

WIDESPREAD OCCURENCE OF TRIASSIC LIMESTONES NORTHWEST OF UTHAI THANI IN WEST THAILAND

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ABSTRACT

Two long series of limestone hills, prominent features in the plain of Uthai Thani, are assigned to the Triassic because of abundant fossils discovered recently in many hills. Previously, the limestones had been considered Permian in age to the west and Silurian-Devonian in age to the east. The new discoveries lead to an important change in the geology of the region.

INTRODUCTION

Northwest of Uthai Thani and west of Nakhon Sawan (Amphoe Nong Chang 4939I, Amphoe Sawang Arom 4940II and Amphoe Banphot Phisai 4940I Map Sheets of the Royal Thai Survey Department of scale 1:50,000), two long series of limestone hills extending in a northerly direction are prominent features in a large plain of Quaternary alluvium (Fig. 1). The hills rise from 30 to more than 250 m above the plain. They are surrounded by steep cliffs giving them a castellated topography (Figs. 4 and 5). They commonly display caves and shelters which are more or less important. Limestone is mainly massive, rarely bedded.

The western series of hills extends along the longitude 99°45'30"E. It consists of seven hills distributed over a distance of 22 km from Khao Pathawi (also called Khao Pha Lat) to Khao Phra North. Between 16 and 18 km due south of Khao Pathawi, two limestone hills (Khao Pun and Khao Prommachan) appear to be the continuation of the western series, indicating a length of 40 km (Figs. 1 and 2). All the limestones from Khao Prommachan to Khao Pathawi and Khao Phra North were considered Permian in age in the past and assigned to the "Ratburi Group" (Geological Map of scale 1:250,000, Changwat Nakhon Sawan Sheet by BUNOPAS *ET AL.*, 1976). "Ratburi Limestone" or "Ratburi Group" are stratigraphic names which have been used in Thailand for limestones and associated clastic sediments of Permian age (BROWN *ET AL.*, 1951; JAVANAPHET, 1969; PIANCHAROEN, 1992). The limestone of the western series is only very slightly recrystallized.

The eastern series of limestone hills extends along the longitude 99°58'E. It consists of eight hills distributed over a distance of 35 km from Khao Ngo to Khao Hin Ploeng (Figs. 1 and 3). To the north, it is probably continued by a series of limestone hills slightly bending towards the west, from longitude 99°55'30"E (Khao Rua) to longitude 99°53'E (Khao Kaeo, Khao No). Accordingly, the eastern series may extend over a distance of

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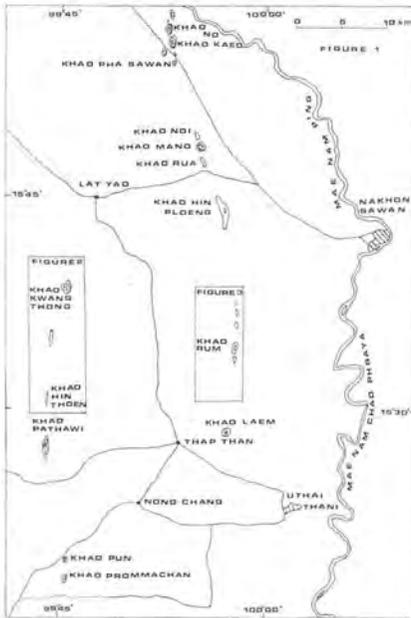


Figure 1. Map showing the general distribution of limestone hills in Uthai Thani area.

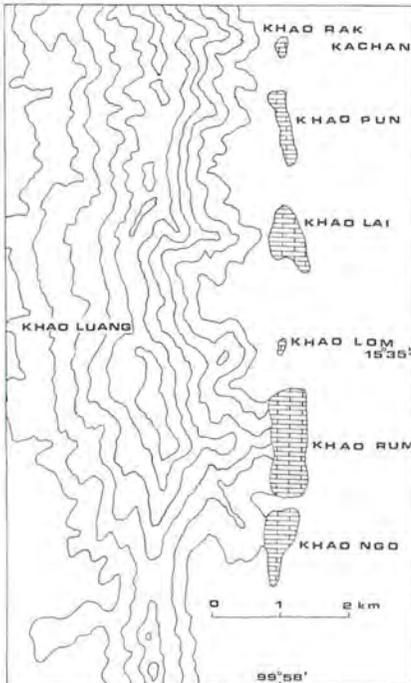


Figure 3. Map of the eastern series of limestone hills with a continuous ridge of other associated rocks.

