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BY OFFICERS OF THE
GEOLOGICAL SURVEY OF CANADA,
APRIL 1973 TO MARCH 1974**

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This report contains titles, and in most cases abstracts, of 128 papers prepared by officers of the Geological Survey (or in a few cases, by our staff members who directed authorized projects) and which were published in Scientific Journals and books between April 1, 1973 and March 31, 1974. The material is arranged alphabetically and in the case of multiple authorship only the name of the Survey officer is underlined. The abstracts are identical to those prepared by the journals article, only the title is listed and if both French and English abstracts were published, both are reproduced in this volume.

The papers herein listed and the various reports of the Geological Survey listed in Paper 74-3, the Index of Publications 1973-74 represent most of the scientific output of the branch for the fiscal year 1973-74.

Agterberg, F. P.

PROBABILISTIC MODELS TO EVALUATE REGIONAL MINERAL POTENTIAL; Paper M2 (pp. 3-38) Proc. of Symposium on Mathematical methods in geoscience, held at Pribram, Czechoslovakia, October, 1973.

The problem to be discussed consists of estimating the probability that a relatively small cell within a larger region contains one or more mineral deposits of a specific type. Secondly, we are interested in the probability distributions for total amount of metal of the different commodities that may be present in the deposits.

The data base consists of coded data for geological features present in small cells. Most of the resulting random variables are of a dichotomous nature, and in general, they cannot be regarded as spatially homogeneous in the entire region of study. The linear multivariate model used to compute probabilities of occurrence is based on the method of least squares. Initially, biased probabilities are estimated for all cells in the area of study. Two methods based on (1) definition of a control area, and (2) Jackknife statistics, are used for removing the initial bias. This method was kept flexible in order to cope with (1) the lack of homogeneity in the geological framework, and (2) possible metallogenic differences between the mineral deposits lumped together for statistical analysis. The reliability of the computed probabilities can be evaluated by using the Jackknife method.

The model is applied to data on massive sulphide deposits of Archean age in parts of the Superior Province of the Canadian Shield.

Agterberg, F. P., and Chung, C. F.

GEOMATHEMATICAL PREDICTION OF SULPHUR IN COAL, NEW LINGAN MINE AREA, SYDNEY COAL-FIELD; Can. Mining Met. Bull., v. 66, p. 85-96, 1973.

Prediction of a variable sulphur content in Cape Breton seams is important for planning the production of a high-grade metallurgical coal. Two extrapolation methods (Kriging and a version of Universal Kriging) to predict sulphur content in blocks of coal before mining are presented and applied to the New Lingan Mine reserves in the Harbour seam. The uncertainty of the predicted values is expressed by using standard deviations.

Some statistical results for the Phalen seam, which occurs about 400 ft. below the Harbour seam, are presented for comparison. The two mathematical models consist of two sets of equations which have been used in computer algorithms. Some limitations of the present approach and possibilities for further statistical work are indicated.

Allan, R. J., Cameron, E. M., and Durham, C. C.

LAKE GEOCHEMISTRY - A LOW SAMPLE DENSITY TECHNIQUE FOR RECONNAISSANCE GEOCHEMICAL EXPLORATION AND MAPPING IN THE CANADIAN SHIELD; Int. Geochem. Exp. Symp., 4th, London 1972, Proc. p. 131-160.

Kemp, A. L. W., Anderson, T. W., Thomas, R. L., and Mudrochova, A.

SEDIMENTATION RATES AND RECENT SEDIMENT HISTORY OF LAKES ONTARIO, ERIE AND HURON; J. Sediment. Petrol., v. 44, no. 1, p. 207-218, 1974.

Sedimentation rates and changes in organic carbon, nitrogen, phosphorus and mercury concentrations were determined for 14 core locations, representing basins of fine-grained sediment in Lakes Ontario, Erie and Huron. Sedimentation rates were estimated by averaging the weight of sediment deposited above the Castanea (chestnut) pollen decline dated at 1930 for Lake Ontario and 1935 for Lake Erie, and above the Ambrosia (ragweed) pollen rise, dated at 1850. Present-day sedimentation rates were high in Lake Erie, ranging from

847 to 5,049 g/m²yr, low to intermediate in Lake Ontario, ranging from 366 to 1,156 g/m²yr and low in Lake Huron ranging from 147 to 325 g/m²yr. There has been a three-fold increase in sedimentation rate in Lake Erie since 1935 and the Kingston basin of Lake Ontario since 1930.

The nutrient and Hg concentrations are enriched at the sediment surface in all the cores from Lakes Ontario and Erie, while the Huron cores show little change at the surface from their background concentrations. The enrichments are attributed to increased nutrient and Hg loading to the Ontario and Erie sediments, with the major increases after about 1950. The present-day loading of nutrients and Hg to the sediments parallels the rates of sedimentation at each location, being greatest in Lake Erie. Early-colonial loading of nutrients and Hg to Lakes Ontario and Erie are generally similar to the modern loading of Lake Huron. The total loading of sediment, nutrients and Hg was estimated for each lake. Present-day sediment accumulation of 4,600 X 10³, 23,400 X 10³, and 3,900 X 10³ metric tons was estimated for Lakes Ontario, Erie and Huron respectively.

Ansell, H. G., and Steacy, H. R.

ON THE REPORTED URANITE, URANOCHRE AND URACONITE OF THE SEYMOUR IRON MINE, MADOC TOWNSHIP, ONTARIO; *Can. Mineral.*, v. 12, pt. 3, p. 232-233, 1973.

A yellowish stain occurring on magnetite-rich specimens from the old Seymour iron mine, Madoc township, Ontario, proves to be ferrimolybdate. The identification corrects the periodically repeated description of the stain as a secondary uranium mineral variously named uranite, uranochre, or uraconite. The published correction was believed necessary apropos recent reports of uranium minerals at the nearby Richardson Mine at Eldorado, Ontario (see Steacy, H. R. et al., *Geol. Surv. Can.*, Paper 73-1, Pt. B, p. 103-105).

Balkwill, H. R.

STRUCTURE AND TECTONICS OF CORNWALL ARCH, AMUND RINGNES AND CORNWALL ISLANDS, ARCTIC ARCHIPELAGO; *in Proc. Geol. Assoc. Can. - Can. Soc. Pet. Geol.; Symp. on Geol. Can. Arctic*, p. 39-62, 1973.

Northwest-plunging Cornwall Arch dominates the structural geometry of Upper Triassic to Upper Cretaceous marine and nonmarine terrigenous clastic rocks on Cornwall and Amund Ringnes Islands. The arch is at least 200 kilometres long, about 70 kilometres wide, and has structural relief of about 4,000 metres; it is asymmetric, with a homoclinal, gently dipping western flank, and a steeper, structurally disrupted eastern flank.

New evidence indicates that the age of the arch is Late Cretaceous or early Tertiary: Maestrichtian strata lie conformably on the Mesozoic succession, but

Paleocene - Eocene deposits are discordant with underlying rocks and structures. Local evaporite-cored diapirs may be considerably older than the arch.

The structural style of Cornwall Arch may be accounted for by a tectonic model that relies on crustal fracturing and great vertical uplift as the dynamic mechanism.

Baragar, W. R. A., and Robertson, W. A.

FAULT ROTATION OF PALEOMAGNETIC DIRECTIONS IN COPPERMINE RIVER LAVAS AND THEIR REVISED POLE; *Can. J. Earth Sci.*, v. 10, no. 10, p. 1519-1532, 1973.

The paleomagnetic pole of a segment of lavas from the upper part of the Coppermine River Group is displaced relative to that previously obtained for the lower part of the group by a 28-degree, counter-clockwise rotation. The inclinations are approximately the same. This segment of lavas is separated from the lower part of the group by a fault zone. Elsewhere where the stratigraphic sequence is continuous, sediments and lavas of the upper part of the group give pole positions, which, although scattered, are in large part close to that of the lower part of the group. Hence, the displaced pole can reasonably be attributed to local rotation along a fault rather than to apparent polar wandering. Recognition of the tectonic rotation of the paleomagnetic pole leads to an interpretation of the faulting in the Coppermine River flows as rift faulting closely following extrusion of the lavas.

New Coppermine River pole positions are calculated combining the data previously obtained from the lower part of the Coppermine River Group with that from lavas (4 sites) and sediments (5 sites) from the upper part of the group. The new Coppermine River pole from the lavas is at 02N, 180E and from lavas and sediments combined is at 03N, 182E ($\delta p = 3$, $\delta m = 6$). The latter is the pole recommended for use. That this is a Coppermine River pole rather than a Mackenzie pole is emphasized with a thought that the various elements of the Mackenzie magmatic events may ultimately resolve into a succession of discrete episodes.

Barnett, D. M.

ANTHROPOGENIC ICE: NOTES ON A DRAMATIC EPHEMERAL CRYERGIC LANDFORM; *J. Glaciol.*, v. 12, no. 66, p. 508-511, 1973.

A brief photographic history of a man-induced ice cone is given. This ephemeral feature created around a gas well on Melville Island, N. W. T., Canada, indicates that the present climate is not capable of sustaining a natural ice mass. Disappearance of the ice is projected by 1974 without intervention of man.

