gence). An examination of samples taken at 40-cm. intervals down cores from both north and south of the Polar Front shows that several cores located north of the Polar Front contain alternating layers of the two faunas, whereas cores located at the south show no such faunal fluctuations. If the alternating faunal zones observed in the northern cores are caused by a shift in the position of the Polar Front, then the data collected so far suggest that the Polar Front today may be as far south as it has been during the time period represented by the cores sampled.

Other changes are exhibited by 10 cores from the area. In these cores there is an abrupt change from a fauna composed predominantly of recent species, the majority of which are not found living in Antarctic waters today. This change in the radiolarian assemblage is accompanied in 80 cores by a large decrease in other siliceous or calcareous organisms. In two cores the carbonate content drops from 40–60 per cent to zero. In one core the older assemblage is associated with abundant discoasters and on this basis is tentatively assigned a Late Tertiary age.

The cause of the change in planktonic assemblages from Late Tertiary to Quaternary is not known, but it is suggested that it may be due to a change from a relatively stable stratification of the Antarctic Ocean during Late Tertiary to a stronger degree of vertical convection in the Quaternary associated with the cooling of this part of the world during the growth of the Antarctic ice cap.

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Lithium Metasomatism Around Pegmatites

A widespread exogenetic effect accompanying the crystallization of lithium pegmatites is the introduction of small amounts of lithium into the wall rocks. Lithium is not found in altered wall rock around pegmatites that do not contain independent lithium minerals. This metasomatic lithium is housed in a number of different minerals, especially muscovite, biotite, tourmaline, and holmquistite. Lithium-bearing hedenbergite and hornblende each have been reported from a single deposit. Likewise, lepidolite and zinnwaldite have each been reported once, but proof of their identities has not been given. Thus it may be affirmed that the major pegmatic species (spodumene, lepidolite, petalite, amblygonite, Fe-Mn-Li phosphates) are not formed exogenetically.

Mineralogically, two types of lithium metasomatism are known. (1) The lithium is restricted to combinations of muscovite, biotite (usually also contains Li, Rb, Cs) and tourmaline. This type occurs typically in micaceous schists or gneisses around zoned or structurally complex pegmatites that contain lepidolite, amblygonite, Fe-Mn-Li phosphates ± spodumene. (2) The lithium occurs chiefly in holmquistite (± a narrow Li-biotite zone closer to the pegmatite). This is developed invariably in hornblendic wall rocks around unzoned, poorly zoned (Kings Mtn. type), or zoned pegmatites that contain early-crystallized spodumene, usually as the sole lithium species, or with petalite, rarely with lepidolite.

The number of holmquistite occurrences is now known to be ten, with a new discovery at Bernic Lake.

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Properties of the Crust

Early refraction studies of the crust used widely spaced observing points. Consequently, secondary arrivals, including possible reflections, could not be identified. This required the use of first arrivals, which limited the definition of the method.

Under the Vela Uniform project for the improvement of seismology, techniques and instrumentation have been developed closely paralleling those used in the study of sedimentary columns: continuous profiles, close spacing of observation points, high recording speed, use of magnetic tape recording, etc. These techniques have been applied widely in the United States, less widely in Canada; analogous techniques are well advanced in the Soviet Union.

The crust in continents varies from a thickness of about 20 km. in some coastal areas to as much as 50 km. in high plateau areas. Over most continental areas of moderate elevation the average thickness is 35 km. The number of layers in the crust is open to question. It is generally accepted that there are two layers, an upper granitic one and a lower basaltic one, but these are clearly defined only in some high plateau areas. In most regions a model involving a functional increase of velocity with depth fits the data as well as any system of discrete layers.

Most recent studies show no simple relationship between crustal thickness, surface elevation, and gravity values. Isostatic compensation may be accomplished through variation in the thickness, or the mean density of the crust, or by mass redistribution in the mantle.

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Genetic and Geometric Relations Between Structures in Basement and Overlying Sedimentary Rocks, with Examples from the Colorado Plateau and Wyoming

Field studies of jointing, faulting, and folding in the San Juan-Grand Canyon region, Arizona, and the Bighorn-North Laramie region, Wyoming, show that tectonic movements are primarily vertical. Maximum deformation of the rocks occur along narrow, linear zones which appear to follow elements of a primordial fracture pattern in the Precambrian basement. Sedimentary rocks play a passive role in the formation of folds and structural lineaments.

Fold geometries are determined by the developing geometry of the basement surface. The basic causes and mechanisms of deformation are generated in basement rocks below the level of the sedimentary strata. Structures in the sedimentary strata are of secondary origin, generated as a result of folding following basement deformation.

Prominent fracture trends of Precambrian age in the basement rocks of the Grand Canyon region are present as major elements of the joint patterns in overlying sedimentary rocks.

Large-order structural lineaments in the Bighorn region are long, narrow zones of deformation in sedimentary rocks which reflect deformations in the underlying basement rocks. Areally, structural lineaments follow some element of the regional fracture pattern.

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Normal and Reverse Pleochroism in Biotite

Normal biotite has the absorption formula $Y>Z>>X$ with Y reddish brown, Z greenish brown (thick sections only) and X pale brown. Rarely biotite is pleochroic with absorption $X>>Y>Z$. Blue River, B. C., biotite is of the second ("reverse") type with the pleochroism especially pronounced in the short-wave portion of the visible spectrum. Brown biotite-phlogopite from Old Chelsea, P.Q. is optically similar. The effect is caused by a broad transmission maximum for light vibrating parallel with the mica sheet and a narrow transmission maximum for light vibrating across the sheet. Green phlogopite from Old Chelsea shows less marked reverse pleochroism. With thick sheets transmission maximum Y is at 6200 Å and Z at 5800 Å. No absorption maxima were noted in these varieties. Chemical data suggest the reverse pleochroism may be associated with ferric iron in tetrahedral sites.

