Geol. Soc. Malaysia, Bull. 8, December 1977, pp 61–74

Upper Mesozoic strata near Padang, West Sumatra

T.E. YANCEY[1] and SYARHOEL A. ALIF[2]
[1]Dept. of Geology, Idaho State University, Pocatello, Idaho 83209
[2]Conzinc Riotinto, Indonesia.
(Submitted 27 February 1974; revised version accepted 19 August 1974)

Abstract: Upper mesozoic strata are exposed beneath the Cenozoic volcanic cover near Indarung, a few kilometres east of the city of Padang, on the west coast of central Sumatra. These strata are separated from the overlying Cenozoic volcanic rocks by a major unconformity, and were deformed and moderately folded before deposition of the volcanics. The pre-Tertiary strata at Indarung are all of upper Jurassic-lower Cretaceous age. The carbonates contain a distinctive biota of coralline fossils whose most important member is the coral-like *Lovcenipora*, which is age restricted to the upper Jurassic-lower Cretaceous, and is a useful guide fossil for regional correlations.

The upper Mesozoic strata belong in the newly described Indarung Formation. This formation consists of interbedded calcareous, terrigenous and siliceous strata, and contains two distinctive subunits, the Ngalau Member of bedded cherts near the top of the formation, and the Karang Putih Member of massive limestone near the base of the formation.

The Indarung Formation section has been used in cross-fault comparisons to determine offset along the Sumatra Fault. Dating the section as upper Mesozoic invalidates previous comparisons which gave estimates of 250–270 kilometres, and revised correlations suggest a maximum of 200 kilometres separation.

INTRODUCTION

Within a radius of 25 kilometres of the city of Padang, west Sumatra, thick sequences of pre-Tertiary sedimentary strata are exposed in several areas beneath a thick, widespread Cenozoic volcanic cover. These strata are structurally discordant to the overlying volcanic sequence, and are separated from it by a major unconformity. The pre-Tertiary strata consist of interbedded carbonates, terrigenous and siliceous strata, but are predominantly of terrigenous lithology. In many places the strata are fossiliferous, especially the carbonates, which contain distinctive fossils for age determinations.

The pre-Tertiary strata near Padang are part of a north-south structural belt of pre-Tertiary exposures running northwards from Padang towards Lake Singkarak, and south of Padang along the coast and in inland river valleys near Teluk Terusan (Fig. 1). Exposures of these strata are common in the valleys of the Padang area, and form extensive high hills west of Lake Singkarak. The southern and northern exposures along this belt are moderately metamorphosed, while close to Padang they are relatively unmetamorphosed and have less structural complication.

The pre-Tertiary strata outcropping in this structural belt are separated from the nearby pre-Tertiary strata of the Padang Highlands (east of Lake Singkarak) by the Sumatra Fault, which has a minimum of 25 kilometres lateral displacement (Katili & Hehuwat, 1967), and bear no relationship to each other. Pre-Tertiary strata east of Lake Singkarak are primarily Permian and Triassic in age, while those to the west are primarily Jurassic-Cretaceous in age. Although there are many published reports on the strata east of

