TEXTURAL ANALYSIS OF MARINE SEDIMENTS AT THE USGS WOODS HOLE SCIENCE CENTER: METHODOLOGY AND DATA ON DVD

Lawrence J. Poppe, lpoppe@usgs.gov; S. Jeffress Williams, jwilliams@usgs.gov; and Valerie F. Paskevich, vpaskevich@usgs.gov, Coastal and Marine Geology Program, U.S. Geological Survey, Woods Hole, MA 02543

Abstract: Marine sediments off the eastern United States vary markedly in texture (i.e., the size, shape, composition, and arrangement of their grains) due to a complex geologic history. For descriptive purposes, however, it is typically most useful to classify these sediments according to their grain-size distributions. In 1962, the U.S. Geological Survey began a program to study the marine geology of the continental margin off the Atlantic coast of the United States. As part of this program and numerous subsequent projects, thousands of sediment grab samples and cores were collected and analyzed for grain size at the Woods Hole Science Center. USGS Open-File Report 2005-1001 (Poppe et al., 2005), available on DVD and online, describes the field methods used to collect marine sediment samples as well as the laboratory methods used to determine and characterize grain-size distributions, and presents these data in several formats that can be readily employed by interested parties. The report is divided into three sections. The first section discusses procedures and contains pictures of the equipment, analytical flow diagrams, video clips with voice commentary, classification schemes, useful forms and compiled and uncompiled versions of the data-acquisition and data-processing software with documentation. The second section contains the grain-size data for more than 23,000 analyses in two "flat-file" formats, a data dictionary, and color-coded browse maps. The third section provides a GIS data catalog of the available point, interpretive, and baseline data layers, with FGDC-compliant metadata to help users visualize the textural information in a geographic context.

INTRODUCTION

We have compiled the textural methods and data from the USGS Coastal and Marine Geology Program's Woods Hole Science Center and released them on DVD as Open-File Report 2005-1001 (Poppe et al., 2005). The purpose of that report is to describe the field methods used to collect marine sediment samples, primarily from along the U.S. east coast, and the laboratory methods used to determine and characterize the grain-size distributions. The report also provides a verified and well-documented sediment database in formats that can be readily employed by interested parties and supersedes a more limited report by Poppe and Polloni (2000).

Grain size is the most fundamental sediment property. Geologists use sediment grain size information to study trends in surface processes that are related to dynamic conditions of transportation and deposition, ecologists use it when studying benthic habitats, engineers use it to study permeability and stability of sediments under load, geochemists use it to study kinetic reactions and the affinities of fine-grained particles and contaminants, and hydrologists use it when studying subsurface fluid migration (Blatt and others, 1972; McCave and Syvitski, 1991). Furthermore, many scientific questions and policy issues related to the offshore require sediment data of historical and regional scope. Because data acquisition is both expensive and time consuming, existing data from different sources need to be compiled and coherently presented.

A detailed catalog of the sediment grain-size data produced at the Woods Hole Science Center provides users with a quantitative foundation for future work and a means of optimizing data acquisition strategies. As one example of value, the data from this report have been imported into usSEABED (Reid et al., 2005), a large data compilation and mining program, and used to provide regional information on sea-floor sedimentary character with applications to aggregate resources suitable for beach nourishment and coastal restoration, benthic habitat mapping, and sediment transport studies.

The new digital report (Poppe et al., 2005) provides an accessible, documented compilation of existing USGS east-coast sediment data and analytical techniques. It also provides the means for environmental managers, policy-makers, scientific researchers, and interested members of the public to gain access to this information.

PROCEDURES

Because many geological observations consist of measurements made on a large number of specimens, the techniques and equipment used for particle-size analysis must be fast, accurate, and yield highly reproducible results. However, the precision of these measurements is limited by the initial sampling techniques, storage conditions, analytical methods, equipment, and the capability of the operator. Therefore, we have incorporated a procedures section into the report to serve as a training manual and reference source for the analyst and as metadata for the scientist.