Barnett, D. M., and Holdsworth, G.

ORIGIN, MORPHOLOGY, AND CHRONOLOGY OF
SUBLACUSTRINE MORAINES, GENERATOR LAKE,
BAFFIN ISLAND, NORTHWEST TERRITORIES,
CANADA; *Can. J. Earth Sci.*, v. 11, p. 380-408, 1974.

The morphology and chronology of exposed sublacustrine moraines is discussed. These are shown to have been formed in a sublacustrine environment. The moraines are characterized by their occurrence in large numbers within a former ice dammed lake basin and by their asymmetric cross-section. Using moraine volume estimates combined with the time control, a till depositional rate is calculated.

A radiocarbon chronology for the Generator Lake area over the last 4500 years is presented.

Hydrological relationships are established which are shown to influence the formation of sublacustrine moraines. The relationships are physically connected and are not empirical. Current studies of the calving ice front at Generator Lake show that moraines must be forming under the tapered ice ramps which flow into the lake. Measurements of debris content within the ice combined with ice flow rate measurements show that the present till supply rates are consistent with those calculated from the exposed moraine field.

A model is set up which connects the lake hydrology with the existence or destruction of the ice ramps, as controlled by bending induced by buoyancy forces. The time of existence and subsequent behavior of the ramps is shown to influence the geometry and indirectly the spacing of the sublacustrine moraines.

Blake, W. Jr.

FORMER OCCURRENCE OF MYTILUS EDULIS L. ON
COBURG ISLAND, ARCTIC ARCHIPELAGO; *le naturaliste canadien*, v. 100, p. 51-58, 1973.

Investigations on Coburg Island, Arctic Archipelago, have revealed that the blue mussel, Mytilus edulis Linne, formerly lived 350 km north of its present limit. The age of the mussels on Coburg Island is >38,000 radiocarbon years (GSC-1425), and the deposit probably relates to the warm interval, with accompanying higher sea-level, which corresponds to the Sangamon Interglacial of continental North America.

Boyle, R. W., and Davies, J. L.

BANDED IRON FORMATIONS; *Geochim. Cosmochim. Acta*, v. 37, no. 5, p. 1389, 1973.

Boyle, R. W.

RADIOACTIVE SILVER IN EAST EUROPEAN SILVER BARS; *Nature*, v. 243, no. 5408, p. 460-461, 1973.

Brideaux, W. W., and McIntyre, D. J.

LUNATADINIUM DISSOLUTUM GEN. ET SP. NOV.,
A DINOFLAGELLATE CYST FROM LOWER
CRETACEOUS ROCKS, YUKON TERRITORY AND
NORTHERN DISTRICT OF MACKENZIE; *Bull. Can. Pet. Geol.*, v. 21, no. 3, p. 395-402, 1973.

A new and distinctive dinoflagellate cyst, Lunatadinium dissolutum, gen. et sp. nov., characterized by a smooth wall and a type 3P precingular archeopyle, is described from Lower Cretaceous (Hauterivian to Middle Albian) rocks of northern Canada.

Campbell, R. B.

STRUCTURAL CROSS-SECTION AND TECTONIC
MODEL OF THE SOUTHEASTERN CANADIAN
CORDILLERA; *Can. J. Earth Sci.*, v. 10, p. 1607-1620, 1973.

Recent models for the structural evolution of the southern Canadian Rocky Mountains have emphasized 'thin-skinned' tectonics whereby thrust sheets piled up from west to east above a décollement on a passive crystalline basement. The concept implies that the more westernly Omineca Crystalline Belt, including granitoid gneiss believed to be basement more than 800 m.y. old, is allochthonous and has moved eastward by at least the amount of shortening in the thrust-faulted zone.

Mildly deformed and metamorphosed stratified rocks in the northern Columbia Mountains (central Omineca Crystalline Belt) and adjacent Rocky Mountains permit construction of well-controlled structural and restored stratigraphic cross-sections, which show that the Crystalline Belt and Main Ranges were relatively uniformly uplifted by about 35,000 ft (11 km) whereas flanking regions experienced minor uplifts. Combined with other evidence this indicates that 'thick-skinned' tectonics with vertical movements of the entire crust affected the Omineca Crystalline Belt and the Main Ranges; major horizontal movements seem unnecessary. The Omineca Crystalline Belt is regarded as an autochthon in which the basement was extensively deformed and it is suggested that basement is deformed beneath the Main Ranges. The zone of thrusting and décollement above the basement is restricted to the Front Ranges and Foothills and may result from westward underthrusting of the craton.

Carson, D. J. T., and Jambor, J. L.

MINERALOGY, ZONAL RELATIONSHIPS AND
ECONOMIC SIGNIFICANCE OF HYDROTHERMAL
ALTERATION AT PORPHYRY COPPER DEPOSITS,
BABINE LAKE AREA, BRITISH COLUMBIA; *Can. Mining Met. Bull.*, v. 67, p. 110-133, 1974.

Porphyry copper deposits in the Babine Lake area, including the Granisle and Bell orebodies, are associated with Tertiary biotite-plagioclase porphyry intrusions. Detailed studies of seven deposits that range in grade from < 0.1% to > 0.5% Cu have shown that all have similar zonal patterns of sulphides and hydrothermal alteration minerals. The normal outward zoning is from biotite-chalcocopyrite to chlorite-carbonate-pyrite. An intervening quartz-sericite zone of variable intensity may be present. The higher-grade Babine copper deposits have a core containing bornite plus chalcocopyrite; the outward progression from the bornite-bearing core is to chalcocopyrite ± pyrite → pyrite ± chalcocopyrite → pyrite ± pyrrhotite (the pyrite halo). Lower-grade deposits lack central bornite zones and have relatively weak pyrite haloes.

Electron microprobe analyses show that biotite phenocrysts in biotite-plagioclase porphyry contain an average of 4.3% TiO₂, whereas hydrothermal biotites average 2.8% TiO₂. At Granisle, MgO in secondary biotites decreases from an average of about 17% in the ore zone to less than 15% in the pyrite halo. Deep brown, coarse-grained, sugary-textured hydrothermal biotites are associated with relatively strong copper mineralization, whereas greenish and/or fine-grained hydrothermal biotites are indicative of weak copper mineralization. It is concluded that economic and sub-economic deposits can be distinguished from one another by thin-section studies because the size and grade of each copper zone corresponds with the areal extent and character of hydrothermal biotite. This relationship between potassic alteration and the grade of copper mineralization also seems to be applicable to most non-Babine porphyry copper deposits.

Chandler, F. W.

CLASTIC DYKES AT WHITEFISH FALLS, ONTARIO AND THE BASE OF THE HURONIAN GOWGANDA FORMATION; Geol. Assoc. Can., Sp. Paper no. 12, p. 199-209, 1973.

Clastic dykes occur in Huronian sedimentary rocks on the North Shore of Lake Huron. They are most abundant in formations contiguous to the Bruce Formation and are considered mainly to have been injected from that formation. Several field observations indicate that some pebbly sandstone dykes at Whitefish Falls have been injected down from the Gowganda Formation into the unlithified Serpent Formation.

Paraconglomerate at the base of the Gowganda Formation may have been mixed during deposition with quartzo-feldspathic sand from the top of the Serpent Formation. A similar contamination of paraconglomerate may have occurred during its injection as dykes into the Serpent Formation.

Since the matrix material of the resultant conglomerate dykes resembles that of conglomerate of the Bruce Formation, petrographic criteria alone may be an

unsound basis on which to place comparison of a dyke with a possible source.

Earlier reports of incorporation of lithified clasts from the Serpent Formation into the base of the Gowganda Formation on the North Shore of Lake Huron are not compatible with the proposed unlithified state of the Serpent Formation during Gowganda sedimentation.

A glacial, tectonic or gravity mechanism may have caused Bruce and Gowganda Formations paraconglomerates to slide upon underlying sands, thereby incorporating frozen or weakly coherent sand bodies or loose sand into interformational mixed zones.

Cook, D. G., and Aitken, J. D.

TECTONICS OF NORTHERN FRANKLIN MOUNTAINS AND COLVILLE HILLS, DISTRICT OF MACKENZIE, CANADA; Arctic Geology, Mem., no. 19, Amer. Assoc. Pet. Geol., 1973.

The northern Franklin Mountains and the Colville Hills, District of Mackenzie, are a series of ridges of divergent trends separated by broad, mostly drift-covered valleys. Some ridges are supported by thrust plates, and others by asymmetric anticlines. These structures, which represent shortening of the sedimentary cover, record tangential compression. Despite a variety of structural trends, there is no evidence for more than one phase of compression.

The structural province is characterized by enigmatic thrust reversals. Typically, one end of a range is underlain by a southwest-dipping fault and the other by a northeast-dipping fault. The abrupt transition takes place via a transverse fault which separates the opposing blocks, and which seems to require longitudinal shortening of the range in addition to the more obvious shortening perpendicular to it. Reversals along the trend of a particular range are inadequately explained, but the close geometric relation between reversals and transverse faults suggests an interrelated origin dependent on longitudinal shortening in conjunction with lateral shortening.