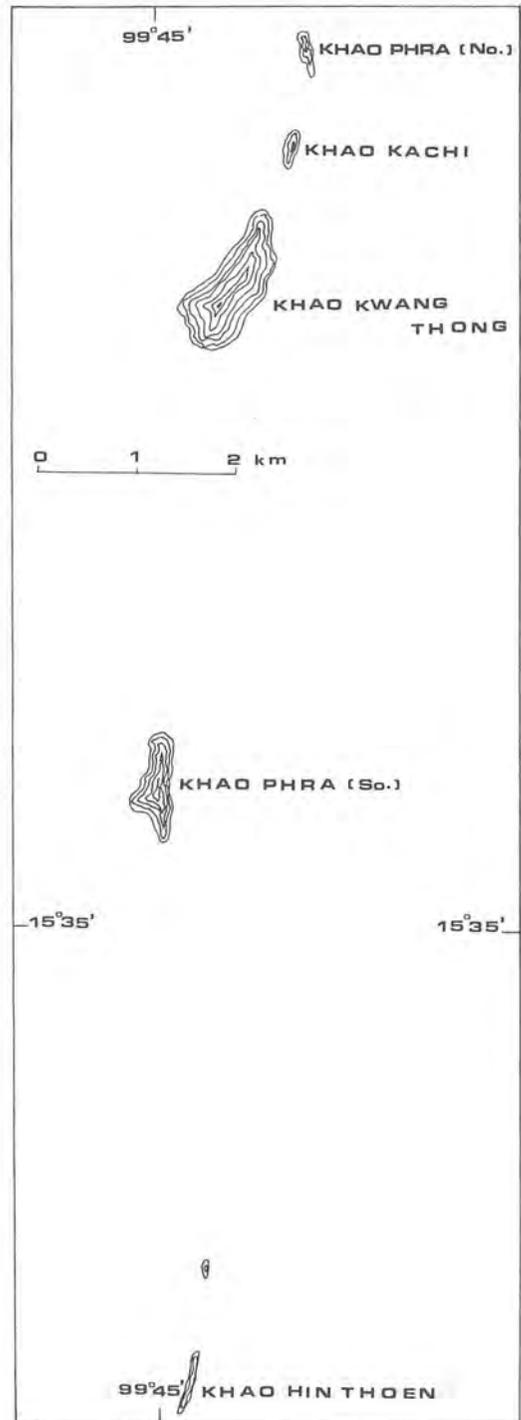


Figure 2. Map of the western series of limestone hills.

more than 50 km (Fig. 1). All the limestones of the eastern series were considered Silurian–Devonian in age in the past and called “Khao Mano Marble” (Geological map, scale 1: 250,000, changwat nakhon Sawan Sheet by BUNOPAS *ET AL.*, 1976). Khao Mano (Coordinates 15°48'30"N., 99°55'E) is located north-northwest of Khao Rua; the term “Khao Mano Marble” has not been selected as an important name in the “Lexicon of Stratigraphic Names of Thailand” (PIANCHAROEN, 1992). All the limestones of the eastern series are strongly recrystallized.

HISTORY OF THE NEW RESEARCH

By chance during cursory fieldwork in 1996, fossils were noticed by two of the authors (H. F. and V. S.) at Khao Pathawi (or Khao Pha Lat). Samples were collected and studied by means of thin sections. They clearly indicated a Triassic age; they were mentioned in a short note (FONTAINE *ET AL.*, 1996). They raised a problem: did this represent an extension of Triassic in the Uthai Thani area?

In 1997, additional research was carried out by the same authors (H. F. and V. S.) in a much larger area northwest and north of Uthai Thani. The result was a surprise; the Triassic appeared as very extensive and involved rocks previously assigned to the Permian and also to the Silurian–Devonian. A note was submitted to the Siam Society for publication in the *Natural History Bulletin*. The reviewers were also surprised and were not perfectly sure that the Rosetta stone was really deciphered. They induced us to organize a third field trip which was conducted by two of us (H. F. and S. S.) in March of 1999.

The new observations were easy and successful because of the very dry weather of March and intensive burning to clear the land of grass and bushes before a new agricultural season. Many fossils were observed at many places; they largely confirmed what had been noticed previously. D. Vachard has assisted in identifying the microfossils of the new samples.

