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GEOLOGY OF THE KEVERI AREA, EASTERN PAPUA

by

R.P. Macnab

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SUMMARY

The area described in this report is 100 miles east of Port Moresby ($9^\circ45'$ - $10^\circ10'$S, $148^\circ30'$ - $148^\circ50'$E), and extends from the Domara and Adau River headwaters in the north to the south coast at Cloudy Bay. It centres around the Keveri Valley on the Adau River headwaters.

The predominant rock unit is the Lower Miocene Wavera Volcanics (new name) which consists of basic volcanics with some thinly-bedded calcilutite and some reef-shoal limestone. The rocks are finely jointed and sheared and commonly hydrothermally altered, and are intruded by dolerite, andesite porphyry, some gabbro, and minor peridotite. A zone of shearing and metamorphism in the upper Domara River strikes 295°. The Wavera Volcanics are probably continuous along strike with the Urere Metamorphics (Smith and Green, 1961).

A mafic/ultramafic complex (part of the Papuan Ultramafic Belt) is faulted against the Wavera Volcanics in the north, and forms steep emergent mountain blocks. The main rock types are gabbro, norite, peridotite and pyroxenite.

Much of the area is blanketed by the Pleistocene Domara River Beds (Smith and Green, 1961); these consist of folded and faulted alluvium with minor volcanics and one possible marine horizon. The main rock types are conglomerate, sandstone, siltstone and claystone, with some lava and agglomerate, and these are locally intruded by lamprophyre and andesite porphyry. Molluscs occur on several horizons.

Pleistocene or Recent basic lavas form foothills near the south coast; these lavas are here named the Cloudy Bay Volcanics.

The area is remarkable for the amount and magnitude of Quaternary faulting which has caused the tectonic emplacement of large fault-block mountains on the north flank of the main range, and the breaking up and steep tilting of Pleistocene sediments.

Alluvial gold mining in the <u>Keveri Goldfield</u> yielded 4,770 ozs of fine gold between 1904 and the middle 1920's. Most of the gold came from the western end of the Keveri Valley, with some coming from the Domara

River and some from a small creek (Suzy Creek) on the south fall of the main range.

Copper mineralization was found in several outcrops along the upper Domara River, and very small amounts of native copper occur in vesicles in volcanic rock at the eastern end of the Keveri Valley.

A boulder containing nickel sulphides was found at latitude 9°51'S, longitude 148°39'E, in a stream draining from the mafic/ultramafic rocks into the Domara River; this assayed 34% nickel. At latitude 9°47'S, longitude 148°37'E, nickel-staining of sedimentary rocks of the Domara River Beds was observed at some distance from the contact with ultramafic rocks.

INTRODUCTION

The Keveri area is 110 miles south-east of Port Moresby, Papua, and lies to the south of the Musa River area mapped by J.W. Smith and D.H. Green of the Bureau of Mineral Resources in 1958 (Smith and Green, 1961). It extends from the headwater tributaries of the Musa River, over the main range to the south coast. Three weeks were spent in the field in late April and early May, 1966, mostly in the northern part of the map area (Plate 1).

The programme was suggested by H.L. Davies to supplement his own mapping in a nearby part of the Papuan Ultramafic Belt. The writer was landed by helicopter on the Domara River, at the southern limit of the 1958 traverse by Smith and Green (about 10 miles south of Safia), with two native field assistants, six carriers, and supplies for traverses in the upper Domara River area. Supplies were also positioned at Apaeva village (Keveri Valley) for traverses in the east end of the valley, and for the trip to the coast.

In late May, 1966, the writer visited the abandoned gold workings at Suzy Creek for one day. These workings are on the south fall of the main range, about 7 miles north of Amau, and were at that time being prospected by J.R. Avinal.

Complete aerial photograph coverage of the area is included in the Mount Clarence, Keveri, Abau and Durama photomap areas, photographed from 25,000' by Adastra Airways in May, 1963. These photos were used to plot field information, and in the preparation of an uncontrolled base map at photo scale, which was subsequently reduced to approximately 1 inch to 1 mile (plate I).

About 100 thin sections were prepared in Port Moresby, and information gained from the study of these is incorporated in this report; petrographic descriptions are generally not included in the text, but may be found in the Appendix.

Physiography

The area can be divided into six topographic units (figure 1): (1) coastal plain, (2) southern foothills, (3) main range, (4) fault-block mountains north of the main range, (5) upper Domara River-Keveri Valley depression, and (6) northern foothills.

The main range is a low part of the Owen Stanley Range, the central divide of eastern Papua. The crest ranges in elevation from saddles at about 2,500 feet above sea level to peaks as high as 6330 feet (Mount Clarence). Drainage to the north is into the Domara and Adau Rivers, which are tributaries of the Musa River, and to the south into the Godaguina and Mori Rivers.

Vegetation

Rain forest covers most of the area, but gives way to sago swamps and fringing mangrove swamps on the coastal plain, and to areas of grassland and open eucalypt forest in the northern foothills and upper Domara River - Keveri Valley depression.

Rainfall

At Abau, in the mouth of Cloudy Bay, the average annual rainfall is 73 inches, most rain falling between the months of February and September. During these months the rainfall is considerably higher in the main range area, and probably also on the north fall of the range; flooded rivers were sometimes a problem during the April-May field work. During the months of October to January the coastal region is relatively dry and the local people advise that September, October and November are dry months in the main range area.

Access, population

Airstrips are maintained in the Musa Valley at Safia (open to DC3 aircraft) and on the south coast at Cloudy Bay (light aircraft). Foot tracks connect the Keveri Valley to Safia in the north, and to Babaguina Plantation, on Cloudy Bay, in the south.

