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Daily growth and tidal rhythms resolved in modern and Miocene giant clams via ultra-high resolution LA-ICPMS analysis and image processing

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Giant clams (*Tridacna spp.)* are particularly attractive sclerochronological archives owing to their rapid shell growth rates, longevity and resultant exceptional shell size and thickness. The occurrence of a well-visible seasonal banding pattern within the aragonite shell of *Tridacna spp.* is well-known and has been investigated by numerous studies to reconstruct (past)environmental conditions[1,2,3]. Less-utilized is the fact that the bivalve secretes its shell daily, recorded as microscopically visible daily growth increments in the shell structure[4,5]. Thus, environmental changes - reflected as variations in the shell's geochemical inventory - are continuously recorded in chronological order and at extremely high temporal resolution (possibly even hourly).

To resolve daily compositional variability in giant clams using LA-ICPMS, we use an adjustable rotating rectangular laser aperture (spot size on target: 4 x 50 μm) of our RESOlution M-50 (193 nm ArF) with Laurin two-volume sample cell[6]. We performed continuous path ablation at very slow profiling speed ($\leq$1.5 μm/s) via careful alignment of the rectangular slit parallel to visible daily growth increments in thin sections. ICPMS total sweep times were kept short ($\leq$ 350 ms) by analysing maximal 5 isotopes simultaneously.

Our initial results showcase that compositional cyclicity at the $\sim$15 μm scale is easily resolvable. In our investigated modern and Miocene ($\sim$9 Ma) giant clam shells[3], striking co-variation of Mg/Ca, Sr/Ca, B/Ca (and Ba/Ca) is discernible, yet also tantalizingly, sub-daily shifts between these element/Ca ratios can be observed. These results expand upon earlier NanoSIMS work by Sano et al (2012)[5], who report diurnal variations in Sr/Ca, which they link to the daily light cycle. Our initial results of a year-long, ultra-high resolution Miocene record show that a $\sim$15-day periodicity exists superimposed on the observed daily growth cyclicity, corroborating the 14-day periodicity in the sclerochronological pattern of a *Tridacna squamosa* shell linked to tidal rhythms[7].

The geochemical records are complemented using image processing analysis. Preliminary results reveal that elemental composition varies with pixel intensity, resulting in consistent measurements of increment widths obtained from both LA-ICPMS daily resolved profiles and high resolution microscope images.

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[3] Warter et al., 2015. Palaios, 30, 66-82.

[4] Aharon and Chappell, 1986. Palaeo-3, 56, 337-379.

[5] Sano et al., 2012. Nature Communications, 3, doi: 10.1038/NCOMMS1763.

[6] Müller et al., 2009. JAAS, 24, 209-214.

[7] Pannella and MacClintock, 1968. In: Macurda, D.B., Jr., paleobiological aspects of growth and development: A Symposium. Paleontological Society Memoir, 2, 64-80.