| International Journal of Speleology | 47 (3) | 393-405 | Tampa, FL (USA) | September 2018 |
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International Journal of Speleology

Official Journal of Union Internationale de Spéléologie

# Merging the concepts of pseudokarst and paleoseismicity in Sweden: A unified theory on the formation of fractures, fracture caves, and angular block heaps

Nils-Axel Mörner[1] and Rabbe Sjöberg[2]

[1]Paleogeofysics & Geodynamics, Stockholm, Sweden
[2]Obbola, Umeå, Sweden

**Abstract:** Sweden has thousands of caves cut into the bedrock, two thirds of which occur in the crystalline bedrock, and hence represent pseudokarst phenomena. The formation of these caves can only be understood in terms of paleoseismics. In this paper, we review the parallel evolution of the concept of pseudokarst caves and of the concept of paleoseismic activity in Sweden, and combine both concepts into a unified theory on the formation of fractures, fracture caves and angular block heaps.

**Keywords:** pseudokarst, fracture caves, block caves, paleoseismics, methane venting tectonics

*Received 21 August 2018; Revised 5 October 2017; Accepted 7 October 2018*

**Citation:** Mörner N.-A. and Sjöberg R., 2018. Merging the concepts of pseudokarst and paleoseismicity in Sweden: A a unified theory on the formation of fractures, fracture caves, and angular block heaps. International Journal of Speleology, 47 (3), 393-405. Tampa, FL (USA) ISSN 0392-6672 https://doi.org/10.5038/1827-806X.47.3.2225

## INTRODUCTION

The Swedish Speleological Society has a database including 2871 classified caves (SSF, 2018). Out of those, 410 (14.3%) refer to true karst caves, 309 (10.8%) refer to shore caves (including "tunnel caves"), and the vast majority of sites (1919 or 66.8%) refer to block and fracture caves. This is an effect of the fact that Swedish bedrock predominantly consists of crystalline bedrock, especially gneisses and granites. The word "pseudokarst" has a somewhat unclear definition. It implies, however, that it is not a question of dissolutional weathering, but coastal erosion (shore caves), bedrock fracturing (the cave formation of which has been termed quite differently; viz.: granite caves, bedrock caves, boulder caves, block caves, block heaps, etc) and scree deposits.

In this paper we review the evolution of observing, documenting and understanding such pseudokarst caves and scree accumulations in Sweden. Previous standard references were by Sjöberg (1994a, b), Mörner (2003) and Mörner & Sjöberg (2011).

The Swedish speleological society (Sveriges Speleolog-Förbund, SSF) was formed in 1966 by Leander Tell. It issues a journal named "*Grottan*" (The Cave), has a publication series named "*Svenska Grottor*" (Swedish Caves) and a database "*Grottdatabasen*" (SSF, 2018). In 2007, SSF hosted the Baltic Speleological Congress on the Island of Gotland (Gustafsson, 2007), and in 2011, it hosted the *Second International Conference on Granite Caves* (Mörner & Sjöberg, 2011).

Figure 1 shows the distribution of caves registered in the SSF database (SSF, 2018). Table 1 gives the distribution of numbers and lengths of pseudokarst caves in Sweden: the majority are less than 25 m long and the longest 2,633 m long. The lengths of the 10 longest pseudokarst caves are given in Table 2.

Fracture caves and block caves are formed by tectonic processes and typically consist of fracture patterns and angular blocks with sharp edges, as illustrated in Fig. 2. Tunnel caves (Sjöberg, 1986a, 1990) are formed by littoral erosion as illustrated in Fig. 3.

Leander Tell is regarded as the "Father of Swedish Speleology" with a benchmark book (Tell, 1955), followed by other books (Tell, 1962, 1969) and a number of cave catalogues (Tell, 1963, 1966, 1970, 1974).

Caves have, of course, been observed far back in history. In the early 17th century, King Karl XI was carried up to a shore cave hanging in the mountainside at 120 m a.s.l. in Ångermanland (Fig. 4), where the rate of uplift has been at its maximum. During his travel to Lapland, Carl von Linné visited this cave and several other caves along the Bothnian coast (Linnaeus, 1732). Caves were often hiding places for robbers and malicious people. In pre-historic times, however, they seem to have been avoided for mythological reasons, rather than used for habitation

*morner@pog.nu

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