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Heat Flow and Gas Hydrates on the Continental Margin of India: Building on Results from NGHP Expedition 01

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Q9 report for DOE Award No. DE-NT0005669.

Heat flow and gas hydrates on the continental margin of India:

Building on results of the NGHP Expedition 01

In October 2008, graduate student Peter Kannberg and Professor Anne Trehu began working on the National Energy Technology Laboratory (NETL) funded project entitled *Heat flow and gas hydrates on the continental margin of India: Building on results from NGHP expedition 01.* This project is designed to complete analysis, interpretation and modeling of downhole temperature data that were acquired in spring 2006 at 21 sites drilled in gas hydrate-bearing sediments on the continental margin of India. In addition to finding several rich gas hydrate deposits, this expedition provided a number of important new insights into the geologic conditions leading to such deposits .

Work during this quarter (Q9) focused on revising 1-dimensional modeling of the effect of sedimentation on the temperature vs depth profile in the Andaman Sea using a new model for the sedimentation rate at drilling site 17 (J. Johnson, personal communication, December, 2010). The temperature profile at site 17 is of particular interest because the temperature gradient of 19^{o}C/km is surprisingly low, leading to a very thick region in which gas hydrate is stable. High ash concentrations in this forearc environment leads to excellent gas hydrate "habitat." We also modeled effects of sedimentation in the KG basin to see if that could explain an observed and enigmatic correlation between increasing water depth and increasing heat flow and are incorporating results from the Andaman Sea and KG basin modeling into the revision of the manuscript that was submitted to Marine Geophysical Researches in the 2nd quarter of 2010. The manuscript was returned from peer review with a request for more modeling and interpretation.

The detailed modeling effort for the Andaman Sea presented in the Q8 report was based on the sedimentation rate model in the initial cruise report (Collett et al., 2008). While discussing our work with sedimentologist K. Rose (NETL) we learned of a new, unpublished sedimentation rate model developed by J. Johnson (Un. New Hampshire). This new model, which is based on 14 data points that extend from near the seafloor to ~700 meters below seafloor (mbsf) and nearly 10 million years before present (mybp), is a dramatic improvement over the model in the initial report, which is based on only 2 data points and extends only to 108 mbsf and 2 mybp (Fig. 1). To incorporate this new information, we are recalculating some of the scenarios Q8 report and developing new scenarios. Final results will be presented in the Q10 report. Initial results suggest that the extreme sedimentation rates needed to reproduce the observations with a conductive sedimentation model are not allowable. Final results will be presented in the Q10 report.

