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Record 1972/35

BAIYER RIVER - JIMI VALLEY RECONNAISSANCE GEOLOGY

by

D.E. Mackenzie and J.H.C. Bain

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SUMMARY

Reconnaissance geological mapping of the Baiyer River-Jimi Valley area in 1970 has shown that several of the formations previously mapped in the Bismarck Mountains (Dow & Dekker, 1964), the Kubor Anticline (Bain et al., 1970), and the South Sepik Region (Dow et al., 1968), are continuous across the Ramu 1:250 000 Sheet area.

In the southern part of the map area is the Jimi-Wahgi divide composed of mainly Upper Triassic Kana Volcanics intruded by Miocene Kimil Diorite. At the western end of the divide, Kana Volcanics overlie pre-Permian Omung Metamorphics and Permian Kubor Granodiorite, and are overlain by Upper Jurassic Maril Shale. On the northern flanks of the divide, the Kana Volcanics are overlain unconformably by Lower Jurassic Balimbu Greywacke which is in turn overlain by Maril Shale.

Farther north, between the Lai-Sau River system and the Yuat River, Maril Shale and Kana Volcanics are intruded by a batholith of Maramuni Diorite. The northern side of the Jimi Valley is marked by the Jimi Fault which has juxtaposed Kana Volcanics and Upper Jurassic Maril Shale against Lower Cretaceous(?) Kumbruf Volcanics. Miocene gabbro-diorite stocks (Oipo Intrusives of Dow & Dekker, 1964) intrude the Cretaceous rocks.

The Pleistocene stratovolcano, Mount Hagen (or Hagen Range) in the southwest of the map area, poured lahars, ash flow tuff, agglomerate, and lava into the Baiyer, Lai-Jimi-Yuat, and upper Wahgi valleys. Damming of the Baiyer and Wahgi Rivers by lava caused extensive lacustrine sedimentation in the Baiyer and upper Wahgi valleys.

Small quantities of copper, gold, and molybdenum occur in small shear zones in Kimil Diorite in some tributaries of the Tsau and Ganz Rivers. Alluvial gold in the Marramp River is worked by a locally owned co-operative.

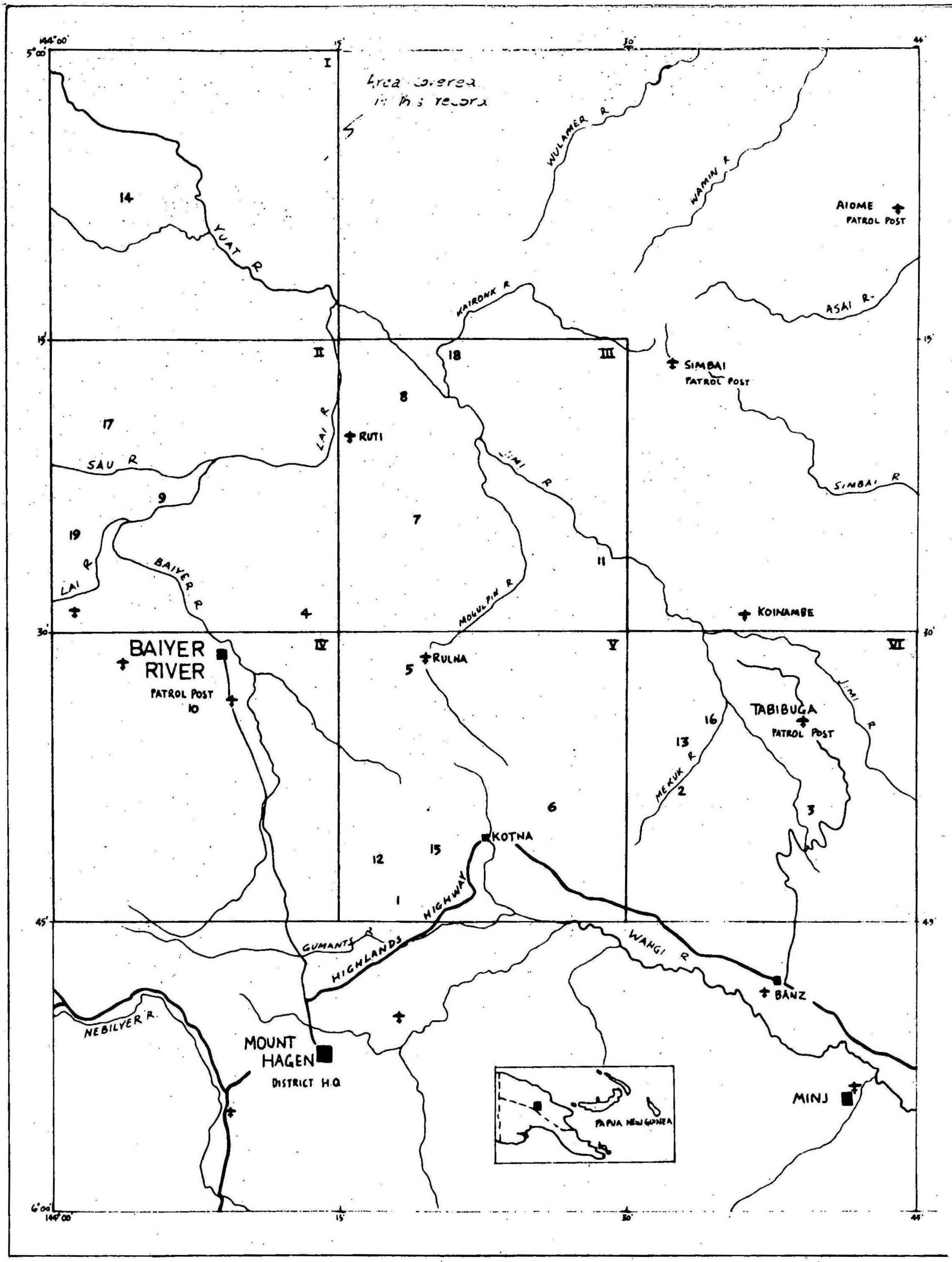

FIG. I LOCALITY DIAGRAM

To accompany Record 1972/35

B55/A5/39

Fig. 2 The Baiyer valley, from the northwest; Baiyer River cattle station and airstrip near centre. Note alluvial fans on far side of valley.
Neg. GA5089.

Fig. 3 Baiyer River valley viewed from near the Baiyer River-Lai River junction. Note the deep gorge developed in Quaternary volcanics. Neg. GA 5676.

INTRODUCTION

This Record is an account of the results of reconnaissance mapping carried out in July-August 1970 by the Bureau of Mineral Resources, (BMR), with the aim of completing mapping in those parts of the Ramu 1:250 000 Sheet area for which recently flown aerial photographs were available; it should be read in conjunction with Record 1970/79. The survey was also a follow-up to field work in the Kubor Range area (Bain et al., 1970). Mapping in adjoining areas has been carried out by Bain (1967) to the north, Dow et al. (1968) to the west, Dow and Dekker (1964) to the east, and Bain et al., (1970) to the south. J.H.C. Bain and R.J. Ryburn mapped in the area in 1967 and the results of their work are included in this Record. The 1970 work was carried out in conjunction with a regional gravity survey from a base at Baiyer River Patrol Post. After an initial helicopter reconnaissance, helicopter-supported stream traverses at about 10 km intervals were made.

Base maps at 1:50 000 scale were prepared in the photogeological section of BMR from all available aerial-photographs, side-look ng radar imagery (Fig. 11), and Division of National Mapping control points. Note: All localities mentioned in the text are in zone 55 on the international metric grid.

STRATIGRAPHY

PRE-PERMIAN

Omung Metamorphics

Lithic arenite, grit, fine conglomerate, green tuffaceous(?) sandstone, and multi-coloured volcanolithic conglomerate occupy a small area (1)* about 20 km northeast of Mount Hagen airport (Map 5). These rocks are correlated with the Omung Metamorphics of Bain et al. (1970); they are overlain unconformably by Upper Triassic Kana Volcanics and Upper Jurassic Maril Shale.

UPPER TRIASSIC

Kana Volcanics

Red, green, and multicoloured volcanics and interbedded sediments, correlated with the Kana Volcanics of Dow & Dekker (1964), Dow et al. (1968), and Bain et al. (1970), crop out along the Jimi-Wahgi divide from the head-waters of the Jimi River to the Sau River, and along the Jimi and Yuat Rivers. Less extensive outcrops are present 4 km west of Baiyer River and in the Black Hill area north of Mount Hagen.

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* Number refers to locality, on Fig. 1.

Although partly altered, almost all the rocks are hard and massive and form deep gorges and waterfalls in all but the largest streams. Because of this, few streams were traversed for any length, and the extent and nature of the beds has been deduced largely from observations made along walking tracks and from examination of stream boulders.

In the Mekuk River area, (2; map 6) a northeasterly dipping sequence more than 2500 m thick is well exposed in numerous deeply incised streams. Massive dark green and multicoloured basic to intermediate agglomerate, basalt flows and dykes, and maroon and grey-green tuff and conglomerate predominate. Light coloured acid(?) lava, fine volcanic breccia with purple clasts, pillow lava, black greywacke and recrystallized coral limestone are also present in the sequence.

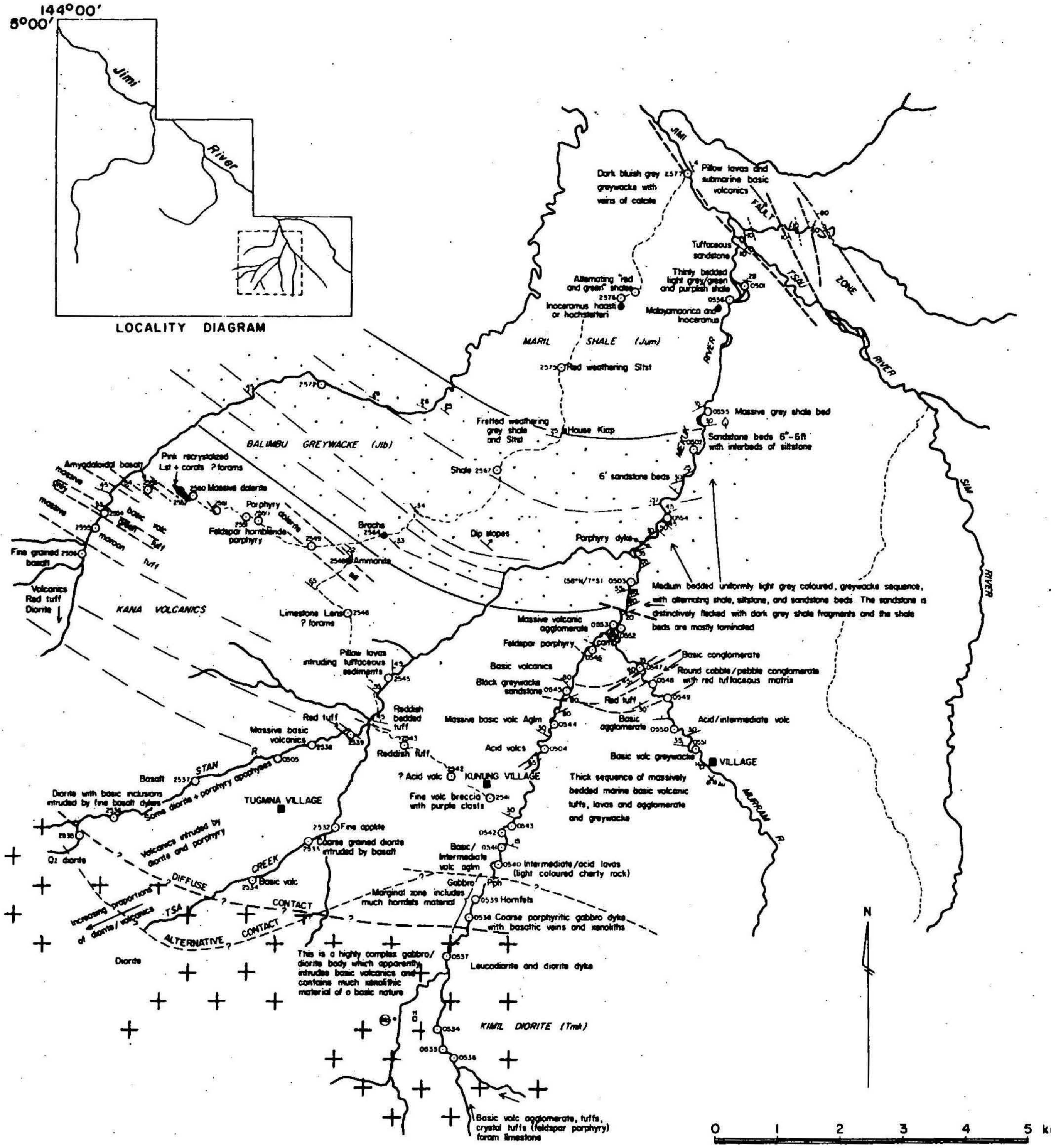
In the headwaters of the Tsau River (3; map 6) near Karap village, hard compact multicoloured fine volcanic breccia predominates, with lesser massive green agglomerate, well indurated bedded green tuff, and friable maroon tuff (Fig. 4). The rocks are sheared in many places, and the agglomerate is strongly altered.

