EMPLACEMENT OF THE MERATUS ULTRABASIC MASSIF: A GRAVITY INTERPRETATION

by

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ABSTRACT

Based on gravity data, extensive outcrops of igneous ultrabasic rocks at Meratus Range in Southeast Kalimantan have been interpreted as part of oceanic crust emplaced onto the margin of the Sundaland. The Meratus ultrabasic massif appears to be a thin slab with relative thickness of 300 m, thickening to 350 m to the southeast. If serpentinization of ultrabasic rocks is taken into account, the thickness of the allochtonous masses will increase to 780 m. Considering the occurrence of similar rocks in Kukusan Mts, Laut Island and the South Arm of Sulawesi, we suggest that the Meratus massif forms part of a larger oceanic crustal segment emplaced during the Middle Cretaceous obduction.

I. INTRODUCTION

The Meratus Range (Fig. 1) corresponds to the central part of the area referred to as the Meratus Graben by Rose and Hartono (1978), where deepsea sediments, ultrabasic and metamorphic complexes are present, covered unconformably by Cretaceous sediments. The same rock types also occur in the Laut Island, but in addition, post-Eocene diabasic extrusive rocks are also present. To the southeast of Banjarmasin, Late Miocene sediments rest unconformably upon Pretertiary, indicating that the Meratus Range was uplifted prior to Late Miocene times.

To a less extent similar rock asemblage occurs to the east of Meratus Range at the Kukusan Mts and further east across the Makassar Strait in the southwest part of the South Arm of Sulawesi (Hamilton, 1979).

Previously, those ultrabasic rocks were regarded as deep seated intrusive bodies (van Bemmelen, 1949), however, since the advent of plate tectonic theory they are now considered as part of Mesozoic oceanic crust obducted onto the margin of the Sundaland (Katili, 1978). Further support for obduction hypothesis based on gravity data is presented in this paper.

II. THE MERATUS ULTRABASIC MASSIF

The ultrabasic complex outcrops in the NE–SW trending Bobaris and Meratus Ranges, known in the literatures as the Bobaris and Meratus ultrabasic massif (Plate 1A, B). Predominantly green to greenish - gray in color, the rocks have been affected by strong weathering and are very often strongly sheared and serpentinised. The ultrabasic rocks are made up mainly of serpentinised dunite, lherzolite, pyroxenite, with some hornblendite and wherlite. Gabbro, diorite and granite are commonly observed to occur in the areas where ultrabasic rocks crop out. These intrusions do not occur in the sedimentary unit. In some localities, basalts are found associated with basic or ultrabasic rocks.

The associated gabbro is greenish-gray, holocrystalline and commonly composed of plagioclase, pyroxene and hornblende. Plagioclase is often altered into clay minerals, whereas hornblende and pyroxene are altered into chlorite and iron oxides. In the offshore area, Taka Talu-2, an exploration well, penetrated basement made up of gray, inequigranular, holocrystalline diabase/gabbro. Essential minerals are plagioclase and hornblende, the first is saussuritized and the latter altered into chlorite. Accessory minerals are apatite, zircon, biotite, quartz, sphene and opaque ore minerals.

Basalt is gray-green in color, holocrystalline, occasionally porphyritic in texture, with plagioclase, pyroxene and hornblende embedded in fine mafic minerals and plagioc. groundmass. Alteration is common in plagioclase to form clay minerals, whereas part of the hornblende is altered into chlorite and

