

## **The nature of annual lamination in flowstones from non-karstic fractures, Vinschgau (northern Italy)**

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The Vinschgau is an inneralpine valley in the Southern Alps. The region is built up by metamorphic rocks characterised by a high degree of tectonic deformation. Although karst is not known in the Vinschgau, calcite and calcite-aragonite flowstones are deposited from supersaturated groundwater along the South-facing mountain slope as a result of strong evaporation (Spötl et al. 2002).

Flowstone precipitation is strongly connected to fracture openings created by deep-seated gravitational slope deformations. The carbonate-depositing springs are part of an extended groundwater system controlled by the geometry of the deep-seated gravitational slope deformation. Although the mean residence time of the groundwater is up to several decades (Spötl et al. 2002), a few flowstones show macroscopically visible laminae whose annual origin is confirmed by U-Th dating.

These laminae are composed of a darker and a lighter sublamina forming couplets whose thickness ranges from 0.2 to 2 mm. In thin section, the darker sublaminae show a higher abundance of opaque particles, whereas the light ones are inclusion-poor. Strong epifluorescence confirms the organic origin of these dark inclusions. The crystal fabric, dominated by the fascicular-optic type, shows no change across lamina boundaries.

Laminated calcite shows  $\delta^{18}\text{O}$  oscillations with an amplitude of up to 1.4 permil. These oscillations are also present in unlaminated calcite, albeit at much smaller amplitude.  $\delta^{13}\text{C}$  lacks such a regular pattern in laminated samples, and only shows small variations which do not correlate with  $\delta^{18}\text{O}$  in a consistent way. Changes in  $\delta^{13}\text{C}$  show smaller amplitudes than  $\delta^{18}\text{O}$ . The extent of correlation between petrographic laminae and the stable isotopes varies both in time and space. During the late Younger Dryas darker sublaminae mostly coincide with  $\delta^{18}\text{O}$  lows, whereas in the Mid-Holocene they usually correlate with isotope highs.

These data reflect the high degree of heterogeneity of such fracture zones in deep-seated gravitational slope deformations. The annual signal is still preserved by the  $\delta^{18}\text{O}$  values, but the development of laminae varies both in space and time.

Spötl, C., Unterwurzacher, M., Mangini, A., Longstaffe, F.J., 2002: Carbonate speleothems in the dry, inneralpine Vinschgau Valley, northernmost Italy: Witnesses of changes in climate and hydrology since the Last Glacial Maximum. *Journal of Sedimentary Research*, 72, 793–808.