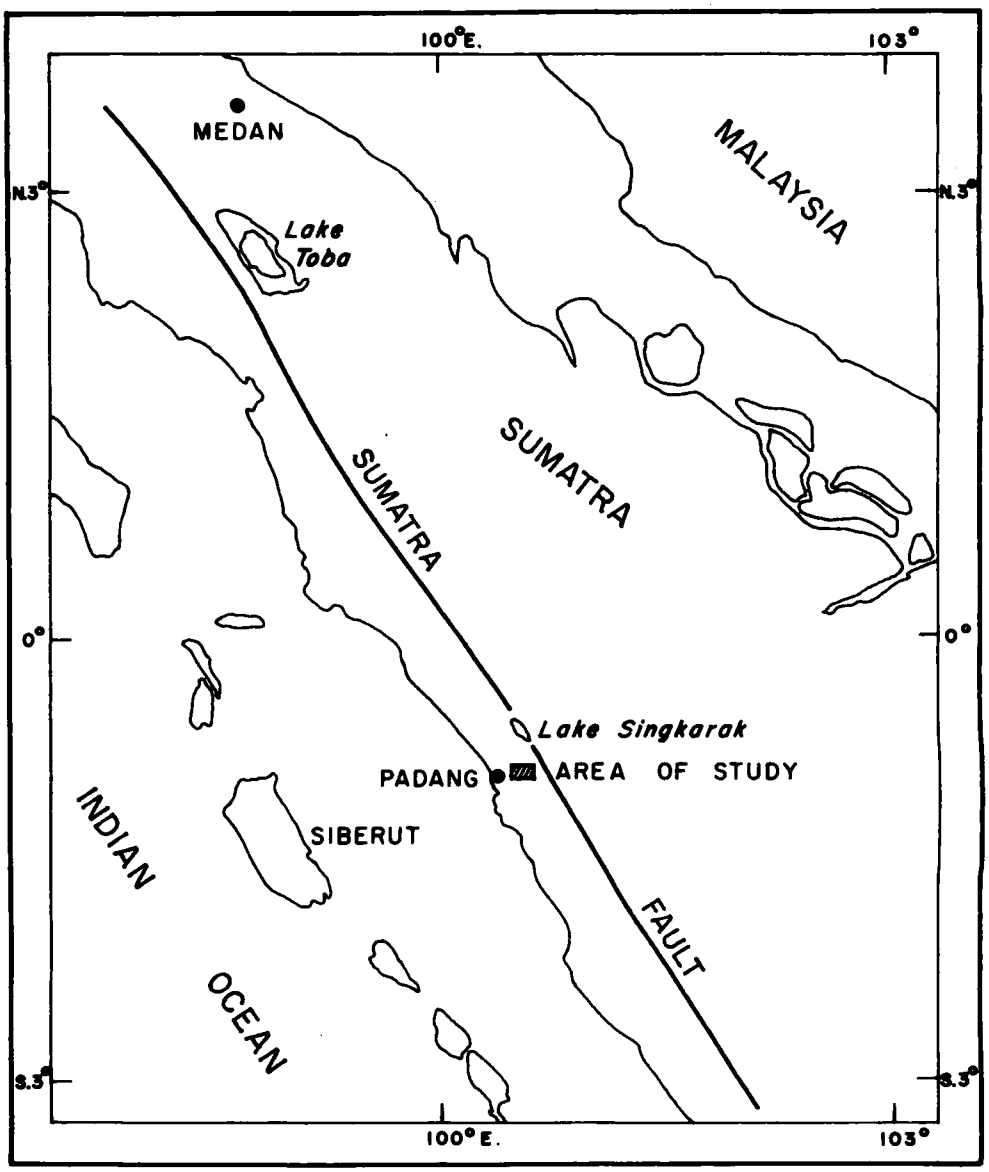

100°E.
103°
MEDAN
MALAYSIA
N.3°
Lake
Toba
SUMATRA
SUMATRA
0°
Lake Singkarak
PADANG
AREA OF STUDY
INDIAN
SIBERUT
FAULT
OCEAN
S.3°
100° E.
103°

