

NSF Workshop: Community Sedimentary Model for Carbonate Systems, Part II



January 26-27, 2009

Kindly Hosted by: CSDMS

Community Surface Dynamics Modeling System

Dr. James Syvitski, Director

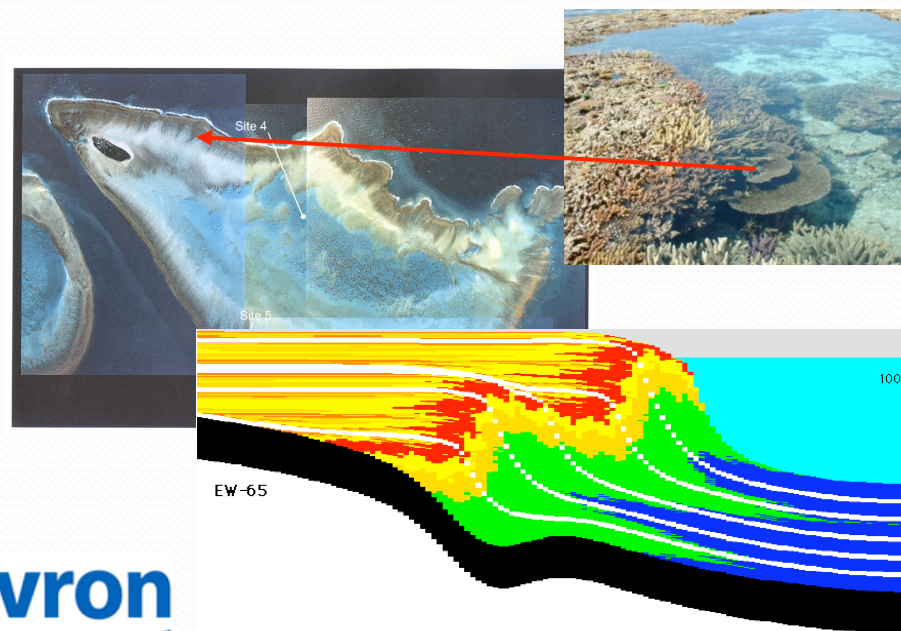
Co-conveners:

Peter Burgess, RHUL, UK

Rick Sarg, CERl, Colorado School of Mines

Gene Rankey, Univ. of Miami

Evan Franseen, Univ. of Kansas & KGS



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Review of the 2008 Meeting

NSF Workshop on Community Sedimentary Model for Carbonate Systems, Golden, CO

Date: February 27 to 29, 2008



“The purposes of the workshop were to identify grand challenges for fundamental research on ancient and recent carbonate systems, and to identify promising areas for advancing the next generation of numerical process models to enhance our ability to meaningfully and accurately model carbonate systems”, Sarg et al, 2008

Review of the 2008 Meeting

Attendees:



| | |
|----------------------------------------------|---------------------------------------------------------|
| Rick Sarg, CSM – co-convenor | Andrew Ashton, Woods Hole Oceanographic Inst. |
| Evan Franseen, Kansas GS – co-convenor | Jody Webster, James Cook Univ. / U. of California-Davis |
| Gene Rankey, Univ. of Miami – co-convenor | Pete Smart, Bristol Univ., UK |
| Dave Budd, Univ. of Colorado-Boulder | James Syvitski, Univ. of Colorado – Boulder/ CSDMS |
| Bob Demicco, Binghamton Univ. | Albert Kettner, Univ. of Colorado – Boulder / CSDMS |
| Andre Droxler, Rice Univ. | Eric Hutton, Univ. of Colorado – Boulder / CSDMS |
| Ben Gill, Univ. of California-Riverside | Shell – Peter Burgess |
| Cedric Griffiths, CSIRO, Australia | Shell – Conxita Taberner |
| Pamela Hallock-Muller, USF, St. Petersburg | ExxonMobil – Karen Love |
| Bjarte Hannisdal, U. Bergen, Norway | ConocoPhillips – Bill Morgan |
| Bill Hay, University of Colorado Museum | ConocoPhillips – Steve Bachtel |
| Jon Hill, Edinburgh, UK | Chevron – Mitch Harris |
| Linda Hinnov, Johns Hopkins Univ. | Chevron – Gareth Jones |
| Chris Kendall, Univ. of South Carolina | Chevron – Jean Hsieh |
| H. Rich Lane, NSF | Andrew Svec, CSDMS Executive Asst. |
| Timothy Lyons, Univ. of California-Riverside | Dixie Termin, CERI Program Asst. |
| Bernhard Riegl, Nova SE Univ., FL | |

