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Karst geomorphology on sandstones in the area of Ban Dong Tong (Nong Khai), Thailand

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ABSTRACT

Tham Din Pieng (cave) is by far the largest and deepest sandstone cave in all of Thailand. Its entire maze has a total length of 2,510 m and a vertical range (VR) of 31.3 m (Valenas, 2024b). The area around the village of Ban Dong Tong presents a surface karst and a typical endokarst, similar to karst and endokarst in limestone but in the Ban Dong Tong area there is no limestone, only Cretaceous sandstones, with a carbonate cement (binder). In all of Thailand, the Ban Dong Tong area is an absolutely special case.

INTRODUCTION

The area is located in Nong Khai province of Thailand (Figure 1), 10 km from the Mekong River, heading south, in the territory of the village of Ban Dong Tong, within the large Buddhist temple Wat Tham Si Mongkhon. The upper entrance of Tham Din Pieng has the coordinates: 48Q 214218 1987915, alt. : 349 m, the lower entrance (which is in the center of the studied area): 48Q 214218 1987890, alt.: 339 m (Ellis 2017).

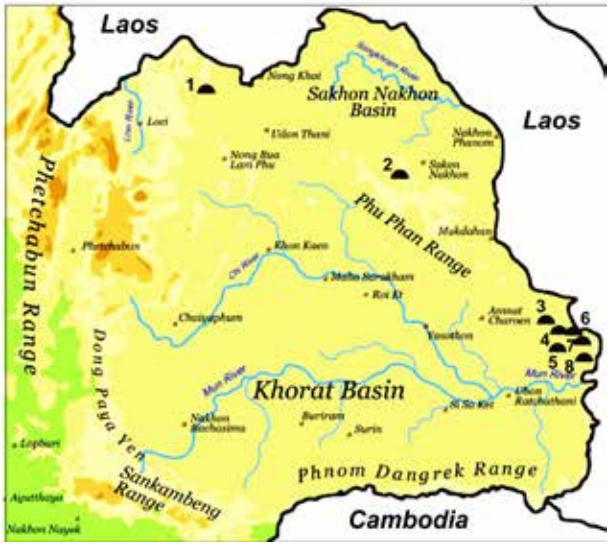

Figure 1. Map of Northeast Thailand, with the main sandstone caves. No. 1: Ban Dong Tong area.

The main valley, which is in front of entrance No. 2 of Tham Din Pieng, disappears 30 m away from the cave in a typical ponor. In the immediate vicinity of the cave there are also two large sinkholes (Figures 2 and 3), with diameters between 50 and 60 m. The sinkholes are not suffosion sinkholes, but typical sinkholes developed in the same rock. Tham Din Pieng probably drains by

Figure 2. Sinkhole with a small pothole near entrance no. 2 of Tham Din Pieng (photo Liviu Valenas).

Figure 3. Great sinkhole with a small cave near entrance no. 1 of Tham Din Pieng (photo Liviu Valenas).

a more important karst spring, located in the dry valley next to the cave. The main spring is located approximately 100 m north of the terminal sump of the Tham Din Pieng (Figure 4). There are three other karst springs in the area, but it is not known whether they are hydrologically related to the cave. The karst landscape is completed by five smaller potholes (Figures 5 and 6), two of which have not