Fig. 1

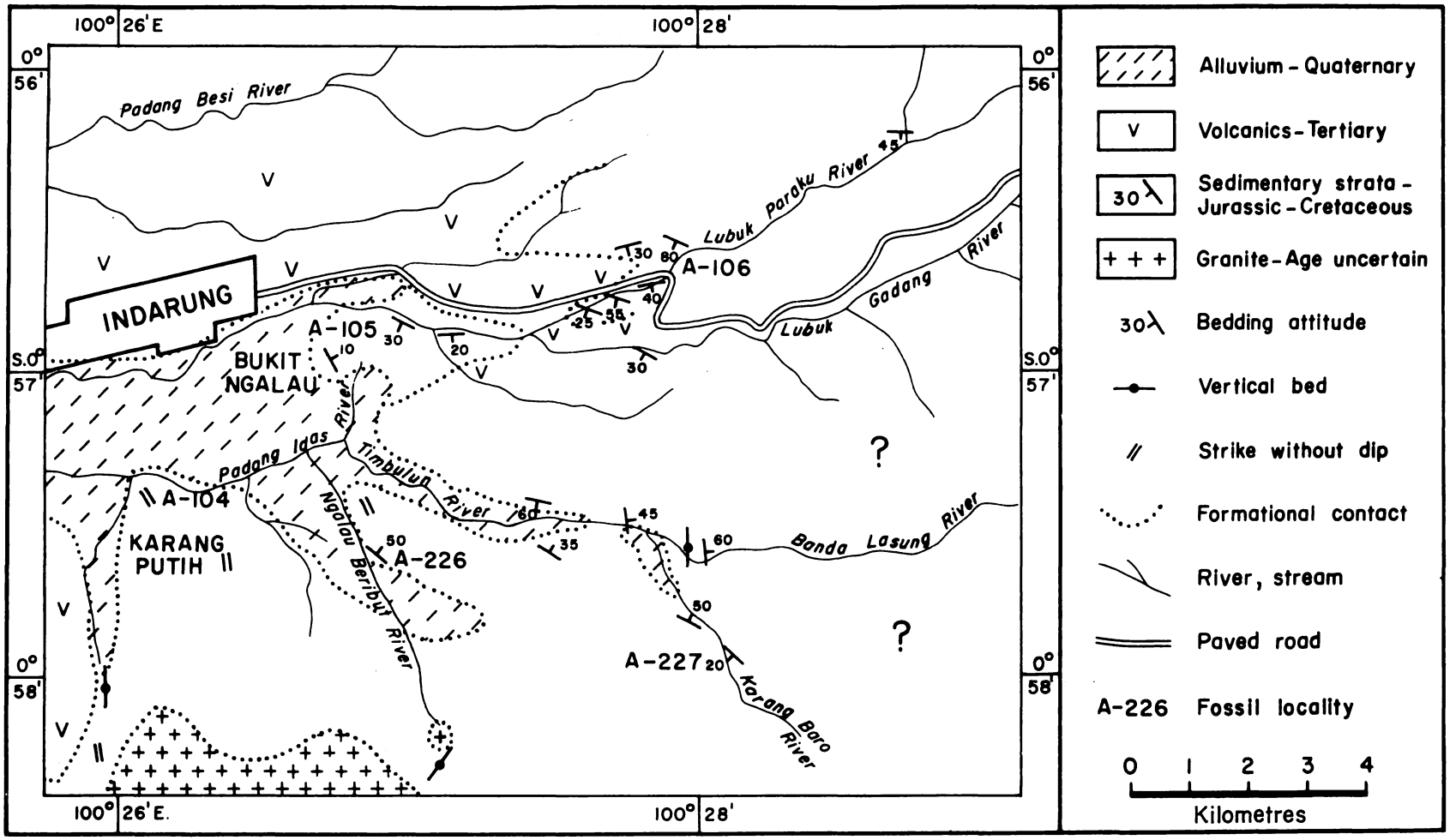

100° 26' E
100° 28'
0° 56'
0° 58'
S.0° 57'
Padang Besi River
Lubuk Paraku River
Lubuk Gadang River
INDARUNG
BUKIT NGALAU
A-105
A-106
A-104
A-226
A-227
KARANG PUTIH
Padang Idas
Timbulun River
Ngalau Beribu River
Banda Lasung River
Karang Baro River
Alluvium - Quaternary
Volcanics - Tertiary
Sedimentary strata - Jurassic - Cretaceous
Granite - Age uncertain
Bedding attitude
Vertical bed
Strike without dip
Formational contact
River, stream
Paved road
Fossil locality
0 1 2 3 4
Kilometres

Plate 2

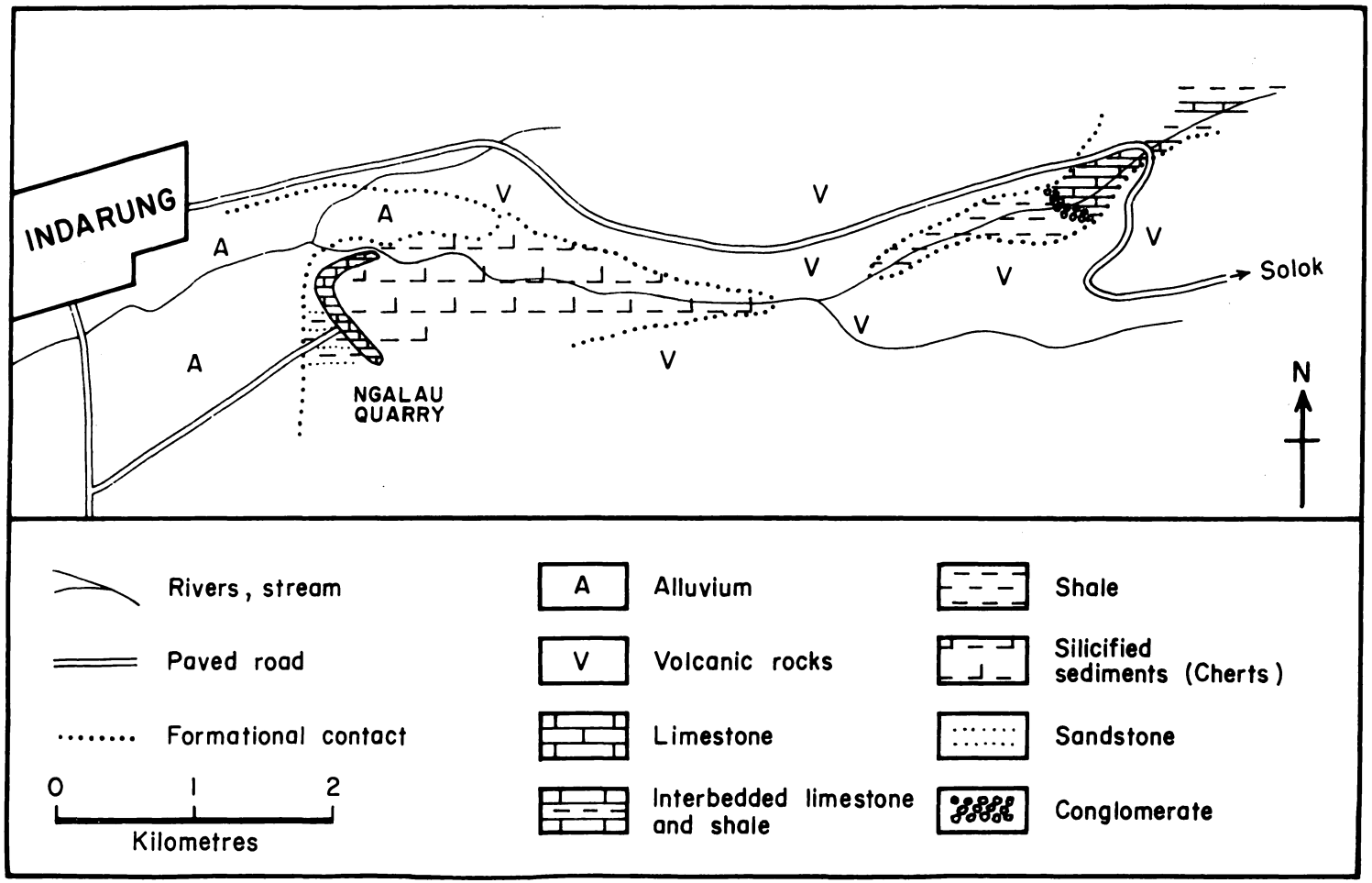

INDARUNG
A
A
A
V
V
V
V
V
V
V
V
Solok
NGALAU
QUARRY
N
Rivers, stream
Paved road
Formational contact
0
1
2
Kilometres
A
Alluvium
V
Volcanic rocks
Limestone
Interbedded limestone and shale
Shale
Silicified sediments (Cherts)
Sandstone
Conglomerate