GEOLOGICAL SETTING

The limestones are not entirely isolated in the Uthai Thani Quaternary plain; they are associated with other rocks which give also important information (See the geological map of BUNOPAS *ET AL.*, 1976, and the geological map of Fig. 13 of this paper). These rocks consist of rhyolite, tuff and granite. Tuffaceous rocks have been called “Khao Luang Tuff” by BUNOPAS *ET AL.*, 1976. In addition to the volcanic rocks, a granite outcrop elongated in a northerly direction and 15 km long is exposed near and west of the eastern series of limestone hills in the area from Khao Ngo (or Khao Tham Phra) to Khao Hin Ploeng (See Fig. 13). North of Khao Hin Ploeng, the limestone hills are scattered in the plain and are not associated with other rocks.

The two series of limestone hills are associated with volcanic rocks, rhyolite and rhyolitic tuff, the rhyolite being more widespread west of the western series of limestone hills. Another difference between the two series of limestone hills is the development of a foliation and the appearance of fine-grained muscovite and sericite in the volcanic rocks exposed near the eastern series (See Figs. 10 to 12). Apart from these differences, the

volcanic rocks are quite similar. The tuffs contain fragmented plagioclase and/or quartz crystals. Quartz shows crystal embayment. The crystals are included in microcrystalline groundmass of devitrified glass. Glass shards have been noticed in a sample from the western series.

At the two series of limestone hills, there is an apparent transition from the tuff to the limestone, a transition consisting of crystal-tuffaceous limestone. A rock with coarser grains, a calcareous volcanic conglomerate, has been found at the western series and is in continuity with fossiliferous limestone. In addition to that, two samples of muscovitized medium-grained equigranular granite and foliated andesite have been collected as float rocks in a creek near Khao Rum.

OBSERVATIONS OF THE LIMESTONES

The limestone hills are in a plain; they are easily accessible, but the rocks may be more difficult to reach, especially for a detailed stratigraphic study.

The Western Series of Limestone Hills

After the description of the hills from Khao Pathawi to Khao Phra North, a short remark will concern Khao Pun and Khao Prommachan.

Hills from Khao Pathawi to Khao Phra North (Figs. 1 and 2)

Khao Pathawi (or Khao Pha Lat; 15°28'20"N, 99°45'40"E. Fig. 4) is a large limestone hill, 700 m long, 300 m wide and 245 m above sea level. It is inhabited by many monkeys. The limestone is mainly massive, being bedded only in a small part of the top of the hill. It is locally rich in diverse fossils visible to the unaided eye: sponges, solitary, fasciculate and massive corals (see Fig. 7 of this paper), brachiopods, bivalves, gastropods, crinoids. Solitary corals are locally in abundance; they reach 6 cm in diameter and more than 20 cm in length. Fasciculate corals are particularly common at the northern end of the hill; they may reach up to 1 meter in diameter. The corals appear to be Triassic in age to the naked eye. In addition to that, fusulinids are not visible although the limestone is rich in fossils, and especially, corals. Because of that, the Permian age indicated in the past became very doubtful. In a first study, a few Triassic foraminifers were found (FONTAINE ET AL., 1996). In the newly collected samples, microfossils are again not in abundance. However, they consist of *Tubiphytes*, common Solenoporaceae, Diplotrematidae, Duostominidae, *Duotaxis*, *Endothyra*, *Aulotortus* sp. and *Sigmoilina schaeferae* Zaninetti, Altiner, Dager & Ducret. Diplotrematidae and Duostominidae suggest clearly a Triassic age. Because of the large development of the corals, the age of the limestone cannot be older than the Ladinian. *Aulotortus* indicates a Late Triassic age. The acme of *Aulotortus* is during the Norian. *Sigmoilina schaeferae* has been reported from the Norian of Slovakia. Limestone is commonly a wackestone to packstone, rarely a grainstone.

Khao Hin Thoen (15°32'30"N, 99°45'10"E; Fig. 5) is a narrow elongated hill, 162 m above sea level, 7.5 km north of Khao Pathawi. Limestone contains fossils similar to that of Khao Pathawi from its southern end to its northern end. Solitary and fasciculate corals are relatively rare, fasciculate corals have a diameter of 20 to 80 cm. Bryozoans are

especially abundant. Many are cylindrical in shape, 1 to 3 cm in diameter with a length which may reach more than 20 cm. Others are massive. These bryozoans seem to build a reef. Gastropods occur occasionally. The thin sections from the collected samples commonly show bryozoans, calcareous sponges and some fragments of *Tubiphytes*. Foraminifers are almost absent; they consist of *Endothyra* and a few poorly preserved specimens of *Aulotortus*.

