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Record 1972/62

BASE MAP COMPILATION AND GEOLOGICAL INTERPRETATION OF SIDE-LOOKING RADAR IMAGERY, WESTERN CENTRAL RANGES, PAPUA NEW GUINEA

by

H.L. Davies and P.G. White

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ILLUSTRATIONS

SUMMARY

In 1971 the Bureau of Mineral Resources mapped the geology of an area of about 22 500 km^2 in the west central ranges of Papua New Guinea. Side-looking radar imagery was utilized for preparation of base maps and for geological interpretation of more than half of the survey area. The imagery was found to contain significant distortions in both range and azimuth scales. Definition is poorer than in conventional aerial photographs, however major rock units and structures can be distinguished. Some major structures are more obvious on the radar imagery than on aerial photographs because (a) any one radar imagery strip covers a large area with constant "illumination" and (b) the oblique angle of the radar beam, like low sun angle aerial photography, accentuates some structural features.

INTRODUCTION

In June-December 1971 the Australian Bureau of Mineral Resources mapped the geology of the western central ranges of Papua New Guinea, an area of about 22 500 km^2 (Fig. 1). The area is mountainous and almost completely covered in rain forest. Side-looking radar imagery was utilized for preparation of base maps and for geological interpretation for more than half of the survey area. The object of this paper is to briefly assess the utility of radar imagery in this instance, and to present some examples of lithologic and structural interpretation.

The imagery was obtained under contract in 1970 by the Australian Department of Army, which is engaged in the preparation of 1:100 000 scale topographic maps of Papua New Guinea. The contract called for side-looking radar imagery of various areas in which vertical air-photograph cover was inadequate. The largest such area was the western central ranges, an area of consistent cloud cover.

The contract was executed by Westinghouse-Raytheon, using a declassified APQ97 radar unit mounted in a DC6B aircraft. The aircraft flew at about 6 000 m maximum altitude and produced radar strip imagery at scales between 1:210 000 and 1:223 000 with a ground range sweep of about 20 km. The APQ97 operates in the K_a radar band with a nominal wave length of 8.6 mm.

BASE MAP COMPILATION

Under the terms of the contract, the Department of Army was provided with original imagery strips, an opposite-look radar mosaic, and form-line-and-drainage topographic maps. We found the radar mosaic useful as a field map for helicopter flight and ground traverse planning; however, it contained too many inaccuracies to be used as a base for preparation of final geological maps. These inaccuracies included omission of drainage where adjoining strips overlapped, repetition of drainage where adjoining strips failed to meet, and obliteration of drainage detail where mosaicing had been achieved by cutting along the approximate line of a river channel. The same inaccuracies were reproduced in the contractor's form-line-and drainage topographic maps.

Topographic base maps have since been prepared by BMR with assistance from Department of Army, using original imagery strips and the little horizontal control that was available. The following problems were encountered:

1. Scale variations and distortions inherent in the original strips include (1) along-track or azimuth scale variation which is illustrated in Figure 2; (b) cross-track or range scale variation in near and far range; (c) range scale variation due to topographic relief, including layover; and (d) other anomalies caused by the aircraft crabbing and flying a curved path.

2. Layover distortion and shadow were particuarly accentuated by the high relief of the central ranges (from 50 to 3 500 m above sea level), and the relatively low altitude of the aircraft (6 000 m).

3. All control points within the survey area are on high ground, as is customary for ground survey where maximum line of sight is required. These control points were thus in the region of maximum layover distortion and because of this, most cannot be located accurately relative to adjacent drainage on the imagery strips. Ideally, control points for such a survey should be on low ground, at readily identifiable points such as stream junctions.

4. Because of circumstances beyond the control of Department of Army and the contractor, radar reflectors were not positioned at the control points. This led to difficulty in locating some of the control points on the imagery.

The radar imagery has poorer definition than conventional aerial photography. In practical terms this means that potential helicopter landing areas such as gravel banks and small clearings can not be distinguished. However, the imagery has some advantages for the geologist in that it portrays a large area at constant "illumination" and, as a result, major structures such as fault lineaments are more obvious. Also the oblique angle of the radar beam, like low sun angle aerial photography, accentuates some structural and geological features.

GEOLOGICAL INTERPRETATION

Examples of lithological and structural interpretation have been selected from a north-south zone across the western central ranges at about 4°20' - 6°S, 142°30' - 142°40'E. In each case the imagery is accompanied by a simple geological map based on scattered ground observations and interpretations.

The northernmost example is an area of low hills north of the Hunstein Range and south of Ambunti on the Sepik plains (Figs. 3 and 4). The main rock units are (1) metamorphics, (2) ultramafics, (3) volcanics, and (4) diorite. The metamorphics are predominantly mica schist and garnet-mica schist (field names). These are former Mesozoic? pelitic sediments metamorphosed probably in late Oligocene - early Miocne. The ultramafic body is harzburgite with metamorphic texture and was probably emplaced by late Oligocene faulting. The volcanics are lava and probable submarine autobreccia of unknown age (K-Ar dating in progress), and the diorite is lower Miocene (Page, 1971). Particularly characteristic topography is developed on both the diorite (fine dendritic drainage, generally low relief) and the ultramafic body (smooth convex slopes). The volcanics can be distinguished from the metamorphics by their more blocky and angular topography. A pattern of NNE and NNW lineaments is apparent in the imagery, and some of these are taken to be normal faults.

The second example (Figs. 5 and 6) is 35 km south of the first, in the middle reaches of the April and Sitipa Rivers, on the edge of the Sepik plains. Geological interpretation is based on Dow et al. (in press). The east-west Frieda Fault splays southeastward into a series of straight and curved faults, some of which are marked by lenses and irregular bodies of ultramafic rock. Characteristic smooth convex surfaces are developed over the ultramafic bodies. Fine dendritic drainage and remnants of sub-horizontal bedding surfaces mark the area of Miocene sediments. The Eocene and Jurassic rocks are not readily distinguished in this image.

The third example (Figs. 7 and 8) is about 65 km south of the second, and immediately north of the government station at Lake Kopiago. Jurassic siltstone and shale are conformably overlain by Cretaceous siltstone and sandstone, which is in turn overlain by upper Oligocene-middle Miocene limestone, and middle Miocene to Pliocene limy and clastic sediments. The entire sequence is concordant but has been folded and faulted in the Pliocene and Quaternary.