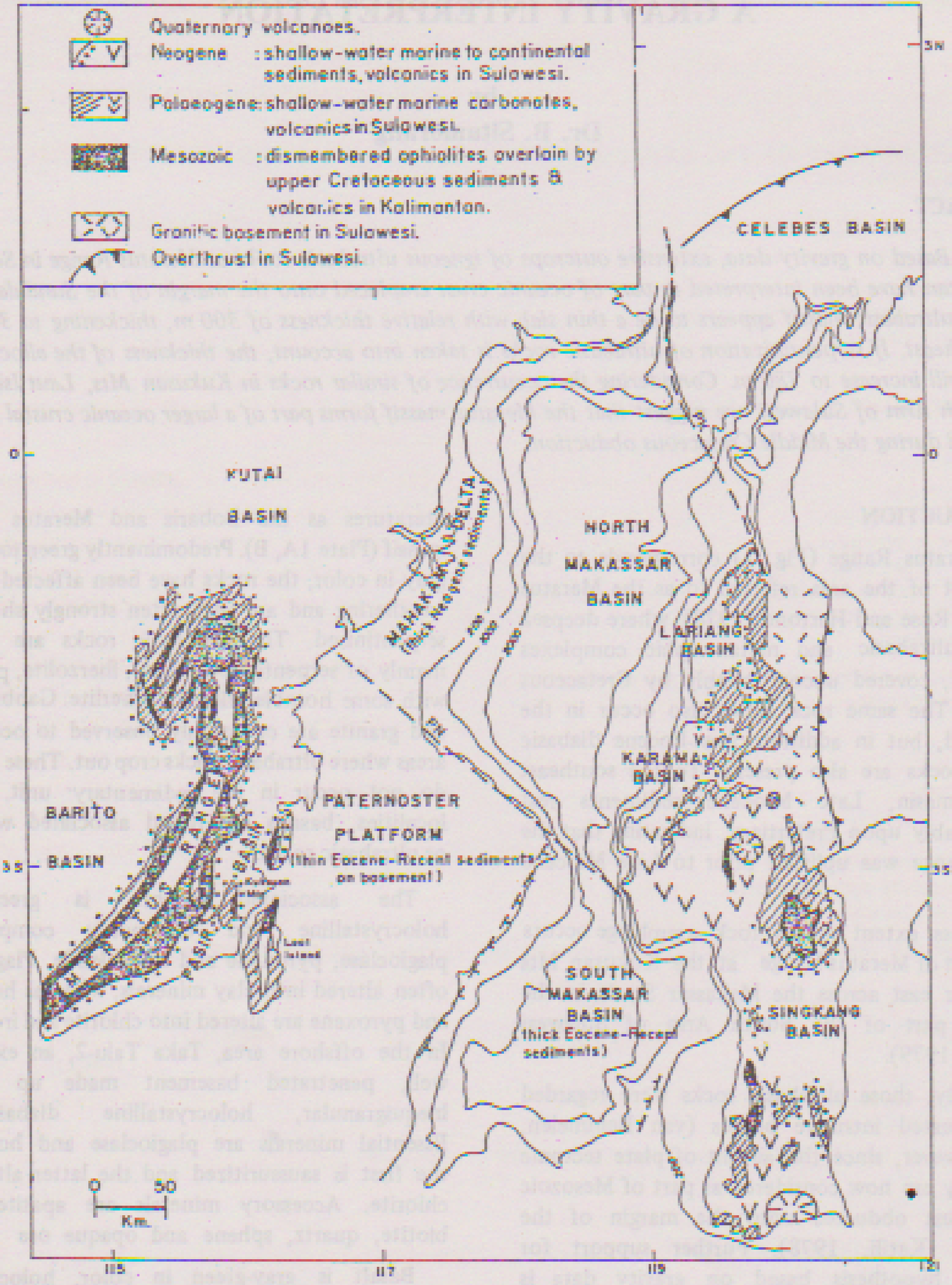

Figure 1 **Major structural elements of the Meratus region and surroundings. Faults from Hamilton (1979) with the northwest part of Palu Koro Fault (PK) modified to fit bathymetry data. Trace of subduction zone northwest of Sulawesi after Hamilton (1979). PN: Paternoster Fault. Bathymetric contours are in m.**

opaque ore minerals. Vesicles sometimes can be observed, and also fine carbonate veins. Geochemical analysis of some basalts was kindly provided by the Geological Survey of Indonesia; the results indicate the SiO_2 contents in the range of 43%–51%, K_2O from 0.1%–0.4%, and TiO_2 from 0.7%–1.6%, which characterized the abyssal tholeiites as defined by Miyashiro (1975).

Granite has a white-gray color, is holocrystalline, and is made up of quartz, feldspar, hornblende and biotite. Feldspar is altered into clay minerals and sericite. Hornblende is commonly altered into chlorite and opaque ore minerals. Some specimens exhibit a graphic texture, where quartz is intergrown with feldspar (Plate 2A, B).

The ultrabasic complex is commonly intruded by greenish-with-gray diorite, holocrystalline, euhedral to subhedral, occasionally with porphyritic texture and with essential minerals of feldspar, hornblende and guartz in a fine grained feldspathic matrix (Plate 3). Fractures are developed and filled by calcite.