Small hill 1 km north of Khao Hin Thoen (15°33'10"N, 99°45'15"E), a massive limestone contains again bryozoans, associated with *Tubiphytes*, Solenoporaceae, sponges and gastropods. Solitary corals are rare. The limestone is wackestone to packstone.

Khao Phra South (15°35'40"N, 99°45'05"E) is a large limestone hill, 1 km long and 190 m above sea level. Limestone is massive, fine-grained, dark gray to black. Fossils are very rare; however, *Aulotortus* appears to be present in a thin section of a sample collected from the western side of the hill. The limestone is commonly a micstone.

Khao Kwang Thong (15°38'30"N, 99°45'30"E) is a large limestone hill, 1.5 km long and 356 m above sea level. It is rich in fossils, especially in solitary and fasciculate corals as well as in bryozoans. Bivalves are present and seem to include *Daonella*. Other fossils are *Tubiphytes*, Solenoporaceae which are locally in abundance, a few foraminifers (Duostominidae, *Duotaxis*, *Aulotortus* ex gr. *sinuosus* Weynschenk, *Aulotortus oscillens* Oberhauser, *Ophthalmidium* sp.), a few gastropods and rare ostracods. *Aulotortus sinuosus* Weynschenk ranges from Carnian to the end of Norian. *Aulotortus oscillens* Oberhauser shows a slightly longer range; it appears in the Upper Ladinian and disappears at the end of the Norian. The age of the limestone is very similar to that of Khao Pathawi; the abundance of *Aulotortus* is rather suggestive of a Norian age.

Khao Kachi (15°39'N, 99°46'E) is a small hill poor in macrofossils; bryozoans are present at the northern end of the hill where a coral fragment, sponges and a few foraminifers (*Aulotortus*, Duostominidae) have been noticed.

Khao Phra North (15°39'50"N, 99°45'45"E) is a small hill. Limestone is massive and contains bryozoans in abundance. Solitary and fasciculate corals as well as gastropods occur occasionally. Solenoporaceae and Duostominidae are visible in thin sections as well as *Aulotortus*. A coprolite (*Parafavreina* aff. *thoronetensis* Broennimann, Caron & Zaninetti) occurs in a single thin section. This coprolite species ranges from Norian to Early Jurassic.

Khao Pun and Khao Phrommachan (Fig. 1)

Khao Pun (15°19'N, 99°45'30"E) is 16 km due south of Khao Pathawi. It is built up by a thickly bedded to massive limestone, poor in macrofossils. A fasciculate coral (60 cm in diameter) and bryozoans have been noticed in the field.

Khao Prommachan (15°17'30"N, 99°45'30"E) is 1.5 km south of Khao Pun. It is built up by a dark gray bedded to massive limestone, very poor in fossils. In thin sections, the limestone appears as recrystallized in fine crystals.

Conclusion: In the western series of hills, the limestone is generally not metamorphosed; it is only slightly recrystallised. The fossils are easy to notice in the field and appear as well-preserved in thin sections. The facies of the limestone is uniform and the fossils are identical. No Permian fossil has been found. Conversely, Triassic fossils are widely distributed; they consist of Diplotrematidae, Duostominidae, *Duotaxis* (close to *Duotaxis birmanica* Zaninetti & Broennimann), *Ophthalmidium*, *Sigmoilina* and *Aulotortus*. The corals are clearly different from Permian corals; they cannot be older than the Ladinian.

The foraminifers indicate clearly a Late Triassic age. The relative diversity of *Aulotortus* material suggests a probable Norian age, an age also favoured by the species *Sigmoilina schaeferae*, *Duotaxis birmanica* and *Parafavreina thoronetensis*.