Fig. 3

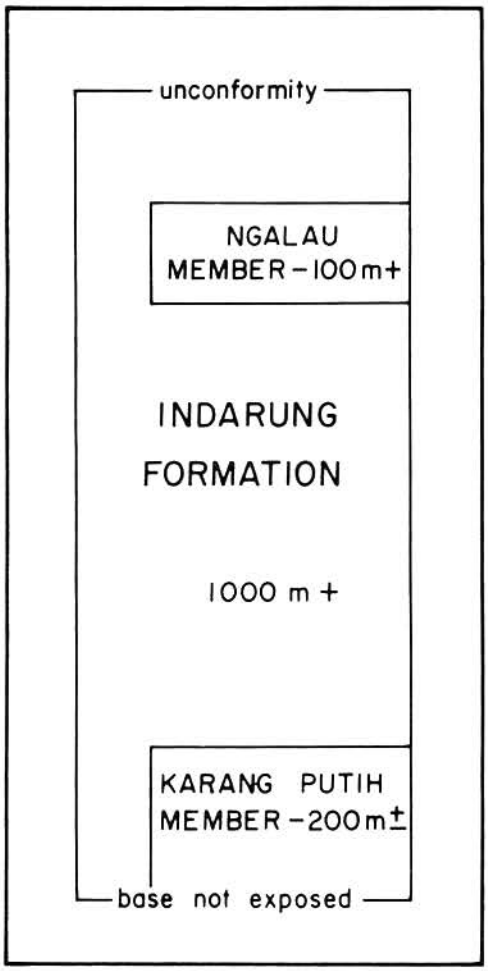

unconformity
NGALAU
MEMBER – 100 m+
INDARUNG
FORMATION
1000 m +
KARANG PUTIH
MEMBER – 200 m±
base not exposed

Fig. 4

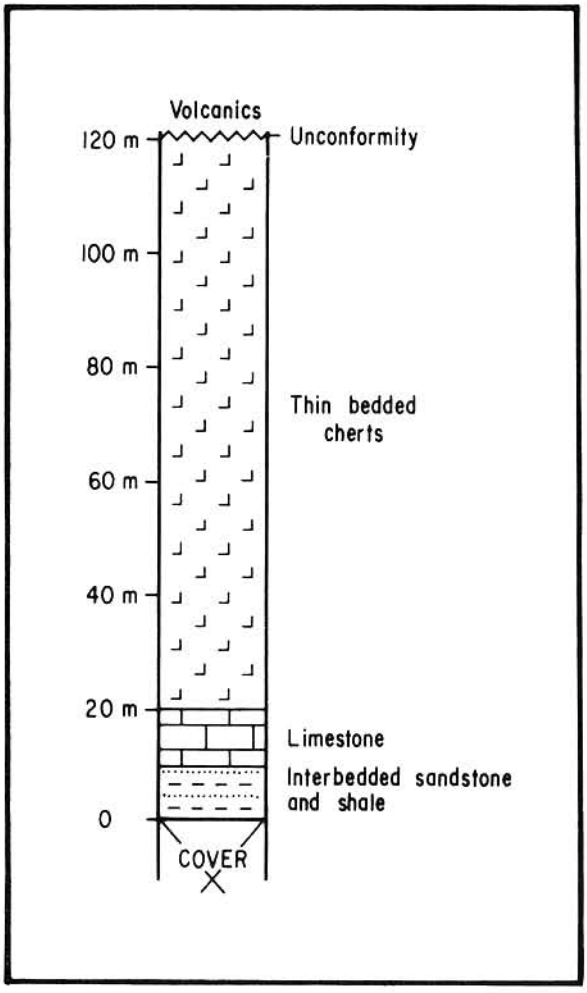

Volcanics
120 m
Unconformity
100 m
80 m
Thin bedded
cherts
60 m
40 m
20 m
Limestone
Interbedded sandstone
and shale
0
COVER

Fig. 5

Lake Singkarak, there are no published descriptions of the pre-Tertiary strata of the Padang area known to us. Their pre-Tertiary age has been recognized when shown on previous geological maps, but they have been shown as lower Mesozoic units, apparently on the basis of lithologic comparison with strata in the Padang Highlands east of the Sumatra Fault.

The area of study lies several kilometres due east of the city of Padang, in the vicinity of the town of Indarung. Sedimentary strata are exposed in the bottoms and on the lower slopes of the Padang Idas, Ngalau Beribut, Timbulun, and Lubuk Paraku river valleys. The exposures are located south, southeast, and east of the town of Indarung, where the cement quarries are located, for at least 5 kilometres in these directions, but the total extent of exposures within this area has not been determined. The geology of the study area is shown in Fig. 2 & 3.

INDARUNG FORMATION

All of the pre-Tertiary strata in the Indarung area are of upper Mesozoic age, and are part of a stratigraphic unit which is here named the Indarung Formation. The formation is moderately folded, and has an eroded and unconformable top. The base of the formation has not been determined, and is probably concealed beneath Tertiary volcanic deposits. The pre-Tertiary strata exposed north and south of Padang (west of Lake Singkarak, and near Teluk Terusan) are lithologically similar, except for effects of metamorphism, and are probably correlative to the Indarung Formation.

The Indarung Formation is characterised by its alternating terrigenous and carbonate units, with limestones forming 20%—40% of the sequence. The formation includes a variable sequence of lithology, containing units of pure and impure carbonates, shales, sandstones, cherts and conglomerates. The sandstones often contain calcareous ooliths, commonly having cores of quartz or other terrigenous materials. Most of the carbonate strata contain high proportions of terrigenous materials (clay minerals and quartz silt and sand) and are generally gray to black in color. Some volcanic tuffs occur in the formation.

