Geophysical Research Abstracts
Vol. 17, EGU2015-3068, 2015
EGU General Assembly 2015

The role of crystal structure and fabrics in early diagenesis: examples from continental and marine settings

Silvia Frisia (1), Andrea Borsato (1), Petra Bajo (2), and John Hellstrom (2)

(1) School of Environmental and Life Science, University of Newcastle, Callaghan 2308, NSW, Australia. (silvia.frisia@newcastle.edu.au), (2) School of Earth Sciences, University of Melbourne, Parkville 3010 Victoria, Australia.

Palaeoclimate research based on geological archives relies on the assumption that the system has remained closed to phase transformation and re-mobilization of chemical species, the extent of which depends on the crystallization pathways. Early diagenesis, in fact, encompasses processes that occur soon after deposition, from a few hours to centuries.

In the last decade, speleothems-based palaeoclimate research has gained momentum. Speleothems (cave secondary mineral deposits) have provided geochemical records of climate, pollution, volcanism, land use and vegetation changes at seasonal to millennial scale for the past million year. Critically, the accuracy of their records relies on the absence of diagenetic modifications. Yet, contrary to late diagenetic dissolution and re-precipitation, early diagenesis is difficult to detect in stalagmites and flowstones.

A striking example is a Holocene stalagmite from Corchia cave, whose fabrics appear compact and of primary origin. Nevertheless, U-Th dating by mass spectrometry of 5 out of 47 samples shows offset from neighboring samples of up to 40%. Careful petrographic observations reveal that elongated columnar fabric contains microstructural defects, expressed by irregular crystal boundaries, which allow for the percolation of diagenetic fluids and U loss.

Speleothem allow for the precise dating of diagenetic processes. Aggradation of micrite into microsparite may occur in less than a hundred year. Similar aggrading neomorphism of micrite has been documented for subglacial carbonates, where aggradation occurred at secular scale. Aggradation can be fingerprinted by the stable isotope ratio values, commonly more positive than in the columnar fabrics.

In speleothems, aragonite may be transformed into calcite in less than 100 years. The phase transformation may partially preserve the original fabric, and appears to commence from calcite nucleated on organic compounds at twin boundaries, taking advantage of crystal defects as previously documented in marine facies. In speleothems, the process comes to a halt if the flow of the diagenetic fluid stops, which commonly happens when a new “impermeable” layer is formed atop the partially replaced aragonite. Yet, if dripwaters are allowed to percolate through crystal boundaries, the aragonite below can be completely replaced by a mosaic of calcite and geochemical properties re-set. Preservation of the original fabric, or part of it, is then influenced by both the “exhaustion” of the diagenetic fluid and the presence of organic carbon surfaces.

Speleothem diagenetic pathways are not dissimilar to what occurs in the marine environment. Primary and early diagenetic dolomites seem to be preserved in some Triassic sabkha facies, being “protected” by clay or organic layers. In other “early diagenetic dolomites”, such as the case of the Early Pliocene makatea reef terraces (Cook Islands, South Pacific), original, highly porous facies were replaced by a mosaic of fabric-destructive dolomite with a few relicts of organic-rich micrite.

Thus, original fabric and porosity, crystal defects, crystal boundaries and presence of organic matter in carbonates dictate the diagenetic pathways, while the composition of the diagenetic fluids and the duration of the diagenetic process control the extent of geochemical re-setting of the system.