Most of the northern Franklin Mountains appear to be floored by a decollement zone in shale and evaporite beds of the Cambrian Saline River Formation. Structures above the zone probably are accentuated by tectonic thickening of the Saline River Formation. The décollement is assumed to extend beneath the Colville Hills about 175-200 mi (280-320 km) northeast of the Mackenzie Mountain front. In the McConnell Range on the south and the Mackenzie Mountains on the southwest, the décollement zone must be at a lower stratigraphic level, because beds older than the Saline River Formation are exposed in structures.

Berdan, Jean M., and Copeland, M. J.

OSTRACODES FROM LOWER DEVONIAN FORMATIONS IN ALASKA AND YUKON TERRITORY; U. S. Geol. Surv. Prof. Paper 825, 1973.

Residues of samples, dissolved in acetic and formic acid from the limestone and shale member of the McCann Hill Chert of eastern Alaska and the Michelle and Prongs Creek Formations of Yukon Territory have revealed the presence of a varied, silicified ostracode fauna. This fauna may serve as a basis for correlating strata from the Alaska-Yukon international boundary near lat. 65° N. northeastward for more than 200 miles.

Of the more than 40 genera present, hollinaceans and beyrichiaceans are the most distinctive. The hollinaceans find their closest affinity with genera from lower Middle Devonian (Eifelian) beds from the mid-continent region of North America, and the beyrichiaceans with genera from Lower Devonian and Silurian strata of Appalachian North America and of Europe. Conodonts and dacryoconarid tentaculites indicate that the age of the collections from which the ostracodes were obtained is late Early Devonian (Emsian), but the ostracode assemblage reported here does not resemble any described Emsian fauna.

These ostracodes are considered to represent a provincial assemblage with some Silurian survivors and some precursors of Middle Devonian forms which subsequently migrated to Eurasia and central North America. In all, 73 taxa, including 6 new genera and 33 new species, are described and illustrated.

Yochelson, E. L. , and Copeland, M. J.

TAPHONOMY AND TAXONOMY OF THE EARLY ORDOVICIAN GASTROPOD Ceratopea Canadensis (BILLINGS), 1865; Can. J. Earth Sci., v. 11, no. 1, p. 189-207, 1974.

Several hundred silicified specimens of Pleurotomaria canadensis Billings, 1865 and other rare fossils indicative of a late Canadian age have been collected from the Oxford Formation, southwest of Ottawa, Ontario. Redescription of this neglected gastropod species permits its assignment to the genus Ceratopea, even though no ceratopean opercula have been found.

Rare faunal elements include ribeirioids and open coiled gastropods that may have lived, respectively, in and on a mud bottom. There is no evidence that they have been transported. It is suggested that Ceratopea canadensis lived on algal mats some distance away from the shore and from where it is now found. After death, the soft parts of this gastropod decayed and the heavy operculum rotted off. The lightened shell, filled with gas, floated shoreward, likely under conditions of relatively calm water. Discovery of opercula within the Oxford Formation would provide evidence to support this hypothesis.

TOTAL MERCURY IN SEA WATER IN THE NORTH-WEST ATLANTIC OCEAN; Deep-Sea Res., v. 21, p. 139-144, 1974.

Total mercury was determined using a shipboard method of analysis for sea-water samples collected on two identical cruises along a section between Halifax and Bermuda. Concentrations decreased seaward, but there were no significant vertical gradients. The concentrations, averaging $0.15 \mu\text{g l}^{-1}$, are the highest yet reported for open ocean water. Experiments indicated that an average of 57% of the total mercury can be lost if samples are stored before analysis for 10 days at pH 1.

Darnley, A. G.

AIRBORNE GAMMA-RAY SURVEY TECHNIQUES - PRESENT AND FUTURE; Int. Atomic Energy Agency, 1973.

There are a variety of spectrometer systems available for commercial use. To use them in the most effective way it is necessary to consider the problems involved. Districts containing uranium mineralization generally fall within or on the margin of regions containing above-average abundances of all the radioelements. These radioactive regions can be readily found by airborne surveys which measure only total radioactivity. Sometimes the mineralization controls within an area may be so well known that it is unnecessary to use spectrometer systems. In general it is advantageous to use the discriminating ability of a spectrometer to identify anomalies containing significant amounts of uranium. This selection of anomalies is most essential wherever the costs of ground work are high. The most sensitive spectrometers available are capable of measuring the mean ground level abundances of potassium, uranium and thorium, which can be expressed in conventional units of concentration. From an exploration viewpoint the most important parameters which can be measured are the relative concentrations of uranium to thorium and uranium to potassium. These are diagnostic for identification of zones of anomalous uranium concentration. Good counting statistics are essential to obtain meaningful ratio measurements. These are obtained by maximizing detector volume and minimizing ground speed of the aircraft. Minimizing flight elevation improves sensitivity for small area targets, but it entails closer line spacing for a given percentage coverage of an area. As a general principle, airborne gamma-ray surveys should be aimed primarily at finding target zones with linear dimensions of the order of hundreds or thousands of meters, where the mean enrichment of uranium at the surface may be only one or two parts per million higher than the surroundings. It can be shown that high-sensitivity equipment is most cost-effective for this purpose. The availability of fully corrected data, with a comprehensive display of all the

parameters in profile and map form, is essential to extract maximum value from a survey with such equipment.

Davies, G. R., and Nassichuk, W. W.

UPPER PALEOZOIC CARBONATE MOUNDS OF THE SVERDRUP BASIN, ARCTIC CANADA; Symp. on Geology of Canadian Arctic, Can. Soc. Pet. Geol. - Geol. Assoc. Can., Saskatoon, May 1973, a Program and Abst., p. 7.

Biogenic carbonate mounds characterized by fenestrate bryozoans and the hydrozoan? Palaeoaplysina are exposed in upper Paleozoic rocks of the Sverdrup Basin on Ellesmere and Axel Heiberg Islands. Bryozoan mounds of Moscovian (Middle Pennsylvanian) age occur near the base of the Hare Fiord Formation on Ellesmere Island. Mounds more than 800 feet (≈ 265 m) thick lie in a belt parallel with the eastern margin of the Central Shale Belt of the basin; in this area, the upper part of the underlying Otto Fiord Formation, typically composed of anhydrite and limestone, contains thick sandstone units. The bryozoan mounds are characterized by fenestrate bryozoans enclosed in multiple-generation calcite cements (inorganic boundstone) of probable submarine origin, associated with internal sediment filling and sedimentary dykes.

Mounds and biostromes of Palaeoaplysina occur throughout the eastern and western Carbonate Belts of the Sverdrup Basin in rocks of Asselian to Sakmarian (Early Permian) age. Palaeoaplysina accumulations have been found in the Belcher Channel and Tanquary Formations of south-central Ellesmere Island, and in the upper parts of the Nansen Formation of central and north-western Ellesmere and northwestern Axel Heiberg Islands. Belcher Channel mounds up to 70 feet (≈ 23 m) thick occur in multiple buildups. Palaeoaplysina deposits are associated with shallow-water carbonates including oolitic and bioclastic grainstones, and with phylloid algae and the problematical organism Tubiphytes.

Facies relationships suggest that the bryozoan mounds accumulated during early phases of a major Pennsylvanian marine incursion into the Sverdrup Basin trough, eventually becoming enclosed in basinal shales and limestones of the Hare Fiord Formation. In contrast, the Palaeoaplysina mounds characterized a shallow-water carbonate shelf environment representing the regressive phase of Early Permian sedimentation in the Sverdrup Basin.

Upper Paleozoic bryozoan and Palaeoaplysina mounds in other areas form reservoirs for oil. Potential of the Arctic mounds depends on questions of porosity-cement relationships, size, and economics.

Davies, G. R.

SUBMARINE CEMENTATION, FRACTURING, AND INTERNAL SEDIMENTATION IN PENNSYLVANIAN-PERMIAN CARBONATE BUILDUPS, ARCTIC ARCHIPELAGO; Amer. Assoc. Pet. Geol. Soc.,

Economic Pal. Mineral., Annual Meetings Abs., v. 1, p. 25, 1974.

Biogenic carbonate buildups characterized by fenestrate bryozoans, phylloid algae and the hydrozoan? Palaeoaplysina are exposed in upper Paleozoic rocks of the Sverdrup Basin on Ellesmere and Axel Heiberg Islands. Mid-Pennsylvanian (Moscovian) bryozoan buildups 300 m or more thick, buried by sediments of deep-water aspect, are cemented by inclusion-rich radiaxial fibrous calcite neomorphic after earlier multi-generation acicular cement. Compositionally-zoned sparry calcite fills most remaining spaces. Cement-lined fractures within the mounds are filled by dolomitized crinoidal packstones similar in composition to the enclosing basinal sediments. A cement-lined cavern within one mound is filled with pisoids and molluscs. Fabric relationships, interlayering with internal marine-origin sediments, isotopic composition (high positive δC^{13} values) and possibly elemental composition (from microprobe analyses for Ca, Mg, Sr, Fe, Mn, K, Na, Cl) support the interpretation of an early submarine origin for the precursor of radiaxial fibrous calcite cements. Radiaxial and other cements may be replaced by acicular calcite distinguished by low positive δC^{13} values.