Themes for fundamental research:

- Develop **next -generation** of predictive facies & platform concepts
- Focus on **main processes** e.g., biologic & chemical sediment production, transport by waves & currents
- Stress integrated study of processes, environments, basin architecture, climate, & sea Level in modern and ancient systems
- Develop minimum of two levels of **numerical models** – long-term, time averaged, & short-term event-level scale depositional processes
- Not one model, but a **suite of inter-connectable process modules** with common architecture for defining model domain and boundary & initial conditions
- **Diagenesis** will be included e.g. reactive transport modeling

Then What Happened?

Day 1

- Introduction from Rick Sarg
- Keynote presentations - James Syvitski, Gene Rankey, Dave Budd, Peter Smart, Bill Hay
- Discussion
- Definition of working groups for breakout sessions

Day 2

- Rick recaps
- Breakout sessions for working groups
- Working groups report

Day 3

- Gene recaps
- Synthesis of working group results into rough draft framework document & formulation of joint research agenda
- Workshop adjourns

Workshop Breakout Sessions

Objectives for each Breakout Group:

- 1) Current level of knowledge – qualitatively & quantitatively.
- 2) What are our grand challenges for the future?
- 3) What are our knowledge gaps? What experiments are necessary to close those gaps?
- 4) What kinds of data do we need, and who are the necessary partners?
- 5) Concise white paper summary.

Workshop Breakout Sessions

Breakout Topics:

- Physical Controls on Carbonate Deposition

- Morgan & Demicco

- Biologic Controls on Carbonate Deposition

- Webster & Hallock-Muller

- Tools & Approaches for Quantifying Controls & Improving Time Scales

- Hinnov & Droxler

- Modeling Diagenesis

- Budd & Jones

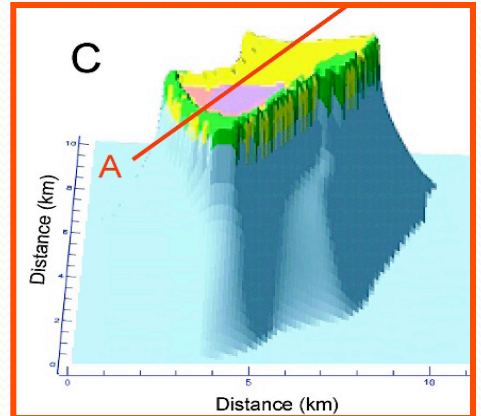
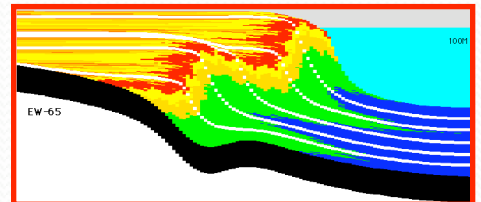
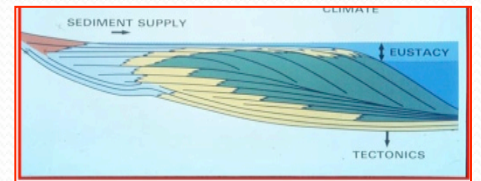
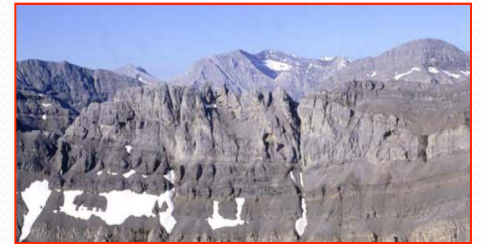
- Numerical Modeling Strategies

