motion made. Island chains and aseismic ridges, formed by plate motion over mantle hot spots, show the direction of motion of the plates over the mantle. It has been found that by adding a single constant to this relative motion synthesis, a system of absolute plate motion over the mantle can be established which satisfies the relative motion data and the island chain /aseismic ridge trend data. This evidence is used to support a theory of deep mantle convection whereby plumes rising beneath the hot spots provide the driving force for continental drift.

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TECTONICS AND STRATIGRAPHY OF DEAD SEA REGION

The Dead Sea rift is a key structural element in a region of tectonic complexity. It is a linear system of faults extending from the Gulf of Aqaba 1,200 km northward to the Taurus Mountains where it veers eastward, and disappears into the overthrust belt. Near the Dead Sea the fault has left-lateral offset of 130 km. The offset diminishes northward. In the Beka'a Valley an eastern branch divides, curves northeastward and loses identity in the Anti-Lebanon and Palmyra folds; a western branch continues northward.

The nature of the fault has been debated for 100 years, but recent exploration in Jordan and Israel provides control for isopach-lithofacies maps which clearly indicate offset strandlines of Cambrian, Triassic, and Cretaceous strata.

Principal movement on the rift occurred in late Oligocene or early Miocene time. The system has been one of weakness since the Precambrian as indicated by a strong north-south joint system in Paleozoic and Precambrian rocks. Offset stream drainage indicates Holocene movement. Oligocene and older rocks spread across northeast Egypt-Sinai without interruption but Miocene-Pliocene strata are confined to a trough in the Gulf of Suez with a meridian width up to 120 km.

The Dead Sea rift is conjugate with the Gulf of Suez–Red Sea block fault (graben) system. The northwest and northeast orientation of these faults is the result of a regional stress couple acting meridionally—the strike of the Dead Sea rift. Marginal foundering increased the width of the Red Sea.

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CLAY MINERAL COMPOSITION OF BEAUFORT SEA SEDIMENTS, ARCTIC OCEAN

Clay mineral composition of the less than 2- and 4-μ size fractions of Beaufort Sea sediments was analyzed by X-ray diffraction techniques. In all except one sample illite is the predominant (51.58–89.46%) clay mineral, kaolinite is present in significant amounts (10.54–42.82%), and chlorite is almost absent. These observations are interesting because of the generally accepted view that kaolinite is a "low latitude" clay mineral and chlorite a "high latitude" one. The presence of kaolinite in the Beaufort Sea is explained by the polycyclic nature of its sediments which have their primary source in kaolinite-rich Mesozoic sedimentary rocks of the North Slope. This explanation is indicated by the large (36.79%) amount of kaolinite in the Colville, the largest river draining from those rocks to the Beaufort Sea. The shore ice, presumably deriving its entrapped sediment from the hinterland, also contains large amounts of kaolinite. It is concluded that a part of this kaolinite is ice rafted to the deeper Beaufort Sea.

The use of clay minerals as a key for the inference of paleoclimates of source rocks on the basis of earlier generalizations may lead to erroneous conclusions, as attested by the present results. For a correct interpretation of paleoclimates it is suggested that clay-mineral data be substantiated by additional data, such as paleontologic and chemical.

Preliminary studies suggest that most illite of Beaufort Sea has formed by illitization of an illite-montmorillonite (?) type mineral.

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TRANSLOCATION OF CHEMICAL CONSTITUENTS AND PEDOGENESIS IN EARLY EOCENE WILLWOOD FORMATION IN NORTHWESTERN WYOMING

Chemical data on a 4-ft red mudstone, in association with intense color mottling, high fossil content, and great lateral extent, indicate the development of a soil (paleosol) within the red-banded, fluviatile Eocene Willwood Formation in northwestern Wyoming. Quantitative analyses of free iron, aluminum, and manganese from a vertical section through the mudstone indicates zones of concentration at the 16–30 in. and 35–42 in. intervals from the top. Mudstone textural analysis indicates increased amounts of fine clay (less than 10 Φ) in the 16–30-in. level. Organic carbon content throughout the profile is unusually high compared with similar Willwood mudstones. Carbonate minerals are essentially absent. The distribution of free aluminum through the profile displays a strong statistical correlation ($r = +.748$) to fine clay distribution, whereas free iron ($r = +.094$), free manganese ($r = -.160$), and organic carbon ($r = +.004$) show essentially no correlation to fine clay content.

Pedogenesis was characterized by organic matter concentration and mobile chemical constituent translocation to lower levels within a parent material of alluvium. Solution and movement resulted primarily from a shallow, fluctuating groundwater table, which produced alternating oxidizing and reducing conditions. Low concentration values and deeper movement of manganese compared with iron may reflect its higher solubility in the reduced state. Mobile ion concentration at the 35–42 in. level probably resulted from minor water table fluctuations directly above an underlying, more permeable sandstone. A significant reduction in the rate of sediment accumulation appears to be the major factor allowing for *in-situ* development of a soil upon the Willwood alluvial plain.

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ORIGIN OF TUFFS IN STANLEY GROUP, OUACHITA MOUNTAINS, ARKANSAS AND OKLAHOMA

Five major tuff sequences (8–120 ft thick) are interbedded with marine graywacke and shale in the 11,000 ft-thick Mississippian Stanley Group. They are present in the basal 1,500 ft and upper 350 ft of the highly folded flysch group. These widespread sequences are thickest and best exposed in the southern Ouachitas, but are traceable to the central Ouachitas.

