COMMONWEALTH OF AUSTRALIA.

DEPARTMENT OF NATIONAL DEVELOPMENT.

BUREAU OF MINERAL RESOURCES

GEOLOGY AND GEOPHYSICS.

RECORDS.

1961/160

THE RELATIONSHIP BETWEEN THE KAINDI METAMORPHICS AND CRETACEOUS ROCKS AT SNAKE RIVER, TERRITORY OF PAPUA AND NEW GUINEA.

by

D.B. Dow.

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SUMMARY

Cretaceous rocks at Snake River, New Guinea, were previously regarded as part of the Kaindi Metamorphics. However, discordance and difference in metamorphic grade between the Cretaceous rocks (here named the Snake River Greywacke), and the more complexely folded and more highly metamorphosed Kaindi Metamorphics suggest that the metamorphics are considerably older than Cretaceous, and are probably Palaeozoic.

INTRODUCTION

Cretaceous fossils were found in 1943 by F.W. Whitehouse in rocks of the Lower Snake River, Territory of New Guinea, which Fisher (1944) had previously included (by inference) in the Kaindi Metamorphics. Whitehouse recognised the Mesozoic affinities of the fauna.

A more complete collection of the fossils was made in 1946 by G.A.V. Stanley and the age of these was determined as Cretaceous by M.F. Glaessner (1949). N.J. MacKay (1955), mapped the area in 1954 and extended the known occurrence of the fossils.

MacKay and Glaessner both included the Cretaceous rocks in the Kaindi Metamorphics. In order to clarify the relationship between these rocks the writer remapped, in detail, an area which embraces parts of Roamer, Mt. Missim, Wago, and Bulowat 1-mile Sheet areas. The writer was helped in the field during February and March, 1959, by E.W. Turner, who was, for a short time, on the Resident Geological Staff at Wau.

The lower part of the valleys of the Snake River and the Watut River were mapped on the Bulolo Valley aerial photographs at a scale of about 1200 feet to one inch; a chain and compass survey was made of the Snake River and its main tributaries between Mumeng and Mapos Creek, and the rest of the area was mapped on the existing military maps. The finished map was compiled at a scale of one mile to one inch.

The mapping was hampered, as in most of New Guinea, by lack of outcrop, particularly in critical localities such as the contact between the Snake River Greywacke and the Kaindi Metamorphics. The best chance of outcrop is in the beds of streams. All the larger streams in the map area were traversed, but, even in streams where outcrop was considered good, only about 70 percent of the section was exposed. In critical areas the ridges were traversed in the hope of finding outcrop.

Description of the Area

The area mapped is deeply dissected, with mountains rising to 10,000 feet above sea level. The northern part of the area is drained by tributaries of the Markham River, the chief of which is the Wampit River; the Snake River and other tributaries of the Watut River drain the rest of the area. Most of the region is covered by tropical rain forest, but extensive clear areas of Kunai grass occur, especially along the Snake River.

Figure 1. Mumeng Patrol Post and the lower Snake River Valley in the foreground.

The Lae - Wau Road trends north through the middle of the area, and a network of graded walking tracks gives ready access to most parts. The area supports a large native population; there is a Sub-District Office at Mumeng (see Figure 1), and Commonwealth Works Department camps and Lutheran Missions at both Mumeng and Gurukor.

STRATIGRAPHY

General

The oldest rocks of the area are the Kaindi Metamorphics which are unconformably overlain by the Cretaceous Snake River Greywacke. Granodiorite and porphyritic microgranodiorite belonging to the Morobe Granodiorite batholith, and minor intrusives, ranging in composition from intermediate to basic and ultrabasic, intrude these sediments.

Kaindi Metamorphics

The Kaindi Metamorphics, as named by N.H. Fisher (1944), include the metamorphic basement rocks of the Morobe District: the name is derived from Mount Kaindi, near Wau, where the rocks are well developed.

The Kaindi Metamorphics crop out in the south-eastern corner of the map area as part of a larger area of these rocks which extends north-eastwards to the coast. Intruding Morobe Granodiorite and overlying Otibanda Lake Beds separate these rocks from the Kaindi Metamorphics of the Wau area, and prevent direct correlation, but there is little doubt that the rocks belong to the same formation. However, in the Wau area the Kaindi Metamorphics appear to belong to a slightly higher grade of regional metamorphism.

Before metamorphism, the Kaindi Metamorphics in the map area consisted of a sequence of thick-bedded and massive greywacke, limestone lenses (now recrystallised to marble), and minor conglomerate and siltstone. The rocks are now regionally metamorphosed, and belong to the greenschist facies. In addition, contact metamorphism is intense near the granodiorite and porphyritic microgranodiorite.