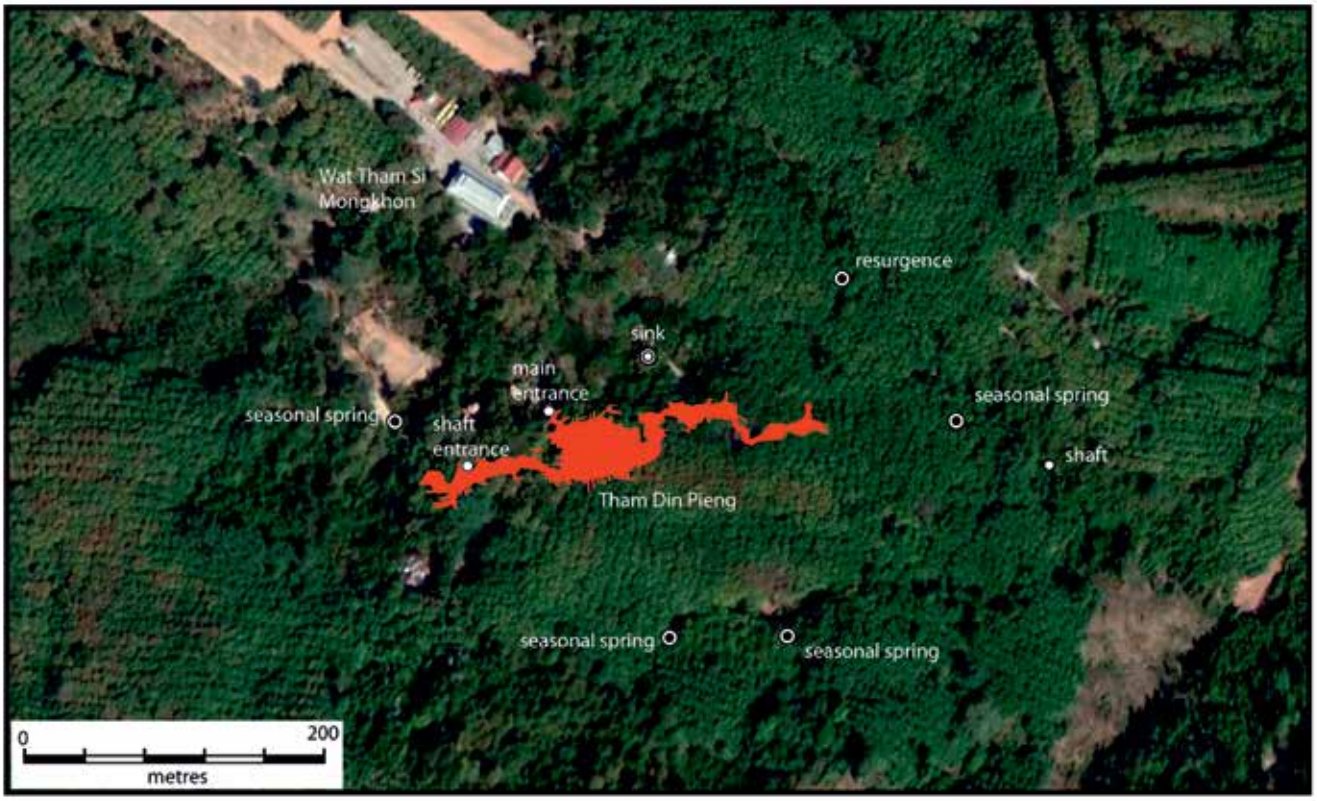

Figure 4. Tham Din Pieng in relation to the surrounding area. Base image from Google Earth. Cartography by Martin Ellis, Liviu Valenas and George-Emil Pleş.

Figure 5. Small pothole to the east of Tham Din Pieng (photo Liviu Valenas).

Figure 6. Small pothole to the east of Tham Din Pieng (photo Liviu Valenas).

been explored yet. All of them are morphologically related to the Tham Din Pieng. It is interesting, however, that no karren appear in the area, although the karst landscape is otherwise almost complete here. Probably the lack of karren can be explained by the fact that the whole area is completely forested and very rarely does the sandstone bedrock appear on the surface.

MATERIALS AND METHODS

The geological map used was the 1:50,000 map of Nong Khai province, made by the Department of Mineral Resources (DMR) in Bangkok (Figure 7).

