Near equilibrium methanogenic carbonate formation in Krishna-Godavari Basin, Bay of Bengal inferred from clumped isotopes.

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Globally, cold-seep carbonates are associated with gas hydrate deposits along continental margins. Previous studies have shown the strong influence of site conditions on cold-seep carbonate formation[1,2]. Here, we investigate cold seep carbonates from the Krishna-Godavari Basin in Bay of Bengal[3,4], to unravel their equilibrium formation conditions. We carried out $\delta^{13}C$, $\delta^{18}O$, and Δ_{47} measurements of the stratigraphically-controlled carbonates. The samples showed highly negative $\delta^{13}C$ excursion (-27 to -52 ‰, VPDB) and higher $\delta^{18}O$ values (3 to 5 ‰, VPDB), indicative of methane-related origin. Present day bottom water temperature at the site of carbonate synthesis was used to define the true clumped isotope values. The $\Delta_{47offset}$ values, (-0.10 to 0.05 ‰) indicate near equilibrium formation of the carbonates under prevailing conditions. We attribute the authigenic carbonate formation in the upper 20 mbsf to anaerobic oxidation of methane. Below this depth, $\Delta_{47offset}$ is more positive, and somewhat correlate with higher $\delta^{13}C$ and lower $\delta^{18}O$ values. Porewater chemistry (Ca, Mg, Sr, Cl^-, DIC and $\delta^{13}C_{DIC}$)[5] suggests mixing of resident HCO_3^- with external DIC pools. Alternatively, porewater SO_4, NH_4 and TOC potentially suggests the role of microbially-driven oxidation of organic matter. We attempt further to correlate our findings with global sea level changes and also assess the merits of using clumped isotopes as an exploration tool for gas hydrate deposits.

[1]Zhang et al. (2019), *EPSL.* [2]Loyd et al. (2016), *Nat Comm.* [3] Mazumdar et al. (2009), *GGG.* [4]Kocherla et al. (2015), *Mar Pet Geo.* [5]Solomon et al. (2014), *Mar Pet Geo.*