



GEOLOGICAL
SURVEY
OF
CANADA

DEPARTMENT OF ENERGY,
MINES AND RESOURCES

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PAPER 71-4

ABSTRACTS OF PUBLICATIONS
IN SCIENTIFIC JOURNALS
BY OFFICERS OF
THE GEOLOGICAL SURVEY OF CANADA,
APRIL 1970 TO MARCH 1971



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This report contains titles, and in most cases abstracts, of 103 papers by officers of the Geological Survey of Canada which were published in scientific journals and books during the period 1 April, 1970 to 31 March, 1971. Most of these papers included abstracts and these have been reproduced from the published text. The abstracts are arranged alphabetically according to author.

The papers published in scientific journals together with the various reports of the Geological Survey (memoirs, bulletins, papers, economic geology reports, miscellaneous reports, maps and open file items) which are listed in the Index of Publications (GSC Paper 71-1) represent most of the published scientific output of the Geological Survey for fiscal year 1970-71.

Allan, R.J., and Hornbrook, E.H.W.

DEVELOPMENT OF GEOCHEMICAL TECHNIQUES IN PERMAFROST, COPPERMINE RIVER REGION; Can. Mining J., vol. 91, No. 4, pp. 45-48, 1970. Title only.

Austin, G.H., and Howie, R.D.

REGIONAL GEOLOGY OF OFFSHORE EASTERN CANADA; Abstract of paper presented at Earth Science Symposium; Dept. Energy, Mines and Resources, Ottawa, Feb. 1971.

The Continental Shelf of Eastern Canada extends from the Gulf of Maine off Nova Scotia, to the head of Baffin Bay in the Northwest Territories (Lat. 42°N to Lat. 77°N), a distance of approximately 3,500 miles. On the mainland, the Atlantic Provinces, exclusive of Labrador, occupy the northern part of the Appalachian System. This belt of folded and unfolded rocks, were involved in the Middle and Late Ordovician (Taconic) and Middle Devonian (Acadian) orogenies. Middle and Late Paleozoic faulting and folding along the narrow Fundy geosyncline resulted in the deposition of Carboniferous continental and marine sediments intermontane troughs, followed by flat-lying late Pennsylvanian and Permian sediments. Triassic sediments occupy an area of renewed faulting in the Bay of Fundy and Chedabucto Bay. The region has been positive since that time. On the Continental Shelf and Slope sediments overlying a granitic or metamorphic basement as calculated from seismic refraction, magnetics and estimates from the total depth of 17 wells are indicated to be greater than 5 km (16,000 feet), on the Scotian Shelf and greater than 6 km (20,000 feet), on the Grand Banks and Newfoundland Banks. Results of drilling show typical Coastal Plain sediment, Jurassic to Tertiary in age, covered by a layer of Quaternary sediments that includes glacial drift. Triassic and Late Paleozoic sediments may be represented in troughs on the inner Shelf. In the northern part of the Gulf of St. Lawrence and on Anticosti Island, nearly flat-lying Early Paleozoic platform rocks dip gently to the south and are at least 12,000 feet thick. In the central and southern part of the Gulf, sediments reach a maximum thickness of 7.6 km (25,000 feet); velocity data and extrapolation from onshore geology suggests the presence

of mainly Permo-Carboniferous and possible Triassic sediments. No information has been released on three wells drilled in the Gulf to date. No published refraction data is available for the Bay of Fundy, but large thicknesses of Triassic and Carboniferous sediments are predicted from onshore geology and from seismic profiler results. Seismic refraction profiles display up to five velocity layers which can be roughly correlated throughout the area: Layer 1 (1.8-2.2 km/sec); Layer 2 (2.2-3.4 km/sec); Layer 3 (3.0-4.5 km/sec); Layer 4 (4.3-5.6 km/sec); Layer 5 (5.0-6.3 km/sec). An approximate correlation of the layers is made with Tertiary, Upper Cretaceous, Lower Cretaceous-Jurassic, Permo-Carboniferous and "Basement". The distribution of the deepest refraction layers suggests a fragmentation of the underlying "Basement" in post-Carboniferous time with initial deposition in marginal troughs, followed by the onlap of Coastal Plain sediments. North of the Appalachian System and at right angles to it are the narrow Labrador and Baffin Shelves, presumably underlain by Proterozoic basement rocks ranging in date from Kenoran to Grenville. The total thickness of sediments on the Labrador Shelf, based on magnetics, is in excess of 6 km (20,000 feet), with compressional velocities consistent with the Coastal Plain sediments to the south. On the Baffin Shelf a total thickness of sediments in excess of 9 km (30,000 feet) has been inferred from magnetics. Onshore geology suggests the Shelf may be underlain by Jurassic, Cretaceous and Tertiary sediments. Ordovician rocks are present in down-faulted structures along the coastline. Although oil shows and seepages have been reported in each of the Atlantic Provinces, the only commercial oil and gas production is from the Mississippian Horton Group at the Stony Creek field in New Brunswick. Many of the recent offshore wells contained shows of oil and gas, but no commercial production has been reported by the operators. Petroleum exploration on the Atlantic Continental shelves has stimulated research in the theory of continental drift, which could have a direct bearing on the nature and distribution of sediments and, hence, petroleum along the continental margin.

Barnett, D. M.

AN AMENDMENT AND EXTENSION OF TIDE GAUGE DATA ANALYSIS FOR CHURCHILL, MANITOBA; Can. J. Earth Sci., vol. 7, No. 2, pp. 626-627, 1970.

An amended rate of land emergence at Churchill, Manitoba is given as 1.3 ft (39 cm) per century with 95% confidence limits of 1.68 ft and 0.85 ft (51.2 and 25.9 cm). It is based on a polynomial regression analysis of tide gauge data for 1940-1968 using the linear function as the most satisfactory.

Barnett, D. M.

GENERATOR LAKE, BAFFIN ISLAND, N. W. T. AND TASIUJAQ COVE, EKALUGAD FIORD, BAFFIN ISLAND, N. W. T. 1968; Can. Oceanographic Data Centre: Oceanographic Data Record Series No 1; 62 pp., 1970.

The following data are presented: an interpretative map of bathymetry based on over 1,000 soundings; 26 lake bathythermograph profiles

supplemented by reversing thermometer data. Chemical composition of lake bottom water samples from 21 locations. Two longitudinal bottom profiles each approximately 6 km long. The lake is ice dammed and over 60 m deep.

Bik, M. J. J.

THE ORIGIN AND AGE OF THE PRAIRIE MOUNDS OF SOUTHERN ALBERTA, CANADA; *Biuletyn Peryglacjalny*, No. 19, 1969.

The distribution of prairie mounds in the Foremost-Cypress Hills area in particular and in the area between the Cypress Hills and Edmonton in general, is described and analyzed. Earlier hypotheses of super- or subglacial origin of the prairie mounds do not account for the breaches of the mound rim and cannot explain their occurrence on both glacial and proglacial deposits. A periglacial mechanism of formation is more likely.

In aspect of form the prairie mounds are similar to, but not identical with the collapsed pingos of western Europe. However, there is an excess of material in the former. The low Atterberg limits of the till of the mounds of the Foremost-Cypress Hills area, and the high content in montmorillonite of the clay fraction suggest that subsurface displacement of this material under supersaturated conditions is probable.

The frost-heave potential of the till of the mounds is substantial and ice-lenses of considerable thickness could have formed in it. The parent relief of the mound fields was probably a rolling till plain or lacustrine plain with low internal relief. Under periglacial climatic conditions, ice segregation would start earlier and continue longer below the depressions than beneath the convexities of such a relief, if the till is saturated with water. Below the downwards advancing freezing front supersaturation occurs only when ice segregation has ceased; it ensues earlier under the convexities than beneath the depressions of the parent relief. The "eruption" and subsurface movement of deposits towards the mound sites is explained from the formation of "closed systems" of supersaturated till between an arched permafrost front above and a remnant permafrost layer or a hardrock surface below.

The majority of prairie mounds occurs in belts that regionally run parallel to proglacial lacustrine deposits; these belts appear to be located in the shore-zones of former proglacial lakes. In the Foremost-Cypress Hills area the deposits of a proglacial lake along the margin of which mound fields formed, are less than 20,600 years old. The minimal age of the prairie mounds was determined to be 12,500 years.

Blake, W., Jr.

STUDIES OF GLACIAL HISTORY IN ARCTIC CANADA; I; PUMICE, RADIOCARBON DATES, AND DIFFERENTIAL POSTGLACIAL UPLIFT IN THE EASTERN QUEEN ELIZABETH ISLANDS; *Can. J. Earth Sci.*, vol. 7, No. 2 (Pt. 2), pp. 634-664, 1970.

Dark brown pumice has been discovered recently on raised beaches of Ellesmere and Devon Islands, and in archeological sites on Baffin Island. It is similar in appearance and chemical composition to pumice associated

with raised marine features throughout northern Europe, especially along the coasts of Norway and Spitsbergen. The source area for the pumice is uncertain, but Iceland is a good possibility.

Dates on driftwood and whale bones imbedded in beaches at the "pumice level", as well as at higher and lower elevations, indicate that the pumice arrived approximately 5000 radiocarbon years ago.

The pumice serves as a time-line and provides a means of correlating widely-separated marine features. Because these features now occur at different elevations, the amount and direction of tilt can be calculated. Also, former ice centres can be delineated, as the areas which have undergone the greatest uplift are those where the ice cover was once thickest. In Arctic Canada the "pumice level" rises westward along Jones Sound - from 16.5 m a. s. l. at the mouth of South Cape Fiord, Ellesmere Island, to 24.5 m at the eastern tip of Colin Archer Peninsula, Devon Island, ca. 130 km away. It also rises northwestward toward the head of South Cape Fiord.

The Jones Sound information, plus dates from elsewhere in the Queen Elizabeth Islands indicating the approximate position of the shoreline at the same time, shows that there is a region in the central part of the archipelago where >25 m of uplift has occurred during the last 5000 years. This region, including considerable areas that are now sea, is believed to have been covered by a major ice sheet during the last glaciation.

Boyle, R. W.

GEOCHEMISTRY IN CANADA; Chemistry in Canada, vol. 22, pp. 20-25, 1970. Title only.

Boyle, R. W., and Garrett, R. G.

GEOCHEMICAL PROSPECTING - A REVIEW OF ITS STATUS AND FUTURE; Earth-Sci. Rev., vol. 6, pp. 51-75, 1970.

A brief review of the history of geochemical prospecting is given and the various methods are described and discussed. The present and future applications are mentioned, with discussion of the advantages and drawbacks. Emphasis is laid on the ever-increasing future possibilities for the utilization of chemical methods. An extensive review of the relevant literature is given.

Brideaux, W. W.

RECURRENT SPECIES GROUPINGS IN FOSSIL MICROPLANKTON ASSEMBLAGES; Palaeogeography, Palaeoclimatol., Palaeoecol., vol. 9, pp. 101-122, 1971.

The Binomial Test is used to demonstrate the presence and distribution of recurrent species groups in fossil microplankton assemblages. These assemblages were recovered from deposits of the lower Colorado Group, Late Albian in age, from central Alberta, Canada.

The composition of the recurrent groups differs at two localities investigated in detail. In both instances, however, evidence indicates that the recurrent groups are responsive to changes in the sedimentary or environmental regime. The sequential appearance and development of the recurrent groups may be related to changes in lithology, fluctuations in the total miospore/total microplankton ratio, and proximity of ancient shoreline. Certain of the groupings were established under transgressive conditions, while others became established under more stable conditions.

Recurrent groups have value in that they allow a more refined correlation of species occurrence data with other palynological indices. They do not have stratigraphic value in themselves but may have value in the selection of local biostratigraphic markers.

Campbell, R. B., and Tipper, H. W.

GEOLOGY AND MINERAL EXPLORATION POTENTIAL OF THE QUESNEL TROUGH, BRITISH COLUMBIA; Can. Mining Met. Bull., vol. 63, No. 699, pp. 785-790, 1970.

The Quesnel Trough is underlain by a thick sequence of mainly Upper Triassic and Lower Jurassic volcanic-clastic and sedimentary rocks that lie between the highly deformed Proterozoic and Paleozoic rocks in the Omineca Geanticline to the east and the Upper Paleozoic Cache Creek Group in the Pinchi Geanticline to the west. Broad areas of the Trough between Kamloops and Williams Lake are covered by Eocene volcanics and sediments and by Miocene-Pliocene plateau lava.

Granitic intrusions were apparently mainly confined to two major episodes; one about 200 m. y. ago (coeval with the Guichon batholith) and one about 100 m. y. ago. In addition, the region includes small granitic and syenitic intrusions, some porphyritic, that may be all or partly still younger.

Exposures in the region are generally small and scattered, obscured by widespread, not necessarily thick glacial deposits. This, together with the extensive Tertiary cover, makes prospecting difficult.

The part of the Quesnel Trough discussed here is the direct north-westward extension of the copper-rich Kamloops-Merritt-Princeton region. It contains the Boss Mountain molybdenum mine, related to a breccia zone induced in a batholith of the oldest group by a younger intrusion, and the Cariboo Bell copper deposit in Lower Jurassic volcanic-clastic rocks and syenitic intrusions. The Gibraltar deposit, in a 200-m. y. intrusion, is within the Pinchi Geanticline close to the margin of the Trough. Molybdenum prospects are mainly restricted within or near the 100-m. y. granitic rocks. Copper prospects, on the other hand, are most prominent in the volcanic-clastic rocks and in the 200-m. y. -old granitic rocks, although they can also be spatially related to younger intrusions. Copper thus has a wide potential distribution.

The writers believe that the region is deserving of careful and comprehensive exploration by directly applying the knowledge and techniques developed in the important producing areas to the south. All of the major pre-Tertiary geological elements seem to have potential for mineral deposits; none should be ignored. A thorough knowledge of the thickness and distribution of the Tertiary rocks and the development of geophysical methods to "see through" them is of particular importance.

Churcher, C.S., and Stalker, A. MacS.

A LATE, POSTGLACIAL HORSE FROM PASHLEY, ALBERTA; *Can. J. Earth Sci.*, vol. 7, No. 3, pp. 1020-1026, 1970.

Elements from the left hind foot of a small horse, probably *Equus conversidens* Owen, are reported from a few miles southeast of Medicine Hat, Alberta. The bones were found below a buried soil contained within an eastward-striking glacial spillway. A date of about 8000 y B. P. is suggested for the specimens on stratigraphic considerations. If this date is correct, these bones probably represent the youngest indigenous fossil horse known in North America.

Collett, L.S., and Bell, C.K.

AFMAG USE IN GEOLOGICAL INTERPRETATION; *Can. Inst. Mining Met.*, *Trans.*, vol. 64, pp. 33-41, 1971.

An AFMAG survey was flown in 1968 over the Upper Nelson River area, Manitoba. The flight direction was northwest-southeast and flight spacing was 2 miles. In the Cross Lake Subprovince, AFMAG showed that an isolated peridotite outcrop was part of a dike that extended over 80 miles. Diabase dikes are not always marked by an anomaly, but isolated crossovers, when used in conjunction with geological and magnetic data, permit their extrapolation. Anomalies coincide with areas of sulphide mineralization. In the Flin Flon Subprovince, known and unknown northeast-trending faults are detected. The Berry Creek fault was extended south through Tramping Lake, then under the Paleozoic cover. Conductors were detected at, or near, the axes of major synclines within Amisk and Snow Group sediments. Granitic terranes have low conductivity and, because they are characterized by smooth AFMAG profiles, they can be delimited. AFMAG is being recognized as a geophysical method that can aid geological mapping and interpretation. Its most important contribution to the geologist will be in regions where outcrops are sparse.

Cumming, L.M.

ABRAHAM GESNER (1797-1864) AUTHOR, INVENTOR AND PIONEER CANADIAN GEOLOGIST; *Geol. Assoc. Can., Proc.*, vol. 23, pp. 5-10, 1971.

Abraham Gesner was in the forefront of scientific advancement in his day and generation. This Canadian, at an early date, clearly visualized the enormous extent to which the practical use of mineral resources benefits all people. As a geologist, he was the first to map large areas of the Maritime Provinces and to create interest in the economic potential of their mineral resources.

Abraham Gesner was a man of many capabilities. He was the inventor of the process of distilling kerosene, a writer of importance, and a practicing physician. He was a working geologist during the early and late parts

of his career and was Canada's first consulting geologist. As the first provincial geologist in the British Empire, he devised and carried out a five year plan of geological mapping of the Province of New Brunswick. He also produced, on short term contract, geological maps and reports for Nova Scotia and Prince Edward Island. He authored important volumes containing information for immigrants to Eastern Canada and founded the first natural history museum in Canada (at the Mechanics Institute) in Saint John, N. B.

Cumming, L. M.