Relatively good stratigraphic sections are exposed near Indarung, and along the Lubuk Paraku River at and above the highway bridge, and along the Timbulun, Karang Baro and Banda Lasung rivers. A type section for the formation is selected along the Padang Idas River from Karang Putih quarry to Bukit Ngalau quarry, and continuing up the Lubuk Paraku River for 2 kilometres. The strata along this traverse are not continuously exposed, but they have similar attitudes over most of the area, and are probably part of a continuous section. In the eastern part of this traverse the cherts are folded into open folds.

The stratigraphic section near Indarung is at least 1000 metres thick, and contains two distinctive lithologic subunits (Fig. 4). Assuming that the strata are not overturned, and that the oldest strata occur to the west, the oldest unit is the massive limestone of the Karang Putih Member, followed by a partially covered sequence of sandstones and shales with interbedded limestones, followed by the bedded cherts of the Ngalau Member, which has an unconformable top. A stratigraphic section of the upper part of this se-

quence, present at Bukit Ngalau and adjacent parts of the Lubuk Paraku River, is shown in Fig. 5. At Bukit Ngalau quarry the lower part of the chert unit and about 20 metres of the immediately underlying strata are well exposed. Immediately underlying the Ngalau Member cherts at this quarry is a 10 metre thick dark gray clay-rich limestone (fossil locality UM A-105), consisting of small and well rounded bioclasts set in a dirty micrite or sparite matrix. Fossils from this horizon provide age control for the upper part of the section.

Karang Putih Member

The Karang Putih Member belongs in the lower part of the formation, and consists of nearly pure light coloured limestone, massive and thick bedded. Indications of bedding are usually not apparent on outcrops, but layering can occasionally be seen, and a rough alignment of clasts is often visible in thin sections. The apparent lack of bedding is probably due to intense biologic reworking of the sediment. The rock types present in the strata at Karang Putih range from micrite to biosparite to oolitic calcarenite, while the most common rock type is biosparite containing abundant bioclasts.

Many of these rocks have two grain size modes – one in the coarse sand to pebble grain size range composed of shell fragments, and another in the silt to fine sand grain size range composed of small pellets packed between the shell fragments. Recrystallization is prevalent in both the bioclasts and matrix of the rock, so that recognition of primary textures is sometimes difficult. Bioclasts usually show evidence of breakage and rounding before deposition and few fossil remains are preserved whole. In most rocks both the shell fragments and the pellets are loosely packed, and are set in a matrix of fine sparite. This sparite matrix is the same in nearly all thin sections examined, and may be partly formed by recrystallization of micrite.

The common occurrence of coralline fossils and of calcareous algae indicates shallow water, marine deposition. Calcareous algae are depth restricted during life and live only within the photic zone, which normally is 50 metres or less, but may reach 200 metres below sea level in exceptional cases (Adey & MacIntyre, 1973). The presence of unbroken coralline fossils, great thickness of pure carbonates, and the common occurrence of pellets suggests deposition in shallow water, and probably on a shelf area. The coralline fossils are likely to have lived in reefy patches rather than in large reefs, because the limestone is not known to contain any organic reef framework.

The type section for this unit is at the Karang Putih quarry and adjacent cliff exposures at Batu Gadang, due south of Indarung on the banks of the Padang Idas River. The base of the unit is not exposed, but the unit is probably about 200 metres thick.

Ngalau Member

The type section for this unit is at Bukit Ngalau and in the adjacent Lubuk Paraku River, and is at least 100 metres thick. The base of the unit is exposed in Bukit Ngalau quarry, and the section continues up river until the cherts are unconformably overlain by volcanic sediments.

AGE OF THE STRATA

Age diagnostic fossil collections were made at Karang Putih quarry (loc. UM A-104), Bukit Ngalau quarry (loc. UM A-105), near the highway bridge over the Lubuk Paraku River (loc. UM A-106), on the Ngalau Beribut River (loc. UM A-226) and on the Karang Baro River (loc. UM A-277). Locality numbers are from the collections of the Department of Geology, University of Malaya, and the fossil locations are shown in Fig. 2. The fossil assemblages at these sites are similar, containing many of the same species, although the Lubuk Paraku strata contain more molluscs and fewer coralline fossils. The taxa found at the first three localities are shown in Table 1. *Lovcenipora* has also been found at the other two localities (UM A-226 and UM A-227). The Karang Putih locality (UM A-104) is from the Karang Putih Member, and the Bukit Ngalau locality (UM A-105) is from the limestone underlying the Ngalau Member, while the other localities are from undetermined horizons in the formation.

The age of the strata can be determined from the stromatoporoids, corals, and calcareous algae. All of these groups occur commonly in the strata. Foraminifera are uncommon, and no distinctive forms were found for age determination. The most diagnostic taxa are *Lovcenipora,* which has a known geologic range of upper Jurassic-lower Cretaceous (van Bemmelen, 1949, p. 72 & p. 661), and *Actostroma,* which is known only from the upper Jurassic (Hudson, 1958), although the species present here is probably a new species. The coralline algae and corals both are typical of upper Mesozoic forms, and alone are enough to suggest an upper Mosozoic age. The age of strata is clearly upper Jurassic-lower Cretaceous, and possibly is upper Jurassic. The age of all fossil localities comes within this age interval. Radiolaria from the Ngalau member in the upper part of the formation are also upper Jurassic – lower Cretaceous, and possibly are lower Cretaceous in age (H.Y. Ling, pers. comm., 1976).

