come a general service field providing new concepts and techniques to industry, but this will require: (1) better utilization of publications and meetings, (2) early declassification of non-critical military information and greater awareness of its availability, and (3) training and utilization of a new class of physical scientist.

As an example, a general investigation into the effects of laser beams on natural targets led to a concept of compositional probing which is specific for one material, ruby. The same principles may have interesting applications in the direct detection of oil and gas at the surface from low-flying aircraft.

In any case, the petroleum geologist needs to be aware that this and other new systems are constantly appearing, and that some of them may aid him in his specialized work.

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Modal Functions of Sediment Size Distribution

Variation in sizes of sediment particles deposited together under the same hydraulic regime is related to normal fluctuations in fluid properties and to differences between particle shape and specific gravity. Differences in size-frequency distributions between mineral species can be ascribed to these fluid and sediment properties. A useful way of comparing the differences is by modal sizes.

In heavy-mineral analysis the differences in modal sizes ($\delta\phi$) between each heavy mineral and the light minerals can be used to express the hydraulic equivalence of heavy and light minerals. Modal separation ($\delta\phi$) is a function of shape of the heavy mineral (Z_H) and the light mineral (Z_L), and of the relative specific gravities of the heavy mineral (ρ_H') and light minerals (ρ_L') in the fluid stream:

$$\delta\phi = \log_2 \left[(Z_L/Z_H)^{0.354}(\rho_H'/\rho_L')^{0.5}\right]$$

A test of this function was made in the heavy minerals in Tertiary sediments of Huerfano Park, Colorado, whose age, mode of deposition, direction of transport, and local source areas had already been established by independent field observations. The mean computed ($\hat{\delta\phi}$) and measured ($\delta\phi m$) modal separations and their statistical deviations are as follows.

Mineral	$\hat{\delta\phi}$	$\delta\phi m$	S	$S/\sqrt{n}$
Tourmaline	0.01	1.01	0.81	0.27
Hornblende	0.07	0.62	0.78	0.22
Apatite	0.05	0.74	0.51	0.12
Epidote	0.36	0.14	0.50	0.14
Sphene	0.44	0.82	0.59	0.13
Garnet	0.52	0.43	0.52	0.10
Zircon	0.61	1.10	0.69	0.16
Ilmenite	0.62	0.40	0.47	0.09
Magnetite	0.72	0.30	0.19	0.04

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Cationic Substitutions in the Alunite Group

Minerals of the Alunite group are designated as $AB_3(SO_4)_2(OH)_6$ with A=Na, K, Pb, NH_4, Ag or H_3O and B=Al (alunite) or Fe^{+++} (jarosite). Synthesis studies of Na-K and Al-Fe substitutions produce a series of solid solutions for which natural counterparts have been found. Synthesis has been successful at temperatures ranging from 78°C. to 180°C. with pressures up to 6 atmospheres. At the lower temperatures, analyses show a univalent cation deficiency and an excess of $+H_2O$, indicating the presence of H_3O^+. DTA curves of hydronium-bearing jarosites show three endothermic reactions at approximately 350°C., 400°C., and 800°C. The 350°C. reaction is broad and represents a loss of hydronium ion. Similar results have been noted for natural, low-temperature jarosites.

Synthesis of alunites and jarosites with variable K-Na ratios shows a marked preference for K^+. The Na-K substitution produces little change on the a_0 dimension, but a pronounced effect upon c_0 is recorded. The opposite effect obtains upon substitution of Fe^{+++} for Al. The preference for Fe^{+++} in the structure is lowered with increased temperature and reduced acidity.

Currently the parameters controlling the incorporation of Ag and Te in the alunite structure are being investigated.

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Sediment Sorting in Alluvial Channels

The formation of primary sedimentary structures in and along an alluvial channel occurs as a result of interactions between gravity, the physical characteristics of the sediment and fluid as well as the hydraulic environment. However, the actual process by which recognizable structures develop arises from sorting of the sediment with respect to size, shape, or density, both along the bed and within the stream. The settling rates of the particles, turbulent diffusion, gravitational sliding, and the shear stress in the vicinity of the bed, all contribute to the sorting processes. Certain aspects of the various sorting processes may be predicted by analytical means, whereas others may be determined only by laboratory experiments. Using an alluvial channel together with the normal sequence of bed regimes as a point of departure, a discussion of the underlying principles of the various aspects of sorting in alluvial channels along with some related laboratory experiments is presented in this paper. From the laboratory experiments, quantitative information pertaining to the spectrum of bed forms, including subaqueous dunes and ripples which develop in an alluvial channel, is presented, and the data are compared with existing empirical and analytical relationships. Under favorable conditions of preservation, limited estimates of the hydraulic environment may be made by measuring the physical characteristics of cross-stratified units and related bed forms.

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Shape and Structure of Saharan Cambro-Ordovician Sand Bodies—Paleocurrents and Depositional Environment

The older Palaeozoic of the Libyan Sahara consists of the following terms. Above a highly folded Precambrian (Proterozoic) metamorphic series is found a locally restricted intermediate formation called "Infra-Cambrian" as in the eastern Fezzan (Mourizidie formation). The Cambrian consists of a mantle of cross-bedded coarse sandstones of the Hassaouna formation. The absence of feldspars and heavy minerals, except in some areas, and the general orientation of the sedimentary structures lead one to suppose that material was transported some distance from the south (central Africa). What can be the agents of transport and the conditions of deposition—rivers and deltas over a width of several thousand kilometers—or a shallow sea with wave action? We can only imagine a Cambrian world very different from that existing now.