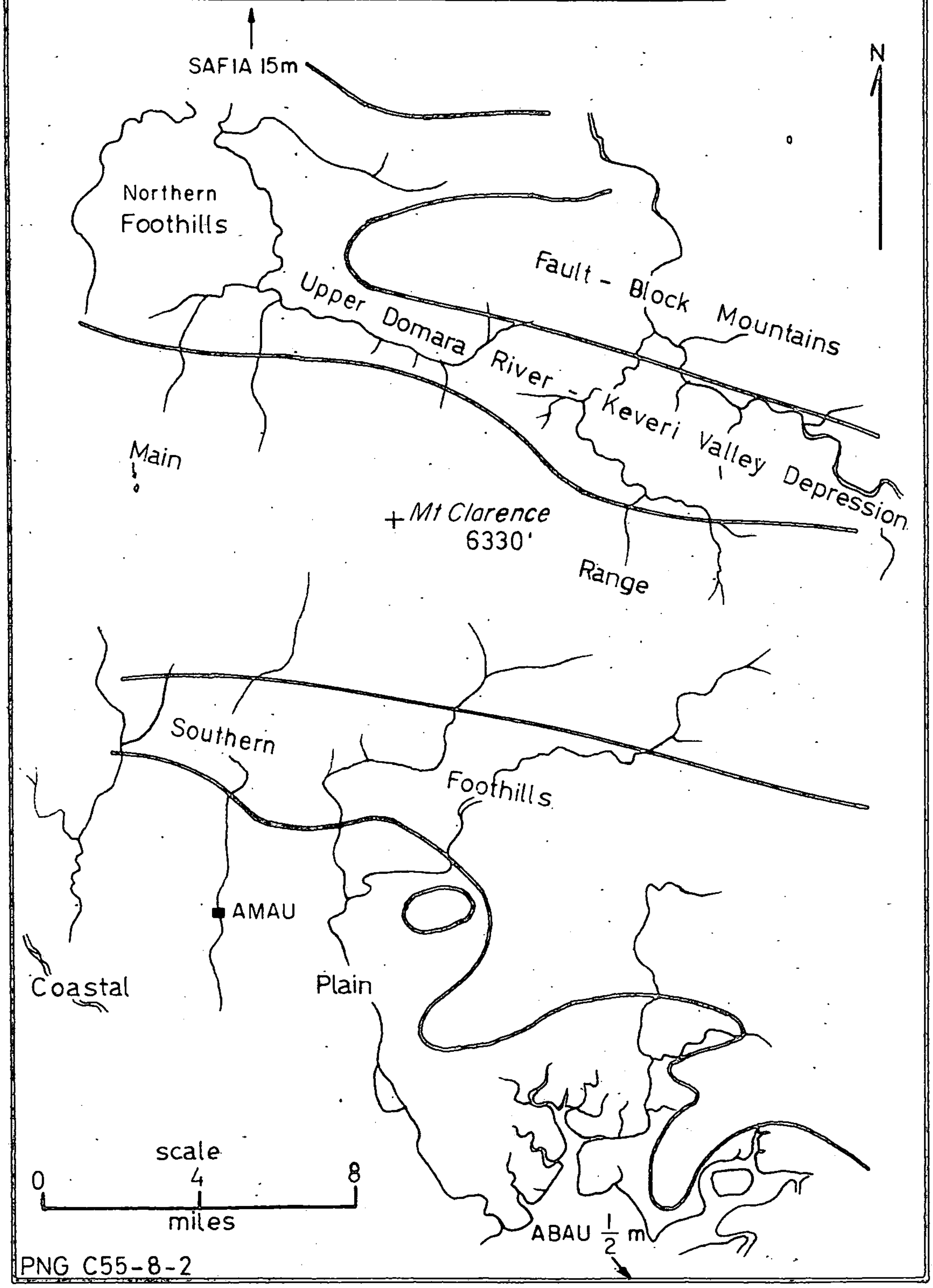
Population is concentrated in coastal villages; there is no permanent settlement inland except for several families at Apaeva. In the Domara River-Keveri Valley area, however, there is evidence of at least 6 abandoned villages, and reports of patrols into the area, carried out from Tufi about 15 years ago, show that several of these were then occupied. A slow exodus to the south coast has been taking place for a considerable period of time, probably because of the lack of Europiean contact and schooling facilities. The area has plentiful game, the soil is suitable for gardens, and living conditions are considerably better than those of the coastal area.

STRATIGRAPHY AND LITHOLOGY

The oldest rocks in the Keveri area are th Wavera Volcanics, submarine volcanics with several horizons of carbonate rocks. They are Lower Miocene in age, and are overlain by the Pleistocene Domara River Beds, which are lacustrine or fluviatile sediments with some volcanics. On the north flank of the main range, mafic/ultramafic fault-block mountains have been upfaulted into the Wavera Volcanics, disturbing the Domara River Beds. Small bodies of intermediate, basic and some ultra-

Figure 1

PHYSIOGRAPHIC REGIONS



mafic rocks intrude the Wavera Volcanics; the Domara River Beds are intruded by intermediate and basic rocks. Coarsely porphyritic, vesicular-basic lavas (the Cloudy Bay Volcanics) crop out in the southern foothills and around Cloudy Bay.

WAVERA VOLCANICS

This name is proposed by writer for rocks cropping out in the headwaters of the Wavera River, south of the Keveri Valley, at latitude 9°55'S, longitude 148°45'E. They also crop out extensively to the west and east of the Keveri Valley, and on the north and south fall of the main range. The Wavera Volcanics are equivalent to part, at least, of the Urere Metamorphics of Smith and Green (1961).

The Wavera Volcanics are predominantly marine volcanic rocks, with several horizons of calcareous sediments. The volcanic rocks are fine-grained spilite, with basalt and some fine-grained dolerite; they are typically massive and structureless (some pillow structures are preserved) in outcrop, and indications of orientation are rare. The calcareous sediments include a thickness of laminated calcilutites, here named the Mount Clarence Calcilutite Member (probably an eatward extension of the Foasi River Limestone of Smith and Green, 1961), and a large, lenticular reef-shoal limestone member, here named the Adau Limestone Member. These calcareous members contain Lower Miocene microfossils. Foliated metamorphic rocks developed in a narrow zone along the upper Domara River are also a part of the Wavera Volcanics. The volcanics are intruded by small bodies of intermediate and basic rocks and less common ultramafic rocks.

In hand specimen the volcanic rocks are fine-grained, highly jointed and broken, with an uneven fracture, and fairly common calcite, epidote, and zeolite veining. They are generally black, dark grey-green, blue-green, or green, and occasionally red-brown (hematite staining); vesicle or amygdale fillings of calcite, chlorite, zeolite or epidote are common.

In thin section the spilite is seen to comprise altered phenocrysts and infilled vesicles in a dark, fine-grained groundmass which generally contains sodic plagioclase. Ferromagnesian phenocrysts predominate over plagioclase, and are generally pseudomorphs in chlorite or, rarely, pale green fibrous amphibole; they are rarely fresh augite. The plagioclase may be calcic, but is commonly partly or completely altered, and is rarely sodic. Vesicles are generally present and may be lined with chlorite; they are filled by zeolite, calcite, chlorite or, rarely, epidote. The groundmass is dark and fine-grained to very fine-grained, and is generally composed of acicular or lathlike sodic plagioclase, incipient ferromagnesian growths, interstitial chlorite and abundant fine oxide. Interstitial cryptofeldsite may be present and veining is very common.

The fine-grained dolerite and basalt are interbedded with and intrude the spilites. They are highly fractured and jointed, with abundant fine veining and common vesicles, and vary in grainsize from fine-grained dolerite to very fine-grained basalt. They may be porphyritic or equigranular, and have an essential composition of augite, calcic plagioclase, interstitial glass or chlorite, and accessory iron ore. Alteration varies from minor to extreme; small crush zones and evidence of slight strain are common.

Several periods of carbonate development took place during deposition of the Wavera Volcanics, resulting in the formation of the Mount Clarence Calcilutite, and Adau Limestone Members. Minor carbonate development elsewhere in the section includes argillaceous limestone in the south-eastern portion of the Keveri Valley, and small, highly deformed, marginally recrystallized pods and lenses of limestone mixed into submarine volcanics in places.

(1) Mount Clarence Calcilutite Member

Fine-grained, laminated red, red-brown and white calcilutite and limestone occur along what appears to be a single stratigraphic horizon in the Wavera Volcanics, either as a continuous body or as a number of lenses. They are generally contorted, with local shearing and folding, and are in places partly recrystallized and epidotised. Thick beds of laminated calcilutite are interbedded with the dark, structureless rocks (lavas, possibly sedimentary rocks) more typical of the Wavera Volcanics. This unit is here named the Mount Clarence Calcilutite Member, because of its projected outcrop along the north flank of the Mount Clarence ridge (approximate position 148°39'E, 9°55'S). The position and attitude of the Foasi River Limestone (Smith and Green, 1961) indicate that it is probably an exposure of the same rock unit.