The age of this ultrabasic complex is still uncertain. According to van Bemmelen (1949) the ultrabasic complex was emplaced at the end of the Lower Cretaceous, to coincide with the first geanticlinal upwarp in Meratus region and intruded into the younger Alino and Paniungan Formations. He suggested that intrusions varied in composition with time, starting with ultrabasic and basic, finally ended with an acid intrusions. But as has been pointed out, nowhere are these rocks seen to be introdued into the sediments of the Alino and Paniungan Formations. Katili (1978) is of the opinion that obduction of the ophiolites-to which the ultrabasic massif included- in the Meratus Range took place at the end of Pliocene due to the collision between West Sulawesi and East Kalimantan. The present author (in preparation) suggested that emplacement of an ultrabasic wedge, once part of oceanic crust onto the margin of the Sundaland where it is presently found in the Meratus Range and South Sulawesi took place in the Middle Cretaceous (Albian-Cenomanian).

III. GRAVITY DATA

The Bouguer gravity anomaly map of Barito and Kutai Basins of East Kalimantan is the only gravity data available for the Meratus region. The map was prepared by Lemigas/Pertamina/Beicip (1971) in the framework of Kalimantan Basin Studies, compiled from all petroleum activities between 1939 to 1954. Part of the map with Bouguer anomaly superimposed on the geological map is presented in Fig.2, which covers the Barito Basin, Meratus Range and Pasir Basin.

It can be seen that the Barito Basin anomaly exhibits an asymmetrical form with a westward gentle gradient and a steep gradient in the east, suggesting a fault contact along the western front of the Meratus Range. This has been confirmed by Pelton (1974) using seismic reflection data. The negative anomaly (-20 mgal) is due to the sediment fill in the basin.

The Meratus Range is characterized by a positive gravity anomaly with a maximum value of 70 mgal in the northeast. A gravity profile across the Range has been constructed (AA in Fig.2) and is chosen to cross the large outcrop of ultrabasic rocks in the southwestern part of the Range. A crustal density of 2.70 g/cm^3 is used as reference density, and the density of ultrabasic rocks is taken as 3,25 g/cm^3, a value similar to the one used by Silver et al. (1978) in East Sulawesi, where ultrabasic rocks are assumed to be unserpentinized. The density of the Tertiary sediments is taken as 2.50 g/cm^3. The density contrast is then 0.55 g/cm^3 for ultrabasic rocks and –0.20 g/cm^3 for the sediments.

Following the method described by Talwani et al. (1959), a two dimensional model corresponding to profile AA in Fig.2 has been constructed (Fig.3). The Barito Basin in the middle part of the profile and the Pasir Basin at the southeastern end approximate to 5-sided and 4-sided polygons respectively, and their gravity attraction is calculated. As the value of 2.70 g/cm^3 is used as the reference density a residual anomaly obtained by substracting the gravity attraction of the sediments from the observed anomaly is due to variation of crustal thickness and hence depends only on the depth to M-discontinuity. Maximum sediment thicknesses for the Barito Basin and the Pasir Basin are estimated at 7 km and 5 km respectively from average values obtained from Lemigas / Pertamina / Beicip (1971).

To estimate depth to the M-discontinuity, a mean value of 25 km is used as an approximation. This value is obtained by Grushinsky (1967) for the Paternoster Block just to the east of the profile, based on a worldwide statistical analysis of the relationships between Bouguer anomalies topography and depth to the M-discontinuity.

Gravity attraction due to variation of the thickness of the crust is then calculated, and the depth to M-discontinuity is adjusted as necessary in order to obtain the best fit between calculated anomaly and residual anomaly. Any discrepancy over the Meratus Range is due to the effect of the ultrabasic rocks.

The computer program used in this calculation is due to Dr. M. Bacon. Brifly, the program calculates the gravity attraction of a two-dimensional model, which consists of prisms infinite in one horizontal (y) direction (Bacon, 1979). The effect is calculated at various points with uniform spacing along the x-axis of an x-z system of coordinates, where the model (approximated as n-sided polygon) lies in the x-z plane. The contributions of all polygon sides are evaluated by the program, and summed for each point.