The greywacke was fine-grained to coarse-grained, and consisted of up to 60 percent angular to sub-angular quartz, feldspar, and sedimentary rock fragments chaotically distributed in a fine-grained argillaceous matrix. The matrix has been recrystallised to form biotite, muscovite, chlorite, and clinozoisite, and shows a weak planar structure which imparts a schistosity to the rock. The feldspar was predominantly plagioclase but it has mostly been partly albitised. The margins of the feldspar fragments are recrystallised, and they contain small, indeterminate, idiomorphic crystals which are regarded as having been formed by metamorphism. The quartz grains are usually partly recrystallised, and have corroded margins.

Marble occurs as lenses several hundred feet thick, and the largest has been traced over 8 miles along the strike. It is fine-grained and light grey, and contains thin, fine-grained, micaceous partings which were originally argillaceous impurities. The Morobe Granodiorite intrudes the marble in a tributary of the Baiune River and gives rise to spectacular skarn rocks within about 500 feet of the contact. The pure marble is unaltered, but the impure members give rise to a variety of calc-silicate rocks the most common of which contains abundant red garnet.

Sheared and stretched pebble conglomerate was seen at several localities in the Snake River between Mumeng and Mapos. It occurs as beds up to 20 feet thick, and consists of pebbles of quartz, quartzite, greywacke, siltstone, schist, and fine-grained igneous rocks, in a matrix of schistose greywacke. The less competent pebbles such as siltstone have been drawn out into long thin lenses, whereas the competent ones, such as quartz and quartzite, have merely been flattened and distorted.

The original siltstone beds are now fine-grained quartz mica schist. They are black and dark grey, and some show remnants of tightly folded thin bedding.

The sediments of the Kaindi Metamorphics were probably deposited fairly close to the shoreline of a land-mass that was supplying abundant basic and intermediate volcanic debris. The limestone lenses were probably off-shore coral reefs, though all trace of organisms has been obliterated by subsequent metamorphism.

Snake River Greywacke (New Name)

The type locality for the formation is the Snake River between Mumeng and the Watut River, (approx. 146°37', 7°00').

The Snake River Greywacke crops out as a linear belt from south of Reidy's Creek, in the southern part of the map area, to near Mount Sungol in the Upper Snake River area. It is defined as a formation of micaceous greywacke and minor quartz sericite schist, which, in the type area, probably rests unconformably on rocks of the Kaindi Metamorphics; it is overlain, apparently conformably, by fine-grained schistose siltstone and greywacke. The Snake River greywacke is resistant to erosion, and forms a prominent ridge through which both the Snake River (6 miles upstream from its junction with the Watut), and the Watut River have cut steep-sided gorges.

The formation is about 5,000 feet thick, and consists mainly of fine-grained to medium-grained greywacke, which ranges from a grey sandy rock with no fissility in the coarser-grained types, to a dark blue quartz sericite schist in the finer-grained types. It is massive to medium-bedded, and consists of sub-angular quartz and feldspar fragments and prominant detrital mica, in a matrix of sericite, fine-grained quartz, and feldspar. It also contains fragments of chert, shale, and fine-grained acid igneous rock.

The greywacke has undergone little regional metamorphism, and distortion of fossils shows that there has been only minor shearing parallel to, and compression at right angles to, the bedding. Near the granitic intrusions the Snake River Greywacke has been altered to hornfels, in which fossils are still preserved. In areas remote from granitic intrusions the rocks are recrystallised only to a very minor degree. The larger detrital grains in the greywacke are unaltered, except for slight marginal corrosion of the quartz; the matrix has been only very slightly recrystallised. The amount of reconstitution of both the larger detrital grains and the matrix could have been caused by diagenetic processes alone.

Slate is interbedded with the greywacke, and it commonly has two cleavages, the better-developed being parallel to the axial plane of the folds. Microscopic examination shows that minor recrystallisation has resulted in the formation of small amounts of sericite and chlorite. Thin-bedding and laminae are rarely seen in the slate, which is mostly massive.

Fossils occur in the Snake River Greywacke at scattered localities from three miles north-east of Mumeng, to Reidy's Creek.

The fauna was described by Glaessner (1949), who recognised the following forms: Cucullaea (Ashcroftia) distorta sp. nov., Glycymeris sp., Trigonia (Acanthotrigonia) phyllitica sp. nov., Cardium sp., Volsella sp., and Tibia? morobica sp. nov. The age of the fauna is Cretaceous.