The prominent ridges in Figure 7 are formed by the Oligo-Miocene limestone, which is 800 - 1 000 m thick and typically forms cliffs and dip-slopes. Less prominent strike ridges below the limestone are Cretaceous sandstone horizons, and ridges above the limestone are younger Miocene-Pliocene limy and clastic sediments. Strata are folded into a series of ESE-trending synclines which have apparently been disrupted by vertical or strike-slip faulting. The narrow boat-shaped syncline in north centre may owe its shape to diapirism in the underlying Mesozoic sediments (Jenkins & White, 1969). Along strike to the ESE the limestone has possibly been repeated by low-angle reverse faulting or gravity sliding; karst topography is developed on the upper limestone horizon. The anticline in Jurassic sediments on the Urei River is not obvious in this part of the radar strip.

The fourth example (Figs. 9 and 10) is the Lavani Valley on the summit of the Mueller Range, 40 km south of Lake Kopiago. The Mueller Range is a major NW-trending anticline involving Jurassic and Cretaceous clastic sediments and the Oligo-Miocene limestone. The Lavani Valley is on the axis of the anticline where the limestone carapace has ruptured and been partly removed to expose the underlying late Mesozoic sediments (Buchan & Robinson, 1969). The imagery shows the contrasting surface texture of limestone and clastics, and a pattern of NE and NNW-trending lineaments most of which are probably vertical dip-slip faults. The area of porphyritic microdiorite cannot be confidently defined from the imagery alone. About one-third of the imagery strip is in shadow, owing to the considerable elevation of the area (3 500 m) with respect to the aircraft (about 6 000 m).

Figures 11 and 12 illustrate an area about 30 km south of the Lavani Valley on the southwestern flank of the Mueller Range anticline. Oligo-Miocene limestone and conformable Miocene sediments have been intruded by Plio-Pleistocene stocks of porphyritic microdiorite. Volcanic agglomerate and tuff, related to the Plio-Pleistocene intrusives, overlie the south-eastern part of the area. Karst topography has developed over the limestone of the Karius anticline. The northwestern porphyry stockhas caused a doming of the Miocene sediments which dip off at 30°. The southeastern stock apparently intruded less forcefully.

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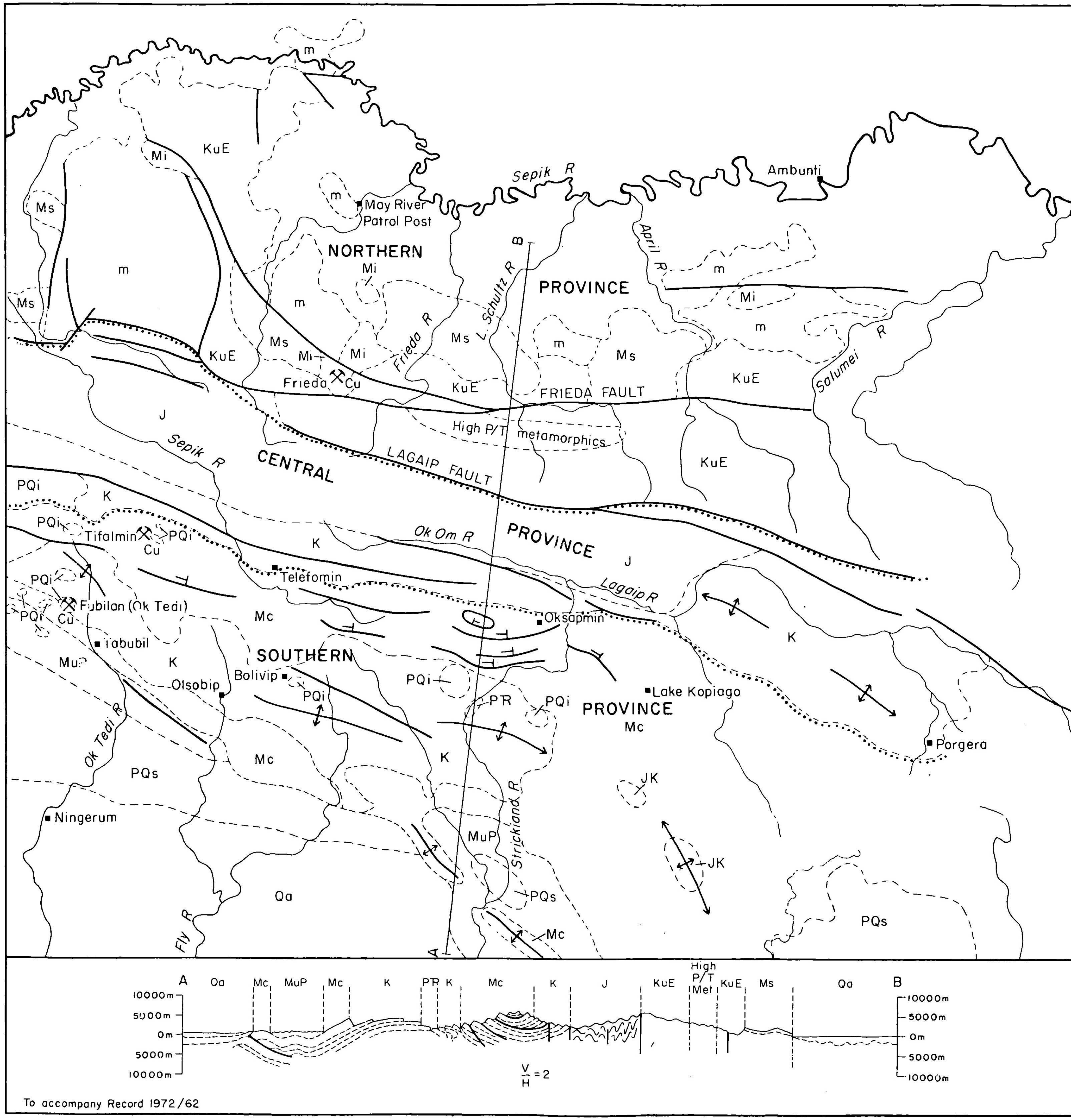
Fig. I

STRUCTURE AND SIMPLIFIED GEOLOGY WEST CENTRAL RANGES, P.N.G.