The usual fossil *Lovcenipora* (Plate 1, figures 6–7; Plate 2, figure 1) is a distinctive form that is widespread in upper Mesozoic carbonates of Indonesia (van Bemmelen, 1949). It is common in Timor (Vinassa de Regny, 1915), the Molucca and Sunda Islands, and Sumatra (van Bemmelen, 1949). By convention this fossil is regarded as a stromatoporoid, but it is not closely related to typical stromatoporoids, and it could equally well be classified as a chaetetid "coral". (It is worth noting that Hartman & Goreau, 1970, have presented good evidence to support the idea that both the Mesozoic stromatoporoids and chaetetid "corals" are in fact true sponges). For a long time *Lovcenipora* was considered to be an upper Triassic marker in the Indonesian archipelago, until its correct geologic age was determined by van der Sluis. Occurrences of *Lovcenipora* in the well studied section of east Ceram (in the Molucca Islands) are restricted to the upper Jurassic (van der Sluis, in van Bemmelen, 1949, p. 72), and van Bemmelen cites many other examples where the genus is restricted to upper Jurassic deposits in the Mediterranean countries. In Sumatra, van Bemmelen quotes van der Sluis (p. 661) to the effect that *Lovcenipora* is upper Jurassic-lower Cretaceous, and lists it as occurring in the Saling Series of south Sumatra (p. 667) where it occurs with loftusian foraminifera and nerinean gastropods. The Saling Series has been reliably dated as lower Cretaceous, but it is not

known if the *Lovcenipora*-bearing horizons are the same as the loftusian foraminiferan bearing horizons. At the present time, therefore, the *Lovcenipora*-bearing strata in Indonesia are best dated as upper Jurassic-lower Cretaceous.

The fossil *Actostroma* (Plate 2, figures 2–3) is a typical Mesozoic stromatoporoid, which is a group most common in the upper Jurassic, and most species are restricted to that unit of time. The taxonomy of this group is highly confused, and the basic affinities of the group have not been resolved, so the species have been overlooked by biostratigraphers in the past. Nevertheless, the accumulated work during the last 50 years indicates that they may be very useful in Tethyan correlations.

The coralline fossils (calcareous algae, stromatoporoids, and scleractinian corals) of the Indarung Formation carbonates are similar to coralline fossils of upper Jurassic-lower Cretaceous carbonate biotas in the Timor-Moluccas area, in Sumatra, and in northwest Borneo (see Wilford, 1965). This distinctive biota appears to have occurred throughout the Indonesian and Malaysian archipelago, and to be a useful marker in the Mesozoic stratigraphic sequence. It is also similar to upper Jurassic biotas in the southern Mediterranean countries. Arabian Peninsula, and Japan, where the strata containing these biotas have been well dated. They appear to be characteristic of the Tethyan biogeogrpahic province, and can be expected to be of widespread occurrence in south-east Asia.

REGIONAL STRATIGRAPHIC RELATIONSHIPS

The discovery of upper Jurassic-lower Cretaceous fossils at Indarung and the description of the lithologic units in this thick sequence makes this stratigraphic interval one of the better described pre-Tertiary sequences in Sumatra. The occurrence of Mesozoic sediments in Sumatra has been summarized by van Bemmelen (1949), whose summary reveals the relatively small amount of work that has been done on them. Most of these strata in Sumatra have been called Triassic in age, especially in central Sumatra, but this determination applies to many rock units which have not been reliably dated and would better be called simply Mesozoic. Cretaceous strata are known, especially in south Sumatra, but only in one place have Jurassic strata been reasonably determined previously.

Van Bemmelen (1949, p. 661) reports that the "least disputable Jurassic" is known from along the Temalang River in the Tambesi-Rawas Mountains of Djambi, and mentions several other occurrences of limestones containing coralline fossils that might be of Jurassic age in north and central Sumatra. These occurrences lack ammonoid evidence to support them, but all of the limestones mentioned have the common characteristic of containing conspicuous stromatoporoids and/or corals, similar to those from Indarung. The several references to biotas of this type in scattered areas of Sumatra indicates the probability that considerable amounts of Jurassic strate occur in the area.

RELATIONSHIP TO THE SUMATRA FAULT

The Indarung Formation is the most southern occurrence of pre-Tertiary sediments west of the major right-lateral Sumatra Fault, and provides an important control point for determining the total amount of offset along the Sumatra Fault. Lateral offsets ranging

from 20 to 270 kilometres have been proposed for this fault based on many criteria, including the offset of streams and rivers (Katili & Hehuwat, 1967), the matching of stratigraphic units across the fault (Tjia & Posavec, 1972), and the matching of volcanic complexes across the fault (Posavec and others, 1973). The 20–25 kilometre offset proposed by Katili & Hehuwat (1967), based on stream and river offsets, records movement during Pleistocene or Holocene time and is a minimum figure. Estimates an order of magnitude larger were made by Posavec and others (1973) of 95–130 kilometres, and by Tjia & Posavec (1972) of 190–270 kilometres.

