Anaerobic biodegradation of isoprenoid biomarkers

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Isoprenoid hydrocarbons contribute up to 30% by mass of crude oil deposits and include nearly all of the biomarker compounds used in paleoenvironmental and paleoecological reconstructions of earth history. The branched isoprenoid pristane was degraded by a denitrifying microcosm [1] and a methanogenic, sulphate reducing enrichment [2], but no information about the phylogeny or biochemistry of this process has been reported. Here we describe pristane biodegradation and accompanying loss of nitrate in an activated sludge enrichment. Nitrate consumption accounts for loss of ~ 5% of the initial pristane added in 181 days.

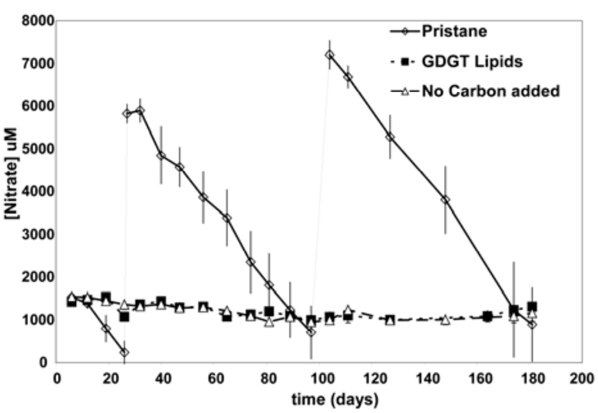

Figure 1: Nitrate disappearance in microbial enrichments containing pristane as a sole carbon source.

We followed the evolution of the enrichment community using 16S rDNA clone libraries and fluorescence *in situ* hybridization (FISH). Later generation cultures had lower diversity and a greater percentage of clones related to denitrifying β-proteobacteria. Consistent with changes observed in clone libraries, FISH experiments showed an increase in cells hybridizing with a probe specific for Betaproteobacteria (BET42a) in later generation cultures. The enrichment degrades pristane and archaeal diether lipids, but not tetraethers. Experiments in progress are designed to establish reaction stoichiometries and to monitor intermediates that may yield insight into the degradation pathway. These data will have implications for the fate of biomarkers in modern anoxic environments and in geologic reservoirs

[1] Bregnard *et al.* (1997) *Appl. Environ. Microbiol*. **63**, 2077-2081. [2] Grossi *et al.* (2000) *Org. Geochem*. **31**, 769-772.

The role of volatiles during asteroidal differentiation

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Achondrite meteorites GRA 06128/9 establish that hitherto unrecognised differentiated and evolved asteroidal crust formed early in Solar System history. GRA 06128/9 have ‘andesitic’ bulk compositions and are predominantly composed of Na-rich feldspar [1]. GRA 06128/9 also have similar $\Delta^{17}O$ values to olivine-rich brachinite meteorites that, in combination with brachinite petrology, suggests a genetic- or process-related association with these rocks, allowing possible elucidation of differentiation mechanisms in small rocky bodies during the earliest stages of planet formation.

Evidence for an origin by partial melting of volatile-rich source regions comes in various guises. First, brachinites and GRA 06128/9 have highly siderophile element abundances within a factor of 2-3 of chondrites and near-chondritic $^{187}Os/^{188}Os$, implying a lack of metal-silicate equilibration in a chondritic parent body. Second, rare-earth element data for the meteorites are consistent with ~20-30% partial melting, and with melting experiments performed on chondritic materials [2]. Third, evidence for volatile retention comes from the elevated abundances of K, Na, S, Rb, Cl and Pb in GRA 06128/9.

Combined, these data support the model of a GRA-brachinite parent body that accreted with a significant volatile component and within which wholesale melting and differentiation did not occur, at least for some portions of the parent body. This evolutionary scenario contrasts with known mechanisms of differentiation in volatile-poor bodies such as the Moon, or asteroidal parent bodies of reduced meteorites such as the HED suite or angrites. Results for GRA 06128/9 require partially differentiated and volatile-rich asteroids in the asteroid belt. Furthermore, the evolved composition of the GRA 06128/9 meteorites provides the first natural data to support earlier experimental studies suggesting that felsic asteroidal crust can be generated by partial melting of a volatile-rich chondritic source [2]. These observations may have relevance for understanding potentially evolved crustal compositions on terrestrial planets and asteroids that have not witnessed plate tectonics, and for remotely recognising volatile-rich source regions on such bodies.

[1] Day *et al*. (2009) *Nature* **457**, 179-182; [2] Feldstein *et al.* (2001) *Meteor. Planet. Sci*. **36**, 1421-1441.