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GEOLOGICAL RECONNAISSANCE FOR A POSSIBLE HYDRO-ELECTRIC SCHEME ON THE LAUIS RIVER, MANUS ISLAND, T.P.N.G. 1968

by

J.C. Braybrooke and P.E. Pieters

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SUMMARY

The Lauis River system drains the eastern part of Manus Island, entering the sea in Kelaua Harbour (Plate 1). The damsite investigated is located in a gorge 7 miles south of Lorengau and about 3 miles upstream of the river mouth. The confluence of the Lauis and Irru Rivers is a short distance upstream from the gorge.

A marine tuffaceous sequence covers most of the catchment area. The sequence dips gently to the southeast, is soft, weak and probably impermeable at depth. A porphyritic basalt flow, with its nose at the position of the gorge, fills a former depression within the sediments parallel to their strike. The basalt is hard, strong, and has closely-spaced columnar joints. The joints are probably open at depth, giving the basalt a high permeability.

The Upper Lauis River runs in deeply incised meanders within the tuffaceous sequence; the Irru River cuts through the basalt. Both valleys are steep-sided and have a low potential storage capacity.

In the gorge, the entire left bank appears to consist of tuffaceous siltstone bedrock. Most of the right bank has glassy basalt in situ. Huge boulders of glassy basalt up to 900 cubic yards in volume litter both sides of the gorge and river bed. These boulders will make detailed damsite investigation both difficult and dangerous, and will present difficulties during cleaning of dam foundations.

No natural spillway site is apparent. There is a good power house site on the left bank below the gorge. Adequate supplies of good quality rockfill or aggregate can be quarried from the basalt, but no natural supplies of clean sand are present close to the site.

INTRODUCTION

In 1965, members of the Commonwealth Department of Works made a reconnaissance investigation on Manus Island for potential sites for a hydro-electric scheme to serve Lorengau. The only suitable damsite seen was in the Lauis River, about three miles upstream of Kelaua Harbour at the eastern end of the island. Barometric levels were taken at intervals along the river above the potential site.

At the request of the Director of Works, the writers accompanied Messrs I.C. Brookes and B. de G. Neale to Manus Island in January, 1968. Four geologist-days were spent doing a geological feasibility study of the proposed damsite and its surrounds: one geologist-day was spent mapping around the damsite and the other three geologist-days were spent traversing the Lauis and Irru Rivers and their tributaries.

LOCATION AND ACCESS

The Upper Lauis River drains 11.1 square miles and the Irru River 9.3 square miles of the eastern portion of Manus Island, and enter the sea, in Kelaua Harbour, three miles below their confluence and seven miles southwest of Loniu Bridge. The proposed scheme is located in a gorge on the Lauis River about 200 yards downstream from the confluence of the Upper Lauis and Irru Rivers. Speedboats can traverse the river to within 10 minutes walk of the base of the gorge.

"Number 2" road, built by U.S. Forces during the war, runs from Lorengau through Rossun village (3 to 4 miles) to the Lauis River (at least another 6 miles). As far as Rossun, the road is paved with either a mixture of crushed coral and cement or with basalt aggregate, and has a fair to good surface. From Rossun, the road is unpaved and runs over red clay, very slippery when wet and impassable to all but a 4-wheel-drive or tracked vehicle.

A walking track also connects Lauis village, on the coast, to the gorge. This passes over river flats which are flooded after heavy rain.

PREVIOUS WORK

Thompson (1952) made four quick crossings of Manus Island, primarily to prospect for bauxite. High ground was traversed in preference to stream beds, hence geological boundaries for the regional geology are only approximate, (see Plate 1).

Owen (1953) made a second visit to the three bauxite localities found by Thompson. He confirmed Thompson's interpretations of the sequence of deposition.

During the present survey, the geology around Lorengau was superficially studied. Some observations on degrees of weathering have been incorporated in this report. In addition, at the time of the survey, Dr P. Williams, of the Australian National University, Canberra, was studying some of the limestones present on Manus Island.

PRESENT INVESTIGATIONS

Officers of Commonwealth Department of Works carried out tacheometric and level surveys of the upper half of the gorge, and of a possible power house site on the left bank at the base of the gorge. Points of geological interest were plotted.

Reconnaissance geological mapping was plotted directly onto 1:25,000 topographic maps (see Plate 2). Contours on these maps are inaccurate: between the confluence of the Lauis and Irru Rivers, and the base of the gorge, there is a drop in elevation of 40 feet which is shown as a 10 foot drop on the topographic map.

PHYSIOGRAPHY

The area investigated rises from a swampy lowland extending half to one mile inland from the shore, to Thompson's (1952, p.4) "dissection plateau in early maturity". This has hills and ridges 150 to 400 feet in height. Aerial photographs and contour maps show that "the tops of hills and ridges are usually flat and of uniform elevation, suggesting former peneplanation or sub-horizontal deposition". Tuffaceous mudstones and siltstones "occur generally over the eastern end of the island. This formation would weather uniformly and rapidly producing a mature topography in a comparatively short time" (op. cit., p.4).

Upstream of the gorge, the Lauis River flows within incised meanders. The Irru River and a number of tributaries to both rivers are parallel to the regional strike of the mudstone. Both the Upper Lauis and Irru Rivers have narrow, steep sided (45 degrees or more) V-shaped valleys. Hence there is no potential high capacity storage area. Both valleys also have small remnants of high level river terraces. There is a high gap at the head of the first major tributary above the gorge on the left bank of the Upper Lauis River.