Accumulations of broken plates of Palaeoaplysina and phylloid algae in carbonate shelf and shelf edge environments, particularly in Early Permian time, were also subject to early submarine cementation. Radiaxial fibrous calcite cements binding algal plates and bryozoans are found in displaced lithoclasts derived from the shelf edge within carbonate debris beds enclosed in basinal sediments.

Bryozoan, hydrozoan? and algal buildups form producing reservoirs for hydrocarbons in upper Paleozoic rocks of the United States and U. S. S. R. In the Arctic, potentially excellent paleogeomorphic and stratigraphic traps with very high depositional porosities have been downgraded by pervasive early submarine cementation.

Davies, G. R., and Ludlam, D.

ORIGIN OF LAMINATED AND GRADED SEDIMENTS, MIDDLE DEVONIAN OF WESTERN CANADA; Geol. Soc. Am. Bull., v. 84, p. 3527-3546, 1973.

Beds composed of laminated calcite, dolomite, and anhydrite form the basal unit of the Muskeg and Prairie evaporitic succession in the Middle Devonian Elk Point Basin of western Canada. These laminated rocks (laminites) are restricted to the basal intermountain succession between carbonate mounds and banks of the Keg River and Winnipegosis Formations. Laminae occur as couplets composed of a microcrystalline mineral layer and a non-skeletal organic detrital film; bioclasts of benthonic organisms are absent. Individual dolomitic and anhydritic laminae in various sectors of the Elk Point Basin in northern Alberta have been correlated visually and statistically over distances up to 25 km. Graded clastic carbonate beds with eroded basal contacts, conformable tops, tabular clasts, and occasional

benthonic bioclasts are common in some dolomitic laminite sections and apparently are more frequent close to the flanks of carbonate buildups.

By comparison with modern depositional basins of various size and water chemistry, the Devonian Elk Point laminites are interpreted as having accumulated subaqueously in a physically and chemically stratified water mass in which the lower water stratum was anoxic. The probable generative mechanism was precipitation within the upper stratum, seasonal in effect and possibly biochemically controlled. Bioturbation and physical disruption of the deposited laminae were prevented by the anoxic bottom environment and the physical stratification of the water mass. The interbedded graded beds are interpreted as turbidites or debris flows related in source to proximity of carbonate buildups.

As both carbonate and sulfate laminae are involved in this interpretation, and as these laminae grade upward into bedded anhydrite and halite deposits, the same subaqueous environmental interpretation, albeit with evolving hypersaline water chemistry, is suggested for the overlying evaporites.

Dean, W. T.

THE LOWER PALEOZOIC STRATIGRAPHY AND FAUNAS OF THE TAURUS MOUNTAINS NEAR BEYŞEHİR, TURKEY III. THE TRILOBITES OF THE SOBOVA FORMATION (LOWER ORDOVICIAN); Bull. Brit. Mus. (Nat. Hist.) Geol., London, v. 24, no. 5, p. 279-348, 1973.

Dean, W. T., Özgül, N., and Metin, S.

LOWER PALEOZOIC STRATIGRAPHY AND FAUNAS OF THE EASTERN TAURUS MOUNTAINS IN THE TUFANBEYLİ REGION, SOUTHERN TURKEY; Bull. Min. Res. Exploration Inst. Turkey, no. 79, 1973.

Lower Paleozoic formations crop out along the Eastern Taurus mountain range near Tufanbeyli. The oldest known unit in the area is the Emirgazi Formation composed primarily of chlorite-sericite-quartz schists and metaquartzites. These rocks underlie conformably the Değirmentaş Limestone which is believed to be of Lower (?) - Middle Cambrian age. The observable thickness of the Değirmentaş Limestone is 110 m and it is formed of white to light-gray and black to dark-gray limestones, with nodular limestone of various colors at the top. These are similar in character to the Çaltepe Limestone, of Lower (?) - Middle Cambrian age in the Seydişehir region, and are assumed to be of similar age. The Armutludere Formation of Tremadoc and Arenig age overlies the Değirmentaş Limestone. It consists mainly of shales with chlorite-sericite-quartz schist towards the lower levels. Silurian basal conglomerate lies unconformably upon the Armutludere Formation.

Eckstrand, O. R.

VISIT TO AUSTRALIAN NICKEL SULPHIDE DEPOSITS YIELDS IMPRESSIONS, INFERENCES FOR CANADA; Northern Miner, v. 59, no. 3 (Nov. 29) p. 64-65, 1973.

Eisbacher, G. H.

IN-SITU GESTEINSSPANNUNGEN UND MECHANISMEN DER KLUFTEÖFFNUNG; Geol. Rundschau, v. 62, no. 1, p. 29-53, 1973.

Orientation of post-orogenic joints in Proterozoic sedimentary rocks of the Elliot Lake area (Canada) seems to be directly related to elastic-strain-recovery as measured in boreholes. Steep local and regional joint sets without displacement are parallel with the axis of maximum elastic-strain-recovery (i. e. the direction of the major principal in-situ stress component). Consequently these joints are interpreted as extension joints.

Fahrig, W. F., Christie, K. W., and Schwartz, E. J.

PALEOMAGNETISM OF THE MEALY MOUNTAIN ANORTHOSITE SUITE AND OF THE SHABOGAMO GABBRO, LABRADOR; Can. J. Earth Sci., v. 11, no. 1, p. 18-29, 1974.

Fahrig, W. F., and Chown, E. H.

THE PALEOMAGNETISM OF THE OTISH GABBRO FROM NORTH OF THE GRENVILLE FRONT, QUEBEC; Can. J. Earth Sci., v. 10, no. 10, p. 1556-1564, 1973.

Fahrig, W. F., and Schwarz, E. J.

ADDITIONAL PALEOMAGNETIC DATA ON THE BAFFIN DIABASE DYKES AND A REVISED FRANKLIN POLE; Can. J. Earth Sci., v. 10, no. 4, p. 576-581, 1973.

Frith, R. A., and Doig, R.

Rb-Sr ISOTOPIC AGES AND PETROLOGIC STUDIES OF THE ROCKS IN THE LAC ST. JEAN AREA, QUEBEC; Can. J. Earth Sci., v. 10, p. 881-899, 1973.

The granulite facies meta-igneous and meta-sedimentary rocks that surround the Lac St. Jean anorthosite yield an Rb-Sr age of 1480 m. y. Intrusive monzonite, possibly genetically associated with the anorthosite, was emplaced slightly prior to 1513 m. y. ago. Pre-anorthosite rocks were variously affected by

the intrusion of the anorthosite and related rocks and affected again by the Grenvillian orogeny. Intrusive monzonite, granite, and syenite associated with the Grenvillian orogeny yield Rb-Sr ages between 1300 and 1000 m. y. Amphibolite facies rocks to the east of the anorthosite-monzonite granulite terrain were not as intensely affected during the Grenvillian orogeny. These granitic paragneisses record a metamorphic age of 1380 m. y. which suggests, in this area, continuous metamorphism between 1550 and 1000 m. y. ago. Thermal peaks at 1500 and 1100 m. y. are considered probable.

Froese, E., and Gordon, T. M.

ACTIVITY COEFFICIENTS OF COEXISTING PYROXENES; Amer. Mineral., v. 59, p. 204-205, 1974.

The ferrous iron-magnesium distribution between coexisting pyroxenes in granulites from Quairading, Australia, has been shown to be markedly dependent on chemical composition (Davidson, 1968). By assuming a simple-mixture solution model (Guggenheim, 1967) for both of these pyroxenes, activity coefficients and the equilibrium constant of the exchange reaction are derived. The activity coefficients at infinite dilution of orthopyroxene and clinopyroxene are 1.56 and 1.87, respectively.

Froese, E.

THE ASSEMBLAGE QUARTZ-K FELDSPAR-BIOTITE-GARNET-SILLIMANITE AS AN INDICATOR OF P_{H_2O} -T CONDITIONS; Can. J. Earth Sci., v. 10, p. 1575-1579, 1973.

The assemblage quartz-K feldspar-biotite-garnet-sillimanite is common in high-grade pelitic rocks. Diverse compositions of biotite and garnet from this assemblage reflect differences in P_{total} , P_{H_2O} , and T. For rocks from a small area, P_{total} probably was nearly constant. In order to show the separate effects of P_{H_2O} and of T on mineral composition, a plot of conditions indicated by various rocks with this mineral assemblage on a P_{H_2O} -T diagram is presented. This is accomplished by treating the minerals and the fluid phase as ideal solutions, by assigning reasonable P_{H_2O} -T values to one rock, and by assuming entropies for two dehydration reactions. Rocks from the Thor-Odin gneiss dome in British Columbia reflect a temperature range of about 200°C and relatively low water pressures.

Froese, E., Gordon, T. M., and Hutcheon, I.

THE ASSEMBLAGE QUARTZ-SILLIMANITE-GARNET-CORDIERITE AS AN INDICATOR OF METAMORPHIC CONDITIONS IN THE DALY BAY COMPLEX, N. W. T.; Contr. Mineral. Petrol., v. 44, p. 29-34, 1974.