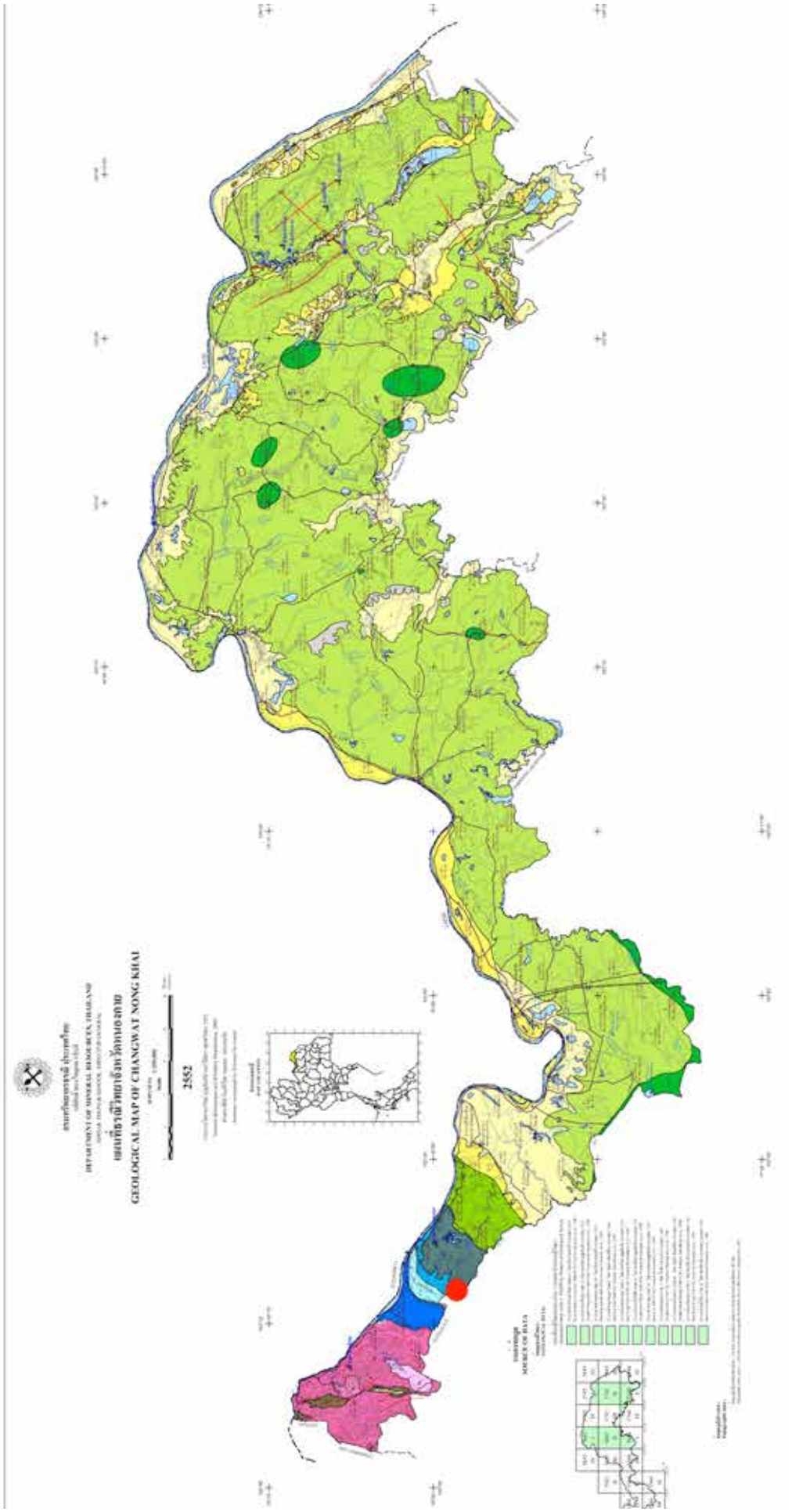

Figure 7 Geological map of Nong Khai province, made by the Department of Mineral Resources (DMR) in Bangkok. The red circle in the North-West extremity of Nong Khai province represents the Ban Don Tong area.
For key/explanation, see Figure 7A. p. 22