- Hannisdal & Griffiths

Physical Controls on Carbonate Deposition

Major knowledge gaps:

- The effects of sea level fluctuations on sediments,
- How to predict sedimentation patterns in a non-linear and complex system, as opposed to assessing sediments in a 1:1 linear relationship vs. depth;
- Processes and time scale of geomorphic and facies patterns formation
- Quotidian vs storm influence
- Models for different environments - reefs, shoals, platform interior and tidal flats
- Physical processes vs hardgrounds and benthic mats
- Phanerozoic sea water chemistry controls on facies development.



Physical Controls on Carbonate Deposition

Short-Term Goals: Achievable by assembling existing data

1. An inventory of modern platform types and depositional systems and an associated inventory (database) of physical measurements and models from these systems, leading to

- A new classification of different platform types and depositional environments
- Indication of gaps in physical measurement data that are inhibiting modeling;

2. Sensitivity analyses on ranges of parameters in existing numerical modeling to delineate physical parameters that need to be measured or better understood. E.g. “friction factor” in CARB3D⁺ - important but vague.

3. Assemble a catalog of existing numerical siliciclastic models to assess parameters these models use as input, and explore for possible overlap with carbonate cousins

Physical Controls on Carbonate Deposition

Medium-Term Goals:

1. Collecting oceanographic measurements (waves, tides, and currents) across one or two different platforms.
2. Development of preliminary “sector models” of various specific environments to provide “modular” input to a larger community model. For example, we would envision a “reef model”, one or more ooid shoal models; a tidal flat model, and a platform interior model.

Long-Term Goals:

1. A detailed coring program on one or more platforms to evaluate the platform depositional architecture, to provide information to test models.

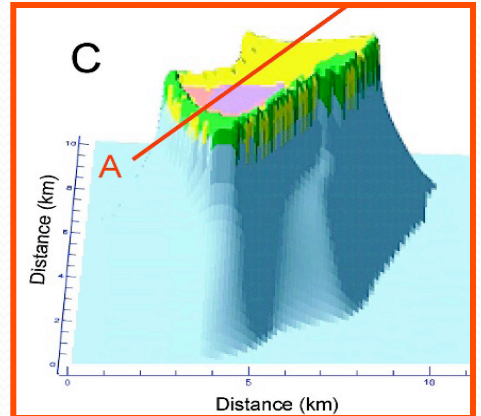
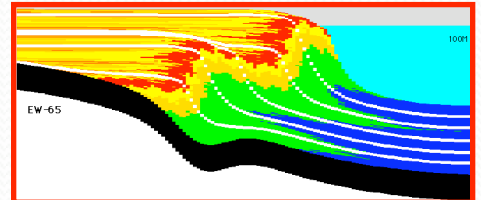
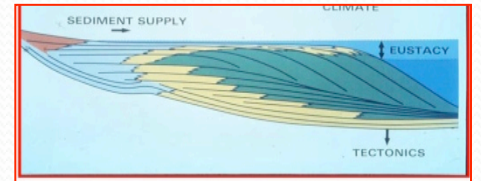
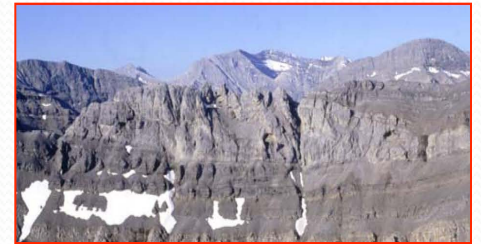
Biological Controls on Carbonate Deposition

Major knowledge gaps:

- Lack of quantitative understanding of
- The boundary conditions for hypercalcification
- Rates of production and how they relate to rates of deposition & accumulation
- Relative rates of bioerosion and physical erosion
- The nature and origins of spatial heterogeneity

Basic questions

- How do carbonate producing communities function and how does the sediment produced accumulate?
- What is the relative importance of different biota under different boundary conditions?
- how does the seascape heterogeneity translate to stratigraphic heterogeneity?
- what are the origins of lime muds?



