

Karst Landscapes in the Bay of Ha Long, Vietnam

Photos: H. Mark

Since becoming a part of the world natural heritage in 1994, Ha Long Bay has become an internationally popular travel destination. The fascination exerted on humans by the islands of northern Vietnam is due particularly to the fact that the limestone formations in the tropics produce a particularly spectacular treasure chest of shapes – karst formation.

Generally the term “karst” subsumes all surface limestone formations, whose development results from chemical dissolution processes. Rainwater always contains a certain amount of acids determined, among other factors, by the omnipresence of carbon dioxide in the atmosphere and also particularly in the soil air (Mark 2005). When rainwater enriched with acids comes into contact with limestone, the latter is dissolved until a chemical balance is reached, namely the saturation of the water with lime. The visible result is “cavities” in the landscape – hollow formations – which form the typical wealth of shapes in karst depending on local factors of tectonics, composition of the stone and climatic conditions.

Karst: surface shapes in limestone resulting from dissolution

This richness of shapes is always clearly visible because dissolution of the lime also occurs deep in the subsurface of the formation. When water seeping into the fragmented subsurface of the formation mixes, additional carbon dioxide going beyond the saturation rate is released which is again capable of dissolving the limestone. This chemical process known as “mixing corrosion” is also responsible for a further characteristic formation in karst regions - caves.



Figure 1: Location of Ha Long Bay in Vietnam

Source: westermann

The complex interaction of precipitation, temperature, rock and tectonics provide for the development of a wealth of shapes which is simultaneously scientifically interesting and fascinating. The Dinaric karst, the Moravian karst and in Germany, the Swabian Mountain karst are well-known examples of intensively researched landscapes which are also appreciated by visitors and tourists (Liedtke 1962). However, the karst



Photo 1: Karst scenery of Ha Long Bay, Vietnam

as distinguished in its full tropical karst formation at present in the Ha Long Bay is particularly attractive (*Photo 1*).

Development of Ha Long Bay

Ha Long Bay is located along the boundary between Vietnam and China at 20° north latitude, approximately 160 km to the east of the capital Hanoi. It is part of the Gulf of Tonkin, an extension of the southern Sea of China and covers an area of 1,566 km² within which 1,969 islands rise out of the water (*Figure 1*).

As a characteristic development of the full tropical karst formation, these islands appear as steeply rising limestone mountings with a distinguished crest shape which can reach heights of between 50 and 100 m, some even as height as 200 m. The limestone originates from the Carboniferous and Permian eras. During the Caledonian mountain formation 300 million years ago, northern Vietnam was part of a region consisting of alternating mounting chains and deep oceanic depressions in the shape of waves. Lime with thickness between 2,400 and 2,600 m was deposited in these depressions. The later geological history of this region is very complex and still unclear in many details. The fact is that the lime deposits were subjected to a series of Tectonic phases of lifting and sinking whereby they were also distorted and cocked. Deviations in the sea level during phases of transgressions and regressions also affected the development of the shape. It is certain that major portions of Ha Long Bay were dry during the ice ages. Fossil valleys witnessing a significantly lower sea level during the ice age pervade the ocean floor between the islands (*Waltham 2005*).

Which factors are responsible for development of the wealth of shapes which present themselves today? An important prerequisite is the fact that the limestone formation was lifted above the level of the receiving bodies of water at some time because the latter always provides a local base for corrosion. This means that when the limestone formation rises vertical dissolution operations can occur, ending wherever the crevices in the limestone are filled with water (phreatic zone). The upper limit of this phreatic zone corresponds to the level of the receiving bodies of water – expressed in simple form. The limestone islands which one sees today are basically the remains of a once mighty and extended limestone formation, the majority of which was dissolved by corrosion. For this reason the limestone formation continues as a “trunk formation” below the surface of the water – rarely more than 10 m. Limestone strata, once located above this, have disappeared.