Sericite Schist and Greywacke

Sericite schist, green silicified greywacke, and conglomerate overlie, apparently conformably, the Snake River Greywacke. These rocks crop out in the western half of the map area, and were examined by the writer only near the Wampit River, and in the Waime and Wafi Rivers and Reidy's Creek. These rocks were mapped along the Lower Watut River by MacKay (op. cit.), who included them in the Kaindi Metamorphics.

The sericite schist is dark, commonly massive, and rarely thin-bedded and laminated. Examination of thin sections shows the rock to be composed of detrital quartz and mica set in an extremely fine-grained sericitic matrix which is commonly heavily impregnated with graphite. Mild regional metamorphism has imparted a vague schistosity to the rock. The greywacke is silicified, light green or grey, and fine-grained to medium-grained; it occurs as beds from two inches to about two feet thick. Only one thin section of this rock was examined, and it was seen to consist of anhedra of oligoclase and patches of altered mafic material set in a cryptocrystalline matrix of felsic material. The rock could be an altered crystal tuff.

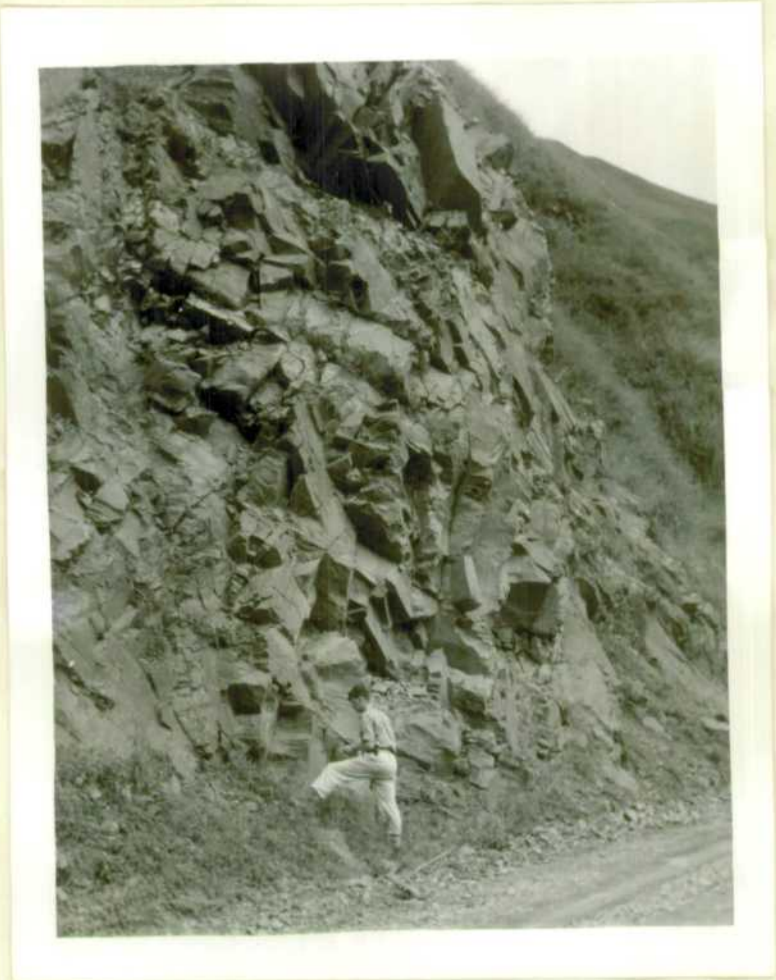


Figure 2. Road cutting in Snake River Greywacke. Bedding is dipping away from the camera.

Figure 3. Small bedding plane shear in Snake River Greywacke. Road cutting near Mumeng.

Massive pebble and cobble conglomerate beds up to several hundred feet thick occur near the head of the Waime and Wafi Rivers, and are possibly the lateral equivalents of the Snake River Greywacke, as they are in approximately the same stratigraphical position (section, Plate 1). The conglomerate is well indurated, but shows little or no effects of regional metamorphism. This is in marked contrast to the conglomerate of the Kaindi Metamorphics, in which the pebbles are invariably so stretched and sheared that the rock is commonly almost unrecognisable as conglomerate. In the Wafi and Waime conglomerate, the pebbles and cobbles are well rounded, and comprise quartz, chert, indurated siltstone, schist, and fine-grained igneous rocks. The matrix is dark, indurated greywacke.

The sericite schist cannot be distinguished from the finer varieties of the Kaindi Metamorphics in the field, especially where contact metamorphism reinforces the slight regional metamorphism. In addition, there are broad zones of more intense metamorphism within younger schist, where the finer beds have yielded to the regional deforming forces, mainly by shearing. This shearing is accompanied by stronger recrystallisation.

Small, irregular quartz veins which probably originated in the granodiorite are common in the finer members of these beds.

