Characteristics of Sunda Subduction Zone

The Sunda Arc is continuous from east of Java northwest to Burma and has a wide lower trench slope, an outer-arc ridge, and a fore-arc basin with a thick sediment fill. South of Java, a thin cover of hemipelagic sediment is carried into the trench on the subducting plate, whereas northwest of Sumatra up to 6 km of Bengal Fan sediments enter the trench. This change in sediment thickness produces a corresponding change in trench slope structure. Off Java, trench and hemipelagic sediments are accreted in thrust packets with no discernible internal structure. In the north, the fan sediments are deformed into large coherent folds. The outer-arc ridge, which is 1 to 3 km below sea level off Java, becomes emergent to the northwest as Nias, Mentawai, Nicobar, and Andaman Islands. Subduction is oblique west of Sumatra, and the fore-arc region is cut by strike-slip faults. The fore-arc basin is segmented into smaller basins along its strike by transverse structural highs. Fore-arc basin sediments are derived from the old crystalline terranes of Sumatra and the volcanic terrane of Java. Sedimentary sequences in the fore-arc basin reflect several periods of uplift and deformation of the outer-arc ridge and the magmatic arc.

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Contrasts in Paleogene Tectonic Style, Kodiak Accretionary Complex: Ridge-Trench Interaction and Reduced Convergence Rate

The Paleogene Sitkalidak and Ghost Rocks Formations, along the southeastern side of the Kodiak Islands, respectively comprise the youngest and second youngest deep-sea deposits exposed adjacent to the eastern Aleutian Trench. The Paleocene Ghost Rocks Formation consists of a trench and/or trench slope turbidite sequence with interstratified oceanic basalts and andesites which were deformed and intruded by tonolitic plutons by 60 Ma. The Eocene Sitkalidak Formation comprises a trench slope and trench-filling fan sequence, lacking lavas and plutons, but petrographically correlative to the Aleutian abyssal fan. Regional metamorphism to prehnite-pumpellite and zeolite facies with maximum temperatures of 200 to 240°C and 100 to 125°C, respectively, characterize the Ghost Rocks and Sitkalidak Formations. Offscraped parts of the Ghost Rocks Formation exhibit more intense deformation than the comparable obductively offscraped unit of the Sitkalidak Formation.

The near-trench volcanism and plutonism, and regional metamorphism of the Ghost Rocks Formation is most simply explained by interaction with the Kula-Farallon Ridge, which plate reconstructions place near Kodiak 60 Ma. The Eocene progradation of sediment from the Kodiak area to the Aleutian abyssal fan requires a filled trench and probably reflects a reduction in convergence rate. Both the Paleocene demise of the Kula-Farallon Ridge and any Eocene northward motion of the Alaska Peninsula would have reduced the convergence rate beneath the Kodiak region during progradation of the Aleutian abyssal fan. Obductive offscraping of the Sitkalidak Formation is consistent with slow convergence beneath a prograding fan sequence. Cessation of siliciclastic turbidite accumulation on the Aleutian abyssal fan about 30 Ma suggests an increase in the convergence rate and/or decrease in sediment influx at this time.

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Genetic Lithostratigraphy of Dunkard Group, Southwestern Pennsylvania and Northern West Virginia

The Dunkard Group (Late Pennsylvanian–Early Permian) consists of 400 m of clastic sedimentary rocks with thin limestones and coals that were deposited in deltaic and alluvial-plain environments during the final stages of late Paleozoic sedimentation in the Appalachian basin. Lithofacies indicative of deposition in prograding, tidally influenced, high-constructive deltas dominate the lower Dunkard; these lithofacies are superseded up-section by alluvial-plain lithofacies. The distribution of lithofacies and paleocurrent data indicates that the fluival-deltaic systems prograded northward during deposition of the Dunkard. Sandstones of the Dunkard Group are typically multistory belt sands which were deposited by meandering rivers and highly sinuous delta distributaries.

Petrographic analysis indicates that Dunkard sandstones are immature to submature litharenites derived from a mixed sedimentary, metasedimentary, and volcanic terrane, suggesting a collision orogene provenance related to Alleghenian suturing. Composition of the sandstones is strongly grain-size controlled and depositional environments influenced composition by controlling grain size. Constant composition through the section suggests no major change in source lithology or tectonic regime of the source area during Dunkard deposition.

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Landsat Imagery as Tool for Determining Potential Oil and Gas Resources

Several hydrocarbon-bearing areas in the world have been examined using custom processed Landsat imagery along with geologic interpretations to determine potential hydrocarbon resources. Project areas are located along the Texas Gulf Coast, the western Overthrust Belt, the Athabasca Canadian region, and the South China Sea area.

Digital Landsat data were processed to produce 1:250,000 scale edge-enhanced, false-color, and high pass filter images. All the images were geometrically corrected with topographic controls and nonlinear deconvolution techniques (coverage = 13,000 sq mi or 33,800 sq km). These specially processed images have been used to map surface geology, lineament systems, and geomorphic anomalies in relation to subsurface geologic and geophysical data. Project areas are defined in terms of their tectonic genesis, structural trends, and hydrocarbon potential. Numerous exploration targets and several modes of hydrocarbon entrapment are identified by image interpretation.

The pressing need for more energy resource demands an accelerated large-scale exploration program. Landsat imagery has been utilized as a tool in the four project areas for structural, stratigraphic, and geomorphic analysis to locate geologic anomalies. Image analysis provides a better understanding of the regional stress-strain relations for tectonic correlation. This information can be used to identify a suite of exploration targets to be integrated into industry seismic programs.