PRECAMBRIAN-PHANEROZOIC CONTACTS AND ORDOVICIAN
SEDIMENTATION IN THE HUDSON BAY AREA; Abstr. with Program,
Geol. Assoc. Can./Mineral. Assoc. Can., p. 17, 1970.

A peneplaned surface below the base of Ordovician strata in northern Manitoba is exposed on the North Knife, Churchill and Nelson Rivers. Best exposures are on the Churchill River, below Portage Chute, where the slope of the peneplain towards the centre of Hudson Bay is approximately equal to the river gradient. This peneplaned surface has also been encountered in a number of shallow drill holes in the Hayes-Nelson Rivers region and in deeper holes near the Hudson Bay coast.

Basal Paleozoic beds in the Hudson Bay Lowlands are Upper Ordovician in age. Typically, the lowermost Ordovician strata are well sorted platformal sandstones with a carbonate cement. These sandstones fill in the local relief on the peneplaned surface, which appears to be in the order of 10 feet in areas where basement rocks are uniform in composition. Locally, these sandstones have a pyrite cement. Locally also, the lowermost Ordovician strata are unconsolidated clays.

Environment of deposition of a burrowed carbonate mud facies in the Ordovician outcrop belt on Gods River suggests infratidal deposits relative to surrounding subtidal Ordovician lime muds. This burrowed mud facies may reflect a basement ridge, of low relief, parallel to the boundary between the Churchill and Superior structural provinces. Ordovician carbonates of the Hudson Bay Basin appear to have accumulated in a northern arid climatic zone.

Currie, K. L.

NEW CANADIAN CRYPTOEXPLOSION CRATER AT LAKE ST. MARTIN,
MANITOBA; Nature, vol. 226, No. 5248, pp. 839-841, 1970. Title only.

Darnley, A. G., Grasty, R. L., and Charbonneau, B. W.

HIGHLIGHTS OF GSC AIRBORNE GAMMA-RAY SPECTROMETRY IN
1969; Can. Mining J., vol. 91, No. 4, pp. 98-101, 1970.

This is a short report illustrating the variety of results obtained by the Geological Survey of Canada's airborne gamma-ray spectrometry system in 1969. It refers to a detailed survey in the Bancroft area of Ontario and to

a cross-country reconnaissance from Ottawa to Yellowknife, N. W. T., and some profiles are reproduced. The mineralogical basis for assessing the economic significance of U:Th ratio variations is explained, and the essential operational parameters of the GSC system are listed.

Davidson, A.

NEPHELINE-K-FELDSPAR INTERGROWTH FROM KAMINAK LAKE, NORTHWEST TERRITORIES; Can. Mineralogist, vol. 10, Pt. 2, 1970.

Results of electron probe micro-analysis of vermiform nepheline - K-feldspar intergrowth in alkalic rocks from Kaminak Lake, N. W. T., indicate chemical equivalence of the intergrowth to leucite containing 39 weight per cent soda-leucite. Mechanisms of origin are discussed, and formation by cotectic crystallization of nepheline and K-feldspar is suggested.

Dence, M. R., Douglas, J. A. V., Plant, A. G., and Traill, R. J.

PETROLOGY, MINERALOGY AND DEFORMATION OF APOLLO 11 SAMPLES; Apollo 11 Lunar Science Conference, Proc., vol. 1, pp. 315-340, 1970.

Eleven Apollo 11 rocks, three type A, one type Band seven breccias, and, in addition, 5 g of fines were studied by microscopic, X-ray and electron microprobe methods. The crystalline rocks and fragments of similar composition in the fragmental samples are interpreted as being members of a local suite of titanium-rich igneous rocks crystallized at shallow depths from dry, highly reduced melts. Evidence for slight crystallization fractionation and for repeated magmatic episodes, as well as the absence of xenoliths, indicates generation by internal volcanism rather than by impact. Low oxygen fugacity (10^{-12} - 10^{-14} atm) and low rates of diffusion in the melt produced extreme iron enrichment, significant strain in zoned clinopyroxene and permitted metastable pyroxferroite to crystallize the tridymite and cristobalite. The final residuum is granitic.

Breccias and fines yield glasses of variable composition, shock metamorphosed crystals and meteorite fragments. This indicates the fragmental materials were generated by meteoritic bombardment. A small proportion of the fragments and glasses are exotic to the Apollo site, and are characterized by high modal or normative plagioclase and low TiO_2 . They are probably derived from the lunar highlands, and suggest early lunar differentiation to form a feldspar-rich crust.

Douglas, J. A. V., Plant, A. G., and Traill R. J., et al.

TITANIAN CHROMITE, ALUMINIAN CHROMITE AND CHROMIAN ULVÖSPINEL FROM APOLLO 11 ROCKS; Apollo 11 Lunar Science Conference, Proc., vol. 1, pp. 81-86, 1970.

Solid solutions between the endmembers ulvöspinel (Fe_2TiO_4) and chromite ($FeCr_2O_4$), with lesser but significant amounts of hercynite

(FeAl_2O_4) are described from Apollo 11 fines, microbreccias, and basaltic-type igneous rocks. The phases vary in composition, ranging from titanian chromite to aluminian chromite to chromian ulvöspinel. Optical, chemical and X-ray data are presented and occurrence of the phases is described. Presence of the minerals suggests that lunar rocks formed under lower oxygen fugacities than comparable terrestrial rocks. Variable composition of the phases in lunar rocks and of similar minerals in terrestrial rocks and meteorites suggests that complete miscibility exists between ulvöspinel (Fe_2TiO_4) and chromite (FeCr_2O_4) and, at least in part, with hercynite (FeAl_2O_4).

Donato, R. J., and Hobson, G. D.

TRANSIT SONAR MEASUREMENTS IN LAKE ONTARIO OFF THE MOUTH OF THE NIAGARA RIVER; 11th Conf. Great Lakes Res. 1968, Proc. pp. 179-187, Internatl. Assoc. Great Lakes Res., 1970.

Records obtained from a Kelvin Hughes Transit Sonar instrument have been spliced together and a comparison made between amplitude of signal and bottom samples to identify bottom materials. Supplementary data from hydrographic charts enables a fairly comprehensive interpretation to be made.

There is virtually no penetration into the bottom sediments by the sound beam from the sonar, penetration being about 1 inch into the very recently deposited sediments. The recorded intensity of the reflected beam is dependent both upon bottom topography and the sediment materials at the water-sediment interface.

One profile was surveyed along about five miles of the Niagara River above Niagara-on-the-Lake. This record shows the strong reflection from the east bank of the river as well as a strong indication of a sand and mud bottom. Some prominent ridges are revealed which, from their shadow region, may be 8-10 ft high. Twenty other profiles were surveyed in Lake Ontario off the mouth of the Niagara River. These records are shown with an interpretation as to bottom materials and a correlation with data from coring stations and hydrographic charts.

Eisbacher, G. H., and Bielenstein, H. U.

ELASTIC STRAIN RECOVERY IN PROTEROZOIC ROCKS NEAR ELLIOT LAKE, ONTARIO; J. Geophys. Res., vol. 76, No. 8, pp. 2012-2021, 1971.

Elastic strain recovery in boreholes was measured in underground mines near Elliot Lake, Ontario, Canada. Maximum elastic strain recovery is horizontal and parallel to the local postorogenic joint sets. Close to the mine workings this relationship is disturbed by the stress field induced by mining. The magnitude of the stress tensor increases with depth. The in situ stresses are interpreted as remanent tectonic stresses that were imprinted onto the rock during the Hudsonian orogeny (1700 m. y. ago). Unloading and reorientation of the stresses was achieved by long-lived arching along an

easterly trending axis. A parallelism of maximum elastic strain recovery (maximum compressive stress) and axes of regional arching in eastern North America is inferred from available data.

Eisbacher, G.H.

CONTEMPORANEOUS FAULTING AND CLASTIC INTRUSIONS IN THE QUIRKE LAKE GROUP, ELLIOT LAKE, ONTARIO; Can. J. Earth Sci., vol. 7, No. 2, Pt. 1, pp. 215-255, 1970.

Contemporaneous faults and clastic intrusions near Elliot Lake are common within the Espanola Formation of the Quirke Lake Group. Contemporaneous faults formed in response to differential vertical displacements which controlled regional paleocurrents and basin slope. The normal faults within the sedimentary succession probably channeled the intrusive material of the clastic dikes. Four types of clastic dikes occur in the Espanola Formation: internally sorted conglomerate dikes; internally unsorted conglomerate dikes; thin sand- and siltstone dikes; and discordant sandstone masses with scattered quartz pebbles. Emplacement of the conglomerate masses into the Espanola Formation may represent a sub-permafrost phenomenon, provided the glacial origin for the boulder conglomerates within the Huronian succession is accepted.

Eisbacher, G.H.

DEFORMATION MECHANICS OF MYLONITIC ROCKS AND FRACTURED GRANITES IN COBEQUID MOUNTAINS, NOVA SCOTIA, CANADA; Bull. Geol. Soc. Am., vol. 81, pp. 2009-2020, 1970.

Mylonitization in the southern part of the Cobequid Mountains resulted from deformation of igneous and sedimentary rocks during the Devonian Acadian orogeny. Detailed analyses of mineral lineation, penetrative s-surfaces, and mineral grain fabrics suggest that uniform tectonic flow within the mylonite zone produced rock strains with extension parallel to the mineral lineation. Quartz fabrics originated when large quartz crystals deformed into elongate granular aggregates. A regional compression axis, inferred from a laminar flow model for the mylonite zone, is compatible with a compression axis derived from slickensided fractures in granitic rocks north of the mylonite zone. The subhorizontal, southeasterly trending compression axes are perpendicular to the regional trend of the Appalachians mountain chain in Nova Scotia.

Ermanovics, I.F.

ZONAL STRUCTURE OF THE PERTH ROAD MONZONITE, GRENVILLE PROVINCE, ONTARIO; Can. J. Earth Sci., vol. 7, No. 2, Pt. 1, pp. 414-434, 1970.

The Perth Road pluton is a lenticular, grossly conformable body emplaced in metasedimentary rocks of the Grenville series during a period in which the enclosing gneisses deformed by plastic flow. The body is zoned

and from the center outward comprises gabbro, diorite, monzonite (the dominant rock-type), quartz monzonite, and granite. The change from one rock-type to the next is gradual and the progressive acidification toward all the contacts, without regard to the type of enclosing gneiss, is taken as an indication of cogenesis of the plutonic assemblage; modal mineral variations of quartz, alkali-feldspar, plagioclase, and color index demonstrate this mineral progression.

The enclosing crystalline metasedimentary rocks have been metamorphosed to the hornblende granulite facies, and although recrystallization has kept pace with deformation some cataclasis pervades all rocks. The pluton occupies a flattened crestal position of a doubly plunging fold, and all folds show a combination of fold-styles depending on the relative competence of the various rock-types. Flow models demonstrate that the early magmatic precipitates collected in regions of maximum velocity of the magma during folding of the enclosing envelope of gneisses and that syntectonic differentiation in this manner obtains for the Perth Road and other plutons in the area.

Froese, E.

CALCULATED PHASE RELATIONS IN THE SYSTEM $\text{CaCO}_3\text{-SrCO}_3$;
Can. Mineralogist, vol. 10, Pt. 4, pp. 665-676, 1970.

The two compounds CaCO_3 and SrCO_3 both exhibit an orthorhombic \rightleftharpoons rhombohedral transition, and, in the system $\text{CaCO}_3\text{-SrCO}_3$, orthorhombic and rhombohedral solid solutions may coexist over a considerable range of pressure and temperature. From existing experimental data, it is possible to derive ΔV and ΔS of the transitions in pure CaCO_3 and SrCO_3 , if it is assumed that these values remain constant and that the solid solutions are ideal. On the basis of the same assumptions, the derived values of ΔV and ΔS may be used to calculate the composition of coexisting solid solutions at any combination of pressure and temperature. In this way, experimentally determined phase relations may be extrapolated to conditions at which no experimental data are available.

Grant, D.R.

RECENT COASTAL SUBMERGENCE OF THE MARITIME PROVINCES,
CANADA; Can. J. Earth Sci., vol. 7, No. 2, Pt. 2, pp. 676-689, 1970.

Hydrographic, archeologic, and geologic evidence indicates that for the last 4000 years the Maritime Provinces have been submerging three to five times faster than the 6 cm/century rate of eustatic rise of sea level. After correcting for the eustatic change, the Bay of Fundy shows an anomalous submergence of 24 cm/century, of which at least 15 cm/century is probably due mainly to rise of high tide, or increase of tidal range, beginning 4000-6000 years ago as eustatic sea-level rise widened and deepened the entrance to the Gulf of Maine. Submergence of the Atlantic coast of Nova Scotia, on the other hand, exceeds the eustatic rate by 9 cm/century, which can be largely explained by new mathematical models as hydro-isostatic subsidence of the earth's crust as the sea deepened eustatically over the continental shelf.

Only a small part of the residual anomalies of 9 cm and 4 cm/century for the Fundy and Atlantic coasts, respectively, can be attributed to a combination of additional subsidence due to geosynclinal downwarping and relaxation of a possible glacier-margin peripheral bulge, thereby implicating other modes of regional crustal lowering.

Grant, D.R.

LATE PLEISTOCENE READVANCE OF PIEDMONT GLACIERS IN WESTERN NEWFOUNDLAND; Maritime Sediments, vol. 5, No. 3, pp. 126-128, 1970.

Initial ice retreat on the Northern Peninsula proceeded inland across the lowlands prior to 12,000 years ago. The sea encroached to 400-500 feet over the isostatically depressed land. Retreat was interrupted by a readvance back across the inundated lowlands from an ice sheet on the Long Range plateau. Highland ice expanded westward through troughs between nunataks that are recognized as summit areas of patterned felsenmeer, delimited by moraines and ice-marginal meltwater features. Ice tongues debouched on the lowlands as spatulate piedmont glaciers that coalesced and built massive interlobate moraines. This phase may correlate with a similar readvance farther north that culminated 11,000 years ago. During retreat, ice and sea were in contact as evidenced by decreasing marine limit on successively abandoned recessional moraines, and by numerous De Geer moraines that also reveal the pattern and rate of retreat. The coast has emerged 300-400 feet in the last 10,000-11,000 years, but at present is emerging very slowly, if at all.

Grant, D.R.

SURFICIAL DEPOSITS, GEOMORPHIC FEATURES, AND LATE QUATERNARY HISTORY OF THE TERMINUS OF THE NORTHERN PENINSULA OF NEWFOUNDLAND, AND ADJACENT QUEBEC-LABRADOR; Maritime Sediments, vol. 5, No. 3, pp. 123-125, 1970.

Although most of the area is concealed by forest, muskeg, water and glacial debris, minor relief features abound and have been interpreted to reveal much about the glacial and bedrock geology. Structural elements predominate, including a broad pattern of linear ridges that trace folding trends in nearly horizontal strata, and reflect variations in attitude and lithology. Intersecting depressional lineaments mark fracture systems, featuring a complex north-south dislocation zone and several east-west discontinuities. Till is the main surficial material and although thin and patchy, is present in a variety of constructional forms, notably an end moraine, innumerable De Geer moraines, and drumlinoids. These and abundant directional striations reveal a four-phase glacial sequence beginning with passage of Labrador ice over the lowlands, followed by calving retreat toward an ice divide near Hare Bay, interrupted by a moraine-building readvance ca 11,000 years ago, and finally, recession to an ice cap along the median of the Long Range plateau. Drowned cirques, notably on Grey Islands, indicate a low pre-Classical

Wisconsin firn line and the possibility of ice caps on the continental shelf. Whereas marine overlap in southern Quebec-Labrador attained 500 feet, there is only indirect evidence about 250 feet in northern Newfoundland, and none above 400 feet. A modern intertidal bench indicates nearly completed emergence.

Gross, G.A.

GEOLOGICAL CONCEPTS LEADING TO MINERAL DISCOVERY; Can. Mining J., vol. 91, No. 4, pp. 51-53, 1970.

Recognition of favorable areas for prospecting and appraisal of mineral potential is obviously based on comprehensive knowledge of the geological environment necessary for different types of mineral occurrences. Study of the origin of iron-formations in volcanic rocks has developed an appreciation of the association of base metal sulphide mineral facies and their zonal relationship to ancient centers of volcanism. Recent discovery of sulphide deposits in the Canadian Shield confirms concept and predictions about the volcanic-sedimentary origin of stratiform sulphide deposits and their relationship to other types of iron-formation.

Increasing attention should be given to sedimentary environments for black shales and carbonate rocks as these are important domains for copper, uranium, vanadium, lead, zinc and a host of other elements. Recent work on manganese nodules in both ocean and fresh water lake environments suggests possibilities for finding similar important sedimentary deposits in older rocks.