In the head of the Trauna valley (4; map 4), 12 km east of Baiyer River Patrol Post, the lower part of the sequence consists of maroon shale, siltstone and tuff, green volcanolithic conglomerate and agglomerate, and light green fine agglomerate or breccia (average clast size 1 cm) with slightly flattened pumice fragments. This is overlain by a darker green (more basic?) agglomerate (clasts up to 15 cm) with coarse volcanolithic greywacke, some indurated shale beds, and thin to medium-bedded sheared pyritic acid volcanics.

Over the watershed, in the Mogulpin River valley (5; maps 3 and 5), and presumably higher in the sequence, pale green fine agglomerate and breccia, or both, dark green, purple, red, and multicoloured fine to coarse agglomerate and dark grey-green basic agglomerate were observed in scattered outcrops and stream rubble. Light green, dark grey-green and purple lavas, light green crystal tuff and red and purple tuffs are also present, but less common.

Streams draining south from the Mount Jaka area (6; map 5) contain mostly medium to coarse multicoloured agglomerate, dark to light green lavas, and some diorite.

Fine to coarse-grained diorite in various stages of alteration, porphyritic basalt, dolerite, and feldspar/hornblende andesite porphyry dykes and sills are common throughout the Kana Volcanics in the Jimi Wahgi divide. Where large enough to be shown separately, these bodies have been included in the Kimil Dirotie; however most are less than a few metres across.



———	*Geological boundary, accurate*	— — —	*Trend lines*
– – – – –	*Geological boundary, approximate*	✕ Au	*Alluvial workings (Gold)*
– – ? – – ? –	*Geological boundary, inferred*	• Mo	*Minor mineral occurrence (Molybdenum)*
———	*Fault, approximate*	⊙0543	*Sample locality*
⟋80	*Strike and dip of strata*	⊛	*Macrofossil locality*
		□H	*Helipad*

FIG. 4 GEOLOGICAL MAP — TSAU RIVER AREA

A fault-bounded block about 8 km southeast of Ruti (7; map 3) consists of acid volcanic breccia, green volcanolithic boulder conglomerate, green lavas and breccias, dark grey porphyritic hornblende andesite, mottled red and green porphyritic amygdaloidal lava, massive agglomerate, and tuff. Similar rocks, many of them strongly sheared and altered, crop out in the hills between Ruti and the Jimi River (8; map 3). Fine-grained porphyritic hornblende andesite, multicoloured and red and green mottled agglomerate, schistose serpentinite, and mylonite are the most common rock types.

Weathered purple and maroon porphyritic dacite lava crops out in the hills within about 5 km of the junction of the Lai and Baiyer Rivers (9; map 2). Mottled green siliceous volcanic breccia with 2-3 cm-sized clasts and chert layers, buff acid to intermediate amygdaloidal lava, coarse buff feldspathic sandstone, dark green porphyritic dacite and reddish amygdaloidal agglomerate crop out in a small stream (Toga Creek) 3 km southwest of Baiyer River Patrol Post (10; map 4). Maroon tuff, red calcarenite and agglomerate crop out along the Jimi River near its junction with the Ganz River. (11; map 6).

A cliff-forming white to light buff rhyolite is the dominant rock type in the thin (100 m) sequence of volcanics which overlies the Kubor Granodiorite in the Black Hill area (12; map 5) 20 km north northeast of Mount Hagen township. Multicoloured conglomerate and breccia, and green tuff are also present in the sequence.

Although selected specimens (excluding those of dark appearance i.e. basic) were examined in thin section, they represent such a diversity of rock types that only general comments on the petrography can be given. Andesitic breccias and lavas and altered diorites appear to be slightly more common than the dacitic and rhyodacitic tuffs and lavas. All rock types are altered to some extent although original structures and tectures are preserved. Most of the clasts in the multicoloured agglomerate and breccia are of andesitic composition. The pale green fine-grained breccia and tuff are mostly dacitic. The altered diorite and quartz diorite are commonly pale greenish grey, very fine-grained, and similar in appearance to some of the acid volcanics but they may be part of the Kimil Diorite.

Within the map area the base of these beds is exposed in only two areas. In the Black Hill area they unconformably overlie Kubor Granodiorite and Omung Metamorphics and are overlain unconformably by Maril Shale. Similar relationships exist elsewhere in the Kubor Anticline (Bain et al., 1970). In the Tabibuga area they conformably overlie Upper Triassic Jimi Greywacke (Dow & Dekker, 1964). Elsewhere the volcanics are unconformably overlain by Balimbu Greywacke or are fault-bounded.

No identifiable fossils have been found in the beds within the map area. The correlation of the volcanics and related sediments with the Carnian-Norian (Upper Triassic) Kana Volcanics is based on strong lithological similarities and stratigraphical relationships, identical with those in the Chimbu River type area and the Kubor Range area (Bain et al., 1970).

LOWER JURASSIC

Balimbu Greywacke

Unfossiliferous light to dark grey well indurated feldspathic siltstone and fine sandstone which underlie the Maril Shale have been correlated with the Balimbu Greywacke. The greywacke crops out in a 4 to 7 km-wide belt from the Tsau River in the east to the Sau River in the west, a 1 km by 8 km strip west of Baiyer River and in a 6 km by 35 km area southwest of the Yuat River.

In the Tsau River area (13; map 6; Fig. 4), the 2000-m thick sequence consists mainly of strongly indurated medium-bedded light grey greywacke, siltstone, and sandstone with alternating shale and fine siltstone beds. The sandstone is commonly distinctively flecked with dark grey shale fragments; the shale beds are generally laminated. Many of the 1 to 3 m-thick sandstone beds have a distinctive 'honeycomb' style cavernous weathering. Beds dip consistently to the northeast at 30° to 60°, are strongly jointed, disturbed by small-displacement faults, and are intruded by small porphyry dykes.

Similar sequences were also encountered between the Maril Shale and Kana Volcanics in the Ganz River, the headwaters of the Norgeritt River, and north of the Gai and Sau Rivers.

No identifiable fossils were found in these beds, although probable Lower Jurassic fossils have been collected from the Balimbu Greywacke outside the map area (Dow & Dekker, 1964; Dow et al., 1968; Bain et al., 1970). However, the beds conformably underlie the Maril Shale and unconformably overlie the Kana Volcanics. Thus on stratigraphical as well as lithological grounds they are regarded as the Lower Jurassic Balimbu Greywacke. There are two possible, but not favoured, alternatives to the lithostratigraphic correlation of these beds with the Balimbu Greywacke: i.e. they are the unfossiliferous lower part of the Maril Shale, or they are a hitherto undescribed formation of Upper Triassic to Upper Jurassic age.

Unfossiliferous dark grey shale and siltstone and green-grey volcanolithic sandstone beds, immediately southwest of the Yuat River in the northwest corner of the map area (14; map 1), are tentatively correlated with the Balimbu Greywacke. However, lithologically they are more akin to the Kondaku Tuff. Fragmental plant fossils indicate a Jurassic or Lower Cretaceous age (White, 1967) which is consistent with either correlation. The rocks cover an area of about 200 km^2, and unconformably overlie Upper Triassic Kana Volcanics and Jimi Greywacke. A large fault forms the western boundary of the beds, and has caused considerable shearing and minor faulting in them. Near the Yuat River at their northwestern extremity, the beds are overlain by massive lahar material from Mount Hagen.

The beds in Mina Creek, (GR 55/17254300), south of the Yuat River, consist of dark grey to green-shale and siltstone, greenish grey to dark green volcanolithic and feldspatholithic sandstone, and interlaminated siltstone and shale. Shale and siltstone, with minor interbedded sandstone, predominate in the lower half of the section; sandstone, with lesser interbedded laminated siltstone and shale, predominates at the top. The shale and siltstone contain small very dark grey to black ellipsoidal calcareous concretions, and are massive to highly fissile and closely-jointed. The sandstone is fine to very coarse-grained, and contains small dark grey shale or siltstone clasts.

Beds are horizontal to near-vertical, and strongly folded on a scale of a few tens of metres. Small faults and quartz-filled tension gashes cut them in some places.

Another section, in a stream 16 km northwest of Ruti, consists of dark grey-green volcanolithic sandstone, polymict pebble and cobble conglomerate, and dark grey shale. The sandstone and conglomerate are interbedded, and the conglomerate beds are commonly about 1 m to 1.5 m thick, with some over 10 m. In places, cobble conglomerate beds, 20 cm to 10 m thick, grade upwards into pebble conglomerate, then into coarse sandstone, fine sandstone, and finally shale, and are repeated rhythmically. Charred plant remains are found in the coarser-grained sediments. Microdiorite, monzonite, and dolerite dykes related to the nearby Maramuni Diorite cut the sediments at three places in the section. The conglomerate consists of well-rounded pebbles of red and grey fine-grained limestone up to 10 cm across, and subrounded to subangular pebbles of laminated grey-green lithic sandstone, microdiorite, dark grey, grey-green, and green fine-grained volcanic rocks, black hornfelsed siltstone, chert, and red shale or fine tuff. The lithologies represented in the conglomerate suggest that the sediments were at least partly derived from the underlying Kana Volcanics.

UPPER JURASSIC

Maril Shale

Dark to light grey shale, siltstone, and sandstone of the Maril Shale crop out 5 km west of Baiyer River, on the south side of the lower Jimi valley from the Tsau River to the Norgeritt River, on the north side of the Gai and Sau Rivers, and between Kotna and Baiyer River in the hills north of Mount Hagen town. Fossiliferous Maril Shale also crops out in the Jimi River 10 km north-northeast of Ruti. Two small fault wedges of indurated dark grey shale 7 km north of Kotna and 4 km south of Rulna are correlated with the Maril Shale.

Although most of the rocks are well indurated, the shale beds commonly form strongly fretted recessive outcrops, and much of the siltstone is friable. Silicified and hornfelsed beds occur in the vicinity of igneous intrusions but are not common. Thus much of the area underlain by Maril Shale has moderate relief and a lower elevation than that underlain by the much more resistant Kana Volcanics and Kimil Diorite and the more indurated Balimbu Greywacke (Fig. 11).

In the area between Kotna and the Baiyer valley, the formation is well exposed in the beds of numerous small streams. In a small stream (15; map 5 - Wara Klip) 4 km west of Kotna, the sequence is about 2000 m thick and consists mainly of massive light to dark grey shale and siltstone interbedded with laminated shale, siltstone, and fine lithic sandstone. Fossiliferous maroon shale, pyrite laminae and nodules, light grey tuffaceous sandstone, fine-grained black limestone, and quartzose sandstone are present but not common.

In the Tsau River area (Fig. 4; 16) the formation is 2000 to 2500 m thick and consists mainly of massive and thin-bedded light to dark grey shale and siltstone. Laminated light grey, green, and purplish shale sequences, mostly well indurated, are common in the upper part of the formation. Dark blue-grey greywacke with calcite veins and feldspathic sandstone beds are minor components.

North of the Gai and Sau Rivers the Maril Shale is composed mainly of siltstone and shale with subordinate fine-grained sandstone; hornfels is common. Most of the beds are dark grey, although maroon shale and siltstone are also common. The thickness of these beds is probably about 500 m.