Otibanda Lake Beds

Lacustrine deposits which crop out in the southern part of the map area are part of the Otibanda Lake Beds ([illegible], 1938). They consist of unconsolidated sandstone and mudstone and some quartz conglomerate. Near the Sunshine Fault the lake beds contain angular boulders, up to 10 feet across, of fossiliferous siliceous deposits. These are regarded as fragmented siliceous sinter formed by hot springs along the fault, during deposition of the lake beds. The fossils are small, probably fresh water, gasteropod-like organisms, and are completely silicified.

The beds dip between 5° and 15° over most of the area, but near the Sunshine Fault they dip away from the fault at 35° to 40°. They are probably Pleistocene.

Conspicuous alluvial fans occur at Zenag and the head of the Wampit River. These probably resulted from accelerated erosion caused by recent uplift of the Zenag area. Air photographs which have recently come to hand (April 1962) show that the Zenag fan has been dislocated by recent movement on the Wampit Fault.

Morobe Granodiorite

Fisher (1944) named the large body of granodiorite between Wau and the Snake River the Morobe Batholith, the name being derived from the Morobe Goldfields.

Part of the main batholith crops out in the south-eastern corner of the map area, and several stocks and bosses of the granodiorite are exposed throughout the area.

The granodiorite of the map area was not sampled, but Fisher described the main batholith as composed mainly of granodiorite or adamellite together with differentiates such as monzonite, and diorite. None of these differentiates was seen in the map area.

Figure 4. Zenag alluvial fan taken from hills to the east. The Lae-Wau road can be seen winding past M. Leahy's farm to the right of centre. The fault shown on the airphotos to dislocate the alluvial fan crosses the picture from left to right near the far side of the fan. The stream in the middle of the picture has apparently been offset to the right as a result of transcurrent movement on the fault.

Figure 5. A two-stage dissected alluvial fan. Lower Snake River.

The small granitic intrusions within five miles of Mumeng are porphyritic microdiorite consisting of large equidimensional plagioclase phenocrysts, set in a medium-grained groundmass of hornblende, quartz, epidote, pennine, and apatite. The plagioclase is largely saussuritised, and consists of cores of anorthite ringed by andesine. The relationship of this rock to the Morobe Granodiorite is unknown, though it is possibly co-magmatic and slightly younger.

The Morobe Granodiorite is post-Cretaceous, and is unconformably overlain by Miocene rocks 20 miles to the west in the Langimar River.

Other Intrusives

A small complex intrusive body, ½ mile long by ¼ mile wide crops out 1½ miles south-west of Mumeng. It is made up of rocks which range in composition from andesite porphyry to pyroxenite: the andesite porphyry is very similar to the late Tertiary porphyry which crops out near Bulolo, 16 miles to the south, and may be the same age.

STRUCTURE

Folding

The Kaindi Metamorphics are complexly folded along axes which trend between north-east and north-west, and plunge both north and south at angles up to 30°. Bedding is rarely preserved, but where seen it is highly contorted.

Mapping of the marble beds alone would give a deceptively simple picture of the folding. Thus, 3½ miles south-east of Mumeng in a tributary of the Baiune River, the marble dips regularly westwards at 15° to 25°. However, exposures are good in the area, and a section across the valley shows that the underlying and overlying beds are very tightly folded along axes which trend 340° and plunge north at 15° to 25° (see Figure 8).

The marble beds round Wau also have a fairly simple structure which does not reflect the structure of the enclosing Kaindi Metamorphics. It appears that, under high confining pressures, the original limestone reacted readily to the orogenic stress by plastic flow, and where the bed was thick enough it had the effect of "ironing out" the complexity of the folding. Thus the marble reflects only the large-scale regional structures.