In the gorge, the valley sides rise steeply for 160 feet; the slopes are littered with huge boulders of fine-grained to glassy basalt (see Plate 4).

Downstream of the gorge the river has an aggrading, meandering character. The wide ($\frac{1}{4}$ to $\frac{1}{2}$ mile) river valley has channel deposits of gravel, sand and silt, and flood plain deposits of silty sand and clay.

A basalt flow, with its nose at the position of the present gorge, appears to have filled a former depression located approximately where the Irru River is now. The flow may have dammed the Lauis River, creating a local base level for the upper reaches and causing it to aggrade and meander. Uplift of the land or erosion of the barrier possibly caused the Lauis to incise its meanders.

HYDROLOGY

The combined catchment of the Lauis and Irru Rivers is 20.4 square miles but as no hydrological information is available, it is impossible to estimate the hydro-electric potential of the river. Limited rainfall records indicate that the average annual rainfall along the coast varies between 130 and 160 inches with little seasonal variation. January, and June to October are the wettest months. In the hinterland the rainfall is considerably higher. Hence, the river flow can be expected to be fairly constant except after torrential downpours when the river level rises rapidly up to 15 feet within the gorge, and floods the river flats below the gorge. Large trees and boulders are carried along during these times.

REGIONAL GEOLOGY

The regional geology of Manus Island is summarized in Table 1, which is based on Thompson (1952), and Owen (1953). Plate 1 shows the approximate distribution of the rocks.

Table 1 : Summary of Rock Units and Lithology of Manus Island

Age	Rock Unit and Lithology	Remarks
Quaternary		
Recent	Raised coral reefs and alluvium	
Recent to Pleistocene	Tuffs and basaltic and acid flows	Mainly on western end of the island
Tertiary		
Miocene	Marine tuffaceous sediments, ranging from agglomerate to fine mudstone. Well bedded, dipping to east up to 30°.	Extensive over eastern end of island. In part offshore equivalent of Mundrau Limestone(?).
Lower Miocene	Mundrau Limestone: dense crystalline rock	Forms karst topography in centre of island
Palaeozoic(?)	Plutonic basement: Medium-acid suite (quartz diorite)	Central south of island

DAMSITE GEOLOGY

In the damsite area there are two rock types; tuffaceous sediments are basalt. From field evidence, the basalt probably fills a former depression or valley within the sediments and parallel to their strike. The flow is apparently thickest within the Irru River valley and spreads onto the hills on both sides.

In places there is a brecciated zone at the contact between the basalt and the underlying sediments: basalt and some siltstone fragments are incorporated within a glassy matrix. The fragments were probably part of a former flow top breccia which was reincorporated within the flow boundaries, forming an apparent brecciated zone, possibly with inter-connected cavities in places.

Within the gorge, huge boulders and outcrops of slightly vesicular, glassy basalt have elongate, rounded 'pillows' of fine-grained, porphyritic basalt scattered through the matrix. The 'pillows' have an average cross section of one foot by two feet. The presence of glassy outcrops and boulders suggests that the gorge marks the position of the end of the flow.

TUFFACEOUS SEDIMENTS

In outcrop, the well-bedded sediments range in grain size from very coarse sandstone to mudstone. Conglomeratic float was noted in a number of tributaries. These transported boulders consist of fine-grained basalt pebbles and glassy fragments in a tuffaceous matrix. Bedding ranges in thickness from 1 inch (mudstone) to 4 feet (coarser sediments). Generally, the beds are persistent but lensing structures, minor crossbedding and graded bedding occur, the latter both normal and reversed. Specimen 1502* from Lorengau contains Pecten(?) and other Pelocypods. Specimen 1505 from Lauis River contains numerous Foraminifera.

The medium-grained sediments consist of: pyroxene and plagioclase (labradorite) crystals, some sub-rounded; altered basalt fragments; and minor amounts of hematite and magnetite. The grains are normally enclosed in a silt or clay matrix, some of which is slightly calcareous. In specimen 1504, a graded tuffaceous sandstone, the matrix consists of recrystallized calcite.

The regional strike of the sediments is about 050° # with a southeasterly dip ranging from sub-horizontal to 35°. Minor folding occurs.

BASALT Two textural types occur, glassy basalt and porphyritic basalt.

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*All specimen numbers refer to specimens held in the Resident Geological Office, Port Moresby.

All bearings are magnetic.

Glassy Basalt

This is found at the contact between basalt and tuffaceous sediment, and in the gorge. Both outcrops and huge boulders of glassy basalt occur in the gorge. The rock consists of large phenocrysts of plagioclase (labradorite) and smaller crystals of pyroxene, within a matrix of red-brown glass. The glass has a perlitic texture and flow structure. It also includes a number of small, elongate vesicles, some partly rimmed with quartz or zeolites (cf. specimen 1511). Near the eastern boundary of the flow the vesicles are aligned in the direction 067°.

