Oil & Natural Gas Technology

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Quarterly Research Performance Progress Report

(Period ending 10/30/2013)

Application of Crunch-Flow Routines to Constrain Present and Past Carbon Fluxes at Gas-Hydrate Bearing Sites

Project Period: October 1, 2012 – January 31, 2014

Submitted by:

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EXECUTIVE SUMMARY

In November 2012, Oregon State University initiated the project entitled: **Application of Crunch-Flow routines to constrain present and past carbon fluxes at gas-hydrate bearing sites.** This project aims to develop a modeling module that will include all important biogeochemical processes that need to be considered in a cold seep environment. This module will be applied on several DOE-supported drilling expeditions (e.g., Cascadia margin in US, Ulleung Basin in South Korea, and K-G basin in India) to quantify the dynamics of methane at present day and in the past.

We have completed the task 2 in our original proposal focusing on quantifying paleo-methane flux through sedimentary Ba record. We extended the kinetic model that describes the full biogeochemical reactions to include the precipitation and dissolution of barite. By doing so, we simulate the Ba record in the sediments to quantify the past dynamics of methane flux in the southern Hydrate Ridge (ODP Leg204 Site1252) which may be linked to catastrophic dissociation of gas hydrate (Figure 1). We have also compared our current model with the model we developed previously. This comparison shows that the current model, which considers the full reaction network, can better constrain the methane flux that was not produced in-situ in the model frame.

PROGRESS, RESULTS, AND DISCUSSION

We have successfully extended the model to account for the precipitation/dissolution of authigenic barite. Records of authigenic barite distribution in the sediments can be used to infer the depth of SMTZ, which can be linked to the strength of methane flux in the past. The complexity behind is barite could be both authigenic and detrital origin (Figure 2). Besides, increases in methane flux could result from external sources, such as gas hydrate dissociation, or intense methanogenesis from organic matter when a layer of organic matter rich sediments is deposited (Figure 2). It is very difficult to decouple one factor from another from the records alone. In our current kinetic model, the detrital input of barite could be accounted for by assigning boundary condition of barite; this boundary condition can even be time dependent as what we have accomplished in the current model. Moreover, the effect from organic matter degradation can be teased out by matching the observed TOC profile. Methane produced through methanogenesis can shallow the SMTZ. However, as our primary model results suggest, this amount of methane is not enough to account for the observed barite records. An external source of methane is required (i.e., methane inflow from outside the model regime). Comparing with our previous model, which does not consider the full reaction network, the current model can differentiate the methane that is produced in-situ through methanogenesis or supplied externally from other sources such as gas hydrate dissociation. We are now preparing manuscript for this part of work. The following checklist summarizes our progress in this quarter:

Task	Subtasks	Status
TASK 2. Paleo-methane proxies (barite)	2.1 Set up the model framework: discretization of spatial and temporal modeling domain, setup of species (primary, secondary, gas, and minerals) considered, and thermodynamic and kinetic database entries.	done
	2.2 Integrate present day SMTZ model (Task 1) into this framework.	done

	2.3 Verify and adjust our model parameters with field observations. 2.4 Compare the results from CrunchFlow with our previous model	done done

CONCLUSION

We have extended the kinetic model that describes the full suite of biogeochemical reactions to include the precipitation and dissolution of barite. This model is now successfully applied to the sedimentary Ba record in southern Hydrate Ridge. We are able to reconstruct the history of methane flux. Our model can better differentiate the methane produced in-situ through methanogeneis from methane that was delivered externally from outside of the model regime.

COST STATUS

MILESTONE STATUS

Title: Methane fluxes in the past

Planned Date: June 1, 2013

Verification Method: Comparison with our previous model and similar models published.

Status: This milestone is achieved during this quarter.

ACCOMPLISHMENTS

A CrunchFlow modeling routine is developed and ready to be applied in other regions for the purpose of quantifying paleo methane flux through the sedimentary Ba profile. This model is the most comprehensive model to date and is expected to be highly applicable in other regions.

