

# **ANALYSIS OF THE CAUSES AND CONSEQUENCES OF SUBMARINE SLOPE FAILURE**

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## **LONG-TERM GOALS**

Develop: (i) measurements of seafloor morphology that can provide relative but rapid indications of submarine slope stability from bathymetry and high-resolution seismic data; (ii) statistical methods for estimating sediment properties that influence slope stability in areas between and beyond where data exists; and (iii) numerical models of the sediment flows spawned by slope failure and the manner in which they modify continental margin bathymetry and stratigraphy.

## **SCIENTIFIC OBJECTIVES**

- Use estimates of the state of stress in a submarine slope to constrain the likelihood and potential mode of slope failure.
- Establish a method for correlating down-core, sedimentological measurements marred by sediment deformation, anomalous deposits, and varying sediment accumulation and/or erosion.
- Simulate sediment flow erosion, transport and deposition, and its impact on seafloor evolution and stratigraphy formation.

## **APPROACH**

- Collaborate with Ulisses Mello (IBM Watson Research Labs), an expert in numerical methods, to derive: first, an analytical solution for the state of stress in two dimensions in a simple, homogeneous, submarine slope; and second, a numerical solution of the state of stress in slopes with more complicated geometries and that are composed of heterogeneous sediments.
- Collaborate with Doug Martinson (Lamont-Doherty Earth Observatory), an expert in statistics, to develop a statistical algorithm that relates any two geologic time series on the basis of a combined weighted comparison of their amplitudes and shapes.
- Collaborate with Gary Parker (University of Minnesota) and James Syvitski (INSTAAR), experts in sediment dynamics, in developing a 2-D, layer-averaged simulation of turbid flows.

## **WORK COMPLETED**

- A general, analytical solution has been derived for the state of stress in two dimensions in a simple, homogeneous slope. The solution has been coupled with the solution for pore pressures generated by transient fluid flow. It has also been applied toward explaining the geometry of the Humboldt slide in the Northern California STRATAFORM study area.
- A prototype of the correlation algorithm has been developed, and has been exercised on synthetic down-core records.
- A 2-D, marker-in-cell algorithm of turbidity current dynamics has been developed. The algorithm has been used to simulate the movement of a turbidity current over multibeam bathymetry of both the Northern California and New Jersey STRATAFORM study areas.

## **RESULTS**

- The 2-D state of stress solution for a simple, homogeneous slope offers an explanation for the geometry of the Humboldt slide and similar slope failures worldwide. It suggests that such failure geometries are formed under a compressional stress field.

# Report Documentation Page

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- The prototype correlation algorithm correctly identifies the true correlation between synthetic down-core records deformed by variable sedimentation, interspersed with random deposits, and missing sections due to erosion.
- The turbidity-current algorithm is able to simulate the spreading and elongation of a turbidity current as it moves downslope. It also predicts the path a turbidity current will follow over the seafloor.

### **IMPACT/APPLICATIONS**

- Estimating the state of stress in a submarine slope appears to offer an important new approach for understanding the stability of the slope and how it may fail.
- The prototype correlation algorithm is a significant step toward a reliable method for extracting meaningful correlations between sediment records from siliclastic shelf and slope stratigraphy.
- The 2-D turbidity current algorithm offers a tool for understanding how these processes contribute to the 3-D evolution of continental margin morphology and stratigraphy.

### **TRANSITIONS**

- The results of the slope stability analysis support the seismic interpretations of Gardner et al. (special STRATAFORM issue of Marine Geology) as to the geometry of the Humboldt slide.
- The correlation algorithm is still under development, but will eventually aid in correlating down-core measurements to seismic reflection data, and from one core site to another.
- The 2-D turbidity current algorithm represents will be used in a 3-D seascape and stratigraphy evolution model being developed in collaboration with J. Syvitski.

### **RELATED PROJECTS**

- Work has begun on developing a data base of continental margin morphology, sedimentology, oceanography and tectonics with support from MOBIL Technology Center,.
- A collaboration with G. Parker and C. Paola (University of Minnesota) has been initiated to simulate seismic reflection profiles of experimental shelf and slope stratigraphy produced in a large laboratory flume.
- Work is being done with the National Geophysical Data Center to construct merged topography-bathymetry grids of the US coastal zone at a resolution of 3 arc seconds (~90 m).

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<http://www.ngdc.noaa.gov/mgg/bathymetry/fusion.html>