Fig. 5 Inoceramus cf. haasti, from the Maril Shale.

Well preserved Upper Jurassic Malayomaorica malayomaorica and Inoceramus haasti (Fig. 5) occur in at least two levels in the formation and are found at numerous localities. Their presence confirms the lithological correlation of the sequence with the Maril Shale. However, where complete sections have been observed (e.g. Wara Klip), the fossils have been seen only in the upper part of the sequence. Thus the lower part could be older than Upper Jurassic.

The formation conformably overlies Balimbu Greywacke (Lower Jurassic), except in the area between Kotna and the Baiyer valley where it unconformably overlies Kana Volcanics. It is possible that the Balimbu Greywacke is present but very poorly developed in the Kotna-Baiyer area. It is also possible (as explained above) that the Balimbu Greywacke in the map area is actually part of the Maril Shale and thus the Maril Shale would everywhere lie unconformably on the Kana Volcanics. The latter possiblity is considered unlikely, and the apparent absence of the Balimbu Greywacke is probably due to emergence of this area, which is part of the Kubor Anticline, during the Lower Jurassic. To the northeast the Maril Shale is faulted against Kana Volcanics in the Jimi Fault Zone, and to the west it is faulted against Salumei Formation at the Bismarck-Maramuni Fault Zone. It also occurs as small fault wedges in the Kana Volcanics along the Jimi-Wahgi divide. The formation is unconformably overlain by Quaternary volcanics, sediments, and alluvium. It is intruded by gabbro sills and dykes correlated with the Cretaceous Kera Sill (Bain et al., 1970), and by plutons of the Miocene Maramuni and Kimil Diorites.

UPPER JURASSIC?

Kompiai Formation

Dark grey phyllitic mudstone, siltstone, and sandstone of unknown thickness crop out in the southwesterly-trending portion of the Kaironk valley (18; map 1) and are correlated with the Kompiai Formation of Dow & Dekker (1964). Rock types include light grey laminated greywacke siltstone (with dark siltstone clasts) and sandstone, dark grey siltstone, dark grey phyllitic shale, schistose shale, maroon phyllite, and dark grey highly indurated cleaved shale. The beds appear to underlie the Kumbruf Volcanics, but no contacts were seen. They are correlated with the Kompiai Formation on the basis of lithological similarity and relations to the Kumbruf Volcanics.

A stream boulder of highly fossiliferous indurated calcareous sandstone, virtually a coquina, contained the only fossils seen. The molluscan fragments are similar to Malayomaorica malayomaorica of the Upper Jurassic Maril Shale, but are too poorly preserved to be identifiable. An Upper Jurassic age is consistent with the Jurassic-Cretaceous age range allowed by the existence of belemnites in Kompiai siltstone (Dow, 1962).

LOWER CRETACEOUS?

Kumbruf Volcanics

Dark green agglomerate and volcanolithic conglomerate and dark grey amygdaloidal lava of unknown thickness were found in the upper Kaironk valley near Salemp, along strike from previously mapped Kumbruf Volcanics (Dow & Dekker, 1964, Bain, 1967). Massive epidotized agglomerate farther downstream may also be Kumbruf Volcanics. However, without more detailed work it is difficult to distinguish Kumbruf and Kana Volcanics when they are adjacent. The presence of the formation in other parts of the area is deduced from aerial-photograph interpretation and, in the northwest corner of the area, from stream float (Dow et al., 1968).

Dow and Dekker (1964) stated that the Kumbruf Volcanics are probably Upper Cretaceous because they are conformable with a phyllitic shale and siltstone sequence (Asai Shale) which contains a fossiliferous Eocene limestone lens 600 m stratigraphically above the volcanics. If the Kompiai Formation is Upper Jurassic, i.e. the metamorphosed equivalent of the Maril Shale, then the Kumbruf Volcanics are possibly equivalent to the lithologically similar Kondaku Tuff and therefore Lower Cretaceous (Fig. 6).

LOWER CRETACEOUS

Kondaku Tuff

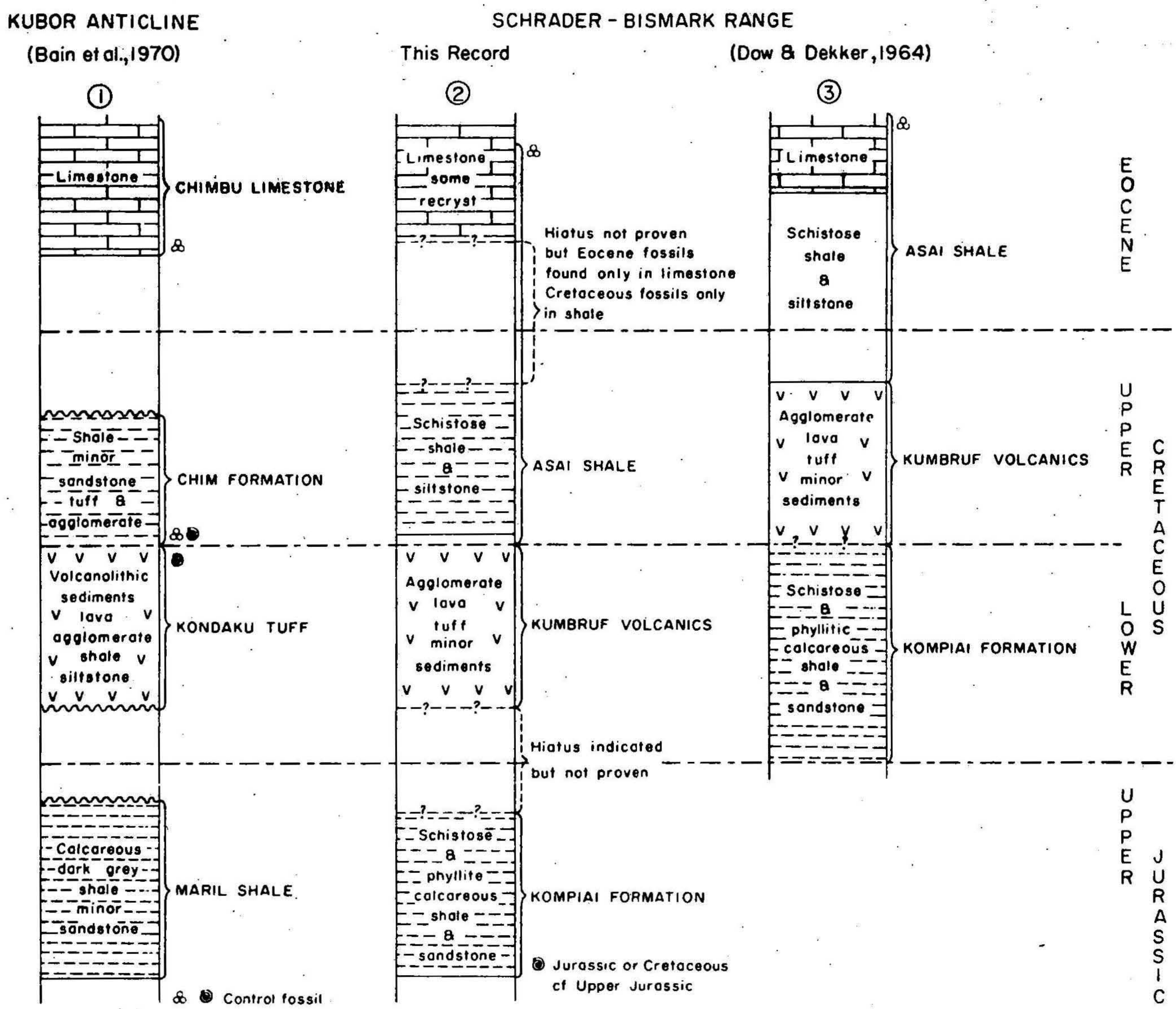
Where shown, it was mapped and described by Bain et al. (1970).

UPPERMOST CRETACEOUS TO EOCENE

Salumei Formation

Shale, siltstone, and sandstone to Campanian to Maestrichtian or late Upper Cretaceous age (Owen, 1972), correlated with the Salumei Formation of Dow et al. (1968) crop out in Waia Creek near Linganas (19) or Renginas (G.R. 55/16804020) on the western edge of the map area (Maps 2, 4). To the northeast the sediments are faulted against Maril Shale; to the southeast they are unconformably overlain by Hagen Volcanics, and to the west they are conformably overlain by Tertiary "e" Stage (Upper Oligocene) Pundugum Formation. In the uppermost part of the Salumei Formation near Linganas there is a 200-m thick bed of calcarenite (Dow, 1961), and grey to reddish brown fine to medium-grained recrystallized limestone. The limestone bed extends south across the Gai River, and north to the Sau River, beyond the

Fig 6



A Reappraisal of the Asai Shale-Kumbruf Volcanics-Kompiai Formation sequence in the Schrader Bismarck Range as described by Dow & Dekker (1964) in the light of controlled and detailed information from the Kubor Anticline (Bain et al., 1970). The formations in column (3) when rearranged as in column (2) can be easily correlated with several equally distinctive formations in the Kubor Anticline (column (1)).

map boundaries. Its stratigraphic position between uppermost Cretaceous and upper Oligocene beds suggests an Eocene to lower Oligocene (Ta-Tc) age and correlation with the Eocene to Oligocene Nebilyer Limestone (Bain et al., 1970), with which it is colinear. Regional dip is about 30° southwest. Main lithologies exposed in Waia Creek are grey, grey-green, and green-grey shale, dark grey laminated shale and siltstone, and grey to dark grey and grey-green feldspatholithic laminated and massive sandstone. Brick-red siltstone, bluish-grey shale, green sandstone breccia, and coarse pebble conglomerate are less common in the section. The conglomerate consists of rounded pebbles of limestone, and green, grey to dark grey, and brick-red sandstone and volcanics. Dykes and sills, probably related to the Maramuni Diorite, of hornblende microdiorite porphyry, diorite, and microgabbro up to 10 m thick cut the sediments in many places.

Outcrops of purple pebbly volcanic grit and siltstone, pebble conglomerate, dark grey silty limestone, and rhyolitic welded ash-flow tuff, which occur in the Laneme River/Lumis mission area about 10 km west of Baiyer River, may belong to the Salumei Formation, or to either the Pundugum Formation or Burgers Formation (both Miocene) of Dow et al. (1968).

QUATERNARY

Hagen Volcanics

The Mount Hagen Range, in the southwest corner of the map area, is a large composite Quaternary* stratovolcano which has erupted rocks of shoshonitic, basaltic, and andesitic composition. The eruptive centre is a deeply-eroded composite caldera, about 13 km wide, which has a smaller cone with a summit crater on its northeastern flank (Fig. 7). The outer slopes of the small cone are almost continuous with, and indistinguishable from, those of the main caldera. From this central complex, lahars and lesser tuff, lava, and derived sediments spread northeast into the Baiyer River valley, where they are overlain by late Pleistocene to Holocene lacustrine and fluviatile sediments (Fig. 1). Lahars moved down the Lai River to the Jimi and Yuat Rivers, where they banked up against the scarp of the Jimi Fault, covered a large area around the Lai-Jimi confluence (Fig. 8), and travelled down the Yuat River to the edge of the Sepik Plains, a distance of almost 130 km from the caldera.

* Whole rock K/Ar dates of 200 000 years have recently been obtained by R.W. Page (pers. comm., 1972).

About 6 km south-southeast of Ruti, a small volcanic cone with a shallow summit depression and a narrow lava field extends about 1.5 km north down an adjacent stream. This cone may be related to the even smaller vent near Linganas and to the basaltic flows near the Yuat River reported by Dow et al. (1968). All of these small volcanic centres may be genetically related to Mount Hagen volcano.

Lava flows exposed in streams on the slopes of the volcano and, less commonly farther away on the flatter volcanic apron, are 1 to 20 m thick, have sharply-defined bases, massive tough interiors, and vesicular tops. The tops of some flows are brecciated and mixed with overlying ash and tuff. Small plugs of biotite-hornblende-pyroxene andesite prophyry crop out in the headwaters of the Anji River (extreme southwest corner of map area), and in the upper Laneme River area.

