domes (which are probably deep-seated salt domes); anticlinal closures associated with regional syn-depositional faults; fault closures; and stratigraphic traps on the flanks of structural noses or closures where no hydrocarbons are trapped on the apex of the structure.

The total estimated ultimate recovery of 691 fields in the area is 9,057,003,000 barrels of oil, 2,223,215,000 barrels of condensate, and 85,688,836,000,000 cubic feet of gas. Using an economic value of one barrel of oil equals 15,000 cubic feet of gas, the total ultimate recovery of hydrocarbons is equivalent to 16,959,196,000 barrels of oil.

Salt domes account for 17.9% of the number of producing fields, 61.09% of the ultimate oil, 18.48% of the ultimate condensate, and 19.48% of the ultimate gas recovery. *Circular* or *elongate domes* account for 20.98% of the producing fields, 18.96% of the ultimate oil, 47.94% of the ultimate condensate, and 47.15% of the ultimate gas recovery. *Anticlinal closures associated with regional syndepositional faults* account for 20.41% of the producing fields, 12.63% of the ultimate oil, 21.88% of the ultimate condensate, and 22.09% of the ultimate gas recovery. *Fault closures* account for 31.74% of the producing fields, 6.43% of the ultimate oil, 9.61% of the ultimate condensate, and 9.04% of the ultimate gas recovery. *Closures on regional noses* account for 3.91% of the producing fields, .56% of the ultimate oil, 1.13% of the ultimate condensate, and 1.29% of the ultimate gas recovery. *Stratigraphic traps* on flanks of structural noses or closures account for 5.06% of the producing fields, .36% of the ultimate oil, .86% of the ultimate condensate, and .95% of the ultimate gas recovery.

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LOCATING THE SOURCE OF SANDS IN FLYSCH TROUGHS

Field characteristics of sand units are stressed in most flysch studies. Megascopic properties of lithology, stratification, and sedimentary structures are essential for interpretation of depositional environments and directions of sediment transport within mobile belts. Problems related to the *source* of sands, however, cannot be solved by field work alone.

In certain studies, two of the most important questions concerning source remain unanswered:

(a) What was the nature of the parent-rocks exposed in the source area?
(b) Where was the source area with respect to the site of flysch accumulation?

Petrographic examination of sands on a regional scale is required to help solve these fundamental problems. Heavy mineral studies are particularly useful in providing paleogeographic information. Heavy mineral assemblages display a lack of diversity (small number of mineral species) in almost all flysch formations where they have been examined. These assemblages are invariably mature to supermature (high percentages of resistant minerals). Sands containing assemblages of this type were probably derived from terrains already lacking a diversity of minerals. Thus, sands in many flysch troughs were largely derived from older clastic formations (re-sedimentation or "cannibalization" process) exposed within or adjacent to the mobile belt.

Furthermore, the distribution patterns of light and heavy mineral fractions vary laterally in these formations indicating the presence of local sediment sources along mobile belts. Petrography serves as a check on the relative importance of lateral versus longitudinal transportation of sands in flysch troughs.

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DIRECTION OF CRUSTAL MOVEMENTS INDICATED BY EARTHQUAKE DATA

Two factors make desirable a re-evaluation of the inferences, drawn from seismic data, concerning the direction of crustal movements: 1) the revision of published fault plane solutions, occasioned by questions of the reliability of the solutions and by the recognition of bias in favor of strike-slip faulting; 2) the development of other methods, including the use of S waves and the application of surface waves in determining the directivity, dimensions, and initial phase of the source.

The most extensive seismic data pertinent to crustal movements are associated with the borders of the northern Pacific Ocean. Data from the smaller earthquakes (magnitude $6\frac{3}{4}$–$7\frac{1}{4}$) indicate predominantly reverse or thrust faulting along fractures parallel to (e.g. Kamchatka-Kurile Island arc) or oblique to (e.g. Aleutian Islands) the trend of the tectonic features, with a lesser transcurrent component of motion. The principal compressive stress is nearly horizontal and is directed normal to the trend of the arc. The major earthquakes, on the other hand, especially as inferred from the data of surface waves, are predominantly strike slip. Fracturing extends for hundreds of kilometers and parallels oceanic deeps.

Examination of other regions, especially South America and regions of the southwest Pacific, permit inferences related directly to the underlying causes of crustal movement.

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LOCAL VARIATIONS IN EARTH TIDES

Observations in various parts of the world show marked inconsistencies in the apparent deformations produced by earth-tides; such variations may in large part result from errors of measurement. However, horizontal variations in crustal composition must produce effects of this kind, and accordingly an attempt has been made to estimate the order of magnitude of such anomalies. The very complicated elastic problem could be solved numerically if we had any idea of the changes of composition involved. In default of such information, a two-dimensional model has been investigated, using a method of successive approximation. Two cases are of special interest—(1) where changes of elastic constants are appreciable within a small fraction of the circumference of the Earth, and (2) where the wave-length is one-half of the Earth's circumference.