The procedures section describes field methods used to collect marine sediment samples and laboratory methods used to determine and characterize their grain-size distributions. The field methods section contains recommended sampling, handling, and storage protocols, as well as a pictorial gallery of common sampling devices including grabs, corers, dredges, bedload samplers, and sediment traps (Fig. 1A). The section on laboratory methods contains analytical flow diagrams, illustrated methodologies, instructional video clips with voice commentaries, pictures and schematics of the analytical equipment, classification schemes for grade scale and nomenclature, comments on quality assurance, useful forms, and software (Fig. 1B). Ancillary techniques, such as procedures for removing organics or calcium carbonate, are also included.

Compiled and uncompiled versions of the data acquisition and processing software are provided with documentation and information on system requirements. Although the data acquisition programs are necessarily dedicated to our analytical equipment, the newer data processing programs are not laboratory specific. These programs are written in Visual Basic, run under Windows 98/ME/2000/XP, provide a window to facilitate program execution, and accept input files in standard comma-delimited ASCII text. For example, the program GSSTAT generates statistics to characterize sediment grain-size distributions and can extrapolate the fine-grained end of the particle distribution. The input for the sediment fractions is weight percentages in whole-phi notation (Krumbein, 1934), and the program permits the user to select output in either method of moments or inclusive graphics statistics. The program SEDCLASS generates verbal equivalents to characterize sediment grain-size distributions. Inputs for this program are percentages of gravel, sand, silt, and clay in the Wentworth (1929) grade scale. The program

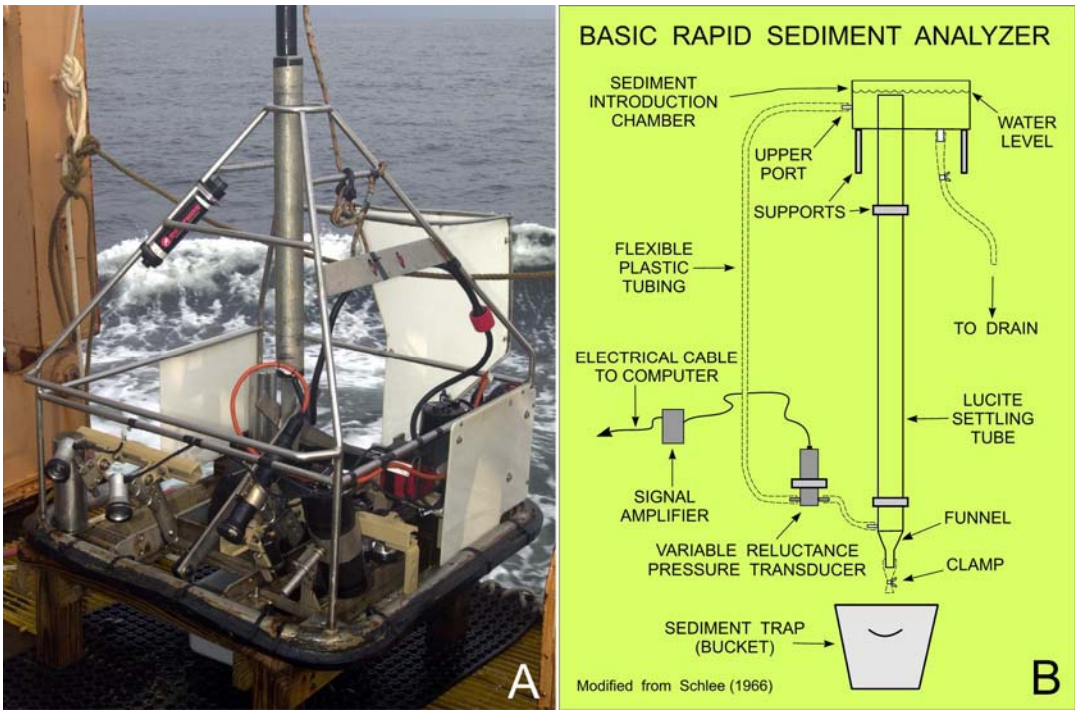

Figure 1. Browse graphics of field and laboratory methods. A. A Van Veen grab equipped with still and video camera systems that is part of the report's gallery of devices used to collect sediment samples. B. The basic design of a rapid sediment analyzer (i.e. settling tube) based on the design by Schlee (1966).

permits the user to select output in either the Shepard (1954) classification scheme, as modified by Schlee (1973), or the Folk (1974) scheme. Users of these programs select options primarily with mouse-click events or through interactive dialogue boxes.

