

3-D Visualization of Morphology and Distribution of Acoustic Facies in the Strataform Study Areas

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LONG-TERM GOAL

Our long-term goal is to provide the fundamental mapping information and visualization tools necessary to support STRATAFORM's multidisciplinary effort to develop a more complete understanding of how short-term oceanographic and geological processes interact to produce the preserved geologic record on the shelf and slope portions of the continental margins.

SCIENTIFIC OBJECTIVES

The fundamental objective of the STRATAFORM Swathmapping Program is **to provide complete (100%) bathymetric and sidescan imagery coverage of the Northern California and N.J. Margin STRATAFORM field areas**. This has allowed STRATAFORM investigators to evaluate the geologic processes of the shelf and slope over a continuum of scales. Complete coverage also has provided STRATAFORM investigators with the knowledge that their studies are based on a complete picture of morphological relationships rather than the interpolation of sparsely spaced data. In doing this, we have produced a bathymetric, geomorphological, and potentially lithological framework upon which all subsequent work can be built. Ancillary objectives are **to further develop techniques for the remote classification of seafloor materials from swathmapping data** and, **to develop techniques for the interactive 3D visualization of co-registered surficial and subbottom data**.

APPROACH

We have chosen to use a state-of-the-art multibeam sonar system (EM-1000) for our mapping. As compared to conventional echosounders, multibeam sonars provide increased source level, lateral resolution, and a substantial increase in data density and areal coverage. Most importantly, the newer systems also provide the ability to simultaneously produce high-resolution sidescan sonar imagery. We have developed a full suite of real-time and near real-time multibeam sonar processing tools to assure that only high-quality data is collected and that this data can be processed in the field. These tools also allow for the interactive 3-D visualization of multibeam data sets and derivative products. We are also developing a range of seafloor classification algorithms with particular focus on techniques that look at the characteristics of the returned waveforms as well as the change in backscatter as a function of angle of incidence. We are also exploring the application of the wavelet transform as a means of removing

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unwanted artifacts from seafloor backscatter data as well as a means of estimating seafloor type. The results of these analyses will be compared to ground truth data collected by other STRATAFORM scientists to explore the limits of extracting quantitative seafloor property information from multibeam sonar data.

WORK COMPLETED

In 1995 and 1996, we completed mapping of the Calif. and most of the N.J. survey areas. In 1997 we completed the remaining deep-water portion of the N.J., processed these data and merged them with the shallow water data. We also processed additional multibeam (Hydrosweep) data from the Eureka area collected by Clark Alexander. We merged this data with the earlier data sets and made the new maps available to all STRATAFORM investigators. We have now focused our efforts on visualization and particularly on the question of remote seafloor classification. We have finalized interactive 3-D fly-throughs of the N. J. margin and have developed a suite of automated algorithms for extracting and parameterizing the backscatter as a function of angle of incidence. We have also nearly completed the software necessary to bring fully georeferenced high-resolution seismic data into our 3-D visualization package. Our focus for sediment classification studies has been the Eureka margin. Seismic data, gas abundance data, as well as data from box cores, piston cores, and camera stations have all been entered into a 2-D GIS system for direct comparison with backscatter data. Work is underway to transition these data sets into our interactive 3-D GIS. Finally, we have completed the algorithms for the application of tree-structured wavelet transforms to multibeam sonar backscatter data and applied this transform to data from the Eureka margin.

RESULTS

The combined bathymetry and imagery of the N. J. margin show a spectacular picture of shelf processes with large scale ridge and swale features that appear to be moving across the shelf, a series of ablation features and, a large region near the shelf break that appears to be covered by old iceberg scours. The ridge and swale topography appears to be overriding the scour features though there are several large scour-like feature that also seem to cut into the ridge and swale deposits. If these large features are iceberg scours, this part of the system has been preserved since the last deglaciation. The deep water data provides direct insight into the origin of submarine canyons, with landward erosion apparently the dominant mechanism. Our parameterization of the angular backscatter response curve appears to be a sensitive indicator of changes in seafloor type or texture. In particular, the shape of the curve below 40° is especially revealing as response in the vicinity of the critical angle may be observed. The use of our 3-D visualization tools has allowed us to directly see the spatial distribution of our extracted classifiers and their relationship to seafloor morphology.

