Biogenic Gas Systems in the Qaidam Basin, NW China

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Large quantities of biogenic gas were accumulated in the Quaternary section of the Qaidam Basin, NW China, with proven gas reserves of 7.9 Tcf. The gases are dominated by methane (>95%), with δ13C1 values in the range from -65 to -68‰. Major source rocks are lean lacustrine shales with average TOCs of around 0.5%. Gas reservoirs, with burial depths generally less than 1900m, are Lower Pleistocene unconsolidated siltstones and muddy siltstones which form carrier beds within the petroleum system. Formation water circulation and early formed syn-depositional anticlines play an important role in the maintenance of the dynamic charge-leak biogenic gas accumulations. Although considerable work has been done, little is understood about the biogenic gas origin and accumulations. Gas compositions, microorganism community, source rock geochemistry, and petrophysical mudstone permeability assessments were thoroughly investigated to identify source rocks and to assess the rate of gas charge and leaking.

Headspace gas profiles suggest that both CO_2 reduction and acetate fermentation occur in the studied area with CO_2 reduction dominating. Microbial community analysis shows that both bacteria and archaea are abundant and viable. Specific biomarkers used to diagnose methanogenesis activity from archaea are well correlated to laboratory simulated gas yields and indicates biogenic gas is mainly derived from processing of lacustrine material rather than land plant detritus. Rock-Eval S1/S2 ratios from a specially designed heating program provide reliable proxies for kerogen reactivity assessment. TOC levels as low as 0.3% in large volumes of mudstone support significant methanogenic activity in the studied area at optimal microbial activity temperature while siltstone carrier beds focus gas to commercial quantities. Gas column heights are controlled by the competence of overlying local seals which are poor seals holding <2 m column of gas before capillary failure. Gas accumulation is a dynamic process, suggesting both charge and leaking are actively going on. Some gas chimneys found on the high-resolution seismic images provide supplemental evidence of dynamic migration and accumulation. The study indicates that with appropriate internal migration routes even lean shale packages can be commercial gas prospects.