Evidence for a high sulphur content in mafic and ultramafic igneous rocks is an important factor in the appraisal of mafic rock bodies as a source of nickel sulphide minerals.

Hacquebard, P.A., and Donaldson, J. R.

COAL METAMORPHISM AND HYDROCARBON POTENTIAL IN THE UPPER PALEOZOIC OF THE ATLANTIC PROVINCES, CANADA; Can. J. Earth Sci., vol. 7, No. 4, pp. 1139-1164, 1970.

Coal rank is used to measure the degree of organic metamorphism, which is of great importance in the evaluation of the hydrocarbon potential of a region.

The rank is determined on true coal seams and coaly inclusions in sandstones by measuring the reflectance of vitrinite, which is a major constituent of coal. A large number of samples, encompassing nearly the entire area of Upper Paleozoic deposition in the Atlantic region, was examined. From these an isoreflectance map has been constructed. The map shows a distinct pattern of regional metamorphism that resembles the tectonic development of the region. The known oil and gas occurrences coincide with the areas of lowest rank.

In this region the coalification is predominantly postdeformational, being caused by the maximum depth of burial that existed after folding. In the higher-rank coals the increase in rank with depth can be measured

accurately by the reflectance (R_0). In these coals different R_0 -depth factors were obtained in different areas, which can be related to different geothermal gradients.

In the lower-rank coals (below 62% fixed carbon) the reflectance parameter is useful only for broad rank assignments, and precise rank predictions at depth cannot be made from surface observations. However, on suitable borehole samples the rank can be measured with the reflectance. This has been done on eight exploration wells and has resulted in finding the approximate vertical position of the oil "deadline" with regards to the degree of organic metamorphism.

Factors limiting the selection of promising areas for future exploration are discussed, with reference to the vertical and regional changes in rank that have been observed.

Hacquebard, P.A., and Donaldson, J.R.

CARBONIFEROUS COAL DEPOSITION ASSOCIATED WITH FLOOD-PLAIN AND LIMNIC ENVIRONMENTS IN NOVA SCOTIA; Geol. Soc. Am., Sp. Paper 114.

In the Sydney coalfield, normal-banded autochthonous coals accumulated in a flood-plain environment. Lithofacies maps show the existence of two main river channels in this plain. The interaction between fluvial sedimentation and peat deposition, which caused the splitting and digitation of seams, is illustrated. The environmental changes in the peat swamps have been interpreted from petrographic variations within the coals. By arranging the latter in "facies triangles," it was possible to plot these changes in cross sections of eight seams. They show that forest-moor and reed-moor environments predominated throughout, but were interrupted occasionally by open moor conditions. Changes in environment were accompanied by changes in vegetation. This was concluded from variations in the spore florules within seams, particularly in the ratios of Punctatosporites and Lycospora. Rapid subsidence with early burial of peat beds is indicated for Sydney basin, by type of clastics and excellent preservation of coal macerals.

In the Pictou coalfield, micro-banded hypautochthonous coals accumulated in a narrow intermontane lake basin. A lithofacies map shows lacustrine sediments, with coal seams up to 44 feet thick, in the central part of the basin and more fluviatile deposits at the margin. Rapid megascopic changes are illustrated between coal and detrital sediments, which caused lateral "lithification" rather than digitation of seams. Uniform ecological conditions are indicated by uniformity in petrographic composition and by constancy of the spore florule within each seam. A slowly subsiding basin with simultaneous accumulations of peat and clastic materials is postulated by the type and preservation of the coal macerals and the presence of numerous, minute quartz grains.

Hacquebard, P. A., and Donaldson, J. R.

COAL RANK STUDIES IN THE ROCKY MOUNTAIN FOOTHILLS BELT OF CANADA; Geol. Soc. Am., Abstr. with Program, vol. 2, No. 7, pp. 564-565, 1970.

In the Rocky Mountains coal rank, as determined from vitrinite reflectance, increases regularly with stratigraphic depth, but not with geologic age, depth of mining or degree of tectonic disturbance. Preorogenic coalification is therefore indicated, but its gradient (in comparable stratigraphic intervals and rank ranges) is not the same throughout the Foothills region. This is illustrated with rank-depth curves of ten coal bearing sections of Cretaceous age, that are situated between the Crownsnest coalfield in the south and the Peace River area in the north.

For each curve the coalification gradient is expressed in terms of per cent reflectance (Ro) - change per 100 m increase in depth. Different Ro-depth factors were obtained, which by comparison with a standard coalification curve can be related to different geothermal gradients.

This Ro-depth factor also controls the availability of coking coals within the section. With a low factor the corresponding rank range of these coals is present over a greater stratigraphic interval, with the possibility of a larger number of seams, than with a high factor.

Within limited areas of the same coalfield, the Ro rank values can be used for correlating coal seams of bituminous rank, provided they lie at least 100 feet apart stratigraphically. This result has been obtained with the seams of the Canmore coalfield.

Helmstaedt, H., and Skinner, R.

STRUCTURAL HISTORY OF THE TETAGOUCHE VOLCANIC BELT, NORTHERN NEW BRUNSWICK; Geol. Soc. Am., Abstr. with Program, vol. 3, No. 1, p. 37, 1971.

Volcanism in the Tetagouche belt was initiated upon a continent-derived quartz-rich substratum of Early Ordovician age which was laid down on a sialic basement. The earliest volcanics were rhyolitic. These were later accompanied, then superseded by andesitic and basaltic volcanics. Volcanics and related intrusives, together with sedimentary rocks, form a complex sequence that contains the important base metal sulphide deposits of the Bathurst-Newcastle district. From Middle Ordovician to Late Silurian (Ludlovian) the entire sequence, including sulphide deposits, was deformed during at least two distinct structural events (D₁, D₂), both manifestations of the Taconian Orogeny. The most penetrative, D₁, resulted in a generally steep regional foliation, local mineral lineation, low-angle thrusts, and in part tight isoclinal folds on all scales. A regional greenschist metamorphism locally transitional to blueschist facies was synchronous with and in

places outlasted D₁. A less penetrative crenulation cleavage formed during D₂. A final major structural event, D₃, a consequence of the Acadian Orogeny, produced large regional folds and numerous faults. The geometry of strain, and the role of the Tetagouche volcanic belt in relation to plate tectonic hypotheses are discussed.

Hobson, G. D., and Hunter, J. A.

IN-SITU DETERMINATION OF ELASTIC CONSTANTS IN OVERBURDEN USING A HAMMER SEISMOGRAPH; *Geoexploration*, vol. 7, pp. 107-111, 1969.

Shear wave energy can be recorded on a portable hammer seismograph and this energy complemented by compressional wave data permits a determination of Poisson's ratio and other elastic constants for overburden in-situ. There are direct applications to engineering projects. The majority of values for Poisson's ratio obtained by this in-situ method are considerably higher than those observed in consolidated rock.

Hobson, G. D.

BEDROCK FEATURES OF THE MER BLEUE AREA BY SEISMIC METHODS; *Can. Field Naturalist*, vol. 84, pp. 35-38, 1970.

A seismic survey has been conducted over the Mer Bleue peat bog and portions of the surrounding area. Initially, seismic data were acquired using a portable hammer refraction seismograph and was confined to the immediate Mer Bleue area but the trends of the bedrock topography map derived were so interesting that the survey was extended using conventional seismic surveying instruments to give a more complete display of the bedrock topography. The seismic survey is complimentary to the geological, biogeochemical, and other studies conducted in the area.

Hobson, G. D., Herdendorf, C. E., and Lewis, C. F. M.

HIGH RESOLUTION REFLECTION SEISMIC SURVEY IN WESTERN LAKE ERIE; 12th Conf. Great Lakes Res. 1969, Proc., pp. 210-224, Internatl. Assoc. Great Lakes Res.

The Geological Survey of Canada, in cooperation with the Ohio Geological Survey, undertook a continuous marine seismic profiling survey in the western part of Lake Erie during August-September 1968. Seismic coverage, totalling 818 mi, was obtained approximately every 5 minutes of latitude and longitude west of Point Pelee in both Canadian and United States waters. Record quality varies considerably over the survey area. East of Pelee and Kelleys Islands, data are good and provide a reliable interpretation of thickness of bottom sediments and stratification within them. The westernmost portion of the basin, yields poor data; this is probably due to gaseous organic material, sand bodies, or buried peat deposits.

Drift thickness from drill holes and from the survey correlate well and range from zero up to 120 ft. A major reflector within the drift indicates the surface of glacial deposits and the general pattern of late glacial and post-glacial drainage during low-level phases of Lake Erie.

Offshore bedrock elevation varies between 390 and 571 ft above sea level. Bedrock highs underlie Point Pelee and the islands whereas bedrock lows in inter-island areas and the central basin are readily outlined. An interpretation of preglacial drainage is presented.

Hodgson, D. A., and Løken, O. H.

ON THE SUBMARINE GEOMORPHOLOGY ALONG THE EAST COAST OF BAFFIN ISLAND; Can. J. Earth Sci., vol. 8, No. 2, pp. 185-195, 1970.

A reconnaissance survey was made of the submarine geomorphology along the east coast of Baffin Island using an echo sounder. The survey focused on: (1) the continental slope, (2) the continental shelf, and (3) the fiords. The depth contours on the continental slope are roughly parallel to the coastline. The overall steepness of the slope is typically 2-3°, with the steeper sections near the top. Small irregularities of unknown origin are commonly found in the slope profiles.

Transverse troughs with depths of almost 900 m are the most distinct features of the 30-50 km-wide continental shelf. The larger channels are associated with major fiord-valley systems on the island. Ridges, interpreted as lateral moraines, extend along the trough margins. Marginal channels commonly found along glaciated coasts appear to be absent from this section of the Baffin Island coast, but subbottom profiles are not yet available.

The fiords of east Baffin Island show the typical fiord characteristics and reach a maximum depth of 900 m. The deepest part is usually below the highest mountains along the fiord. All fiords continue into offshore channels of varying depth.

Many significant changes to the bathymetric map of the west side of Baffin Bay have been made. This is partly due to the survey plan and partly to the greatly improved plotting charts which were used.

Hood, P.

POSITION-FINDING METHODS IN AIRBORNE GEOPHYSICAL SURVEYS, IN THE POSITION FINDER; Geospace Engineering Co. Ltd., Ottawa, pp. 2-3.1 to 2-3.10, 1970.

This article reviewed the various positioning systems which have been used to recover the aircraft track in airborne geophysical surveys. These positioning systems can be divided into two main categories: 1) those which are self-contained within the survey aircraft; these include tracking cameras and Doppler navigation; 2) those requiring external references which includes all the electronic positioning systems such as Decca, Shoran, Toran etc.

Hood, P.

GEOPHYSICAL DEVELOPMENTS TO AID ORE QUEST; The Northern Miner, pp. 33-37, Nov. 26, 1970.

This popular article reviewed the various scientific endeavours of the Exploration Geophysics Division of the Geological Survey of Canada. These included the search for an effective airborne EM mapping system, the application of the INPUT system to groundwater studies, and experimental AFMAG and VLF EM surveys to delineate large geological structures such as faults, shear zones etc. The development of the GSC Queenair high resolution airborne magnetometer and the Skyvan radiometric spectrometer were described, and some of the capabilities of these two airborne geophysical survey systems were outlined.

Hood, P.

MINERAL EXPLORATION: TRENDS AND DEVELOPMENTS IN 1970; Can. Mining J., vol. 92, No. 2, pp. 185-214, 1971.

This article reviewed the following topics for the year 1970:

- (1) New geophysical, geochemical, data recording, and compilation techniques.
- (2) New airborne and ground instrumentation.
- (3) New services offered by the survey companies.
- (4) The important articles on mineral exploration including research and case histories.
- (5) Anything else which appeared to be of interest to those engaged in exploration for mineral deposits.

In the 1970 review the characteristics of commercially-available induced polarization equipment and airborne and ground scintillation counters and spectrometers were tabulated.

Hood, P., and Bower, Margaret E.

LOW-LEVEL AEROMAGNETIC SURVEYS OF THE CONTINENTAL SHELVES BORDERING BAFFIN BAY AND THE LABRADOR SEA; Abstr. for Paper 35, Earth Science Symposium on Offshore Eastern Canada, Ottawa, February 22-24, 1971.

Since 1962, the Geological Survey of Canada and the National Aeronautical Establishment have co-operated in joint low-level aeromagnetic surveys of the continental shelves and deep-ocean basins adjacent to Canada. Reconnaissance aeromagnetic profiles at about 60 mile intervals have been obtained from the southern tip of Greenland to the Kane Basin between Ellesmere Island and northern Greenland. Over the Labrador shelf, there is a marked change of character in the aeromagnetic profiles some tens of miles from shore. The anomalies are relatively sharp close in to shore and

then quite abruptly the wavelength of the anomalies increases and the amplitude decreases. This change is due to a sudden increase in the depth to the crystalline basement and may mark the boundary between continental and oceanic crust. Depth determinations on the profiles indicate that the thickness of sedimentary rocks on the outer Labrador shelf exceeds 20,000 feet over a wide area. Two zones of anomalies run up the Labrador Sea but are lost in the Davis Strait area. In central Baffin Bay the magnetic anomalies are quite flat but anomalies of 50 gammas amplitude having a wavelength of 20 km are discernible, indicating deeply buried sources. Because of the low amplitude of these anomalies it is however difficult to demonstrate conclusively that line to line correlation of the anomalies exists. Geological models for profiles in the Labrador Sea and Baffin Bay have been computed in which the dimensions and magnetizations of the various causative bodies have been calculated. Depth determinations carried out on the aeromagnetic profiles on the Canadian side of Baffin Bay show that a considerable sedimentary section exists on the Baffin Shelf. Moreover the presence of high-frequency anomalies on the outer part of the shelf would also strongly suggest that a basement ridge runs along the outer part of the shelf which is probably similar to that found along the eastern seaboard of North America. Depth determinations carried out on the profiles indicate that the thicknesses of sedimentary rock exceed 10,000 feet on the Baffin Shelf. However, sedimentary cover in the central deep-ocean part of Baffin Bay appears to exceed 5 km (16,000 feet) over large areas.

Hopkins, W. S., Jr.

PALYNOLOGY OF THE EOCENE KITSILANO FORMATION, SOUTHWEST BRITISH COLUMBIA; Can. J. Bot., vol. 47, No. 7, pp. 1101-1131, 1969.

Approximately 55 genera and 75 species of plant microfossils are illustrated and described from the Kitsilano Formation of southwestern British Columbia. The general composition of the flora suggests a humid, warm temperate climate prevailed at time of deposition. Previous work on plant megafossils indicates a late Eocene to possibly early Oligocene age. Plant microfossils recovered in this study support a probable middle to late Eocene age for the Kitsilano Formation.

Howie, R. D., and Hill, J. V.

DEVELOPMENTS IN EASTERN CANADA IN 1969; Bull. Am. Assoc. Petrol. Geologists, vol. 54, No. 6, pp. 922-935, 1970.

The production of petroleum and natural gas in eastern Canada during 1969 was 1,170,547 bbl and 11,791,984 Mcf, respectively. This represents an increase of 12,120 bbl (1%) of oil and a decrease of 432,941 Mcf (3.7%) of gas from the previous year.

In the Hudson Bay region, industry and various government agencies completed 3 1/2 crew-months of combined geologic and geophysical work. Two stratigraphic tests, 1 offshore in Hudson Bay and 1 on land in the southern rim of the Hudson Bay basin, accounted for 7,319 ft of drilling.

In southwestern Ontario 144 exploratory tests and 64 development wells were completed during the year - an increase of 71 exploratory wells and a decrease of 15 development wells from the previous year. An increase in Lake Erie exploratory drilling combined with greater emphasis on Silurian reef exploration resulted in an overall increase of 46% in total footage drilled in 1969 from 1968.

In Quebec, 3 exploratory wells were completed. Geologic and geophysical surveys totaled 34 3/4 crew-months - 13 by industry and 21 3/4 by government agencies.

In the Atlantic provinces considerable interest was focused on the offshore continental shelves. A 13,085-ft exploratory well was completed on the Scotian Shelf 18 mi southwest of Sable Island. On the Labrador coast a 1,217-ft stratigraphic test was completed on Akpatok Island in Ungava Bay. Offshore east-coast holdings increased by more than 53,850,000 acres (26.2%) in 1969 to an all-time high of 258,986,024 acres. In the offshore areas industry accounted for 43 1/2 crew-months of geologic and geophysical activity, and government and scientific institute activity accounted for 80 3/4 crew-months.

Howie, R. D.

OIL AND GAS EXPLORATION - ATLANTIC COAST OF CANADA; Bull. Am. Assoc. Petrol. Geol., vol. 54, No. 11, pp. 1989-2006, 1970.