The wavelet transform has proven to be a robust technique for the removal of artifacts from backscatter data. Backscatter data characteristically is degraded by ship-track parallel artifacts that are the result of the incomplete correction for specular energy at nadir (i.e., the lack of sidescan at nadir). These artifacts are easily identified as “channels” at certain levels of the wavelet transform and thus easily removed (Fig 1). Once the artifacts are removed we can continue to use the wavelet transform to identify regions of characteristic backscatter statistics that we then relate to changes in seafloor roughness. We are using quantitative roughness data provided by other Strataform investigators to ground truth these studies.

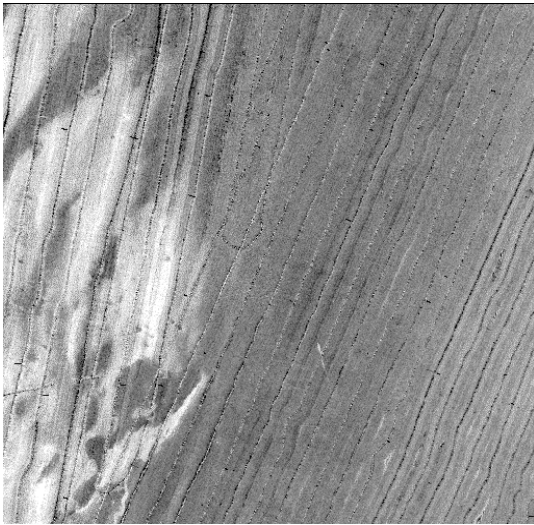


Fig 1. A. EM-1000 backscatter data with dominant ship-track parallel nadir artifacts

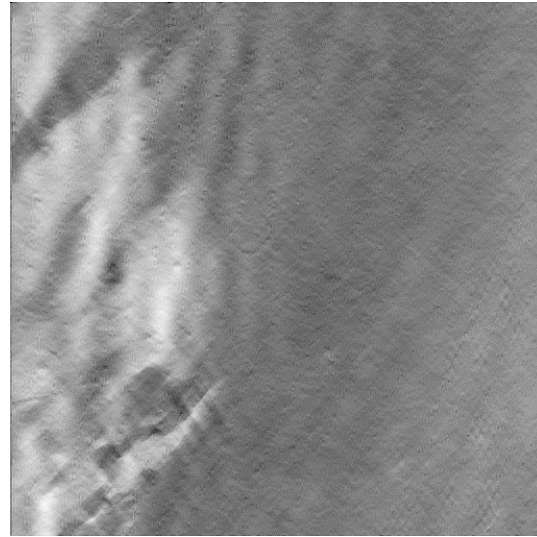


Fig 1 B. Backscatter data from Fig 1A with artifact removed via wavelet transform

IMPACT/APPLICATIONS

The swathmapping results from the Eureka and the N. J. margins provide all STRATAFORM investigators with an unprecedented, detailed look at both the bathymetry and distribution of sediments on the shelf and slope. These results have already been used in planning the deployment of a series of long-term moorings, seismic profiling and coring cruises, as well as for planning ROV, submersible work, and ODP sites. Quantitative measurements of slope and sediment-type distributions will inevitably lead to improved models of shelf and slope development, the primary goal of the STRATAFORM program. Our initial results from the New Jersey margin indicate that pervasive ice scouring is evident further south than previously reported and may have impact on our overall understanding of the evolution of shelf stratigraphy. The ability to interactively explore large and complex data sets in a 3-D GIS will greatly facilitate our understanding of the seafloor processes at work in the Strataform areas and particularly their relationship to seafloor morphology. In addition, through the use of backscatter as a function of angle of incidence and wavelet transforms we hope to provide a new and rapid means of exploring lateral changes in seafloor roughness and composition.

TRANSITIONS

Our maps and data have been used by numerous investigators both in and out of STRATAFORM, including several other Navy programs (e.g., SWARM, NRL). Our processing and visualization software is being used by NAVO, NRL, NOAA, USGS as well as a number of universities and private sector companies (Shell, Exxon, Woodside, WAPET).

RELATED PROJECTS

NSERC Chair in Ocean Mapping – a consortium of 14 sponsors that provide base support for general research in the field of ocean mapping.

PUBLICATIONS

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