should be found in the upper marine shoreline sandstones wherever they are well developed.

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EARTH RESOURCE PHOTOGRAPHY—PAYOFF IN SPACE

Spectacular successes in lunar flights and in weather and communications satellites demonstrate presently available technology for obtaining worldwide color photography. The synoptic perspective afforded by satellite photography adds a new dimension to geologic investigation, as demonstrated by interpretations of many photos from Gemini and Apollo flights.

A logical first step in an earth resources program would be a small, automated, short-lived, film recovery stereoscopic color coverage of the entire earth's land area. Among the advantages of such a program are (1) effective geologic interpretation of the data is readily available, (2) obsolete maps could be updated throughout the world, and (3) standards would provide for interpretation of later, more sophisticated data.

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GEOMORPHOLOGY—INTERESTING ACADEMICS OR APPLIED SCIENCE?

A new era for geologic exploration is emerging for 2 basic reasons: (1) exploration methods of the past are simply not adequate to meet the present and future demands of a burgeoning world population with an accelerated appetite for mineral and petroleum resources, and (2) the space age is bringing with it new technology that holds great promise for revolutionizing the exploration techniques of yesterday.

Notable advances in exploration within the past decade have been made in on-the-ground geophysical technology. The new devices have proved effective for accurately detecting deep-seated petroleum structures and buried mineral deposits. However, by their very nature, involving great expense in relation to area analyzed, these are for the most part detailing or focusing tools that must be used selectively in areas having the greatest exploration potential. A prerequisite to their proper and efficient use is the conduct of effective preliminary reconnaissance surveys to localize the areas of most promise.

The greatest hope for meeting the challenge of the future lies in achieving commensurate advances in reconnaissance exploration technology. Broad-scale exploration programs must be planned and conducted from a regional framework of understanding. An integrated exploration concept utilizing a wide and varied range of reconnaissance remote sensing devices offers the greatest potential to achieve the necessary broad perspective.

What is the role of photogeology in general and applied geomorphology in particular for these new exploration programs? For effective reconnaissance exploration, the surface is the place to begin—not only in areas of abundant outcrops and obvious structure, but also in glaciated regions, dense jungles, or featureless coastal plains, areas where the surface has previously been neglected in the search for oil, gas, and minerals. The practical application of geomorphic principles to these problem areas offers interesting possibilities for future large-scale exploration programs.

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FRACTURED SHALE AND BASEMENT RESERVOIR, LONG BEACH UNIT, CALIFORNIA

The Wilmington oil field in the south-central Los Angeles basin has produced oil from fractured basement rocks since 1945. Oil was discovered in a fractured upper or middle Miocene shale and basement reservoir by Thums in the Long Beach unit in March 1968. Oil production is from a southeasterly-thickening prism of fractured black micaceous shale, siltstone, cherty shale, and marly limestone up to 1,385 ft (421 m) thick, and from fractured Franciscan schist. The black shale is correlated with the Palos Verdes Peninsula Altamira Shale of early Mohnian and Luisian age. No definite unconformity has been recognized in the black shale member in contrast to the strong hiatus commonly seen between the upper and middle Miocene in the Los Angeles basin.

The absence in Long Beach unit wells of a thick schist breccia and associated volcanic rocks cored at Seal Beach 3 mi (4.8 km) northeast, indicates a northeasterly source of sedimentation. Correlation with similar rocks across the Newport-Inglewood fault zone suggests a possible 15 mi (24 km) of right-lateral displacement.

The oil is thought to have originated in the shale and to have migrated into an interconnected network of vertical, high-angle and horizontal fractures with migration occurring during several geologic episodes. The fracture system was produced by breakage of the brittle rocks along fold axes and adjacent to the larger faults.

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DYNAMIC RELATIONSHIP BETWEEN ESTUARY HYDRAULICS AND SEDIMENTATION

Flood- and ebb-tide cycles produce differing bedforms, sedimentary structures, thicknesses of sedimentary units, and most important, grain-size distributions. Differences are the result of changes in bed shear, flow regime, and mechanisms of sediment transport.

The salt wedge developed in flood-tide flow produces a stratified estuary with highest flow velocity below the highest rate of salinity change. This relation results in upper flow regime as predicted by the densimatic Froude relation; trochoidal sand waves to 2 m in height are formed. Surface waves and internal waves are seen in the salinity stratification. Ebb flow modifies the sand wave surface, and sediment transport is by ripples and dunes in the lower flow regime. Large-scale planar crossbedding is produced by flood flow; small-scale ripple and dune structures are developed by ebb flow.

The estuary is an effective mechanism for size segregation. Suspension populations are removed by both flood and ebb flows. There is a net inland transport of suspended sediment with deposition on tidal flats and marshes. A single log-normal source population is fractionated into several differing populations by bedload transport, suspension, and recycling during successive tidal cycles. Characteristic log-probability size distributions are developed in different environments.