shelf level. The lower part of the continental margin (continental slope) increases in average declivity from about 1° to 10°, and is modified by numerous ridges, hills, benches, and valleys.

Stratigraphic, structural, and geophysical data suggest that during the Tertiary as much as 20,000 feet of sediment accumulated off the central coast of Oregon in the area of the present continental shelf.

Recent sediments in this region consist of well-sorted, fine to very fine, detrital sands on the inner shelf, grading to poorly-sorted glauconite-rich clayey silts on the outer shelf. Continental slope sediments are primarily clayey silts containing small percentages of Foraminifera, radiolarians, diatoms and sponge spicules.

Lithologic and faunal similarities of the Recent sediments to sedimentary rocks exposed along the coast and on the shelf and slope indicate that deposition during late Tertiary time occurred in shelf and slope environments. The fossil faunas also indicate that parts of the continental margin may have been uplifted as much as 4,000 feet since the late Tertiary, and that there has been a general westward shifting of the sites of sediment accumulation.

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PALYNOLOGY OF MODERN SEDIMENTS, GULF OF CALIFORNIA AND ENVIRONS

Several hundred bottom samples from the Gulf of California, distributed systematically over its entire area, and comparable samples from streams and arroyos in all surrounding areas, have been analyzed for spore and pollen content and for qualitative and quantitative relationships of various groups of these palynomorphs to each other and to other associated organic entities of comparable size.

Some of the more conspicuous concentration patterns of these palynomorphs indicate distance from shoreline, current patterns, depth of water, coarseness of sediment, seasonal wind patterns, and some source-vegetation distribution areas. Other distribution patterns are complicated by unidentified factors or combinations of factors among which the principal controlling agency is not discernible.

Conspicuous concentrations of spores occur off the months of the major tributary streams, adding evidence to the conclusion that stream transportation plays an important role in spore distribution. Spores from the mainland, particularly from the slopes of the Sierra Madre Occidental, reach the Gulf principally by way of the streams because the prevailing winds would not contribute extensively from this direction. A heavy concentration of palynomorphs off LaPaz is due in part to the effects of wind distribution from the tropical vegetation on the southern tip of the Baja Peninsula and in part to the interruption of the long-shore currents by the configuration of the structurally controlled southern tip of the peninsula and by the position of some offshore islands.

There is generally an increase in total number of palynomorphs seaward from very low amounts in the narrower belt of shallower coastal waters, and then a gradual diminution toward the center of the Gulf. The pollen frequency is less in the very shallow areas and in the very deep basins. Relative frequencies of spores are about the same for the various types of sediments except the coarser types. Some correlation of patterns of palynomorphs and radiolarians is indicated, but there is no clear relation of spore patterns to the distribution of diatoms and some other organisms.

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DEFINING A GRADIENT IN A SAMPLE OF SEDIMENTARY ROCK

Three orthogonal planes (two vertical and one horizontal with respect to the recognizable bedding structure) of a core sample of apparently graded graywacke sandstone have been petrographically analyzed in order to determine the characteristics of the lithologic gradients in the specimen.

Compositional and textural properties were sampled in thin section according to an orthogonal grid pattern on each of the three faces.

Variability among rows and columns (plus interaction) with respect to each petrographic variable was tested by analysis of variance using a two-cross classification. A larger number of properties show significant variability among rows (in a vertical direction) in the two vertical planes of the specimen than in the horizontal plane.

Quality control models with confidence limits which expose graphically the trends displayed by individual constituents indicate that feldspar proportion, mica proportion, and quartz grain size show significant gradients in the vertical direction perpendicular to the bedding. Quartz proportion oscillates in a non-systematic fashion, and quartz grain shape shows no trend in the vertical planes of the specimen. The petrographic variability observed in the horizontal plane of the bedding is generally trendless. Independence of the individual gradients is apparent, reflecting the influence of explicit processes on the spatial distribution of the petrographic variables in the rock.

Partial trend surfaces show the trends in quartz grain size to be dominant, according to the comparative amounts of variance accounted for by each fitted surface. Again, the major portions of variability are explained by the surfaces in the planes perpendicular to the bedding. The textural homogeneity of the rock in the horizontal (bedding) plane is reflected in the minor trends defined by the surfaces in this direction.

These results indicate that only apparent gradients in the lithologic properties of the rock are detectable by these methods. To assess accurately the "real" gradients, rotational transformations, which would bring the faces into complete orthogonality with the trend, and criteria (such as maximum variance explained) should be employed.

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DIAPIRIC STRUCTURES AND UPPER PROTEROZOIC TO LOWER CAMBRIAN SEDIMENTATION IN THE FLINDERS RANGES, SOUTH AUSTRALIA

During deposition of the Adelaide System (Upper Proterozoic) and Lower Cambrian Series, which together exceed 50,000 feet in thickness, an incompetent dolomite-siltstone sequence (Callanna beds) formed piercement structures which influenced sedimentation.

More than thirty discrete diapiric structures occur along fairly well-defined trends which are regarded as a basement fault system. Surface diameters of the eroded cores of the domes range up to several miles but the injection of carbonate-siltstone breccia has caused complication of some folds and resulted in irregular bodies with dike-like tongues.

[1] Published with the consent of the Hon. Minister of Mines for South Australia.

The main period of folding in the early Paleozoic has resulted in cross-sectional exposures of several diapirs. Bald cap structures and interdigitation of conglomerates with basin sediments along the flanks of the domes indicate repeated phases of diapir movement. Adjacent diapirs show evidence of uplift at widely different times from the glacial phase of the Late Proterozoic to the Early Cambrian.