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AGE OF SOME CALIFORNIA COAST RANGE LOWER TERTIARY MARINE RED BEDS

Microfossils, including benthonic and planktonic foraminifera as well as coccolithophorids and related nannoplankton, are abundant in the marine red beds of the California Coast Ranges. These have usually been assigned a middle Eocene age. Comparative studies of the foraminifera and nannoplankton in these red beds have revealed two of these microfossil assemblages (from San Miguel Island, Santa Barbara, and the Oakland hills) to be of Campanian, Upper Cretaceous age; two others (from the lower red bed, type Anite Shale and the lower Lodo, Media Aqua Creek) are known to be of Paleocene age. However, the bulk of both the foraminiferal and nannoplanktonic assemblages collected from several geographically distinct areas throughout the Coast Ranges represent the Penutian (West Coast lower Eocene) and/or Ulatisian (West Coast middle Eocene) Stages.

Moreover, the foraminiferal faunal change which characterizes the Penutian-Ulatisian boundary, as well as the nannoplanktonic faunal change found to correlate widely with this foraminiferal change on the West Coast, occur within or close to the Poppin Shale of the Santa Barbara Coast and several of its Coast Range correlatives.

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The Surf-Break: Key to Paleogeography?

The most important element in paleogeography, and perhaps the most difficult to locate, is the shoreline. Specific indicators are rare, faint, or easily destroyed. Nevertheless, we require a "key" which will permit us, tentatively at least, to identify ancient coasts.

River sands placed on modern beaches are modified in a systematic way. The distribution below a critical diameter is filtered to provide a new, distinctive, size curve. The result is an inflection so located in many samples that it does not appreciably affect the standard deviation. The inflection, or "break," which results from surf action may not be an absolute indicator, but it appears to be fairly good. This has been verified observationally (studying near-shore sands) and experimentally (placing fluvial sands in the breakers).

Under wave action, the "surf-break" starts in the "fines" and moves into the coarser sizes. The rate at which it moves is a measure of wave energy level; hence its position depends on both wave energy and duration-of-working. The "surf break" should be common in sands worked by low to moderate energy waves; along coasts having moderate to high energy breakers, the inflection may be missing due to an absence of material coarse enough to record it.

Shorelines of interior seas, such as ancient seaways, are generally marked by low to moderate wave energy levels. Hence the "surf break" may be a widely useful, although not foolproof, device.

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The Use and Detection of Fluorescent Sand Tracers

Two recent developments, fluorescent tracers and a fluorescent particle counter, hold promise as practical means to the quantitative evaluation of littoral drift and sediment transport in rivers. Unlike radioactive material, luminophores present no health hazard or storage problems, offer a wider range of applicability, can be recovered in samples, and are more economical to use. The fluorescent tracers have been employed in studies of such specific problems of sediment migration as beach erosion, inlet stability, dune processes, and artificial beach nourishment.

Fluorescent dyes and thermosetting plastics have been combined to coat sand in a process designed to produce the tracer material, so that the physical properties of tracers and the sediments are nearly identical. Of the several materials and techniques tested, urea-formaldehyde resin, fluorescing organic dyes, and a catalytic procedure imparted the best chemical and physical characteristics to the tracer grains.

The application of tracers to sand transport studies became practical only with the invention of the fluorescent particle counter. This instrument provides a rapid and accurate method of frequency determination of tracer particles in sand samples, and therefore affords a much needed statistical treatment of sediment transport. The particle counter has been built on the principles of optics, electronics, and threshold decision logic, to differentiate simultaneously for four tracers, the fluorescent colors of which have been established through spectrophotometric measurements. Tracers in samples with concentrations varying from 10^{-7} to 10^{-2} are counted, tabulated, and recorded at the rate of 20,000 particles/second.

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Origin of Pisolites

The Permian pisolites of the Guadalupe Mountains of southern New Mexico and west Texas have been widely accepted as being a by-product of algal activity in the shallow lagoonal area behind the platform margin of the Delaware Basin. If this interpretation were correct, one would expect to find smooth pisolite laminations formed by the algae and not the crenulate laminations seen in some of the pisolites. One would also expect to see developed stratification, and interlayering with stromatolites and other algal deposits. Evidence of pisolites being formed by algae somewhere in the world today would be anticipated.

Evidence shows that such conditions are not applicable to the Guadalupe Mountain pisolites. The field relationships suggest that the pisolites developed in porous and permeable calcarenites by a weathering-soils process. The area behind the platform margin was periodically subaerially exposed. The climate was arid with occasional wet periods. The downward migrating surface waters leached calcium carbonate from the upper layers and concentrated it in the lower layers as films or laminae about nuclei. These dense concentrations are the pisolites; they compare very favorably with caliche deposits in the area.

The environment can be completely misinterpreted if the pisolites are thought to have formed in a shallow sea when they actually formed in the soil of an arid climate.

Knowledge concerning the factors which produced the pisolites in the Guadalupe Mountains should be applicable in studies of pisolites elsewhere.

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Geology, Geophysics, and Their Common Ground

During the past ten to fifteen years many subjects for papers and topics for symposiums have hinged about pleas for closer cooperation between geologists and geophysicists. The popularity of the subject reflects the increased effort required to find new oil reserves and suggests the possibility that one group of professionals suspects the other of not doing all they can to make the job easier. This polite but definite pointing of the finger is a natural and human reaction to the necessity of facing an unexpected and unpleasant situation.

Any altercation between a geologist and a geophysicist can literally and figuratively be described as a family fuss—for a family we are. We feed from the same trough, we are subject to the same management, and we have exactly the same objectives, i.e., the discovery of more oil at less cost. In certain areas, we use the same tools and speak exactly the same language, but from the