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SUCCESSION OF TORNOCERAS AND RELATED GENERA IN THE DEVONIAN OF NEW YORK AND ADJACENT STATES

A study of the species of *Tornoceras*, *Parodiceras*, and a *Tornoceras* and *Epitornoceras* from the western U.S.A. provides an independent stratigraphical zonation for the New York State Devonian. It also provides a study of allomorphosis in *Tornoceras*. Comments are made on the protoconch and the significance of the metamorphosis marked by the nepionic constriction in *Tornoceras*.

Where possible in twenty successive faunas, ontogenetic details have been elucidated, and this has been possible from protoconch upward at eleven successive stratigraphic levels. These successional ontogenies shed light on the evolution of the stock. Faunas at each level may be defined morphologically, but few consistently maintained evolutionary trends have been observed. Shell form seems particularly subject to independent, and probably phenotypic, variation. Through the equivalents of the Middle Devonian to the Lower Frasnian, protoconch width appears to increase progressively. Similarly, the suture becomes more undulating, particularly with regard to the ventrad face of the lateral lobe. Later species show reversion to early characters in these respects.

The origin of *Tornoceras* from *Parodiceras* is argued, and it is considered that *Tornoceras* gave rise to all later members of the Tornoceratidae.

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MONTOYA GROUP (ORDOVICIAN) CARBONATE PETROLOGY OF TEXAS AND NEW MEXICO

The Montoya Group (Middle and Upper Ordovician) of west Texas and New Mexico consists of several carbonate types including crinoidal calcarenite with a microcrystalline matrix, crinoidal calcarenite with sparry calcite cement, calcilutite with abundant chert, chert-free calcilutite, shell limestones, calcirudites, and completely or partly dolomitized equivalents of the former.

Dolomitization and silicification are volumetrically important. Recrystallization and (or) replacement obscure much of the original texture and fossils. Dolomitization begins with the formation of sporadic small crystals, which increase in number until a complete dolomitic mosaic results. Coarse fossil debris becomes progressively reduced in texture as the process advances to completion. Texture and degree of silicification are not related in many places. Fluctuating silica supply in the sea water is strongly indicated. Intervals of abundant chert are separated by less cherty strata.

Study of the unaltered rocks show considerable range in environment from high-energy, shallow-water to low-energy, deep-water conditions. Montoya sedimentation can be compared with correlative strata deposited during the Middle and Upper Ordovician submergence of the North American continent. Montoya deposition in the Cincinnatian is estimated to be 320 feet in 10 million years—very slow when compared with 4,500 feet in 10 million years for the Cayugan autogeosyncline of Michigan (Kay, 1951).

Present lithologic and stratigraphic data support rejection of a disconformity within the Montoya Group, although several minor erosional breaks occur.

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PENECONTEMPORARY DOLOMITE IN THE PERSIAN GULF

Carbonate sediments dominate the shallow waters along the arid southwest side of the Persian Gulf. In the more protected parts of the west coast of the Qatar Peninsula, the processes of near-shore sedimentation have created lagoons and embayments with high chlorinity (30–35 g/l) and reduced tidal range; they are separated from the normal Gulf waters (22–24 g/l) with their average 4-foot tides, by many miles of sea less than 2 fathoms deep.

The lowest parts of the lagoonal shores are fringed by salt flats—"sebkhas"—varying in width from a few tens of yards to several miles. The sebkhas pass seaward into the intertidal zone, commonly via an intermediate algal flat. This is just covered by normal high tides, but only with favourable winds can very occasional spring tides reach far onto the sebkha surface which is a few inches higher.

Sedimentation is gradually filling the lagoons by the seaward advance of the environmental belts, so that sebkha sediment overlies stromatolitic algal laminae, and these are underlain by intertidal mud-pellet sands resting on lagoon muds.

The chlorinity of the pore waters increases landward and upward in response to surface evaporation losses. It increases rapidly within the algal flat (50–130 g/l), where small selenite crystals form beneath the higher, landward parts. Together with the continuing precipitation of aragonite, this causes an increase in the Mg/Ca ratio of the pore waters from the normal marine value of 3 in the lagoon to more than 10 at the sebkha edge. Within the sebkha, the ratio falls gradually to below 5, while the chlorinity continues to rise slowly to more than 150 g/l. The water table is close to the sebkha surface, and, beneath the uppermost layer subject to large daily temperature changes, the wet sediment reaches well over 40°C. in summer time. Its pH is low (around 6.7) and decreases downward.

These warm magnesium-rich brines cause diagenetic changes in the aragonite sebkha sediment. Dolomite appears. It occurs as a stiff, sticky, tan or tan-gray mud composed of rhombs 1–5 microns in size. Associated with it are turbid flattened crystals of gypsum up to 5 inches across, enclosing, displacing and sometimes replacing aragonite sediment. Depositional textures tend to become obscured, but both macro- and microscopic evidence of relic structures and the changing chemistry of the pore waters make it clear that both the dolomite and the associated coarse platy gypsum are replacing aragonite. They increase in abundance away from the lagoon until they make up the bulk of the sebkha sediment. The dolomite normally appears a few inches beneath the surface, increases rapidly, and almost disappears again in a more irregular fashion within a depth of 2–4 feet.

Carbon-14 determination on two dolomite samples collected within 9–18 inches of a sebkha surface gave