20 10 0 20 40 Km

	Qa	Alluvium
Plio.-Pleist.	PQs	Volcanic sediments, volcanics
	PQi	Intrusives
U.Mio.-Plio.	MuP	Sediments
M.Mio.	Ms	Arenaceous sediments, volcanics
	Mi	Intrusives
Oligo.-Mio.	Mc	Limestone
U.Cret.-Eoc.	KuE	Fine-grained marine sediments and basic volcanics
Cret.	K	Siltstone and sandstone
Jur.-Cret.	JK	Siltstone and sandstone
Jur.	J	Fine-grained sediments, mostly black slate and schist; metamorphic grade increases northwards
Jur-Cret?	m	Metamorphic rocks, generally sialic
Permo-Triassic	PR	Granite basement

- - - - Geological boundary

Fault

Thrust fault

Anticline

.... Province boundary

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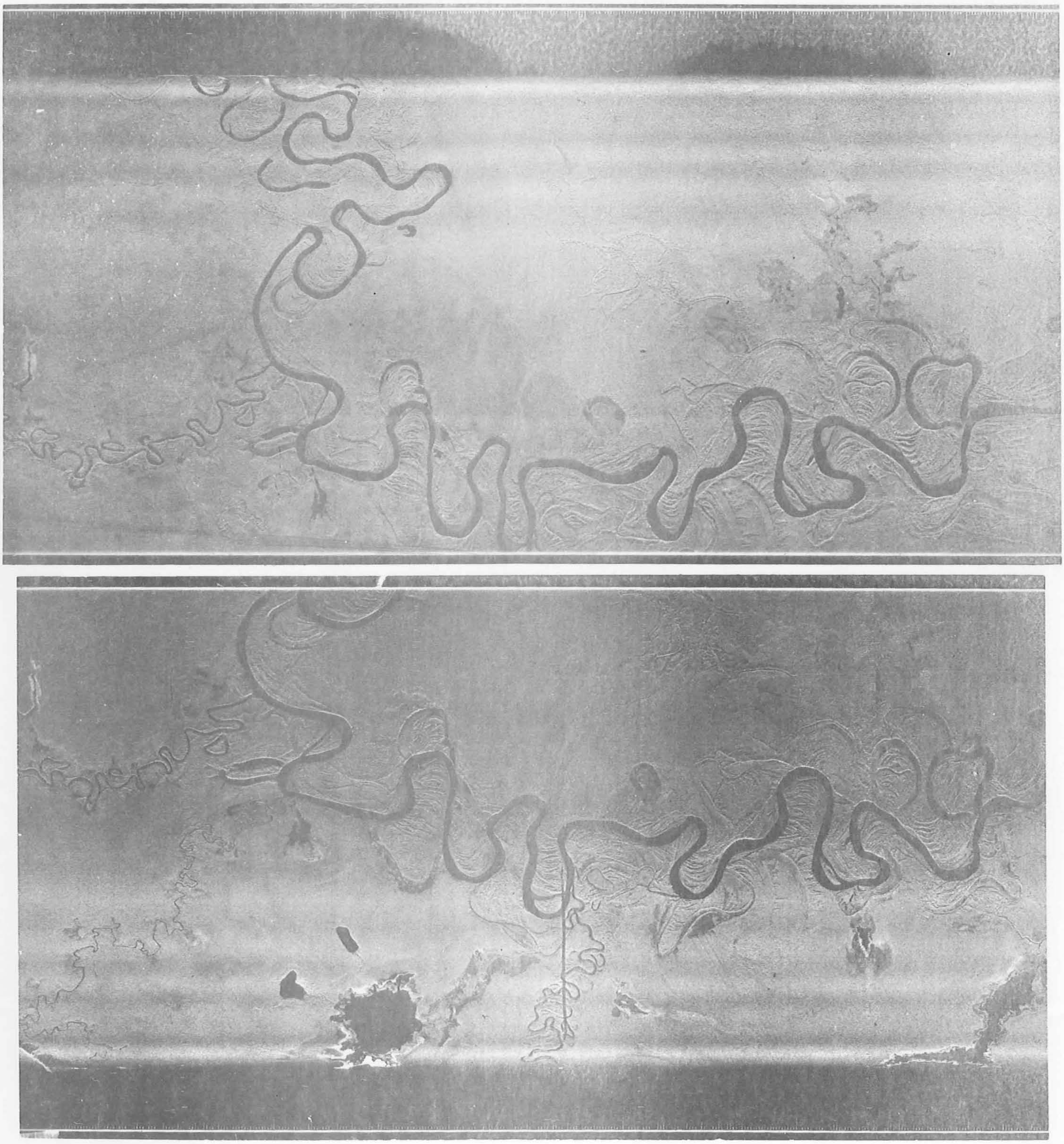