In Quebec, the Atlantic Provinces, and adjacent offshore areas almost all systems are represented. Gas and/or oil shows have been reported from Ordovician, Devonian, Carboniferous, late Mesozoic, and Tertiary rocks. The only commercial production of oil and gas is from a fluviolacustrine sequence in the lower Carboniferous near Moncton, New Brunswick.

In recent years the search for petroleum has expanded to include the Gulf of St. Lawrence, most of the continental shelf, and part of the slope. Offshore geophysical surveys indicate sedimentary thicknesses of 20,000 ft on the outer Labrador shelf, 24,000 ft in the Gulf of St. Lawrence, 20,000 ft on the Scotian shelf, and 18,000 ft on the Grand Banks of Newfoundland.

On the Scotian shelf, shallow drillholes, grab samples, and a 15,106-ft well indicate the presence of Quaternary, Tertiary, and Cretaceous sedimentary strata. On Grand Banks, two holes penetrated Tertiary and Cretaceous strata. One well was abandoned in salt at 4,834 ft and the other at 5,250 ft in siltstone. From 1963 to 1969 the petroleum industry has conducted more than 150 crew-months of geologic and geophysical offshore exploration in Eastern Canada.

Hutchison, W. W.

METAMORPHIC FRAMEWORK AND PLUTONIC STYLES IN THE PRINCE RUPERT REGION OF THE CENTRAL COAST MOUNTAINS, BRITISH COLUMBIA; Can. J. Earth Sci., vol. 7, No. 2, pp. 375-405, 1970.

The metamorphic framework in Prince Rupert - Skeena region of the Coast Mountains of British Columbia comprises schist, gneiss, and

migmatite displaying progressive regional metamorphism that overlaps the Barrovian and Idahoan Facies Series. Although part of the circum-Pacific metamorphic zone, the Coast Mountain metamorphic belt is apparently not paired. Plutonic rocks, which were probably an integral part of the early metamorphic framework, have apparently been mobilized during metamorphism and continued to move out of their original environment while metamorphism waned, some even deforming the pre-existing fabric.

Within the framework, four main plutonic styles have been recognized:

- (1) Autochthonous, migmatitic, plutonic complexes.
- (2) Para-autochthonous, steep-walled (tadpole) plutons.
- (3) Para-autochthonous, tongue-shaped, recumbent plutons.
- (4) Allochthonous, intrusive plutons.

Quartz diorite and granodiorite are the most common plutonic rocks. Diorite and quartz monzonite are less common; gabbro and especially granite are rare.

In the course of moving from the sites of generation to the zones of emplacement, the plutonic rock became:

- (1) more homogeneous.
- (2) less migmatitic and impoverished in inclusions.
- (3) less foliated.
- (4) more acidic, more biotite-rich.
- (5) a rock containing plagioclase of lower average anorthite content and more complex oscillatory zoned crystals.

The complex oscillatory zoning appears in a gross way to reflect the variable history accompanying (pulsative ?) movement during crystallization.

Time of emplacement of most of the plutonic rock is not known. The potassium-argon age dates (between 53°N and 55°N) display a consistent pattern, with a westerly zone yielding the oldest dates (84 to 140 m.y.), a median zone, intermediate dates (64 to 79 m.y.) and the eastern zone, youngest dates (chiefly 40 to 50 m.y.). These dates may reflect sequential emplacement from west to east but some evidence also suggests that they may reflect sequential uplift and unroofing from west to east.

Irish, E. J. W.

THE EDMONTON GROUP OF SOUTH-CENTRAL ALBERTA; Bull. Can. Petrol. Geol., vol. 18, No. 2, pp. 125-155, 1970.

The Upper Cretaceous deltaic and fluvial strata lying between the marine Bearpaw and nonmarine Paskapoo Formations along the eastern side of the Alberta Syncline have been known, for many years, as the Edmonton Formation. Several subdivisions of these strata have been made based on lithologic differences in the exposure along Red Deer River valley. Owing, however, to the interlensed nature of the beds and lack of widespread marker zones, these divisions are useful for local correlation only.

The Whitemud and Battle units within the Edmonton succession have been correlated with the Whitemud and Battle Formations of southeastern Alberta. Together the two units are easily recognized in outcrop and form a marker zone for field mapping; the Battle Formation is readily distinguished also on electric logs of drilled wells and is, therefore, an excellent datum for subsurface correlation. Furthermore, the Kneehills tuff bed within the Battle unit is a time marker. Field work has shown that the lithology of these units is similar throughout the southern Plains of Alberta and, together, they are the only reliable lithologic marker above the marine Bearpaw Formation.

Paleontology, particularly the vertebrate dinosaurian fauna, lends support to a division of the strata above and below the Whitemud and Battle units.

For these reasons the Whitemud and Battle units have been given formational status and the name Horseshoe Canyon Formation is proposed for the nonmarine strata between the Bearpaw and Whitemud Formations. The three formations; Horseshoe Canyon, Whitemud, and Battle are considered to comprise the Edmonton Group.

Owing to the difficulty in defining the rather obscure boundary between Upper Cretaceous strata above the Battle and the overlying Paskapoo Formation it is considered preferable to include those beds, of Lance age, in the Paskapoo Formation. Such a revision results in an upper and a lower boundary for the Edmonton Group that are easily recognized both in outcrop and on mechanical logs of drilled wells.

Irvine, T.N.

CRYSTALLIZATION SEQUENCES IN THE MUSKOX INTRUSION AND OTHER LAYERED INTRUSIONS; 1. Olivine-Pyroxene-Plagioclase Relations; Geol. Soc. S. Africa, Sp. Publ. 1, pp. 441-476, 1970.

From successions of cumulus minerals contained within repeated stratigraphic (cyclic) units in the layered series of the Muskox intrusion it is shown that the order of crystallization of the magma changed from

olivine; clinopyroxene; plagioclase; orthopyroxene

during the early stages of solidification to

olivine; orthopyroxene; clinopyroxene; plagioclase

during later stages. At the level where the change is apparent, the intermediate order

olivine; clinopyroxene; orthopyroxene; plagioclase

is locally evident. A crystallization model is presented whereby the different crystallization paths of the magmatic liquid may be compared, and it is shown that they probably developed through a process combining (a) differentiation by fractional crystallization; (b) repeated replenishment of the magma composition through additions of new magma; and (c) contamination of the magma with salic material melted from the intrusion's roof-rocks. The model is then used to examine the crystallization sequences of several other layered intrusions in relation to the compositions of their chilled margins. Finally, it is shown that the four minerals listed above may have as many as 30 different crystallization orders in basaltic magmas, and that these may give rise to several dozen different cumulate sequences depending on the exact path of the magma. Many of the crystallization paths require only slightly different starting compositions for the magma - with water content and the ratios $\text{CaO}/\text{Al}_2\text{O}_3$ and $\text{Na}_2\text{O}/\text{Al}_2\text{O}_3$ being especially important parameters - or slightly different load pressures.

Irvine, T.N.

HEAT TRANSFER DURING SOLIDIFICATION OF LAYERED INTRUSIONS. I. SHEETS AND SILLS; Can. J. Earth Sci., vol. 7, No. 4, pp. 1031-1061, 1970.

With the advent of crystal settling in a solidifying igneous intrusion, the roof contact of the intrusion may be continuously subjected to temperatures approaching those of the magma itself. This causes steeper temperature gradients in the roof rocks and, consequently, more rapid heat loss and solidification than would occur if the crystals were frozen to the roof. By contrast, the accumulation of crystals in the lower parts of the intrusion acts to lower the floor contact temperature and so reduces temperature gradients in the floor rocks; but since the proportion of liquid near the floor is reduced, the overall effect also is to speed solidification, specifically in this case, from the floor upwards. The present paper reviews in a qualitative way the relation between crystallization mechanisms and temperature in a magma body when crystal fractionation is a major process. It then examines quantitatively, by means of one-dimensional solutions of the heat flow equation, the influence on crystal accumulation rates and roof rock temperatures of (a) variations in magma temperature, (b) pre-intrusion temperature gradients in the roof rocks, (c) shallow emplacement, (d) formation of an upper border zone or floating of crystals, and (e) latent heat effects associated with contact metamorphism. Finally, it considers the effects of heat loss to the floor rocks on (i) crystallization in the magma above the accumulating pile of crystals, (ii) solidification of trapped pore magma, and (iii) contact metamorphism of the floor rocks. Some of the more important equations presented also apply to sills, sheets, and dikes showing no crystal fractionation.

Jansa, L.F., and Carozzi, A.V.

EXOTIC PEBBLES IN LA SALLE LIMESTONE (UPPER PENNSYLVANIAN), LA SALLE, ILLINOIS; J. Sed. Petrol., vol. 40, No. 2, pp. 688-694, 1970.

An earlier discovery (1928) of exotic pebbles in a limestone located above the La Salle Limestone (base of Bond Formation, McLeansboro Group, Pennsylvanian), and a new one in the upper part of the La Salle Limestone, both in the vicinity of La Salle, Illinois, are described. The new occurrence is interpreted as an open marine, shallow water crinoid-brachiopod calcarenite containing irregular bedding planes with small NE-SW trending channels, along which sand-sized grains and pebbles reaching 2.5 cm diameter are present. These materials may be subdivided as follows: 20% igneous rocks; 20% high grade metamorphic rocks; 40% low grade metamorphic rocks; 10% sedimentary rocks and 10% monomineralic grains. The distribution of the exotic components is essentially bimodal associating a gravel fraction to a clay fraction. The latter represents the appearance of kaolinite in an environment of mixed layer clay minerals and montmorillonite. The mineralogical composition of the exotic pebbles indicates a wide source area of Precambrian terrane. The nearest possible one is located in northeastern Wisconsin, about 250 miles northeast of the investigated outcrop. An earlier

fluvial transportation of the exotic pebbles of such a magnitude must be assumed, probably in relation to a change in base-level during typical regressive conditions of a cyclothem. The final distribution in the carbonate basin is assumed to have been as a submarine mudflow which travelled along a narrow path for about 10 to 20 miles, possibly triggered by storms or mild earthquakes

The former interpretation of transportation of the exotic pebbles by ice-rafting, with its climatic implications, is rejected.

Kerr, J. W.

GEOLOGY OF OUTSTANDING ARCTIC AERIAL PHOTOGRAPHS
1. CAPE STORM AREA, SOUTHERN ELLESMERE ISLAND; Bull. Can. Petrol. Geol., vol. 18, No. 4, pp. 463-468, 1970.

Aerial Photograph A16756-149 of the Cape Storm area on the south coast of Ellesmere Island displays many geological features. The bedrock succession includes seven Ordovician to Devonian carbonate and shale formations, and embraces an Early Devonian unconformity. Structures include three main tilted fault blocks, major and minor faults, hinge faults, and a scissors fault. Major valleys contain braided streams and stream-borne alluvium. A broad raised beach that emerged in postglacial times has countless strand lines.

Kornik, L. J.

AEROMAGNETIC SURVEY OF THE ATHABASCA FORMATION: A QUANTITATIVE INTERPRETATION; Can. Mining J., vol. 91, No. 8, pp. 50-53, 1970.

The thickness of the Athabasca Formation as indicated from magnetic depth determinations is in general agreement with the thickness as determined from seismic data. These data outline an elongated basinal structure which contains a maximum of approximately 5500 feet of non-magnetic sedimentary material. Some differences exist between the magnetic and seismic interpretations near the eastern edge of the Athabasca Formation in the vicinity of Pasfield Lake. In this area magnetic depth determinations indicate that the Pre-Athabasca surface is near the present topographic surface not 5000 or more feet deep as suggested from the seismic data.

Lachance, G. R.

FUNDAMENTAL COEFFICIENTS FOR X-RAY SPECTROCHEMICAL ANALYSIS; Can. Spectroscopy, vol. 15, No. 3, pp. 3-11, 1970.

Relative intensities have been computed for elements and oxides in binary and more complex systems from fundamental parameters. The results clearly indicate that fundamental coefficients for use in equations of the type

$$\% A = \text{relative } \% A [1 + \% B (\alpha + \% B \alpha)]$$

can be calculated and used for the practical correction of interelemental

effects in X-ray fluorescence analysis. The data indicate that the error to be expected using a single coefficient is often negligible while the error using first and second order coefficients is less than that of the precision and accuracy of analytical measurements encountered in normal laboratory practice. An assessment is made of the validity of the concept "characteristic radiation excited by an effective wavelength"; of the effect of variation in instrumental geometry on measured intensities; and of the relative importance of minor constituents in methods of correction for matrix effects.

A comprehensive table of coefficients for use in a general method of correction for interelemental effects is presented with numerous examples of its application to experimental data that have appeared in the literature.

Larochele, A., and Schwarz, E. J.

MAGNETIC PROPERTIES OF LUNAR SAMPLE 10048-22; Apollo 11
Lunar Science Conference, Proc., vol. 3, pp. 2305-2308, 1970.

The natural remanent magnetization (3.7×10^{-4} e. m. u. / cm³) and the susceptibility per cubic centimeter (6.3×10^{-3}) of an 18.5-g breccia specimen were determined with instrumentation and techniques currently used in paleomagnetism. The relatively low magnetic stability of the rock in the earth's field and in alternating demagnetizing fields precludes considering it as a reliable carrier of paleomagnetism. A magnetic balance study yields an unusually high Curie temperature (750° C) which is possibly diagnostic of metallic Fe containing less than 5 per cent nickel. The estimated relative abundance of the iron in the sample is about 0.5 per cent.

Lewis, C. F. M.

RECENT UPLIFT OF MANITOULIN ISLAND, ONTARIO; Can. J. Earth
Sci., vol. 7, No. 2, pp. 665-675, 1970.

Differential postglacial uplifting in the Huron basin has long been recognized from the observed deformation of raised shorelines, particularly those associated with the Algonquin series of glacial lakes (12,000-10,500 years B. P.) and the postglacial Nipissing Great Lakes. From Nipissing time, about 5500 years B. P., to the present, lake levels apparently fell in the northern Huron - Georgian Bay region as the basin warped and the outlet was downcut.

Recent emergence of Manitoulin Island in northern Lake Huron was inferred, independently, of raised shoreline data, from sediment sequences in a series of 3 beach sites and 8 small lake basins at various altitudes up to 20 m above Lake Huron Organic sediment (gyttja) in each lake overlies clastic inorganic sand or silt, with the contact horizon demarcating the isolation of each basin as its threshold emerged from the high-energy littoral environment of Lake Huron. Radiocarbon dates and elevations of the basal gyttja sediments and organic beach sediments suggest uplift at a constant rate of 2.2 mm/year over the past 5000 years. This rate refers to Little Current, Ontario, and is for movement relative to the outlet area of Huron basin at Sarnia, Ontario. The value agrees with basin tilting inferred from lake level gauge observations made during the last 100 years.

Lichti-Federovich, S.

THE POLLEN STRATIGRAPHY OF A DATED SECTION OF LATE
PLEISTOCENE LAKE SEDIMENT FROM CENTRAL ALBERTA; Can.
J. Earth Sci., vol. 7, No. 3, pp. 938-945, 1970.

A 5.5 m section of limnic sediment from Lofty Lake in the Mixedwood Section of the Boreal Forest in central Alberta has yielded the first complete Late Pleistocene pollen stratigraphy for the province. The basal organic sediment was radiocarbon dated at $11,400 \pm 190$ y (GSC-1049) and layer of Mount Mazama type ash was recognized at the 398 cm level. This represents the furthest extension into Canada of Mazama ash records. Five pollen assemblage zones have been identified - at the base, a Populus-Salix-Shepherdia-Artemisia assemblage, which is unique in the Late Pleistocene of N. America, and is interpreted as a pioneer forest and shrub community which occupied the area immediately following deglaciation. This is succeeded by a spruce dominated assemblage which conforms in general to many early Late Pleistocene Picea assemblages from western Canada and adjacent United States, interpreted as a pioneering version of the boreal forest. There follows a tree birch-dominated assemblage with poplar and hazel, suggesting a slight amelioration of climate, and this trend appears to have continued to about 6000 B. P. when a birch-alder-herb assemblage reaches its maximum; this is followed by a spruce-birch-alder assemblage, which continued to the present and is interpreted as an expression of a deterioration in climate about 3500 B. P. The apparent absence at the site of grassland, although the birch-alder herb assemblage suggests that the grassland might have advanced closer to the site than at present (240 km (150 miles)), supports the hypothesis that there was never a Late Pleistocene connection between the Peace River and the main southern grasslands.

Little, H. W.

DISTRIBUTION OF TYPES OF URANIUM DEPOSITS AND FAVOURABLE
ENVIRONMENTS FOR URANIUM EXPLORATION; Intl. Atomic Energy
Agency, Vienna, 1970.