Good exposures of the Mount Clarence Calcilutite Member were seen in the Godaguina River headwaters, and in a southern tributary of the upper Domara River; boulders of laminated calcareous rocks were seen in the wash of several other rivers on the north fall of the main range. The location of exposures, and the observed attitudes of bedding, suggest that they comprise a single stratigraphic unit, striking about 295° and dipping variably to the north, probably with local offsets due to faulting. The total thickness of the calcareous sequence is not known, but it is possible that it exceeds 1,500 feet: about 3,000 feet of exposure were traversed in a tributary of the upper Domara River; the thick beds of laminated calcilutite are interbedded with dark structureless ?lavas and have a fairly uniform strike, from 270° to 300° magnetic, and dip to the north generally at 45° to 80°. The traverse ended before the base of the sequence was reached. There is no suggestion of tight folding.

A number of specimens from the Mount Clarence Calcilutite Member were collected in the Godaguina River headwaters (1275, 1278) and in the upper Domara River area (1274, 1279) and these were found by A.R. Lloyd (Bureau of Mineral Resources, Canberra) to contain abundant planktonic foraminifera, indicating a Tertiary, ?Miocene age.

Argillaceous limestone in the south-eastern portion of the Keveri Valley may be a part of the Mount Clarence Calcilutite Member, but the apparent difference in stratigraphic position, together with its different character, suggests that it represents a separate phase of carbonate development. The limestone is grey-brown, with fine mudstone bands; the outcrop (1407) is small and highly sheared along one margin, giving no indication of the extent of carbonate development.

The age of the grey-brown argillaceous limestone was found by A.R. Lloyd (pers. comm.) to be Lower Miocene; foraminifera present include Miogypsina sp., Miogypsinoides sp., Lepidocyclina spp., Eliphidium sp., and Operculina sp..

(2) Adau Limestone Member

Adau Limestone Member is proposed by the writer for a large lenticular body of limestone forming prominent pinnacles along several miles of the Adau River, at the east end of the Keveri Valley (latitude 148°48'E, longitude 9°53'S). The limestone member occurs within the Wavera Volcanics but is bounded to the south by a fault; it appears to have a normal contact with the volcanic rocks to the north, and probably represents shallow water reef-shoal sedimentation late in the development of the succession. It is made up of massive, light-coloured limestone, with some darker, impure limestone, and some soft-weathering calcareous sediments in the south-western part of the outcrop. The calcareous sediments are silty limestones and calcareous mudstones with limestone lenses. At the west end of the outcrop, on the left bank of the Adau River, the limestone is unconformably overlain by the Domara River Beds. The surface of unconformity appears to be fairly flat-lying and is seen again a half-mile to the south, where the Domara River Beds overlies both the Adau Limestone Member and fine-grained volcanic rocks of the Wavera Volcanics. The limestone and the volcanics are here separated by a fault which is probably vertical, but there are a number of flat-lying fault planes at the margin of the limestone.

The limestone member is locally highly fossiliferous, with algae, bryozoa, some brachiopods and foraminifera. The age has been determined by Lloyd to be Lower Miocene, Tertiary f_{1-2}, this being based on the identification of the foraminifera (in specimen 65520702, collected by H.L. Davies) Globigerina sp., Planorbulinella sp., Miogypsina sp., Amphistegina sp., Katacycloclypeus martini., and ?Gypsina sp.. A specimen submitted by the writer contained the foraminifera Lepidocyclina sp., Operculina sp., Globigerina sp., and Textularia sp., indicating a Lower or Middle Miocene age.

Foliated Metamorphic Rocks

In several areas rocks of the Wavera Volcanics have developed a very marked, fine phyllitic texture, and are in places further deformed by numerous small kink bands. In other areas there is a noticeable but poorly defined foliation in hand specimen, often due to the segregation of dark and light minerals. Petrographic examination of these rocks shows them to be largely recrystallized, displaying varying degrees of metamorphic differentiation; closely related rocks are recrystallized with a hornfelsic texture.

It is significant that the majority of these outcrops fall within a narrow linear zone, striking about 295°, roughly concurrent with the course followed by the upper reaches of the Domara River, but extending to the east and west. The zone may continue east-south-east into the Godaguina River headwaters, where the carbonate and related rocks of the Mount Clarence Calcilutite Member are very highly deformed, and have suffered considerable alteration. It is probable that thermodynamic metamorphism is confined largely to this narrow zone of maximum strain, and is not a regional feature.

MAFIC/ULTRAMAFIC COMPLEX

Mafic and ultramafic rocks form the massive fault-block mountains in the north-eastern part of the area. They are deep-seated plutonic rocks which have been up-faulted into the Wavera Volcanics on the north flank of the main range, disturbing the Pleistocene Domara River Beds. Rock types include gabbro and peridotite, with norite, pyroxenite, dunite, and, in one area, anorthosite.

These rocks were not studied in detail by the writer, but form part of the study being carried out by Davies on the Papuan Ultramafic Belt.

DOMARA RIVER BEDS

The Domara River Beds were named by Smith and Green (1961) because of their continuous exposure along the lower part of the Domara

River. They persist to the south of the type area in the middle reaches of the Domara River, where they form several prominent strike ridges, and in the Keveri Valley, where they are generally flat-lying and form low hills.

Within the area covered by this report, the Domara River Beds comprise lacustrine or fluviatile claystone, siltstone, sandstone and pebble, cobble and boulder conglomerates, with rare lava flows (or sills), and, at one locality, a basal volcanic phase of lava and agglomerate. Fossil molluscs occur in several calcareous horizons, one of which may represent a marine intercalation. They are in places intruded by fine-grained basaltic rocks, biotite-lamprophyres and andesite porphyries.

The Domara River Beds are probably Pleistocene (Smith and Green, 1961) but fossil molluscs collected are not suitable for accurate dating purposes; it is possible that deposition began in the Pliocene and continued into the Pleistocene. The thickness of the Domara River Beds exceeds 2000 feet within the area examined, however only partial successions are seen because of faulting.

The conglomerates of the Domara River Beds are composed of boulders of fine-grained basic and some intermediate volcanic rocks, some gabbro and peridotite, and rare limestone (similar to the Adau Limestone Member), in a clay and sand matrix, commonly with smaller fragments and pebbles. The finer conglomerates (boulders less than 6 inches diameter) are generally fairly well sorted, but the coarser conglomerates, which include angular boulder conglomerates, are poorly sorted.

