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Dissolution of calcite in glacial water; evidence of inhibition and consequences for subglacial speleogenesis.

S.-E. Lauritzen
Department of Earth Science, Univeristy of Bergen. Norway (stein.lauritzen@geo.uib.no)

Subglacial speleogenesis (i.e. formation of caves by ice-contact underneath or along glaciers) is an important speleogenetic modus that have taken place in many previously glaciated areas. It is however controversial how efficient this process is when compared to speleogenesis under non-glacial conditions: Can caves be formed from 'scratch' – from a pristine, microscopic fracture (speleogenesis sensu stricto) - or is this process more intensive under non-glacial conditions, so that ice-contact water can only widen pre-existing conduits (speleogenesis sensu lato)? Subglacial waters are low in CO_2 and close to zero degrees. A critical parameter for transforming a fracture into a cave is the breakthrough time, tB, which is the time from commencement of flow until undersaturated water can flow freely through the full length of the flowpath. The breathrough effect (i.e. when radial widening accelerates) is dependent on the switching concentration, Cs, which drops dramatically with low CO_2 in the system. Apart from the initial aperture and length of the percolation paths through the rock mass, two additional factors are important for tB: 1) the concentration of glacial rock flour and 2) its ability to interfer with the carbonate chemistry. A series of thermostated dissolution experiments using marble and various additions of authentic glacier silt and crushed metamorphic rocks demonstrate and support theoretical considerations that subglacial speleogenesis in low CO_2 waters is slower than first anticipated. The sensu stricto mechanism is also severely hampered by the clogging effect of glacial silt, whilst the sensu lato mechanism is sluggish because corrosion of the large specific area of silt particles consumes aggressiveness thus slowing first-order rates when the water comes in contact with the karst surface. Also, for the same reason, Cs may be exceeded before the water enters karst, so that breakthrough may be totally suppressed. Interglacial waters seem > 50 times more efficient at creating caves than subglacial waters.

It is therefore likely, that "subglacial caves", as described by Horn (1947) most probably developed from tight fractures and evolved to hydraulically efficient caves under interglacial conditions before being subsequently overprinted by subglacial processes.