

## Tilbake til Bryggfjelldalen

### Bryggfjelldalen revisited

**Regional description.** The valley of Bryggfjelldal and its stream Bjuråga drain an area northwest of Okstind in south Nordland (Figure 1). Geologically, the region is part of the Rødingsfjell Nappe Complex of the Scandinavian Caledonides that contains medium to high grade metamorphic rocks of Cambrian – Silurian age. The region contains several caves in folded marbles (Figure 1). Bryggfjelldal is one of the largest and deepest glaciated valleys in central Scandinavia, being 5000m wide and 800m deep. A Caves have been found in the four sub-areas of Ytterlia, Næverskard, Bjuråga and middle Røssåga. The Scandinavian cave system that is much deeper than any other south of Rana is Ytterlihullet, which has a depth of 180m and a length of 700m (Heap, 1975). The UTM coordinates provided are to WGS84 (blue grid). All dimensions are in metres. A=Altitude, L=Length, VR=Vertical Range.

**Historical introduction.** The first caving expedition to this region was led by David Heap in 1974 (Heap, 1975, pp9-11). His party explored the east side of Bryggfjelldal (Figure 2). The author's first visits were in 1997 and 2000, whilst gathering data for his research project (Faulkner, 2005). The new cave at Næverskard was one of the objectives of a 2004 mini expedition that comprised Trevor Faulkner, Nigel Graham and Adrian Scott. We visited the Næverskardhullet entrance chamber on 17 July. The exploration and survey of Næverskardhullet was finally completed with a stronger team of Trevor Faulkner, Nigel Graham, Alan Marshall and Buck White on 21/22 August 2006.

**Cave Descriptions.** Bryggfjeldhullet (B). The unnamed stream flows south from a catchment area of c. 1km<sup>2</sup> and sinks along the bases of several gorges until just c. 2 litres/0.5m<sup>3</sup>s<sup>-1</sup> is left to flow into this canyon entrance (Figures 3 and 4). Ytterlihullet (Storhola, Y). Heap (1975) described this cave as a typical "Yorkshire pothole": it has a turbulent noisy stream that drops down eight shafts that require ladder or rope to descend (Figure 5). The upper Jordåga flows from a catchment area of c. 0.4km<sup>2</sup> at a discharge of 0.2/0.7m<sup>3</sup>s<sup>-1</sup> and plunges as a waterfall into the cave (Figure 6).

**Ytterlia hydrology and speleogenesis:** Faulkner (2005) deduced that during the Eemian interglacial, the Jordåga sank at the long doline southwest of the present Ytterlihullet entrance (Figure 2). Following erosional changes caused by the Weichselian glaciation, the present sink was established upstream. Both the now-abandoned Inlet Passage and Upper Stream Passage have vadose entrenchments of c. 4m. Because vadose passages in other caves in central Scandinavia rarely reach heights of 5m (Faulkner, 2005), the greater vertical extent of c. 10m of the Lower Stream Passage is probably the result of vadose flows during both the Eemian and the Holocene interglacials, coupled with paragenetic enlargement during the Weichselian deglaciation.

Additionally, according to White (1990, p170), karst waterfalls erode headward at a maximum rate of c. 1.2mma<sup>-1</sup>. Hence, waterfalls that were active for all 10ka of the Holocene have potentially eroded backwards for distances up to 12m. Headward erosion has commonly occurred over distances from 2–10m in central Scandinavia, agreeing with a Holocene timescale. However, some waterfalls in Ytterlihullet exhibit 14m of movement, indicating that some of the vadose erosion occurred prior to the Holocene. This provides supporting evidence that Ytterlihullet was active during the Eemian.

**Bjuråga area.** The marble outcrop above Ytterlia splits into several limbs that cross the large stream Bjuråga and lead south to Grønfjell (Figure 1). The descriptions of the caves in this area (Figure 7) are taken almost verbatim from Sutcliffe (1985, 67-68).

**Næverskard Sink.** A tributary of Bjuråga that flows northwest from Tverrfjellet sinks near the valley shoulder at the head of Bryggfjelldal. A nearly vertical fracture is visible above the entrance (Figure 8) and the passage has formed between layers of mica schist that are seen in the roof and floor (Figure 9).

**Næverskardhullet.** The water from Næverskard Sink flows from this resurgence at the head of a waterfall (Figure 10). The entrance gives a magnificent view out over Bryggfjelldal (Figure 11). The larger size of the Entrance Passage may indicate that it was enlarged at the surface of an ice-dammed lake (IDL) during deglaciation (Faulkner, 2005). The whole system has formed at a Valley Shoulder cave location, which Faulkner (2005) showed is very favourable for the formation of tectonic inception fractures along and orthogonal to stratigraphical discontinuities during deglacial seismicity (e.g. Figure 8).

**Kniksengrotta.** The next stream north of Næverskard sinks near this cave, which can be followed north along a sinuous rift and small tube towards the cliff edge as far as a fallen block (Figure 12).

**Stabbfors Jettegrytene.** The area near the first power plant tunnel exit is reached via a footpath from the hairpin bend on route 806 west of Stabbfordsdalen. A tourist display case (Figure 13) discusses 20-30 local jettegryter. The largest of these marble jettegryter has a diameter of 6-7m and can be descended to -12.5m. It has an open neotectonic fracture that must have formed by deglacial seismicity after the top of the shaft was formed (Figure 14).

**Remnant Cave.** 230m north, but on the west bank and 3m above Røssåga, this cave consists of cleanwashed phreatic tubes and shattered chambers that are sandwiched between an amphibolite roof and a 0.5m-thick horizontal band of shattered amphibolite at floor level (Figure 15). The cave has been heavily eroded by Weichselian glaciation, which it must therefore pre-date, from the evidence of the de-walling of its entrances (Figure 16).

**Further discussion.** Most of the described caves are formed in Low Angle Karst, with dips of foliation  $\leq 30^\circ$ . They

commonly exhibit sub-horizontal aquicludes of mica schist or amphibolite at roof and / or floor level that clearly guide passage morphology and influenced cave inception and development. The theory of tectonic inception (Faulkner, 2006) proposes that passage enlargement occurs along near-surface inception fractures created by deglacial earthquakes that are commonly parallel to, or orthogonal to, the foliation of the marble. For these caves, the tectonic openings seem to have formed preferentially at the contact between the marble and the aquiclude.

All parts of the streamway in Ytterlihullet are  $\leq 93\text{m}$  below the surface (Figure 5). Thus, this system and most other active caves in central Scandinavia act in harmony with local hydrology and have an intimate, epigean, association with their local landscape. Hence, it seems safe to assume that these caves evolved in association with, and at a similar time to, their local topography, which was governed by the cycle of glaciation and deglaciation that has been repeated many times since the late Tertiary. Ytterlihullet achieves its exceptional maximum 93m distance from the surface because it follows this low angle foliation, in accordance with the finding that cave vertical range in central Scandinavia is commonly inversely proportional to the dip of the foliation (Faulkner, 2007). Nevertheless, the inception fractures formed along the amphibolite layers still remain within the maximum one-eighth ratio of subsurface cave distance to depth of local glaciated valley that was found to constrain deglacial seismicity and cave development in Caledonide marbles (Faulkner, 2007).

Faulkner (2005) estimated that the deglacial icesheet surface lowered at a rate of c.  $0.5\text{ma}^{-1}$ . Thus, because Ytterlihullet is 180m deep, it must have remained partially blocked at its resurgence by a Bryggfjellidal valley glacier for several hundred years after its sink entrances emerged above the level of the local deglacial ice-dammed lake. It could therefore have remained completely flooded for some of this time.