In Thailand, Permian limestones have been known for more than 50 years, largely because of the presence of fusulinids. In the past, other limestones deprived of fusulinids and scattered all over Thailand were also assigned to the Permian by lithological correlation because they really resemble Permian limestones in their aspect. During the last 20 years, many of these limestones without fusulinids have yielded Triassic fossils (For instance, see FONTAINE & SUTEETHORN, 1988; IGO ET AL., 1988; FONTAINE & TANTIWANIT, 1992; AMPORNMAHA, 1995; FONTAINE & SALYAPONGSE, 1997). Triassic corals have been noticed at many localities. They were mentioned as early as 1969 in Amphoe Long, Changwat Phrae (PITAKPAIVAN ET AL., 1969). They have been observed also in Phatthalung area, Peninsular Thailand (ADACHI ET AL., 1993), at Khao Noi Si Chomphu and Khao Thep Nimit Banphot in eastern Thailand (FONTAINE ET AL., 1996). Two main groups of corals have been reported: solitary corals including "*Montlivaltia*" and fasciculate corals belonging to "*Thecosmilia*". The corals of Uthai Thani area display affinities with those of Phrae, Phatthalung, and eastern Thailand.

The Eastern Series of Limestone Hills

The eastern series of hills is much more difficult to study because the limestone is strongly recrystallized. However, corals are clearly visible to the naked eye at the surface of the limestone at several places, although they are not strikingly visible as those of the western series (see Figs. 6, 8 and 9). The eastern series is divided into two groups.

Hills from Khao Laem to Khao Hin Ploeng (Figs. 1 and 3)

Khao Laem (15°27'N, 99°57'E) is built up by tuffaceous sandstone and shale containing a few limestone interbeds. Limestone is recrystallized and laminated; only traces of fossils are visible.

Khao Ngo (or Khao Tham Phra) (15°33'N, 99°58'E) is a massive limestone displaying traces of fossils at the surface of the rock and in thin sections: solitary corals, sponges, bryozoans, crinoids. Fasciculate corals are present, but consist only of a few small fragments. The limestone is recrystallized in fine crystals.

Khao Rum (15°33'30"N, 99°58'E) is a large hill. Limestone is massive and contains bryozoans in abundance at the southern end of the hill. Solitary and fasciculate corals (Fig. 6) are also present; they are similar to those of the western series of hills. In the thin sections which have been prepared, fossils have not been observed; the limestone is entirely recrystallized.

At Khao Lom (15°35'N, 99°58'E), limestone is massive and entirely recrystallized. It is locally dolomitised. No fossil has been noticed so far.

Khao Lai (15°33'55"N, 99°57'55"E) is composed of a limestone containing solitary (Fig. 9) and fasciculate corals. The fasciculate corals reach 40 cm in diameter; according to the corallite diameters, they belong at least to two species.

Khao Pun (15°36'40"N, 99°57'45"E) is built up by a limestone locally rich in large fasciculate corals, reaching more than 1 m in diameter and consisting of at least two

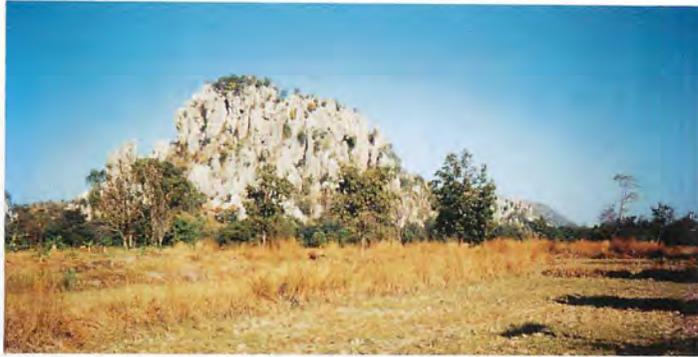


Figure 4. Khao Pathawi (or Khao Pha Lat) is a large limestone hill, 700 m long, 300 m wide and 245 m above sea level.



Figure 5. Khao Hin Thoen is a narrow elongated hill, 162 m above sea level, 7.5 km north of Khao Pathawi.



Figure 6. Limestone block containing fasciculate corals and seen at the southern end of Khao Rum, a hill belonging to the eastern series of hills (Fig. 3). These fossils are similar to those of the western series.



Figure 7. Fasciculate coral of Khao Pathawi, easily visible at the surface of the limestone to the unaided eye.