DATABASE

The sediment database incorporates information on the collection, location, description, and texture of samples taken by numerous marine sampling projects, most of which are from off the east coast of the United States (Fig. 2). The database presently contains data for over 23,300 samples, which includes texture data for approximately 3,800 samples taken or analyzed by the Atlantic Continental Margin Program, a joint USGS/Woods Hole Oceanographic Institution project conducted from 1962 to 1970 (Emery and Schlee, 1963; Hathaway, 1971). Texture data for approximately 19,500 samples analyzed after 1980 in the Woods Hole Science Center's Sediment Laboratory make up the rest of the database. Although most records contain complete grain size analyses, some are simple bottom descriptions from rocky and bouldery locations where samples were not taken. Most of the samples were collected with some type of grab sampler, though a few were obtained by coring.

Database Platform and Formats: The basic structure of the sediment database is a matrix where rows are records representing individual samples and columns contain information on sample identification, navigation, classifications, analyzed parameters, and comments. This is a

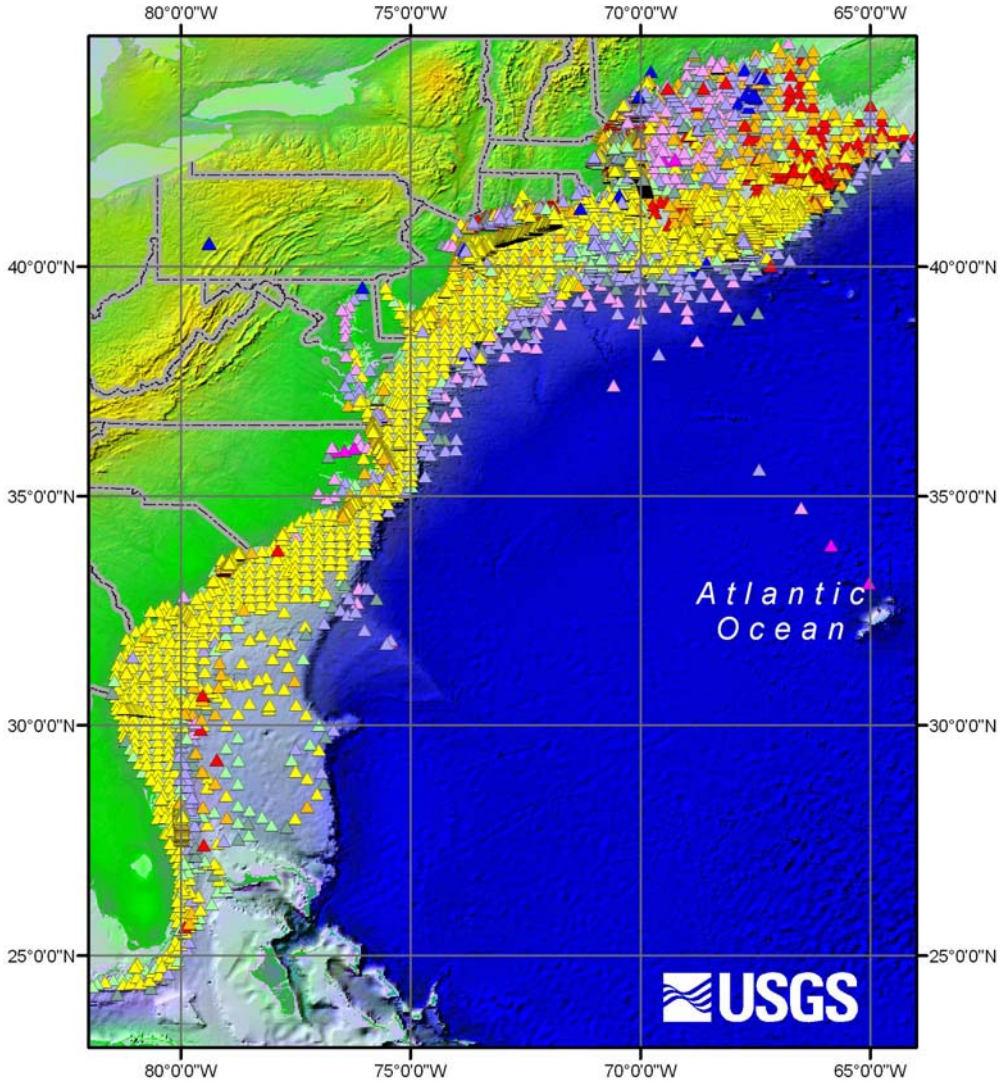

Figure 2. Graphic shows station locations in the USGS East-Coast Sediment Texture Database for those samples from off the U.S. east coast. Similar graphics are available for other areas (e.g. Carribean and Gulf of Mexico). Colors denote sediment classification, but, in cases where a sediment type is uncommon, colors may represent more than one class (e.g. silty sand and clayey sand are both light green).

"flat-file" format, which means that it is not "normalized" (i.e., of reduced redundancy). While this is considered inefficient from the point of view of database management, it is the most general way of presenting the basic data. This structure was chosen to avoid ambiguity, and to make the process of locating fields, entering data and validating simple yet comprehensive. Since neither the software capabilities of the user nor the probable uses of the data were known, no attempt was made to split the files or to reduce blank fields. If the user wishes to make the database more efficient through "normalization," we feel that it is better that this be done by the user to fit both the applications available to the user and the database structural logic that is familiar to the user. The price paid for the "flat-file" approach is additional storage space, exceptionally wide records, and the possibility that corrections made here at the source may fail to be carried through to all forms of the affected data. Browse graphics are supplied to help users visualize the geographic distribution of the stations and sediment types (Fig. 2).