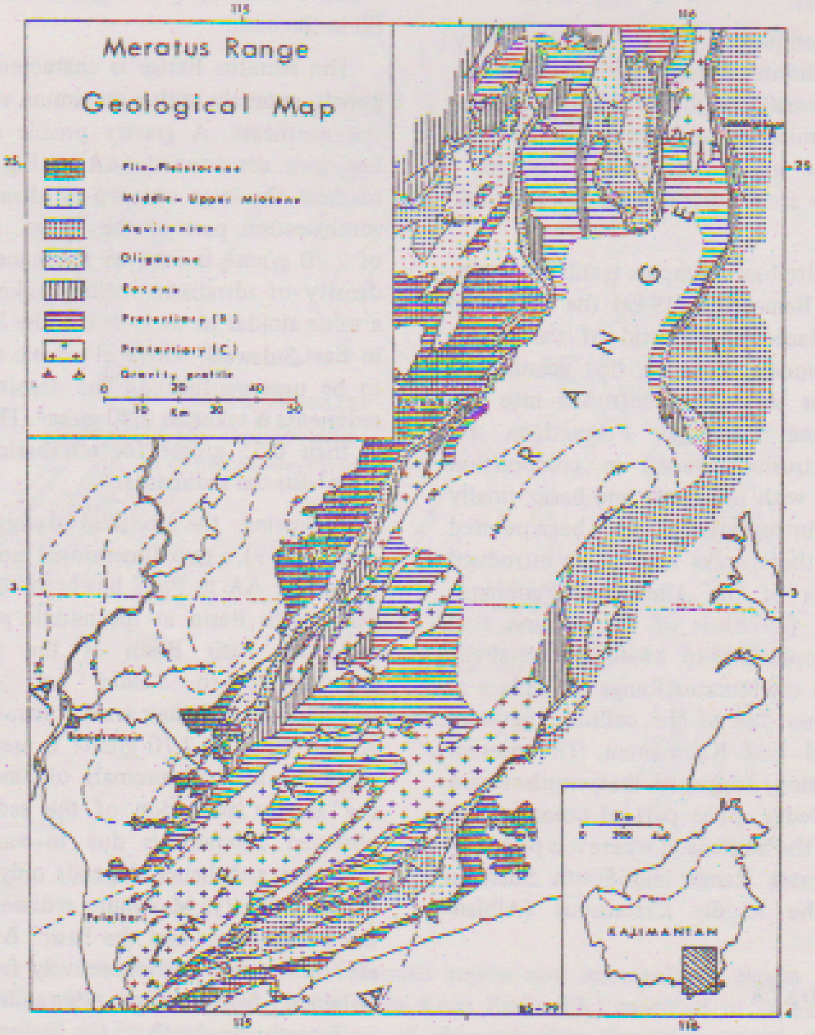

Figure 2 Geologic map of Meratus Range and surroundings; gravity contours (in mgal) are superimposed.

