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Heavy-Mineral Distribution Along Coastline of Ghana, West Africa

As part of a natural resource appraisal of beach and shelf sediments of Ghana, the mineralogy and texture of beach sands along the Ghana coastline was studied. Precambrian (Dahomeyan) rocks rich in heavy minerals are widely distributed throughout Ghana, providing varied mineral suites along the coast. Most of the beach sediments studied were moderately well-sorted medium sands. Opaque and micaceous minerals constitute between 19 and 17% of the total heavy mineral suite, which on average comprises 46% of the sand. Five mineral provinces, based on relative frequency of the most abundant nonopaque and nonmicaceous heavy minerals, are recognized. (1) Tano province (between Half Assini and Esiama) is characterized by high staurolite (26%) and the least amounts of garnet (0.3% vs. an average of 8.3%) + amphibole (4.6%) + kyanite (1.6%) + epidote (1.8%) + pyroxene (1.3%). (2) Ankobra province (between Axim and Shama) is characterized by increased amphibole (15%) + staurolite (11%) + kyanite (2.7%) + epidote (2.6%). The marked increase in amphibole may be attributed to local outcrops of hornblende-rich Dixcove Granite. (3) Pra province (between the Pra and Densu Rivers) is characterized by increased staurolite (24%) + amphibole (11.3%) + kyanite (4.8%) + garnet (3.7%) + tourmaline (1.5%) + relatively high local occurrences of zircon. The Cape Coast Granite complex exerts a significant influence in this area. (4) Densu province (between the Densu River and Ada) is characterized by staurolite (26.8%) + garnet (16%) + amphibole (15.2%) + kyanite (3.5%) + epidote (3.2%), whose sources are the acidic division of Lahomeyan epidote-bearing hornblende schist and kyanite-bearing marble exposed near Accra. (5) Volta province (between Anyanui and Aflao) is characterized by garnet (17.5%) + staurolite (11.7%) + amphibole (9%) + kyanite (5%) + epidote (4.5) + pyroxene (3.8%). Except for rutile and zircon, heavy mineral content of the area appears to be independent of sedimentary texture. However, the distribution patterns of the heavy minerals reflect the dynamic conditions of the littoral drift in the dispersal of sediments along the coastline of Ghana.

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Diagenetic Controls on Reservoir Quality, Matagorda Island 623 Field, Offshore Texas

Matagorda Island 623 field is a large gas accumulation in overpressured, lower Miocene *Siphonina davisi* deltaic sandstones. Production is from fine, moderately well sorted sublitharenites deposited in distributary-mouth bars and channels. Reservoir depth is 10,000-14,000 ft (3,050-4,275 m) and bottom-hole temperatures approach 275°F (135°C). Pay-sand porosities range from 15 to 35% and permeabilities range from 10 to 3,000 md.

Between 60 and 85% of the porosity is primary intergranular. Porosity preservation is dependent upon the following: (1) early formation of chlorite grain coats, (2) a stable mineralogic framework, (3) overpressuring, and (4) entry of gas into the reservoir. Chlorite coats form as much as 8% of the rock and originated from a chemical decomposition of volcanic rock fragments (VRF). These coats inhibited quartz cementation and retarded compaction related to pressure solution.

Secondary porosity originated mainly from feldspar and VRF dissolution. Although calcite cement is locally common, evidence is lacking that calcite leaching formed significant porosity. Evidence against large-scale carbonate dissolution includes the following: (1) unaltered carbonate lithoclasts, (2) reworked Cretaceous foraminifers, (3) preservation of delicate chlorite crystal morphology, and (4) the absence of pitted or serrated surfaces on quartz overgrowths, which formed prior to calcite cementation.

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Nature of Secondary Porosity Created by Dissolution of Aluminum Silicates

Porosity enhancement in sandstone reservoirs cannot be due to dissolution of aluminum silicates without implying aluminum mobility. However, aluminum has yet to be reported in reservoir fluids at greater than trace concentrations. Predicted aqueous aluminum concentrations in subsurface fluids approach a level that Curtis has termed "a good approximation of zero."

Several studies of secondary pore systems formed by aluminum silicate dissolution demonstrate that aluminum is conserved on a scale of a few inches, in the form of diagenetic clay minerals—notably kaolinite. Our examinations indicate that the products of dissolution of aluminum silicate grains (which include feldspar and many rock fragments) can be accounted for in thin section primarily by the presence of adjacent pore-filling kaolinite and possibly authigenic quartz and albite. At high temperatures, the diagenetic mineral is often illite.

Secondary porosity formed by dissolution of aluminum silicate grains should not necessarily be construed as adding to total porosity, but should rather be thought of as a "rearrangement" of porosity already present. Indeed, the process may actually be harmful, inasmuch as the newly formed clay minerals can greatly reduce permeability. Calcite resorption remains the principal means of adding to total porosity through a dissolution process.

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Occurrences of Sphalerite in Reservoir Rocks of North Texas and Gulf Coast

Chemical evolution of pore fluids during diagenesis is important to oil and gas origin and migration and mineral deposits. Authigenic sphalerite, a potential geochemical indicator, has been found in reservoir rocks that include the following: (1) Mississippian Osage formation, (2) the Pennsylvanian Strawn Formation, (3) the Jurassic "Gray" sandstones (Smackover), (4) the Jurassic Cotton Valley Formation, and (5) the Cretaceous Hosston Formation. These and two previously reported occurrences in the Smackover suggest a widespread occurrence of sphalerite in subsurface pre-Tertiary sedimentary rocks of north Texas and the Gulf Coast.

Preliminary examinations reveal the following two modes of sphalerite occurrence: (1) as finely crystalline patches of cement in sandstones or limestones, and (2) as individual crystals in ooids or in the cement of oolitic limestones. In some sections, formation of sphalerite appears to be early, with zinc and reduced sulfur derived from nearby shales. In others, late formation and distant sources seem to be most likely. Further studies of the chemistries of sphalerite and fluid inclusions, associated host rock alterations, and temporal and spatial distribution of sphalerite may lead to improved understanding of pore-fluid chemistry during hydrocarbon origin and migration.

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Spectrum of Ancient Shelf Sandstones

Processes that have operated on the seabed of the shelves of the world in the past include waves, storms, permanent currents, subtidal currents, and turbidity currents. As a result of the wide variety of processes, sand bodies with different geometries have resulted, and they commonly contain different sedimentary structures or different sequences of sedimentary structures. On ancient shelves the most common sedimentary structures in current-deposited sandstones are planar-tangential to *planar-tabular cross-beds, and current ripples. Wave-deposited* sandstones are characterized by horizontal to subhorizontal laminations and symmetrical ripple forms. One of the most common shelf sequences reflects upward-increasing energy. However, a sequence reflecting upward-increasing energy and consequent increase in grain size is not unique to shelf sandstones.

Shelf sandstones may be classified on the basis of their position on the shelf (shoreface-attached, inner shelf, middle shelf, outer shelf) and on the basis of whether they are deposited during a transgression, regression, or a stillstand. Both vertical and lateral sequences of lithologies vary with position on the shelf, processes of deposition, and position within transgressive-regressive spectra.

Cretaceous sandstones used to characterize a variety of these processes, geometries, and shelf locations include the "Gallup" (Tocito), Shannon, Fales, and Frontier sandstones.

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Cincinnatian Series—Model for Cyclic and Episodic Deposition of Carbonates and Shales on a Storm-Dominated Ramp