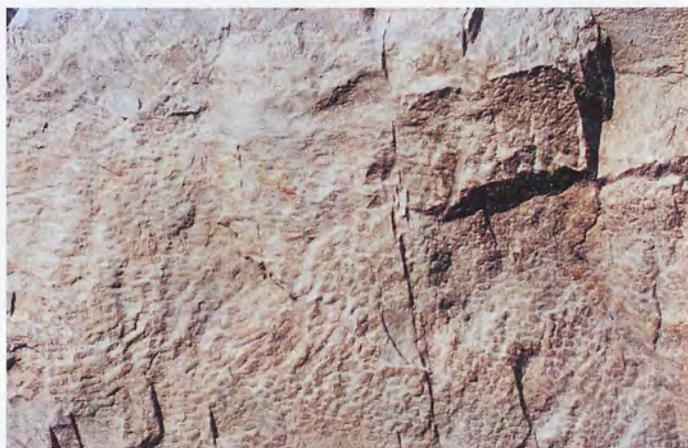


Figure 8. Fasciculate coral of the eastern series of hills. This coral is visible, but not so clearly as the coral of Khao Pathawi.



Figure 9. Solitary coral seen at the surface of the limestone of Khao Lai, a hill belonging to the eastern series of hills.

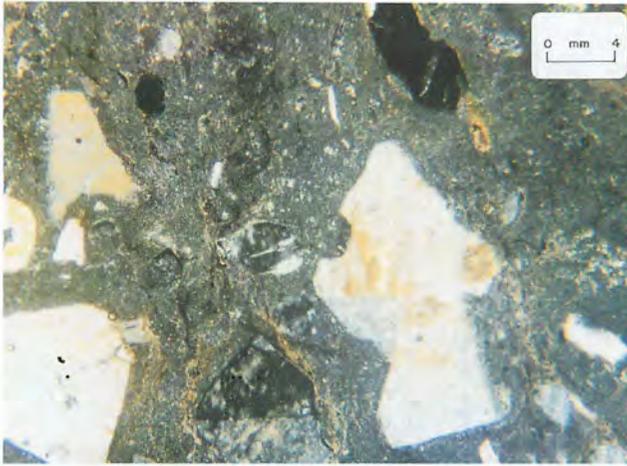


Figure 10. Volcanic rock cropping out near the western series of limestone hills, near Ban Tha Cha-Om southwest of Khao Pathawi (Geographic coordinates 15°25'40"N, 99°43'40"E). It is a rhyolitic tuff, not foliated, containing crystals of plagioclase and quartz which show embayment. These crystals are in a microcrystalline devitrified glassy matrix.

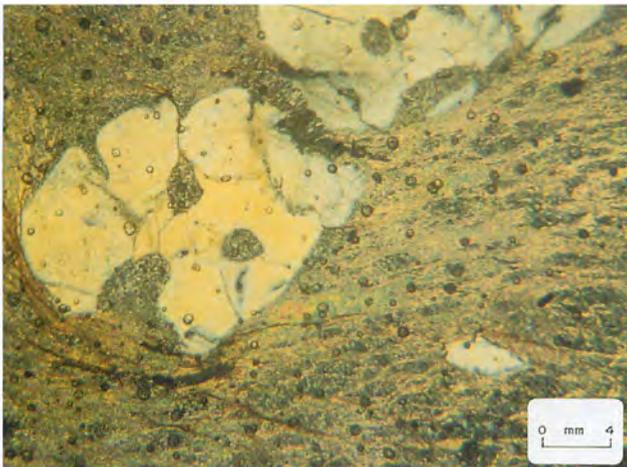


Figure 11. Volcanic rock exposed near the eastern series of limestone hills, southwest of Khao Ngo (Geographic coordinates 15°32'00"N, 99°57'30"E). The rhyolitic tuff is foliated with embayed crystals and a sericitized-devitrified microcrystalline matrix.