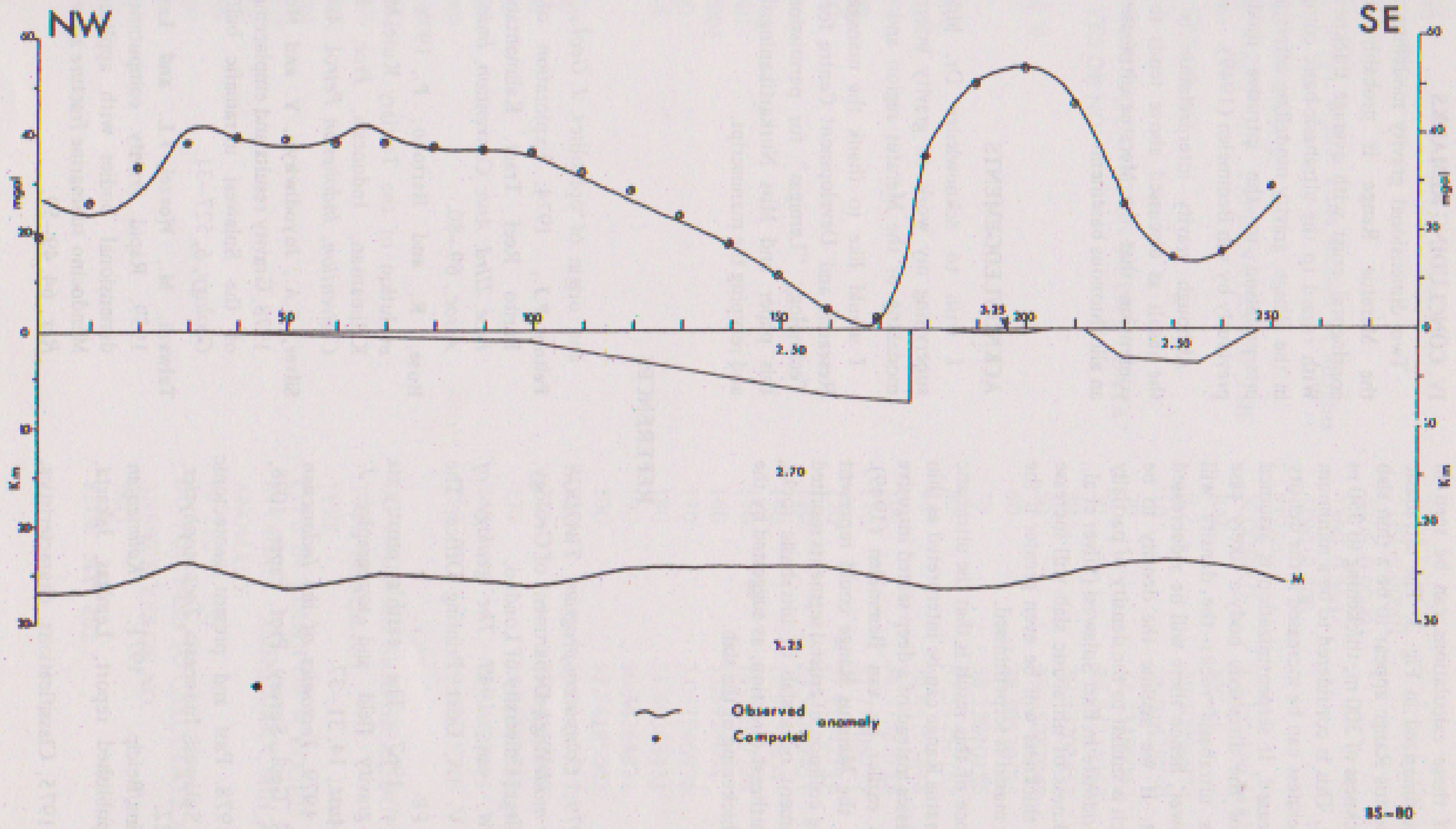

Figure 3 Crustal model for Southeast Kalimantan, satisfying the observed Bouguer gravity anomalies along profile AA in Fig.2. Numbers in the model are density in g/cm^3.

The result of these calculations can be seen in Appendix and summarized in Fig. 3. The ultrabasic rocks in the Meratus Range appear to be a thin slab with relative thickness of 300 m, thickening to 350 m to the southeast. This is considered to be a minimum value, as the thickness can be increased if the density contrast is decreased. If serpentinization is assumed to affect part of the ultrabasic body-a likely case for the Meratus ultrabasic rocks--the density will be somewhat lower, hence there will be a decreased density contrast. If we assume the density to be 2.93 g/cm^3 which is similar to the density of partially serpentinised peridotite in East Sulawesi (Silver et al., 1978), the thickness of ultrabasic slab will increase to 780 m. The thickness will be even greater if the whole ultrabasic massif is serpentinised.

The importance of this result is that the ultrabasic rocks in the Meratus Range can be interpreted as thin allochtonous masses instead of a deep seated intrusive body as stated earlier by van Bemmelen (1949). In this respect, the Meratus Range could represent a place where the collision of crustal segments resulted in the emplacement of a slab of ultrabasic rocks, derived from southeast direction, as suggested by the southeastward thickening of the slab.

IV. CONCLUDING REMARKS

Two dimensional gravity modelling suggests that the Meratus Range is probably underlain by continental crust with average thickness of 26 km. With regard to the ultrabasic-basic complex exposed in the Range, gravity modelling offers an alternative interpretation to the intrusive model proposed previously by van Bemmelen (1949).

Although gravity interpretation is not unique, the result as discussed above tends to support the contention that the Meratus ultrabasic complex is an allochtonous basement.

ACKNOWLEDGEMENTS

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APPENDIX

Computer output, crustal cross section of Meratus Range.

