Paleo-methane emission events in Krishna-Godavari basin, Bay of Bengal: Geochemical signatures

ANINDA MAZUMDAR

Gas Hydrate Research Group, Geological Oceanography,National Institute of Oceanography, Goa - 403004, India

Marine cold seep associated authigenic carbonates are known from modern and past geological records. Cold seeps are characterized by expulsion of fluid enriched in methane, hydrogen sulfide, and bicarbonate from the seafloor that results in the precipitation of calcium carbonates and pyrite at or below the sediment-water interface, often associated with a proliferation of chemosynthetic communities. Cold seeps are known to be associated with methane hydrate deposits. Methane hydrate, a crystalline, ice-like form of methane and water (molar ratio 1:6) exists within the marine sediments at suitable temperature-pressure conditions [1]. In the Krishna-Godavari (K-G) Basin (Bay of Bengal), seismic data show the regional presence of gas hydrates manifested in the form of a bottom simulating reflector (BSR). BSRs represent a phase boundary where low-velocity gas-charged sediments occur below the hydrate stability zone. Recent drilling and logging activities on-board JOIDES Resolution in the Indian margin under the aegis of Indian National Gas Hydrate Program (NGHP) have confirmed the existence of massive gas hydrate deposits in the K-G Basin [2]. Extensive fault and fracture zones in K-G basin sediments are apparently responsible for the advective transportation (focussed flow) of methane rich fluid from the base of gas hydrate stability (BGHSZ) to the sediment water interface. The sharp perturbation in sulfate, sulfide and bicarbonate concentrations at the sediment -water interface is attributed to the anaerobic oxidation of methane (AOM) performed by a syntrophic consortium of CH_4-oxidizing archaea and sulfate-reducing bacteria [3]. Here we report repeated evidence of such methane expulsion events in K-G basin in the quaternary period. Highly ^{12}C enriched authigenic carbonates in the form of chimneys, massive crusts, chemosynthetic clams and other faulnal records indicate cold seep events[3]. Destabilization of deep seated methane hydrate is one possible cause for these sudden methane pulses. Shale tectonics induced fault and fracture opening and change in geothermal gradient could be one of the plaussible reson for focussed gas emission events.

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Thermal structure of the Sgurr Beag thrust, NW Scotland

S.E. MAZZA[1]*, R.D. LAW[1] AND M.J. CADDICK[1]

[1] Dept. of Geosciences, Virginia Tech, Blacksburg, VA 24061, USA (*correspondence: mazza@vt.edu)

In the Caledonides of NW Scotland, well-understood *metamorphic* temperatures (*T*m) and *deformation* temperatures (*T*d) [i.e. 1, 2] progressively increase up structural section in the Moine thrust sheet at the foreland edge of the orogenic wedge. However, the thermal history of the hinterland thrust sheets is less well-constrained [3]. This study is focuses on determining *T*d and *T*m for the Sgurr Beag thrust sheet in the hinterland of the Scottish Caledonides, to test whether potentially thrust-related inversion continues into the structurally higher thrust sheets that are penetratively deformed at higher (upper amphibolite) temperatures.

Preserved microstructures imply a wide range of possible deformation temperatures, which are quantified with the quartz c-axis fabric opening angle thermometer [4]. *T*d from quartz opening angle thermometry increases up section, ranging from 395°C to 583°C ± 50°C. This indicates that if the isothermal surfaces dip towards the hinterland, thrust-related thermal inversion continues into the Sgurr Beag nappe. This study also presents new metamorphic *P-T* constraints for the Sgurr Beag nappe, based on garnet-biotite thermometry and GASP barometry, indicating *T*m of ~620°C at 5.8 to 7.4 kbar. Together, *T*d and *T*m indicate that deformation continued past peak metamorphic conditions in the Sgurr Beag thrust sheet.

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