Figure 2
Example of azimuth-scale variation

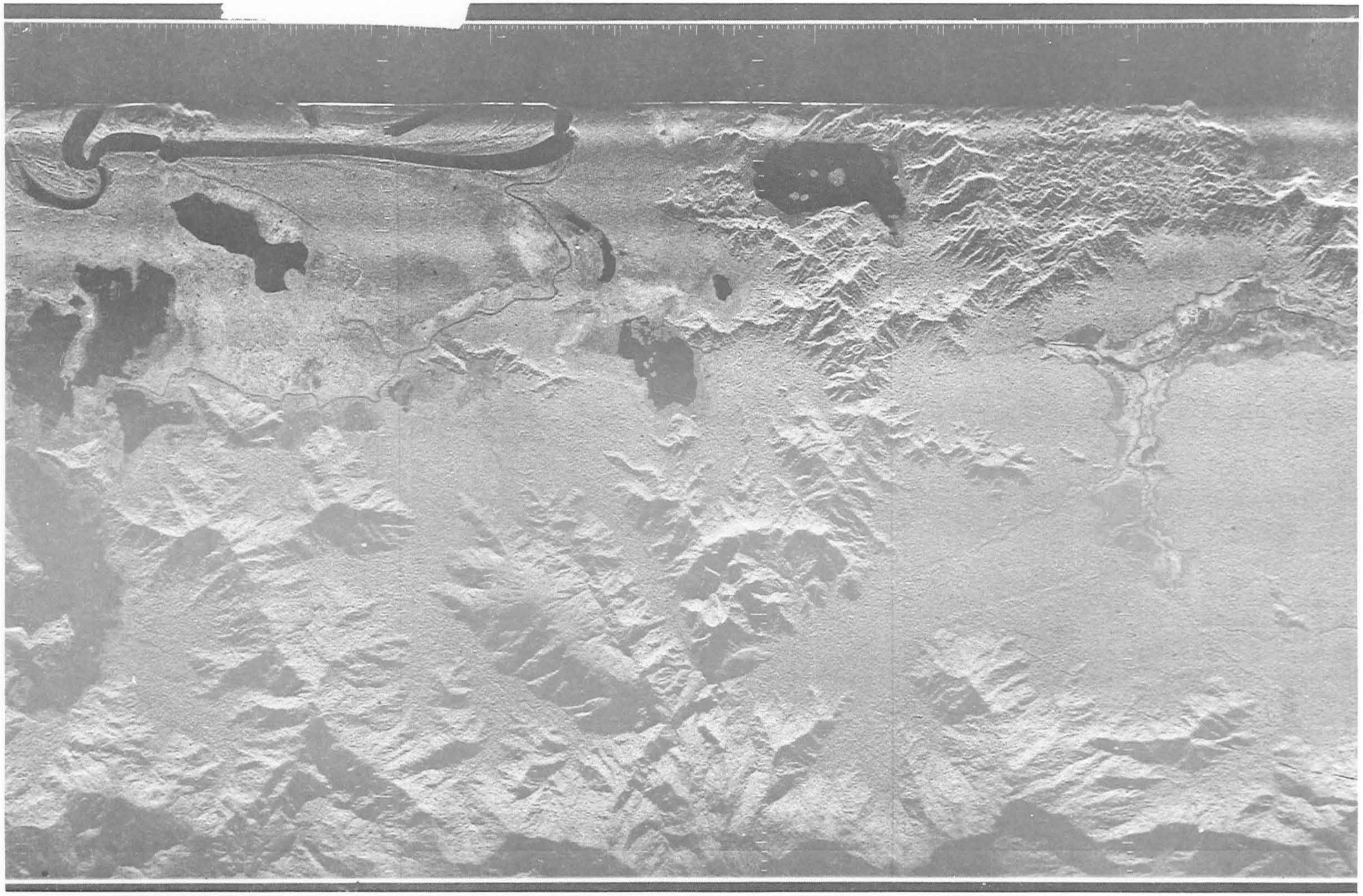
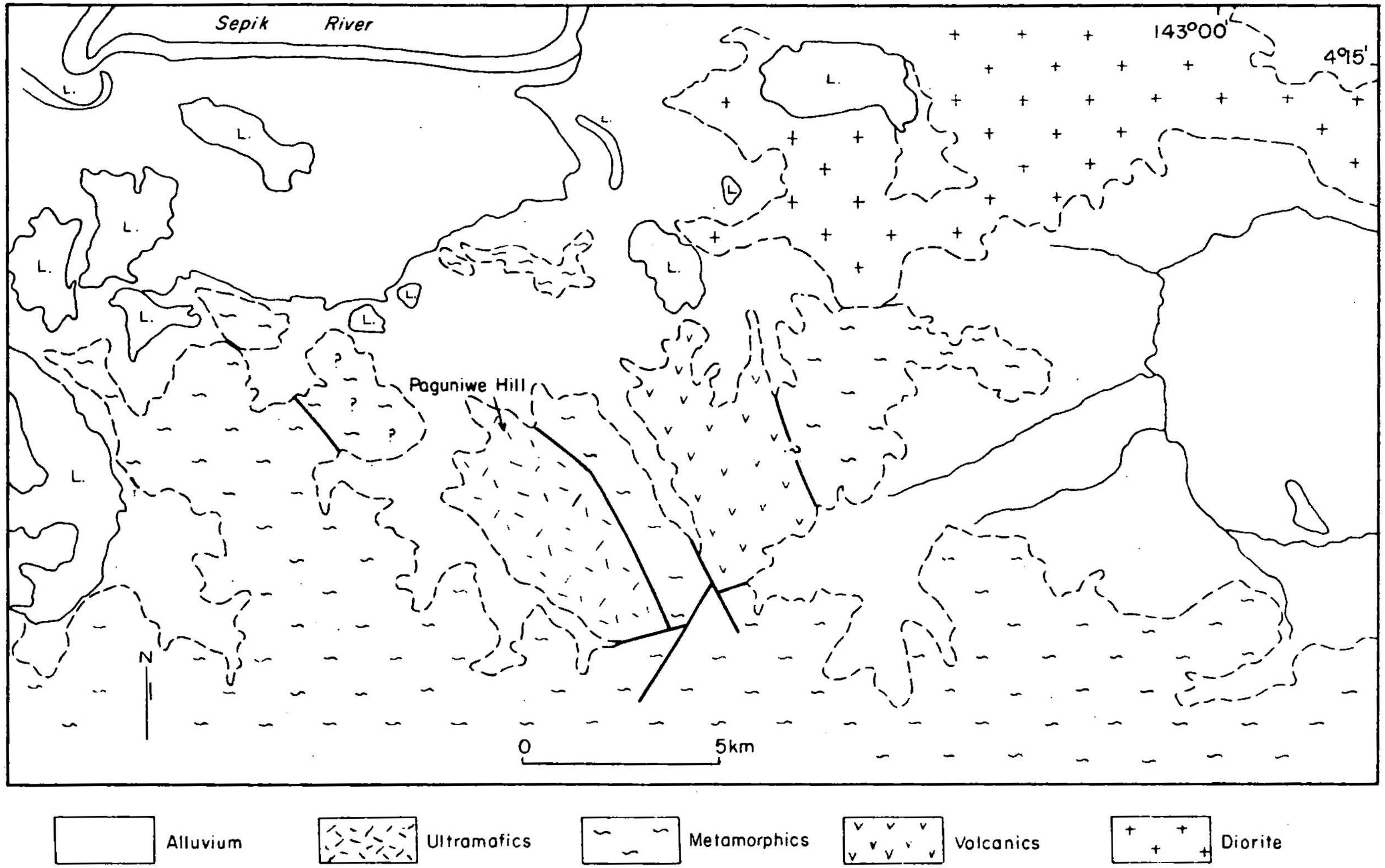