The lahar material is highly compacted and consists largely of angular blocks of massive lava 1 cm to 3 m across; average size of the fragments is about 15 cm. Boulders of lava over 30 m across have been sighted in 100-m high terraces in the middle Yuat River. In some areas there is little of the fine-grained detritus typical of lahars, and in places there is evidence of welding; such rocks are more closely ak n to agglomerate. All the above features suggest that the unit was formed by explosive eruptive activity either associated with the formation of the caldera of the Hagen Range, or when the caldera (perhaps water-filled) was breached. In either case, the volume and nature of the material and the distance it has moved indicate catastrophic disturbance of the volcanic complex.

The following rocks, collected mainly from massive lava flows around the lower slopes of the volcano, were examined in thin section:

Rock type	No. of Specimens
Absarokite	1
Shoshonite	16
High potash olivine basalt	11
2-pyroxene basalt	3
Hornblende-olivine- 2-pyroxene basalt	1
High potash hornblende-olivine basaltic andesite	2
Olivine- 2-pyroxene andesite	1
Olivine-hornblende-2-pyroxene andesite	3

Fig. 7 Mount Hagen Range, viewed from the outskirts of Mount Hagen town. Light-coloured grass covers the once glaciated southern summit area. Note the almost flat-topped profile.
Neg. GA5091

Fig. 8 Terraced beds of Hagen Volcanics in the upper Yuat River valley, immediately downstream from the Lai River/Jimi River confluence. The Jimi Fault Zone extends along the base of the hills at left.
Neg. GA481

Hornblende-2-pyroxene andesite	3
Biotite-hornblende-2-pyroxene andesite	1
2-pyroxene-hornblende andesite/dacite	1

The number of specimens is probably an approximate guide to the abundance of each rock type.

The absarokite consists of augite and olivine phenocrysts in a groundmass of plagioclase, augite, magnetite, olivine, potash feldspar, ilmenite, and apatite. The shoshonite, basalts, and basaltic andesites consist of plagioclase, augite phenocrysts, and olivine, hornblende, and hypersthene phenocrysts as listed above, in a fine-grained groundmass of plagioclase, augite opaque oxides (generally titaniferous magnetite), and minor interstitial alkali feldspar. The amount of alkali feldspar is least in the rocks that lack olivine, or contain appreciable amounts of hypersthene. The andesites contain a variety of phenocrysts, as indicated above, but all contain plagioclase, augite, and hypersthene phenocrysts. One rock contains tridymite as interstitial patches up to 2 mm across. It is the most acid rock yet collected from Mount Hagen volcano and is probably close to dacite in composition.

The amphibole in the Hagen Volcanics is generally deep yellowish brown basaltic hornblende with rims of fine-grained pyroxene and magnetite; in two of the most acid rocks the amphibole is common green hornblende.

Mackenzie & Chappell (1972) discussed the chemistry and petrogenesis of the Highlands volcanoes, including Mount Hagen.

Quaternary lake sediments, fanglomerates, and alluvium

An unknown thickness of Quaternary lake sediments with interbedded and overlying fanglomerates and a thin but extensive veneer of alluvium covers the floors of the Baiyer valley (Fig. 1) and the northwestern end of the Wahgi valley. The latter area has been described by Bain et al. (1970). Alluvium also occurs as river-terrace and valley-fill sediments throughout the map area, although only the largest outcrops are shown on the accompanying maps.

Large areas of the upper parts of the lake sediments in the Wahgi valley are composed of peat and minor silt and tuff layers (R. Blong, pers. comm. 1971). However, the lake sediments in the Baiyer valley appear to contain far less organic material. Tuff, sand, and pebble conglomerate are common. A 1-2 m thick bed of diatomite occurs about 5 km east of Baiyer River Patrol Post (p. 24).

The lake sediments in both valleys appear to have resulted from damming of the rivers by Quaternary Hagen Volcanics. The fanglomerates probably formed during a period of accelerated erosion during the late Pleistocene, although some small fans are still being formed.

INTRUSIVE ROCKS

Kubor Granodiorite

Coarse-grained plutonic rocks equivalent to the Permian Kubor Granodiorite of the Kubor Range (Bain et al., 1970) crop out in the low hills on the north side of the upper Wahgi valley, 13 km northeast of Mount Hagen town. The rocks are deeply weathered tonalite, granodiorite, diorite, and gabbro which intrude Omung Metamorphics (p. 2), and protrude from onlapping Hagen Volcanics and Quaternary fanglomerate and alluvium. To the northeast they are overlain unconformably by Upper Triassic Kana Volcanics and Upper Jurassic Maril Shale. Boulders of fresh hornblende diorite and porphyritic hornblende microgabbro were collected from a stream near Paglum Mission.

Kimil Diorite

Kimil Diorite (Bain et al., 1970) occurs as a number of small diorite-tonalite-dolerite bodies intruding the Kana Volcanics throughout the Wahgi-Jimi divide. Southeast of Ruti, Maril Shale is intruded by andesite and trachyandesite porphyries correlated with the Kimil Diorite. Lithologically, the Kimil Diorite is similar to the Oipo Intrusives (Dow & Dekker, 1964), though generally less complex, and is about the same age: 15 m.y., or middle Miocene (Page, 1971).

The largest intrusions are east of Tigi Plantation (G.R. 55/19603820), in the headwaters of the Ganz River (G.R. 55/21803840), and close to Baiyer River Patrol Post (G.R. 55/18403910) (Maps 4 and 5). Smaller intrusions occur in the Mogulpin River, north and northwest of Banz (Map 5, Fig. 4), and south of Tabibuga (Map 6; G.R. 55/23803800). In general, the intrusions consist of coarse-grained to porphyritic diorite, granodiorite, or tonalite, intruded by complex networks of gabbro and dolerite dykes and veins. The larger dykes extend up to 1 km or more into the host rocks.

The intrusion east of Tigi Plantation consists of medium to coarse-grained diorite intruded by a complex network of dolerite (commonly porphyritic) and gabbro dykes and veins which constitute up to 70 percent of individual outcrops. Pyrite is common in and around a diorite porphyry at the southern end of the complex. Altered hornblende-augite gabbro, altered augite dolerite, and altered quartz-hornblende microdiorite porphyry were examined in thin section; the petrographic data are summarized in Table 1. Kennecott Explorations (Australia) reported that the intrusive complex in the Ganz River consists of a southern older 'granodiorite/quartz diorite mass' intruded by east-west linear 'granite/quartz porphyry/granodiorite mass' (Jones, 1970). Close to Baiyer River, coarse-grained granodiorite or tonalite is criss-crossed by at least three generations of diorite, dolerite, microgranodiorite or tonalite, and gabbro dykes and veins. In places, apophyses of granodiorite intrude mineralized (pyrrhotite?) dolerite. One rock from about 5 km northeast of Baiyer River is an altered hornblende-augite mangerite porphyry (Table 1).

An intrusive body of unknown extent occurs near the contact between Kana Volcanics and Maril Shale, about 8 km south-southeast of Ruti. It consists of hornblende andesite or diorite porphyry which contains euhedral hornblende phenocyrsts up to 15 cm across, and trachyandesite (or micromonzonite) porphyry. The trachyandesite contains phenocrysts of heavily altered oligoclase-andesine and sanidine, and kaersutite (α = pale yellow-brown, β = deep brown-red-brown, γ = yellow-brown) rimmed by small aegirine-augite crystals. The groundmass consists of plagioclase and sanidine laths, small equant aegirine-augite grains (pleochroic in deep green, yellow-brown, and yellowish green), interstitial analcite and zeolite, and minor amounts of magnetite, biotite, and apatite.

Stocks and dykes too small to be shown on the maps (Plate 1) occur throughout the area. These are generally pyroxene and hornblende-pyroxene dolerite and gabbro.

Maramuni Diorite

The large intrusive body in the northwest corner of the map area, west of Ruti, is continuous with the Maramuni Diorite of Dow et al., (1968). Within the Ramu Sheet boundary, the batholith covers an area of about 400 km^2, and intrudes Upper Triassic Kana Volcanics, Lower Jurassic Balimbu Greywacke(?), and Upper Jurassic Maril Shale. K/Ar and Rb/Sr dates on the Diorite range from 11 to 13 m.y. (Page, 1971), i.e. upper Miocene. It consists largely of granodiorite, monzonite, and gabbro. Petrographic data are summarized in Table 1.

In the far northwest of the map area (Map 1), south of the Yuat River, the batholith is partly fault-bounded and consists of leucocratic biotite-hornblende granodiorite (strongly sheared near the fault), and less common augite-hornblende gabbro, hornblende microdiorite porphyry, and hornblende-biotite rhyodacite porphyry. The granodiorite and gabbro are medium to coarse-grained and fresh; the microdiorite porphyry is a marginal phase and contains either hornblende or plagioclase phenocrysts. Farther east, near the eastern end of the batholith (G.R. 55/19184188), float of medium-grained biotite augite monzonite was collected, and dykes of hornblende microdiorite and dolerite porphyry intrude both Kana Volcanics and Balimbu Greywacke. On the southern side of the batholith, 5 km east of Labalam, diorite is the main plutonic rock type and is associated with porphyritic hornblende diorites, microdiorite, andesite, and dolerite dykes. To the east, 5 to 6 km north of the Sau-Lai River junction, the batholith consists of diorite or granodiorite and porphyrytic hornblende diorite (with plagioclase and/or hornblende phenocrysts). It is flanked by a 1.6-km wide hornfels zone and is associated with dykes and sills, up to 60 m thick, of hornblende diorite (porphyritic and non-porphyritic), andesite, and dolerite which have intruded Maril Shale.

Minor Intrusives

Apart from the numerous small stocks, dykes, and sills associated with the Kimil and Maramuni Diorites already described, there are several dykes and two large sills of dolerite, gabbro, and microdiorite intruding the Maril Shale south of Tigi plantation. The largest of these bodies are shown on Map 5. In places, the diorite or dolerite is cut by small aplitic veins and dykes. The dyke, about 2 km south-east of Tigi (specimen 20NG 1349, Table 1), is an altered quartz-hornblende microdiorite porphyry. These intrusives may be related to the nearby Kimil Diorite (middle Miocene), or may be a correlative of the Kera Sill, which is possibly Cretaceous (Bain et al., 1970).

TABLE 1. ESTIMATED MODES OF SPECIMENS OF INTRUSIVE ROCKS.