If cordierite is treated as an anhydrous mineral, the composition of garnet and cordierite, coexisting with quartz and sillimanite, depends on total pressure and temperature. Phase relations may be deduced by combining some available experimental work with several approximations. Assuming ideal ionic solution in garnet and cordierite, analyses of coexisting garnet and cordierite permit the determination of total pressure and temperature. Five rocks from the Daly Bay Complex, N. W. T., collected from locations up to 35 miles apart, indicate a range of 610-760° and 5.3-6.6 kb.

Garrett, R. G.

REGIONAL GEOCHEMICAL STUDY OF CRETACEOUS ACIDIC ROCKS IN THE NORTHERN CANADIAN CORDILLERA AS A TOOL FOR BROAD MINERAL EXPLORATION; Int. Geochem. Exp. Symp., 4th., London 1972, Proc., p. 203-219, 1973.

Gordon, T. M.

DETERMINATION OF INTERNALLY CONSISTENT THERMODYNAMIC DATA FROM PHASE EQUILIBRIUM EXPERIMENTS; J. Geol., v. 81, no. 2, p. 199-208, 1973.

Grant, D. R.

PLEISTOCENE AND RECENT HISTORY; in Nfld. Dept. Tourism, Parks Div., Park Interpretation, Publ. 3, p. 27-31, 1973.

Grasty, R. L., Loijens, H. S., and Ferguson, H. L.

AN EXPERIMENTAL GAMMA-RAY SPECTROMETER SNOW SURVEY OVER SOUTHERN ONTARIO; Can. Inland Waters Directorate, reprint 301, 1973.

In the winter of 1972-1973, four gamma-ray spectrometer surveys, each 1850 km long, were flown over Southern Ontario at 150 m, using a 50,000 cm³ sodium iodide detector system. Total radioactivity and potassium information was used to calculate a snow-water equivalent for 16 km sections along each flight line. The airborne results are compared with ground data from 10 snow courses established along the flight lines.

A root mean square deviation of 1.2 cm water equivalent was found between the ground and potassium-airborne results, whereas a deviation of 1.7 cm water equivalent was calculated between data from the ground and those from the total radioactivity information.

Soil moisture corrections from measurements at selected sites were found to decrease the calculated snow-water equivalent an average of 1.7 cm. Errors in the soil moisture measurements and background variations encountered along the flight lines were found to be more important than statistical errors.

Loijens, H. S. , and Grasty, R. L.

AIRBORNE MEASUREMENT OF SNOW-WATER EQUIVALENT USING NATURAL GAMMA RADIATION OVER SOUTHERN ONTARIO, 1972-1973; Can. Inland Waters Directorate, Sci. Ser. no. 34, 1973.

Four gamma-ray spectrometer surveys, each 1850 km in length, were carried out using a 50,040 cm³ (3,054 in³) sodium iodide detector assembly, flown at 150 m altitude, in a Skyvan aircraft fitted with a radar altimeter and Doppler navigation system. Total radioactivity, potassium, and thorium, recorded digitally on magnetic tape were used to calculate an average snow-water equivalent for 16 km sections along each flight line. The air-borne results were compared with the measurements from 40 existing snow courses and ten experimental courses established along the flight lines.

Soil moisture corrections from measurements at selected sites were found to decrease the calculated snow-water equivalent by an average of 2.6 cm for potassium and 3.3 cm for total count. Background radiation measurements were also important because of large fluctuations in atmospheric bismuth-214.

An average absolute difference of 0.9 cm water equivalent was found between the potassium air-borne and the ground results for the experimental courses. This indicated that the potassium channel can be used without making prior calibration flights at different altitudes to determine the air absorption coefficient. A larger variation of 2.1 cm between the total count and ground results suggests that calibration flights are necessary. Problems were encountered in comparing the air-borne and ground results for the existing courses because of differences in survey dates.

Gross, G. A.

THE DEPOSITIONAL ENVIRONMENT OF PRINCIPAL TYPES OF PRECAMBRIAN IRON-FORMATIONS; in Genesis of Precambrian iron and manganese deposits. Proc. Kiev Symp., 1970. (Earth Sciences, 9.) p. 15-21, Unesco, 1973.

Haworth, R. T.

GRAVITY AND MAGNETIC NATURAL RESOURCE MAPS (1972), OFFSHORE EASTERN CANADA; Int. Hydro. Rev., v. 51, no. 1, p. 131-155, 1974.

The final product of a recent data processing contract issued by the Atlantic Geoscience Centre was a suite of 72 Natural Resource maps published by the Canadian Hydrographic Service representing the most comprehensive published collection of marine gravity and magnetic data on the eastern Canadian continental shelf. Because of the techniques employed, the charts have a style different from that employed on previous charts in the series. The method of preparation of the charts is

described together with consideration of the basic limitations of a contour chart used as a source of data. Deficiencies in the data collection and processing and chart preparation techniques are discussed.

Ferrians, O.J. Jr., and Hobson, G.D.

MAPPING AND PREDICTING PERMAFROST IN NORTH AMERICA: A REVIEW, 1963-1973 (1); PERMAFROST: The North American Contribution to the Second International Conference; Nat. Acad. Sci.

Permafrost, which is soil or rock material that has remained below 0°C (32°F) continuously for more than 2 years, underlies approximately 20 percent of the land area of the world, including approximately 50 percent of Canada and 85 percent of Alaska. It is defined exclusively on the basis of temperature; however, one of the most important aspects of permafrost is the amount of ice that it contains. Permafrost with little or no ice generally does not cause engineering or environmental problems, but permafrost that is ice rich can cause extremely serious problems if allowed to thaw.

The recent discovery of vast amounts of oil and gas in arctic regions of North America has stimulated exploration and development and has focused attention on the many potential permafrost-related problems posed by this activity. The orderly development of these regions requires a thorough understanding of permafrost, especially the determination of its distribution and character.

Mapping and predicting permafrost are inherently difficult because permafrost occurs below the ground surface under the active layer, which generally ranges from 15 cm to 5 m (6 in. to 15 ft) in thickness. In addition, the ground conditions that determine the character of permafrost can vary greatly within short distances, both vertically and horizontally.

For this report, the methods of mapping and predicting permafrost have been divided into two broad categories: the traditional methods and the geophysical methods. In practice, the two categories overlap, and optimum results can be achieved only by utilizing aspects of both. To determine the best method or methods to use for a specific investigation, several factors must be considered - the most important of which are type and detail of information required, amount of area to be covered, complexity of the natural physical conditions in the area, and time and money available for the study.

Of primary concern to engineering in permafrost areas are the character of the permafrost soils and the way in which a proposed structure (building, pipeline, road, etc.) and these soils would interact. Wherever possible, areas that are underlain by ice-rich permafrost should be avoided for most engineering projects; otherwise structures must be designed to accommodate the ice-rich condition of the natural foundation material, and special construction techniques acceptable for permafrost areas must be used.

The primary purpose of this report is to

summarize the accomplishments in mapping and predicting permafrost in Canada and Alaska since 1963, when the First International Conference on Permafrost was held. Several papers presented at that conference relate to methods of mapping and predicting permafrost, and a paper by Barnes described the state of the art in geophysical methods.

Hood, P. J.

EXPLORATION GEOPHYSICS; Canadian Geophysical Bull., v. 25, p. 263-292, 1972.

This report is an annual compilation of research and development in exploration geophysics carried out by industry, government and the universities in Canada. The Canadian Geophysical Bulletin is published by the Associate Committee on Geodesy and Geophysics of the National Research Council of Canada. A bibliography of 85 articles on exploration geophysics published by Canadians and 17 theses submitted for degrees at Canadian universities is appended to the report.

Hood, P. J.

MINERAL EXPLORATION: TRENDS AND DEVELOPMENTS IN 1973; Can. Min. J., v. 95, no. 2, p. 163-214, 1974.

This article reviewed the following topics for the year 1973:

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

In the 1973 review, the characteristics of commercially-available airborne electromagnetic, ground resistivity and self-potential equipment were tabulated.

Hood, P. J., and Bower, Margaret E.

AEROMAGNETIC RECONNAISSANCE OF THE LABRADOR SEA AND BAFFIN BAY; 43rd. Ann. Int. Meeting., Soc. Expl. Geophys., Mexico City, Oct. 21-25, 1973.

Since 1962, the Geological Survey of Canada and the National Aeronautical Establishment have cooperated 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. Correlation of the anomalies on the profiles indicate that a triple-spreading junction

existed in the Labrador Sea at approximately 56°50'N, 41°40'W. Moreover from a correlation of the anomalies with those on the flanks of the Reykjanes Ridge it is deduced that sea-floor spreading terminated in the Labrador Sea just after Anomaly 13 was generated some 38 million years ago.

Over the continental shelves, 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 anomaly increases and the amplitude decreases. This change is due to a sudden increase in the depth to the crystalline basement, and therefore marks the edge of the wedge of sedimentary rocks which underlie the outer part of the continental shelf. The double asymmetrical anomaly which marks the transition from continental to oceanic rocks is also recognizable on most profiles enabling this boundary to be delineated. Depth determinations on the profiles indicate that the thicknesses of sedimentary rocks on the continental slopes and rises exceed 20,000 ft over wide areas.