In any one area, the Domara River Beds are generally dominated by one of the three major phases; conglomerate, sandstone or claystone/siltstone. Cyclic deposition, probably caused by repeated sudden subsidence, is evident in several sections. In a continuous river section of at least 1500 feet thickness, exposed downstream from the westward flowing part of the upper Domara River, there is, from bottom to top, a boulder conglomerate (6 inches mean diameter) with narrow sandstone bands, 6 inches to 3 feet thick, overlain by massive sandstone which grades up into siltstone with some interbedded sandstone. This is overlain by massive angular boulder conglomerate with some sandstone bands, which becomes more sandy, grading into interbedded sandstone and fine conglomerate. The average dip throughout is about 40°, but this steepens to 60° at the end of the section. A short break in outcrop is followed by about 400 feet of continuous exposure, comprising 300 feet of near vertical, thin-bedded clayey siltstone overlain by angular conglomerate, which is in turn overlain by 20 feet to 30 feet of siltstone and fine sandstone. This displays excellent soft-sediment deformation structures, and is overlain by conglomerate. The outcrop terminates with a low bluff of massive, steep-dipping angular conglomerate.

At several localities, carbonized wood up to 3 feet long occurs in angular boulder conglomerate which is composed of very poorly sorted fragments of volcanic rock, often oxidized, in a sandy, clayey matrix. At one locality, narrow bands (less than ½-inch wide) of coal are common through the conglomerate and in the interbedded carbonaceous sandstone. In the same area, carbonaceous bands are common in the sandstone/claystone succession.

Fossiliferous beds

Fossil molluscs were collected from several outcrops, but they have proved unsuitable for dating purposes.

In the lower part of the upper Domara River (on the northern margin of the map) a sequence of carbonaceous sandstone and shale displays current bedding and soft sediment deformation structures and includes a number of dark and light-coloured limestone beds 1 inch to 6 inches wide. Several of these beds contain thin-shelled planispiral and conispiral gastropod remains.

A quarter of a mile upstream, on the south side of a wide fault zone is a sequence of dark, calcareous, finely jointed and thin-bedded shale and sandy shale, with interbedded fine-grained grey sandstone. The sandstone is generally 2 feet to 3 feet thick but varies form 6 inches to 7 feet, and occurs at 3-foot to 10-foot intervals. In one place the shale contains three thin coquina bands, 1 inch to 3 inches wide, and about 6 inches apart, made up of very well preserved mollusc shells (mainly gastropods), in a friable, shaley matrix. About 80-foot vertical thickness of this succession is exposed in outcrop, but further limited outcrop suggests that it grades up into massive sandy shale and sandstone. The examination in thin section of a specimen of dark, calcareous shale from the sequence shows it to be a silty limestone, composed of about 65% fine calcite, the rest being sub-angular to rounded silt-sized fragments of quartz, green and brown (oxidised) chloritic material, and minor plagioclase and detrital epidote. There are several narrow bands of slightly coarser material, in which the detrital fraction is slightly more abundant and contains more plagioclase and minor biotite and clastic calcite. The molluscs in the coquina bands appear to be quite different from those of the previous section, and this, together with the nature of the succession, suggests that it might be of marine origin.

Volcanics

Lava flows or sills are present within the Domara River Beds at several localities, and at one locality a basal volcanic phase includes tuff and agglomerate.

In the headwaters of the Domara River, a large outlier which comprises pebble conglomerate, sandstone, and sandy and clayey siltstone with pebble bands, includes a lava flow or sill 15 to 20 feet thick, with the composition of an olivine basalt.

In the Keveri Valley, where the Domara River Beds are generally shallow-dipping, there is a narrow wedge along the north-east margin (Adau River) in which they dip south at about 45°. Within this rotated block, the Domara River Beds are made up of coarse and fine conglomerates and some sandstone, with a massive interbedded flow or sill of porphyritic leucite-augite basalt.

A basal volcanic phase within the Domara River Beds was encountered in the south-east part of the Keveri Valley, where the Domara River Beds unconformably overlie the Wavera Volcanics. The lowest beds in the Domara River succession are a brown claystone, which is overlain by massive, blocky, basic lava. In the creek section this is repeated following a break in outcrop, but this repetition is probably due to faulting. The lava, a porphyritic lamprobolite - augite basalt, is overlain by massive boulder agglomerate, with a clayey tuffaceous matrix and some tuff bands. This grades up into volcanic conglomerate, in which the matrix is probably largely tuffaceous. The boulder size decreases, and interbedded sandstones become more common. The remaining several hundred feet vertical thickness of the section comprises claystone and sandstone, with interbedded pebble, cobble and boulder conglomerates; the total thickness of the basal volcanic phase probably does not exceed 100 feet.

On the southern fall of the main range, south of the Godaguina River headwaters, is a small prominent outlier of sedimentary rocks, which has a shallow dip to the south. This has not been visited, but it appears from helicopter examination to be an agglomerate, probably an erosional remnant of the basal Domara River Beds.

CLOUDY BAY VOLCANICS

The Cloudy Bay Volcanics is the name given by the writer to the volcanic rocks which form the southern foothills zone between the main range and Cloudy Bay, and crop out round Cloudy Bay. They are coarsely porphyritic and vesicular (with unfilled vesicles), generally not sheared or jointed, and possibly have a slight southerly dip; they are quite different from the finer, darker volcanic rocks of the Wavera Volcanics and are probably separated from them by a system of vertical faults.

Very coarse lateritized volcanic-boulder conglomerate which forms low hills near the Coudy Bay sawmill may be a part of the Cloudy Bay Volcanics, but is possibly a more recent derivative from them.

The Cloudy Bay Volcanics are probably Quaternary, possibly Recent.

RECENT COASTAL ALLUVIUM

In the Cloudy Bay area the coastal plain has suffered some Recent subsidence, with the flooding of low coastal hills in the immediate vicinity of Cloudy Bay; however the arresting, or possibly reversal, of this subsidence has resulted in the rapid building up of an extensive coastal plain. Former strand lines can be discerned for up to four miles inland from the pressnt coast line; further inland they give way to featureless swamp, for distances up to 12 miles from the present coast-line.

INTRUSIVE ROCKS

Relatively small bodies of intrusive rocks are widespread throughout much of the area mapped. The Wavera Volcanics are commonly intruded by andesite porphyry and dolerite, and less commonly by gabbro, diorite and rare pyroxenite. In one area serpentinite crops out in the Wavera Volcanics but is not clearly intrusive. The Domara River Beds are intruded by andesite porphyry, basalt and lamprophyre.

Intermediate Intrusive Rocks

Porphyritic rocks of intermediate composition are widespread, extensively intruding the Wavera Volcanics, and in the northwest corner of the area, sedimentary rocks of the Domara River Beds. They are largely (augite)-hornblende andesite porphyries, and are generally unsheared, commonly hydrothermally altered, and in places highly pyritic.

Plutonic rocks of intermediate composition are less common, cropping out only on the watershed between the Domara River and Keveri Valley. These rocks were not seen in outcrop, but creeks draining into the Keveri Valley from the watershed contain abundant wash of a composite basic diorite intrusion, and a hybrid rock with the composition of a monzonite. Of the two rock types, the composite diorite is the most common, being composed of a number of different phases, varying in grainsize, colour and texture, injected into each other. The essential mineral composition is plagioclase, hornblende and augite. The monzonite is a hybrid rock comprising plagioclase, hornblende, augite and biotite grains enclosed in large anhedral orthoclase grains; the orthoclase-plagioclase grain boundaries show exaggerated reaction relationships.

