RECOGNITION OF DELTAIC ENVIRONMENTS FROM SMALL SAMPLES

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It is recognized that exploration for sedimentary accumulations of petroleum, natural gas, and other economic minerals is greatly aided by studies of the physical environment in which these mineral resources accumulate. To date, however, most studies of the depositional environment of ancient detrital sediments are carried out only from continuous cores or outcrop exposures. In both cases vertical successions of sedimentary structures can be examined.

In many areas of subsurface exploration small sidewall plugs replace the more expensive continuous cores for purposes of formation evaluation. If these small samples could be used to evaluate the physical environment of sedimentation, our ability to predict areas of favorable mineral accumulations would be greatly enhanced.

Data on detrital mineralogy, quartz size, and sorting of small samples from recent and ancient deltas reveals that these variables are significantly affected by changes in depositional environment.

Initial investigations considered only variations in quartz abundance and size. These early investigations suggested that major environmental complexes (barrier, fluvial, and deltaic) were sensitive to changes in quartz content and size. Other mineral and rock fragment species (feldspar, mica, phyllite, schist, polycrystalline quartz, etc.) were largely ignored.

Recent investigations have considered all of the detrital components of a sediment, and have attempted to evaluate differences among specific environments characterized by dissimilar processes.

In order to analyze simultaneous fluctuations of minerals, rock fragments, and texture in a multicomponent system such as a rock it is necessary to utilize multivariate statistics. A change in environment of deposition will result in simultaneous changes not only in the size of the sediment, but also changes in individual minerals and fragments. To evaluate these simultaneous changes in abundances of quartz, mica, feldspar, rock fragments, matrix, accessories, quartz size, and sorting, discriminant function analysis was used.

Recent deltas investigated include the Mississippi Delta, and the Burdekin Delta, Queensland, Australia. Within the Mississippi Delta complex, transgressive beach, natural levee-channel-delta front, open bay, and closed bay-marsh-prodelta environments can be discriminated. Transgressive beaches are areas characterized by prolonged winnowing and sorting of sediment by wave induced currents. Thus, transgressive beaches contain the largest percentages of quartz and feldspar grains, locally derived sedimentary rock fragments (mud balls) and the least amount of fine-grained matrix. Fine-grained marshes, closed bays, and prodelta environments are characterized by deposition of sediment from suspension. They have the largest percentages of fine-grained clay matrix. Natural levee, channel, and delta front environments are characterized by a combination of suspension and saltation and contain less clay matrix and greater percentages of quartz and feldspar. Open bays are areas dominated by suspended sediment transport with intermittent periods of saltation resulting from high tides or storm induced currents which appreciably affect sedimentation patterns. This environment is characterized by large percentages of mica and by relatively poor sorting.

The Burdekin Delta, Queensland, Australia, unlike the Mississippi Delta, is characterized by strong marine tide and wave induced currents which redistribute sediment locally along the shoreline. Results of petrographic analyses reveal that channel-tidal channel, natural levee, low tide flat, and beach-dune environments can be segregated on the basis of differences in mineralogy, quartz size, and sorting. Low tide flats contain the largest percentages of quartz; natural levees the largest percentages of mica and fine-grained matrix; beach-dune the largest percentages of heavy minerals; and channels and tidal channels the largest percentages of rock fragments, the largest mean size, and the poorest sorting.

Deltaic sediments from the Wilcox Group (Eocene) of Texas; Muddy Sandstone Formation (Lower Cretaceous) of Montana-Wyoming; Sonyea Group (Upper Devonian) of New York; and the Caseyville Formation (Lower Pennsylvanian) of Southern Illinois have also been analyzed petrographically. Results of these analyses reveal that environmental segregation, similar to that found in Recent deltaic sediments, is possible.

Changes in mineralogy, quartz size, and sorting also result from changes in source area, transport distance, tectonics, and diagenesis. Variations resulting from these processes, however, can be largely controlled by proper design of sampling plans (vertical and lateral stratigraphic controls) and by establishment of petrographic criteria in areas of outcrop control.

If these controls are possible, petrographic analysis of detrital sediments provides the researcher with environmentally sensitive, quantative data that is easily obtained from small subsurface or surface samples.

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