	Plagioclase (%; Comp.)	Quartz (%)	Augite (%)	Hornblende (%)	Other Minerals (primary; secondary)	Notes
1	50	10	5-7	1	10% K-felds, 26% mt, tr. ap; 15% musc, 3% chl, tr. pr	Plag heavily sericitized; hbl largely chloritized, mantles augite; qtz & or graphically intergrown

	Plagioclase (%; Comp.)	Quartz (%)	Augite (%)	Hornblende (%)	Other Minerals (primary; secondary)	Notes
2	75(An_{57})		10	1-2	2% mt, tr.ap; 5-7% act, 2% chl, 1% leuc, tr. ep	Hbl mantles & corrodes augite, is largely uralitized
3	70(An_{65})		15		2% mt; 2% act, 5% chl, 1% leuc	Subophitic texture
4	80	2-5		5-7	1% mt, tr.ap; 2-3% cc, tr. ep, chl & act	Hbl heavily altered
5	sericitized		15		2% op; 20-30% ser, 7-8% chl, tr. leuc & ep	Aug. partly chloritized
6	80-85	5		5	1% op, tr. sph; 1% each cc, ep, chl & ser	Plag. partly recrys hbl partly alt
7	45-50		15		2% mt, 1% ilm, tr. ap; 20% chl, 3% cc, 1-2% serp; 3-4% natrolite, 5% analcite	Olivine(?) pseud. by aggregates of cc, chl, & serp
8	50(An_{20-40})		10(a-a)	2-3(k)	30% sanidine, 1% mt, tr. bi, ap, & aen; 2-3% analcite, 1-2% chabazite	Feldspars heavily altered
9	60	5	tr.	20	1% mt, tr.ap; 5% chl, 1% ep, 5% cc, 1-2% act, tr. leuc	Plag. heavily sericitized; hbl partly repl. by cc, chl, & act
10	20 (relict)	1-2			3% op, 2-3% ap; 30% ser, 3-5% chl, 7-8% cc, 30% alunite(?)	Almost completely altered
11	63(An_{35})	20		3	5-7% K-felds, 5% bi, 1%mt, tr. ap & sph	Orthoclase poikilitic

	Plagioclase (%; Comp.)	Quartz (%)	Augite (%)	Hornblende (%)	Other Minerals (primary; secondary)	Notes
12	45(An_{35})	30		5	10% k-felds; 5% bi, 1% mt, tr. ap & sph; 2% chl	Bi partly chloritized, ortho-clase microperthitic
13	?	? 6		6	5% bi, 1% mt, tr. ap & sph; tr. cc	F/g bi rims hbl; extremely f/g grou[illegible] mass
14	25		10-15	50	1% mt, tr.ap; 5% ep, 3% ser, 1% pr	Melanocratic; ragg[illegible] aug. cores in hbl.
15	40-		15		30%+ K-felds, 5% bi, 1% mt, 1-2% ap, tr. sph; 3% ser, tr. cc	Feldspar heavily altered
16	70	2		15	1% op, tr. ap.; 7% ep, 3% chl, tr. musc	Plag. partly alt. to ep; hbl partly alt to chl & ep

Kimil Diorite

1. Hornblende-augite mangerite porphyry (20NG0667)
2. Hornblende-augite gabbro (20NG0671)
3. Augite dolerite (20NG0677)
4. Hornblende microdiorite porphyry (20NG0681)
5. Pyroxene gabbro (20NG0696)
6. Quartz-hornblende microdiorite porphyry (20NG1358)
7. Olivine(?)-augite basalt porphyry (20NG1516)
8. Kaersutite-aergirine augite trachyandesite porphyry (20NG1535)

Maramuni Diorite

9. Quartz-hornblende andesite porphyry (20NG1474)
10. Hornblende andesite porphyry (20NG1566)
11. Hornblende-biotite granodiorite (20NG1572A)
12. Biotite-hornblende granodiorite (20NG1572B)
13. Hornblende-biotite rhyodacite porphyry (20NG1572D)
14. Augite-hornblende gabbro (20NG1572E)
15. Biotite-augite monzonite (20NG1581A)

Minor intrusion

16. Quartz-hornblende microdiorite porphyry (20NG1349)

Abbreviations: a-a - aegirine-augite, act - actinolite, aen - aenigmatite, alt - altered, ap - apatite, aug - augite, bi - biotite, cc - calcite, chl - chlorite, ep - epidote, f/g - fine-grained, hbl - hornblende, ilm - ilmenite, k - kaersutite, k-felds - potash feldspar, leuc - leucoxene, mt - magnetite, musc - muscovite, op - opaque minerals, Or - orthoclase, plag - plagioclase, pr - prehnite, qtz - quartz, repl. - replaced, ser - sericite, serp - serpentine, sph - sphene.

STRUCTURE

The two main structural elements (as defined by Bain, 1972) within the map area are the Kubor Anticline to the southwest and the New Guinea Mobile Belt to the northeast (Fig. 9).

Kubor Anticline

The Kubor Anticline lies southwest of a fault zone which trends southeast along the northern side of the Baiyer and Wahgi valleys and is colinear with the Bismarck Fault Zone (Bain et al., 1970) and the Maramuni Fault Zone (Dow et al., 1968). Within the map area the anticline is cut by two, or possibly three, major northerly-trending splays of this fault zone. It is extensively covered by Quaternary Hagen Volcanics which have been extruded from centres on or near the intersection of the faults and the trend of the axis of the Kubor Anticline.

In the hills between the Baiyer and Wahgi valleys, Triassic and Jurassic beds dip northeasterly at 20 to 50° off the Kubor Granodiorite, and are cut by small-displacement normal faults oriented radially to the anticlinal axis. These faults, as well as the major north-trending splay faults, have step-faulted the northern flank of the anticline (west side up).

New Guinea Mobile Belt

The New Guinea Mobile Belt is characterised by large well defined anastomosing fault zones e.g. Bismarck - Maramuni Fault Zone, Jimi Fault Zone, Bundi Fault Zone (Fig. 9), and numerous small shears and fractures, all with a general northwesterly trend.

The main branch of the Bismarck-Maramuni Fault Zone is a clearly delineated, topographically recognizable break between beds of different age and lithology. However, the numerous similarly-trending small shears and fractures in the beds and intrusions immediately north of the main fault indicate that the fault zone is considerably wider than indicated on the map. In fact, most of the area of Kana Volcanics and Kimil Diorite in the Jimi-Wahgi divide can be regarded as lying within the Bismarck Fault Zone.

The Jimi Fault Zone is a shear zone 2 to 5 km wide which follows the line of the Yuat and lower Jimi Rivers, in part separating Triassic and Cretaceous beds. In the southwest near Bokapap, it splays into two arms, the southern arm merging with the Bismarck Fault Zone near Mount Udon, and the northern arm trending towards the Bismarck Intrusive Complex. Estimates of the magnitude and nature of the movements that have taken place along the Jimi Fault Zone are hampered by its complexity. However, it is apparent that the south side has moved upwards some 2000 m or more relative to the north side. On the southern, Tsau River, splay of the fault zone, the movement appears to have been in the opposite sense. Horizontal movements may have occurred on this and other major fault zones such as the Bismarck Fault Zone (Dow et al., 1968), but we found no evidence within the map area to support or discount this possibility.

A 30 km-wide parallel-sided horst block, composed almost entirely of northeasterly-dipping Triassic and Jurassic sediments and volcanics intruded by Miocene acid to intermediate plutons, lies between the Bismarck-Maramuni and Jimi Fault Zones. The horst has been uplifted about 2000 m relative to the adjacent blocks.

Younger Mesozoic and Palaeogene sediments and metasediments northeast of the Jimi Fault Zone also dip generally to the northeast and are strongly faulted.

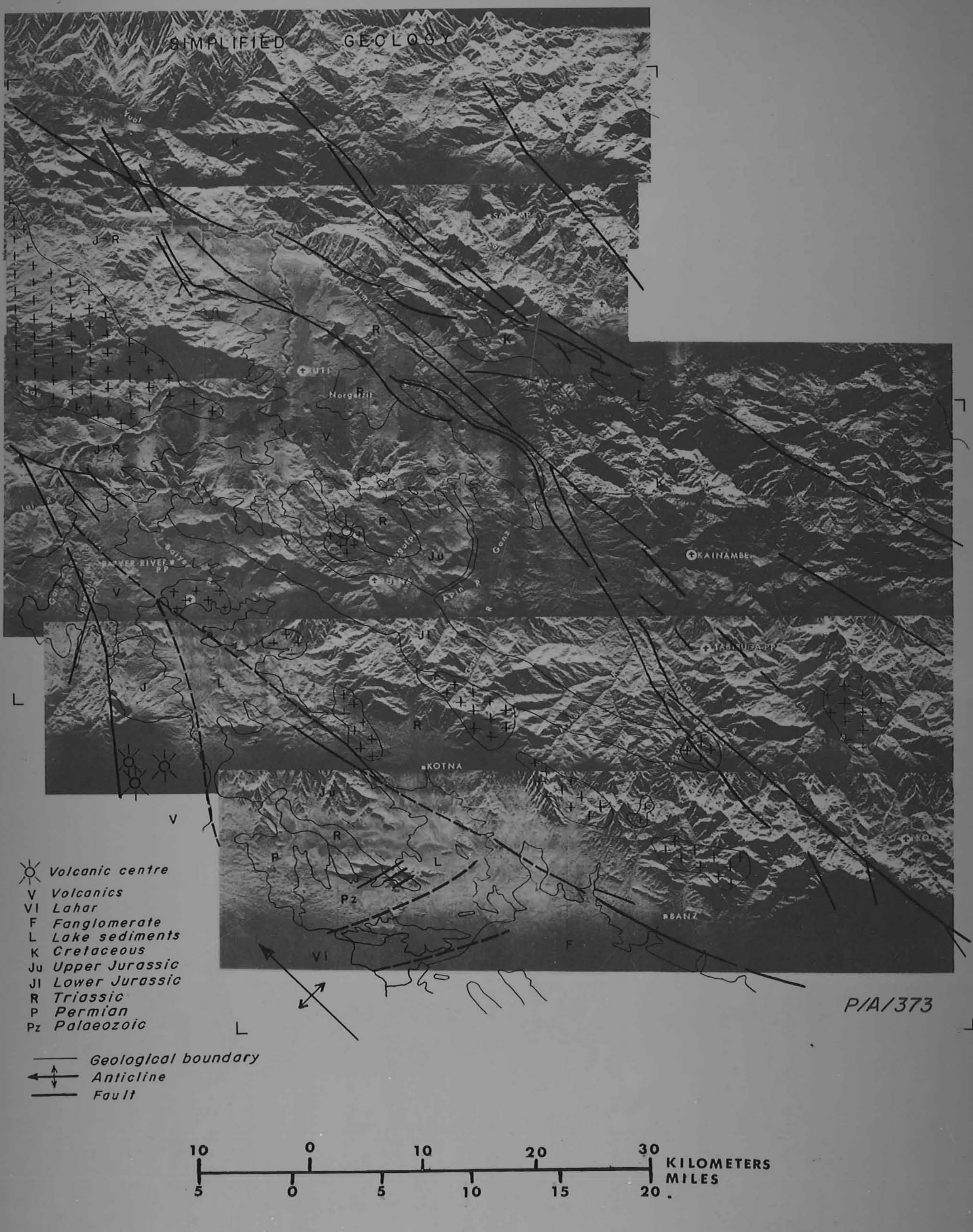
Interpretation of SLAR imagery

Side-looking airborne radar (SLAR)* imagery (Fig. 9) obtained for the Department of the Army by Westinghouse-Raytheon was supplied to BMR several months after completion of the Baiyer-Jimi geological reconnaissance. Initially the imagery obtained was in mosaic form at about 1:250 000 scale. Interpretation of this data was difficult because defects had been introduced, emphasised, or camouflaged in the production of the mosaics. For example, the irregular nature of the mosaic cuts makes them extremely difficult to detect. This is a disadvantage when determining whether imagery has been duplicated or ommitted from the mosaic. In addition, adjacent imagery strips are of opposite look (i.e. the shadows are to the north on one strip, to the south on the next). Thus parts of the mosaic appear to have inverted relief.

* See Appendix 2 for technical details.