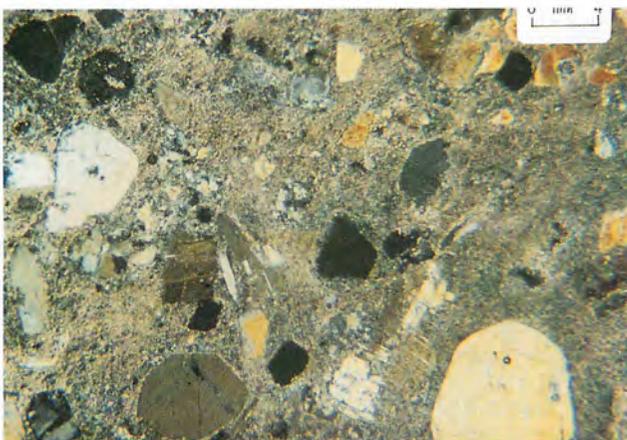
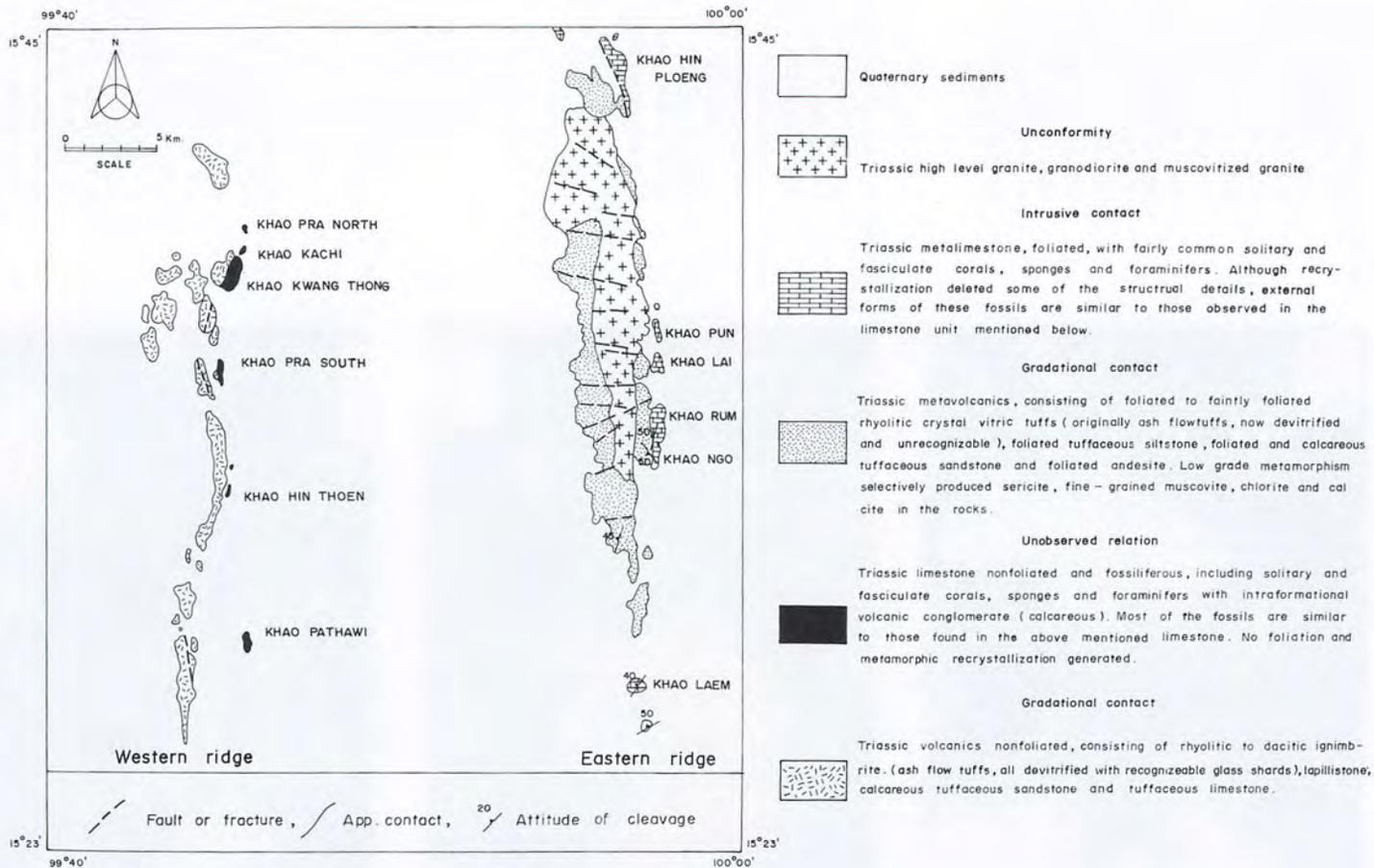


Figure 12. Volcanic rock belonging to the southern end of Khao Luang and exposed 1.5 km west of Khao Nang Buat (Geographic coordinates 15°30'30"N, 99°56'40"E). The rhyolitic tuff is faintly foliated, showing quartz and plagioclase crystals in sericitized and calcified microcrystalline devitrified-glassy matrix.