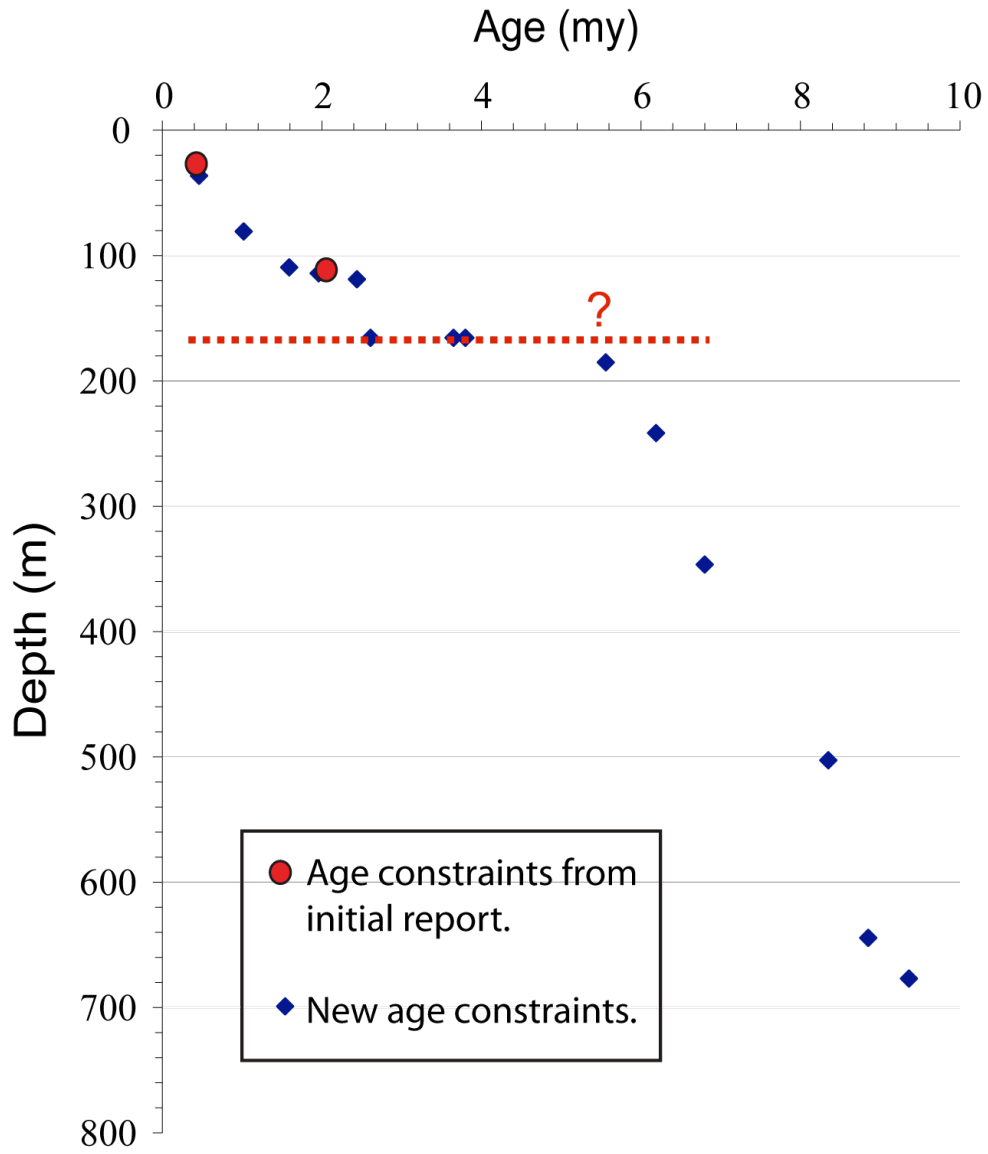

Figure 1. New age model from J. Johnson (personal communication, 2010).

For the KG basin, we explored the to degree to which spatial variations in the slope of the heat flow/water depth relationship can be explained by observed variations in local stratigraphy and structure as defined by seismic data (Fig.2). We are also comparing our models and interpretations with new results on the structure and heat flow in this region that have been published by other researchers in the past few months (e.g . Shankar et al., 2010). One dimensional, conductive heat flow models, assuming a background sedimentation rate of 25 cm/ky was used (Rao, et al. 1994), were used to see if the low heat flow in the western KG basin can be due to rapid sedimentation as sediments were trapped by a now-buried ridge. Such a model requires a sedimentation rate of 300 cm/ky to explain the low heat flow in this region (~25 mW/m^2). This is 12 times faster than sedimentation rate reported by Rao et al.

(1994). The seismic data, however, indicate that sedimentation in the center of the basin is only 2-3 times greater than on the edge, where sampling occurred – not enough to explain the data. Advective heat transport along stratigraphic horizons in the basin is probably required. Final results for this analysis will also be presented in the Q10 report.