On the Labrador Shelf, the sediments extend all the way along the outer part of the continental shelf and rise deepening towards Hudson Strait and are underlain to a large extent by oceanic rocks. The sediments would appear from the sea-floor spreading to be mostly of Mesozoic age making these areas attractive for the petroleum industry to prospect. In central Baffin Bay the magnetic anomalies are of low amplitude anomalies up to 50 gammas in amplitude having a wavelength of 20 km and are readily discernible in the central part indicating that the basement rocks are oceanic. Basalt extrusives cover large areas on both sides of Davis Strait and extend as far south as Frobisher Bay presumably over a thick sedimentary cover. Sedimentary cover in the central deep-ocean part of Baffin Bay appears to exceed 16,000 feet (5 km) over large areas.

Hood, P. J., and Holroyd, M. T.

RESULTS OF GSC EXPERIMENTS INDICATE HIGH RESOLUTION AEROMAGNETIC SURVEYS HAVE POTENTIAL FOR MORE DEVELOPMENT; N. Miner, v. 59, no. 37, p. 42-44, Nov. 29, 1973.

Aeromagnetic survey techniques have been under active development in the Geological Survey of Canada since the first airborne magnetometer was introduced shortly after World War II by modification of submarine detection equipment. This development work and its subsequent utilization in aeromagnetic surveys by GSC staff eventually led in 1961 to an aeromagnetic survey program for the whole of the Canadian Precambrian Shield. The program was jointly funded by the federal and provincial governments and has been entirely carried out under contract. To-date 4,344,000 line miles of aeromagnetic data have been obtained. The resultant aeromagnetic maps have been issued on scales of one mile and four miles to the inch using a 10-gamma contour interval. In addition a 1:15,000,000 magnetic anomaly map of Canada has been produced in which the

masking effect of the earth's main field has been removed.

With the introduction of the first high resolution airborne magnetometers, in the early 1960s, which were of the optical absorption type, there began a revolution in the aeromagnetic surveying technique. The recording of high resolution data has necessitated that the data be recorded in a digital format rather than solely on an analog chart in order to solve the dynamic range problem, and this permits the map compilation process and any subsequent data processing to be computerized. Digital recording also permits the application of various kinds of mathematical treatment to high resolution aeromagnetic survey data, most of which may be considered to be types of filtering which enhance either the high or low wavelength components of the data. The GSC has now carried out a number of high resolution experimental aeromagnetic surveys, and the resultant maps when contoured using a 2- or even 5-gamma interval show much more detail than the equivalent standard sensitivity (10-gamma) maps.

Because vertical gradient data defines near surface geology much better than does total field data, the Geological Survey of Canada is presently constructing an inboard gradiometer system on a Queenair aircraft in which the sensors are vertically separated by about two meters. The resultant measured vertical gradient values are of course objective repeatable diurnal-free potential field values and can be used as a starting point for subsequent filter processing.

Another problem with which the Geological Survey of Canada has been concerned for more than a decade is an effective aeromagnetic survey technique for areas of rugged terrain such as the Cordillera. During 1973, an experimental high resolution aeromagnetic survey was flown at constant barometric elevation in the Kamloops area of British Columbia. From a comparison of the resultant high resolution maps and those which resulted from a drape-flown fluxgate survey of the same area carried out in 1967, it is clear that high resolution aeromagnetic surveys flown at a constant height above mean sea level are effective aids to geological mapping programs in areas of considerable topographic relief.

Hood, P.J., and Tyl, I.

RESIDUAL MAGNETIC ANOMALY MAP OF GUYANA AND ITS REGIONAL GEOLOGICAL INTERPRETATION; Second Latin American Geological Congress, Caracas, Venezuela, Nov. 11-17, 1973.

A residual magnetic anomaly map of Guyana has been compiled from the existing aeromagnetic maps which cover about two-thirds of the country. The residual magnetic anomaly map has been obtained by removing the earth's main magnetic field, which has its origin in the earth's core, using the International Geomagnetic Reference Field in order to emphasize those magnetic anomalies which are related to crustal geology. The resultant 1:1,000,000 published map, the first of its kind in South America, has been printed using six (6) colours each representing a 200-gamma interval with intermediate

100-gamma contours. The paper is presented to illustrate the value of residual magnetic anomaly maps and to make the case that such maps should be a standard end product of aeromagnetic surveys.

The residual magnetic anomaly map of Guyana contains anomalies having two distinct wavelengths. The longer wavelength of the order of 100 km must be due to deep-seated crustal effects, whereas the shorter wavelength anomalies, usually less than 5 km wide, are due to individual rock formations which outcrop or are overlain by sediments.

The limit of the Southern Province of Guyana is readily evident on the map, and a separation of the "Upper Berbice Triangle" within the Southern Province can be made. There appears to be a connection between the Coastal and Takutu Basins, and the Takutu Basin itself appears to have an extension to the east along the Takutu Arc. Thus there is a distinct possibility that the Takutu Basin forms one arm of a triple-spreading junction, several times reactivated. The position of the Makarapan granite within the Northern Province is also evident from the map. Comparison between the Kanuku Group and the Falawatra Group in Surinam indicates a different development. Major folds and lines of weakness within the Northern Province are readily discernible and northwest-striking interpreted rupture lineations could control eugeosynclinal development. Comparison of the magnetic anomaly map with known locations of diamond and gold deposits in the Guiana Shield indicates that the regional magnetic patterns provide a guide to prospecting for these valuable minerals.

Dixon, J., Hopkins, W.S. Jr., and Dixon, O. A.

UPPER CRETACEOUS MARINE STRATA ON SOMERSET ISLAND, N. W. T.; Can. J. Earth Sci., v. 10, no. 8, p. 1337-1339, 1973.

Upper Cretaceous marine shale and limestone beds are present in a faulted outlier in the vicinity of Creswell Bay, Somerset Island. The contained microflora indicates a Senonian age and the strata are correlated to the Kangaku Formation of the Arctic islands.

Howie, R.D., and Barss, M.S.

UPPER PALEOZOIC IN THE GULF OF ST. LAWRENCE AND THE ATLANTIC PROVINCES; AGS Colloquium on the Geological Evolution of the Eastern Seaboard of Canada, Fredericton, N. B., January 18-19, 1974.

The Acadian (Devonian) Orogeny stabilized the Appalachian Geosyncline from the northeastern part of the St. Lawrence Platform to the continental shelf. This newly cratonized area initiated a new set of tectonic elements that prevailed into the Permian. Late stage working of the area affected by the Acadian Orogeny appears to have been mainly confined to a narrow north-east trending, lens shaped taphrogeosyncline that accumulated over 30 thousand feet of clastics and evaporites.

The configuration of post-Acadian basement and subsequent infilling of sediments have been determined by lithological and palynological studies of exploratory wells, combined with regional seismic, gravity, ship and air magnetometer surveys, and field observations. In the deeper areas of the basin, salt swells, ridges, domes, diapirs and walls of Windsor Group evaporites and shale, estimated to be at least 16 thousand feet thick, may have produced a variety of stratigraphic traps in the overlying sediments suitable for the accumulation of oil and gas.

Hunter, J. A. M.

THE APPLICATION OF SHALLOW SEISMIC METHODS TO MAPPING OF FROZEN SURFICIAL MATERIALS (1); PERMAFROST: The North American Contribution to the Second International Conference; Nat. Acad. Sci.

Hutchison, W. W.

PROGRESS ON AN AUTOMATED SYSTEM OF DATA RETRIEVAL, ANALYSIS AND CARTOGRAPHY AT THE GEOLOGICAL SURVEY OF CANADA; Commonwealth Geol. Liaison Office Newsletter, CGLO (73) NL5, p. 7-9, 1973.

Jeletzky, J. A.

BIOCHRONOLOGY OF THE MARINE BOREAL LATEST JURASSIC, BERRIASIAN AND VALANGINIAN IN CANADA; in The Boreal Lower Cretaceous; Geol. J., Spec. Issue 5, 1973.

Marine rocks with boreal faunas of latest Jurassic to Valanginian age occur in the Sverdrup Basin, the Porcupine Plateau - Richardson Mountain Trough, and adjacent parts of the Arctic Coastal Plain. Among macroinvertebrates, only Buchia species and ammonites are of value for zonal subdivision. One Buchia zone is recognised in the uppermost Volgian and two in each of the Berrisian and Valanginian stages. Buchia species are used for internal correlation while ammonites, although irregularly and sparsely distributed, are the principal means of correlation with other parts of the world. One new ammonite species, Praetollia antiqua, is described and figured.

Jonasson, I. R., and Allan, R. J.

SNOW: A SAMPLING MEDIUM IN HYDROGEO-CHEMICAL PROSPECTING IN TEMPERATE AND PERMAFROST REGIONS; Int. Geochem. Exp. Symp., 4th, London 1972, Proc., p. 161-176, 1973.

Katsube, T. J., and Collett, L. S.

ELECTRICAL CHARACTERISTICS OF APOLLO 16 LUNAR SAMPLES; Proc. of the Fourth Lunar Sci. Conference, Supplement 4, Geochim. Cosmochim. Acta, v. 3, p. 3101-3110, 1973.