Productive uranium deposits in Canada are of four types: conglomeratic, hydrothermal veins and disseminations with simple mineralogy, hydrothermal veins and disseminations with complex mineral associations, and pegmatitic. All occur in the Canadian Shield near its edge.

Extensions of known deposits and new orebodies adjacent to known ones have been outlined recently, notably at Elliot Lake, Bancroft and Beaverlodge. In addition, promising indications of deposits in new districts, both of the types above and of new types not previously reported in Canada have been uncovered in several parts of the country. Mineralization has been reported in the Cypress Hills of Saskatchewan and at Padlei and Baker Lake in District of Keewatin, but little exploratory drilling has been done in Keewatin. More promising discoveries have been made at Rabbit Lake in Saskatchewan, Makkovik-Kaipokok area in Labrador, and at some other localities from which information is not yet available for publication.

New discoveries have confirmed some predictions of favourable environments for certain types of uranium deposits; for example pyritiferous conglomerates of Early Proterozoic age wherever found are in varying degrees uraniumiferous, but similar conglomerates of Late Proterozoic age are not. Lignitic uranium deposits are being drilled in Oligocene beds predicted to be favourable. In the Canadian Shield new discoveries have been made of pegmatitic and of vein and replacement deposits in areas that had previously been pointed out to be lithologically and/or structurally favourable.

Lowdon, J. A., Wilmeth, R., and Blake, W., Jr.

GEOLOGICAL SURVEY OF CANADA RADIOCARBON DATES X;
Radiocarbon, vol. 12, No. 2, pp. 472-485, 1970.

Twenty-five radiocarbon age determinations on archeologic samples made by the Geological Survey of Canada Radiocarbon Dating Laboratory are reported. They are on samples from various areas as follows: Quebec (1); Manitoba (1); Alberta (6); British Columbia (5); Yukon (6); Northwest Territories - Mainland (3); Northwest Territories - Arctic Islands (2); Alaska (1). Many of the ages reported have been corrected for isotopic fractionation. Testing of a charcoal sample with different pretreatment techniques indicated that considerable contaminating material may be present even though all visible rootlets were removed.

Lowdon, J. A.

CARBON-ISOTOPE FRACTIONATION DURING DRY COMBUSTION OF
OXALIC ACID; Radiocarbon, vol. 12, No. 2, pp. 347-349, 1970.

Dry combustion offers a reliable method of producing CO₂ standard gas from oxalic acid. Negligible fractionation of the carbon isotopes occurs, which is one of the main drawbacks with the wet combustion method.

MacKenzie, W. S.

ALLOCHTHONOUS REEF-DEBRIS LIMESTONE TURBIDITES POWELL
CREEK, NORTHWEST TERRITORIES; Bull. Can. Petrol. Geol., vol. 18,
No. 4, pp. 474-492, 1970.

Carbonate strata of the Middle Devonian Ramparts Formation outcrop in the vicinity of Powell Creek, about 50 mi west-northwest of Norman Wells in the Northwest Territories. These sediments, about 100 ft thick and composed mainly of lime muds at Powell Creek, increase to about 800 ft in thickness a short distance to the west and are present in a "reefal" facies with corals and stromatoporoids. At Powell Creek about 53 ft of allochthonous beds consisting of argillaceous limestones and calcareous shales, the "unnamed beds" of Braun (1966), overlie reef-margin carbonates of the Ramparts Formation. Large blocks of coral- and stromatoporoid-bearing limestone occur within thin-bedded argillaceous carbonates in the lower part of the unit,

and graded echinoderm beds occur among the overlying calcareous shales. The limestone blocks are allochthonous debris derived from the nearby carbonate bank. The graded echinoderm beds were deposited by turbidity currents which, from time to time, swept skeletal remains from relatively shallow water near the carbonate bank into deeper water where shales were accumulating.

Macqueen, R. W., and Sandberg, C. A.

STRATIGRAPHY, AGE, AND INTERREGIONAL CORRELATION OF THE EXSHAW FORMATION, ALBERTA ROCKY MOUNTAINS; Bull. Can. Petrol. Geol., vol. 18, No. 1, pp. 32-66, 1970.

The Exshaw Formation of the Alberta Rocky Mountains and foothills consists of a lower, black shale unit and an upper, siltstone unit, which are separated by a gradational contact. At the type section on Jura Creek, near Exshaw, Alberta, the upper contact of the Exshaw is redefined so that the formation includes all, rather than merely the lower part, of an unbroken sequence of dark-yellowish orange-weathering calcareous siltstone. At the type section, the black shale unit is 33 ft thick and the siltstone unit 127 ft. X-ray diffraction data from the type section indicate that the shale is composed mostly of quartz and contains only minor amounts of illite, feldspar, and carbonates. The siltstone has considerably more calcite and dolomite than most of the shale. Throughout its area of outcrop, the Exshaw unconformably overlies limestones of the Devonian Palliser Formation, and is sharply (disconformably?) overlain by shales at the base of the Mississippian Banff Formation.

The silts and clays, and some of the carbonaceous material in the black shale unit, were probably derived from soils and deposited in shallow-marine, euxinic lagoons. The siltstone unit was deposited in a regressive, marginal-marine environment of widespread, well-oxygenated tidal flats.

Physical continuity is demonstrated between the Exshaw Formation and a) lower two members of the Bakken Formation in the subsurface of southeastern Alberta and Saskatchewan, b) the Sappington Member of the Three Forks Formation in Montana.

Conodont evidence from the Exshaw Formation and circumstantial conodont and spore evidence from the Sappington Member and Bakken Formation show the age of the Exshaw to be Devonian and Mississippian. The systemic boundary is probably positioned near the middle of the black shale unit. Evidence previously cited for the age of the Exshaw at Crownsnest Pass is shown to be more pertinent to the age of the overlying Banff Formation.

Macqueen, R. W., and Ghent, E. D.

ELECTRON MICROPROBE STUDY OF MAGNESIUM DISTRIBUTION IN SOME MISSISSIPPIAN ECHINODERM LIMESTONES FROM WESTERN CANADA; Can. J. Earth Sci., vol. 7, No. 5, pp. 1308-1316, 1970.

Electron microprobe techniques were used to examine the distribution of Mg, Ca, and Fe in six samples of Mississippian skeletal and oölitic

limestones from the Alberta Rocky Mountains. All samples show extremely low values of Fe. The following distributions of Mg (in wt % $MgCO_3$) were observed: in four samples from the Loomis Member (Meramec) of the Mount Head Formation, echinoderm grains show highly variable Mg content averaging 1.11-1.43, whereas sparry calcite cement and the outer rings of ooids show much more uniform values averaging 0.73-0.84. In one sample from the Livingstone Formation (Osage), echinoderm grains show large Mg variation with a mean of 0.95; sparry calcite cement shows more uniform values with a mean of 0.50. A second, highly recrystallized sample from the Livingstone Formation has echinoderm grains which show large Mg variation with a mean of 0.43. The stroma canal structure characteristic of living echinoderms is not generally preserved in the grains. All of the echinoderm grains analyzed contain abundant dolomite crystals 1 to 6 μ in diameter which appear to account for the variable values of Mg distribution, but are not obviously related to the original stroma canal structure. Sparry calcite cements and ooid rings are free of dolomite crystals. The small size of the dolomite crystals, combined with their widespread distribution within and restriction to echinoderm grains, suggests an exsolution origin. Exsolution is suggested to have taken place subsequent to a) loss of most of the Mg from the original magnesium-rich echinoderm calcite, and b) precipitation of pore-filling calcite within the echinoderm grains. The minute dolomite crystals are thus interpreted as representing a late stage exsolution product of small residual amounts of Mg from both the original grains and their pore-filling calcite.

Maxwell, J. A., Peck, L. C., and Wiik, H. B.

CHEMICAL COMPOSITION OF APOLLO 11 LUNAR SAMPLES 10017, 10020, 10072 AND 10084; Apollo 11 Lunar Science Conference, Proc., vol. 2, pp. 1369 to 1374, 1970.

Major, minor and trace element analyses, by three separate laboratories, are reported for the lunar rocks 10017, 10020 and 10072, and for the fine surficial material, 10084. Brief details of the analytical procedures used are also given. The analyses confirm in general the results previously reported for lunar material, especially the high titanium content; water, carbon dioxide, fluorine, chlorine and Fe(III) are either absent or present in negligible amounts. It was not possible to determine metallic Fe but the anomalous reducing capacity of some lunar material has been demonstrated. The composition of the samples differs markedly from that of known rocks and meteorites.

Maxwell, J. A., and Wiik, H. B.

CHEMICAL COMPOSITION OF APOLLO 12 LUNAR SAMPLES 12004, 12033, 12051, 12052 AND 12065; Earth and Planetary Sci. Letters, vol. 10, pp. 285-288, 1971.

Major, minor and trace element analyses are reported for the lunar rocks 12004, 12051, 12052 and 12065, and for a sample of the lunar regolith, 12033, with brief details of the analytical procedures used. Volatile constituents

such as water, fluorine and chlorine are again present only in very low concentrations, as are the alkalis and, possibly, metallic iron. The Apollo 12 samples differ significantly from those of the Apollo 11 mission in having higher SiO₂ and TiO₂ contents.

McDonald, B. C., and Shilts, W. W.

QUATERNARY STRATIGRAPHY AND EVENTS IN SOUTHEASTERN QUEBEC; Bull. Geol. Soc. Am., vol. 82, pp. 683-698, 1971.

Quaternary stratigraphic units have been mapped in the Appalachian region of southeastern Quebec, and formal stratigraphic names for these units are proposed. Evidence exists for four separate glacial phases, the last three of which are represented by tills. The three tills, from oldest to youngest, have been named Johnville, Chaudière, and Lennoxville, respectively. Stratified sediments interbedded with the tills record significant nonglacial intervals between each of the glacial phases. It is suggested that the last three glacial phases are of Wisconsin age and that the Lennoxville Till represents the entire late Wisconsin. Ice-flow directions were determined using dispersal shadows (indicator trains), till fabrics, and striations. Johnville ice flowed from the northwest; Chaudière ice flowed initially from the northeast, but later from the northwest; Lennoxville ice flowed from the northwest. Late Wisconsin glaciers did not flow northward or northwestward into Quebec from New England. Pre-Johnville stratified sediments probably record pre-Wisconsin deposition. The Massawippi Formation, recording the nonglacial interval between the Johnville and Chaudière glacial phases, may correlate with the St. Pierre peat beds of the St. Lawrence Lowlands. The Gayhurst Formation, recording the nonglacial interval between the Chaudière and Lennoxville glacial phases, may correlate with some of the Port Talbot interstadial sediments of southern Ontario. The Quebec Appalachians were finally deglaciated by about 12,500 C¹⁴-yrs B. P.

McGee, B. A.

THE CANADIAN INDEX TO GEOSCIENCE DATA: A NEW NATIONAL SERVICE FOR MINERAL EXPLORATION; Geol. Soc. Am., Abstr. with Program, vol. 2, No. 7, p. 613, 1970.

The Canadian Index to Geoscience Data is a computer-based, coordinate keyword index indicating the sources of available data on the geology of Canada. It is new in the sense that this is the first Canada-wide indexing project involving all interested geoscience agencies, including companies. Further, it is unique in the fact that it identifies quantitative geoscience data. The first edition, which contains about 20,000 document titles, is available in the form of individual indexes to the provinces and territories of Canada, together with a thesaurus of authorized indexing terms. The need for such an index was recognized in 1967 by a nationally representative body and implementation has been carried out by the Geological Survey of Canada. Input to the Index is received from contributing geoscience agencies throughout Canada on a voluntary basis. Processing is managed by federal personnel

and a commercial computer service in Ottawa using an information system (SIS-II) donated to the federal government by Imperial Oil Limited. Searches, retrievals, and other Index services for the public are performed by the Canadian Centre for Geoscience Data, a new unit of the Geological Survey of Canada.

McGregor, D. C., Sanford, B. V., and Norris, A. W.

PALYNOLOGY AND CORRELATION OF DEVONIAN FORMATIONS IN THE MOOSE RIVER BASIN, NORTHERN ONTARIO; Geol. Assoc. Can., Proc., vol. 22, pp. 45-54, 1970.

Spore assemblages from thirteen samples of core from the Ontario Department of Mines Jaab Lake No. 1 well have been identified and keyed into the rock stratigraphic succession of the Moose River Basin, northern Ontario. Agedeterminations based on the spores confirm those obtained for some of the formations according to the invertebrate fossils. In addition, the spores demonstrate that the upper part of the Kenogami River Formation is Gedinnian and possibly Siegenian, the lower part of the Stooping River Formation is Siegenian and early Emsian, and the non-marine Sextant Formation of the Argor ETA Kiasko River No. 2 well is correlative with the upper beds of the Stooping River Formation of middle to late Emsian age. The Sextant, upper Stooping River, and Kwataboahegan Formations are correlated with the Gaspé Sandstone of eastern Gaspé Peninsula.

McGregor, D. C.

HYMENOZONOTRILETES LEPIDOPHYTUS KEDO AND ASSOCIATED SPORES FROM THE DEVONIAN OF CANADA; Colloque sur la Stratigraphie du Carbonifère, Congrès et Colloques Univ. Liège, vol. 55, pp. 315-326, Liège, Belgium, 1970.

Assemblages of spores containing Hymenozonotriletes lepidophytus Kedo are reported from the lower part of the Horton Group in Nova Scotia; the Kettle Point Fm., Bedford Shales and overlying Formations in Southern Ontario and the Imperial Fm. in Yukon Territory. Data are summarized in Table 1. The stratigraphic potential of these assemblages in Canadian rocks is emphasized.

McGrath, P. H., and Hood, P. J.

THE DIPPING DIKE CASE: A COMPUTER CURVE-MATCHING METHOD OF MAGNETIC INTERPRETATION; Geophysics; vol. 35, No. 5, pp. 831-848, 1970.

A self-adjusting curve-matching computer program for the interpretation of magnetic anomalies produced by dike-like bodies is described. The method yields an optimum set of dike parameter values by selecting a best-fit model anomaly curve for a given set of discrete observed data along

a profile across a two-dimensional anomaly. The criterion used by the computer for the selection of a best-fit curve may be either the linear or least squares condition. Convergence to either of these conditions requires the solution of a nonlinear problem. In the present case, solution is achieved by automatic trial and error modifications of an initial model. Selection of the initial model is based upon the shape of the observed anomaly; the proper choice of an initial model assures convergence of the error of fit to an absolute rather than to a relative minimum. The repeatability of the convergence of the iterative process can be tested by changing the initial model within the allowable ranges of variation of the dike parameters. Interpretations of finite strike length anomalies are achieved through the use of a correction curve. With this method, best-depth estimates to the top of dike-like bodies may be determined and for cases of induced magnetization, the effective susceptibility contrast and the dip of the dike may be calculated. Two practical applications of the method are presented.

McGrath, P.H., and Hood, P.J.

AN AUTOMATIC LEAST SQUARES MULTIMODEL COMPUTER METHOD FOR MAGNETIC INTERPRETATION; Abstr. for Paper R-20, 40th Ann. Intl. Meeting Soc. Expl. Geophys., New Orleans, Nov. 8-12, 1970.

The magnetic anomalies caused by such diverse model shapes as the finite-strike-length thick dike, the vertical prism, the sloping step, the parallelepiped body, etc., may be obtained through an appropriate numerical integration of the expression for the magnetic anomaly produced by a finite thin plate. An automatic computer method uses models generated in this manner for the interpretation of magnetic data. The numerical approximations for the magnetic anomalies produced by the various model shapes are nonlinear in parameters of shape and position. Therefore in order to obtain values for the parameters which yield a least squares best-fit anomaly curve of a given model to a set of discrete observed data, it is necessary to use an iterative procedure. The interpretation method described uses the Powell algorithm for this purpose. This procedure appears to be more efficient, especially in the vicinity of convergence, than does the Marquardt algorithm. The method has been used in petroleum and mining cases.

McGrath, P.H., and Hood, P.J.

MAGNETIC SURVEYS OF THE GULF OF ST. LAWRENCE AND THE SCOTIAN SHELF; Abstr. for Paper 22, Earth Science Symposium on Offshore Eastern Canada, Ottawa, Feb. 22-24, 1971.

Aeromagnetic surveys have been flown in the southern half of the Gulf of St. Lawrence as far north as 48° N. There are several large wavelength anomalies in the central part of the Gulf which have been interpreted using a curve-matching computer technique. Depths to magnetic basement in excess of 14,000 feet were obtained west of the Magdalen Islands. These interpretations have been supported by measurements of the magnetic properties of rocks collected from the land masses surrounding the Gulf

of St. Lawrence. Sea magnetometer and aeromagnetic surveys of the major portion of the continental shelf southeast of Nova Scotia were carried out during the last decade. Close to the shoreline the Meguma Group of slates and quartzites produces a characteristic pattern of sharp linear magnetic contours which parallel the coastline. Several circular granitic intrusions are apparent due to their low intensity of magnetization and the fact that they tend to have magnetic aureoles around their peripheries. Further to the southeast the amplitude of the magnetic anomalies decreases and their wavelength increases because of greater depth to the crystalline basement, i. e. thickness of sedimentary rock. Depth-to-crystalline basement have been carried out on most of the significant anomalies on the Scotian Shelf and it would appear that the greatest thickness of sediments occurs in the vicinity of Sable Island.

