Tools/Approaches for Quantifying Controls and Increasing Resolution of Systems and Time Scales

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Need to define what systems we want to discuss:

Global carbonate system –

1. pelagic
2. benthic
    a. photic
    b. aphotic
        i. continental crust margins
        ii. MOR – chemosynthetic carbonate

2a. Benthic – photic

Continental Crust vs Oceanic Crust

- tectonics clastic
- influence of sediments
- size-extent?
- geometry

Platform/slope system

1. rimmed
2. ramp

Components:
Reef
Sand shoals
Foreslope
Interior - subtidal
Tidal Flats
Supratidal (islands)

What are the significant timescales?
Different times in geological history, you get very different systems than right now. For instance, now continental shelf carbonate systems are small as opposed to Cretaceous times when the shelves were widespread. It would affect the controls and perhaps what you would measure to understand the platform.

What scale do we want to be modeling our platforms? Do we want to understand the timescales at 1000's of years or 100's years of 10's of years? What is delta-t (time)?

Might want to focus on certain growth rates of platforms that control what scales we want to look at these. Do we have the tools to get the measurements we need to understand time?

Do we have the knowledge to know how to model ancient cool-water carbonates? Do we know how they grow now? We need to continue to study these since we really don't know

Do we know what we want to measure that could be the proxies for the controls on carbonates?

Do we have knowledge of the critical timescales in all the components?

Looking at the components, margins (reefs and sand shoals) have been studied in the modern with a pretty good understanding.
Foreslope is usually considered with transport of material off the platform and pelagic contribution. Perhaps we need a better understanding of these environments.

Critical path is the component that needs to be modeled at the smallest time step.

What is the fundamental challenge?

What tools do we have now and what do we need to develop?

1. Modern
   - remote sensing (optical)
   - lidar (airborne/submarine); light-detection and ranging (bathymetry tool; also new versions have spectral response capability)
   - sonar (bottom topography; bottom sediment typing (backscatter))
   - acoustic Doppler profiling (current velocity)
   - bottom-mounted meters for wave measurements (in situ);
   - Synthetic aperture radar (space); shore-based radar (wave/current measurements)
   - Turbidity, temperature, alkalinity sensors

2. Ancient (pre- ~11,000 yrs)
   - well logs (technology is there, just getting the $$$ to pay for modern logs for academic purposes – maybe make it attractive to the companies to test tools in the academic wells)
   - core recovery (need engineers to improve this)
   - stable isotopes
   - Sr isotopes
   - magnetostratigraphy
   - biostratigraphy (losing the knowledge, haven't captured the knowledge of what has been done into databases and made in publicly available)
   - magnetic susceptibility/rock-magnetic techiques
   - QEMSCAN – super SEM (new tool)
   - chronostratigraphy (absolute dating of layers)
   - seismic

3. Integrated approach
Integrated outcrop → near-subsurface (behind the outcrop) → deep subsurface =
3D CARBONATE PLATFORM MODEL

To achieve better stratigraphic resolution:

* High-precision radioisotope dating: U-Pb, U-Th and Ar/Ar dating recently improved to 0.1% error. Partner with Earthtime (NSF sponsored initiative), Earthtime Europe

*High resolution biostratigraphy: CONOP (constrained optimization); high resolution event sequencing of assemblages of biostratigraphic sections. Can provide resolving power better than 0.5 myr scale.

If we had a new location – no coordinated way to make sure that all the data that should collected is collected. For instance in an outcrop section, such as Arrow Canyon, marked the section permanently so that others can come by later and know where they are to collect study. Need composite standards.

*Cyclostratigraphy: astronomically calibrated stratigraphy offers resolving power at 0.02 to 0.4 myr level for the Cenozoic-Mesozoic. (Modeling objectives ought to include testing for astronomical signal in cyclic carbonate systems.)

Validation tools:

1. Time series analysis tools: needed to quantify the time-frequency evolution of carbonate accumulation.
    a. spectral analysis provides means to assess variability of carbonate sedimentation as a function of frequency
    b. degree of randomness of sedimentation
    c. identification of external forcing mechanisms

2. Distribution analysis tools (PDF's/CDF's): distributions of modeled carbonate sedimentation as a function of space/time (clustering of modeled parameters).

Recommendations
Need a better coordinated effort by the community for data collection (all aspects)
Need an archiving system to capture information that is there already, then new information (sharing)
Need to identify new tools

How much is our understanding limited by the outcrop? What if you took a core behind the outcrop? Do we need a drilling program for carbonates?

Have a system where if you make a proposal for a well and have it approved, all the tools are available already (the infrastructure to collect core, run logs etc).