Biological Controls on Carbonate Deposition

Short-Term Goals:

- An updated literature search of biota- and habitat- specific rates of carbonate production, accumulation, and bioerosion, including microbial contributions and interactions should provide essential information for modeling
- Identification of key experimental sites and gradients provides a necessary first step for quantifying carbonate biotic heterogeneity

Biological Controls on Carbonate Deposition

Medium-Term Goals:

- Research to constrain controls on rates and nature of calcification by key biotic groups (e.g., corals, coralline algae, calcareous green algae, larger benthic foraminifera, microbes, including cyanobacteria)
- Data to constrain seascape dynamics and patterns at targeted locations, both on the surface and stratigraphically, and across gradients

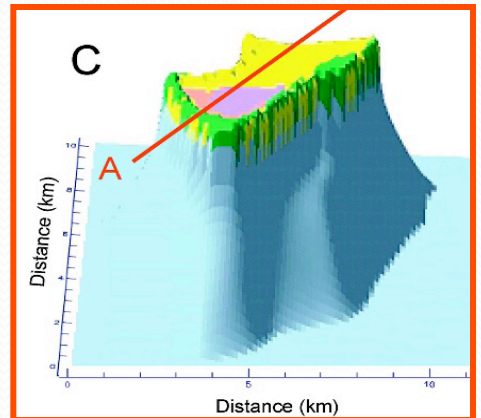
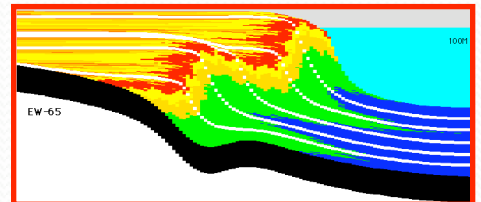
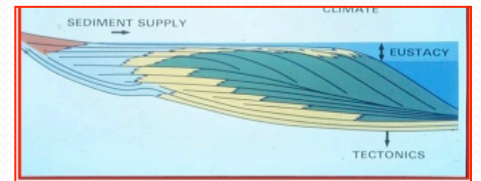
Long-Term Goals:

- A rigorous understanding of the geochemical and physical constraints on carbonate production, and its spatial heterogeneity
- Translation of this understanding into numerical models...

Diagenesis

Major knowledge gaps:

- The lack of benchmarks for the 3D rather than 1D distribution of processes and products in time and space
- Significant uncertainty in many input parameters to diagenetic models e.g. fluid chemistries, some thermodynamic and kinetic properties of carbonate minerals, and the nature of many mechanical processes.
- The possible existence and influence of thresholds in diagenetic processes, and other nonlinear feedbacks of processes, products, and geochemical attributes
- The role of biogeochemical reactions (i.e., catalysis, facilitators)
- Empirical rules associated with some key processes (esp. cementation)
- When to use transport- vs. reaction-controlled processes
- The nature of diagenetic outcomes at the full spectrum of scales, from thin section to platform-scale*



Short-Term Goals:

- Dissemination of current numerical codes to grow the user community, and to develop community libraries of validation cases.
- Develop consistent input parameters (e.g., depositional porosities), and improve most problematic of process rules.
- Test existing tools at the pore scale.
- Establish examples of 3D diagenetic processes and products in select settings to have data sets to validate numerical codes.
- Partnering with larger carbonate community.

Medium-Term Goals:

- Couple second generation diagenetic models with improved sedimentary process models.

