MOLECULAR EVIDENCE FOR A MICROBIAL ROLE IN MODERN OOID FORMATION AND IMPLICATIONS FOR THEIR OCCURRENCE AND MEANING IN THE GEOLOGICAL RECORD.
S.S. O'Reilly[1], V. Klepac-Ceraj[2], A.R. Winter[2], T. Bosak[1], F. McDermott[3], R.E. Summons[1], [1]Massachusetts Institute of Technology (Department of Earth, Atmospheric and Planetary Sciences, Cambridge, MA, 02139, USA. oreillys@mit,edu), [2]Wellesley College (Department of Biological Sciences, Wellesley, MA, 02482, USA), [3]University College Dublin (Department of Geological Sciences, Belfield, Dublin 4, Ireland).

Ooids are small, concentrically laminated carbonate grains, typically limited to shallow tropical coastal settings in modern environments (e.g. Bahamas, Persian Gulf). However, they are common in the geological record, particularly in the Precambrian[1] and after mass extinction events[2]. Despite their geological significance and much interest, controversy remains about processes that form and shape ooids. Numerous abiotic and biotic formation models have been proposed. Abiotic models typically favour precipitation in suspension in supersaturated, agitated water. However, they fail to account for the high organic matter content of ooids. Indeed the sources of this organic matter [3], and microbial diversity associated with ooids [4] has received little attention until recently. Without an understanding of how modern ooids form, our understanding of their significance in the rock record and how ooids can inform us about major events in Earth's history remains limited.

In this study, modern Bahamian ooids were sampled along a transect at Cat Island, from the high-energy surf zone, to low-energy waters 150 m offshore. Ooid morphology changes with the location, whereby in the surf zone ooids are shiny and rounded, while offshore ooids are dull, coated in organic matter, and eventually become cemented into composite grains called grapestones. A 'conveyor-belt' hypothesis for ooid formation at Cat Island has been proposed [5], whereby ooids accrete just offshore away from the surf zone, but are cyclically transported to and from the surf zone, where they are abraded and rounded. Eventually ooids reach a size threshold and drop out of the 'conveyor-belt' to become grapestones.

Using lipid biomarkers and 16S rRNA phylogenetic analysis to characterize microbial communities and organic matter associated with ooids, we sought to test the following hypotheses: 1) changes in the microbial community composition along the transect reflect changes in processes that form ooids; 2) if abiotic precipitation in suspension was the formation mechanism, then lipids associated with the external ooid surfaces should reflect lipid distributions within the cortex, and 3) if the conveyor-belt model operates instead, the lipid distributions in the inner ooid cortex should be similar between the high- and low-energy zones.

Extract masses from outer surfaces were much lower in the surf zone, reflecting the high-energy abrasive conditions. Variation in biomarker profiles and 16S rRNA taxa were also apparent. Acidomicrobiales, Rhodothermaceae, Flammeovirgaceae, and *Desulfococcus* sp. were abundant at the surf zone, while Alphaproteobacteria, unclassified Deltaproteobacteria, *Inquilinus* sp., and eukaryotes were more abundant offshore. Cyanobacteria changed from Xenococcaceae in the surf zone to Pseudanabaenaceae offshore. Bacterial fatty acids, bacteriohopanepolyols and glycerol dialkyl glycerol tetratethers were abundant, while algal sterols and polyunsaturated fatty acids were much higher offshore. The distributions of lipids bound within the inner cortex, released by acid dissolution were very similar along this transect, but exhibited markedly different composition to surface lipids. Bound lipids lacked algal sterols and fatty acids and there was an increased prominence of bacterial biomarkers. Compound specific stable carbon isotope analysis confirmed that bound fatty acids were from a distinct source compared to those from the ooid surface. Lipid profiles were remarkably similar to those recently reported in ooids from other diverse settings [3].

Changes in alkalinity due to cyanobacterial photosynthesis and sulphate reduction may facilitate benthic ooid precipitation offshore, while fatty acid binding to Ca^{2+} sites may provide nucleation sites for further carbonate precipitation. These findings indicate that a common bacterial community is involved in ooid formation. The similarity in bound lipid profiles in the surf zone and offshore support the 'conveyor belt' model that ooids accrete in the presence of microbial mats offshore. These results have implications for ooid formation in both modern and ancient environments. Further work may reveal biomarkers for past microbial communities and environmental conditions associated with ooids in the geological record.

References

[1] Sumner D.Y. and Grotzinger J.P. (1993) *J. Sed. Petrol.* 63, 974–982 [2] Li F. et al. (2015) *Earth-Sci. Rev. in press* [3] Summons R.E. et al. (2013) *Geobiology* 11, 420–436 [4] Edgcomb V.P. et al. (2013) *Geobiology* 11, 234–251 [5] Mariotti G. et al. *under review*.