Porphyritic Basalt

This forms the bulk of the flow. The margins are fine-grained, and the grain size gradually increases towards the interior of the flow. A fine-grained groundmass of plagioclase, pyroxene, magnetite, and secondary chlorite encloses large (up to 0.25 inches long) phenocrysts of labradorite and lesser amounts of pyroxene. Many of the plagioclase and pyroxene phenocrysts have resorbed cores and zoned rims. Many pyroxene crystals are partially or completely altered to green chlorite, magnetite and calcite.

STRUCTURES

Joints

The joint pattern in the tuffaceous sediments differs from that in basalt (see Plates 5 & 6). Insufficient joint measurements were made to determine accurately the joint pattern for the area. The major joint system in the sediments strikes between 060° and 065°; most joints dip steeply SSE, a few dip NNW. These joints are open at the surface. A secondary joint system cuts the main system approximately at right angles and dips steeply WNW and ESE. The joints of this system are tight at the surface and some have a thin film of calcite on their planes. A few joints, some of them bedding-plane joints, have flat dips.

Joint spacing is variable. Where bedding is massive the spacing ranges between 1 and 5 feet. Where bedding is well-developed, joints are between 3 and 10 feet apart.

Quadrilateral columnar jointing is prominent in the basalt. Cross-joints break all columns into cubic or rectangular blocks. The orientation and dimensions of the columns vary from place to place. Normal columnar joint spacing is between 1 and 18 inches with an average spacing of 8 inches. Deeper within the flow, larger columns occur with dimensions 2 feet by 2 feet by 5 feet and greater. A number of other joint systems also occur; one strikes between 008° and 022°, dipping steeply ESE, while a number of major, open joints strike between 060° and 080°, parallel to the lower portion of the gorge. The latter produce large joint faces, and have a joint spacing of between 18 inches and 6 feet.

Faults

A vertical shear zone that strikes 055°, occurs on the Upper Lauis River one third of a mile above its confluence with the Irru River. The 6-inch-wide shear zone contains clay and brecciated siltstone. No other evidence of faulting was observed in the field. However, a number of northwest-trending lineations in the vicinity of the gorge can be distinguished on the aerial photographs (see Plate 2).

WEATHERING

Tuffaceous sediments

At the surface the siltstone is highly weathered, brown in colour, and crumbling when crushed in the hand. Near Lorengau, the siltstone is only slightly weathered to five feet below the surface, with moderate to severe weathering along bedding and joint planes. The slightly weathered material is soft, brusing with a single geological hammer blow, and weak, requiring one to three hammer blows to break it up.

A number of minor slides (about 300 cubic yards) have occurred on steep slopes within the siltstone sequence. The slide masses have moved along the interface between soil or highly weathered siltstone and less weathered siltstone.

Basalt

Within the valley, the basalt is hard, strong and virtually unweathered. On the plateau between the Upper Lauis and Irru Rivers, near-surface porphyritic basalt has been completely weathered to a yellow-brown clay.

ENGINEERING GEOLOGY

For topographic reasons, the gorge is the only feasible damsite. The profile of the gorge excludes the possibility of damming the river by blasting down both abutments, but it is favourable for a rockfill or concrete structure (see Plate 4).

DAMSITE

The head of the gorge lies entirely within tuffaceous siltstone. A contact between siltstone and basalt occurs on the left bank, 30 yards up a stream about 80 yards down-river from the confluence of the Upper Lauis and Irru Rivers (Plate 3). Down-river from the stream, outcrop is sparse, being hidden by soil cover and huge boulders of fine-grained and glassy basalt. Some of the boulders which litter both sides of the valley and river bed are at least 900 cubic yards in volume. The number and size of boulders will make detailed damsite investigations very difficult and possibly dangerous. Also, much difficulty would be experienced in cleaning dam foundations.

The high content of glassy basalt in this area suggests that it is the lower margin of the basalt flow. Hence, it is likely that basalt would only be in situ in the right bank of the gorge and that the left bank would consist entirely of siltstone.

The siltstone may not be deeply weathered. It is soft and weak, will be easily ripped and will not withstand high stresses. Joints in the formation tend to be tight at depth and should not cause leakage. This will have to be confirmed by water pressure tests.

The basalt is strong, hard and fresh. However, though it does not appear cavernous, columnar and other major joints are open at the surface and can be expected to be open at depth. Also, the contact between basalt and the sediments may be a potential leakage zone. Drilling and water pressure testing will be required to determine the joint permeability of the basalt.

SPILLWAY

There is no apparent natural spillway from the proposed storage area. The high gap at the head of the first major tributary above the gorge on the left bank of the Upper Lauis River (see Plate 2) could be developed as a spillway. As soft, weak tuffaceous sediment is believed to occur along its whole course, the spillway channel would have to be lined. An over-the-wall spillway appears to be a better alternative.

POWER HOUSE SITE

Below the gorge there is a good power house site on the left bank of the river. The site is on a high, flat, alluvial river terrace consisting of gravel, silty sand and clay. There is at least 25 feet of alluvium overlying siltstone. Drilling, or a seismic survey, or both, will be needed to determine the exact thickness of alluvium.

SEISMICITY

The seismicity of the area is of the same order as that for Port Moresby, with maximum expected intensities of 3 to 5 on the Modified Mercalli Scale.