The 270 kilometre offset suggested in Tjia & Posavec (1972) is based on a comparison of the Indarung sequence with stratigraphic units near Surulangan in central Sumatra (02° 40′S.; 102° 45′E.) – which are of presumed Triassic age. Dating the Indarung sequence as upper Jurassic-lower Cretaceous invalidates this comparison. Likewise, the 250 kilometre offset suggested in the same paper is modified because it is made on comparison of Jurassic strata at Bangko (the "least disputable Jurassic" occurrence in the Tambesi-Rawas Mountains mentioned by van Bemmelen, 1949) with probable Jurassic strata near Lake Manindjau. Identifying Jurassic strata at Indarung reduces the cross fault separation of Jurassic strata in central Sumatra to about 200 kilometres.

Therefore the greatest allowable offset using the comparison in Tjia and Posavec (1972) is about 190–200 kilometres. This compares reasonably with the probable offset of 130 kilometres suggested in Posavec and others (1973) based on matching of volcanic complexes. Taken together, these comparisons show that the maximum offset along the Sumatra Fault is probably not more than 200 kilometres.

ACKNOWLEDGEMENTS

The material on which this report is based was first collected by geologists of P.T. Riotinto Bethleham Indonesia (RBI) while working on a geological mapping program in western Sumatra in the first half of 1972, and from collections made by us during a period of time when the junior author was employed by RBI. We would like to thank RBI for providing transport, and shipping the rock collections, and to thank Dr. K.J. Ackermann and Theo M. van Leeuwen of RBI for their interest and encouragement during the preparation of this report. We wish to thank Theo M. van Leeuwen for discussions and criticisms of early drafts of this report. Most of the geologic mapping is by Syahroel A. Alif, while fossil studies are the responsibility of T.E. Yancey. Photography is by Jaafar bin Haji Abdullah, and drafting is by Ching Yu Hay of the Department of Geology, University of Malaya. Prof. N.S. Haile, Dept. Geology, University of Malaya, supplied valuable data on the bedded cherts of the Ngalau member.

REFERENCES

Adey, W.H. & I.G. MacIntyre, 1973. Crustose coralline algae: a re-evaluation in the geological sciences: Bull. Geol. Soc. America, *84*, 883–904.

Bemmelen, R.W., van, 1949. The geology of Indonesia; Indonesia Bureau of Mines, *1*, 732 p.

Hartman, W.D. & T.F. Goreau, 1970. Jamaican coralline sponges; their morphology, ecology and fossil relatives; Zool. Soc. London, Symposium no. 25, 205–243.

Hudson, R.G.S., 1956. Tethyan Jurassic hydroids of the family Milleporidiidae; J. Paleontology, *30*, 714–730.

Hudson, R.G.S., 1958, *Actostroma*, gen. nov., a Jurassic stromatoporoid from Maklesh Hathira, Isreal; Palaeontology, *2*, part 2, p. 87–98.

Hudson, R.G.S., 1960. The Tethyan Jurassic stromatoporoids *Stromatoporina, Dehornella* and *Astroporina*; Palaeontology, *2*, part 2, 180–199.

Johnson, J.H., 1964. The Jurassic algae; Q. Colorado School of Mines, *59*, no. 2, 129 p.

Katili, J.A. & F. Hehuwat, 1967. On the occurrence of large transcurrent faults in Sumatra, Indonesia; J. Geoscience, Osaka City Univ., *10*, Art. 1, 5–17.

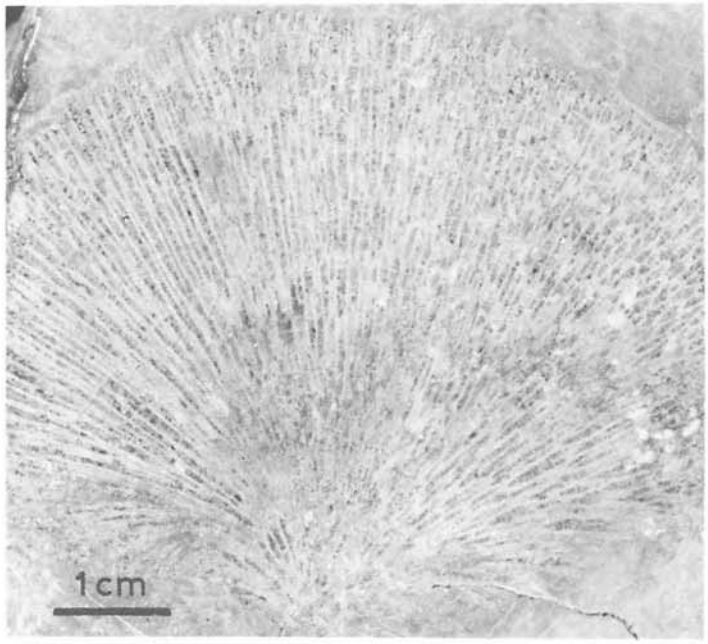
Posavec, M.M., D. Taylor, Th. van Leeuwen & A. Spector, 1973. Tectonic controls of volcanism and complex movements along the Sumatran Fault System; Bull. Geol. Soc. Malaysia No. 6, 43–60.

Powers, R.W., 1962, Arabian upper Jurassic reservoir rocks. In Ham, W.E., ed., Classification of carbonate rocks. Am. Assoc. Petroleum Geologists, Mem. 1, 122–192.

