BIOLOGICAL CONTROLS ON CARBONATE DEPOSITION

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I. Current level of knowledge

- Modern tropical shallow-water coral reefs
  - Comparatively well known
  - Many fundamental questions remain
- Other modern carbonate systems less well known
  - Tropical meso-/oligophotic reefs/ carbonate systems
  - Cool-water carbonate systems
    - Shallow water
    - Aphotic worldwide
- Broad base of paleontological knowledge of fossil biotas
- Fundamental question – how good are tropical shallow-water reefs as analogues for ancient carbonate buildups

II. Grand Challenges

- How useful are Holocene-based analogues for understanding ancient carbonate buildups?
  - What are the caveates and limitations?
- How have changes in biogeochemical boundary conditions changed modes and rates of calcification?
  - CO_2, alkalinity, salinity, Mg/Ca ratios
- Defining scales and uses of models
  - Models to test hypotheses
  - Models to predict response to global change
  - Models to inform resource exploration/development

III. What are our knowledge gaps?

- Physical/energetic/biogeochemical boundary conditions for hypercalcification (for rapid carbonate production)
- Rates of production and how they translate to rates of deposition/accumulation
  - Bioerosion and physical erosion
- Understanding spatial heterogeneity
  - Seascape (landscape) issue:
  - How do carbonate producing communities function?
  - How does the sediment produced accumulate?
- Geomorphological evolution
  - How does the seascape heterogeneity translate to stratigraphic heterogeneity?
- What are the origins of muds? Where is each process operating and under what boundary conditions?

  - What are the roles of microbes in mud production?
    - Whitings, microbialites, sulphate reduction, etc.
  - Bioerosion
    - Relative importance of different biota under different boundary conditions

IV. What experiments/strategies can close those gaps

- Develop experiments with physiologists and geochemical modelers to understand
  - How changes in geochemical parameters may influence rates of biomineralization
- Interact with population ecologists to interpret
  - How changes in environment (chemical, physical etc) translates to population dynamics
  - How that translates to spatial heterogeneity within and between reefs
- Interact with paleontologists/carbonate sedimentologists to compare modern with ancients systems
- Identify modern test cases as possible analogues for ancient carbonate buildups
  - Tropical meso-/oligophotic reefs or carbonate systems
  - Cool-water carbonate systems
    - Shallow water
    - Aphotic worldwide
- Identify ancient test cases for testing hypotheses developed in modern systems

- How does the seascape heterogeneity translate to stratigraphic heterogeneity?
  - Habitat mosaic
  - Constituent organisms and dynamics
  - Rates of sediment production and accumulation
  - Identification in the stratigraphic record –
    - relationship to rates of vertical accretion?

- Characterizing seascapes and inherent dynamics of biota across turnon-turnoff gradients
  - Latitudinal (E/W Australia, E/W Florida, E Africa, Hawaii to NW Hawiian islands
  - Current-dominated: Nicaraguan Rise
  - Depth gradients:
    - Light, trophic resources, temperature, internal waves, etc. (i.e., most modern margins)
    - Primarily light – e.g., Gulf of Aqaba
  - Terrigenous/turbidity gradients

V. Necessary partners for inherently interdisciplinary efforts

- Developers of ocean observing systems, esp. shelf-based systems
- Ocean engineers/technologists to develop/apply monitoring systems for experimental studies

- “Landscape” ecologists/modelers
- Microbiologists
- Geochemists, geochemical modelers
- Developers of experimental mesocosms and macrocosms testing changing geochemical and atmospheric boundary conditions
- Physiologists to help translate implications of geochemical models to predicting how specific biota might have responded
- Paleontologists/paleobiologists to translate understanding of modern biotas to interpreting fossil systems
- Taphonomists and sedimentary geochemists to assist in constraining syndepositional loss
- Paleoceanographers to understand paleoceanographic changes that influence fossil carbonate producing communities

VI. Short-term goals

- Updated literature search of rates (review articles/MS theses or lit reviews for dissertation research)
    - Production
    - Accumulation
    - Bioerosion
    - Specific to biota
    - Specific to habitats
    - Microbial contributions and interactions
- Further identifying gaps in understanding
- Identifying key experimental sites and gradients

VII. Mid-term goals

- Research to constrain biogeochemistry of hypercalcification by key biotic groups
        - Corals
        - Coralline algae
        - Calcareous green algae
        - Larger benthic forams
        - Microbes, including cyanobacteria
- Constrain “seascape” dynamics and patterns
    - At targeted locations
        - Surface and stratigraphic
    - Across gradients

VIII. Resource Needs

- Obtain resources/infrastructure to do needed seismic surveys and drilling
- Infrastructure for experimental validation of models, field observations and predictions
- Coastal ship time and resources
    - To utilize technology currently available
        - submersibles, ROVs, geochemical sensors
    - To develop new technology

IX. Long-term goals (where would we like to be in 10 years?)

Geochemical and physical constraints on carbonate production well understood

Spatial heterogeneity understood and translated to pertinent models

X. Societal implications

- Inherent value of reefs/carbonate systems
  - Shoreline protection
  - Fisheries habitat
  - Hydrocarbon reservoirs
  - Aquifers
  - Building material
  - Records for past global change
  - Reservoirs of biodiversity
  - Tourism