

volcanic rocks. Economic deposits are within the competent members of any rock type.

Nickel-bearing sulphides are directly related to ultrabasic and basic intrusive rocks. The sulphide deposits occur at the bottom of sills or in structural traps in the underlying rocks.

Molybdenum, bismuth, and lithium mineralization is spatially related to late granites. Iron formations containing magnetite have potential economic value and are stratiform, sedimentary deposits.

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#### DIGITAL SEISMIC SYSTEM IN PETROLEUM EXPLORATION

Digital seismic instrumentation and techniques have been developed as components of a broad petroleum exploration system. The objective of this system is to lower the cost of oil-finding through greatly increased reliability of seismic data. Characteristics of the system include defining the exploration objective, identifying associated problems, optimizing field procedures, applying a series of pertinent data-enhancement techniques, and interpreting the results in terms of the specified objective. Digital seismic instrumentation and techniques permit the explorationist to apply the system on a more scientific and less empirical basis.

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#### LATTICE PARAMETER STUDIES OF SYNTHETIC NEPHELINE SOLID SOLUTIONS AND OTHER TRIDYMITITE-TYPE STRUCTURES

Lattice parameter determinations of pure sodium nephelines, crystallized from gels and glasses at 1,000 Kg/cm<sup>2</sup> water vapour pressure, show that the parameters of this mineral are very variable and that they can not be correlated either with their crystallization temperatures or with the length of the experiments, unlike the parameters of albite (MacKenzie, 1957). In contrast, the lattice parameters of nephelines of composition Na<sub>3</sub>KAl<sub>4</sub>Si<sub>4</sub>O<sub>16</sub>, which more closely approach those of natural nephelines and of pure kalsilites, do not vary with their crystallization temperatures. Investigation of the lattice parameters of nepheline solid solutions in the systems NaAlSi<sub>3</sub>O<sub>8</sub>—NaAlSi<sub>3</sub>O<sub>8</sub>—H<sub>2</sub>O, and NaAlSi<sub>3</sub>O<sub>8</sub>—CaAl<sub>2</sub>Si<sub>2</sub>O<sub>8</sub>—H<sub>2</sub>O indicates that the addition of very small amounts of both the NaAlSi<sub>3</sub>O<sub>8</sub> and CaAl<sub>2</sub>Si<sub>2</sub>O<sub>8</sub> molecules produces an increase in the *c* parameter and also stabilizes both the *a* and *c* parameters of the nepheline solid solutions. No change in nepheline solid-solution lattice parameters was found in the system Na<sub>3</sub>KAl<sub>4</sub>Si<sub>4</sub>O<sub>16</sub>—CaAl<sub>2</sub>Si<sub>2</sub>O<sub>8</sub>—H<sub>2</sub>O. These results are discussed in terms of three hypotheses proposed by Smith and Tuttle (1957), and it is concluded that the main factor causing the variability in pure nepheline parameters is the collapse of the framework structure about the small sodium atom, although the substitution of hydroxyl ions for oxygen atoms and variations in the starting materials in these experimental studies may also contribute to these variations.

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#### GEOPHYSICS APPLIED TO EXPLORATION PROBLEMS

The present facilities for isotope age measurements at the Shell Development Company, Exploration and Production Research Division Laboratory, permit measurement by all of the well established age methods—potassium-argon, rubidium-strontium, uranium-lead, and thorium-lead. This gives us the advantage of a wide

choice of minerals, and at least among the igneous and metamorphic rocks some age data can usually be obtained by at least one of the methods mentioned. Age measurements are often used to determine the age of igneous rocks encountered in wells. This enables the geologist to judge whether additional sedimentary reservoirs could be expected. In some places the age might suggest that "true igneous basement" has been reached and that no further sedimentary section can be reasonably expected. In other places, the presence of igneous sills and dikes, or volcanic layers is suggested, below which additional reservoirs could be expected. Samples of bottom-hole rocks from wells drilled prior to the general use of age determination methods have now been examined with the same objective. In general the results of these measurements on wells in different parts of the United States can be shown to fall in line with the suggested basement periods (G. R. Tilton and S. R. Hart, *Science*, vol. 140, p. 357, 1963).

Frequently age determinations are used to determine time and influence of igneous activities in new exploration areas. In this case surface samples are used. This type of information helps to unravel the structural evolution of an area. This is important background for any study of the hydrocarbon potential of a new exploration province.

The use of glauconite for potassium-argon and rubidium-strontium dating of sediments has been common for many years in oil exploration for obvious reasons. The use of the minerals in bentonite to date sediments is the subject of another paper in this symposium (R. E. Folinsbee, H. Baadsgaard, G. L. Cumming, and J. Nascimbene, Radiometric Dating of the Bearpaw Sea). The first dates on both biotite and zircon in bentonites were those measured at the Shell laboratory.

Recently we have been measuring the age of detrital minerals in sediments as an aid in determining the source of conglomerates and micaceous sandstones, and this work is continuing.

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#### RELATIONSHIP OF MINERALIZATION TO THE PRECAMBRIAN VOLCANIC-SEDIMENTARY COMPLEXES IN THE PORCUPINE AND RED LAKE AREAS, ONTARIO

The early Precambrian rock sequences at both localities consist of three major types, metabasalt, acidic welded tuff, and sediments. At Red Lake the Keewatin sediments are graywacke and argillite with conglomerate beds high in the sequence. In the Porcupine area the Keewatin sediments are mainly argillite which is unconformably overlain by Timiskaming conglomerate, graywacke, quartzite and argillite. The intrusive rock suites are also generally similar and range in composition from early basic and ultrabasic rock to later intermediate and acid rocks.

New information has been added on the type, thickness, persistence and relative ages of the major units of country rocks. Similar rock types in a similar sequence indicate a rhythmic volcanic-sedimentary cycle.

Known copper mineralization of economic grade is restricted to the Pearl Lake porphyry in the Porcupine area. Gold orebodies occur in a variety of rock types but some particular types are restricted to individual beds.

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#### BASEMENT: NOT THE BOTTOM BUT THE BEGINNING

Borehole myopia, isotropism, and symmetresis are occupational geological diseases of petroleum geologists