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Grottenes utvikling

The development of caves

The article is an outline of a comprehensive model for non-network cave development in metamorphic marbles with general applications. It is based on the work of Ford (1971) together with own observation and definitions.

Major cave passages are described as developing through the stages of (1) Integration, the moment when groundwater starts moving; (2) Selection, as a simple system of flow channels evolve from a multitude of joints; (3) Trunk flow conduit development, when the channels are able to swallow a considerable part of surface drainage; and (4) the final stage, after the main flow has ceased.

Integration is described as an event bearing close relationship to the rapid deepening of glacial valleys. Many large north Norwegian cave systems are found where steeply dipping marbles are exposed in valley sides.

Selection involves many controlling factors. In our environment one would expect joint plane miniature tubes to be more common than anastomoses.

Trunk flow conduit development commonly starts up in the phreatic zone. But the increasing conductivity of the conduit causes water levels to drop gradually. In this way vadose feeder trunk flow conduits may form near the sinks. Further downstream, the conduit undulates in a series of phreatic loops towards the resurgence. Falling water levels will eventually encourage vadose downcutting from loop tops. (Perched) Water tables of the individual loops now appear as stacked in a staircase fashion along the trunk flow conduit.

Downcutting occurs between the passpoint (overflow point) of one loop, and the introduction point of the next. (Passpoint is a Norwegian term for the over flow from a glacial lake) Alternating phreatic/vadose segments are thought to be typical for much of a trunk flow conduits active lifetime. A fossil conduit may still yield evidence of water level successions and it is essential to identify such inner controlling mechanisms before suggesting external base level control.

The gradual change in pressure conditions around a trunk may encourage renewed selection resulting in a superseding phase of trunk flow conduit development. Several phases may form, the younger below the older even if no change in water input or resurgence level occurs. Renewed selection between neighbouring loops may produce adjustment passages, yielding a still more graded long profile along the trunk.

The Final Stage can be summarised with an example of well-known processes: Sedimentation - Wash-out of fill - Vadose modification - Abandoning - Mineral deposition - Collapse - Denudation. They appear in no fixed order, and some may be repeated.

Segments of an old trunk flow conduit may be adopted by a new phase through inheritance. Large tubes may result, or, if the water level drops sufficiently, a keyhole profile.

In north Norway, such inheritance appears to be more common close to the outlet than up towards the sinks; trunk flow conduits of different phases link up gradually towards the resurgence. A strict external base level control would probably have produced the opposite. This underlines the importance of inner mechanisms giving the impulse to new trunk phases, by lowering water tables in loops producing renewed selection.

The level of the outlet from a trunk flow conduit may be determined largely in the early stages of selection. Thus the evolving trunk would reflect the external base level at the time of early selection, rather than the contemporaneous landscape. The trunk flow conduit will be belated in development compared to the landscape, and in north Norwegian caves this could give a hanging effect, pronounced.by the rapid surface lowering in glacial/inter-glacial times.

The model of development outlined here gives principles for reconstructing the chronology of multiphase caves in steeply dipping marbles, and it could certainly be revised to fit other environments than those known from northern Norway.