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PROGRAM?
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?NO
DO YOU WANT EXPLANATION OF INPUT DATA?
ANSWER YES OR NO
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?-0. 20
?5
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TYPE IN LIMITS OF X COORD AND ANOMALY
IN ORDER : XMIN,XMAX, MIN ANOMALY, MAX
ANOMALY
?0 250 0 100
DO YOU WISH TO CALCULATE ANOTHER MODEL?
ANSWER YES OR NO
?NO
STOP AT 862
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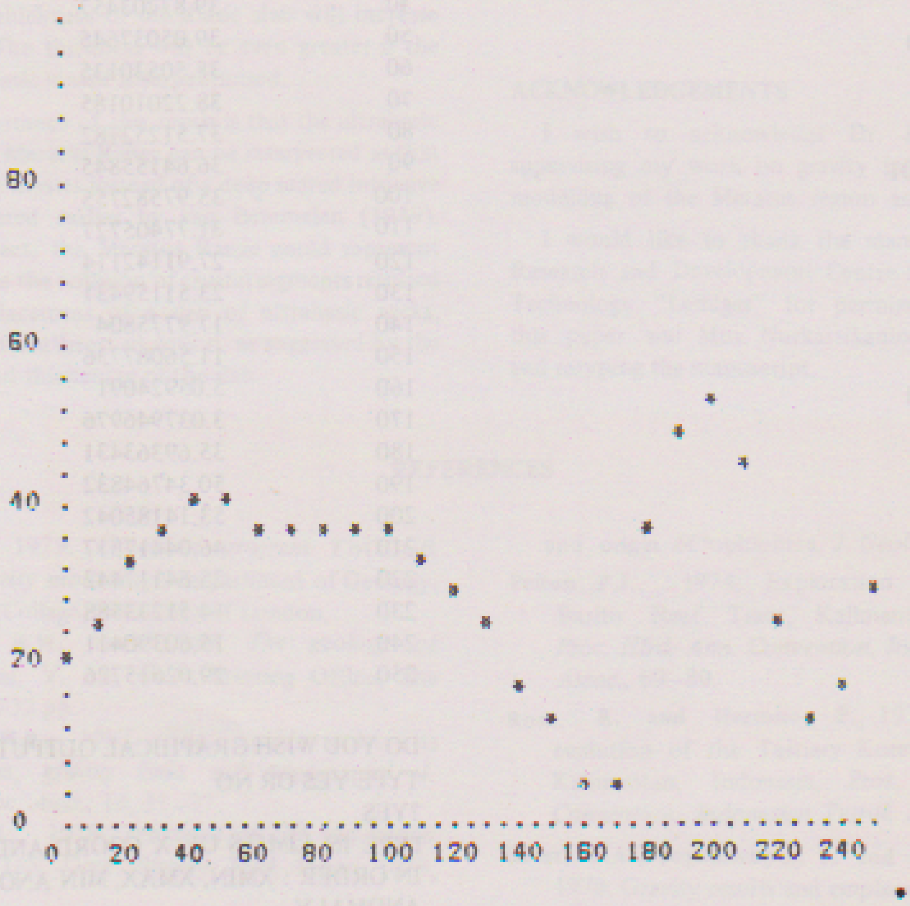

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Plate 1A The Meratus ultrabasic massif viewed from the northwest, with Riam Kanan Reservoir in the foreground. Undulated hills are occupied by the Late Cretaceous Manunggul Formation. The (submerged) type locality of this formation is in the lower left corner of the photograph.

Plate 1B Typical outcrop of serpentinised ultrabasic rocks, Kuaro, Northern Meratus Range.

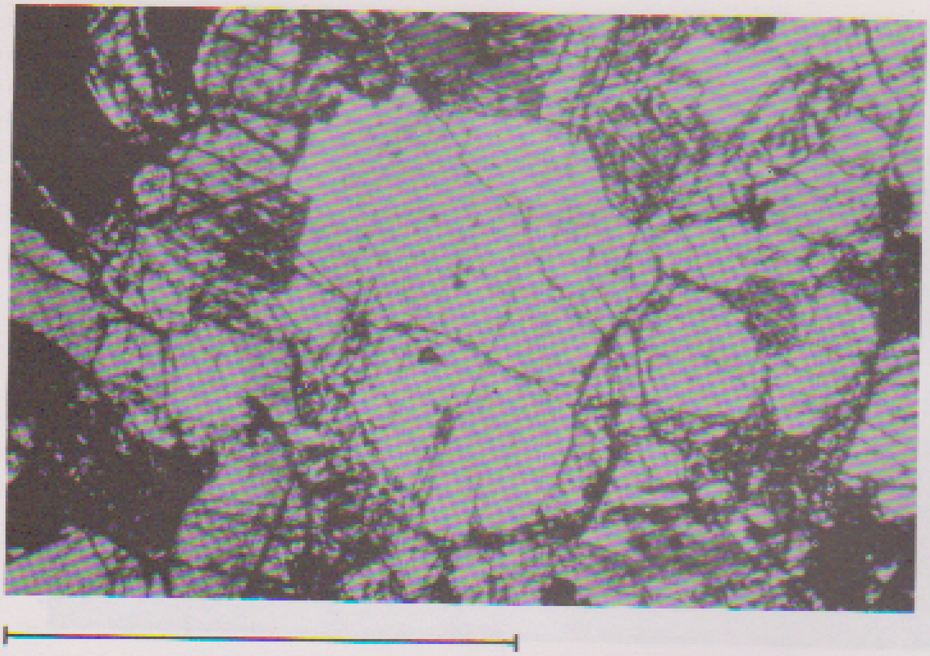

Plate 2A Photomicrograph of lherzolite, Batangbanyulinuh, South Cempaka, Martapura. Cross polarised light, scale bar : 1 mm.

