

# Geology of Hin Chang Si Sandstone Geoheritage in Khon Kaen Province for Geotourism Planning of Northeastern Thailand

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## Abstract

One of the most distinguished sandstone geoheritage resources in the Khorat Plateau is Hin Chang Si located in the Nam Phong National Park, Khon Kaen Province. The clastic sedimentary rocks of the Phra Wihan Formation of the Khorat Group covered this area. As a result of the lithologic study, the Hin Chang Si consists of pebbly sandstone, moderately sorted medium- to coarse-grained sandstone, and a small amount of siltstone interbedded with laminated shale. The characteristics (colors, cementation, and degrees of weathering) divided sandstones into two groups, including white grain-supported sandstone with silica cement and matrix-supported sandstone with Fe-rich cement. In addition, these sandstones present primary sedimentary structures, which comprise tabular cross-bedding and normal grading as well as bioturbation. Hin Chang Si demonstrates many geomorphological features, including cliffs, potholes, rock pillars, polygonal cracks, caves, tafoni, runnels, and natural arches according to inventory. The weathering and degradation processes in humid tropical conditions are the main processes that caused these geomorphological features. Whereas many primary factors affected various types of morphology that are composed of joints, folds, and faults. The national park provides the natural trail map, tourism information, and biodiversity data to visitors; however, geological information about sandstone landforms should be actualized for geotourism development.

## Keywords

Landform, Geomorphology, Geoheritage, Geotourism, Weathering, Khorat Group

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## 1. Introduction

Khon Kaen Province is a part of the Khorat Plateau (northeastern Thailand) with a high geodiversity, presenting a diversity of valuable geological features on earth, *i.e.*, rocks, minerals, fossils, landforms, landscapes, and structures based on geodiversity theory [1]. Nowadays, Thailand is developing in geotourism planning and encourages the areas that comprise unique geoheritage resources to establish geopark [2] [3], especially Khon Kaen Geopark. Moreover, this national geopark is dominated by the world's new dinosaur species and unique sandstone landforms in the Phu Wiang National Park, the eastern part of Ubon Ratana Dam [4]. Meanwhile, the eastern part of Ubon Ratana Dam also has a remarkable geological site, namely, Hin Chang Si natural trail. The meaning of Hin Chang Si is a stone scraped by a wild elephant and then left with traces of soil attached to the rock [5]. The Hin Chang Si area is situated in the Nam Phong National Park, which is covered by distinguished clastic sedimentary rocks of the Phra Wihan Formations of the Khorat Group (**Figure 1**), which mainly consists of pebble sandstone, sandstone, and siltstone [6]. This formation was deposited in a braided stream environment and on top of meandering rivers in the Late Triassic to Early Jurassic, as indicated by the palynomorphs [7] [8].

There are numerous sandstone landforms along the natural route, which are usually attractive to tourists in many sites by their uniqueness. Moreover, the Hin Chang Si area is also helpful for geological education, *e.g.*, sedimentology and stratigraphy for understanding the Phra Wihan Formation of the Khorat Group. This work is the first study focused on the preliminary geological study of the geologic setting and geomorphological features of the Hin Chang Si area that can guide further in-depth geological research, such as sandstone occurrence, processes, and unique landforms.