Another important factor determining the intensity of corrosion to a decisive degree also contributed to formation of this tropical karst – the climate. It can be assumed that intensive corrosion occurs particularly at high temperatures and high precipitation rates such as under climatic conditions that exist today. However, it may possibly have been even more distinguished in earlier phases of the earth's history, for example in the Tertiary period.

Interestingly the intensity of corrosion appears to be the decisive criterion responsible for development of the full karst formations. It is recognizable at many points in the Ha Long Bay that the wealth of shapes developed almost completely independently of the stratification of the stone.

Richness of karst shapes in Ha Long-Bay

In Ha Long Bay we find the typical richness of shapes characterizing tropical karsts such as are also present in other tropical countries such as Mexico, Jamaica, Cuba, Thailand, Malaysia, Indonesia and China. Witnesses of the once extended and contiguous limestone formation are the numerous caves of which Thien Cung, Dau Go, Sung Sot, Tam Cung and Bo Nau are the most familiar. Some of these caves are significantly above sea level and therefore developed at a time that the affected limestone strata were located at the phreatic level. As a result of tectonic increases and decreases in the sea level and the subsequent vertical corrosive erosion processes, these caves were frequently cut open making them visible along the walls of the karst towers (*Photo 2*).

If one rides through Ha Long Bay in a boat, a large number of typical minor karst shapes can be recognized. Where the limestone is flat, more or less round lapies (“Trittkarren”) occur, small, usually circular depressions which are separated from one another by

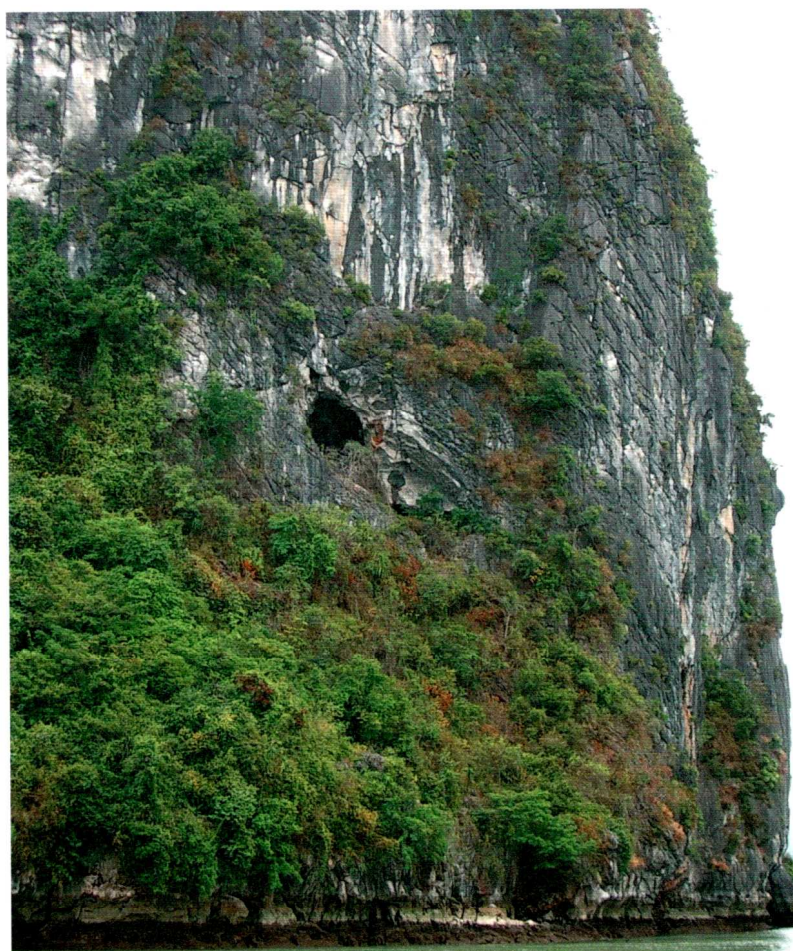


Photo 2: Truncated cave at the wall of a karst tower



Photo 3: "Trittkarren" on a karst surface

frequently razor-sharp ridges (*Photo 3*). The steep walls of the karst hills are, by contrast, subdivided by longitudinal extending ridges ("Rillenkarrn", *Photo 4*). Both of these formations are the result of dissolution and can also be found outside the tropics. "Trittkarren" result during the initial stage, frequently through collection of products from weathering, such as plant residues which provide for intensive corrosion of the local areas whose depths continues to increase in time. "Rillenkarrn", by contrast, result from dissolution of lime by the rainwater flowing down the slopes.