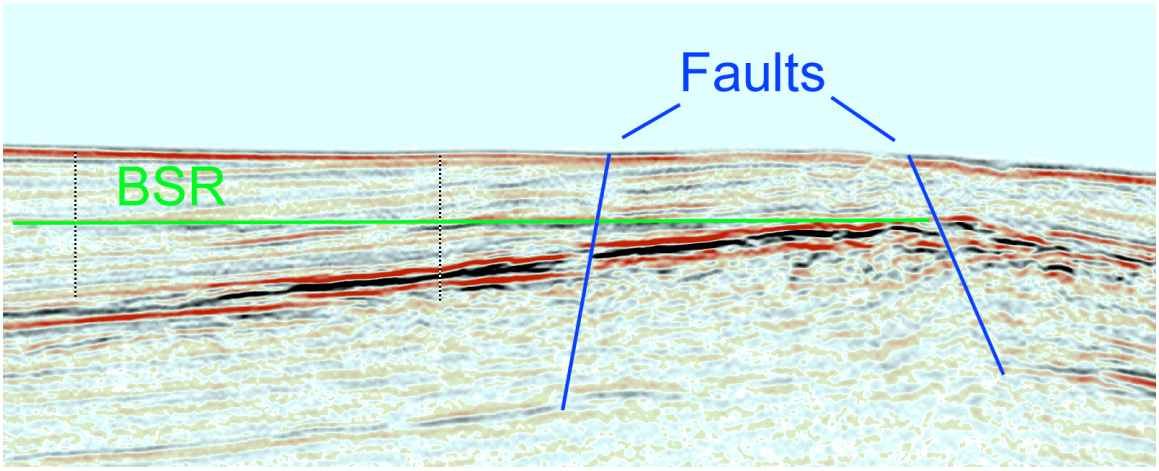

Figure 2. Seismic data illustrating the stratigraphic and structural setting of the KG Basin.

We note that Q9-Q11 are being performed under a no-cost extension. The project is supporting development of human resources for hydrate studies by supporting tuition for Kannberg to take courses leading to a Masters degree in oceanography and geophysics. Completion of this project has been delayed because Kannberg has had the opportunity to divide his time between this project and two other projects (one supported by an NSF grant to this PI and one supported by a DOE grant to another researcher). Participation in these other projects, which examine other aspects of gas hydrate dynamics and distribution, are broadening Kannberg's potential to develop into an independent hydrate researcher. By the end of the no-cost extension, we expect that Kannberg will have 2 papers in press, a third in the works, and that he will have defended his MS thesis and will be poised to take his qualifying exam to become a PhD student.

References:

Collett TS, Riedel M, Cochran J, Boswell R, Presley J, Kumar P, Sathe A, Lall M, Sibal V, and the NGHP Expedition 01 Scientists (2008), National Gas Hydrate Program Expedition 01 initial report, Dir. Gen. of Hydrocarbons, Minist. of Pet. and Nat. Gas, New Delhi.

Rao, D.P., et al. (1994) Analysis of multi-chennel seismic reflection and magnetic data along 13^{O} N latitude across the Bay of Bengal. Mar Geophys Res. 16:225-236

Shankar, U., Riedel, M., Sathe, A.V., (2010) Geothermal modeling of the gas hydrate stability zone along the Krishna Godavari Basin, Marine Geophys. Res., 31:17-28.

Table 6. Project costing profile for Budget Period 9. Budget period 9 represents work conducted during a no-cost extension of the project. Unexpended funds were available to cover work during this time period because other funds were used to support related efforts during earlier budget periods. Consequently we spent less than planned during several earlier budget periods. In particular, PI salary has been systematically undercharged since the beginning of the project. GRA salary was charged to a different project during an earlier quarter.

	October (planned)	October (actual)	November (planned)	November (actual)	December (planned)	December (actual)
PI salary & fringe benefits	0	2501.47	0	2499.23	0	246.46
GRA salary & fringe benefits	0	2312.85	0	2312.85	0	2312.85
Computer subscription	0	250	0	250	0	250
Travel and supplies	0	0	0	0	0	0
Tuition	0	3474	0	0	0	0
Indirect Costs	0	2979.15	0	2979.15	0	2979.15
Total	0	11517.47	0	8041.23	0	7948.46

PUBLICATIONS, CONFERENCE PRESENTATIONS AND OTHER PRODUCTS:

No publications, conference presentations or other products related to this project were produced during this quarter. A publication submitted to Marine Geophysical Research in June 2010 (budget period 7) was received and revisions that incorporate new results are underway.

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