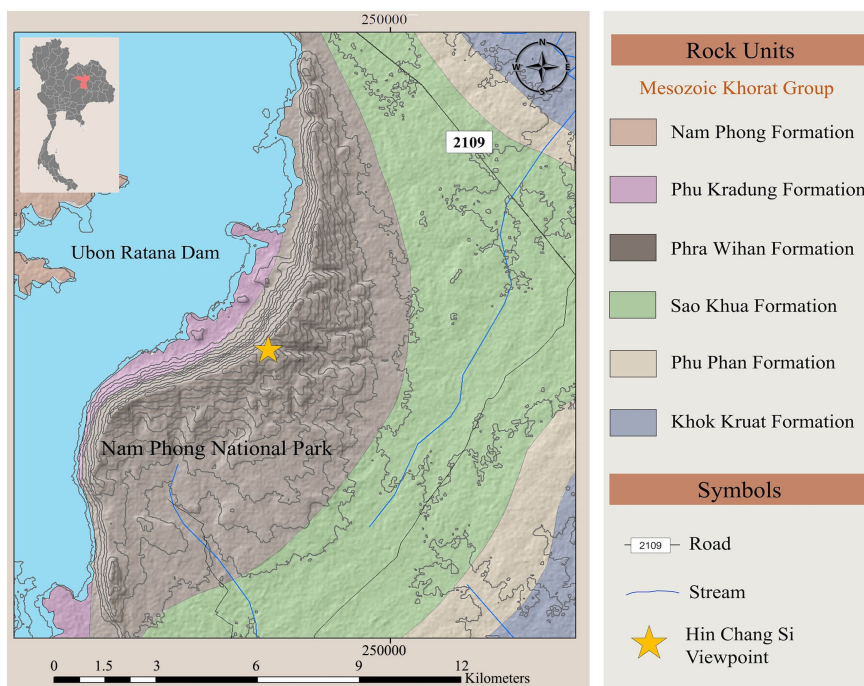
## 2. Materials and Methods

The materials for this preliminary geological study are literature related to the research topic and study area, topographic map, geologic map of Khon Kaen Province, as well as field equipment, compass, and camera. The methods of this research comprise literature review, field observation, and characterization of sandstone landforms. During field observation, the lithology details were described, then the characterization of the sandstone landforms was carried out. Furthermore, the characterization is actualized by reliable information from field investigation integrated with previous works. In addition, geomorphological analysis using the Google Earth Pro 7.3.3.7786 (64-bit) and ArcGIS 10.4 for Desktop (64-bit) was integrated to determine the elevation, slope, and area cover as well as generate the geologic map in **Figure 1**.

## 3. Result and Discussion

### 3.1. Geological Characteristics

The characteristic of clastic sedimentary rocks in the Hin Chang Si area mainly



**Figure 1.** Geologic map of the Nam Phong National Park, Khon Kaen Province modified from DMR of Thailand [9] and analyzed by ArcGIS 10.4 for Desktop.

comprises pebbly sandstone, medium- to coarse-grained sandstone with moderately sorted, and siltstone interbedded with laminated shale. The exposed sandstone beds are rather sub-horizontal or very gentle slopes with a dip angle of approximately  $17^\circ$  and a dip direction in the eastern ward. The western part of the mountain range presents sandstone cliffs, which is the escarpment slope of the Phra Wihan Formation overlaying on the Phu Kradung Formation. This flank is also the area of the Ubon Ratana Dam, which is the first multi-purpose dam of the Electricity Generating Authority of Thailand (EGAT) in the northeastern part of Thailand. The dam was built across the Phong River and is also the control center of electricity generation in the Northeast. The sandstones along the natural route cloud were divided into two groups by their lithology, characteristics, and weathering degrees: 1) white grain-supported sandstone with silica cement, with lower weathering degree due to the rock texture having more homogeneously and 2) pale-yellow medium to coarse-grained sand with pebbles, matrix-supported sandstone with limonite cement, higher weathering degree (Figure 2). These sub-horizontal sandstone beds also demonstrated a co-set of tabular cross-bedding, normal grading, the orientation of pebble grain, and burrow (bioturbation) as shown in Figure 2. In addition, the geological structures of the Hin Chang Si area are made up of joints, folds, and faults, which are one of the factors that influence differential types of sandstone morphology.