Photo 4 shows that the karren on the slope of the full karst formations are not distinguished everywhere.

Fresh fracture zones interrupt the ridge structures at individual points, testifying to active morpho-dynamics. In fact distinctively intensive denudation dynamics on the slopes of the full formations are typical for tropical karst. The fractures are activated from the notches formed everywhere in Ha Long Bay. These have developed in the tide variation area at the base of the full karst formations as a result of lime dissolution and have cut up to several meters deep into the limestone. From time to time pieces of this suspended stone break-off resulting in the characteristic steepness of the slopes. As a matter of principle, these notches formed by dissolution are present not only in the full karst formations surrounded by the sea but are also present at the base of many terrestrial karst towers.



Photo 5: Foot caves and notches

The influence of the sea water on the morpho-dynamics of the karst formation is shown by the dissolution of the notches as well as by the formation of so-called foot caves. These are present in Ha Long Bay, particularly in the area of the Ho Ba Ham Islands as well as at other points – here usually in less spectacular form (*Photo 5*). Their development is also assumed to be associated with the phenomenon of mixing corrosion, whereby the conjuncture of clevis water resulting from precipitation from the inside of the limestone hills and the sea water releases additional dissolution forces which are capable of creating hollow cavities – some of which can even be navigated with boats.

In the caves themselves as well as at individual points in the outer area on the slopes of the full karst formation; sintered shapes can be recognized, some forming mighty stalactites. Such exterior stalactites, as shown in *Photo 6*, attest to high limestone turnover; lime dissolution and lime precipitation are located close to one another spatially. In comparison to the karst formations in Phang Nga Bay in southern Thailand, these visible precipitation processes in the form of exterior stalactites in Ha Long Bay are, however, not