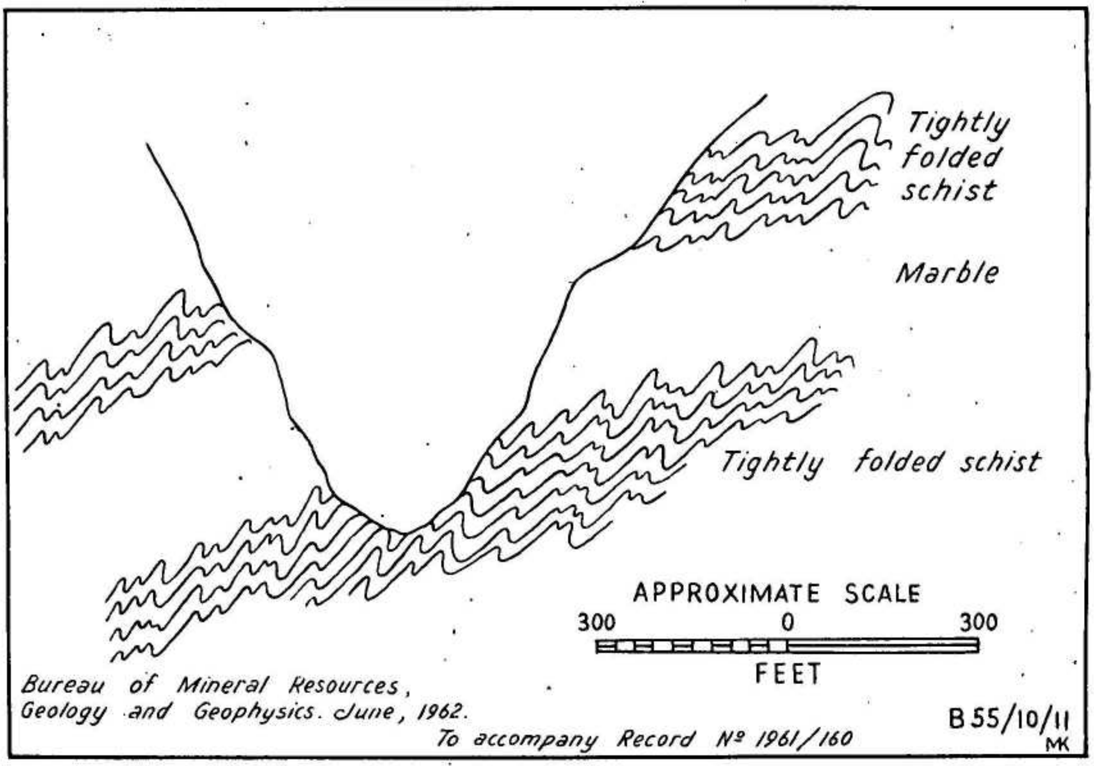


Figure 8. Diagram of folding in a tributary of the Baiune River, 3½ miles south-east of Mumeng. Section across the creek valley looking north.

The Snake River Greywacke strikes about 30° and dips regularly north-westwards at 35° to 45°; it crops out on the eastern flank of an open synclinorium which also affects the overlying beds. The axis of the synclinorium is roughly horizontal, and trends about 30° in the south of the map area and gradually swings to west of north near the Markham River. Tight drag folds on the limbs of the major folds in the Watut Beds are a common feature.

Faulting

The Pleistocene Otibanda Lake Beds have been downfaulted against the Snake River Greywacke west of the Baiune River by a fault, called here the Sunshine Fault. The name is derived from the Sunshine alluvial gold workings which are on the south bank of the Watut River near the fault. The Lake Beds, which normally dip at angles between 5° and 20°, dip steeply away from the fault at 35° to 40°. A small basal remnant of Lake Beds on the upthrow side of the fault is about 500 feet above the top of the Lake Beds on the downthrow side, indicating a vertical throw of 550 feet to 600 feet. The Sunshine Fault continues south-westwards to Slate Creek, a tributary of the Upper Watut River.

Figure 6. Zenag Gap in distance taken from the Wau-Edie Creek road. Mt. Sungol is cloud-capped to the right. The scarp of the Sunshine Fault can be seen trending across the photo in the middle distance. The basin in the middle distance is occupied mainly by Otibanda Lake Beds.

Figure 7. The Sunshine Fault follows the gully in the middle of the photograph. Steeply dipping Otibanda Lake Beds can be seen on the left abutting against Snake River Greywacke on the right. Photograph taken from the Lae-Wau road looking west.

A fault, called here the Wampit Fault, follows the Wampit River from the Markham River to Zenag, from which point it swings south-east to the Baiune River. The Snake River Greywacke is displaced laterally by about 3,000 feet, indicating a downthrow to the west of about 3,000 feet, assuming that there was no transcurrent movement. The Morobe Granodiorite near Gurukor cuts out along the fault, also indicating downthrow to the west. Airphotos taken after the field work was completed show that the alluvial fan at Zenag has been dislocated by recent movement along the Wampit Fault (Figure 4). The dislocation seen could be explained by transcurrent movement with west block moving south, or else by vertical movement with downthrow to the east.

EVIDENCE OF UNCONFORMITY

Glaessner (1949), and MacKay (1955), assumed that the Cretaceous rocks in the Snake River area were part of the Kaindi Metamorphics, but detailed work has shown that the fossiliferous beds are not as highly metamorphosed, nor as complexely folded as the Kaindi Metamorphics. On the field evidence the contact between the two formations could be either an unconformity or a large thrust. No evidence of thrust faulting was found in the map area, and the writer favours the interpretation of an unconformity.