With the Ordovician we have a more classic marine sedimentation, with the development of a transgressive regularly bedded series (Haouaz formation) which ended with erosion and an infilling which is stratigraphically chaotic (Memouniat sandstone). From then on the sedimentary structures never had the homogeneity of the Cambrian, being affected by local factors.

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PETROLOGY OF THE WESTERN CANADA BASEMENT

The Western Canada sedimentary basin is floored almost completely with igneous and high-grade metamorphic rocks which crystallized during the Hudsonian orogeny, dated at 1,800 m. y. Since that time most movements in the basement have been epeirogenic, in response to isostatic adjustments following long periods of erosion. Five areas of the basin floor, defined on the basis of geophysical anomalies, inferred faults, and positive or negative tectonic history, show distinct variability in percentage of rock types. Basement areas of persistent negative tendency contain higher than average percentages of sedimentary, volcanic, and basic intrusive rocks. The isostatically positive arches are composed dominantly of granitic gneisses.

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ENVIRONMENTAL AND STRATIGRAPHIC SIGNIFICANCE OF DEVONIAN STROMATOLITES OF COLORADO

Upper Devonian carbonates of west-central Colorado contain abundant stromatolites. These finely laminated, crenulated, and commonly brecciated calcareous dolomites and dolomitic limestones comprise most of the Dyer member of the Chaffee formation along the west side of the Sawatch Range, in the McCoy area, and in the White River Plateau.

These fine-grained carbonates display striking structural and textural resemblance to laminated sediments now being produced by algae on western Andros Island, B.W.I., and in Florida Bay. The environment of present-day stromatolitic sedimentation is intertidal where only occasional flooding occurs during spring tides or periods of storm waves. Carbonate mud deposited by these waters is laminated by the trapping and binding functions of filamentous blue-green algae. Desiccation polygons may become dislodged during flooding to form intraclastic breccias. If, in this case, "the present is the key to the past," these Devonian sediments represent quiet-water carbonate deposition in the littoral environment.

The Dyer in the eastern and northeastern part of the study area is predominantly stromatolitic, but to the west the lower portion is a neritic carbonate accumulation. During lower Dyer time the intertidal environment existed on the east and northeast and an offshore environment existed on the west. During upper Dyer time the intertidal environment regressed westward and southwestward behind the waning Upper Devonian sea.

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GEOLOGY OF A PORTION OF THE CONTWOYTO LAKE AREA, NORTHWEST TERRITORIES

Approximately 24 square miles of Archean(?) igneous and metamorphic rocks have been mapped at a scale of 1 inch equals 1,000 feet in an area centered 5 miles south of the central part of Contwoyto Lake, N.W.T.

The oldest rock unit is apparently a quartz-plagioclase-biotite-K-feldspar paragneiss containing numerous pegmatitic segregations of quartz, plagioclase, K-feldspar, and minor amounts of muscovite, tourmaline, and apatite. A sequence of low- to medium-grade metasediments overlies the paragneiss. In the northern part of the area, these rocks are largely quartz-chlorite-muscovite phyllites. As the grade of metamorphism increases southward, biotite, almandite, andalusite, cordierite, and staurolite become common. Approximately 20 beds of quartz-hornblende-almandite amphibolite up to 10 feet in width have been mapped in the schist sequence. The phyllites, schists, and amphibolites are believed to be correlative with the Yellowknife group.

Two biotite granite bodies approximately one mile in diameter intrude the Yellowknife group metasediments. The sediments are also cut by diabase dikes 20–100 feet in width, and a gabbro stock $\frac{3}{8}$ mile in diameter.

Pyrrhotite, pyrite, and arsenopyrite are found locally in a few of the amphibolite beds. Gold mineralization is locally present in some of the tightly folded pyrrhotite and arsenopyrite-bearing amphibolites.

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DISTRIBUTION OF PTEROPODS IN WESTERN NORTH ATLANTIC SEDIMENTS

The pteropod assemblages in 120 post-Wisconsin cores were studied from an area between the Atlantic continental shelf of North America and the Mid-Atlantic Ridge. Pteropod shells are one of the major constituents in the calcareous pelagic sediments at depths ranging from 350 to 4,200 m., particularly along the Mid-Atlantic Ridge, the Bermuda Pedestal, the Blake Plateau, and the Gulf of Mexico.

The subarctic species *Limacina retroversa* and the temperate species *Clio pyramidata* are present in the Mid-Atlantic Ridge sediments north of about 45° N. Lat. They indicate the faunal mixing zone between subarctic and warmer North Atlantic Drift waters.

Subtropical species *Limacina inflata*, *L. bulimoides*, and *Styliola subula* are the dominant pteropod species in the middle-latitude sediments of the Mid-Atlantic Ridge and the Bermuda Pedestal, and the overlying water of the Sargasso Sea. The subarctic species was present in the pelagic sediments of the Bermuda Pedestal, but is at present not living in the overlying water; it is inferred from this that subarctic waters invaded the Bermuda region some time ago. The maximum concentration of pteropod shells was found in the pelagic sediments of the Bermuda Pedestal at a depth of approximately 2,200 m. The number of specimens decreases considerably in sediments containing less than 80 per cent calcium carbonate at water depths greater than 3,600 m. No pteropods were found below 4,200 m.

Tropical *Creseis acicula* is the predominant species on the ocean floor of the Gulf of Mexico and Blake Plateau, and the overlying water of the Gulf Stream currents. The delicate hexagonal surface reticulation of *Peraclis reticulata* shells were obscured after deposition on the ocean floor; probably this resulted from greater solution of its projecting ridges. Two pteropod species, *Peraclis*