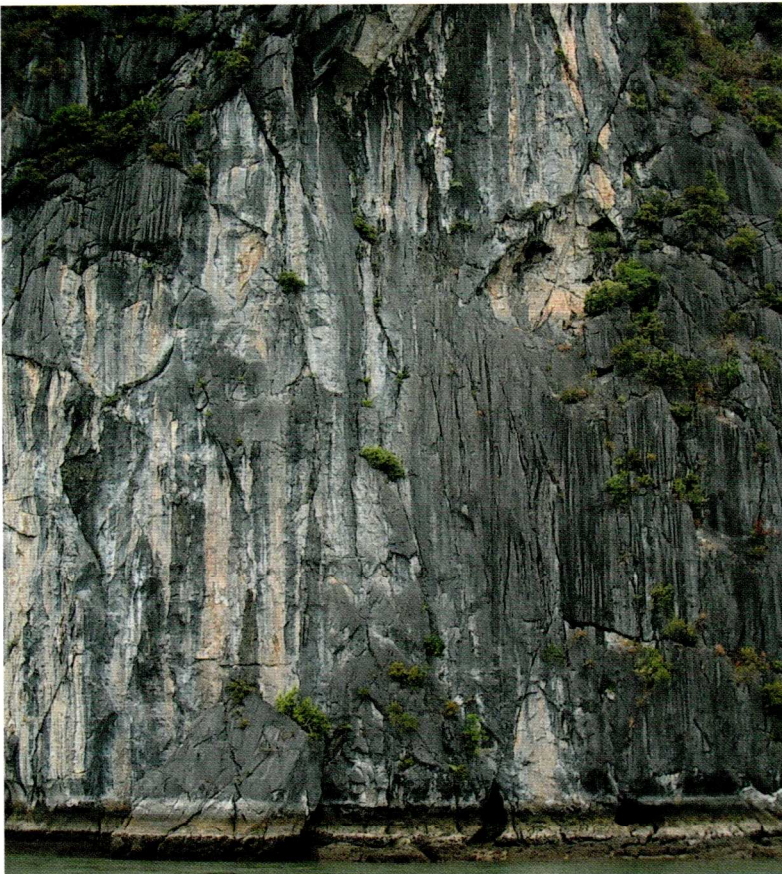


Photo 4: "Rillenkarrn" and fresh fracture zones



Photo 6: Exterior stalactites

very prevalent – an indication that the lime exchange and dissolution intensity decreases in proportion to the distance from the Equator (Mark 1991).

Ha Long Bay as tourist magnet

Hardly any other type of landscape provides as much tourist potential as tropical karsts. In this sense it is highly significant as an economic factor (Mark 1997, Vorlaufer 2005). Since Vietnam opened up its gates to tourist traffic in the beginning of the 1990s, Ha Long Bay is one of the most popular tourist attractions in the country. In 1994 UNESCO declared a major portion of Ha Long Bay to be a part of the world natural heritage thereby significantly increasing its international popularity.

According to figures from the tourist office in Quang Ninh, more than 315,000 tourists visited Ha Long Bay during the first quarter of 2006. The number of visitors has been increasing continuously for years. Typically tourists remain at Ha Long Bay for one to two days. However the provincial government in Quang Ninh has been making increasing efforts during the past two years to improve the infrastructural prerequisites for longer stays. Numerous hotels in the luxury category have been erected in Ha Long city; resorts with artificially constructed sandy beaches also offer a vacation atmosphere for families with children.

The “Ha Long Bay Beach Vacation Adventure” usually provides tourists with boat tours lasting several hours to several days (Photo 7), concentrating on the center core area of Ha Long Bay. Presently boats are available for simultaneous transport of approximately 5,000 tourists.

Tourists not only experience Ha Long Bay with its breathtaking wealth of karst formations as a natural wonder but also as a habitat for humans – a special settlement area in beautiful surroundings which have always demanded a great deal from the residents (Photo 8). Approximately 1,600 people live here in houseboats, go to school and engage in commerce. However here as in other tourist areas, life styles change quickly: Fishing, the original source of income, is becoming less and less important, losing ground to other economic occupational opportunities offered by tourism in the Ha Long Bay karst. ■



Photo 7: Tourist boats at the entrance of Sung Sot Cave



Photo 8: A “swimming village”

Dedication

This essay is dedicated to my venerated mentor, Professor Dr. Herbert Liedtke, University of Bochum/Germany, on the occasion of his 80th birthday.

References

- Liedtke, H. 1962: Eisrand und Karstpoljen am Westrand der Lukavica-hochfläche (Westmontenegro). *Erdkunde* 16, pp. 289–298
- Mark, H. 1991: Karststudien in Thailand. Paderborn (Bochumer Geographische Arbeiten 54)
- Mark, H. 1997: Die Bedeutung tropischer Karstlandschaften für den Tourismus. *Geowissenschaften* 15 (12), pp. 408–412
- Mark, H. 2005: Karstmorphologie – eine Einführung. *Geographische Rundschau* 57 (6), pp. 4–10
- Vorlaufer, K. 2005: Karst und Tourismus. *Geographische Rundschau* 57 (6), pp. 34–43
- Waltham, T. 2005: Karst and Caves of Ha Long Bay. *Speleogenesis and Evolution of Karst Aquifers* 3 (2), pp. 1–9

Author

Dr. Harald Mark
 MSP Dr. Mark, Dr. Schewe & Partner GmbH,
 Hasenwinkeler Straße 139, 44879 Bochum /
 GERMANY
 mark@msp-bochum.de