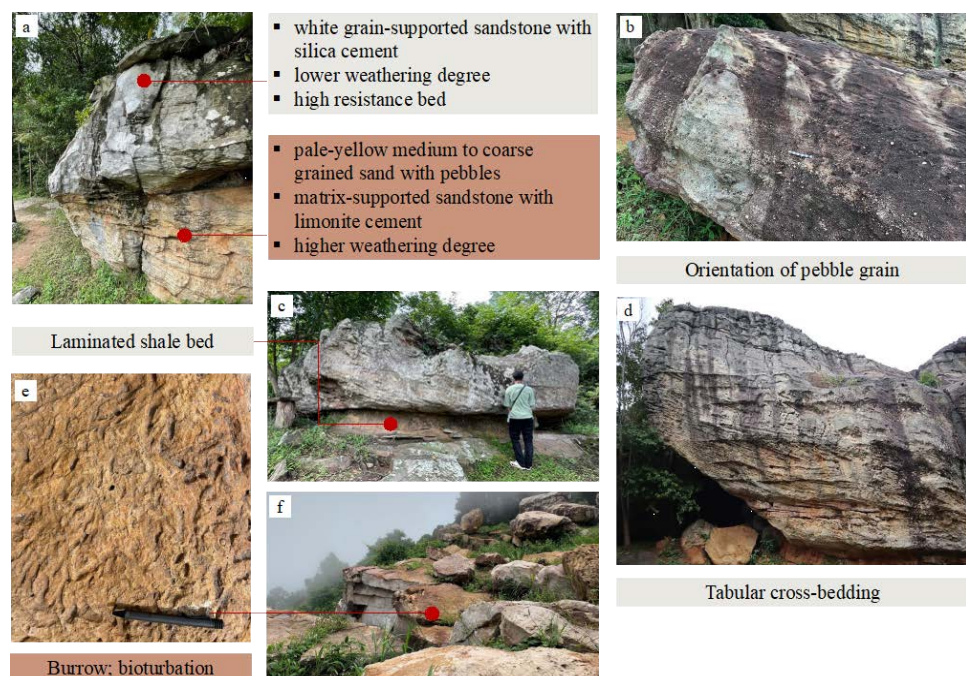
### 3.2. Geomorphological Features for Geotourism Development

The exposed sandstone bedding of the Phra Wihan formation is a highly resis-

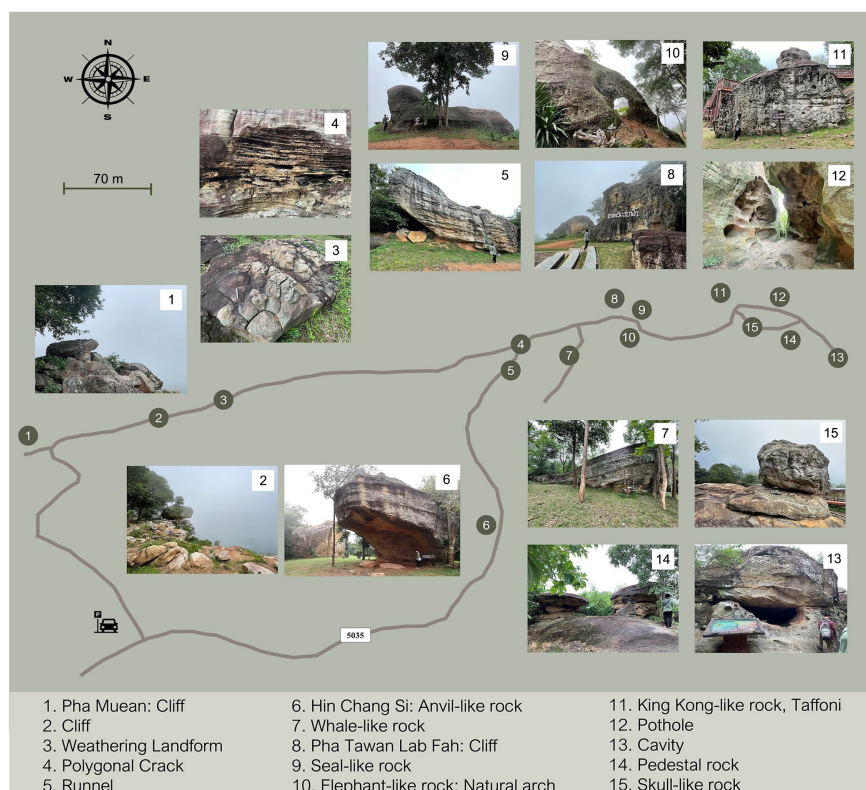
tant rock that always appears morphology as a ridge and representative sandstone landform in Khorat Plateau. Based on inventory, the unique sandstone landforms in this area consist of cliffs, potholes, rock pillars, polygonal cracks, caves, anvil-like rocks, tafoni, runnels, and natural arches (Figure 3). Similar characteristics from previously studied sandstone landforms characterize the epithets of these landforms, including shapes, sizes, and features as well as their spectacular sceneries [10] [11] [12] [13] [14]. In terms of the pothole site, this area shows lateral paleo-pothole characteristics that were eroded in the past and were lifted up by geologic structure [13]. The sandstone morphologies are the product of weathering and degradational processes with the difference in resistance to erosion of bedrocks. The initial occurrence of these sandstone morphologies is caused by joints in the rock mass. Simultaneously, running water infiltrates through the fractures, bedding planes, and porosity of rocks to create various landforms.