Figure 1.3: Geologic map of the western part of Uthai Thani and Nakhon Sawan Provinces.



species. Solitary corals are present, but not in abundance. The corals have been observed for the first time in 1999 thanks to the absence of vegetation after the seasonal burning by the farmers.

Khao Rak Kachan (15°37'30"N, 99°58'E) has not been visited. It is only 0.5 km far from Khao Pun to the north.

Small hill northeast of Khao Hin Ploeng (15°44'45"N, 99°56'50"E), limestone contains fasciculate corals and bryozoans. It is 15 km far from Khao Pun to the north.

Hills from Khao Rua to Khao No (Fig. 1)

Khao Rua (15°48'N, 99°55'30"E) is built up by a massive to thickly bedded limestone which is recrystallized, but displays locally a few bryozoans.

Khao Mano (15°48'30"N, 99°55'E) is similar to Khao Rua. Although limestone is recrystallized, it displays very locally a few bryozoans. Khao Mano has been quarried for the production of marble.

At **Khao Noi**, 300 m northwest of Khao Mano, limestone is entirely recrystallized.

Khao Pha Sawan (15°54'30"N, 99°53'E) is similar to Khao Noi, but contains very rare bryozoans, observable on the surface of the rock and even in the thin sections which have been prepared.

Khao Kaeo (15°56'N, 99°52'30"E) is a large hill, 2 km long and 314 m above sea level. It displays very locally rare solitary corals.

Khao No (15°57'N, 99°52'30"E) is composed of recrystallized limestone, but displays very locally bryozoans and crinoids on the surface of the rock.

Conclusion: The limestones of the eastern series are commonly strongly recrystallized and locally laminated. A dolomitisation has been observed locally at their base. At first glance, they look different from the limestones of the western series; they seem older than those limestones. It is easy to understand why they were assigned to an old age (Silurian–Devonian) in the Geological Map (BUNOPAS *ET AL.*, 1976). However, they show some fossils on their surface (Figs. 6, 8 and 9) and these fossils, although they are crystallized, display similarities to the fossils of the western series. Accordingly, the eastern series of limestone hills appears to be of the same age as the western series of hills and to belong also to the Triassic. The limestones of the eastern series have been strongly recrystallized by thermic action and also slightly laminated by tectonism. Fossils have disappeared entirely in some places; elsewhere, they are poorly preserved, but still easy to recognize at the surface of the limestone.

GENERAL CONCLUSIONS

Extensive limestones located northwest of Uthai Thani were previously considered Silurian–Devonian and Permian in age. They are assigned to the Upper Triassic in this paper. They reach a thickness of 200 m. They have yielded Triassic fossils in a good state of preservation to the west. To the east, recrystallization is very important because of thermic and dynamic metamorphism; the Triassic evidence is obliterated partly and the fossils are largely destroyed, but locally still visible at the surface of the limestone and occasionally still visible in thin sections.

Corals are in abundance at many localities. They indicate an age not older than the Ladinian. As a matter of fact, Rugosa disappeared entirely at the end of the Permian and then, there was a large time gap between the last assemblage of diverse Rugosa and the first assemblage of diverse Scleractinia. Corals are practically unknown in the Lower Triassic. Their diversity started only during the Ladinian. The foraminifers are indicative of a Late Triassic age and probably of a Norian age. Because of the absence of a great part of the Norian everywhere in Thailand, the Triassic limestones of Uthai Thani area probably have to be restricted to an Early Norian age.

BUNOPAS (1981) has introduced the term "Uthai Thani Limestone" for a limestone which has yielded a Middle Permian (Murgabian) assemblage of fusulinids identified by INGAVAT ET AL., (1975). The type section is 70 km west of Uthai Thani and thus west of the area concerned by this paper. However, Bunopas thought that the "Uthai Thani Limestone" might possibly extend to the east and include the western series of hills described above and mapped in the past as Ratburi Group. According to our results, the "Uthai Thani Limestone" does not extend to the two series of hills described in this paper; it is restricted to a relatively small area located farther to the west.

The volcanic rocks associated with the limestone do not suggest two series of limestone hills of different ages. They show similarity in composition indicating they were apparently derived from the same volcanism. However, the foliation that exists in the volcanic rocks of the eastern series is probably related to dynamic metamorphism caused by a subduction and more active zone to the east.

East of the two series of hills concerned by this paper, Permian limestone exposures are widely distributed east of longitude 100°15' in Takli area (FONTAINE ET AL., 1994).

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