Basic Intrusive Rocks

(a) Dolerite, basalt and lamprophyre

In some areas dolerite intrusions which are younger than the Wavera Volcanics can be identified. These rocks have an essential composition of augite, calcic plagioclase, interstitial glass or chlorite, and accessory iron ore, and can only be distinguished from the dolerite intrusions which are penecontemporaneous with the Wavera Volcanics by field relations.

In the upper Domara River area basaltic rocks and lamprophyres intrude the Domara River Beds and the adjacent Wavera Volcanics; the basalt may have been intruded penecontemporaneously with the deposition of the sedimentary rocks but the lamprophyre, a biotite-augite lamprophyre, is clearly younger, and forms a number of dykes and small intrusive bodies.

(b) Gabbro

Gabbroic intrusions into the Wavera Volcanics are commonly hydro-thermally altered. Fresh gabbro occurs at a number of localities, notably in a large intrusion between the Wavera and Godaguina River headwaters. It is composed essentially of large grains of augite ophitically enclosing calcic plagioclase, with fairly abundant interstitial chlorite and accessory large skeletal grains of opaque oxide. In the altered gabbro, augite is generally completely altered and plagioclase is kaolinised.

In a western tributary of the upper Domara River an outcrop of partly serpentinised pyroxenite appears to be closely related to a body of altered gabbro. In the same area there are other bodies of pyroxenite and lenticular bodies of sheared serpentinite; one of these in thin/section is seen to comprise antigorite-talc.

STRUCTURE

The area is remarkable for the amount and magnitude of Quaternary faulting. The faults are high-angle, with large vertical displacements, and apparently minor transcurrent displacements, and are a major contributing factor in the present day topography.

On the northern flank of the main range, high-angle (probably near vertical) faulting, post-dating the deposition of the Pleistocene Domara River Beds, has resulted in the tectonic emplacement of the mafic-ultramafic mountain blocks, and the breaking-up and tilting of the Pleistocene sedimentary rocks, with the rotation of some blocks into near-vertical orientations.

On the southern flank of the range, the Wavera Volcanics and the Cloudy Bay Volcanics are probably separated by high-angle faults. Movement on these faults is probably responsible for the uplifting of the mountain range and it is possible that there has also been some transcurrent displacement.

The Quaternary faulting has generally caused only narrow crush zones. Older faulting, which may have large transcurrent displacements, has caused wide zones of mylonitization in the Wavera Volcanics, which generally do not have any reflection in the present day topography. Strain and movement on closed joint planes are common in the Wavera Volcanics.

The Domara River Beds are broadly folded (Smith and Green, 1961). The Wavera Volcanics are faulted and probably folded, but this is not adequately demonstrated because of lack of bedding and suitable marker horizons. Contortion of calcilutite laminae is soft sediment deformation rather than a tectonic affect.

GEOLOGICAL HISTORY

The oldest rocks in the area are the Wavera Volcanics, which were probably deposited largely in the Lower Miocene. These rocks are submarine spilites and associated extrusive and contemporaneous intrusive fine-grained basic volcanic rocks. Several periods of carbonate development took place between periods of vulcanicity; a thick succession of laminated calcilutite and argillaceous limestone was interbedded with fine, dark volcanic or sedimentary rock (Mount Clarence Calcilutite Member) and a late-stage shallow water reef-shoal limestone was developed (Adau Limestone Member). Small bodies of mafic and ultramafic rocks intruded the Wavera Volcanics and may have been emplaced penecontemporaneously with their development. These small bodies are possibly related to deeper-seated large-scale mafic and ultramafic plutonic activity. Hydrothermal activity appears to have been widespread during the development of the Wavera Volcanics.

Following deposition, the Wavera Volcanics were deformed by shearing, tilting and broad folding. During this time they were probably uplifted, and were intruded by small bodies of mainly porphyritic basic and intermediate rocks.

The Domara River Beds were laid down in the Pleistocene, but deposition possibly began in the late Pliocene. Sedimentation took place in a lacustrine or fluviatile environment, probably close to sea-level, and minor marine transgressions may have taken place. Volcanic activity was widespread in the early stages of deposition, and later intrusives include basalt, lamprophyre, and andesite porphyry.

The Cloudy Bay Volcanics are probably younger than the Domara River Beds; they consist of coarsely porphyritic basic lavas.

In the later part of the Pleistocene and in Recent time, large-scale vertical fault movement has taken place, giving rise to the present-day topography. The most outstanding features of this faulting are the tectonic emplacement of the mafic/ultamafic fault-block mountains in the north flank of the main range, and the rotation of wedges of Pleistocene sedimentary rocks to a near vertical orientation.

ECONOMIC GEOLOGY

Alluvial gold has been worked in the western end of the Keveri Valley, the Domara River, and in Suzy Creek on the south fall of the main range. Copper and nickel mineralization was found by the writer at several localities along the Domara River and in the Keveri Valley.

Gold was discovered in the western end of the Keveri Valley in the early part of the century. On August 5th, 1904, the Keveri Goldfield was proclaimed, to include the area enclosed by boundaries extending from the summit of Mount Suckling, south to Baxter Bay, west to a point south of Mount Clarence, north through Mount Clarence and east to Mount Suckling. This area was considerably enlarged by an amendment in 1919, following controversy about the location of a gold find on the Imila Creek, north of Marshall Lagoon, and the discovery of gold on the Domara, Awara, Urere and Pusai Rivers in the Musa River headwaters. Production from the Keveri Goldfield was only 4,770 ozs of fine gold, and was obtained between 1904 and middle 1920's; most of it was won from the lower Wavera River and a tributary (Umu Creek) immediately above the present site of Apaeva village. The gold is alluvial, but proved difficult to work. The 1905-1906 Annual Report states "......The small creek or gully where the gold is obtained is very rough and expensive to work, and requires a good deal of blasting to get at the gold". Later reports state that there is sometimes quartz associated with the gold, which is possibly derived from reefs. In 1933 T.L. Sefton applied for a 1½ acre lease over part of the Wavera River flats, opposite Apaeva village, and in 1935 N.F. Davies applied for a dredging claim on the Awara River. Neither of these areas was subsequently worked.

The gold in the Keveri Valley is derived from the hills to the south-west of the valley, and sheds from the Wavera Volcanics or from porphyries intruded into the volcanics; analysis by emission spectroscopy of pyritic porphyries from this area failed to detect any gold. Opposite Apaeva village flat-lying conglomerate and pebbly siltstone of the Domara River Beds are overlain by similar looking Recent alluvium which contains the gold.

The major problem faced in working the gold in the Keveri Valley is the handling of large boulders. It is not possible to get a sufficient head of water in a reasonable distance to carry out sluicing operations.

Analysis by emission spectroscopy of a specimen of rock containing copper mineralization from an outcrop on the upper Domara River showed 2 dwt/ton gold and 14 dwt/ton silver.

On the south fall of the main range small quantities of alluvial gold have been won from Suzy Creek, 7 miles north of Amau. The gold is here derived from a soft-weathering feldspar porphyry, which is intruded, along with other intermediate and basic intrusive rocks, into fine-grained volcanic rocks of the Wavera Volcanics. The amount of gold in the alluvium is small, and working conditions are particularly unfavourable.