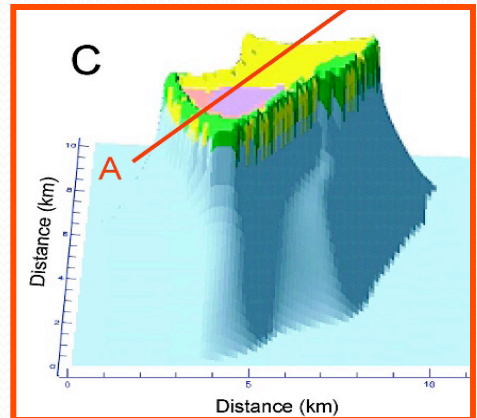
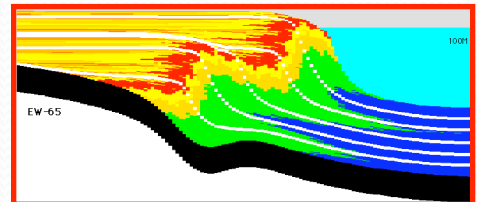
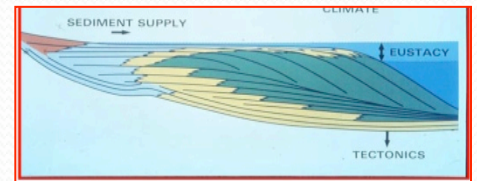
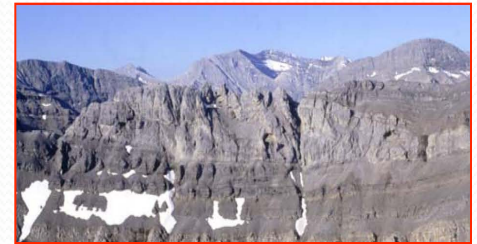
Long-Term Goals:

1. Define some long-term goals...

Numerical Modeling

Major knowledge gaps:

- 1) A lack of basic understanding of many processes
- 2) Uncertainties in scaling of processes temporally and spatially
- 3) Dearth of information on the influences of non-linearity and non-stationarity in biologic aspects of carbonate systems
- 4) Only qualitative insights on the feedbacks between different processes
- 5) Absence of understanding of the controls on heterogeneity at different scales.



Short-Term Goals:

- Assign responsibilities for the cyber-infrastructure (i.e., GUI, protocols, coupling, and visualization).
- Build a module inventory and make modules available worldwide.
- Make available 5-9 modules that could include biogenic and inorganic production, biologic ecosystems and communities, physical and biologic syndepositional processes, dissolution-reprecipitation, cementation, hydrodynamics (e.g. Delft3D, ROMS), and sediment transport (CSDMS, e.g., SedFlux, SedFloCSTMS).
- Verify modules on appropriate time scales, and establish at least one database for testing.

Medium-Term Goals:

- Involve students from geophysics, applied math, and computer science fields
- Have stage 1 modules tested and improved.
- Document modules and begin coupling with climate/ocean/siliciclastic models.
- Conduct initial sensitivity studies, and complete a comparative numerical scheme study.
- Conduct two international workshops in carbonate computational issues, and achieve “buy-in” with non-NSF funds for module development.
- Ensure high performance computing access, and activate partnerships.
- Have modules running efficiently on HPC, and have at least one useful prediction.
- Publish a series of peer reviewed papers using the workbench modules, and conduct a number of sedimentology courses in US using the carbonate workbench as a lab tool.

Long-Term Goals:

- Numerical work-bench for carbonate knowledge generation is available to the carbonate community
- Workbench prediction will be able to influence observatory systems like the Global Ocean Observatory.

