

Marble caves and self-declared paradigms

With interest, we have read Trevor Faulkner's article in the September *NSS News* (Faulkner, 2009). We know Faulkner as an extremely persistent explorer of caves in the southern part of the county of Nordland, Norway, throughout 38 years. This is an area where few caves were known beforehand. In his expansive style, Faulkner has chosen a study area of 40,000 km², making a huge contribution to the knowledge of Norwegian caves and to the national cave databases.

The origin and development of caves in the glaciated Norwegian landscapes have been studied by a large number of scientists and gifted amateurs since the end of the 19th century. Ideas have evolved in accordance with current knowledge of glacial processes, structural geology and general speleogenetic models.

The study of caves in Nordland yields a picture of great morphological diversity. Some caves can be proven to have developed entirely by ice-contact speleogenesis along glacial sheeting fractures (Lauritzen, 1986). Radiometric dating of speleothems and sediments gives ages in excess of 750,000 yrs, demonstrating that many caves have survived most of the Upper Pleistocene (Lauritzen, 1996). In one phreatic network, which is dominated by exfoliation sheets, three contrasting phreatic/paragenetic regimes were identified by morphometric studies (Lauritzen, 1982). Another cave system, which displays complex sequences of deep phreatic loops and isolated vadose canyons (Holbye, 1983) shows evidence that drainage was rearranged in pace with the gradual accentuation of a nearby glacial break-through valley (Holbye, *manuscript in prep.*). Reports from cave diving in Nordland demonstrate that phreatic and paragenetic development continues during the present interglacial conditions. Such conduits may be left dry and hanging by future glacial incision of valley floors. Tectonic settings are also diverse; structural analysis identified both unloading (sheeting) and regional fractures related to plate tectonism as guiding caves in marble. Sheeting, schist horizons and intrusive veins create a compartmental karst where geologic structure and erosion controls the maximum depth of karstification (Solbakk, 2006).

It is not surprising that a glacial cycle offers a whole range of speleogenetic opportunities, from phreatic expansion, vadose downcutting, infilling and wash-out to paragenetic incision, and also stagnation. There is evidence that tubes and canyons have been completely filled with sediments for unknown intervals, introducing the uncertainty of speleogenetic hiatuses. We acknowledge that there are numerous geomorphologic switches at work during one glacial cycle, and that the resulting morphology differs from area to area. Speleogenesis does not obey one strict rule.

Interestingly, the caves of southern Nordland may appear generally shallower and morphologically simpler than their counterparts further north. However, although Faulkner (2005) points out the scarcity of relict vadose passages in his study area, we have observed and mapped numerous complex cave systems there. It would be interesting to test if there are real morphological contrasts between different regions of Norway. Disappointingly, Faulkner offers very little in this respect. Instead, he proposes a speleogenetic model that ignores the general morphogenetic complexity. He claims that most of the present-day caves were formed during the last glacial cycle, that their guiding fractures originate by a deglacial, seismotectonic process, and that the main phreatic expansion was controlled by ice-dammed lakes during deglaciation. This is a situation that represents less than 1 % of the duration of a glacial cycle. He does not give a real answer as to what happened during the remaining 99 % of the time.

Part of a scientific process is to forward different views and hold these up against existing physical evidence. Although we disagree with his theory and not least in the interpretation of the examples used, we encourage Faulkner to continue his study, and to dive into some obvious problems related to his model. What we really think, and what motivated us to present our reaction, is that the title of his article is unjustified. A general explanation of speleogenesis that cannot even be applied to all major caves in Nordland is by no means a "new paradigm". We regard our own contributions towards a complete understanding of Norwegian caves as exploratory, and we include Faulkner's exploration in that company. Being genuinely devoted to the understanding of karst caves in Norway, we trust this discussion to go on in forums other than the *NSS News*.

With regards,

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