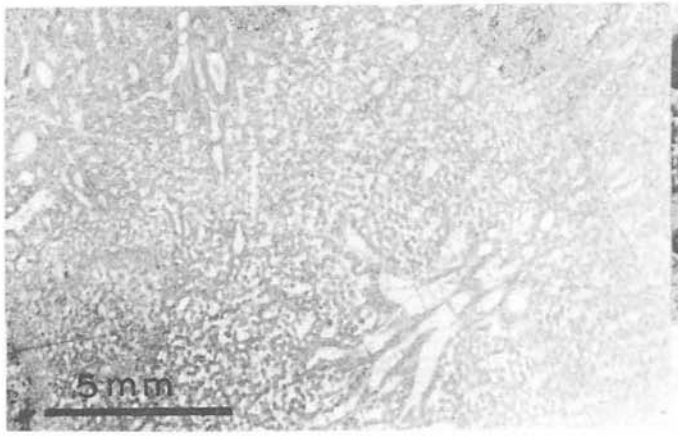
Tjia, H.D. & M.M. Posavec, 1972. The Sumatra Fault zone between Padang-panjang and Muaralabuh. Sains Malaysiana, *1*, 77–105.

Vinassa de Regny, P., 1915. Triadische algen, spongien, anthozoen und bryozoan aus Timor; Palaontologie von Timor, Part 4, no. 7, 75–118.

Wilford, G.E., 1965, Penrissen area, West Sarawak, Malaysia: Geol. Surv. Malaysia, Borneo Region, Report no. 2, 195 p.

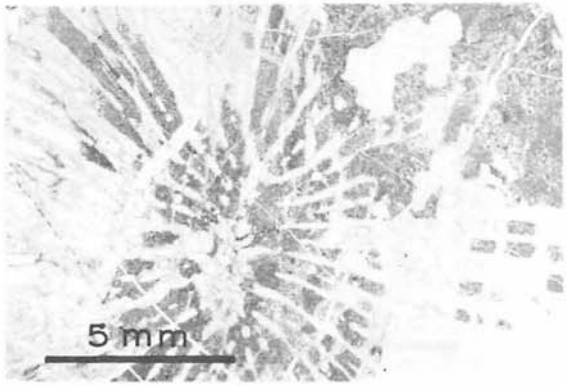


1



2

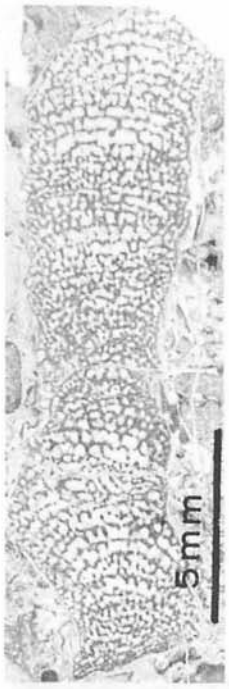
3



4

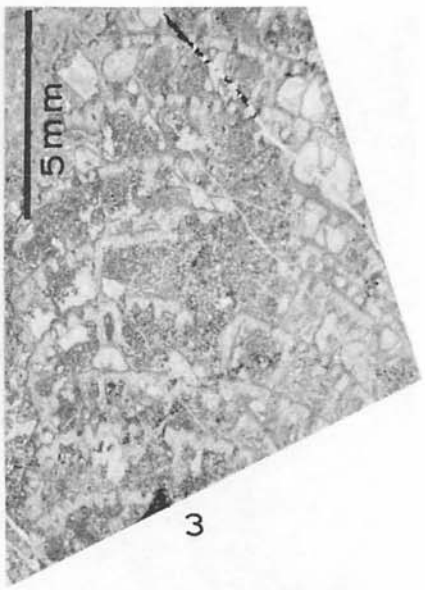
5

Plate 1

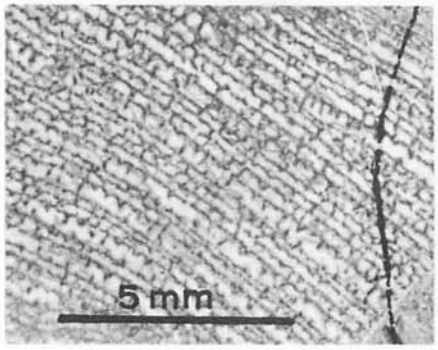


1

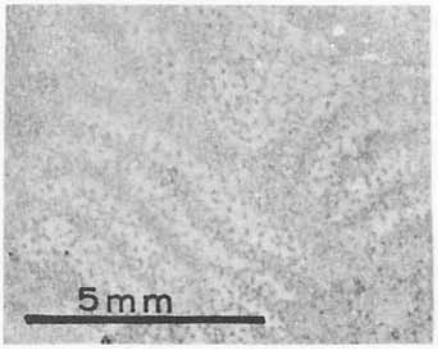
2



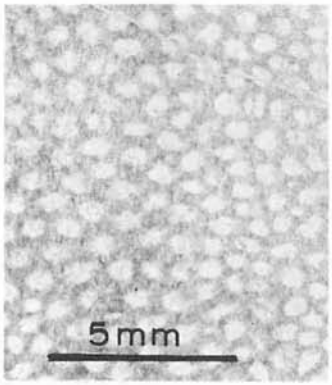
3



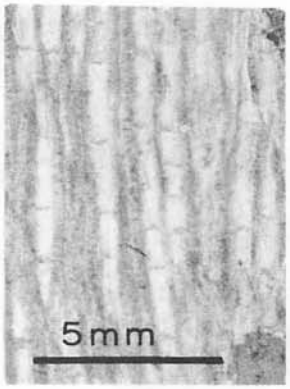
4



5



6



7

Plate 2