Electrical parameters of 1 fine sample (66041) and 4 rock samples (60025, 62295, 66055, and 68815) from Apollo 16 flight have been measured over the frequency range from 10^2 to 1.8×10^8 Hz. The purpose of these measurements is to accumulate data on the electrical characteristics of various rocks, to extend the frequency range of measurement, and to obtain data with sufficient accuracy to characterize the general trend of the electrical parameters. General trends of the 4 samples 66041, 8, 60025, 55, 62295, 17, and 68815, 43 are similar to previous measurements by various scientists. The real relative permittivity ranges from 5 to 7 and shows little variation with frequency. The parallel resistivity decreases with frequency and the dissipation factor generally decreases with frequency but shows a minimum and a maximum at about 10^5 - 10^7 Hz, for certain samples. The breccia sample 66055, 7 shows electrical characteristics that are unusual for a lunar sample in many ways. K' is about 10 at 10^2 Hz, and levels off at 3.7 from frequencies above 3×10^5 Hz. The parallel resistivity is about 3×10^7 ohm-m at 10 Hz, and decreases to about 3×10^4 ohm-m at 1.8×10^8 Hz. This parallel resistivity at the lower frequencies is perhaps the lowest ever reported for lunar rocks. D is about 0.6 at 10^2 Hz and decreases to about 0.001 at 1.8×10^8 Hz. These trends for real relative permittivity, parallel resistivity and dissipation factor at the lower frequency resemble a terrestrial pyroxene or serpentinite. The electrical parameters of this rock seem to have a close relation to the apparent matrix of the specimen at the lower frequencies. These parameters at the higher frequencies seem to be related to the true matrix of the sample.

Katsube, T. J., and Collett, L. S.

ELECTRICAL CHARACTERISTICS OF ROCKS AND THEIR APPLICATION TO PLANETARY AND TERRESTRIAL EM-SOUNDING; Proc. of the Fourth Lunar Sci. Conference, Supplement 4, Geochim. Cosmochim. Acta, v. 3, p. 3111-3131, 1973.

It is essential to have a good understanding of the conductive and dielectric mechanism of the rocks in order to lay a basis for future planetary and terrestrial electrical and EM-sounding. There has been a rapid increase of data on electrical measurements for lunar and terrestrial rocks over the last few years. Based on these data it is possible to characterize the trends for real relative

permittivity, parallel resistivity, and dissipation factor for many rocks over the frequency range from about 1.0 to 10^8 Hz. These trends suggest that from a macroscopic view grain boundaries, insulating and low resistivity minerals are important elements in determining the conductive and dielectric mechanism of rocks in general. There are cases where the dielectric relaxation are also thought to be of importance. At frequencies below the critical frequencies, the effect of insulating materials and grain boundaries vertical to the electric current are important for dry rocks, and the effect of the grain boundaries parallel to the current is dominant for rocks which contain water or other liquids. At frequencies above the critical frequency, the effect of low resistive minerals may be dominant for dry rocks and low porosity moist rocks. These studies on the conductive and dielectric mechanism indicate that, (1) there is a possibility for radar techniques to be useful in detecting conductive materials, (2) information on the content and conductivity of moisture or other liquids contained in the rocks might be obtained by a combination of LF and HF electromagnetic sounding methods, and (3) there are indications that grain boundaries and critical frequency concepts apply to rocks at elevated temperatures.

Kerr, J. W.

CANADIAN ARCTIC RIFT SYSTEM - A SUMMARY;
Am. Assoc. Pet. Geol., Mem. 19, p. 587, 1973.

Keen, C. E., and D. L. Barrett

STRUCTURAL CHARACTERISTICS OF SOME SEDI-
MENTARY BASINS IN NORTHERN BAFFIN BAY;
Can. J. Earth Sci., v. 10, p. 1267-1278, 1973.

Geophysical measurements along tracks crossing some of the main structural features of the northern Baffin Bay shelf are described. The data consist of seismic reflection, seismic refraction, gravity, and magnetic measurements. Results in four areas - Lancaster Sound, Melville Bay, Smith Sound and Jones Sound - are presented. Magnetic and gravity data are used to define the extent of sedimentary basins in these areas. Seismic reflection measurements delineate the structural characteristics of the upper 2 km of the sedimentary strata and allow comparisons between them to be made. Seismic refraction measurements show that the upper 2 km of sediment exhibit low velocities - less than 3.2 km/s. Little deformation of the sediments is observed in any of these areas, however, the strata in Lancaster Sound and in the Melville Bay graben appear to have experienced less faulting than those in Jones Sound and Smith Sound. Normal faults are characteristic of the latter two areas. Jones Sound is a structurally complex area and is filled by a lesser thickness of sediments than

is found in the other basins. These sediments are terminated near the entrance to the sound by Precambrian basement. A deeper sedimentary basin occupies Smith Sound and trends across the Nares Strait lineament. Although the data are insufficient to allow a detailed structural analysis of the strata in these regions, we speculate that the differences in sedimentary structures can be related to the formation of the Baffin Bay ocean basin.

King, L. H., MacLean, B., and Fader, G. B.

UNCONFORMITIES ON THE SCOTIAN SHELF; Can.
J. Earth Sci., v. 11, p. 89- , 1974.

Four erosional unconformities have been recognized within the Mesozoic-Cenozoic succession on the Scotian Shelf, on the basis of data from high resolution seismic reflection profiles. Older unconformities are known from well data and others may be revealed by detailed biostratigraphic studies.

The oldest of the four unconformities discussed in this paper is of Early Cretaceous age and appears to mark, with discordance, the boundary between Jurassic and Cretaceous strata on the western part of the shelf. A second angular unconformity, of Late Cretaceous age, has been recognized on the central part of the shelf where the basal part of the Banquereau Formation (Tertiary and uppermost Cretaceous) oversteps the zero-edge of the Wyandot Formation (Upper Cretaceous) and lies upon truncated beds of the Dawson Canyon Formation (Upper Cretaceous). Cut-and-fill relationships characterize a third unconformity developed during Early Tertiary time. A fourth unconformity was developed in Late Tertiary - Pleistocene time by fluvial processes and later by glacial processes. Although in many areas the latest unconformity appears to be the most conspicuous one on the shelf, its configuration closely follows the geomorphic expression developed during the previous period of erosion. The regional extent of the Cretaceous unconformities is not known, and they might only occur near basin margins and on structural and basement highs.

Kornik, L. J., McGrath, P. H., Holroyd, M. T., and
Hood, P. J.

EVALUATION OF HIGH-RESOLUTION AEROMAG-
NETIC SURVEYS IN THE CANADIAN SHIELD; 43rd.
Ann. Int. Meeting., Soc. Expl. Geophys., Mexico
City, Oct. 21-25, 1973.

The Geological Survey of Canada has been involved in the development of aeromagnetic survey techniques since the late 1940s. During this time the major portion of the Canadian Shield has been surveyed and more than 6000 aeromagnetic maps have been published. It has

become apparent that some information which is geologically significant has been lost in the production of the standard ten-gamma interval maps. In order to advance the state of the aeromagnetic survey art, the Geological Survey of Canada has been involved during the past several years in the development and production of higher sensitivity instrumentation and data handling techniques.

A project was initiated in 1972 to evaluate the usefulness of high-resolution aeromagnetic data as an aid to detailed mapping programs. A test range was established in Godfrey Township in the Timmins area of Ontario. Ground magnetometer surveys which included gradient measurements using both a fluxgate and a proton precession magnetometer were completed using a 50-ft sampling interval along the survey lines. In-situ magnetic susceptibility measurements and oriented drill core samples for remanent magnetism were also collected along the cut lines, and the geology was mapped. The test range was flown with the high-resolution optical absorption magnetometer system aboard the Geological Survey of Canada's Queenair aircraft at 500, 1000, and 2000 ft. The aeromagnetic data were filtered using various numerical operators. The resultant data define much more clearly many of the smaller anomalies which are readily apparent in the ground magnetic data.

High-resolution surveys have also been flown in cooperation with various provincial mines departments in Timmins, Jellicoe, Abitibi, and the Ottawa Valley in Ontario, Val d'Or in Quebec, Bathurst in New Brunswick and Truro in Nova Scotia. Examples from these surveys will be presented showing the correlation of the magnetic fine structure with large scale geologic mapping.

Kurfurst, P. J., Isaacs, R. M., Hunter, J. A., and Scott, W. J.

PERMAFROST STUDIES IN THE NORMAN WELLS REGION, NORTHWEST TERRITORIES; in Aitken, J. D., and Glass, D. J., editors, Proceedings of the Symposium on Canadian Arctic Geology, Geol. Assoc. Can., Saskatoon, Sask., p. 277-299, 1973.

The mean annual temperature of the surface of the Canol Road, built during the Second World War, is significantly higher than that of the ground surface prior to construction. A study of the roadway and its surroundings by drilling and by seismic and electric methods confirms that there has been warming and, in some cases, thawing of permafrost under the road. A geothermal model prepared for one of the sites predicted a depth of thaw much smaller than the depth shown by the drilling. This result suggests that both convection and conduction may be involved in heat-transfer processes under the road.

Lewis, C. P., and McDonald, B. C.

RIVERS OF THE YUKON NORTH SLOPE; Fluvial Processes and Sedimentation; in Proc. Hydrology Symp., Edmonton, 1973; p. 251-271 (publ. Nat. Res. Council, Can.)