The database is provided in two formats: Microsoft Excel 2000, a popular commercial software format, and tab-delimited ASCII text. The Excel file will open in the appropriate software if the user has this application installed and their web browser properly configured or if the file is downloaded and opened directly with Excel. The tab-delimited file contains data as well as headings for the tables of data in uncompressed ASCII format. This file is supplied for users who wish to import the data into applications that can accept ASCII character information. The database contains 58 fields and is supplied with a data dictionary that explains the structure and content of the database. The dictionary contains an index of the parameters measured and their definitions. Extracting data from the database is facilitated by reference to this document because it provides a means to keep track of abbreviations and field names. The specific fields and parameters were chosen based on the data produced in the sediment laboratory at the Woods Hole Science Center and the formats of information typically found in the literature. Most records do not have data in all of the available fields; however, additional fields, qualifiers, and data can be added in virtually unlimited fashion to accommodate specific needs.

GIS DATA

Data in the report are provided with geographic coordinates to facilitate their integration into a Geographic Information System (GIS). A GIS is defined as a system of hardware and software to display, manipulate, and analyze spatial data for mapping and complex data solving. This integrated package provides researchers the ability to combine, analyze, and map multiple datasets to help with economic and social policy-making decisions regarding the environment.

This report uses the Environmental Systems Research Institute's (ESRI) ArcView and ArcGIS software as its GIS mapping tools. Data layers archived here should not require additional processing to be utilized within ESRI software. This does not mean that a user will not wish to do additional processing, especially if utilizing a different GIS software package or ellipsoid, but that it is not necessary to do additional processing simply to utilize the data in its minimum archive format. For those who don't have the ESRI software or a compatible GIS data browser available on their computer, a free viewer, ArcExplorer, is available from ESRI. Although the report provides ArcView and ArcGIS project files, it contains no prepared project file for use with ArcExplorer. If the user chooses ArcExplorer, it will be necessary to add the selected data layers to their own defined project file.

