

**DISCRIMINATING ISOTOPICALLY DISTINCTIVE ORGANIC MATTER SOURCE INPUTS THROUGH THE EDIACARAN SHURAM CARBON ISOTOPIC EXCURSION USING COMPOUND-SPECIFIC CARBON ISOTOPE ANALYSIS.** C. Lee<sup>1</sup>, G. D. Love<sup>1</sup>, W. W. Fischer<sup>2</sup>, J. P. Grotzinger<sup>2</sup>, G. P. Halverson<sup>3</sup>. <sup>1</sup>UC Riverside (900 University Avenue, Riverside, California 92521), <sup>2</sup>California Institute of Technology (1200 East California Boulevard, Pasadena, California 91125), <sup>3</sup>McGill University (3450 University Street, Montreal Quebec, Canada H3A OE8).

Ediacaran (*ca.* 635-541 Ma) marine carbonates capture a global  $\delta^{13}\text{C}$  carbon isotope excursion to extremely negative values (*ca.* -12‰), known as the ‘Shuram excursion’ that cannot be readily explained by conventional carbon isotope mass balance scenarios [1].

Most studies examining paired (carbonate-organic) carbon isotope records from Ediacaran sections that capture the Shuram excursion, produced organic carbon isotope data from bulk sedimentary organic matter and/or samples with low TOC content. The eastern flank of the South Oman Salt Basin contains extremely thermally well-preserved molecular fossils e.g. [2].

Compound-specific carbon isotope analyses (CSIA) lend isotopic insights at the molecular level, providing details about the range of biological source organisms and metabolic processes contributing to bulk  $\delta^{13}\text{C}_{\text{org}}$  values as the carbon isotopic signature conferred on the hydrocarbon skeleton lipids during synthesis is retained on geological timescales. Furthermore, the carbon isotopic variation of bulk organic matter does not directly parallel the changes observed in carbonate carbon through the excursion, suggesting that sedimentary organic matter contains a mixture of biological sources and a substantial proportion of these did not utilise dissolved inorganic carbon in the photic zone of the water column.

Here we present results from detailed compound-specific carbon isotopic analyses of hydrocarbon fractions from organic-rich syngenetic marine facies capturing the build-up, onset, nadir, and recovery of the Shuram excursion in sedimentary strata from a well drilled in the South Oman Salt Basin [3]. Compound-specific carbon isotopic analysis of the major extractable hydrocarbons reveals extremely low  $\delta^{13}\text{C}$  values of extractable long-chain ( $>\text{C}_{20}$ ) *n*-alkanes and mid-chain monomethylalkanes (MMAs) as low as -40‰. This constitutes the first record of very  $^{13}\text{C}$ -depleted organic matter deposited during the peak of the Shuram Excursion.

Such light signatures are rare in marine rocks and provide compelling organic evidence for the idea that

the Shuram excursion reflects primary (and major) carbon cycle perturbation. These organic phases define an excursion magnitude smaller overall than that observed in inorganic carbon—a phase that can be altered by post-depositional processes. Consequently, organic data imply that the primary perturbation to dissolved inorganic carbon (DIC) was at least *ca.* 5‰, and more likely from 7-12‰ in magnitude, accounting for mixed sourcing.

Due to isotopic differences in stratigraphic patterns of the different organic compound series—up to 8‰ during the Shuram excursion—we speculate that the bulk organic carbon (including bitumen and kerogen) may reflect source mixing between two isotopically distinct pools of organic carbon that previously masked the existence of the  $^{13}\text{C}$ -depleted organics from bulk  $\delta^{13}\text{C}_{\text{org}}$  measurements. We propose that marine autotrophs (algae and bacteria) consuming  $^{13}\text{C}$ -depleted DIC made the major source contribution to the  $^{13}\text{C}$ -depleted organic pool while the  $^{13}\text{C}$ -enriched pool was dominated by heterotrophic source inputs fuelled by organic substrates derived from degradation of sub-surface petroleum seeping into the ocean system. The source rocks for these petroleum fluids were likely organic-rich strata deposited significantly prior to the Shuram excursion—which reached oil-window maturity during the deposition of the Shuram Formation. A significant contribution of a more  $^{13}\text{C}$ -enriched pool of organic matter, possibly reflecting heterotrophic microbial biomass and associated DOM fuelled by sub-surface petroleum seepage sourced from underlying formations, buffered the measured  $\delta^{13}\text{C}_{\text{org}}$  and accounts for the well recognised and long-lived global decoupling of inorganic and bulk organic carbon isotopic signatures during the peak of the Shuram excursion.

## References

- [1] Grotzinger, J. P. et al., (2011) *Nature Geoscience* 4, 285-292. [2] Love, G. D. et al., (2008) *Paleontological Society Papers* 14. [3] Lee, C. et al., (2013). *Geobiology* 11(5), 406-419.