CONSTRUCTION MATERIALS

Porphyritic basalt exposed in the Irru River should be suitable for concrete aggregate or rockfill. A single determination of free silica (Sc) versus reduction in alkalinity (Rc) was made by the ASTM (1966) method C289-66 for sample number 1511, a glassy basalt*. This test was to determine the potential reactivity of the basaltic glass with cement. The values recorded were, Sc:260 millimoles per litre, and Rc: 133.2 millimoles per litre, indicating that the glass can be considered as 'potentially deleterious'.

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*Analysis by J. Todd, Chemist, Department of Lands, Surveys and Mines.

The only sands near the site are very silty alluvial deposits. Coral beach sand has been successfully used in the concrete for the piers for Loniu Bridge. The closest source of coral sand is near Lauis Village, on the coast.

CONCLUSIONS

1. A basalt flow, with its nose at the position of the present gorge, appears to have filled a former depression or valley within the underlying tuffaceous sediments and parallel to their strike.

2. Both the Upper Lauis and Irru Rivers have narrow and very steep-sided V-shaped valleys. Hence there is no potential high capacity storage area.

3. The steep sides of the gorge favour a rockfill or concrete structure.

4. Some boulders which litter both sides of the gorge and river bed are at least 900 cubic yards in volume. The number and size of boulders will make detailed damsite investigations very difficult and possibly dangerous. In addition, much difficulty would be experienced during clearing of dam foundations.

5. The left abutment of the dam would probably be founded in soft, weak, tuffaceous siltstone. Depending on the location of the dam, the right abutment could be founded in siltstone or hard, strong, fine-grained and glassy basalt.

6. The tuffaceous sediments are probably not deeply weathered, would be easily ripped and would not withstand high stresses. Joints within the siltstone are likely to be closed at depth.

7. Basalt is unweathered within the gorge and the Irru River valley. The basalt may have a high permeability as joints in it are probably open at depth. The basalt should provide adequate quantities of suitable rockfill or concrete aggregate.

8. Apart from coral beach sand on the coast, there are no natural deposits of sand suitable for concrete.

9. There is no apparent natural spillway from the proposed storage area. A high gap occurs to the north of the gorge. A spillway located in this position would pass over tuffaceous sediments requiring a lined channel. An over-the-wall spillway appears a more practicable alternative.

10. A satisfactory power house site occurs on the left bank of the river below the gorge. The site is on alluvium overlying siltstone.

11. The seismicity of the area is comparable with that of Port Moresby, with maximum expected intensities of 3 to 5 on the Modified Mercalli Scale.

RECOMMENDATIONS

The conclusions set out above are based on reconnaissance mapping only. Before the site can be confirmed as geologically suitable for a dam, additional geological information will be required. In particular, the following investigations are recommended:-

1. Detailed mapping of the damsite.

2. Determination of the thickness of basalt overlying siltstone, and the permeability of the basalt, by diamond drilling and water pressure testing.

3. Determination of the in situ rock type by costeaning to bedrock on the left bank.
   Depending on the results of these investigations, further examinations should include:

4. Determination of the depth of weathering, permeability and physical properties of the siltstone at the dam and power house sites by diamond drilling, water pressure testing, and laboratory testing of core samples. The contact between siltstone and basalt should also be drilled and water pressure tested.

5. At the power house site seismic testing with associated drilling will be required to determine the depth of alluvium overlying bedrock and to confirm the presence of siltstone.

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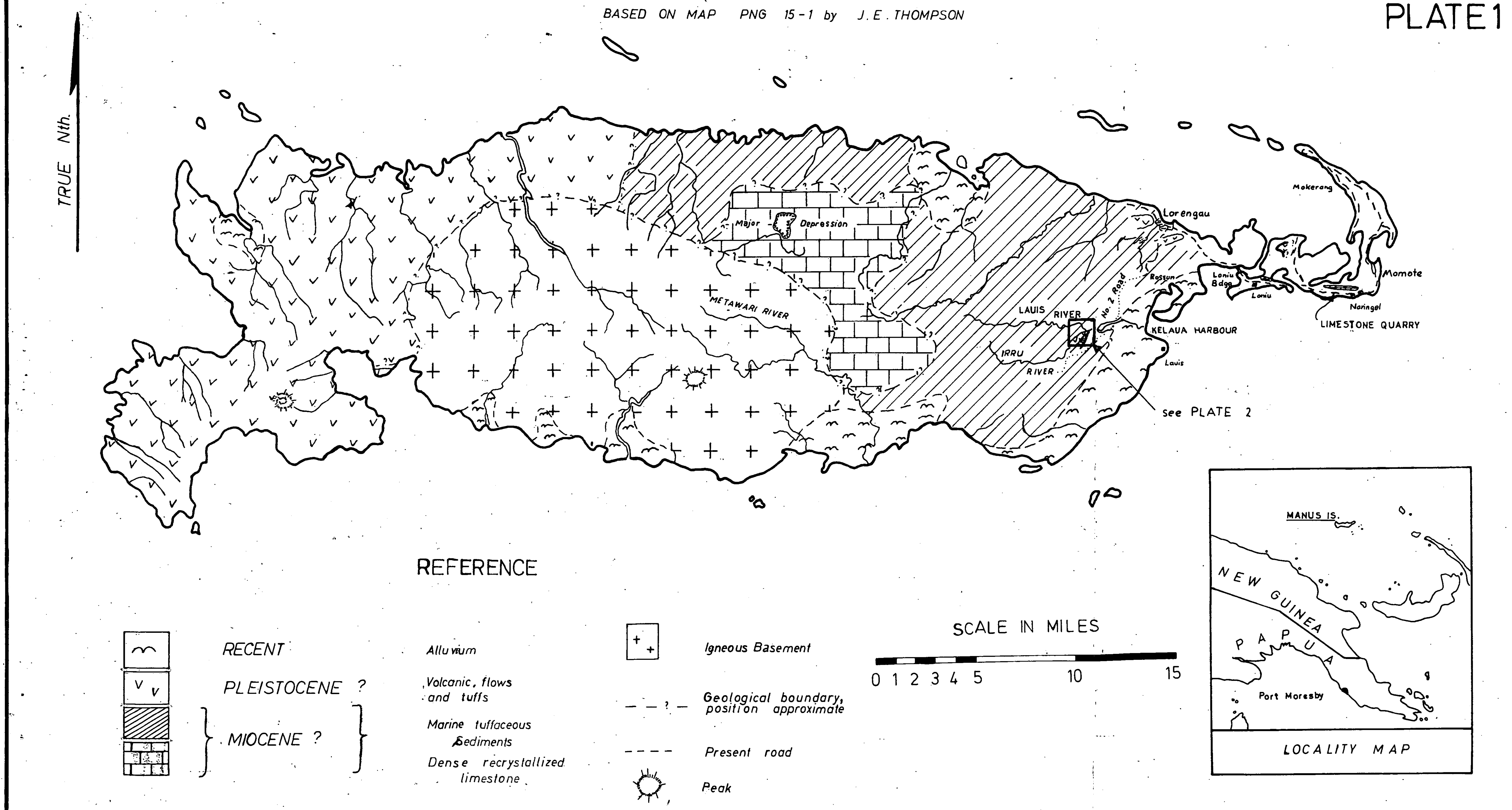
GEOLOGICAL MAP OF MANUS ISLAND