Figure 3

Fig. 4



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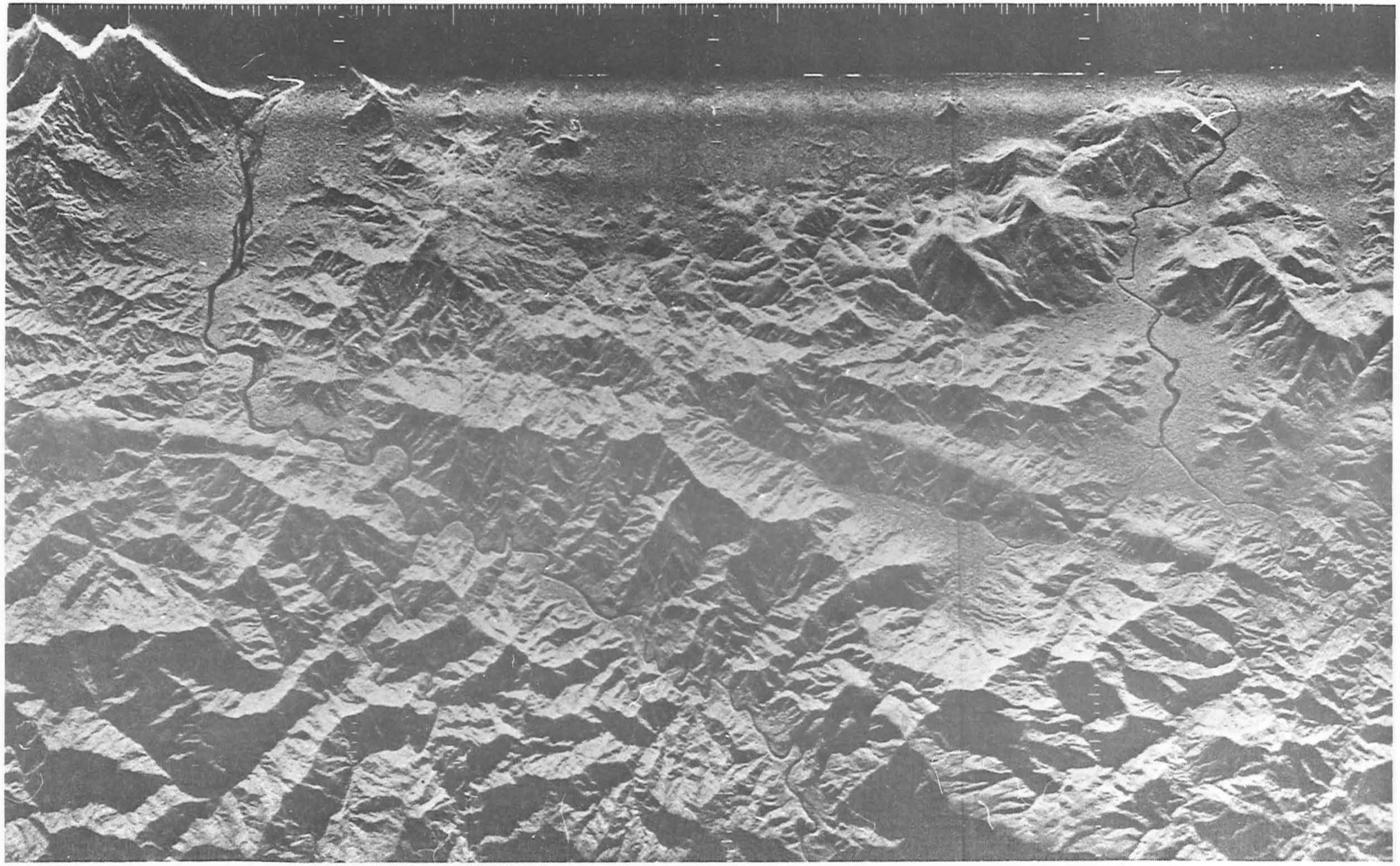
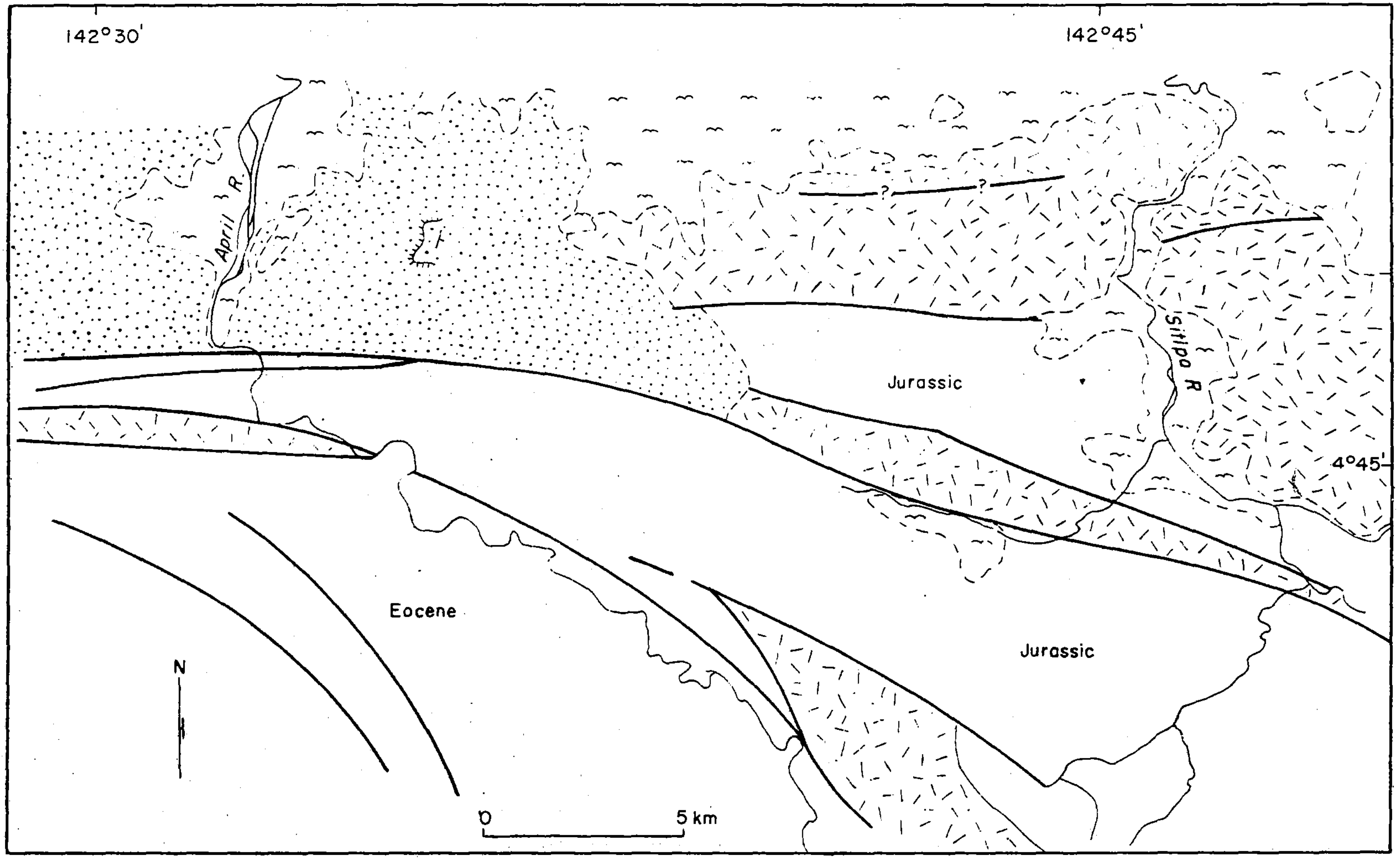