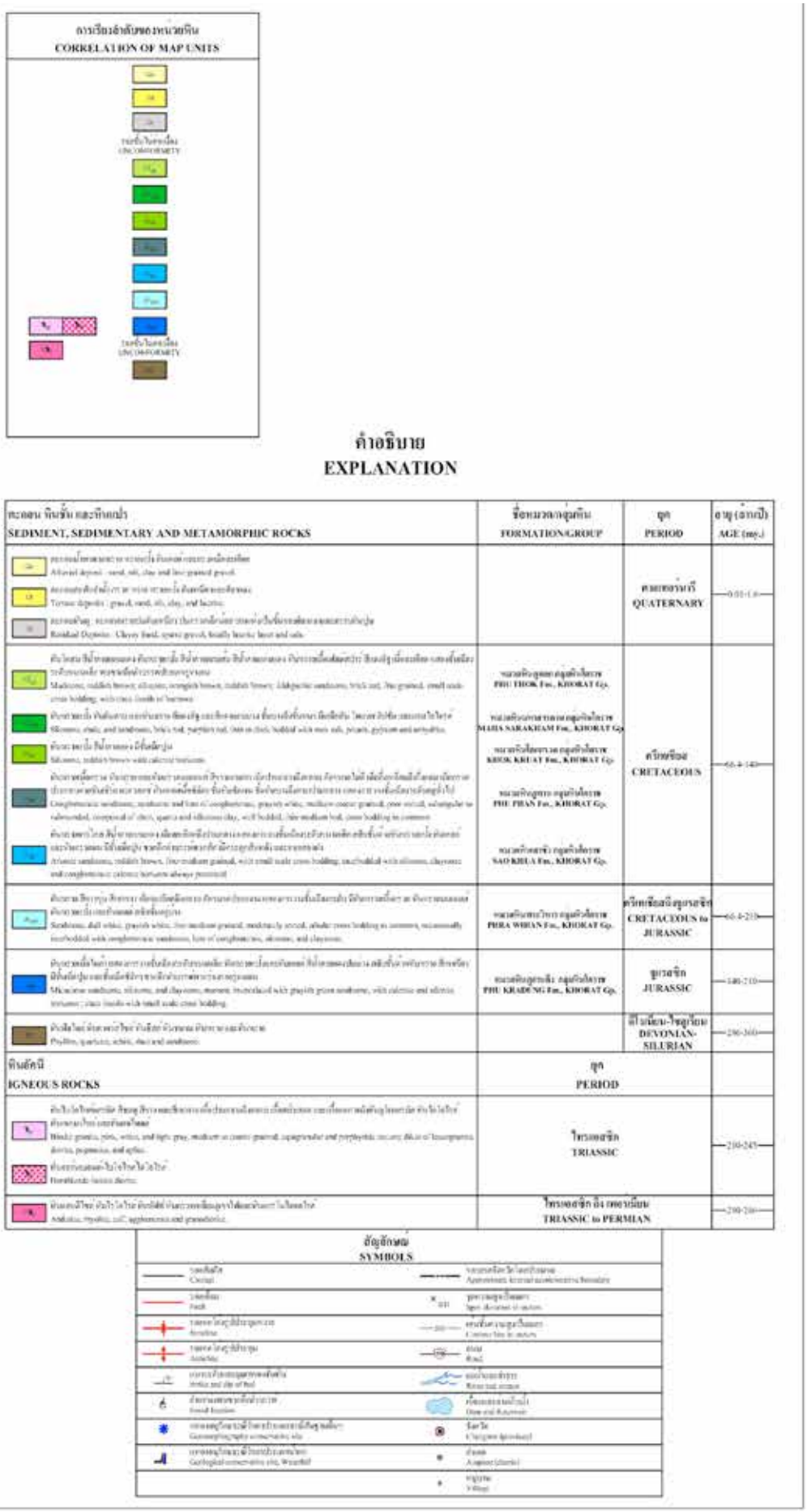

Figure 7A. Key to geological units shown in Figure 7, p. 21.

Tham Din Pieng was surveyed and mapped with Suunto compass, Disto D2 and inclinometer. The cave entrances were positioned with GPS, Garmin 62s. The area was photographed with a Nikon D 5200 camera, Tamron lens, 18-270 mm, UV filter. The galleries of Tham Din Pieng and the main springs have been positioned on a Google Earth map (Figure 4).

LITHOLOGY

Thai geologists have not completely agreed on which particular Cretaceous formation the sandstones in the Ban Dong Tong area belong. Even the geological maps published in Thailand are a little unclear, especially since they are drawn up by province, and the Ban Dong Tong area is just north of the administrative border between Nong Khai and Udon Thani provinces. However, Australian caver John Dunkley has written that the sandstones in which Tham Din Pieng has formed belong to the Phu Phan Formation, which occurs from Ubon Ratchathani province to Nong Khai (Dunkley 2011, Dunkley and others 2018).

According to Martin Ellis (pers. comm. 2024) the Phu Phan formation is composed of conglomeratic sandstone, sandstone and lenses of conglomerate, grayish white, medium-coarse grained, poorly sorted, subangular to subrounded, composed of chert, quartz and siliceous clay, well bedded, thin-medium bed, cross bedding is common.

The 1:50,000 geology map (Figure 7) of the quadrant to the north of Ban Dong Tong area has this description of the Phu Phan Formation: *Sandstone and conglomeratic sandstone, pinkish white and whitish gray, medium- to coarse-grained, poor sorted, subround, moderately to well cemented, cross bedded. The Thai geologist Assanee Meesook, in an interesting work published in 2011, dedicated to the Cretaceous in Thailand, describes the Phu Phan Formation, from the northern sector (close to Tham Din Pieng): The Phu Phan Formation is well exposed along the Mae Khong River banks and in most parts of the Phu Phan Range where it forms cuestas which delineate the outer rims of the range. The rocks generally consist of greyish-white-medium-to coarse-grained cross-bedded sandstones and thin lenses of grey siltstone and mudstone with subordinate conglomerate. In the northern and central parts of the Phu Phan Range, the formation overlies the reddish-brown claystones of the Sao Khua Formation with a distinctvely sharp but conformable contact. Sandstone conglomerates are locally exposed* (Meesook 2011).