Summary & Conclusions

Grand research challenges for advancing understanding of modern and ancient carbonate systems include:

- Quantitatively understanding and modeling facies heterogeneities developed over various timescales, as influenced by changing biotic, paleoceanographic, paleoclimatic, and sea level conditions;
- Understanding the appropriateness of using Holocene tropical shallow-water reefs as analogues for ancient carbonate buildups;
- Developing predictive numerical simulations of diagenetic history from the scale of the pore to the scale of the platform by incorporating and coupling sedimentation, chemical and biological alterations on the seafloor, mechanical overprints, and chemical alterations resulting from fluid flow;
- Resolving cyclostratigraphy to the 0.02-0.4 my level using high resolution biostratigraphy and absolute age dates

Summary & Conclusions

Recommendation to ID field sites for special focus:

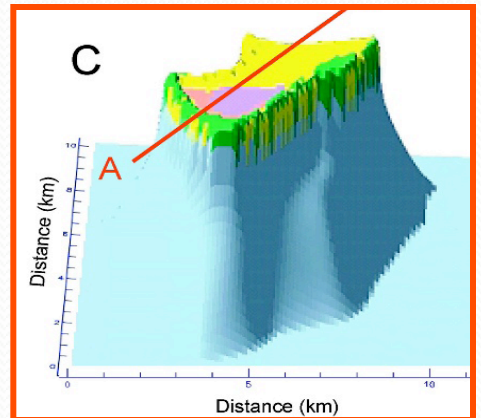
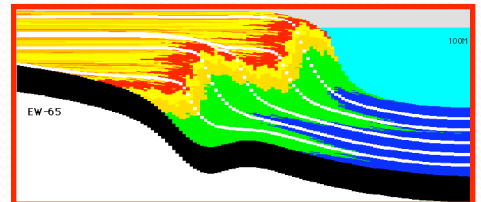
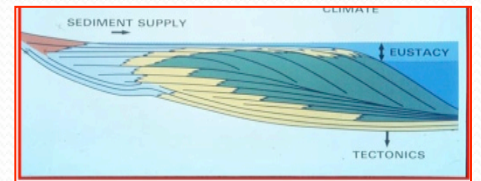
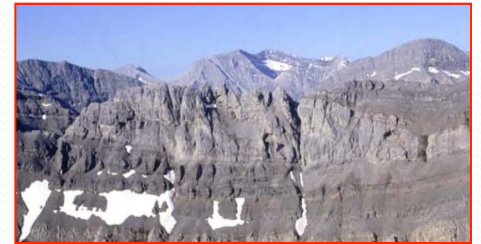
- An area with good modern to Pleistocene strata, to examine the effects of ocean conditions and climate change on carbonate sedimentation, and the evolution of sediments into beds and strata
- Important analog field areas that combine outcrop, behind outcrop access, and subsurface equivalent strata, to build a new generation of 3-D carbonate system models.

So Now What?

We create outline NSF research proposals to begin to implement these research plans

You each need to:

- Help create proposals based on the themes and suggested lines of research from the Feb 2008 meeting, plus whatever new ideas we agree on today and tomorrow
- Consider what role you can realistically fulfil and what resources you would need to do it
- Include absent colleagues who have appropriate expertise and then approach them to be co-investigators on the proposals
- Consider both pure and applied research aspects – input from industrial attendees required
- Aim to leave meeting with outline proposals in place and a clear list of actions for everybody to follow as well as an agreed timescale for completion ...



So Now What?

| | |
|------------------|--------------------------------------------------------------------------------------|
| Monday AM | |
| 09:00 | Intro - scope and purpose of the meeting |
| 09:15 | Update on CSDMS |
| 09:45 | Review of results of last meeting – recommendations etc |
| 10:15 | Coffee |
| 10:30 | Brain storming to decide broad proposal structure e.g How many? Main themes? Etc etc |
| 11:30 | Decide groups accordingly |
| 12:00 | Lunch |
| Monday PM | |
| 13:00 | Generation of outline proposal/s: |
| 16:30 | Review of progress, plans for Tuesday work |
| 17:00 | End of day one |