BASED ON MAP PNG 15-1 by J. E. THOMPSON

PLATE 1



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GEOLOGICAL AND TOPOGRAPHICAL MAP OF LAUIS RIVER HYDRO-ELECTRIC SCHEME

Topography based on 1:25,000 topographic series T 893

sheet 3650 IV NE

Geology based on fieldwork by J.C.Braybrooke and P.E.Pieters

500 250 0 500 1000 1500 ft.

Scale 1:6,250

true North

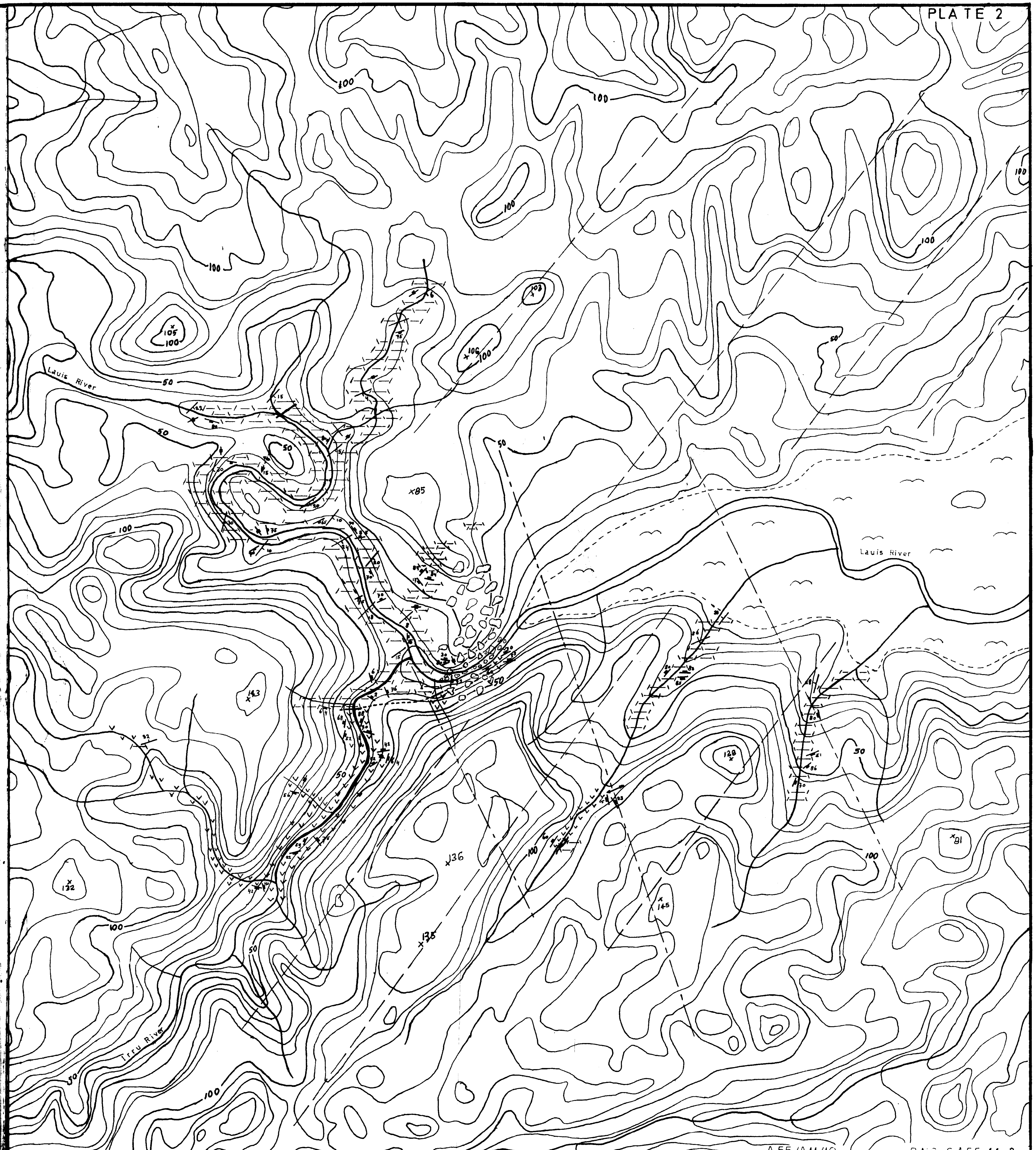
LEGEND

- Tuffaceous sediments
- Basalt
- Boulders of basalt
- Alluvium
- Strike and dip of bedding
- Horizontal bedding
- Strike and dip of fault
- Vertical fault
- Strike and dip of joint
- Vertical joint
- Anticline showing plunge
- Lineation of vesicles in basalt
- Boundary between basalt and tuffaceous sediments
- Inferred boundary between basalt and tuffaceous sediments
- Inferred boundary of alluvium
- Trend line from aerial photographs (strike of tuffaceous sediments)
- Trend line from aerial photographs (fault or dike)