Geologists John Booth and Nares Sattayarak describe the Phu Phan Formation as follows: *The Phu Phan Formation consists of a stacked series of thick-bedded to massive medium- to very coarse-grained, often pebbly, cross-bedded white sandstones interbedded with minor thin red-brown siltstones and claystones. Where this formation crops out in breached anticlines of the Phu Phan Uplift and around the edge of the Khorat Plateau, its resistant sandstones locally form distinctive cuestas. Generally the formation is 75-150 m thick. The sandstones are interpreted as having been deposited as a stacked series of meandering to locally braided rivers. It is observed that while only pebbles of quartz and chert are found in the centre of the basin, various lithic clasts are found along the southern and northern margins. Palaeocurrent directions from studies of cross-bedding indicate that the river systems generally flowed westwards, having entered the basin from the north, east and south. On seismic sections the Phu Phan Formation is imaged as a more-or-less continuous peak-trough-peak cycle and is too thin to display any internal reflection pattern. When drilling wells, the top of the formation is readily apparent as its almost continuous white sandstones contrast with the dark reddish-purple to red-brown claystones and siltstones of the overlying Khok Kruat Formation* (Booth & Sattayarak 2011).

What surprises us in all the geological works (including the authors cited above) and maps that refer to the Phu Phan Formation, is that no reference is made to the fact that both the sandstones and the conglomerates have a calcareous cement. Chemical analyses of the water samples collected by the author in 2023 and 2024 from the two underground rivers in Tham Din Pieng (Figures 8 and 9), clearly showed that there is this calcareous cement. The three water samples analysed have a pH between 7.30 and 7.99, and the content of calcium carbonate ($CaCo_3$) reaches values of up to 185 mg/l. While these values are typical of caves developed exclusively in limestone, this is not the case at Tham Din Pieng (Valenas 2024b).

DISCUSSION

Since the early 20th century, when the term "pseudokarst" was apparently first used (Knebel 1908, cited by Halliday 2004) (with the subsequent unfortunate consequences of this word – see Eberhard & Sharples 2013), there has been heated and contradictory discussion about this term. In recent times, many researchers have denied the existence of "pseudokarst" and simply classified