Monger, J. W. H., and Ross, C. A.

DISTRIBUTION OF FUSULINACEANS IN THE WESTERN CANADIAN CORDILLERA; Can. J. Earth Sci., vol. 8, No. 2, pp. 254-278, 1971.

Fusulinacean faunas in Upper Paleozoic lithological sequences containing volcanic rocks in the western Canadian Cordillera form two assemblages based on geographic association of genera. One assemblage, in Permian strata, is dominated by genera of the family Schwagerinidae and occupies belts in the eastern and western parts of the western Cordillera. This assemblage is associated with brachiopods, bryozoans, horn corals, and crinoids and is in limestones interbedded with clastic rocks and volcanic rocks of variable composition. The other Permian assemblage is dominated by genera of the family Verbeekinidae and occupies a central belt where it occurs with crinoid detritus and algae in thick, regionally extensive limestones associated with cherts, basalt, and ultramafic rocks. The less-well documented Pennsylvanian fusulinaceans appear to occupy similar belts. Because fossils of both assemblages are at least in part time equivalent, their distribution may well be due to differing local environments. In addition, or alternatively, this diversity may be brought about by major crustal movements juxtaposing originally isolated biogeographic provinces.

Nassichuk, W. W., and Spinosa, Claude

HELICOPRION SP., A PERMIAN ELASMOBRANCH FROM ELLESMERE ISLAND, CANADIAN ARCTIC; J. Paleontol., vol. 44, No. 6, pp. 1130-1132, 1970.

Helicoprion has previously been found in the Canadian Arctic Archipelago only in the Assistance Formation on Sabine Peninsula, Melville Island. Two additional specimens are now known from a coeval unnamed formation comprised mainly of black siltstone and chert at Blind Fiord, southwestern Ellesmere Island.

Nigrini, A.

DIFFUSION IN ROCK ALTERATION SYSTEMS: I. PREDICTION OF LIMITING EQUIVALENT IONIC CONDUCTANCES AT ELEVATED TEMPERATURES; Am. J. Sci., vol. 269, No. 6, pp. 65-91, 1970.

Equations for computing mass transfer as a function of activity gradients are reviewed. The calculations require prediction of limiting equivalent ionic conductances. Where few data are available, linear correlations of limiting equivalent ionic conductances with third law entropies,

$$\lambda^{\circ}_{i,25} = a(z) + b(z)S^{\circ}_{i,25},$$

with entropies of hydration,

$$\lambda^{\circ}_{i,25} = a(z) + b(z)\Delta S^{\circ}H_{i,25},$$

and with charge to radius ratios,

$$\lambda^{\circ}_{i,25} = A_1 + A_2 \log z_1 + A_3 r_i / z_i,$$

can be used. A conductance correspondence principle,

$$\lambda^{\circ}_{i,T} = a(T, z) + b(T, z)\lambda^{\circ}_{i,25},$$

provides for the prediction of high temperature limiting equivalent ionic conductances from corresponding values at 25° C. The coefficients required for such predictions are given for temperatures of 60°, 100°, 150°, 200°, 250°, and 300° C for monovalent, divalent, and trivalent cations, halide anions, and monovalent and divalent oxy-anions.

Overton, A.

SEISMIC REFRACTION SURVEYS, WESTERN QUEEN ELIZABETH ISLANDS AND POLAR CONTINENTAL MARGIN; Can. J. Earth Sci., vol. 7, No. 2, pp. 345-365, 1970.

The Arctic seismic program of 1964 and 1965 comprised two refraction profiles between Prince Patrick Island and Melville Island, and one refraction profile extending 192 km onto the ocean northwest of Brock Island. Numerous intermediate layer (\underline{P}_1) and upper mantle (\underline{P}_n) events were also recorded on paths not confined to the profiles, thus allowing a "time-term" analysis for these events.

High-velocity layers within the sedimentary section cause a velocity inversion problem, whereby the lower velocity and depth of the underlying basement complex is not revealed by the seismic refraction method. The bottom of the basement complex is marked by the intermediate layer having a compressional wave velocity of about 6.25 km/s and depths near 10 km.

Velocity of \underline{P}_n events is 8.18 km/s and these were recorded near the critical distance at one station, providing an estimate of the time-term to depth conversion factor of 9.56 km/s. \underline{P}_n events traversing Eglinton Island and the west coast of Melville Island show excess times of 0.6 s to 3 s. This region of apparently low mantle velocity may be related to the geomagnetic variation anomaly reported near by.

The average time-term of 3.67 s represents an average crustal thickness of 35 km. Some variation in crustal time-terms is caused by differing

thicknesses of low velocity sediments rather than undulations on the crust-mantle interface. The time-term of 3.07 s for the most distant shot on the ocean profile does not, by itself, suggest a thinner crust than similar values among the islands; this is shown to be a possible interpretation problem.

A negative correlation between crustal time-terms and Bouguer gravity values is noted to be partly due to the effect of varying proportions of low-velocity - low-density rocks and high-velocity - high-density rocks within a few km of depth.

Poole, W.H.

SOLID-EARTH SCIENCE IN THE APPALACHIAN REGION OF CANADA;
Can. Mining Met. Bull., vol. 64, No. 2, pp. 1-10, 1970.

Geological investigation in the Appalachian region of Canada began more than 150 years ago. The distribution of rock formations, and their ages and regional structure are today reasonably well known in most parts of the region to 1- or 2-mile scale. Most Newfoundland geology is known only to 4-mile scale. About 200 earth scientists carry out research in the region, of whom about 25 per cent are government employees, 50 per cent university staff and graduate students, and 25 per cent industry employees.

Increased activity is needed toward both regional analyses and problem studies through the efforts of multi-disciplinary teams. The ultimate objectives of earth science must be the discovery and development of mineral resources and the use and conservation of natural material in the environment, all for the benefit of the local inhabitants. To accomplish this, the scientific community must carry out an array of research projects ranging from the technical products of geological, geophysical and geochemical surveys through to the research products designed to renew theories and hypotheses bearing on natural processes. Some scientific sub-objectives are listed.

Recommended is the increase and broadening of communication among Appalachian scientists, specifically those resident in the Atlantic Provinces. It is proposed that an Appalachian Division of the Geological Association of Canada be formed to provide a forum for discussion of Appalachian topics. In addition, a committee or council of university, industry and government earth scientists should be formed to examine the state of the science in the region, to identify programs of investigation and individual projects of research, and to recommend methods of approach. If the committee succeeds and the scientific community acts upon the recommendations, the quantity, quality and pertinence of research will increase, and earth science will better serve Appalachian society.

Rampton, V.N.

NEOGLACIAL FLUCTUATIONS OF THE NATAZHAT AND KLUTLAN
GLACIERS, YUKON TERRITORY, CANADA; Can. J. Earth Sci., vol. 7,
No. 5, pp. 1236-1263, 1970.

The Natazhat and Klutlan Glaciers are surging valley glaciers whose present termini are located at the northern edge of the St. Elias Mountains.

Both glaciers have massive ice-cored Neoglacial morainal complexes extending down-valley from their ice termini. At least six separate Neoglacial moraines adjacent the Klutlan Glacier and four adjacent the Natazhat Glacier have been identified from changes in the geomorphic, pedologic, limnologic, vegetational, dendrochronologic, and lichenometric characteristics across the morainal complexes. Dating of the individual moraines by lichenometry, dendrochronology, and ^{14}C implies that most were constructed within the last 550 years, although both glaciers have been relatively inactive near their termini since 1947.

Stratigraphy and ^{14}C dates suggest that the initial Neoglacial advance of the Natazhat Glacier near its Neoglacial maximum occurred ca. 3300 B. P. and that of the Klutlan Glacier ca. 1520 B. P.

Intervals during which the glaciers constructed a number of moraines near their Neoglacial maxima probably were caused by cool summer temperatures, even though individual moraines were formed by glacial surges. A number of factors make impossible precise dating of the intervals of cool summer temperatures.

Rampton, V. N.

LATE QUATERNARY VEGETATION CHANGES IN THE WESTERN YUKON TERRITORY, CANADA: THEIR RELATIONSHIP TO THE REGIONAL LATE WISCONSIN GLACIAL HISTORY; Abstr., Am. Quat. Assoc., 1st Meeting, p. 109, 1970.

A pollen diagram and C^{14} dates from "Antifreeze Pond", southwestern Yukon, suggest the following vegetational sequence: 27,000 B. P. through 10,000 B. P. - sedge-moss tundra; 10,000 B. P. through 8,700 B. P. - shrub tundra; 8,700 B. P. through 5,700 B. P. - spruce woodland; 5,700 B. P. through present - spruce forest. An increase in certain aquatic and semi-aquatic pollen taxa ca. 13,500 B. P. suggest that either a change in limnological conditions or slight warming of the climate occurred at the time. Pollen stratigraphy and C^{14} dates from three sites in the Ogilvie Mts., west-central Yukon, indicate that, locally, sedge-moss tundra was replaced by shrub tundra between 13,800 B. P. and 12,500 B. P., and that spruce invaded the area shortly after 9,600 B. P. "Antifreeze Pond" is ca. 2,000 feet below the tree-line whereas the sites in the Ogilvie Mts. are near or above tree-line.

The early appearance of shrub tundra in the Ogilvie Mts. relative to its appearance in the area of "Antifreeze Pond" may have any of a number of explanations: (1) C^{14} dates relating to the replacement of sedge-moss tundra by shrub tundra are in serious error. This seems improbable as the sequence of C^{14} dates from "Antifreeze Pond" and the C^{14} dates from the Ogilvie Mts. are internally consistent. (2) The pollen stratigraphy may be recording very local changes in vegetation. However, as the analyzed sediments at three of the sites, including "Antifreeze Pond" were lacustrine, the pollen profiles probably represent regional changes in the vegetation. (3) Following a general regional amelioration of climate, the migration of shrub tundra to the "Antifreeze Pond" area from Late Wisconsin refugia was delayed. This also seems improbable as "Antifreeze Pond" is as close or closer to probable refugia than the sites in the Ogilvie Mts. (4) Most probably, the initial late Wisconsin climatic warming was subdued in the

"Antifreeze Pond" area because of the closeness of complex glacier systems south and east of the area. These glacier systems probably had local effects on the climate in areas adjacent to them, such as the "Antifreeze Pond" area.

The glacial history, i. e. glacier recession from the Late Wisconsin maximum ca. 14,000 B. P. to near the present borders by 11,000 B. P., and dated pollen sequences of the western Yukon suggest that glacier recession during the Late Wisconsin was a more dramatic phenomenon than vegetational changes, especially along the northern flank of the St. Elias Mts. One explanation is that the source area of the St. Elias glacier system experienced different climatic changes than the west-central part of the Yukon during Late Wisconsin time. The source area is, in comparison to most of the western Yukon, relatively exposed to the climatic influences of the Pacific Ocean. Another possibility is that the Late Wisconsin deglaciation was caused by changes in precipitation that did not significantly affect the vegetation of the western Yukon.

Rimsaite, J.

EFFECT OF OXIDATION AND DEHYDRATION ON OPTICAL AND X-RAY PROPERTIES OF MICAS; Prog. and Abstr. 19th Clay Min. Conf., Miami, 1970.

Seven chemically analyzed mica concentrates were dehydrated under experimental conditions selected from results of differential thermal and thermogravimetric analyses. Optical and X-ray diffraction properties for the seven original micas and their dehydrated portions are reported. Changes in physical and structural properties of the biotite and phlogopite are related to quantities of oxidized iron and losses of hydroxyl group contents; the unit cell dimensions decrease and refractive indices, birefringence and optic angles increase with increasing quantities of oxidized iron and dehydration. The oxidized and dehydrated biotites become bright orange-red, and the change in colour and birefringence are used to study the process of dehydration and homogeneity of partly-dehydrated biotite flakes. Partly-dehydrated aluminium micas, muscovite and lepidolite, are heterogeneous consisting of unaltered areas in a dehydrated, almost isotropic matrix. The apparently isotropic dehydrated areas increase with increasing time of dehydration, and single-crystal X-ray diffraction patterns indicate a mosaic nature of the partly-dehydrated flakes. Depending on chemical composition, micas retain their structure with only 10 per cent of the original hydroxyl contents remaining in the lattice. On further loss of hydroxyl contents, new phases appear on X-ray patterns, in addition to an amorphous phase. Biotite recrystallizes to iron oxides and spinels, phlogopite to olivine and leucite, and muscovite to corundum and spinels. These properties are useful for the identification of partly-dehydrated natural and synthetic micas.

Rimsaite, J.

ADSORPTION AND RETENTIVITY OF ADSORBED AND RADIOGENIC ARGON IN HEATED MICAS; Prog. and Abstr. Geol. Assoc. Can. / Mineral. Assoc. Can., p. 45, 1970.

Chemically analyzed phlogopite, biotite, muscovite, lepidolite and fine-grained micaceous alteration products were heated in air, in argon and at reduced pressure to temperatures selected from their DTA and TGA data. Argon isotopes, H_2O , F, FeO and Fe_2O_3 were determined after heating and losses of argon were correlated with degree of oxidation and dehydration of the micas. Results indicate that loss of radiogenic argon and adsorption of atmospheric argon vary with chemical composition, grain-size and morphology of the mica. By comparing results obtained on specimens of similar grain size it is shown that the retentivity of radiogenic argon in heated micas decreases in the order phlogopite - biotite - muscovite in direct proportion to their thermal stabilities. With increasing time heated muscovite loses proportionately more argon and water and becomes heterogenous, consisting of unaltered patches enclosed in a dehydrated host. When heated in Ar at 1 atm. pressure, all micas adsorb argon. Coarse-grained muscovite adsorbs less argon than biotite of similar grain size, whereas a fine-grained muscovite-like alteration product adsorbs three times as much atmospheric argon as the coarse-grained muscovite. After reheating in air, phlogopite loses about 10 per cent and biotite about 50 per cent of the adsorbed argon. Partly dehydrated and oxidized micas are stable up to 1200° C. Differential loss and adsorption of argon in coexisting micas, and the capacity of fine-grained micaceous alteration products to adsorb large quantities of argon may account for some discrepancies in K-Ar ages.

Rimsaite, J.

ANIONIC AND CATIONIC VARIATIONS IN ZONED PHLOGOPITE;
Contr. Mineral. and Petrol., vol 29, pp. 186-194, 1970.

Complete chemical analyses of the inner and outer portions of zoned phlogopite indicate differences in concentrations of 15 major and minor constituents. Concentrations of aluminium, sodium and zinc increase while those of other oxides decrease in the rim. Distribution coefficients of major and minor oxides between the rim and the core (K_{Dox}^{r-c}) indicate a slight decrease for Si, Fe^{2+} , Mg, K and Sr (0.99-0.9); a greater decrease for Rb and water (0.86-0.83), and a significant decrease for Ti, Fe^{3+} , Mn, Ni, and F (0.50-0.71).

Physical and structural properties of the phlogopite portions from the core and the rim are similar, but phlogopite in the core contains exsolved rutile needles and fine-grained mica specks (0.5%) which cause white appearance of the core in reflected light.

The zoned phlogopite provides an example of considerable anionic and cationic variations within a single crystal. It is of mineralogical and petrological interest because, unlike in most silicates, the concentrations of its iron and magnesium exhibit the same trend and an opposite trend to that of aluminium. Aluminium increases from 14% to 18%, and replaces Si, Ti, Mg, and Fe thus indicating its geochemical importance during late stages of crystallization.

Ross, Charles A., and Nassichuk, Walter W.

YABEINA AND WAAGENOCERAS FROM THE ATLIN HORST AREA, NORTHWESTERN BRITISH COLUMBIA; J. Paleontol., vol. 44, No. 4, pp. 779-781, 1970.

The fusulinaceans Yabeina and Schwagerina occur with the cephalopods Waagenoceras, Stacheoceras, Agathiceras, and Hyattoceras in the Cache Creek Group in northwestern British Columbia. The species of Yabeina have affinities with Y. ozawai from the lower part of the Neoschwagerina margaritae Zone in Japan and the cephalopods have affinities with those from the Wordian Stage of southwestern North America. This occurrence supports a correlation of the upper part of the Neoschwagerina Zone of the Tethyan faunal province with the upper part of the Zone of Parafusulina in the Midcontinent-South American faunal province.