The Hin Chang Si natural trail is the most famous touristic destination when people visit the Khon Kaen province. The Nam Phong national park provides many facilities to visitors and the accessibility is very good for promotion.

The authorities are ready to serve the tourism information and biodiversity in the area both in museums and outdoor exhibitions along the natural trail. There is a large field of carpark provides the visitor with a high-quality road for access. The visitor can buy the ticket in front of the national park and there is a 50% discount for students. This promotion is one of the strategies for educating students and youth to be more interested in the natural and physical resources in



**Figure 2.** Geological characteristics of the Nam Phong National Park, Khon Kaen Province: (a) outcrops of white- and pale-yellow sandstone, (b) orientation of pebble grain, (c) laminated shale bed, (d) tabular cross-bedding, (e) burrow, and (f) outcrop presented burrow.



**Figure 3.** Geotouristic route and geomorphological features distribution in the Nam Phong National Park, Khon Kaen Province.

the national park and realize their conservation values. Food, drink, and souvenirs are provided at the national park shop. From the car park, the geotouristic trail will lead the visitor to the top of the hill, namely Pha Muean Cliff for an aesthetic panoramic view of the Ubon Ratana Dam (Figure 3). The trail is along the sandstone cliff to the northeastern flank of the area. Thus, the visitors can enjoy the panoramic views of the dam through the trail. Then, there are many geomorphological sites with different degrees of weathering along the trails, including polygonal cracks, tunnels, Hin Chang Si: Anvil-like rock, whale-like rock, Pha Tawan Lab Fah Cliff, Seal-like rock, Elephant-like rock (natural sandstone arch), King Kong-like rock, tafoni, potholes, cavities, pedestal rocks, and Skull-like rock, respectively. These sandstone landforms exhibit their stunning uniqueness and co-star biodiversity in a unified way. These outstanding natural sculptors should be conserved as far as possible.

#### 4. Conclusion

The Hin Chang Si area is one of the most significant geomorphological sites in Khon Kaen Province, northeastern Thailand. Field investigation indicates that the Hin Chang Si area is covered by clastic sedimentary rocks of the Phra Wihan Formation of the Khorat Group. These sandstones comprise white (silica cement) and yellow (Fe-rich cement) pebbly sandstone, medium- to coarse-grained sandstone, and siltstone interbedded with laminated shale. The sandstone outcrops

also show the primary sedimentary structures, including tabular cross-bedding, normal grading, the orientation of pebble grain, and burrow (bioturbation). In addition, the inventory suggests that the unique sandstone landforms in this area consist of cliffs, potholes, rock pillars, polygonal cracks, caves, anvil-like rocks, tafoni, runnels, and natural arches. The Hin Chang Si Natural Route presents the diverse representative sandstone geomorphologic features mainly occurred by weathering in the humid tropical conditions and degradational processes due to the difference in resistance of rocks and the related geological structures. The national park authorities provide much touristic and biological information to visitors and serve many high-quality facilities here. Thus, the geological information from this preliminary study could promote to be an important tool to educate visitors to understand the Earth's processes and encourage them to realize conservation towards geotourism development in Thailand.

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### Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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