The unconformity is recognised by two criteria:

1. Discordance

Angular unconformity is suggested by structural discordance between the Kaindi Metamorphics and the Snake River Greywacke.

The Snake River Greywacke strikes very regularly to the north-east and dips to the north-west at between 35° and 45°. The underlying Kaindi Metamorphics, on the other hand, are irregularly folded along axes which trend between north-west and north-east and plunge north and south at angles up to 30°. The marble beds reflect the large-scale structure, and their outcrops follow a sinuous course which shows no relationship to that of the overlying Snake River Greywacke.

2. Difference in metamorphic grade

The Kaindi Metamorphics in the map area have been regionally metamorphosed, and belong to the green-schist metamorphic facies. Almost all trace of bedding has been obliterated; in the few places where it can be seen, the bedding is highly contorted. In some places the rock breaks into rods caused by micro-folding of the schistosity. Conglomerate beds up to 20 feet thick along the Snake River are stretched and sheared and commonly difficult to recognise as conglomerate. The more competent pebbles, such as quartz and siliceous rocks, have been stretched, whereas the less competent pebbles, such as greywacke and siltstone, have been drawn out to form long lenses.

By comparison, the Snake River Greywacke has undergone little regional metamorphism. The small amount of recrystallisation seen in the argillaceous beds has resulted mainly from diagenetic processes, probably reinforced by the effect of stress during the folding which followed sedimentation.

Anomalous higher-grade metamorphism occurs in rocks of both the Snake River Greywacke and the overlying beds about half a mile north of Mumeng. The rocks are sericite and mica schist indistinguishable from those of the Kaindi Metamorphics. These are on the line of the Wampit Fault, where shearing, and the thermal effects of the nearby Morobe Granodiorite, probably explains the anomaly.

The conglomerate exposed in the Wafi and Waime Rivers shows no effects of regional metamorphism other than induration of the greywacke matrix.

AGE OF THE KAINDI METAMORPHICS

The unconformity between the two formations shows that the Kaindi Metamorphics are older than Cretaceous. The magnitude of the time break is unknown, and the Kaindi Metamorphics could be as young as Jurassic. However, in the absence of contrary evidence, I favour correlating the Kaindi Metamorphics with the pre-Permian Omung Metamorphics of Rickwood (1955), which crop out 150 miles to the north-west, on the basis of similarity of rock type and grade of regional metamorphism.

GEOLOGICAL HISTORY

Rocks of the Kaindi Metamorphics in the map area were originally coarse-grained, and consisted of greywacke, conglomerate, and thick, lensing beds of limestone. Recent work (Dow and Davies, 1961) has shown that there is a nearly continuous belt of marble lenses interrupted only by the Morobe Granodiorite between the Snake River, and the Ono River 140 miles to the south. The Kaindi Metamorphics to the east of this belt are generally finer-grained, and it seems likely that the marble beds were originally reef limestone on the western margin of a Palaeozoic geosyncline in which sediments of the Kaindi Metamorphics were laid down.

The sedimentation may have persisted until Mesozoic time, but it ceased before the Cretaceous with a marked orogeny which regionally metamorphosed the sediments to the greenschist facies.

In the Cretaceous, the Snake River Greywacke and the overlying beds were laid down, probably unconformably, on the Kaindi Metamorphics. The composition of the Snake River Greywacke indicates that vulcanism was active during the Cretaceous, and pebbles of granite in the Wafi conglomerate shows that granite was present in the provenance. Rickwood (op. cit., p.80) has shown that the Cretaceous was a period of general submergence, and it seems likely that the Snake River Greywacke was laid down in an eastern extension of the Mesozoic basin of the Western Highlands.

Deposition ended in Upper Cretaceous or Lower Tertiary time with a mild orogeny accompanied by intrusion of the Morobe Granodiorite.

Apparently there was no more post-Mesozoic marine deposition in the map area, which, during the Tertiary, was a landmass supplying detritus to the Aure Trough to the west and south.

Small ultrabasic to intermediate bodies were intruded, probably in the Upper Tertiary. Pleistocene faulting formed a lake in which the Otibanda Lake Beds were deposited. Eventually, downcutting of the Lower Watut River outstripped the uplift, and the lake was drained. Faulting on the Wampit Fault has continued to the present.

ACKNOWLEDGEMENTS

The writer wishes to acknowledge the assistance given by E.W. Turner, who mapped part of the Upper Snake River while a member of the Resident Geological Staff at Wau, and J.E. Thompson, who, as Senior Resident Geologist at Port Moresby, volunteered many helpful suggestions.