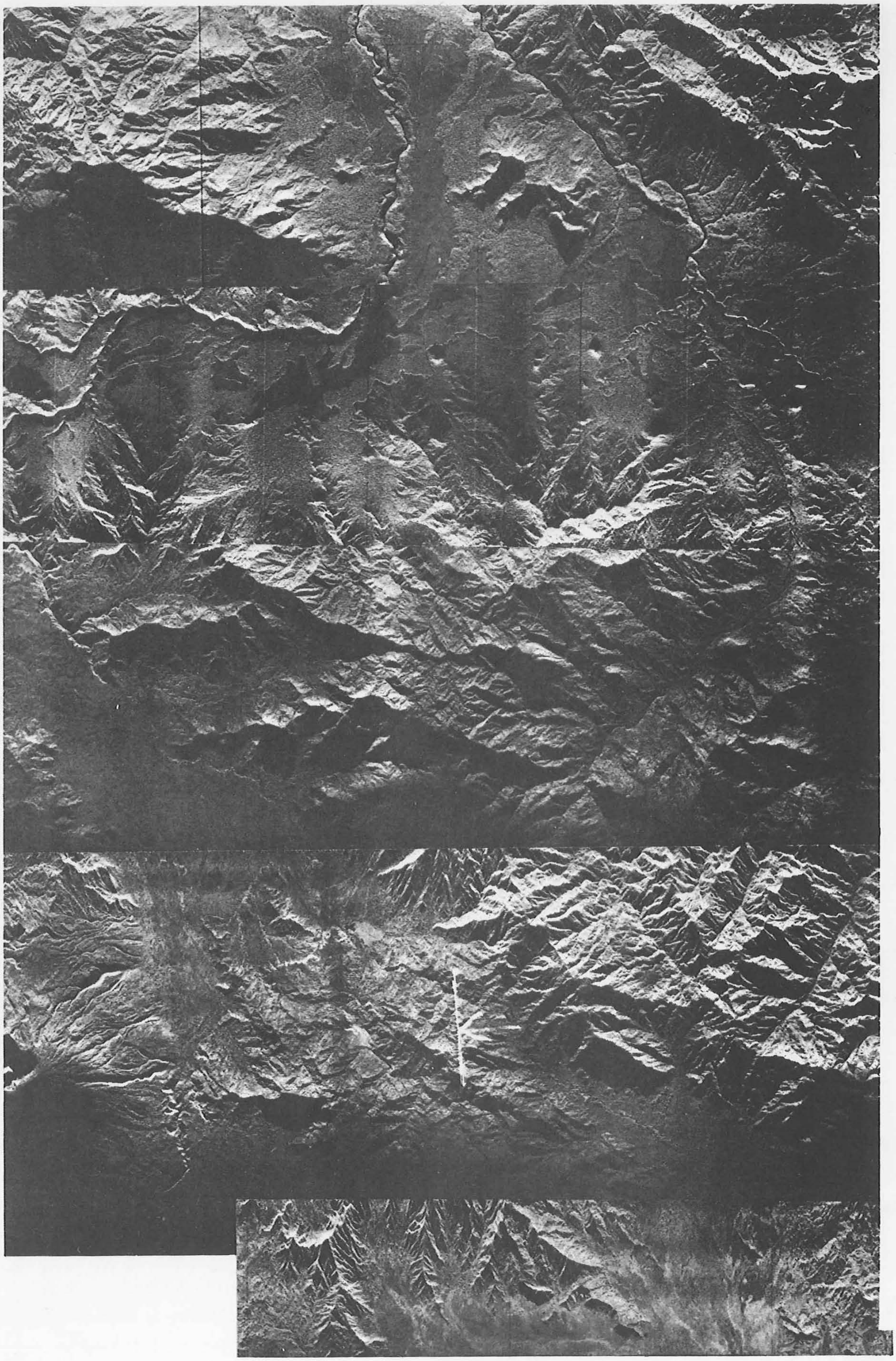
Fig. 9

SIDE LOOKING AIRBORNE RADAR MOSAIC-JIMI VALLEY



Scale : 1:250 000 approx.

Fig.10 AIR-PHOTO MOSAIC OF BAIYER-JIMI REGION



Scale : 1:250 000 approx.

Fig. 11 SIDE-LOOKING AIRBORNE RADAR MOSAIC
OF BAIYER-JIMI REGION

Later, the raw image data - film strips at about 1:220 000 scale - were received. These strips examined individually are much easier to interpret than the Raytheon mosaic. However, there are still numerous problems involved in interpretation and map making. Some of these are inherent in the SLAR system used and some relate more particularly to the quality of the data supplied to us. They include:

1. Azimuth (along track) scale, and range (side look) scale distortions.
2. Near range distortion (layover) e.g. a symmetrical ridge with 45° slopes and strike parallel to flight direction images as a ridge with a single dip-slope dipping away from the near side (aircraft side) of the strip. In Fig. 9 the near side of the northernmost strip is its northern edge.
3. Low to zero contrast in the far range parts of the strip, especially in very mountainous regions. Note Fig. 9.
4. Image imperfections owing to rain squalls, electrical interference, and instrument malfunction.
5. Excessive shadow owing to terrain slope and height.
6. Lack of stereo coverage.
7. Opposite look of adjacent strips. e.g. the two southernmost strips in Fig. 9.

SLAR imagery has many qualities giving it the appearance of aerial photography, but the similarities between the two media are more apparent than real. Thus it should be borne in mind that the light and shadow of the imagery are produced electronically and are not related to sunlight and shadow. In fact the imagery is a measure of the relative reflectances of the scanned surfaces, and thus does not give any information about surface colour variations. The radar beam does not penetrate the vegetation cover and therefore the sensitivity of this remote sensing system in detecting small variations in rock type and structure is severely restricted where the vegetation cover consists of dense forest 30 to 60 m thick as in Fig. 9. However, this has the effect of emphasising the major structures. This is especially important when it is considered that the main advantage of SLAR, apart from its ability to image through a complete cloud cover day or night, is in the detection of major large-scale structures.

To this end, data obtained from the strips is best synthesized on a mosaic, such as Fig. 9, which has widely spaced clearly defined strip boundaries which cannot be confused with real or imagined lineaments. Note that junctions between segments of imagery are far more numerous on the photo-mosaic (Fig. 10) than on the SLAR mosaic (Fig. 11). As these artificial lineaments and the tonal contrast between pieces of the mosaic tend to mask the structural lineaments, it is obvious that the SLAR mosaic is more suitable for interpretation than the photo mosaic.

Fig. 9 depicts the survey area and some adjacent terrain at about 1:500 000 scale; the transparent overlay shows the main geological features. Faults, some lineaments which may be faults or joints, and some dip-slopes are obvious on the radar mosaic. So too are Quaternary volcanoes and volcanics and flat-lying alluvial sediments. However, areas of granitic rock are difficult to detect except where fine dendritic drainage systems are present. Differentiating other rock types is extremely difficult without some knowledge of the local or adjacent geology.

The SLAR imagery was found to be most useful in providing a clear overall picture of the survey area in terms of topography and major structures. It provided a useful satisfactory check on earlier aerial photo interpretation. Unfortunately, no field checking of the radar interpretation has been possible.

ECONOMIC GEOLOGY

Gold

Alluvial gold is being won by local people from the Marramp River (G.R. 55/23103720), a tributary of the Mekuk River. Gold is taken on a smaller scale from several other streams in the Jimi valley, and from Banz Creek on the southern side of the Wahgi-Jimi divide. The bulk, if not all, of this gold is derived from the Kimil Diorite or the nearby Kana Volcanics which it intrudes.

Copper and molybdenum

Kennecott Exploration (Australia) Ltd is investigating copper and molybdenum mineralization in Apin Creek, a tributary of the Ganz River (G.R. 55/21303860), and in the Marramp River. The mineralization is associated with small stocks of Kimil Diorite in Kana Volcanics.

Diatomite

Beds of diatomite up to 1 m thick (total thickness 1-2 m) are interbedded with volcanic sand and ash in the Trauna valley, about 3 km east of Baiyer River Patrol Post. R.J. Tingey, then of Port Moresby resident geological staff, visited the area in 1969 and described an area of about

400 x 100 m of diatomite overlain by thick dark brown soil along a stream about 2 km west of Trauna Valley Farm. When wet, the diatomite is light grey and plastic; when dry, it is almost white and extremely light and friable.

Stone axe quarries

By far the most important economic undertaking of the local people before the agricultural development of the last 20 years was the quarrying of stone and the manufacture of stone axes. Thousands of metric tons of rock has been quarried with sticks and stones from pits in many parts of the Highlands. Chappell (1966) has located seven quarries in the map area: two in the Tsau River area, one in the Ganz River, two in the upper Mogulpin River, one in the hills a few kilometers south of Tigi, and one on the divide above the headwaters of the Ganz River.

Most of the rock types used are silicified shale or siltstone and hornfelsed shale or siltstone of the Maril Shale, or fine-grained lava from the Kana Volcanics.

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APPENDIX 1

Rocks examined in thin section

Specimen Number (prefixed 20NG)	Rock type	Formation
650	recryst tuff?	Kana Volcanics
658	meta porphyritic basaltic andesite	"
662	altered qtz-hbl basaltic andesite (porph)	"
663	epidotized diorite with basic xenoliths and opaques	"
711	zeolitized px andesite	"
713	altered diorite	"
716	dacite?	"
717	dacite? with qtz phenocrysts	"
728	hbl-qtz diorite or andesite	"
729	hbl-qtz diorite or andesite	"
733	rhyodacite or dacite	"
1328	epidotized andesite breccia	"
1328a	altered dacite? tuff	"
1417a	zeolitized breccia of vesic andesite with trachytic text.	"
1417b	altered andesite breccia with trachytic texture	"
1421	recrystallized tuff?	"
667	altered hbl-augite mangerite porphyry	Kimil Diorite
671	altered hbl-augite gabbro	Kimil "
677	altered augite dolerite	Kimil "
681	hbl microdiorite porphyry	Kimil "
696	altered px gabbro	Kimil "

Specimen number (prefixed 20NG)	Rock Type	Formation
1358	altered qtz-hbl microdiorite porphyry	Kimil Diorite
1516	altered oliv? augite basalt porphyry	Kimil "
1535	porphyritic kaersutite-aegirine augite trachyandesite	Kimil "
1349	altered porphyritic qtz-hbl microdiorite	Kera? "
1474	altered qtz-hbl andesite porphyry	Maramuni Diorite
1566	altered hbl andesite porphyry	"
1572A	hbl-bi granodiorite	"
1572B	bi-hbl granodiorite	"
1572D	porphyritic hbl-bi andesite or trachyandesite	"
1572E	augite-hbl gabbro (melanocratic)	"
1581	altered bi-augite monzonite	"

APPENDIX II

Fossils collected

Specimen number (prefixed 20NG)	Fossils	Formation
1385	Malayomaorica malayomaorica + Inoceramis cf haasti	Maril Shale
1386	Malayomaorica malayomaorica +	"
1451	Malayomaorica malayomaorica + Inoceramis cf haasti	"
1460	Inoceramis cf haasti	"
1480	Malayomaorica malayomaorica + Inoceramis cf haasti	"
1481	" "	"
0651	" "	"
0712a	indet. molluscs cf M. Malayomaorica	Kompiai Formation

APPENDIX III

SLAR imagery - technical details

The radar imagery was obtained by Westinghouse-Raytheon in May 1970 while under contract to the Department of the Army. The instrument used was a declassified military APQ97 radar unit mounted in a DC6B aircraft which flew at an average of 5 500 m above mean ground level.

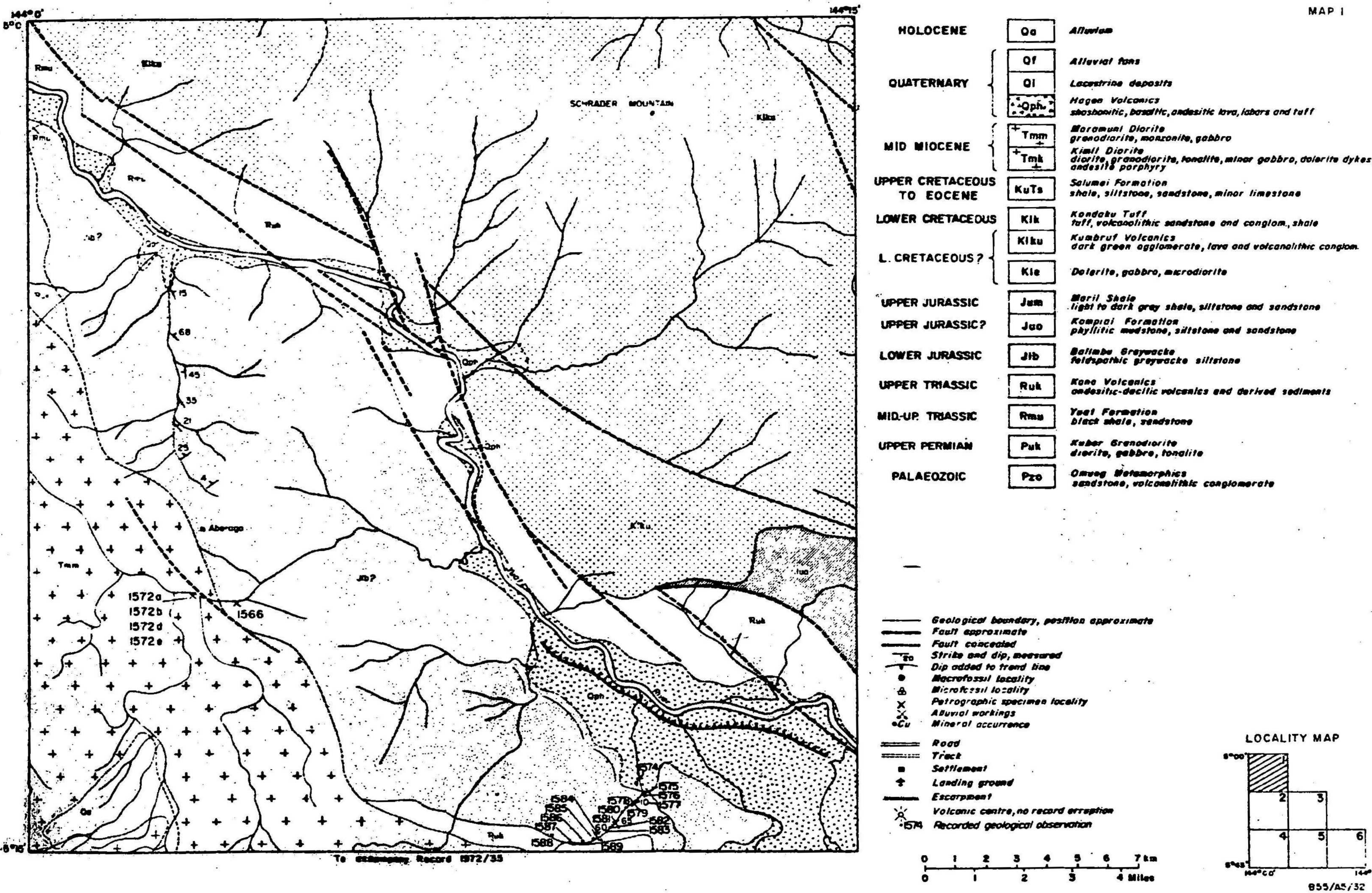
This produced radar strip imagery at 1:218 000 scale over a ground-sweep range of about 20 km. Mosaics at about 1:250 000 scale were prepared by Raytheon Company Autometric Divison.