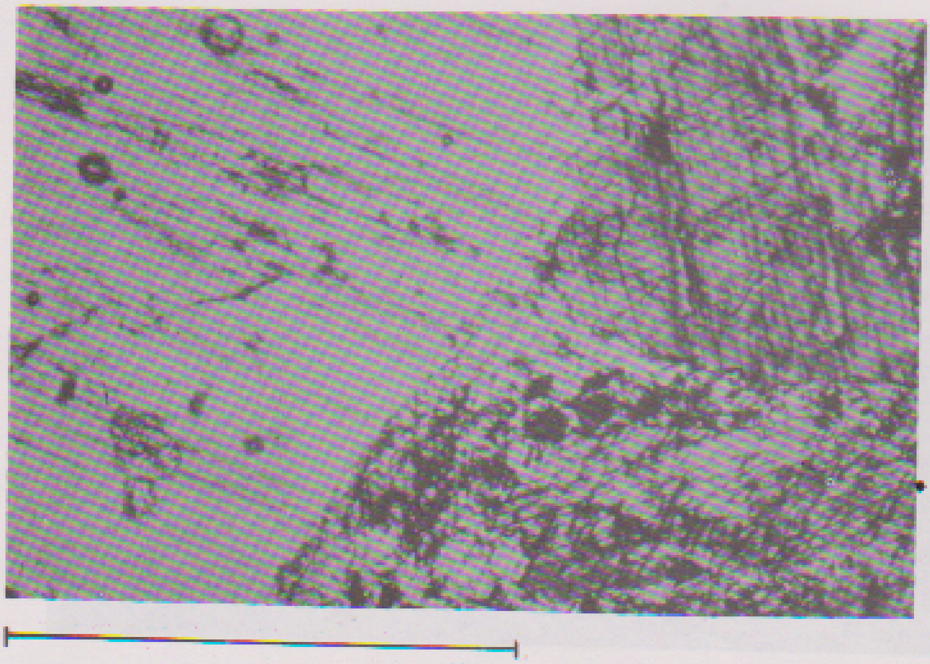

Plate 2B Photomicrograph of hornblendite, Awangbangkal, Martapura. Cross polarised light, scale bar: 1 mm.

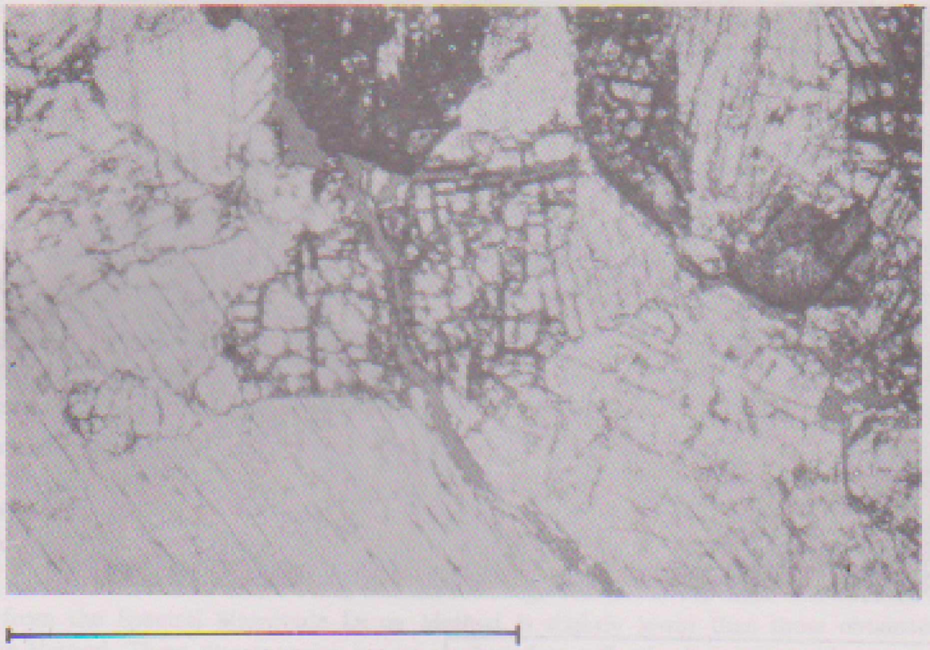

Plate 2C Photomicrograph of pyroxenite, Batangbanyulinuh, South Cempaka, Martapura. Cross polarised light, scale bar : 1 mm.

Plate 3A Outcrop of granite, North Kintap, Southern Meratus Range.

