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Time-integrated variations of microbial processes archived in authigenic carbonates at methane seeps by lipid biomarkers and their compound-specific carbon isotopes

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Authigenic carbonate rocks are common at marine methane seeps and are extraordinary archives of microbial processes. Lipid biomarkers (e.g., membrane lipids) of the microbes thriving at methane seeps can be preserved in the carbonate matrix of rocks that are up to 400 million years in age. The key process taking place at seeps is the anaerobic oxidation of methane (AOM), which is performed by methane-oxidizing archaea and sulphate-reducing bacteria. One peculiarity of AOM is that the involved microbes bear extreme negative $\delta^{13}C$ values in their lipids, which is due to the incorporation of isotopically-depleted, methane-derived carbon. The characteristic lipid biomarker signatures and their isotopic fingerprints vary from site to site, changing with different environmental conditions. Seepage activity and the dynamics of seepage also commonly change over time at one specific site. Most modern seeps are in the deep-sea, where only snapshots of the actual conditions at a distinct time can be monitored. In contrast, authigenic carbonates store processes, which were dominant at any time and occurred over longer time periods. We will present results from two sub-recent, well-studied sites from the Gulf of Mexico: Mississippi Canyon (MC), Alaminos Canyon (AC). At both sites methane seepage occured at least since the last deglacial. All studied seep carbonates contained lipid biomarkers of microbes involved in AOM, but also other processes were preserved, as for example methane production in the shallow subsurface at MC and aerobic methane oxidation in an otherwise anoxic environment at AC.