Figure 5

Fig. 6



Alluvium

Miocene greywacke and siltstone, gently folded

Jurassic and Eocene sediments and volcanics, tightly folded, slightly metamorphosed

Ultramafics

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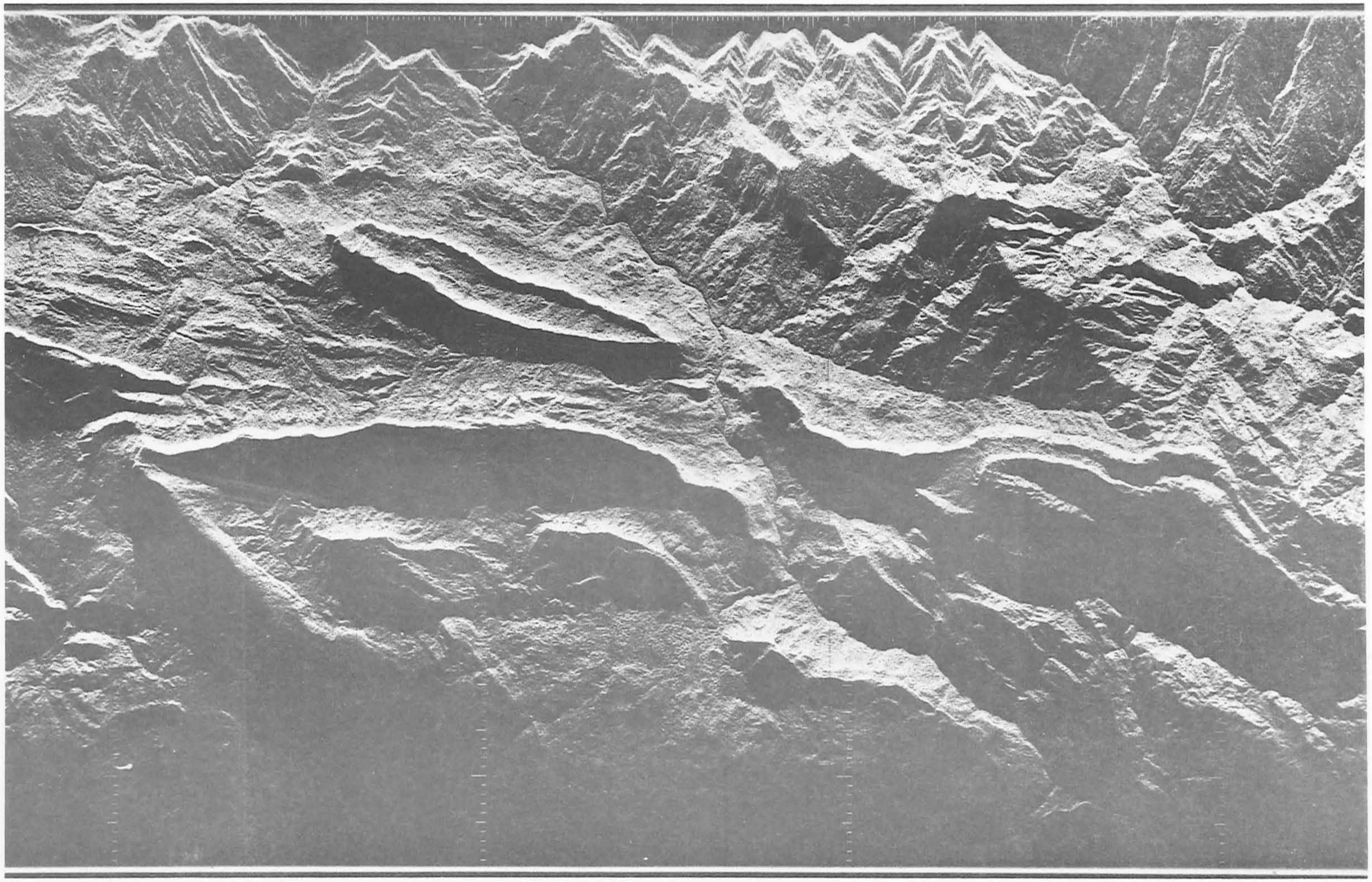
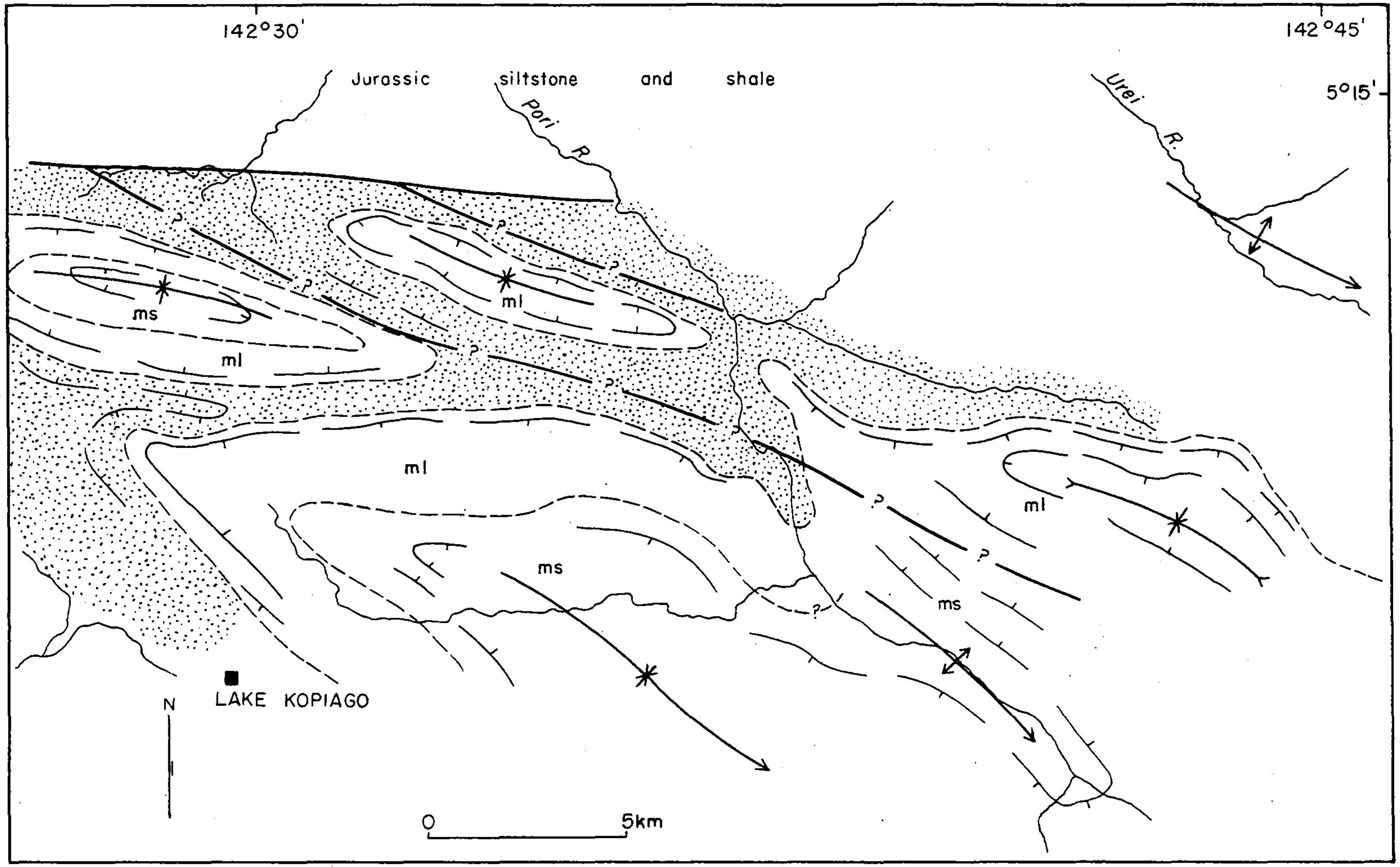


