaced by prehnite.
- (4) Laumontite is the only early-metamorphic zeolite recorded from quartz-bearing members, but analcime and stilbite occur in addition in late veinlets and crush-zones.

#### 2.4. Greywackes and associated volcanics of the "Alpine Facies"

2.4.1. *Mid-Canterbury*. The main highway from Christchurch to the west coast of the South Island via Arthurs Pass provides a discontinuous section about 30 miles long from the edge of the Canterbury Plains to Arthurs Pass on the Main Divide. The basement rocks throughout this distance are monotonous, steeply dipping greywackes and associated rocks of WELLMAN's "Alpine Facies." Their general trend is transverse to the line of section, but their structure remains to be elucidated.

Near the east end of the section, little altered greywackes (15711-15714) containing the annelid *Terebellina mackayi*, of probable Triassic age, are exposed at the upper Kowai River bridge. Detrital grains include unaltered andesine and plentiful biotite which shows incipient bleaching and loss of birefringence, as well as quartz, muscovite, orthoclase, accessory minerals and a variety of rock fragments. Very fine-grained reconstituted chloritic material and calcite are disseminated through the groundmass. Joints are filled with calcite. Boulders (15708-15710) from the Kowai River, which has its source in the Torlesse Range about 5 miles north of the bridge, include prehnite-bearing greywackes, variolitic spilite with veins of quartz-pumpellyite and calcite-prehnite-pumpellyite(-epidote), and radiolarian metachert with pumpellyite-chlorite-quartz(-epidote) veins.

Three miles to the north-west at Porters Pass, the greywackes (15715-15719) are distinctly more altered than at Kowai Bridge although in some cases oligoclase-andesine survives amongst the otherwise albitic detrital plagioclase. Prehnite is a variable but often plentiful constituent, occurring as spongy undulose grains or as better-formed groups of crystals in the groundmass, as inclusions in plagioclase and sometimes even as plates separating the cleavage planes of biotite, which shows marked lowering of birefringence (cf. KOSOVSKAYA and SHUTOV, 1955). Epidote is not abundant and is in part detrital. The rocks are copiously traversed by quartz-prehnite veins varying from a fraction of a millimetre to two centimetres or more in thickness and apparently controlled by early-formed shatter systems, as is commonly the case in rocks of this metamorphic condition in New Zealand. Several episodes of crushing and recementation of the same vein are often apparent. In some cases a quartz-pumpellyite zone occurs near the walls of the vein, the pumpellyite being an iron-poor, pale-green variety. Porters Pass is on the trace of a major active fault and a younger shatter system has been imposed on the older, some of the younger fractures being filled with laumontite.

Rather similar prehnite-stage greywackes, freely traversed by quartz-prehnite or quartz-prehnite-pumpellyite veins, may be collected at numerous points between Porters Pass, the Waimakariri River and the Main Divide. A particularly instructive specimen (15707) from near the bridge over Craigieburn River has the assemblage quartz-albite-prehnite-chlorite-sphene(-epidote) amongst its reconstituted minerals, together with the usual relict detrital minerals, including orthoclase which appears to persist unaltered under prehnite-stage conditions.