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Subtle Porosity and Traps Within Frisco Formation (Devonian, Hunton Group): Geologic-Seismic Waveform Approach, Example from West El Reno Field, Canadian County, Oklahoma

The Frisco Formation is a middle Lower Devonian limestone within the Hunton Group (Upper Ordovician-Lower Devonian). In the Anadarko basin, the Frisco Formation consists of skeletal packstones and grainstones, whose main components are pelmatozoans, brachiopods, and, locally, corals. Depositional intergranular porosity has been mostly obliterated through syntaxial cementation on pelmatozoans, and mechanical and chemical compaction. Only minor intrabryozoan primary porosity remains. Secondary porosity, which formed during subaerial exposure of the Frisco Formation during the late Early and Middle Devonian, occurs locally at the top of the formation in the form of partly leached grains, vugs, and solution channels. This secondary porosity is best developed close to areas where the formation was completely eroded; these areas commonly correspond to Middle Devonian paleostructures.

Hydrocarbon accumulations in the Frisco Formation are mainly in stratigraphic traps situated downdip of the areas where the formation has been severely truncated. The Woodford Shale (Upper Devonian-Lower Mississippian) unconformably overlies the Frisco Formation in the study area and provides a source, trap, and seal for Frisco Formation reservoirs.

Geophysical identification of Frisco Formation porosity is possible using Relative Amplitude (RAM) processing. Mapping of porosity and truncated margins, and identification of potential hydrocarbon traps, are facilitated by using these RAM processed seismic sections. The West El Reno field, Canadian County, Oklahoma, produces gas and condensate from an outlier of the Frisco Formation, and provides a template for this technique.

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Overview of LASL Oil Shale Program

The Los Alamos Scientific Laboratory (LASL) is involved in a broad spectrum of oil shale-related activities for the Department of Energy (DOE), including the bed preparation design of a modified in-situ retort. This aspect of oil shale research has been identified by the DOE as one of the limiting technologies impeding commercial, in-situ development of oil shale.

The retort bed must have uniform particle size, permeability, and void distributions to allow proper retorting and optimum resource recovery. Controlled fracturing using chemical explosives and carefully designed blasting schemes are the only feasible methods to attain this distribution. Our approach to the bed preparation problem is a coordinated research program of explosives characterization, dynamic rock mechanics, predictive computer modeling, and field verification tests.

The program is designed to develop the predictive fracturing capability required for the optimum rubbling of the shale. It takes advantage of the large computing facilities at Los Alamos and the considerable expertise in explosives and computer hydrocodes developed here for other energy and national defense programs. As these codes are developed for oil shale and refined, they are tested with field verification experiments. Tests with up to four boreholes and single-decked charges conducted at the Colony Mine in Colorado in conjunction with ARCO and TOSCO, have demonstrated the ability to predict rock behavior. Larger experiments with more boreholes and decked charges will be done at the Anvil Points Mine near Rifle, Colorado. These field tests will calibrate the fracture modeling codes and confirm their validity to predict explosive fracturing, including the effects of existing joints and fractures in the oil shale. The experiments will also include fluid flow tests to verify the three-dimensional models of multiphase flow that are under development at LASL.

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Mineral Exploration Using Landsat Image Processing and Interpretation Techniques

Custom-processed, enhanced Landsat images were produced to support mineral exploration and resources mapping programs in: (1) the Marfa basin of west Texas, and (2) Puerto Rico. The objective of these projects was to map surface geologic features from the images to aid in geologic analysis of mineral potential.

Contrast-stretched false color images and high-pass filter images ranging in scale from 1:125,000 to 1:250,000 were made for both areas. Through interpretation, a variety of features (linears, curvilinears, drainage patterns, lithology, etc) were successfully mapped. A significant amount of new information was collected (e.g., 30% more linears were mapped in west Texas).

Due to the semi-arid nature of west Texas, techniques that exaggerate spectral differences of the land surface as sensed by the satellite, were used to aid in mapping rock units. A series of ratio images was made to enhance iron oxides, a potential indicator of mineralization in this area. Extensive field work and spectral radiometer studies were used to evaluate initial results and collect data to permit more effective image processing. Ratio images of the visual green and visual red spectral bands proved highly effective for mapping iron oxides.

Due to its synoptic, regional view and effectiveness for mapping a variety of surface geologic features, Landsat image processing and interpretation can provide significant new information that is especially useful in the reconnaissance stages of exploration. When used in conjunction with other data sources and geologic analysis, Landsat can improve exploration programs.

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Paleogeography and Tectonic Implications of Late Cretaceous to Middle Tertiary Rocks of Southern Denver Basin, Colorado

In the southwestern Denver basin, the lower part of the Dawson Formation consists of point-bar sequences composed of andesitic detritus. Eastward, it thickens and becomes predominantly mudstone with subordinate thin point bars. The upper Dawson consists of a basal, eastward-thinning, wedge of feldspathic (braided stream) conglomerates followed by feldspathic or andesitic point-bar deposits, overlain by braided-stream arkoses. Dawson cross-bedding dips eastward. During lower Dawson deposition, the Front Range is interpreted to have only minor topographic expression because andesitic debris came from a source west of the Front Range and was deposited in meandering streams. Early Paleocene erosion of the first Laramide exposure of the Front Range basement produced the lower arkosic unit. Following meandering-stream deposition, a second major arkosic pulse of coarse braided-stream deposits prograded eastward (late Paleocene–early Eocene). Extensive Eocene erosion and stability followed until the Oligocene when the extensive Wall