15A
16A

Figure 7

Fig. 8



Cretaceous sandstone and siltstone ml — Oligo-Miocene limestone ms — Younger Miocene sediments

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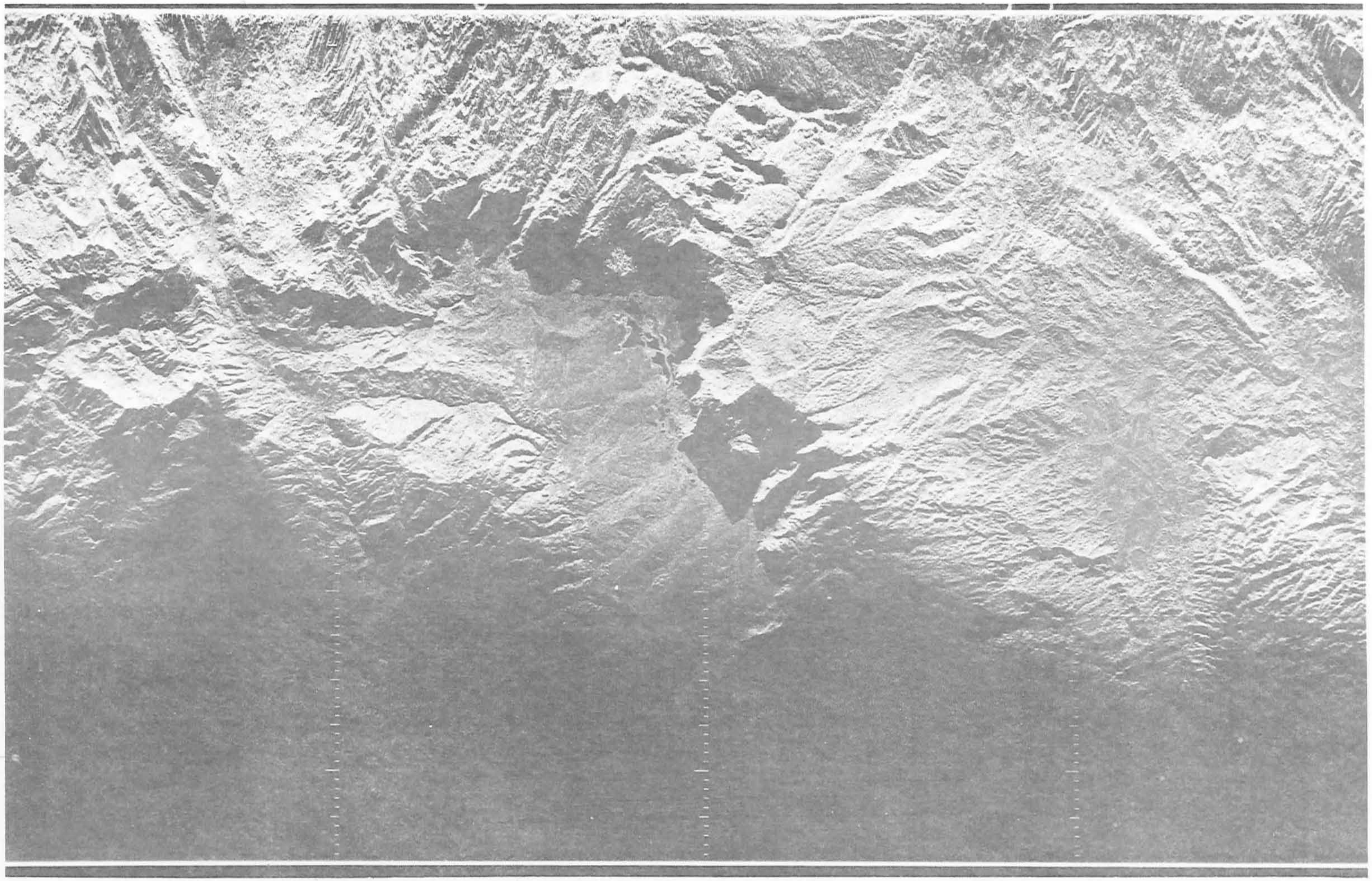