Boulder trains derived from the core of one diapir (Enorama) successively onlap along the flank of the structure and the unconformity may be traced for several miles. The same stratigraphic units (Umberatana Group) on the opposite flank, are truncated by subsequent movements of the core.

An example of a structure of irregular form is the Arkaba diapir, which shows control over facies and thickness from the top of the Umberatana Group through the Wilpena Group to the Lower Cambrian.

Other structures (Frome and Wirrealpa diapirs) exist on an important hinge zone which controlled Lower Cambrian deposition. The Frome diapir shows repeated intervals of erosion near the Adelaide System-Cambrian boundary and offers exposures of both diapiric and depositional contacts. The Wirrealpa diapir and associated faults separate a Lower Cambrian sequence to the south, comprising two formations (2,000 feet in thickness) from an equivalent section to the north, of seven distinct units totalling 10,000 feet in thickness. The diapir core was eroded during this interval.

Exposed is a cross section of a graben which developed during the early Cambrian above a diapir (Oraparinna), the bounding faults of which controlled the development of an *Archaeocyatha* biohermal bank which intertongues with basinal facies.

Diapiric structures which affected late Proterozoic and early Paleozoic deposition have been recorded 750 miles to the northwest of this province from the Amadeus Basin in central Australia. Evaporitic deposits there are reported within the Bitter Springs Limestone which occurs below a late Proterozoic glacial unit.

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BATHYSCAPH OBSERVATIONS IN THE LA JOLLA SUBMARINE FAN VALLEY

Observations, made from the bathyscaph *Trieste* during six dives to depths ranging from 1,800 to 3,000 feet, reveal that submarine erosion is actively modifying a series of step-like terraces forming the internal walls of the La Jolla Submarine Fan Valley. The innermost terrace is cut by a narrow, steep-walled, flat bottomed channel that forms the longitudinal axis of the valley. Beneath a thin mud cover, the channel contains sand and plant fill that is entirely different from that found on or forming the internal terraces. The steep slopes (up to 70 degrees), found where the innermost terraces lead down to the inner channel, have slump scars, striations, and fresh burrows that indicate they are presently being eroded by marine processes. Terrace sediments are bedded and semi-consolidated and do not appear to have been deposited in the present erosional environment of the canyon. On one of the dives, large rounded rock boulders, up to 3 feet in diameter, were found scattered through the interbedded sand, mud, and plant material found in the inner channel. The nearest possible source for these large erratics is more than one-fourth of a mile from their present location.

The following characteristics are arguments against dense, high-velocity turbidity currents as agents of erosion or transportation in the present day La Jolla Fan Valley: (1) the lack of scour depressions around large man-made objects found in the sands of the inner channel, (2) the sinuous course of the inner channel, (3) a low axial gradient, (4) a lack of inner channel sediment on terraces 10 feet above the channel bottom, and (5) the heterogeneous mixture of fragile sea-grass mats, large boulders, and micaceous sands.

Pulsating bottom currents with velocities up to 0.45 knots have been measured. These currents were observed to have sufficient strength to transport fine micaceous sand and unconsolidated clay-sized particles along the bottom of the inner channel. However, the large boulders associated with sands and organic debris, foreign to the surrounding sea floor, must have been transported by another mechanism; gravity creep and progressive slumping of the entire fill of the erosion channel are suggested agents.

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VADOSE PISOLITE IN THE CAPITAN REEF

New evidence on the origin of the pisoliths of the Permian Capitan Reef Complex indicates that they are not of lagoonal algal-nodule origin, but are early vadose concretions and probably Permian pisolitic caliche. If the reinterpretation is valid, the pisolite implies that (1) the climate was dry, (2) the reef complex was subaerially exposed repeatedly during its growth, with attendant opportunities for diagenetic alteration of porosity and for "inorganic binding," and (3) the paleotopographic crest on the complex was not in the so-called organic reef-rock, that is, in the sponge-bearing lime wackestone of the Capitan facies, but instead was in the dolomitized grainstone of the Carlsbad facies.

Basic to the older interpretation is the requirement that the pisoliths rolled about during growth. [Algae cannot grow downward so as to encrust the bottom side of objects at rest, due to their need for light and to the resistance of the substrate.] Evidence of *in situ* downward growth (consisting of fitted polygonal structure, downward elongation of pisoliths, and inclusions of silt perched in the upper parts of concentric growth layers), together with the lack of admixed sediment and of sedimentary structures characteristic of gravel-size deposits, indicate that the pisoliths are not algal nodules, nor even transported sediment, but are concretions.

Evidence that the growth of pisoliths was commonly interrupted by leaching and nontectonic fracturing and was closely associated with cementation and internal sedimentation of silt requires that the concretions grew in a diagenetic environment characterized by complex variability and by water moving rapidly enough to transport silt. The vadose zone alone seems to meet this requirement. The Permian pisoliths significantly resemble known vadose concretions, especially those of pisolitic caliche.

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UPLIFTS, THE PRIMARY STRUCTURES OF DEFORMATION IN THE SHELF AND MIOGEOSYNCLINE OF THE WESTERN UNITED STATES

The large asymmetrical and elongate domes that constitute the basic structure of the ranges of the shelf province of Montana, Wyoming, Colorado, New Mexico, and the Colorado Plateau of Utah and Arizona are depicted as primary structures with the flanking thrusts as secondary gravity slide phenomena.