To accompany Record 1969/6

Geological Office, Port Moresby January 1968

P.E.PIETERS



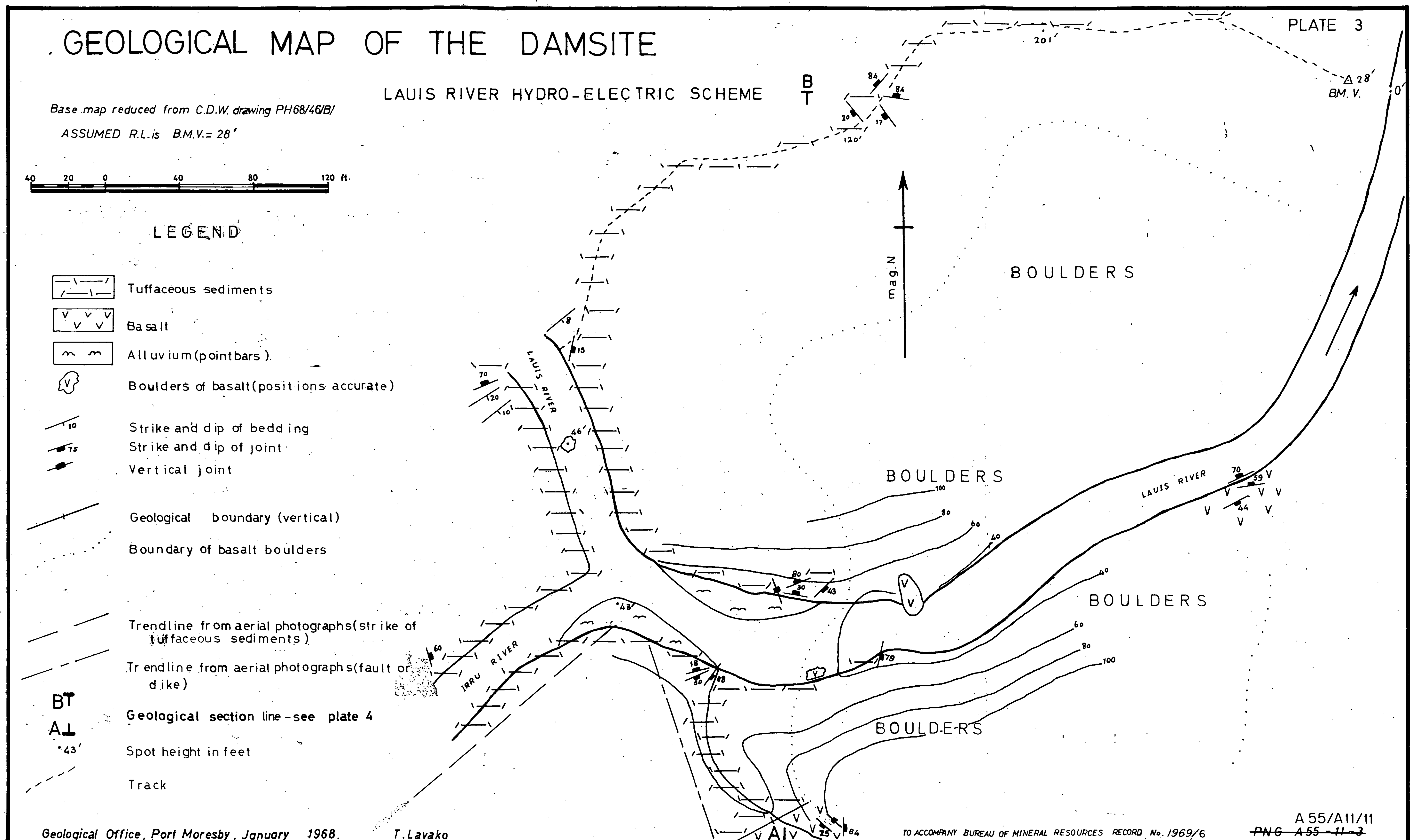


PLATE 3
GEOLOGICAL MAP OF THE DAMSITE
LAUIS RIVER HYDRO-ELECTRIC SCHEME
Base map reduced from C.D.W. drawing PH68/46/B/
ASSUMED R.L. is B.M.V.= 28'
40 20 0 40 80 120 ft.
LEGEND
Tuffaceous sediments
Basalt
Alluvium (pointbars)
Boulders of basalt (positions accurate)
Strike and dip of bedding
Strike and dip of joint
Vertical joint
Geological boundary (vertical)
Boundary of basalt boulders
Trendline from aerial photographs (strike of tuffaceous sediments)
Trendline from aerial photographs (fault or dike)
Geological section line - see plate 4
Spot height in feet
Track
mag. N
BOULDERS
BOULDERS
BOULDERS
BOULDERS
LAUIS RIVER
LAUIS RIVER
IRRU RIVER
BM. V.
Geological Office, Port Moresby, January 1968.
T. Lavako
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PLATE 4