REFERENCES

DOW, D.B., and DAVIES, H.L., 1961 - The Geology of the Bowutu Mountains. Bur. Min. Resour. Aust. Rec. 1961/84 (unpubl.).

FISHER, N.H., 1944 - Outline of the geology of the Morobe Goldfields. Proc. Roy. Soc. Qld., 55(4), 165-181.

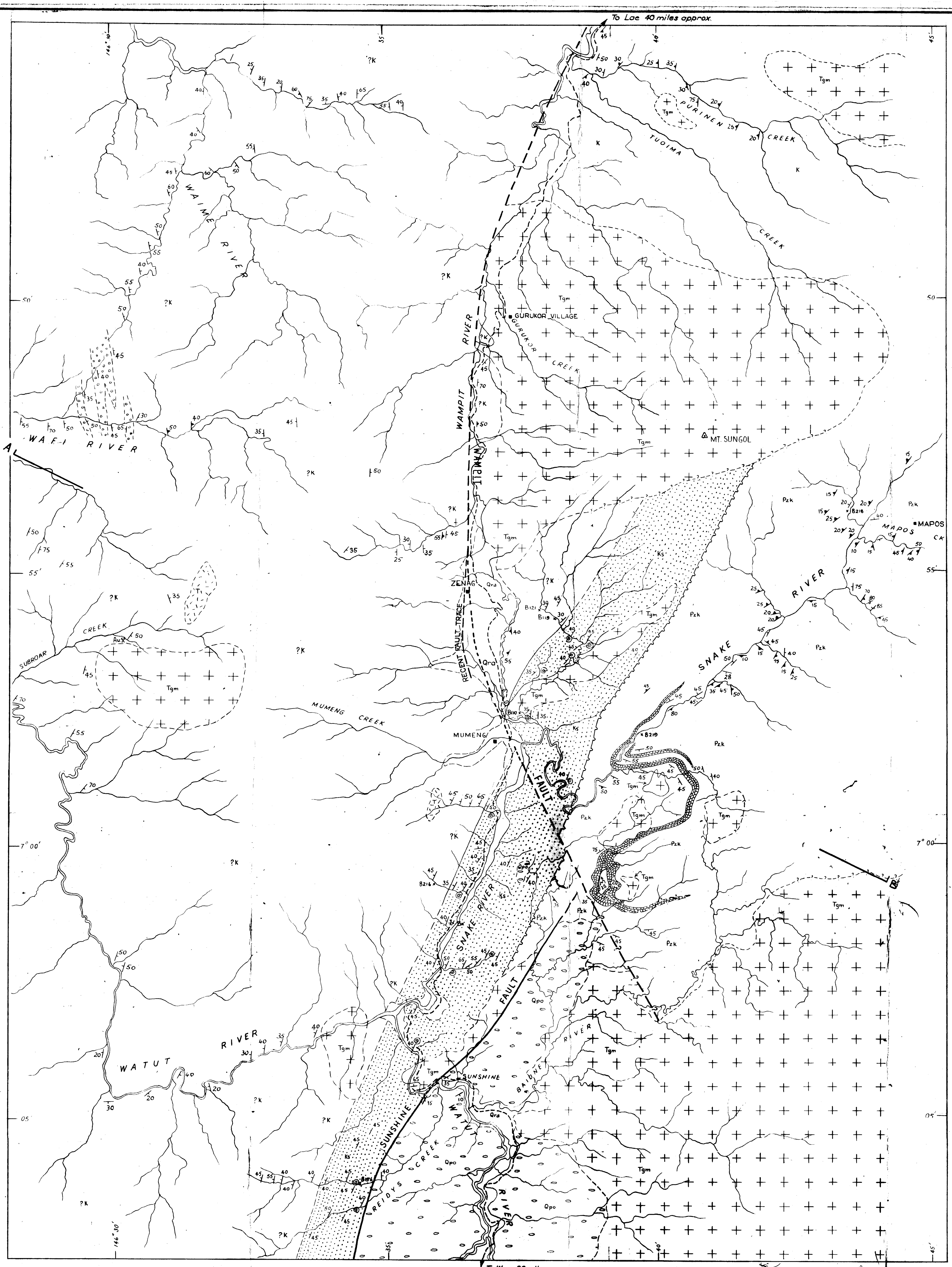
GLAESSNER, M.F., 1949 - Mesozoic fossils from the Snake River, Central New Guinea. Mem. Qld Mus. 12(4), 165-181.

MacKAY, N.J., 1955 - Geological report on a reconnaissance of the Markham and Upper Ramu drainage systems, New Guinea. Bur. Min. Resour. Aust. Rec. 1955/25 (unpubl.).