The APQ97 unit operates in the $K\alpha$ radar band with a nominal wavelength of 8.6 mm. It is a real aperture or 'brute force' system as distinct from synthetic aperture systems such as used by Goodyear Aero-Space Corp. It has a scan angle of 60° (from 15° off vertical to 15° off horizontal) on the port side of the aircraft.

Since radar is a ranging device, there is no compression of the far range with low oblique viewing angles as with angle-dependent devices such as the visual camera. The imagery appears similar to that obtained in vertical aerial photography using very low incident angle illumination.

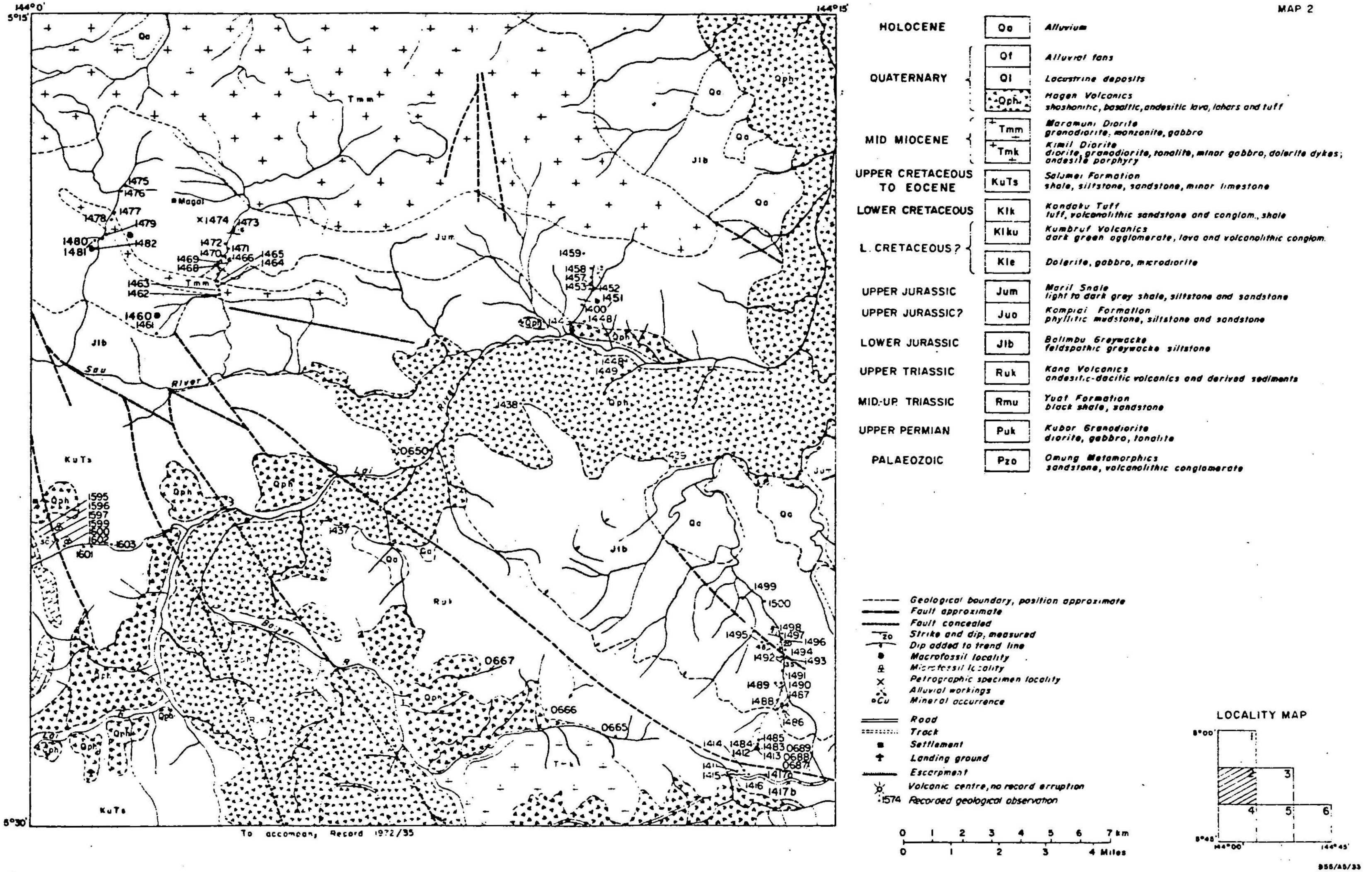
Other radar system parameters:

Slant range accuracy	30 m
Azimuth accuracy	40 m
Range resolution at 16 km slant range	12 m
Azimuth " " " " "	21 m



