The composition of common clinopyroxenes may be defined by measurement of the optical properties $2V_z$ and β. The mole-per cent composition thus obtained differs from that obtained by chemical analysis and for some varieties there is no reliable correlation between the optical properties and the chemical composition. For a diopside from Oka Complex, Quebec, the optical properties ($2V_z=56°$, $\beta=1.685\pm.001$) gave 48.1:41.9:10:0 for the Ca:Mg:Fe ratio, using the best curves available (Hess 1949), and the chemical analysis revealed the ratio 49.4:45.4:5.2.

We have applied optical properties to the determination of Ca:Mg:Fe ratio in various clinopyroxenes and we have observed the following degree of error by referring the composition determined by optical properties with that determined by chemical analysis

1. Diopsides-hedenbergites (mean value of error for 17 specimens) Mg:8.2 Fe:5.8 Ca:4.8
2. Augites (mean value of error for 7 sepcimens) Mg:3.6 Fe:4.5 Ca:3.6
3. Ferro-augites (mean value of error for 7 specimens) Mg:6.0 Fe:6.1 Ca:3.4

It may be possible to obtain a better definition of that composition by exact intensity measurements of X-ray powder diagrams. Several measures on a group of six clinopyroxenes reveal this possibility.

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Geochemistry of the Sulphur Isotopes and Petroleum Exploration

Early investigations of the sulphides and sulphates in sedimentary rocks showed wide variations in the abundance of the sulphur isotopes. More recent investigations of petroleum and related materials show that these also vary markedly in their sulphur isotope content. It is now known that the biological sulphur cycle and in particular the bacterial reduction of sulphate is largely responsible for the fractionation of the sulphur isotopes in nature.

In the interpretation of the sulphur isotopte distribution data in terms of natural processes and earh history, it is essential that we know the base levels of isotope ratio from which fractionation began as well as the extent of fractionation which can occur in any process. Since petroleum is usually formed in a marine or marine-like environment, it is important that we know the sulphur isotope ratio of the sulphate in the oceans and how this ratio has been changing throughout geological time. An extensive study of evaporites in various sedimentary basins has been carried out by Thode and Monster (1962). It is clear from their results that the sulphur isotope ratio of the evaporites reflects the environment and sulphur isotope ratio in the basin at the time of deposition. On the assumption that the lowest S^{34} enrichment found in the evaporites of a given geological period from various sedimentary beds will give the closest approach to the value of the ocean sulphates of the period Thode and Monster have determined the S^{34} content of the ancient seas. The results clearly show that the sulphur isotope ratios of the oceans have changed with time in a complex but cyclic fashion.

The sulphur isotope ratios of petroleum samples also reflect these changes. In particular, these ratios appear to reflect the isotope level and environment of the basin during the time of petroleum formation. However, the petroleum ratios are displaced from those of the contemporaneous evaporites by about $15°/_{oo}$ which is the fractionation to be expected in the bacterial reduction of sulphate. These results suggest that it is the reduced sulphur which becomes incorporated into the petroleum and that ocean sulphate, or sulphate of a large inland sea, is the source of petroleum sulphur. It is not surprising, therefore, that the pattern of isotope distribution in petroleum and related materials in non-marine sediments is completely different from that of those of marine origin. These results will be discussed from the point of view of petroleum exploration.

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Fluvial Processes as Interpreted from Ancient and Recent Fluvial Deposits

Detailed outcrop studies of fluvial deposits in the Missourian of Oklahoma and the Atokan of the Arkoma basin have revealed a systematic vertical variation in grain size, sedimentary structures, bedding characteristics, and morphology of sedimentary units. The frequency with which this "ideal" sequence is developed suggests a common process in the deposition of many of these fluvial sandstones. The "ideal" vertical sequence is as follows: (1) a lowermost festoon cross-bedded zone related to sand wave and (or) "dune" transport; (2) a parallel laminated zone deposited in low amplitude sand waves or in a plane bed; (3) a fine-grained symmetrical ripple zone containing sediment formerly transported in suspension; and (4) a laminated clay and fine-grained sand zone deposited from suspension (commonly outside of the fluvial channel). This sequence has been found in both Recent and ancient fluvial deposits.

Flume and river studies have demonstrated that specific sedimentary structures are directly related to sediment transport and the dynamics of open channel flow. Sedimentary structures in the ancient sandstones of the study area were related to bedforms described from Recent channels. Furthermore, additional information on the morphology of the fluvial channels was obtained from an analysis of the thickness and distribution of specific zones.

The grain-size distribution of the fluvial sands of the study area suggests an upward decrease in energy. Both the mean and maximum grain size decrease upward, and the sediment is progressively more poorly sorted upward. These changes are directly related to variation in the type and size of the sedimentary structures. Discontinuities resulting from successive floods were identified by abrupt changes in grain size and (or) in the sequence of sedimentary structures.

The "ideal" vertical sequence, as given is commonly encountered in the field. This suggests some common underlying cause. This study illustrates that use of the flow regime concept, together with an understanding of river hydraulics and channel behavior, can provide a better insight into fluvial sedimentation.

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Telluric Currents and Their Use in Petroleum Exploration

Telluric currents are electrical currents in the earth induced by ionospheric disturbances. They are always present and contain all frequencies, from cycles per day to cycles per second.