CROSS SECTION A–B LOOKING UPSTREAM

LAUIS RIVER HYDRO-ELECTRIC SCHEME

FOR LOCATION SEE PLATE 3

LEGEND

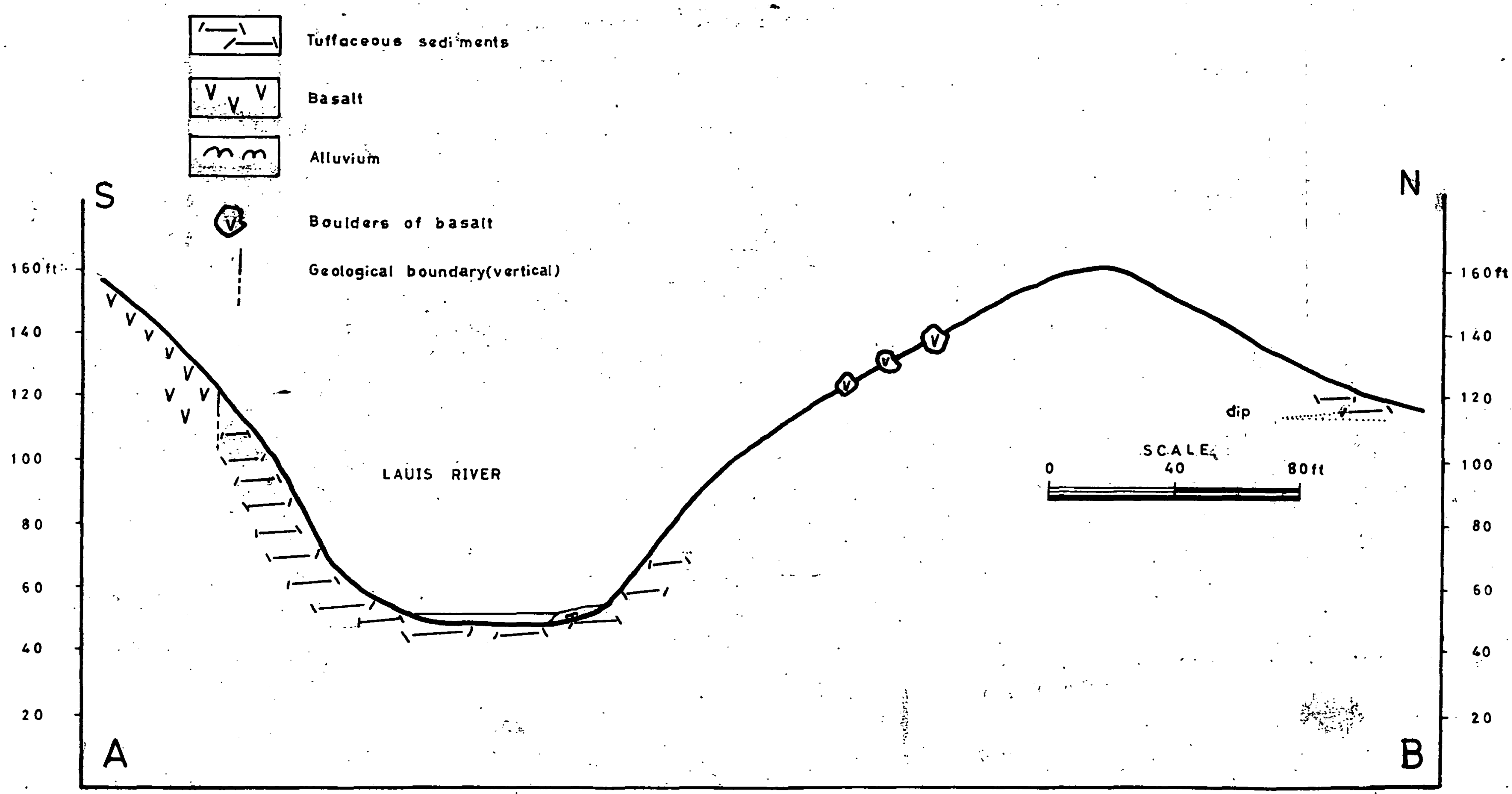

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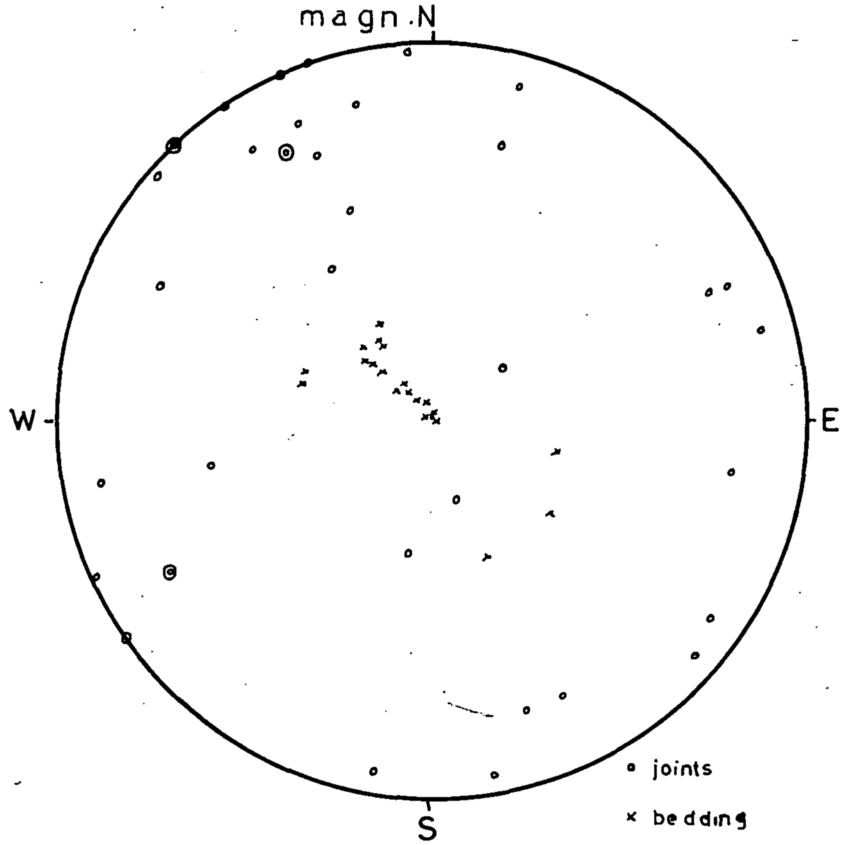
PLATE 5

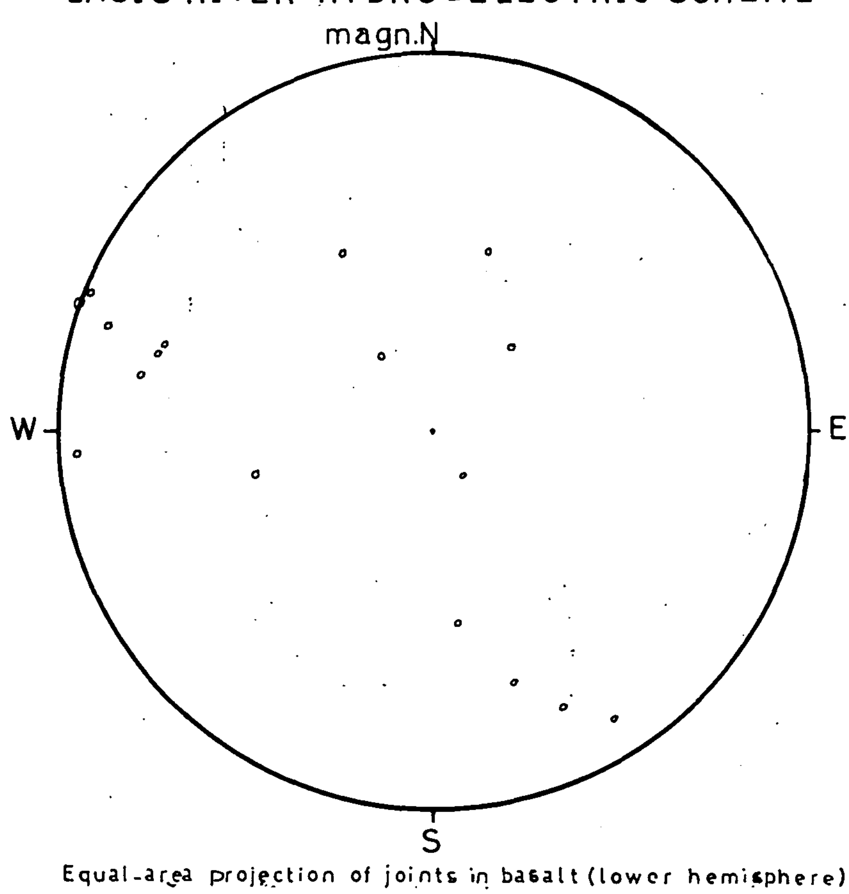
LAUIS RIVER HYDRO-ELECTRIC SCHEME



Equal-area projection of joints and bedding in tuffaceous sediments (lower hemisphere)

PLATE 6

LAUIS RIVER HYDRO-ELECTRIC SCHEME



Equal-area projection of joints in basalt (lower hemisphere)

To accompany Record 1969/6

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