Cave stalagmites provide new clues to Australian climate

Cave stalagmites promise to fill a critical knowledge gap in how Australia's rainfall has changed over past centuries, supplementing the 100-year instrumental record with hundreds to potentially tens of thousands of years of rainfall data. These data will assist water management in Australia through improved mapping and modelling of past and future rainfall patterns.

Unlike other palaeoclimate records, such as tree rings or marine sediments, speleothems – cave stalagmites and stalactites – are well preserved and can potentially be precisely dated via uranium-thorium dating, allowing scientists to pinpoint changes in rainfall. Speleothems also record the ^{14}C 'bomb pulse'[1] from atomic tests in the 1950s and 60s, providing another useful age reference.

Speleothem research has gained pace in Australia since about 2002, as analytical technologies improved. Stalagmites are the cave formation of choice because of their simple stratigraphy (layering). When calcium-rich water drips from the cave roof, regular layers of calcite are deposited on the cave floor, and progressively build up over time.

Stalagmites provide information on the cycle of wet and dry, rather than the actual amount of rain. This information will extend records of El Niño events, but also longer-phase climate phenomena such as the Pacific Decadal Oscillation. Fast-growing stalagmites can provide seasonal records (due to thicker banding), while slow-growing ones can have an annual or two-to-three-year resolution.

Scientists from the Australian Nuclear Science and Technology Organisation (ANSTO) and the University of Newcastle are focussing their research efforts on cave stalagmites from Western Australia and New South Wales that contain rainfall records dating back 700–1000 years. Collaborative and independent research in both states will assist Perth- and Sydney-based water management authorities and is supported by the Sydney Catchment Authority, Indian Ocean Climate Initiative, Water Corporation (WA), Department of Environment and Conservation (WA) and the Department of Environment and Climate Change (NSW).

According to ANSTO palaeoclimatologist Dr Pauline Treble, south-west Western Australia is an ideal site for stalagmite research as it has a Mediterranean-type climate with distinctly wet winters and dry summers. This seasonality produces clear seasonal responses in the chemistry of water seeping into caves. A 10–20 per cent decrease in rainfall across the region since the 1960s is also clearly recorded in the stalagmites, providing a reference point for testing geochemical rainfall proxies.

Dr Pauline Treble (left) and a field assistant inspect the fragile stalagmites of Golgotha Cave, south-west Western Australia. Paul Rustomji

Information is extracted from actively growing stalagmites using a range of proxies that respond to rainfall changes in measurable ways. Among the most reliable are $\delta^{18}O$ – the change in the ratio of the rare oxygen isotope ^{18}O compared to the more abundant ^{16}O – and the trace element magnesium. Other trace elements such as phosphorous, strontium and barium are also used, but are affected by additional geological or hydrological processes that can complicate their measurement.

'Generally, magnesium increases under dry conditions and decreases in wet conditions,' Dr Treble says.

The $\delta^{18}O$, in contrast, provides detailed information on the intensity and duration of rainfall and the origins of the air masses from which the rain fell.

'The ratio of ^{18}O to ^{16}O is affected by evaporation, air temperature, humidity and distillation,' Dr Treble says.

'More intense and long duration rainfall events tend to be depleted in ^{18}O. However, moisture originating at different latitudes, as a result of large-scale changes in atmospheric circulation, also has different ^{18}O signatures.'

These region-specific variables affecting both trace elements and $\delta^{18}O$ mean that stalagmites provide fairly localised rainfall information.

'But by looking at several sites across southern Australia we will eventually be able to piece together more of the puzzle relating to large-scale atmospheric circulation patterns,' Dr Treble says.

'For now though, our focus is on providing modellers with extended rainfall records that will assist the management of Perth and Sydney water resources.'

● **Wendy Pyper**

More information:
Treble PC, Fairchild IJ and Fischer MJ (2008) Understanding climate proxies in southwest Australian speleothems. *PAGES News* **16**(3), 17–19.

1 Marked variation in the uranium-thorium levels coincide with the bomb testing period.