Copper sulphide mineralization was found by the writer in the upper Domara River area, in outcrop along the river, and in the wash of a small tributary. Native copper mineralization was found at the eastern end of the Keveri Valley.

South of the western end of the mafic/ultramafic fault-block mountains copper mineralization occurs in hydrothermally altered rocks of the Wavera Volcanics, cropping out on the left bank of the Domara River. The mineralization is in the form of quartz-pyrite-chalcopyrite veining and disseminated chalcopyrite, with some malachite staining, scattered throughout a 50 feet exposure of dark, fine-grained, altered rock. In thin section this rock is seen to comprise fine pennine chlorite, with small, irregular growths of quartz, and fince, dusty epidote. Abundant fine quartz, quartz-epidote and epidote veining occurs. The copper mineralization was probably introduced by the hydrothermal solutions which altered the country rock. Assay of two samples from this outcrop showed 1.35 and 4.70% copper.

Higher up in the headwaters of the Domara River, abundant quartz rubble with limonite, haematite and malachite staining occurs in two tributaries of a small creek, and is spread over the top of the hill from which they drain. Unaltered pyrite and chalcopyrite are present in the quartz, which is probably derived from large fissure or fault fillings; some of the mineralization has been leached.

Minor chalcopyrite occurs in veins in the Wavera Volcanics lower down the Domara River; this is similar to the occurrences recorded by Smith and Green (1961) in the area to the west, where minor chalcopyrite occurs with pyrite in malachite-stained veins in the Urere Metamorphics.

At the eastern end of the Keveri Valley, to the south of the Adau Limestone Member, native copper occurs in vesicles in boulders of an altered volcanic rock of the Wavera Volcanics. This rock is composed of indistinct feldspar laths, ragged quartz growths, and chlorite and epidote, with abundant magnetite; the vesicles are large and irregular, lined with chlorite, and filled by well crystallized epidote and quartz with some native copper. In the same area, minor chalcopyrite occurs in a quartz-epidote vein in a volcanic rock of the Wavera Volcanics.

South of the Keveri Valley, in the Wavera River headwaters, malachite staining was seen in a boulder of unaltered gabbro.

Nickel mineralization was found associated with the mafic/ultramafic mountain blocks, both as nickel sulphide and as secondary nickel staining.

In the headwaters of the Domara River, in a small creek draining the southern side of the mafic/ultramafic block (latitude 9°51'S, longitude 148°39'E), nickel sulphide was found in a boulder of serpentinous material. A specimen from this boulder was assayed by Australian Mineral Development Laboratories, and found to contain 34% nickel. A mineragraphic examination carried out by J. MacDonald of the Bureau of Mineral Resources in Canberra, showed that the specimen is made up of about 40% sulphides in a serpentinuous matrix. The two major sulphide phases are hazlewoodite, $Ni_3 S_2$, and pentlandite $(Fe, Ni)_9S_8$, in a ratio of 3:1, with a minor phase that is probably a mixture of hazlewoodite and millerite.

Eight miles east of this locality in Doriri Creek, a tributary of the Adau River, nickel sulphide mineralization occurs in a shear zone in mafic and ultramafic rocks (H.L. Davies, pers. comm.).

These two occurrences suggest that nickel sulphides may occur in economic quantity in the area.

In the north-western part of the map area, at latitude $9^{\circ}47'$S, longitude $148^{\circ}37'$E, green nickel-staining occurs in sandstone and conglomerate of the Domara River Beds at some distance from the contact with the northern mafic/ultramafic block. This staining is in the form of a thin green coating on grains and pebbles, and in joints and fractures in the pebbles.

REFERENCES

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APPENDIX

PETROGRAPHY

WAVERA VOLCANICS

Thin-section examination of specimens collected from the Wavera Volcanics show the dark, structureless rocks to be spilite and closely associated fine-grained dolerite and basalt, which sometimes show some alteration. Basic sediments were not identified in thin section, although it is likely that some of the dark rocks interbedded with the calcareous units of the Mount Clarence Calcilutite Member are sedimentary, derived from volcanics of the succession.

Spilites. P1373, 1374, 1380, 1381, 1383, 1385, 1386, 1390, 1397, 1403, 1411, 1413, 1416.

The spilites are composed of altered phenocrysts and infilled vesicles, in a dark fine-grained groundmass which generally contains sodic plagioclase.

The phenocrysts vary in size up to 2½ mm, and may be rare or abundant. Ferromagnesian phenocrysts predominate over plagioclase, and are generally pseudomorphs in chlorite (in places pennine, and in places with rare calcite and epidote) or, rarely, pale green fibrous amphibole, probably replacing original clinopyroxene (in several sections the ferromagnesian mineral is fresh augite, e.g. P1403, 1390). The plagioclase may be calcic (P1335, 1386) but is commonly partly or completely replaced by fine aggregates of colourless ?chlorite, ?sericite or ?feldspar (P1416, 1381); in several sections the plagioclase phenocrysts are sodic (P1381, 1390). Vesicles are usually present, and vary in diameter up to 1½ mm. They are chlorite lined in places, and are filled by zeolite, calcite, chlorite or, rarely, epidote.

The groundmass of the spilites is dark and fine-grained to very fine-grained, and is generally composed of acicular or lathlike sodic plagioclase, incipient growths of ferromagnesian minerals, interstitial chlorite and abundant fine opaque oxide. Interstitial cryptofeldsite may be present and veining is very common. The sodic plagioclase varies from an abundant to a rare component, and is generally clear and well defined, occasionally cloudy. It varies in grainsize from fine to very fine, and is generally divergent, but may be variolitic (P1380, 1397) and rarely defines a flow foliation. In some sections it is partly altered to colourless chlorite and calcite; in several sections it appears to be slightly calcic. The incipient ferromagnesian growths are generally unidentifiable and appear under medium magnification as small dark areas of moderate birefringence, masked by fine opaque oxide. Under high magnification, these are seen to be made up of a moderate relief mineral of variable habit, which is colourless or slightly pleochroic from pale brown to pale green, and is outlined by fine opaque oxide. The habit of the mineral varies from fibrous to prismatic, and is sometimes microlitic, forming fine comb and fish-bone structures which are curved in places (P1386, 1390, 1397). Small patches of the mineral are commonly bounded by plagioclase laths, and have an undulose shadow extinction; however approximate optical continuity in adjacent areas sometimes gives the groundmass a pseudo-subophitic appearance. In several sections, in which the incipient ferromagnesian mineral is best developed, it appears to be augite. Interstitial chlorite is common in the groundmass, and may be colourless, pale green or green brown. Some of it is pennine. Some small, irregular patches of calcite and zeolite are present, occasionally replacing plagioclase. Fine opaque oxide, occasionally hematite, is very common in the groundmass, and rarer cubic grains of a translucent brown isometric mineral occur (P1381, 1383). Veining is present in most sections, and is commonly zeolite and calcite, occasionally chlorite, rarely epidote. In chilled marginal zones (P1383), the groundmass is usually dark, indeterminate material.

The texture and mineral assemblage of the spilitic rock types may be due to low-grade regional metamorphism; however the common close association of these rocks with unaltered basaltic rocks suggests that they are true spilites.