NOAKES, L.C., 1938 - Preliminary geological report on the Upper Watut area. T.N.G. geol. Surv. report (unpubl.).

RICKWOOD, F.K., 1955 - The Geology of the Western Highlands of New Guinea. J. Geol. Soc. Aust. Vol. 2. p. 63-82.

Plate 1



REFERENCE

QUATERNARY	RECENT		Qra	Gravels, fanglomerate.
	PLEISTOCENE	Otibanda Lake Beds	Qpo	Conglomerate sandstone, mudstone.
MESOZOIC	CRETACEOUS ?		K	Schistose carbonaceous siltstone, silicified greywacke, crystal tuff? Conglomerate
	CRETACEOUS	Snake River Greywacke	Ks	Greywacke; minor schistose siltstone.
PALAEOZOIC		Kaindi Metamorphics	Pzk	Quartz mica schist, marble.
IGNEOUS	TERTIARY Upper		T	Andesite porphyry, serpentinite, gabbro.
	TERTIARY Lower	Morobe Granodiorite	Tgm	Granodiorite, adamellite.

Geological boundaries
Established boundary - position accurate
Established boundary - position approximate
Concealed
Inferred.
Angular unconformity

Bedding
Strike and dip of strata
Inclined
Vertical
Tightly folded strata

Foliation
Strike and dip of foliation
Inclined

Fossil locality
B218 Petrological sample locality

Faults
Established fault - position accurate
Established fault - position approximate
Inferred fault.
Concealed fault

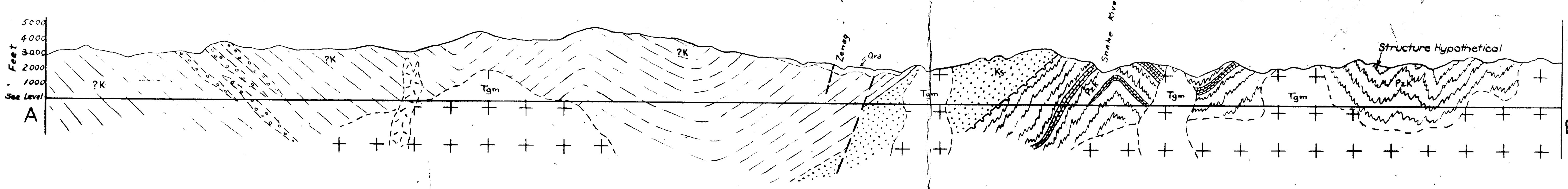
Mine
Au Gold mineralization

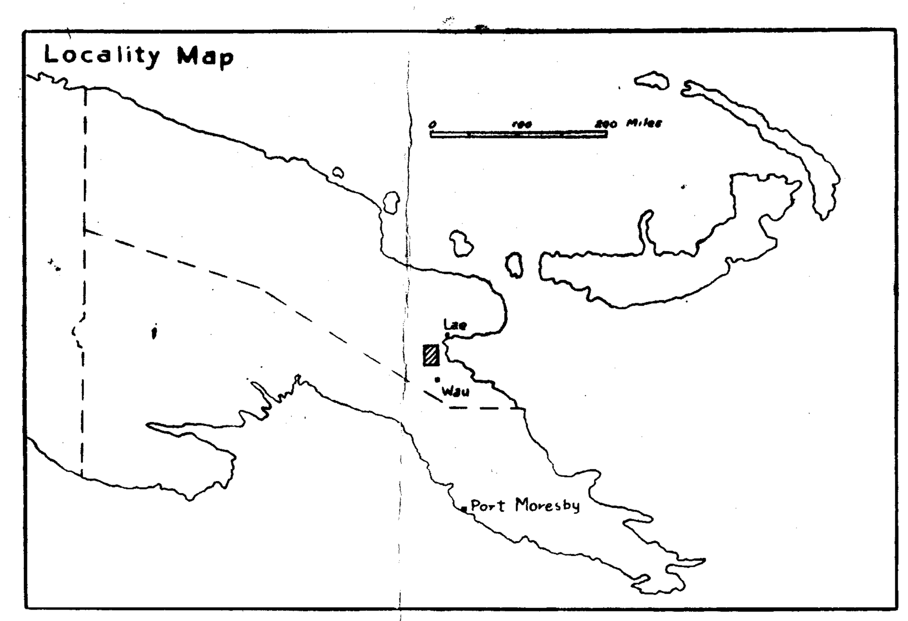
Major peak
Spot height
Road

GEOLOGICAL MAP
SNAKE RIVER AREA
NEW GUINEA

SCALE
1 Mile to 1 Inch

Section A-B





To accompany Record No 1961/160

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