The currents and their associated magnetic fields (micropulsations) provide sensitive indications of changes in electrical conductivity in rocks, such as commonly occur at basement, at shale-limestone interfaces, at faults, etc. Provided that the geometry of the structure is simple enough and that adequate conductivity contrasts exist, measurements can be interpreted in terms of structure. Hence, one can outline basement depth in a sedimentary basin, measure depth to weathering, or delineate a fault by telluric current methods.

The measurements can be made in a number of different ways, among which are the telluric, magneto-telluric, and wave-tilt techniques. Several of these are being actively studied by various research groups. Instrumentation depends on the depth of investigation desired, as well as on the technique used, but seems to present no fundamental problems for exploration applications.

The major problems at the present time are analyzing and interpreting the measurements. Anlaysis (filtering) is now being done in a routine fashion by digital computers, but could be done electronically. Interpretation techniques at present allow at least semiquantitative depth estimates ($\pm 10\%$) and can possibly be refined to enable greater accuracy.

Results of our magneto-telluric measurements in areas of well-known geology show that reasonable information can be obtained by rather brute-force interpretation techniques.

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BASEMENT CONTROL IN THE STRUCTURAL EVOLUTION OF SOUTHERN OKLAHOMA

Southern Oklahoma comprises a complex of structural elements that can be related to recurrent movement on a system of basement faults that had its origin at the time of consolidation of the crystalline basement. Repeated trans-current movements, accompanied by uplift of horsts and deep subsidence of adjacent grabens delineated by this major fault system, have exerted a profound control over the stratigraphic and structural evolution of southern Oklahoma.

The larger faults, the Meers fault of the Wichita Mountains, the Washita Valley and Sulphur faults of the Arbuckle Mountains, and the Choctaw fault of the Ouachita Mountains dominate the minor faults and delineate the major basement blocks, namely, the Wichita block, the Tishomingo-Belton uplift, and the frontal edge of the Ouachita Mountains and the intervening basins. The interplay of these basement controlled blocks and their adjacent grabens has not only influenced sedimentation by establishing the pattern of basin development but they controlled the magnitude and type of tectonism that has occurred throughout the Paleozoic Era.

Transcurrent movement, according to the wrench-fault mechanics of Moody and Hill, on the major faults which border the basement blocks has produced the stress field responsible for the structural complexity produced during the several stages of the orogenic climax in late Paleozoic time.

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OXYGEN ISOTOPE RATIOS IN FRESH-WATER LIMESTONES AS SENSITIVE PALEOCLIMATIC TEMPERATURE INDICATORS

Oxygen-18/Oxygen-16 ratios of marine limestones and calcareous organisms have been widely applied to the determination of water temperatures of ancient oceans after the technique was developed by Urey et al. The use of the carbonate paleogeothermometer has not been extended much past the Cretaceous because of uncertainties in the oxygen isotopic composition of pre-Cretaceous seawater and because of the possibility of isotopic exchange between marine carbonates and isotopically lighter intrastratal fluids.

Freshwater limestones and fossils have not been used for paleotemperature determinations because of the great variation in the O^{18}/O^{16} ratio of the water in which these carbonates were precipitated. Such variations arise from differences in latitutde and altitude at which meteoric precipitation of water took place, the origin and history of the air mass, and the extent of evaporation of stream and lake water. Duplicate isotopic analyses of 157 proven fresh-water limestones of Devonian to Quaternary age which were formed in large bodies of water, excluding saline lakes, and which show no signs of isotopic alteration, suggest that the variation is random and that a large number of samples may provide a mean δO^{18} value which is temperature dependent. Mean δO^{18} values are: Devonian (-8.57), Pennsylvanian (-5.25), Permian (-4.36), Triassic (-5.12), Jurassic (-8.52), Cretaceous (-10.22), Tertiary (-9.65), Quaternary (-8.15), in permil, relative to the Chicago PDB standard. The results form a regular sinusoidal curve with O^{18}/O^{16} maxima in the colder periods of Permo-Caboniferous and Quaternary glaciation, and a minimum for the Cretaceous. Large bodies of fresh water, because of a greater response to worldwide temperature fluctuations than the oceans, form limestones whose isotopic composition may yield significant paleoclimatic information in the form of relative climatic temperatures.

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COMPOSITION AND STRUCTURE OF THE KEEWATIN VOLCANIC ROCKS

Approximately three hundred Keewatin volcanic rocks have been analyzed from nine greenstone areas in the southern part of the Superior province. Basalt-andesite-dacite-rhyolite series are typical of each area and indicate a continental orogenic origin. The non-spilitic composition of the lavas confirms the continental orogenic origin rather than volcanism during accumulation of geosynclinal material.

A regional study of the volcanic areas shows that each area is merely a part of a great volcanic province instead of a series of subparallel volcanic belts. The present state of the volcanic formations is related to the depth of the granitic crust, to the intrusion of granite diapirs, and to major slip folding involving the volcanic series.

The continent was present before the Keewatin volcanism. The earliest known rocks of the Shield consist of a series of sedimentary rocks, possibly 20 km. thick, from which the Kenoran granites were derived by crustal melting.

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CONODONT DISTRIBUTION IN A MIDDLE ORDOVICIAN LIMESTONE

A 59-foot section of the upper Cobourg formation (upper Middle Ordovician) at Colborne, Ontario, was sampled at 2-foot intervals without regard to bedding. The limestone is thin-bedded biomicrite and biosparite,