Three tuff sequences are composed of massive and bedded crystal tuff; 2 are composed of massive and bedded pumiceous vitric-crystal tuff. All five sequences have massive and sometimes laminated fine-grained vitric upper portions. Crystal-rich and pumiceous tuff sequences probably reflect different settling and/or eruptive histories.

Crystal tuff sequences originated from crystal-rich magmas or from crystal enrichment by gravity sorting of pyroclastic debris settling through long water columns, possibly as a result of vulcanian-type submarine eruptions. Bedded crystal tuff was deposited from a series of ash falls and tuffaceous turbidites. Widespread slumping of bedded crystal tuff produced massive crystal tuff.

Pumiceous tuff sequences probably formed from Katmai-like eruptions. Thick, nonwelded pumiceous vitric-crystal tuffs commonly overlain by thin-bedded pumiceous tuffs were produced from submarine pyroclastic flows covered by contemporaneous ash falls.

Fine-grained vitric tuff formed from slow settling of very fine ash. The ash was possibly the finest size remnants suspended in settling columns after major eruptions and/or was produced by weaker ash falls. Rare cross bedding is evidence for some current reworking. Tuff thickness, grain-size trends, paleocurrent indicators, and paleogeography suggest a southern volcanic source, possibly the buried Luling overthrust front in Texas.

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Stratification in Willow Creek Alluvial Fan, Eureka Valley, Inyo County, California

Stratification in the entrenched main channel in the upper 5 mi (of 12) of Willow Creek fan was analyzed by means of continuous-strip photos and sections spaced 2,000 ft apart. Average and maximum bed thicknesses decrease, respectively, from 1.7 and 6.0 ft near the fan head to 1.0 and 3.9 ft downfan. Individual beds extend from 10 to >500 (700?) ft, although few beds extend >200 ft.

Gravel forms *pack* (framework), *pack-float* (transitional), and *float* ("puddingstone") fabrics. Most cobbles and boulders are subspherical and subround, and thus usually do not form distinctly oriented fabrics. Stream deposits exhibit distinct channel geometry, pack fabric, and little silt and clay. Mudflow fabrics vary from pack to float. Some are uniform; others grade laterally from float to pack within 25 ft. Mudflows show high length:thickness ratios; the majority of mudflows lack graded bedding. The ratio of mudflows to stream deposits exceeds 70% and increases downfan.

Float beds generally contain <40% gravel and >15% silt and clay, whereas pack beds usually contain >60% gravel and variable amounts of silt and clay. All deposits are poorly to extremely poorly sorted, and range from strongly coarsely skewed to symmetrical. Silt forms most of the matrix of mudflows, whereas clay ranges from only 1% to 7%. In the silt-clay fraction, feldspars exceed quartz, and clay minerals are minor in amount, the result of semiarid climate (17 in. rainfall/year), dominance of granitic rocks with large feldspar phenocrysts in the drainage basin (>60%), and predominantly mudflow transport.

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Contributions of Seismology to Plate Tectonics

The hard observational facts of seismology have been and are being used to test and develop the hypotheses of continental drift, sea-floor spreading, plate tectonics, and related matters. Three kinds of evidence are particularly important in such studies: (1) seismicity, (2) focal mechanisms, and (3) wave propagation and inferred earth structure. The quality and quantity of such evidence, especially types (1) and (2), increased rapidly in the 1960s as a result of new observational facilities, particularly the World-Wide Standardized Seismograph Network, established under the United States VELA Uniform Project.

In general, evidence from seismology strongly supports and contributes greatly to the new tectonics. Many major and previously unexplained observations, such as the spatial distribution of deep earthquakes and the worldwide pattern of seismicity and focal mechanisms, fall neatly into place. No serious obstacles to the new tectonics are found in seismology.

Present research on this topic is directed toward development and refinement of the model so as to explain the seismologic observations in greater detail. Many major, challenging topics for investigation remain.

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Salt Ridge–Salt Dome Origins in Gulf Coast Area

A working hypothesis of salt-ridge, salt-dome formation in the Louisiana Tertiary was formulated in 1957 to explain the observed phenomena along the Caillou Island, Timbalier Bay, Bay Marchand, West Delta Block 30, Venice, and Delta Duck trend: (1) regional down-to-the-north faults of very large stratigraphic throw on the southerly sectors of the domes; (2) a salt, deep-water facies shale ridge connecting Caillou Island, Timbalier Bay, and Bay Marchand at depth; (3) shallow occurrence of older deep-water shales beneath a condensed section on the upthrown sides of down-to-the-north faults; and (4) thick "normal" facies sections on the north flanks of the domes.

Application of results of seismic, bathymetric, and core data from the Gulf of Mexico continental slope gathered and interpreted by Lamont-Texas A&M and Shell groups shows that these phenomena are the results of wavelike salt ridge formation basinward from a prograding shelf edge due to differential loading.

Such ridges are present on the continental slope and the major down-to-the-north fault planes are postulated to coincide with the northern faces. The salt ridge grows asymmetrically in cross section, lifting the thinly covered upthrown block and allowing a thicker ponding of sediments on the landward downthrown block. Deep-water shales covering the early ridge roots join the diapiric action of the salt and are confined to the upthrown block until the salt breaks upward through the northward-dipping fault plane. As the salt is further buried by the prograding shelf sediments, it may leave the linear control of the fault and form individual domes with the commonly recognized pattern of shallow salt dome faulting and oil and gas accumulation.