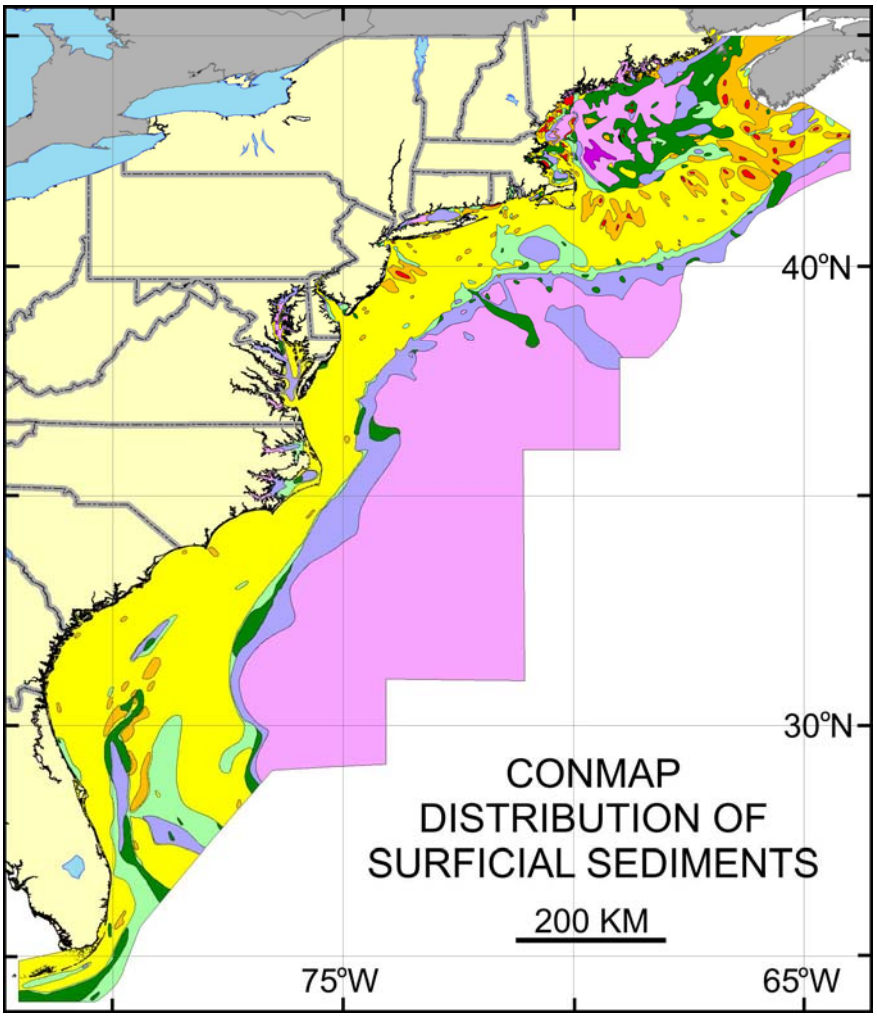

Figure 3. Polygon data layer of the Continental Margin Mapping Program (CONMAP) series composite map for surficial sediments off the U.S. east coast. Data layer is useful as a general overview and to show gross textural trends. See Figure 2 for a color key of classifications.

Data Catalog of GIS Layers: All GIS data layers in this report are available through a data catalog that includes browse graphics and FGDC-compliant metadata in FAQ, HTML, and text formats. These data layers include two sediment data layers and three basemap data layers. The two sediment data layers are the USGS East Coast Sediment Texture Database, which is supplied as a point shapefile, and the Continental Margin Mapping Project (CONMAP) series surficial-sediment maps, which are combined into one layer and supplied as a polygon shapefile (Fig. 3). The sediment maps in the CONMAP series (Klitgord and Hill, 1986; Poppe and others, 1989; Poppe and others, 1994) are regional syntheses of surficial sediment studies compiled from grain-size data produced at the Woods Hole Science Center and from earlier published and unpublished studies. Although old and inaccurate at large scales (e.g. less than 1:1,000,000), the CONMAP data layer is provided as a general overview and to show gross textural trends.

Supplied basemap data layers include internal U.S. state boundaries and color-encoded images of North American and world topography.

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