Basalts and fine-grained dolerites

The basalts and fine-grained dolerites are interbedded with and intrude the spilites. They are highly fractured and jointed, with abundant fine veining and common vesicles, and vary in grainsize from fine-grained dolerites to very fine-grained basalts. They may be porphyritic or equigranular and have an essential composition of augite, calcic plagioclase, interstitial glass or chlorite, and accessory iron ore. Alteration varies from minor to extreme. Small crush zones and evidence of slight strain are common.

The unaltered rocks (P1375, 1393, 1398, 1400, 1401, 1418) are made up of colourless augite and calcic plagioclase (calcic andesine - labradorite), and interstital chlorite, partly chloritized mesostasis or, rarely, feldsitic material. Some augite and plagioclase grains are highly fragmented; the rock is sometimes porphyritic, or may have a sub-ophitic texture. Commonly the chlorite appears to be infilling irregular vesicles, and some vesicles are filled by zeolite. Opaque oxide is generally an abundant accessory. Zeolite, calcite or chlorite veining occurs.

Alteration of the basaltic rocks is common and varied (P1367, 1395, 1404). In the porphyritic rocks, the augite phenocrysts may be partially or completely altered to one or several of the minerals chlorite, serpentine, calcite, fibrous amphibole or zeolite. The calcic plagioclase is less commonly altered to an indeterminate mass (chlorite, calcite, kaolin or sericite, or rare epidote), or to sodic plagioclase. Vesicles are filled by zeolite, calcite, chlorite, epidote or actinolite. Alteration of the groundmass results generally in a green chloritic mass, with some irregular patches of zeolite and calcite. Pyrite is fairly common in the altered rocks.

It is often difficult in the field to distinguish between fine-grained dolerites of the Wavera Volcanics and subsequent dolerite intrusions. In thin section the mineral assemblage and texture of the altered basalts approaches that of the spilites.

Carbonate rocks in the Wavera Volcanics

The principal development of carbonate rocks in the Wavera Volcanics is that of the Mount Clarence Calcilutite Member, thin-bedded calcilutite and impure limestone exceeding 2000 feet in thickness and extending from the Foasi River (Smith and Green, 1961), across the Domara River headwaters (P1370, 1376) into the Godaquina River headwaters (P1420, 1422). Argillaceous limestone crops out in the Keveri Valley (P1407), and in places small deformed pods of fairly pure limestone are associated with the spilites (P1383, 1416). The Adau Limestone Member is probably a late stage reef-shoal limestone development.

The laminated calcilutite (P1370, 1376) and impure limestone (P1420) are composed of microcrystalline calcite, generally with abundant argillaceous material, and contain angular fragments of plagioclase, oxidised fine-grained basic lava, chloritic material, quartz, and some augite, which are present in varying amounts. Fine opaque oxide and oxidised material is generally abundant and is probably responsible for the common red colouring of the limestone. Epidote commonly occurs in the impure limestone and also occurs in calcite-epidote veins. Some calcite and calcite-epidote veins are ptygmatically folded, but later very fine calcite veins, infilling one or more joint systems, are undeformed. The sedimentary bedding is defined by compositional variations between layers, and in places is accentuated by lenses of coarser recrystallised calcite, lying within the foliation. In the more argillaceous rock types, some soft sediment deformation structures are present, but in many areas they are destroyed by subsequent movement.

In the Godaguina River headwaters tectonic deformation is extreme, and appears to be accompanied by the recrystallization of calcite and the strong epidotization of much of the impure limestones. Extreme deformation and alteration (chloritization in part) of the interbedded non-calcareous units have taken place.

The grey-brown limestone in the Keveri Valley (P1407) is composed of microcrystalline calcite and some argillaceous material, with some microfossil fragments and minor small angular fragments of oxidised fine-grained volcanic rock, plagioclase, chloritic material, some augite and some quartz. There are occasional bands of more muddy material.

A dark, impure limestone from the southwestern portion of the Adau Limestone Member is made up of clastic calcite and abundant microfossils, with well rounded fragments of quartz, fine-grained volcanic rock, chloritic material, plagioclase and glauconite, in a dirty limey matrix. This rock is slightly pyritic.

Foliated metamorphic rocks developed from the Wavera Volcanics. Rocks which have been partially or completely altered are relatively common over the area of outcrop of the Wavera Volcanics; however these have generally suffered hydrothermal alteration only. Rocks which have been metamorphosed under conditions of directed pressure are largely restricted in occurrence to a linear zone roughly concurrent with the upper part of the Domara River, trending about 295° magnetic. Two main rock-types are present within the foliated rocks: basic schist and semi-schist, and less common quartz-sericite schist.

The basic schists (P1358, 1371, 1377, 1378, 1382, 1384, 1412) have an essential composition of plagioclase and actinolite, with accessory opaque oxide, and quartz and chlorite occurring in several sections. The actinolite is very pale green and is generally anhedral, but may be fibrous or form prismatic grains. The plagioclase is commonly granulated and cloudy or highly sericitised (relict), or may be clear and recrystallised. It is generally equigranular, but may be elongate when recrystallized. Quartz is a very minor constituent, occurring as small, irregular, unstrained grains. In several sections zones of incompletely altered, crushed plagioclase and fibrous actinolite (with minor sphene) alternate with zones in which recrystallization is complete. These zones lie parallel to the foliation defined by mineral segregation and the alignment of elongate actinolite grains. Chlorite occurs in one section (P1382), both as a major metamorphic mineral (pennine), and as bladed post-tectonic growths. Pyroxene occurs in one section (P1378), of a very finely-jointed rock of a typical composition and texture: this rock is dark and poorly foliated, with the texture in thin section of a hornfels, and is composed of brown hornblende, colourless diopside and plagioclase.

Both ferromagnesian minerals are partly sieved, and the diopside tends to occur separately from the hornblende, in small zones defining a poor foliation within the rock. In the diopside-rich areas, opaque oxide is more abundant than outside, the plagioclase is commonly altered, and chlorite and actinolite are present; the diopside is altering to actinolite, particularly where there is shearing.

The quartz-sericite schists (P1365, 1368, 1388) crop out in a western tributary of the upper Domara River, and have a more restricted occurrence on the divide between the Domara River and the Keveri Valley. They are very fine-grained rocks, and are very well foliated, comprising quartz, sericite and rock dust, in places with abundant small lenses of ?graphite in the foliation. Kink banding is very common, and quartz veins are commonly deformed, and consist of a fine mosaic of strained quartz grains.

In the western tributary of the upper Domara River, creek wash of hard, well foliated quartz-calcite schist is fairly common (P1369). The rock is made up of bands of fairly fine-grained calcite, alternating with bands of very fine-grained quartz, commonly almost fibrous in habit or forming mosaics of very small crushed grains. The rock has probably been caused by very severe mylonitization, with subsequent recrystallization of the calcite.

DOMARA RIVER BEDS

Volcanics

(i) Headwaters of the Domara River (P1391). Olivine-basalt is composed of well-rounded phenocrysts (xenocrysts) of olivine up to 3 mm across, in a matrix of very small prismatic augite grains set in cryptofeldsite, with abundant iron ore and some chloritised material. There are rare small xenoliths with a composition similar to that of the matrix of the rock, but with more abundant augite and coarser groundmass feldspar.