Rouse, Glenn E., Hopkins, W.S., Jr., and Piel, K.M.

PALYNOLOGY OF SOME LATE CRETACEOUS AND EARLY TERTIARY DEPOSITS IN BRITISH COLUMBIA AND ADJACENT ALBERTA; in Geol. Soc. Am., Spec. Paper 127, pp. 213-246, 1970.

Palynological analyses of microfossil assemblages from Upper Cretaceous and lower Tertiary rocks in British Columbia and adjacent Alberta indicate major differences in the evolution of floras between coastal and interior locales. The Santonian-Campanian assemblage on the coast is dominated by an assemblage of ferns, herbaceous angiosperms, and Proteacidites, whereas the assemblage from beds of similar age in western Alberta is typified by different species of ferns, probable herbaceous angiosperms, and Aquilapollenites. These differences suggest the existence of two floral provinces during Santonian-Campanian time, possibly separated by the western cordillera.

A late Maestrichtian-Danian assemblage from the Rocky Mountain trench contains a taxodiaceous-angiosperm complex that differs from an assemblage of essentially the same age in the western interior region (eastern Montana - western South Dakota) of the United States, suggesting again the presence of two different floral provinces at this time.

A comparison of middle Eocene assemblages on the coast with those of the interior plateau regions of southern and central British Columbia shows a coastal assemblage composed of ferns and mainly herbaceous angiosperms, whereas the comparable assemblage east of the Coast and Cascade Mountains contains a predominantly coniferous-hardwood flora.

Rutter, N.W.

PLEISTOCENE PALEOSOL INVESTIGATIONS IN PARTS OF WESTERN CANADA; in Symp. on Pedology Quat. Res., Edmonton, 1969, pp. 83-102.

Very few Pleistocene paleosols have been described in Western Canada and these are confined mostly to buried soils. Three areas are discussed that

offer promise for relict paleosol study at the present time - the Interior Plains, the Rocky Mountains and environs, and parts of the Yukon. Reconstruction of past geomorphology, climate and vegetation, and time relationships may be aided by comparing soils on different surfaces and by individual study.

In the Interior Plains, stillstands and readvances of the last glaciation may be detected by recording differences in weathering intensity and profile thicknesses of soil in till on either side of a former ice front position. In the southern Rocky Mountains and environs three surfaces of widely varying age are present - at lower elevations, Wisconsin; at intermediate elevations, pre-Wisconsin (?); and at higher elevations, unglaciated surfaces. By relict soil study it may be possible to confirm that the pre-Wisconsin (?) surface actually represents an interglacial interval. In parts of the Yukon, at least four distinct surfaces are present. These include a non-glacial surface, at least Miocene age: a high terrace, whose surface dates from pre-Illinoian time; and lower terraces, dating from early Wisconsin or Illinoian and late Wisconsin times. The presence of ancient surfaces at varying elevations permits detailed study of the complexities and inter-relationships of soil development and geomorphic evolution.

Rutter, N. W.

A LATE-PLEISTOCENE GLACIAL ADVANCE, BOW RIVER VALLEY, ALBERTA, CANADA; Quaternary Geology and Climate, Publ. 1701; (U.S.) National Academy of Sciences.

In the Bow River valley, Banff National Park, Alberta, Canada, evidence indicates a relatively recent glacial advance, probably the last significant glacial event in the area. The glacier originated at the head of the Bow River valley (elevation $\pm 6,600$ ft or $\pm 2,000$ m) and flowed as far as Eisenhower Junction (approximately 40 miles or 64 km), receiving ice from numerous tributary valleys along its way.

Evidence for the advance is not based on a distinctive till or stratigraphic sequence, but rather on geomorphic criteria and related glacial deposits, such as relatively fresh lateral moraines and cirques, and breaks in slope caused by glacial scouring and side-glacial stream action. The extent of the advance was determined by an end moraine consisting of ice-contact outwash, by the relative development of the post-glacial Bow River and flood plain plus alluvial fans from tributary creeks upstream and downstream from the end moraine, and by the geographic distribution of relatively fresh cirques and glacial troughs.

Evidence is also present for a minor readvance. Air-photograph interpretation and ground reconnaissance indicate that the Eisenhower Junction advance probably was not local but extended throughout much of the Main Ranges subprovince of the Canadian Rocky Mountains.

The minimum age for the advance may be about $9,330 \pm 170$ years B. P., as dated from charcoal samples collected in a nearby area.

Sangster, D.F.

METALLOGENESIS OF SOME CANADIAN LEAD-ZINC DEPOSITS IN CARBONATE ROCKS; Geol. Assoc. Can., Proc., vol. 22, pp. 27-36, 1970.

Three main types of lead-zinc deposits in carbonate rocks have been recognized in Canada. Two may be termed conformable. One of these occurs peripheral to or between undeformed sedimentary basins in clean, massive or coarse-bedded, vuggy, sometimes reefal, dolomite and consists of massive to disseminated sulphides. Pine Point is of this type. In contrast, the other occurs in intensely deformed, dark, well-bedded dolomite intruded by rocks of granitic to intermediate composition. The sulphide bodies are layered and may be deformed and/or thermally metamorphosed. Remac mine in the Kootenay Arc is an example of this type. Several lines of evidence suggest that the two conformable types are similar in origin but not in time of emplacement.

The third, or non-conformable, type are typically Pb(Zn)-Ag-barite veins. Good examples are found in the marble belt of the southern Grenville province, where evidence suggests that they are related to the Ottawa Valley graben structure of possible Cretaceous age and thus have no close relationship to the rocks that contain them.

Sangster, D.F.

GEOLOGICAL SIGNIFICANCE OF STRATABOUND SULPHIDE DEPOSITS; Geol. Assoc. Can., Proc., vol. 23, pp. 69-72, 1971.

Recognition of the coeval relationship between many stratabound sulphide deposits and their host rocks is having the effect of bringing the study of these orebodies into the mainstream of geological advancements. Examples are presented to illustrate how several earth science disciplines, other than economic geology, could find challenge in, and contribute to, a study of stratabound sulphide ores. Conversely, these deposits contain valuable data which bear upon such geological concepts as global geochemistry, Earth history, primordial atmosphere, basin analysis, and petrochemistry.

Sangster, D.F.

GEOLOGICAL EXPLORATION GUIDES FOR CANADIAN LEAD-ZINC DEPOSITS IN CARBONATE ROCKS; Can. Mining J., pp. 49-51, April, 1970.

The choice of target areas in the search for lead-zinc deposits in carbonate rocks depends to a large extent on recognizing geologically favourable lithologic and/or time-rock units. Economic concentrations of ore minerals occur in time-rock units where they are coincident with appropriate paleogeographic position and/or tectonic overprinting. Some conformable lead-zinc orebodies occur peripheral to undeformed sedimentary basins in clean, massive or coarse-bedded, vuggy reefal dolomite and consist of massive

or disseminated sulphides. Others are found in intensely deformed, dark, well-bedded dolomite intruded by rocks of granitic to intermediate composition. These sulphide bodies are layered and are commonly deformed and/or thermally metamorphosed. The effects of tectonic processes on localization of ore in both types of occurrence are discussed.

Based on the preceding observations, examples of potential ore-bearing sedimentary basins in Canada together with favorable time-rock and lithologic units will be outlined as prospective exploration targets.

Schaeffer, R. M., and Schwarz, E. J.

THE MID-ATLANTIC RIDGE NEAR 45° N. IX. THERMOMAGNETICS OF DREDGED SAMPLES OF IGNEOUS ROCKS; *Can. J. Earth Sci.*, vol. 7, pp. 268-273, 1970.

The thermomagnetic properties of 15 basalts dredged from the Mid-Atlantic Ridge near 45° N were studied in air at low pressure. One of the samples was used for detailed optical, X-ray diffraction, and electronmicroprobe studies. The Curie point and the cell edge of the original ferromagnetic constituents indicate the presence of titanomagnetite with Fe to Ti ratios of about 4.6. This was corroborated by electron microprobe results. During heating up to 550°C, the Curie point and the saturation magnetization increased gradually while the cell edge decreased. This suggests that the titanomagnetite was oxidized to titanomaghemite. After heating above 600°C, a Curie point at -20°C was observed while the saturation magnetization decreased. This may be considered as the result of an exsolution of a titanium-rich phase and a transition of maghemite to hematite. The thermomagnetic properties do not seem to be related with the pattern of alternating magnetic anomalies. However, the increase in Curie point with distance from the ridge suggests natural oxidation. Consequently, a part of the original TRM appears to have been replaced by CRM components, which cancelled out one another as they were acquired in periods of different geomagnetic polarity. This decay of the TRM offers an explanation for the decreasing intensity of the magnetic anomalies with distance from the axis.

Schwarz, E. J., and Symons, D. T. A.

PALEOMAGNETIC FIELD INTENSITY DURING COOLING OF THE SUDBURY IRRUPTIVE 1700 MILLION YEARS AGO; *J. Geophys. Res.*, vol. 75, No. 32, pp. 6631-6640, 1970.

Thirty-three oriented cores were taken along a 300-meter section of felsic norite in the Sudbury irruptive, Canada. Polishes section, thermomagnetic, and electron microprobe investigations show that the norite has a uniform magnetic mineral assemblage of virtually pure magnetite (oxidation states I and II) and ilmenite. This assemblage has a narrow range of blocking temperatures (420-540°C), and was probably formed above the highest blocking temperature. Two specimens from each core were analyzed by the Thellier method and a third by the alternating field demagnetization method of paleointensity determination; 51 acceptable paleointensity and inclination

values were obtained. The within-core variation in paleointensity values is significantly less than the between-core variation. The mean local paleofield intensity and inclination for the norite are 0.24 ± 0.06 oe and $64 \pm 8^\circ$, respectively. The paleofield intensity and inclination variations seem to be caused by variations in the earth's dipole moment except in a small 50-meter part of the section where the variation in intensity can be related to the variations in local inclination.

Schwarz, E. J.

THERMOMAGNETICS OF LUNAR DUST SAMPLE 10084-88; Apollo 11 Lunar Science Conference, Proc., vol. 3, pp. 2389-2397, 1970.

Partial hysteresis curves and thermomagnetic curves were obtained with a recording magnetic balance for lunar dust specimens (up to 20 mg) and a magnetic concentrate. Specimens were heated in the instrument at air pressures of 10^{-2} - 10^{-3} torr or in quartz vials under air pressures of 10^{-6} - 10^{-7} torr. Virtually pure iron and possibly other iron alloys with up to about 30% nickel are present. The abundance of the metallic iron is about 0.5%. The thermomagnetic curves show strong irreversibility while the partial hysteresis curves determined at 20°C and -190°C after heating to 800°C or more show reduced hysteresis, a more linear shape, and a two-fold increase in susceptibility above 4000 oe. These observations are consistent with oxidation of the original ferromagnetic iron to FeO at high temperatures and dissociation of FeO to superparamagnetic Fe and Fe_3O_4 below 570°C . A minor loss of ferromagnetic iron may be incurred by diffusion of Fe atoms into associated troilite. The evidence is that part of the irreversibility is due to the α - γ phase transition in iron containing about 30% nickel. The thermomagnetic curves may be interpreted to indicate the presence of iron with (a) less than 2 at. % Ni, (b) between 5 and 12 at. % Ni, and (c) around 30 at. % Ni. However, these estimates are suspect because of the strong possibility of loss of ferromagnetic iron in the specimens at higher temperatures.

Sen Gupta, Joy G.

DETERMINATION OF CARBON BY NON-AQUEOUS TITRATION AFTER COMBUSTION IN A HIGH-FREQUENCY INDUCTION FURNACE; APPLICATION TO ROCKS, STONY METEORITES AND METALLURGICAL SAMPLES; Anal. Chim. Acta, vol. 51, pp. 437-447, 1970.

Suitable non-aqueous titration methods have been developed for the determination of total carbon in silicate and carbonate rocks, stony meteorites and metallurgical samples by a high-frequency induction furnace. The method has been extended to the determination of carbon dioxide in rocks, clay and limestones by the acid evolution method. A conventional receiver with a buret for continuous titration was unsuitable in the induction heating procedure; and was replaced by two connected borosilicate glass receivers in a closed system. Acetone either alone (for 0-10 mg C) or in 1:1 mixture with methanol (for 10-30 mg C) containing 0.6% (v/v) monoethanolamine and

an excess of standard sodium methylate was found to be a better absorbent for carbon dioxide than pyridine. After reaction, the excess sodium methylate was back-titrated by a standard methanolic solution of benzoic acid with phenolphthalein as indicator. The method gives reliable results up to 47% total carbon dioxide.

Stalker, A. MacS.,

LATE WISCONSIN GLACIATION, AND THE YUKON-ALBERTA ICE-FREE CORRIDOR; Abstr. Am. Quat. Assoc. 1st Meeting, p. 126, 1970.

The presence of an ice-free corridor east of the Rocky Mountains during early recession of the Classical Wisconsin Glaciation now appears much more credible than it did just a few years ago. This is a result of a growing realization of the general weakness of the last Laurentide glacier on the western Great Plains, and its apparent failure to reach the western limits of some earlier glaciers. At the same time, with recent indications of the presence of man in the New World in pre-Classical Wisconsin time, the ice-free corridor concept has lost much of its former archaeological importance. It retains value, however, as a possible route for interchange of populations, ideas, and tools with the Old World, and for re-introduction of man into the New World if early settlers there had become extinct.

In order to solve pertinent archaeological problems, such as origin of the Clovis Complex, such a corridor had to be available as early as possible, and probably by 13,000 years ago. In Alberta, the only postglacial dates of that approximate age are two (13,580 and 13,510 years B. P., elevation 2,800 feet) from about 150 miles west-northwest of Edmonton and a 14,200 year date on bone (as yet uncorroborated) from Empress, in southeastern Alberta. The latter date is particularly interesting, for it comes from a river terrace (elevation 2,000 feet) about 40 feet above Red Deer River and 200 feet below the prairie level, and is associated with an abundant, cool-climate, mammalian fauna. As it is unlikely that ice ever advanced over the terrace, and significant time was necessary both to carve the 200 foot deep valley and to allow spread of the vegetation needed to support the fauna, Classical Wisconsin ice may never have advanced west of Empress. Altogether, it appears that by 13,000 years ago much of southern and west-central Alberta was ice-free and supporting a large animal population.

The recent map of Wisconsin ice retreat in Canada, by Prest, shows an unglaciated corridor through the Yukon to near the British Columbia boundary. Little is known about the remaining section between the Yukon and central Alberta. Absolute dates there are virtually non-existent. However, considering the apparent weakness of Laurentide glaciation farther south, much of that sector might then have been ice free.

Although a largely ice-free corridor east of the Rocky Mountains about 13,000 years ago has become a distinct probability, its suitability for, and use by, human migrants is another matter. Man probably crossed Bering Strait many times during the late Pleistocene, and not necessarily only during glacial episodes, though the lower sea-level at those times would have been a big help. The subsequent journeys southward from Alaska would have been much easier, and more likely took place, when the ice-sheets were far from their maximum positions.

Stott, D. F.

JURASSIC AND CRETACEOUS ROCKS OF PINE RIVER REGION,
BRITISH COLUMBIA; Field Conference Guidebook, Edmonton Geol.
Soc., pp. 58-83, 1970.

Jurassic and Cretaceous rocks in northeastern British Columbia include a thick succession of marine shales and sandstones interbedded with continental, coal-bearing strata. Although the composite thickness of the succession totals well over twenty thousand feet, it is unlikely that so much sediment was ever present at any one locality. Rather, it would appear that a series of depositional troughs developed with the axis of each successively younger one occurring progressively farther east.

Jurassic Fernie and basal Cretaceous Minnes strata of Pine River region outcrop only in the Foothills, where the major exposures occur between Clearwater River and the eastern rim of Carbon Creek basin. Bullhead strata occur along the axes of several major synclines, particularly the Carbon Creek syncline, and in folds as far east as the lower end of Peace River canyon. Successively younger beds outcrop eastward with Lower Cretaceous Fort St. John beds appearing east of Crassier Creek in Pine River valley and east of the canyon of Peace River. The Upper Cretaceous Dunvegan Formation is involved in the folding along the eastern Foothills and extends eastward into the Plains. The younger marine succession of the Smoky Group appears south of John Hart Highway along an escarpment extending from Murray River eastward toward Dawson Creek. The overlying continental Wapiti strata form the bedrock surface of most of the Plains region south of the highway.

Symons, D. T. A., and Schwarz, E. J.

PALEOINTENSITY STUDY OF LATE MIOCENE IGNEOUS ROCKS FROM
BRITISH COLUMBIA, CANADA; Can. J. Earth Sci., vol. 7, pp. 176-181,
1970.