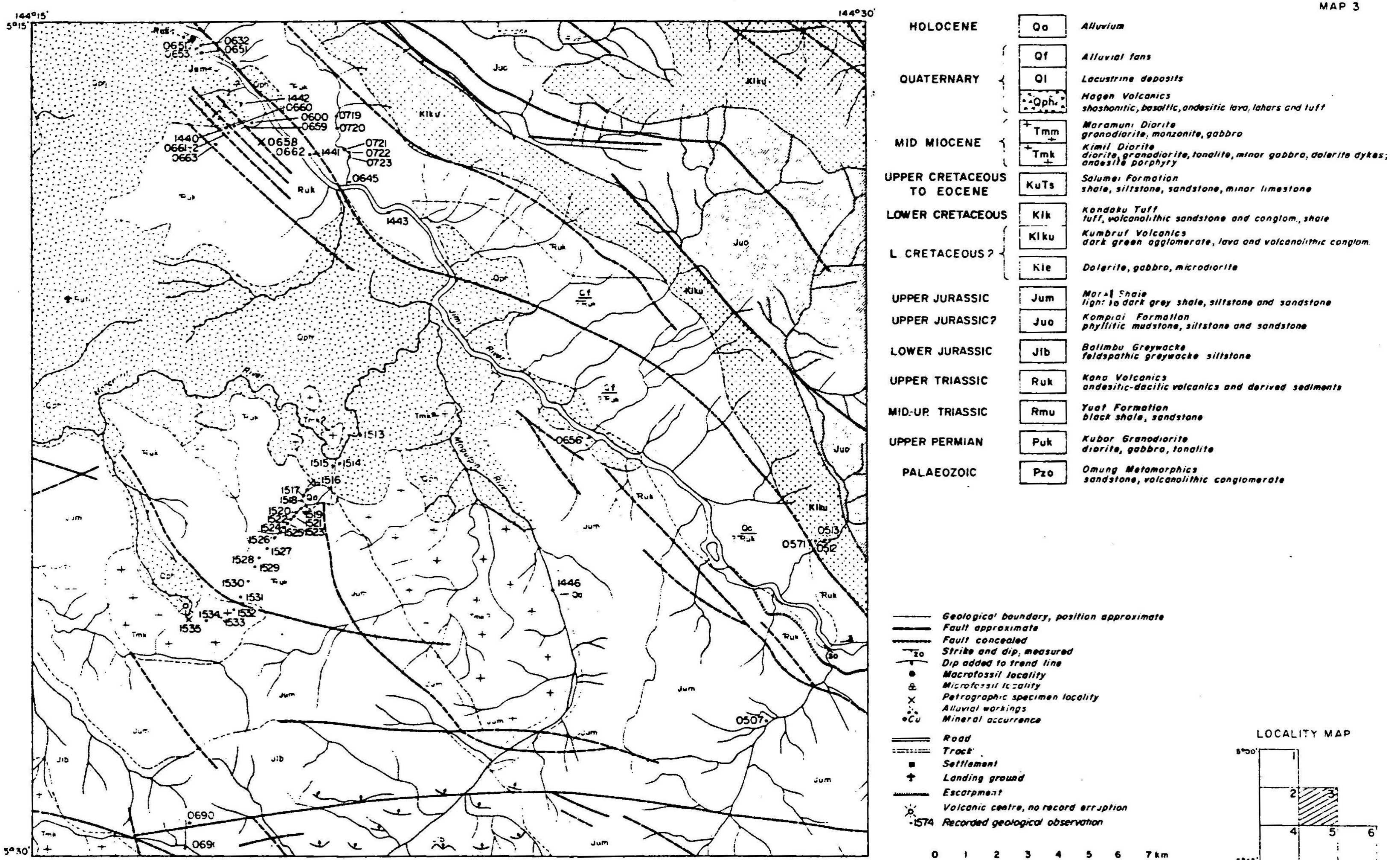
To accompany Record 1972/35

MAP 2



To accompany Record 1972/35

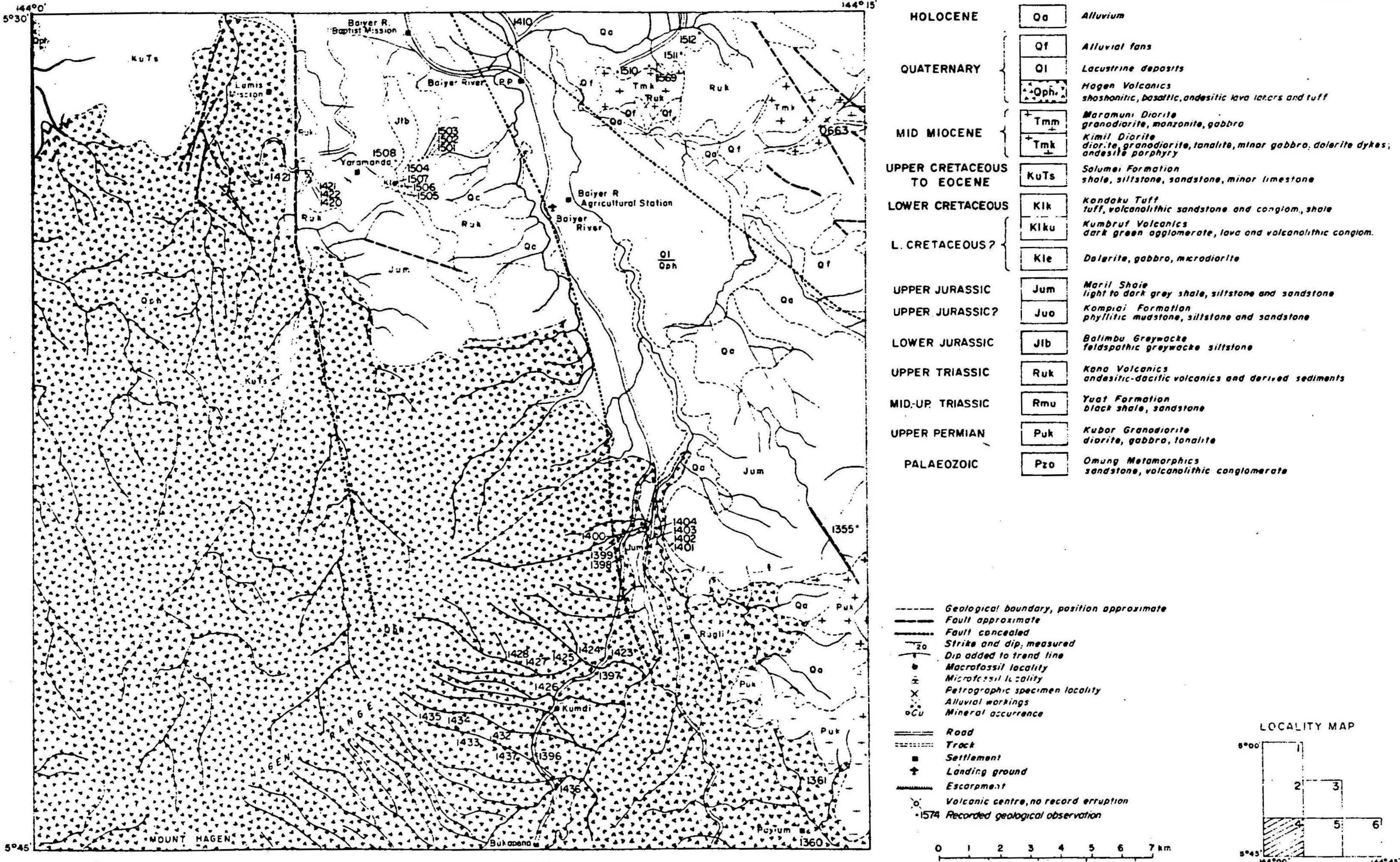
MAP 3



To accompany Record 1972/35

656/A6/34

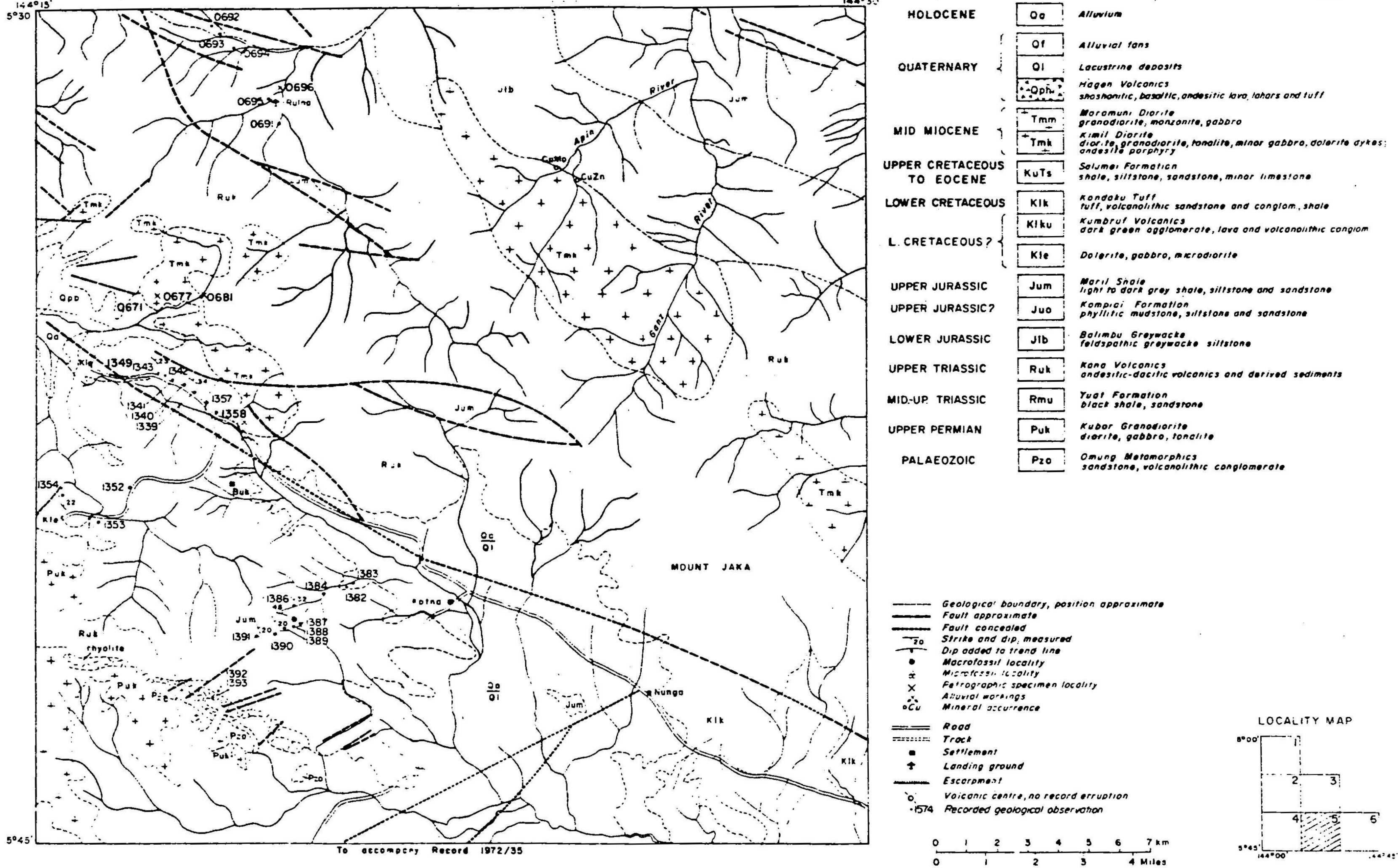
MAP 4



To accompany Record 1972/35

B55/A6/35

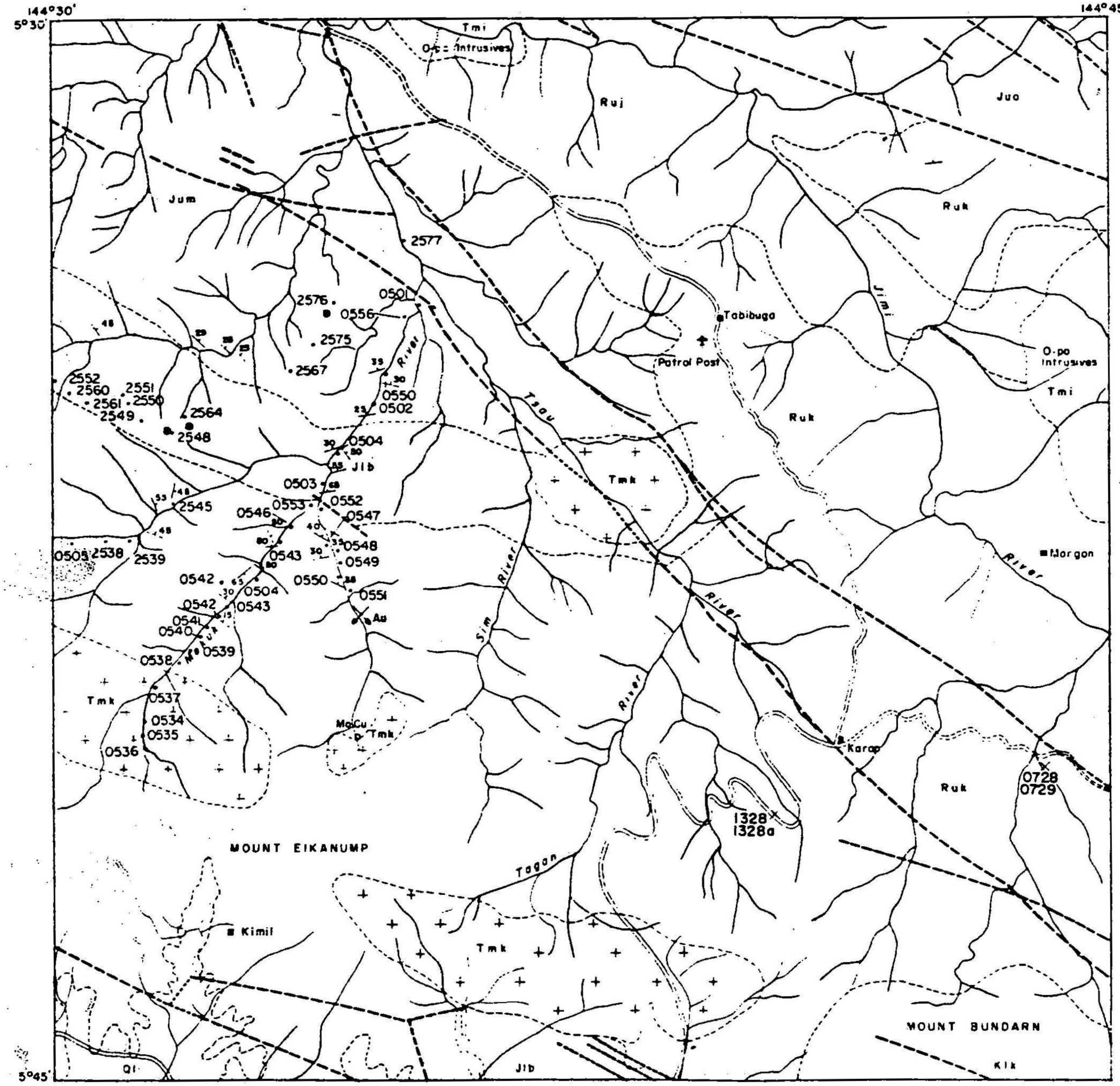
MAP 5



To accompany Record 1972/35

853/A5/3

MAP 6



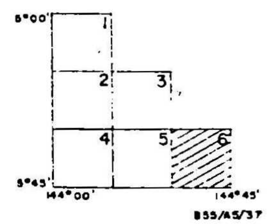
To accompany Record 1972/36

HOLOCENE	Qa	*Alluvium*
QUATERNARY	Qf	*Alluvial fans*
	Ql	*Lacustrine deposits*
	Qph	*Hagen Volcanics* shoshanitic, basaltic, andesitic lava, lahars and tuff
MID MIOCENE	Tmm	*Maramuni Diorite* granodiorite, monzonite, gabbro
	Tmk	*Kimil Diorite* diorite, granodiorite, tonalite, minor gabbro, dolerite dykes; andesite porphyry
UPPER CRETACEOUS TO EOCENE	KuTs	*Salumei Formation* shale, siltstone, sandstone, minor limestone
LOWER CRETACEOUS	Klk	*Kondaku Tuff* tuff, volcanolithic sandstone and conglom., shale
L. CRETACEOUS?	Klku	*Kumbruf Volcanics* dark green agglomerate, lava and volcanolithic conglom.
	Kle	*Dolerite, gabbro, microdiorite*
UPPER JURASSIC	Jum	*Maril Shale* light to dark grey shale, siltstone and sandstone
UPPER JURASSIC?	Juo	*Kompiai Formation* phyllitic mudstone, siltstone and sandstone
LOWER JURASSIC	Jlb	*Balimbu Greywacke* feldspathic greywacke siltstone
UPPER TRIASSIC	Ruk	*Kana Volcanics* andesitic-dacitic volcanics and derived sediments
MID-UP. TRIASSIC	Rmu	*Yuat Formation* black shale, sandstone
UPPER PERMIAN	Puk	*Kubor Granodiorite* diorite, gabbro, tonalite
PALAEOZOIC	Pzo	*Omung Metamorphics* sandstone, volcanolithic conglomerate

Geological boundary, position approximate
Fault approximate
Fault concealed
Strike and dip, measured
Dip added to trend line
Macrofossil locality
Microfossil locality
Petrographic specimen locality
Alluvial workings
Mineral occurrence
Road
Track
Settlement
Landing ground
Escarpment
Volcanic centre, no record erruption
Recorded geological observation

0 1 2 3 4 5 6 7 km
0 1 2 3 4 Miles

LOCALITY MAP



B55/A5/37