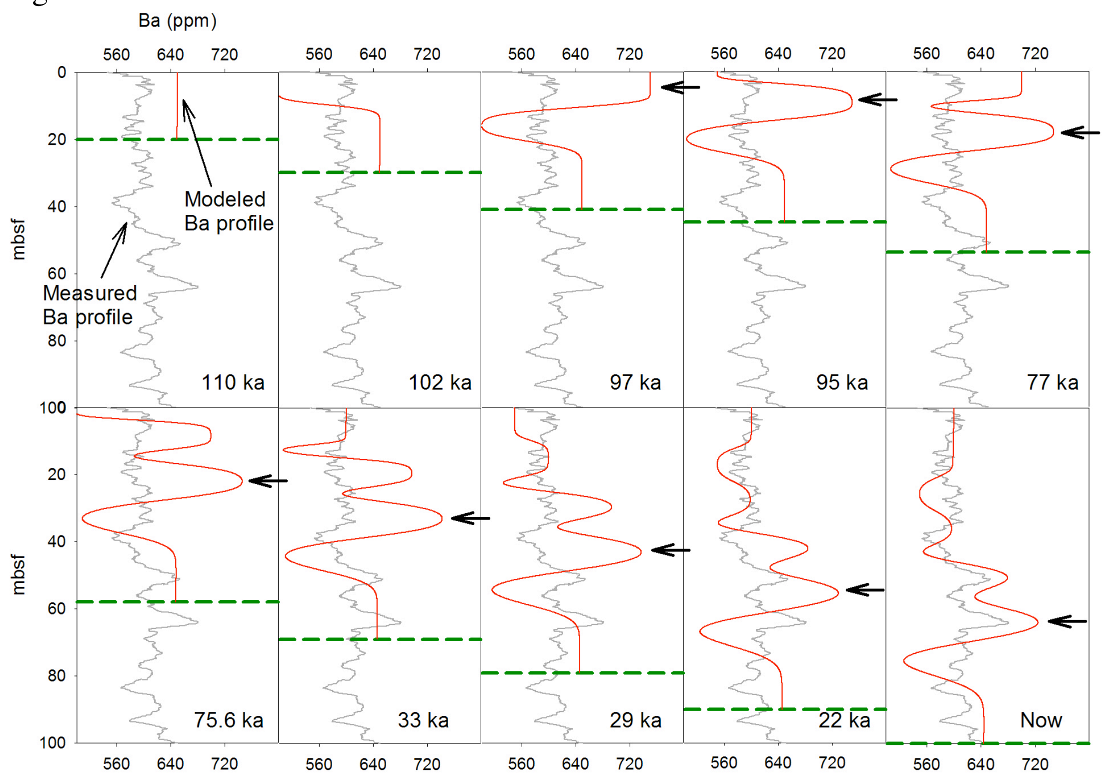
PROBLEMS OR DELAYS

None

PRODUCTS

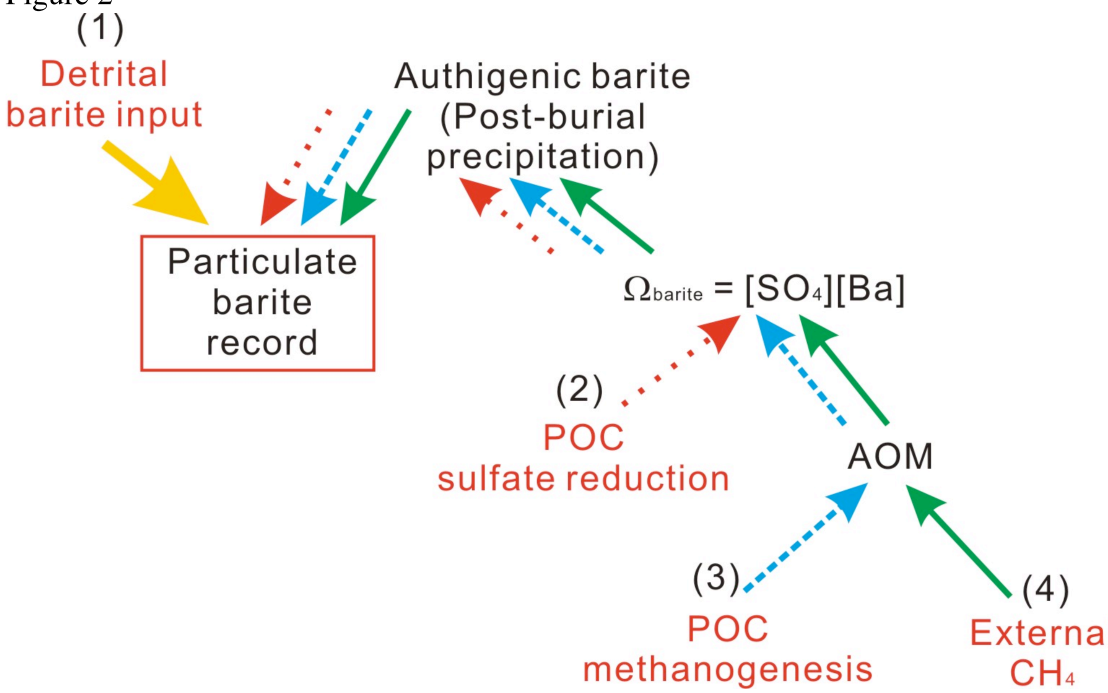
→ This progress report
→ A kinetic model that is ready applicable to other regions to quantify paleo flux of methane using the sedimentary Ba record.

Figure 1



Ba (ppm)
560
640
720
mbsf
0
20
40
60
80
100
Modeled
Ba profile
Measured
Ba profile
110 ka
102 ka
97 ka
95 ka
77 ka
75.6 ka
33 ka
29 ka
22 ka
Now

Figure 2



(1)
Detrital
barite input
Authigenic barite
(Post-burial
precipitation)
Particulate
barite
record
Ωbarite = [SO4][Ba]
(2)
POC
sulfate reduction
AOM
(3)
POC
methanogenesis
(4)
External
CH4

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