7A/8A

Figure 9

Fig.10

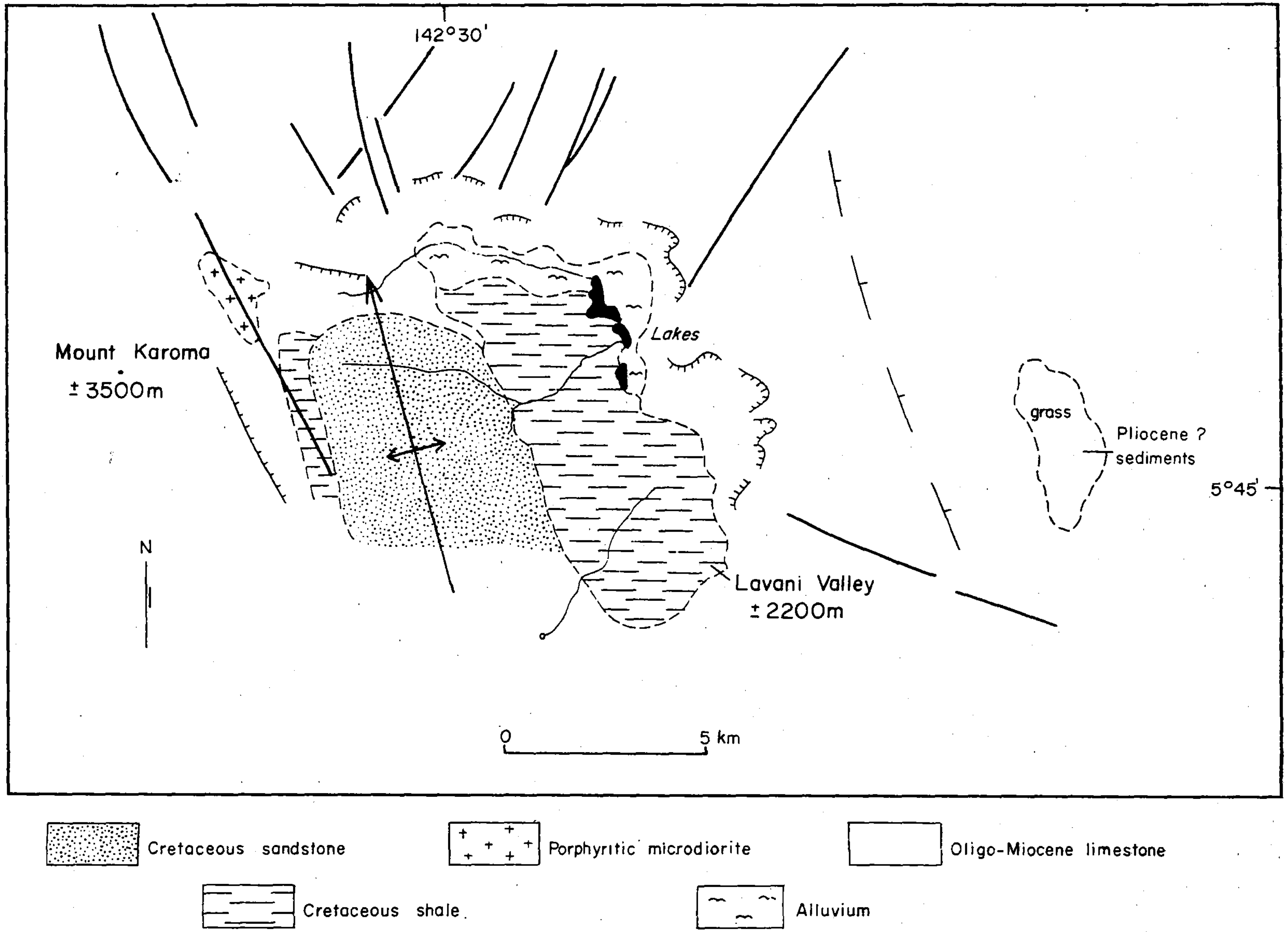

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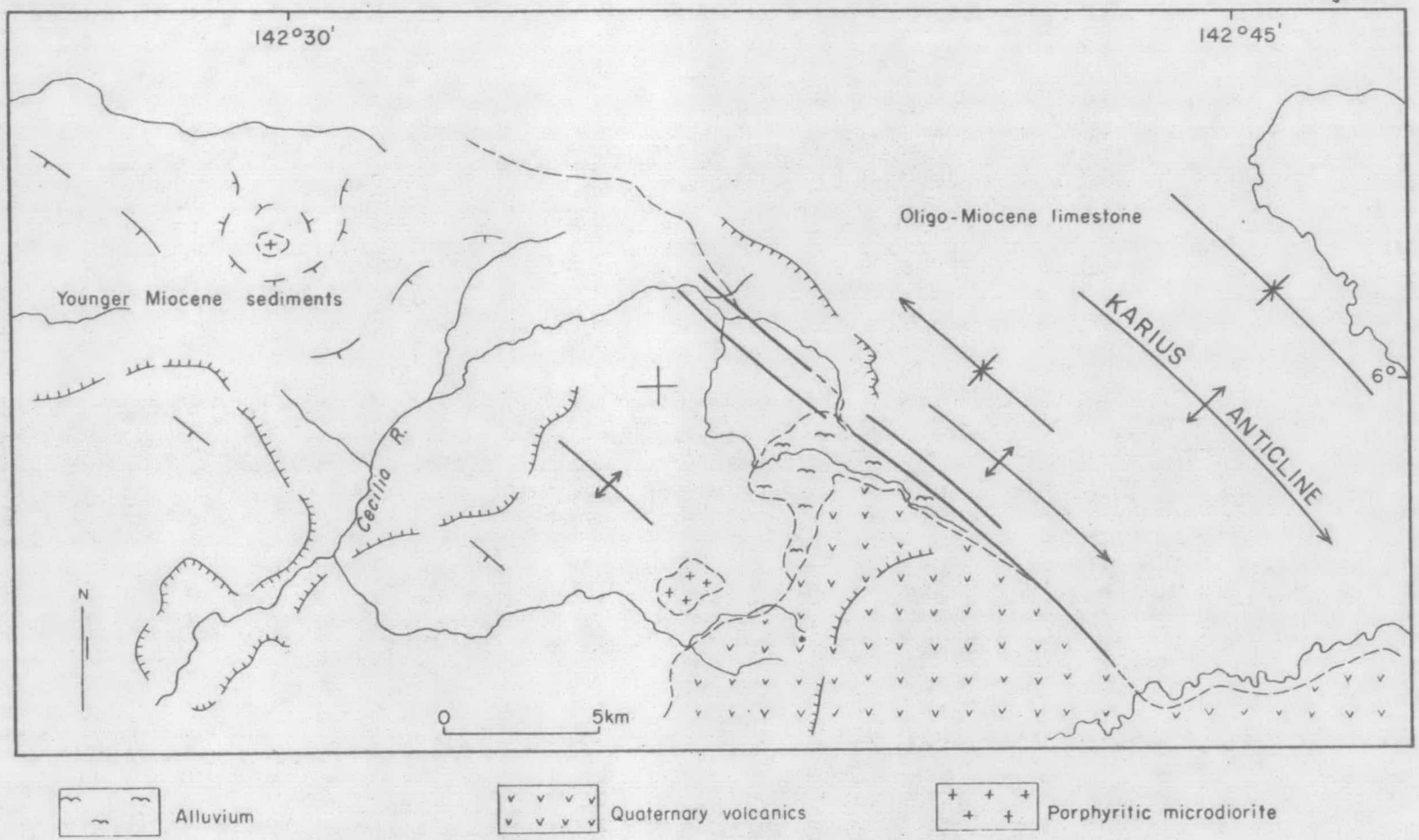
Figure 11

Fig. 12



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