(ii) Adau River (P1399). Leucite-augite basalt is made up of abundant phenocrysts (up to 3 mm long) of pale green augite, and rare phenocrysts of colourless ?orthopyroxene, in a fine, dark groundmass of small augite grains and small euhedral leucite grains in a devitrifying (incipient spherulites) glass, with abundant accessory opaque oxide. The lava is vesicular.

(iii) East end of the Keveri Valley (P1406). Porphyritic lamprobolite - augite basalt is composed of pale green augite phenocrysts (less than $2\frac{1}{2}$ mm long), and fewer, smaller phenocrysts of lamprobolite (replaced internally by green chlorite), in a groundmass of small augite grains and lesser lamprobolite, set in feldspathic material, often with incipient plagioclase growths, and with abundant fine needles of (?)apatite. There are a number of irregular amygdales which are lined with brown (?)chlorite.

CLOUDY BAY VOLCANICS

Thin-section examination of a typical lava from these volcanics (P1424) shows it to be a lamprobolite-augite basalt, comprising very large phenocrysts of pale green augite, with fewer, smaller lamprobolite grains, in a feldspathic groundmass with some fine augite and lamprobolite, abundant iron ore, and large, irregular amygdales, some with a fine zeolite lining.

INTRUSIVE ROCKS

Intermediate Intrusives

(a) Andesite Prophyry (P1361, 1366, 1395, 1409, 1417, 1419, 1421).

In thin section the andesite porphyries are seen to be composed essentially of phenocrysts of hornblende, less common plagioclase, and sometimes augite (P1395, 1417, 1419), in a feldsitic groundmass. Dark green hornblende is generally more abundant, and forms larger phenocrysts, than pale green augite (when present). Plagioclase phenocrysts are well zoned in places, and are commonly altered; they are absent in some sections. The groundmass is composed almost entirely of plagioclase and interstitial feldspathic material (often altered) with minor chlorite, occasional small grains of ferromagnesian minerals, and accessory apatite and primary sphene. Some small patches of zeolite are present. Opaque oxide is invariably present, and commonly pyrite, which forms large skeletal grains in places. In the altered rocks (P1366, 1395, 1419) the ferromagneisan phenocrysts show several kinds of alteration: in one section, P1395a, dark green hornblende is largely replaced by pale green amphibole with wide margins of green-brown biotite, and colourless augite by pale green amphibole and some calcite, with narrow rims of biotite in places; in another section, of a second intrusion from the same outcrop (P1395b) hornblende is largely replaced by calcite, and augite is completely replaced by fibrous amphibole; in the same section the plagioclase phenocrysts are partly replaced by calcite and epidote, and irregular epidote growths occur throughout the rock; it is highly pyritic.

(b) Diorite (P1394, a, b, c)

Three thin sections were prepared from apparently different phases of the dioritic intrusion (P1394, a, b, c).

(i) P1395a. Fine-grained black rock injected by coarser, lighter coloured rock. The fine-grained part comprises equigranular, subhedral to anhedral ferromagnesian minerals (70%) - mainly green hornblende with minor augite, but with patches in which augite predominates with anhedral plagioclase, generally untwinned, and accessory opaque oxide; minor veins of chlorite, opaque oxide and pyrite occur. The medium-grained vein comprises about 60% euhedral to suhedral plagioclase (An 45-55 from albite twins); the rest is subhedral to anhedral green hornblende and lesser augite (often corroded and cloudy). The vein boundaries are sheared, so it was probably injected into a fracture.

(ii) P1395b. Meladiorite is an equigranular, medium-fine-grained rock made up of euhedral to subhedral, well twinned and unzoned plagioclase (60%), green-brown hornblende and colourless or pale green augite, and abundant opaque oxide. The hornblende and augite occur together, but often with patches in which one is dominant. Rarely, hornblende rims the augite, or occurs as small patches within it.

(iii) P1395c. Medium-grained diorite is made up of 80% well zoned or well twinned plagioclase (An 36 by extinction of albite twins), with occasional plates of untwinned feldspar (?orthoclase) enclosing small plagioclase and ferromagnesian grains, the rest being largely ferromagnesian minerals. Grain boundaries are often granulated and some interstital quartz is present. The main ferromagnesian mineral is green hornblende, often marginal about a core of augite; augite also occurs as discrete grains. Minor brown biotite and secondary chlorite are present, and accessory primary sphene occurs. Opaque ore is also present, and has associated with it in several veins, pyrite rimmed by hematite.

Some phases of the mixed "dioritic" intrusion are similar in thin section to the pyroxene-hornblende "hornfels" of the foliated metamorphic rocks of the Wavera Volcanics.

(c) Monzonite. (P1410)

Monzonite is made up of about 25% ferromagnesian minerals (pale olive-green to brownish-green hornblende, commonly spongy; pale green augite; straw brown to dark brown biotite and well zoned grains of plagioclase (2 to 2½ mm long), some of which are broken. The plagioclase grains are highly resorbed marginally, and are commonly enclosed, along with the ferromagnesian minerals, in very large (up to 6 mm) optically continuous plates of orthoclase, which is commonly perthitic. The orthoclase-plagioclase boundaries generally show exaggerated reaction relationships. Very minor interstitial quartz is present, and accessory opaque oxide has some associated pyrite. The rock is of hybrid origin.

Basic Intrusives

Dolerites (P1387, 1389, 1392, 1404)

Fine-grained dolerite intrusions are widespread in the Wavera Volcanics, and in some cases field relationships show them to be intruded subsequent to deformation of the Volcanics. They are essentially similar in thin section to the fine, unaltered dolerites and basalts belonging to the Volcanics, comprising augite, calcic plagioclase, interstitial glass or chlorite, and accessory iron ore.

Lamprophyre

In thin section, the lamprophyre is seen to be a biotite-augite lamprophyre, comprising occasional phenocrysts of augite (less than 1½ mm long), and abundant small prisms and grains of augite and less common brown to colourless biotite, set in anhedral, untwinned feldspar with abundant opaque oxide, minor chlorite, and occasional calcite growths. Minor quartz is present in several sections, and biotite occurs as abundantly as augite in one section. The texture is lamprophyric.

The fresh gabbro (P1363, 1408, 1415, 1423) is composed essentially of large grains of augite ophitically enclosing calcic plagioclase, with fairly abundant interstitial chlorite and accessory large skeletal grains of opaque oxide. Some pyrite is present, and chalcopyrite is a very rare accessory. In one specimen of subophitic gabbro (P1363) interstital micropegmatite occurs, with long apatite prisms.

In the altered gabbro (P1360, 1379, 1402, 1414) the augite is generally completely altered to pale green to olive-green actinolite, but is altered to chlorite in places and, occasionally to calcite; the plagioclase is often highly kaolinised; and the interstitial "glass" is a fine chloritic mass, with some calcite. In one section the opaque oxide appears to be ilmenite with extensive marginal alteration to leucoxene. Quartz is common in one section (P1402), and is probably a primary mineral. The alteration has generally been caused by hydrothermal solutions.

GEOLOGY OF THE KEVERI AREA, EASTERN PAPUA