Sixty-nine specimens representing 49 late Miocene (10-15 m. y. ago) basaltic lava flows and 4 associated gabbroic intrusive plugs were studied in an attempt to estimate the paleointensity of the earth's magnetic field in south-central British Columbia. The paleointensity determination was based on the comparison of the decay of natural remanent magnetism intensity with that of an artificial thermoremanent magnetism ($H = 0.35 \text{ Oe}$) in progressively higher alternating demagnetizing fields (peak: 800 Oe). Only 22 of the 69 specimens were considered to yield reliable paleointensity determinations which give an estimated average equatorial intensity for the late Miocene earth's field of $0.18 \text{ Oe} \pm 0.11$. This result agrees reasonably well with those from contemporaneous rocks from North America, Japan, and Iceland. Several low determinations with consistent, normal, or reversed remanence directions suggest that the intensity of the non-dipole components of the late Miocene earth's field must have been very small in the sampled area.

Taylor, G. C., and Bamber, E. W.

PALEOZOIC STRATIGRAPHY OF PINE PASS, NORTHEASTERN BRITISH COLUMBIA; Edmonton Geol. Soc. Field Conf. Guide Book, pp. 46-57, 1970.

The Paleozoic succession of the Pine Pass area consists of shallow marine carbonates, sandstones, and shales of Cambrian, Ordovician, Devonian, Early Carboniferous (Mississippian), and Permian age. Several major facies changes and unconformities occur within this sequence, which is intermediate in nature between those to the north and south, and is therefore important for the establishment of regional correlations between the Jasper area and the northern Rocky Mountains and Foothills.

Tempelman-Kluit, D. J.

THE RELATIONSHIP BETWEEN SULFIDE GRAIN SIZE AND METAMORPHIC GRADE OF HOST ROCKS IN SOME STRATA-BOUND PYRITIC ORES; Can. J. Earth Sci., vol. 7, No. 5, pp. 1339-1345, 1970.

New data concerning the grain size of sulfide minerals in some ore deposits surrounded by metamorphosed silicate host rocks is presented. These indicate that average grain size of ore and grain size range of individual sulfide minerals show fair correlation with metamorphic grade of host rocks.

Thomas, R. L., Kemp, A. L. W., and Lewis, C. F. M.

THE DISTRIBUTION AND CHARACTERISTICS OF LAKE ONTARIO SURFACE SEDIMENTS; Geol. Soc. Am., Abstr. with Program, vol. 2, No. 7, p. 703, 1970.

A detailed reconnaissance sampling program of Lake Ontario surficial sediments was carried out in 1968. Sampling was carried out on an 8 km polyconic grid using a Shipek grab sampler. Sediment particle size, pH, Eh, organic carbon, carbonate carbon, quartz, and mineral clay were measured in the top 3 cm at each station. Additional information was acquired by echosounding profiles of the lake. From the echograms, sediment types could be characterized and their contacts well defined. Lake Ontario is partitioned by two north to south sills composed of glacial materials into three depositional basins which in turn are separated from the Kingston Basin to the northeast by an east to west trending bedrock sill. The nearshore zone of the lake is characterized by the occurrence of glacial materials. Glacial tills with surface lag gravels and sands outcrop around the periphery of the lake and were derived from the final ice retreat from the region. Offshore the tills are overlain by stiff, fine-grained laminated silty to sandy glacio-lacustrine clays deposited in Lake Iroquois times and characterized by surficial lag sands. The glacio-lacustrine clays are succeeded offshore by the silty clays and clays of the depositional basins. The modern sediments of the lake pro-grade offshore into the deeper waters of each depositional basin.

From inshore to offshore, a decreasing mean grain size is associated with decreasing quartz and increasing clay and organic carbon. The clay minerals are composed predominantly of illite with subsidiary kaolinite and chlorite. Carbonate carbon is related to the silt component of the sediment derived by weathering of the regional limestones.

Toomey, Donald Francis, Mountjoy, Eric W., and MacKenzie, Warren S.

UPPER DEVONIAN (FRASNIAN) ALGAE AND FORAMINIFERA FROM THE ANCIENT WALL CARBONATE COMPLEX, JASPER NATIONAL PARK, ALBERTA, CANADA; Can. J. Earth Sci., vol. 7, p. 946, 1970.

Marine algae and foraminifers occur in the Ancient Wall carbonate complex of Upper Devonian (Frasnian) age in Jasper National Park, Alberta, Canada. This microbiota is the most diverse and abundant yet described and illustrated from North America; it closely resembles other microbiotas from the Upper Devonian of Western Australia and the Volga-Urals region of the Soviet Union.

Strata of the Ancient Wall complex comprise two formations each with two members. They are: the Cairn Formation with a lower Flume Member and an upper member and the overlying Southesk Formation with a lower member and an upper Simla Member. A biota of 15 genera and 21 species is recorded from these rocks. The forms grouped under the algae are: Vermiporella sp., Girvanella sp., Sphaerocodium sp., Renalcis sp. cf. R. turbitus Wray, R. sp., radiosphaerid calcispheres, and algal? borings. The calcareous foraminifers are: Parathurammina sp. cf. P. spinosa Lipina, P. sp., Bisphaera sp., lagenid-like form, Paratikhinella sp. cf. P. cannula (Bykova), P. sp., Tikhinella sp. cf. T. measpis Bykova, T. sp., Evlania? sp., Eonodosaria sp. cf. E. evlanensis Bykova, E. sp., Multiseptida sp. cf. M. corallina Bykova, M. sp., and Nanicella sp.

Calcareous foraminifers, dominantly parathuramminids, comprise about two-thirds of the total biota. The remaining one-third consists of algae, amongst which radiosphaerid calcispheres are the most abundant. The relatively primitive parathuramminids are more numerous in the Cairn Formation, whereas more advanced foraminifers such as tikhinellids, eonodosarids, and multiseptids occur more frequently in the overlying Southesk Formation. There is also an appreciable increase in foraminiferal diversity between the basal Flume Member and upper member of the Cairn Formation. Radiosphaerid calcispheres and parathuramminids are most numerous in skeletal wackestones and tikhinellids, eonodosarids, and multiseptids in less muddy packstones and grainstones.

Study of this biota substantiates previous interpretations of the depositional environment based on stratigraphic and petrographic evidence. In general, these indicate shallow-water environments for both the Cairn and Southesk Formations, with the packstones and grainstones, which occur more frequently in the Southesk Formation, indicative of more agitated and presumably shallower waters.

Trail, R. J., Plant, A. G., Douglas, J. A. V., and Dence, M. R.

PYROXFERROITE, A NEW CALCIUM-BEARING IRON SILICATE FROM TRANQUILLITY BASE; Apollo 11 Lunar Science Conference, Proc., vol. 1, pp. 65-79, 1970.

Pyroxferroite from Tranquillity Base, Moon is defined as the iron-rich analog of pyroxmangite. Pyroxmangite is redefined as the manganese-rich member of the Siebenerketten pyroxenoids. Pyroxferroite is triclinic, $a\ 6.62$, $b\ 7.54$, $c\ 17.35A$, $\alpha\ 114.4$, $\beta\ 82.7$, $\gamma\ 94.5^\circ$; optically biaxial, $\alpha\ 1.753$, $\beta\ 1.755$, $\gamma\ 1.766$, $2V + 35^\circ$. A typical unit cell content is close to $14(\text{Fe}_{0.84}\text{Ca}_{0.13}\text{Mg}_{0.02}\text{Mn}_{0.02})(\text{Si}_{0.99}\text{Al}_{0.01})\text{O}_3$. Density 3.82 calc., 3.76 obs. Yellow color.

Trail, R. J., Plant, A. G., and Douglas, J. A. V.

GARNET: FIRST OCCURRENCE IN THE LUNAR ROCKS; Science, vol. 169, pp. 981-982, 1970.

Three grains of almandine-rich garnet isolated from lunar sample 12021 have the composition $\text{Alm}_{70.7}\text{Gro}_{25.0}\text{Sp}_{2.7}\text{Pyr}_{1.6}$, with cell edge of 11.624 angstroms and refractive index of 1.81 . The garnet probably formed late in the crystallization sequence.

Tremblay, L. P.

THE SIGNIFICANCE OF URANIUM IN QUARTZITE IN THE BEAVERLODGE AREA, SASKATCHEWAN; Can. J. Earth Sci., vol. 7, No. 2, Pt. 1, pp. 280-305, 1970.

Quantitative spectrographic analyses for Cr, V, Cu, Ni, and Co of 219 specimens of the country rocks from the Beaverlodge area, Saskatchewan, and chemical analyses for U of 68 of those rock specimens and for Th of 38 of them have shown that positive relationships exist between the above elements and uranium in quartzite, and that quartzite may be the principal source of uranium in the uranium deposits.

Trettin, H. P.

EARLY PALEOZOIC EVOLUTION OF NORTHERN PARTS OF CANADIAN ARCTIC ISLANDS; Alta. Assoc. Petrol. Geol. Bull., vol. 54, p. 2510, 1970.

A geosyncline occupied northern parts of the Arctic Islands in Late Proterozoic time. It received sediments from the continent and deepened in a northerly direction. A northwestern belt, which included northernmost Ellesmere Island and the present shelf off Ellesmere and Axel Heiberg Islands, underwent an orogeny in latest Proterozoic or Cambrian time. The orogen behaved as an intermittently rising geanticline, and remained a site of volcanism, plutonism, and metamorphism, from Cambrian to Devonian time.

Sediments derived from the geanticline accumulated in a clastic basin on its southeast side. The basin was flanked on the southeast by a subsiding carbonate shelf, in turn grading southward to stable carbonate platforms.

Three phases of sedimentation are recognized in the clastic basin in northeastern Ellesmere Island: (1) Middle to Upper Cambrian(?) post-tectonic deltaic deposition; (2) Early to Middle Ordovician deep-water deposition of starved-basin type (radiolarian chert, graptolitic shale, etc.); (3) late Middle Ordovician to Middle Silurian deep-water deposition of flyschtype (greywacke, shale, etc.).

The trough must have formed by subsidence of the continental crust rather than by sea-floor spreading, because the deep-water sediments lie on shallow-water sediments and not on volcanics. The trough, which was separated from subaerial parts of the geanticline by a shelf on which carbonates, clastics, and volcanics were deposited, expanded until about mid-Silurian time, then migrated southeast, ahead of the southeast-migrating geanticline. The southeast flank of the trough, characterized by graptolitic shales and limestones, has been traced from northwestern Greenland to northwestern Melville Island. There, starved-basin conditions persisted from Early Ordovician to Early Devonian time.

A north-trending belt in the central islands, extending from the stable platform to the geanticline, was elevated in the Early Devonian. The uplift was basement controlled and reflects Precambrian basement trends unrelated to the early Paleozoic basin configuration.

An orogeny of the entire northern regions, locally accompanied by intrusion of quartz diorite, occurred in Middle Devonian to Mississippian time. Deformation and uplift proceeded from northwest to southeast.

Trettin, H. P.

CANADA BASIN AND LOMONOSOV RIDGE: INFERENCES BASED ON PRECAMBRIAN AND LOWER PALEOZOIC GEOLOGY OF CANADIAN ARCTIC ISLANDS; Alta. Assoc. Petrol. Geol. Bull., vol. 54, p. 2509, 1970.

Canada basin truncates and post-dates a belt of north-trending structures in the central part of the Arctic Islands. The trends, though exhibited by Phanerozoic strata, are interpreted as rejuvenated Precambrian basement features because they cut across Phanerozoic basin axes and parallel exposed Precambrian structures on the south. The maximum possible age of the Canada basin, therefore, is the age of these trends — about 1.7 b. y.

A geanticline, characterized by volcanism and plutonism, rose out of a late Proterozoic geosyncline and occupied the northern rim of the Arctic Islands and adjacent present offshore region, from Cambrian to Devonian time. What lay beyond the geanticline is unknown, and speculations about that region depend on the tectonic model used.

If present concepts of plate tectonics are applied, it appears that Canada basin (or some predecessor) opened in middle to late Proterozoic time with a geosyncline developing on the newly formed continental margin. The floor of the basin was thrust beneath the geosyncline from latest Proterozoic or Cambrian to Devonian time, and produced a geanticline above and south-east of the postulated Benioff zone.

Lomonosov Ridge - A belt of north-trending structures in northernmost Ellesmere Island lines up with the southern extremity of Lomonosov Ridge. The volcanic rocks are partly pre-late Middle Ordovician. The belt aligned with Lomonosov Ridge was elevated relative to terrane on the east during 2 Paleozoic orogenies, but not during the Tertiary orogeny. A short distance inland, the north-trending belt terminates against west-trending structures subparallel with the axis of the Franklinian geosyncline. The zone of intersection, marked by ultrabasic intrusions, was a site of repeated crustal extension on a scale of miles.

If the Lomonosov Ridge has oceanic crust the apparent alignment would be coincidental. If it has continental crust, two interpretations are possible: (1) the north-trending belt represents an early Paleozoic "Lomonosov geosyncline" that joined the Franklinian; (2) both Lomonosov Ridge and the north-trending belt in Ellesmere Island are controlled by meridional Precambrian basement trends, but these trends were rejuvenated in a different manner, and perhaps at different times, on Ellesmere Island and in the present Arctic Ocean. This hypothesis is favored.

Trettin, H. P.

ORDOVICIAN-SILURIAN FLYSCH SEDIMENTATION IN THE AXIAL TROUGH OF THE FRANKLINIAN GEOSYNCLINE, NORTHEASTERN ELLESMERE ISLAND, ARCTIC CANADA; in *Flysch sedimentology in North America*, J. Lajoie, ed., Geol. Assoc. Can., Spec. Paper 7, pp. 7-35, 1970.

A submarine trough, characterized by graptolitic shale, radiolarian chert, argillaceous limestone, and calcareous breccia, developed in the interior of northern Ellesmere Island in Early Ordovician time. On the southeast it was bordered by a miogeosynclinal carbonate shelf, and on the northwest by a eugeosynclinal shelf that was a site of both carbonate deposition and intermittent volcanism.

From late Middle Ordovician to Late Silurian time this framework was modified as follows: (1) An Early Cambrian or older orogen, located on the northwest side of the eugeosynclinal shelf - in the present continental shelf region - was elevated intermittently and shed clastic sediments to the southeast, across the eugeosynclinal shelf and into the axial trough, where they formed flysch-like deposits. (2) The axial trough expanded until about mid-Silurian time, then it migrated southeast. (3) Volcanism remained confined to intervals of Ordovician time.

The flysch-like deposits are a thick, monotonous succession of alternating calcareous greywacke, calcareous siltstone, and calcareous shale with local conglomerates and an extremely rare graptolite fauna. Massive and graded bedding, parallel and convolute lamination, ripple marks, and sole marks are the typical primary structures.

Petrographic analyses suggest that about one third of the sediment volume was derived from contemporaneous carbonates, about 90 per cent of the terrigenous fraction from the Cambrian or older metamorphic Cape Columbia Complex, and the remainder from Ordovician cherts and volcanics.

Directional markings on the base of graded beds indicate that paleocurrents descended into the axial trough from the northwest - about parallel

with the structural trend. Longitudinal transport occurred for more than 150 miles, and transverse transport at times for more than 130 miles.

The following succession of facies is inferred for the late Richmondian, a non-volcanic interval. Eugeosynclinal coast and shelf region: (1) nonmarine and littoral coarse clastic sediments, (2) nearshore marine fine clastic sediments and impure carbonates, and (3) shelf-type carbonates with abundant benthonic faunas. Axial trough: (1) graptolitic shale and limestone deposited on the upper part of the northwestern slope of the trough, (2) flysch with transverse current markings, deposited partly on submarine fans and partly on the floor of the trough, (3) flysch with longitudinal markings deposited on the floor of the trough, and (4) graptolitic shale and limestone deposited on the southeastern slope. Miogeosynclinal shelf: carbonates with benthonic faunas.

A characteristic and puzzling feature of the present flysch is the intricate and homogeneous mixing of coarse- to fine-grained terrigenous materials with carbonate particles. The mixing probably occurred within submarine canyons that received sediments from all three facies of the eugeosynclinal shelf and conducted them to the submarine fans.

Waldman, M., and Hopkins, W.S., Jr.

COPROLITES FROM THE UPPER CRETACEOUS OF ALBERTA,
CANADA, WITH A DESCRIPTION OF THEIR MICROFLORA; Can. J.
Earth Sci., vol. 7, pp. 1295-1303, 1970.

Coprolites from the Upper Cretaceous Oldman Formation of Alberta are believed to be those of small to medium-sized reptiles of aquatic habit, probably crocodiles, champsosaurs, or chelonians. The coprolites contain a microflora consisting mainly of lycopods, ferns, hemlocks, and various monocotyledons and dicotyledons, but the complete absence of any macrofloral material is taken as an indication that the coprolites are derived from carnivorous reptiles.