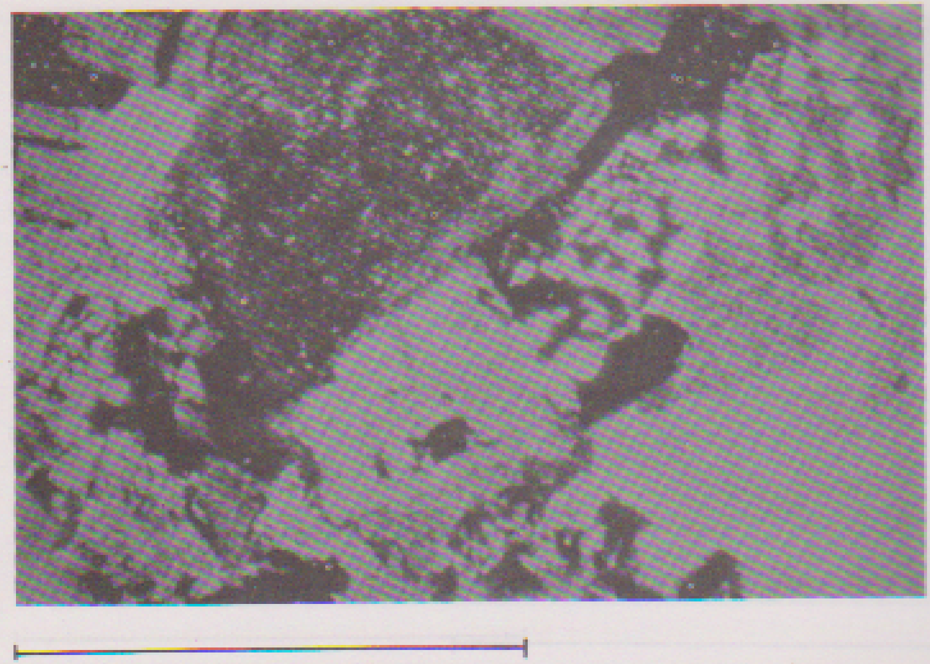

Plate 3B Photomicrograph of granite, showing a graphic texture ; Barabai, Northern Meratus Range. Cross polarised light, scale bar : 1 mm.

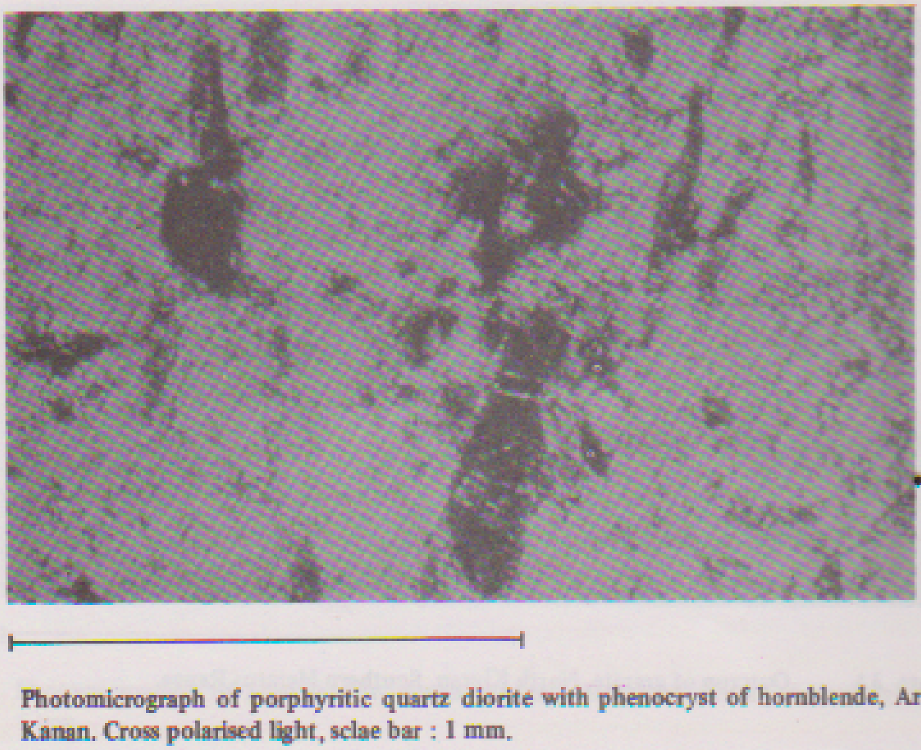

Plate 4 Photomicrograph of porphyritic quartz diorite with phenocryst of hornblende, Aranio, Riam Kanan. Cross polarised light, sclae bar : 1 mm.