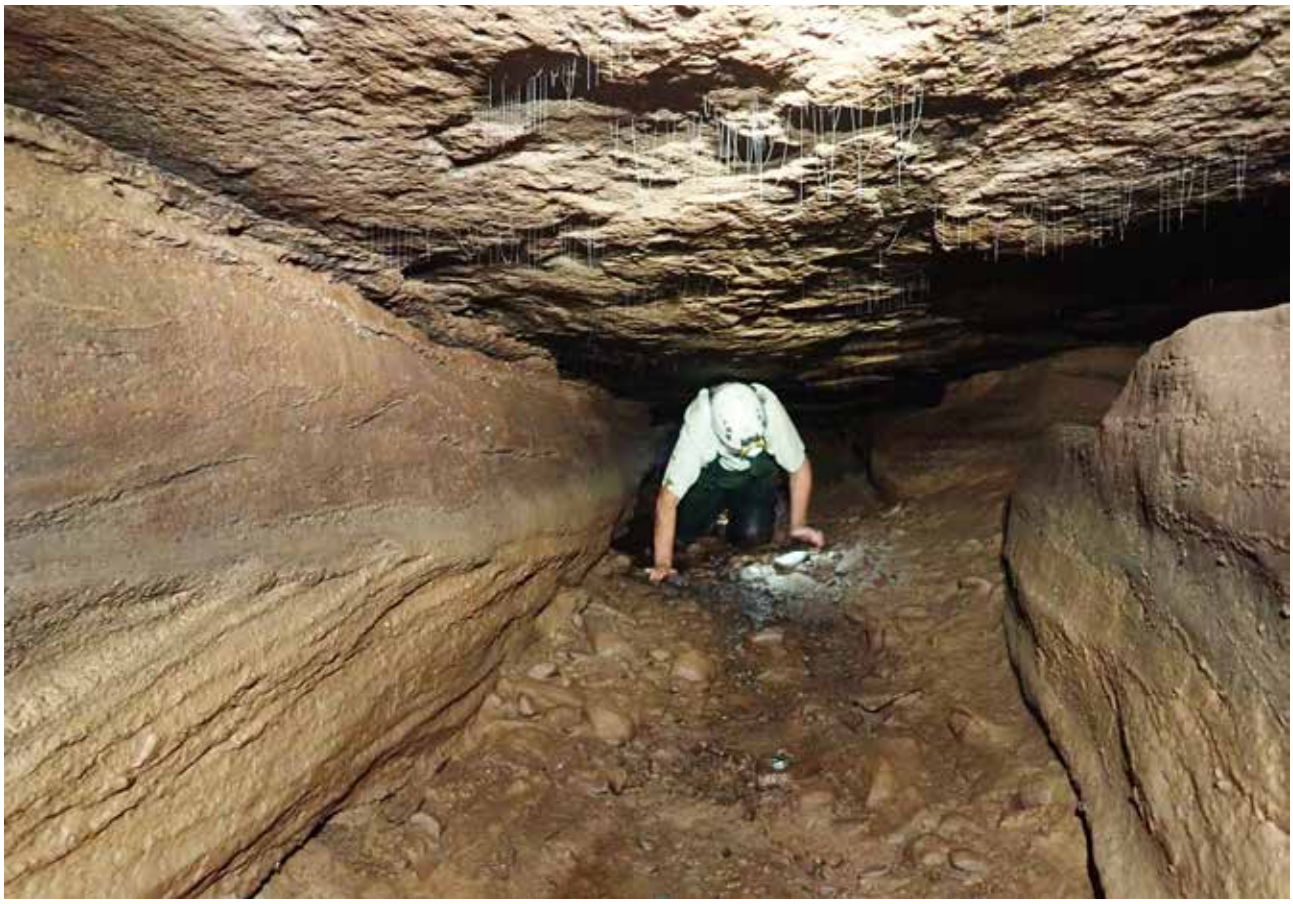

Figure 8. Many of the galleries in Tham Din Pieng are narrow and low. In this photo it is clearly seen that the cave was excavated between different layers of sandstones and conglomerates (photo Mindy Johnson Filer).

Figure 9. The carbonate cement (binder) of the sandstones in which the Tham Din Pieng has developed is directly responsible for the specific shapes in this cave. The picture shows sandstone columns in the Hall of a Thousand Rooms (photo Liviu Valenas).

karst-like relief forms on non-carbonate rocks as karst. Brazilian researchers (Pereira and others 2022) write very clearly that "Karstification in quartzite sandstones is a reality demonstrated globally through the exploration and research of caves in sandstones". However, the French geologist Claude Mouret reached another, in our opinion slightly absurd, conclusion: "Caves must be separated; those that belong to typical karst and those with a complex speleogenesis, which belong to pseudokarst" (Mouret & Urban 2022). In reality, all caves, including those in carbonate rocks, have a complex genesis.

At the international symposium dedicated to 'pseudokarst' in Karlow, Poland (May, 2023) there were heated discussions about whether the term 'pseudokarst' has a scientific basis or not. Most of the participants denied the validity of the term 'pseudokarst'. It is certain that the karst on the quartzite sandstones of Northeast Thailand, on which the author presented (Valenas 2023a), was universally appreciated as a true karst and not a 'pseudokarst'. In our opinion, the term 'pseudokarst' is completely outdated. In the case of the karst in the Ban Dong Tong area, another factor is significant: the sandstones have a carbonate cement and the term 'pseudokarst' could not in any way be justified in this case.

CONCLUSION

In summary, the Ban Dong Tong area presents all the "classic" karst forms, dry valleys (where the water course exists entirely underground), sinkholes, potholes, karst springs and a large maze cave, Tham Din Pieng. The sandstone bedrock was dissolved not only by arrenisation, but also by dissolution of the calcium carbonate that makes up the cement (binder) of these sandstones. Hence, in the Ban Dong Tong area we are dealing with a typical karst and not a pseudokarst. A very important role in the dissolution of sandstones was, and is, played by the extremely high precipitation in the monsoon season, but also by the biocorrosion produced by the roots of tropical vegetation in the area (Valenas 2023b, 2024a). The research in this area is only just beginning; we hope that the new research and explorations that we intend to do intensively in this area in 2025 will bring new data and new clarifications (Valenas 2024b).

ACKNOWLEDGEMENTS

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