The channel patterns of Yukon north slope rivers range from full meandering to braided. These streams have been slowly degrading in recent times but generally flow in their own alluvium. Attempts to estimate dominant (channel-forming) discharges have met with only partial success, largely because of the failure of standard resistance equations to adequately describe gravel-bed rivers. Assessment of bed scour is complicated by the influences of bed imbrication, ice jams, spring flow over ice, and by permafrost. Thermo-erosional niching followed by block slumping is a common process leading to bank failure. Air photographs indicate few areas of rapid channel zone migration over the last 16 to 20 years.

The study is presented as an example of a reconnaissance-level investigation whose primary goal is to provide background information that would be of use in making decisions about future development in the area.

Williams, R. M., and Little, H. W.

CANADIAN URANIUM RESOURCE AND PRODUCTION CAPABILITY; Can. Dept. Energy, Mines Res., Mineral Development Sector, Min. Bull., MR 140, 1973.

Reasonably assured resources of uranium in Canada were estimated at 241,000 short tons of uranium oxide (U_3O_8) exploitable at prices up to \$10 per pound U_3O_8 (reserves) as of December 31, 1972. In addition, 158,000 short tons U_3O_8 were estimated in the same category of reliability, but exploitable at prices between \$10 and \$15 per pound U_3O_8 . Although the majority of these resources occurs in quartz-pebble conglomerate deposits in the Elliot Lake - Agnew Lake area of Ontario, a substantial portion occurs in pitchblende-bearing veins and related deposits, primarily in northern Saskatchewan. As of the same date, estimated additional resources of uranium in Canada were estimated at 247,000 and 284,000 short tons U_3O_8 in the two price categories, respectively, also largely in uraniferous quartz-pebble conglomerates in Ontario.

During 1972 the three operating Canadian uranium mills produced 5,200 short tons U_3O_8 , equivalent to about 85 per cent of their total installed capacity. Developments were under way, however, which will boost Canada's installed production capacity to about 8,500 short tons U_3O_8 per year by 1975, largely due to the addition of a fourth producer. Although there are no firm plans

beyond this, the industry could expand its productive capacity, within a few years, to an estimated 14,000 tons U_3O_8 per year, based on presently known reserves, markets permitting. Expansion beyond this level will depend largely on the discovery of additional deposits, the geological potential for which is believed to be excellent.

Little, H. W.

URANIUM DEPOSITS IN CANADA - THEIR EXPLORATION, RESERVES AND POTENTIAL; *Can. Mining Met. Bull.*, v. 67, p. 155-163, 1974.

Currently, exploration in Canada for uranium has reached its lowest level since the period from 1955 to 1965. Because of anticipated large demand for uranium in the 1980's, there is concern that exploration should be accelerated now in order to meet that expected demand.

Estimates of reserves and resources of uranium in Canada were first published in 1964 and, as a consequence of exploration between 1966 and 1971 inclusive, were revised upward in 1970 and 1972. Concepts of uranium potential in Canada, based on type of deposit and geological environment, were first published in 1958, and several papers were published subsequently as these concepts became more refined and more of the essential basic geological data became available. In this paper, many belts, zones and basins are examined and assessed for their potential relative to one another, based on geological data. Logistics are also considered, although these are less of an economic factor than for base metals.

Little, H. W., and Williams, R. M.

CANADA IN URANIUM, RESOURCES PRODUCTION AND DEMAND, OECD NUCLEAR ENERGY AGENCY AND INTERNATIONAL ATOMIC ENERGY AGENCY

Lowdon, J. A., and Dyck, W.

SEASONAL VARIATIONS IN THE ISOTOPE RATIOS OF CARBON IN MAPLE LEAVES AND OTHER PLANTS; *Can. J. Earth Sci.*, v. 11, p. 79-88, 1974.

A seasonal cycle in $\delta^{13}C$, varying between -22% in early spring and -28% in late fall, has been observed in maple leaves growing under natural conditions. A similar $\delta^{13}C$ cycle, varying between -25% and -30% is indicated for grass growing in the same location as the maple leaves. The seasonal cycle appears to be analogous to the diurnal $\delta^{13}C$ cycle.

$^{14}C/^{12}C$ ratios of various plants from different parts of Canada show that the ^{14}C produced by thermonuclear bombs has approximately a half-life of eleven

years in the atmosphere over Canada. When due allowance is made for the isotope fractionation effect produced by plants, no significant variations in the ^{14}C content in plants from different localities across Canada can be detected. The reported ^{14}C peak observed in atmospheric CO_2 in late summer also shows up in maple leaves but with reduced intensity. ^{14}C levels show clearly that the first leaves in spring are composed primarily of carbon assimilated in the previous fall.

Lynch, J. J., Garrett, R. G., and Jonasson, I. R.

A RAPID ESTIMATION OF ORGANIC CARBON IN SILTY LAKE SEDIMENTS; *J. Geochim. Exp.*, v. 2, no. 2, p. 171-174, 1973.

MacAulay, H. A.

A TOTAL-TIME APPROACH FOR ESTIMATING DEPTH TO BEDROCK IN GLACIATED MOUNTAIN VALLEYS; *Can. J. Earth Sci.*, v. 10, p. 1333-1337, 1973.

A seismic method is described by which depth to bedrock in valleys can be estimated without the need to traverse the valley surface with conventional refraction or reflection techniques. A short detector array on rock outcrop on one side of the valley is used to measure compressional waves from a shot on outcrop on the opposite side, and to measure the seismic velocity of the rock. The shortest travel-time path across the valley follows the bedrock overburden interface, and when the bedrock velocity is known, the length of the path can be computed. The ratio of the length of the bedrock path to the direct distance between source and receiver is a function of the depth to bedrock at the valley center. The success of the method requires that certain valley-shape configurations be reasonably predictable and that the bedrock velocity be uniform throughout. Depth calculations for several field examples have been made using graphical techniques.

Mackay, J. Ross, and Black, Robert F.

ORIGIN, COMPOSITION, AND STRUCTURE OF PERENNIALY FROZEN GROUND AND GROUND ICE: A REVIEW; *Permafrost: The North American Contribution to the Second International Conference*; *Nat. Acad. Sci.*, p. 185-192, 1973.

Mackay, J. Ross

PROBLEMS IN THE ORIGIN OF MASSIVE ICY BEDS, WESTERN ARCTIC, CANADA (1); *Permafrost: The North American Contribution to the Second International Conference*; *Nat. Acad. Sci.*; p. 223-228, 1973.

Mackay, J. Ross

THE GROWTH OF PINGOS, WESTERN ARCTIC COAST, CANADA; *Can. J. Earth Sci.*, v. 10, no. 6, p. 979-1004, 1973.

The growth rates of 11 closed system pingos have been measured, by means of precise levelling of permanent bench marks anchored well down into permafrost, for the 1969-1972 period. As pingo growth decreases from the summit to the base, growth of the ice-core decreases from the center out to the periphery. The pingos have grown up in the bottoms of lakes which have drained rapidly and thus become exposed to permafrost aggradation. The specific site of growth is usually in a small residual pond where permafrost aggradation is retarded. The size and shape of a residual pond exercises a strong control upon the size and shape of the pingo which grows within it. The ice-core thickness equals the sum of the pingo height above the lake flat and the depth of the residual pond in which the pingo grew. Pingos tend to grow higher rather than both higher and wider. Pingos are believed to grow more by means of ice segregation than by the freezing of a pool of water. The water source, and the associated positive pore water pressure, result from permafrost aggradation in sands and silts in the lake bottom under a closed system with expulsion of pore water. The fastest growth rate of an ice-core, for the Western Arctic Coast, is estimated at about 1.5 m/yr, for the first one or two years. After that, the growth rate decreases inversely as the square root of time. The largest pingos may continue to grow for more than 1000 yr. Four growth stages are suggested. At least five pingos have commenced growth since 1935. As an estimate, probably 50 or more pingos are now growing along the coast.

Mackay, J. Ross

A FROST TUBE FOR THE DETERMINATION OF FREEZING IN THE ACTIVE LAYER ABOVE PERMAFROST; *Can. Geotech. J.*, v. 10, p. 392-396, 1973.

A frost tube which can be used in permafrost areas to determine both the downward and upward movements of the two freezing fronts in the active layer, during the fall freeze-back period, is described. The principle, which is based upon the differential vertical migration of fine and coarse particles resting upon an upward moving horizontal ice-water interface, is discussed. Attention is drawn to some of the ice characteristics of the active layer and top of the permafrost which result from upward freezing at the bottom of the active layer.

MacKenzie, W. S.

UPPER DEVONIAN ECHINODERM DEBRIS BEDS WITH GRADED TEXTURE, DISTRICT OF MACKENZIE, NORTHWEST TERRITORIES; *Can. J. Earth Sci.*, v. 10, no. 4, p. 519-528, 1973.

A sequence of Upper Devonian echinoderm debris beds with graded texture, interbedded with shale, overlies the Middle Devonian Ramparts Formation in the subsurface at McDermott Canada GCO South Maida Creek G-56 well on the south side of Mackenzie River near Carajou Ridge.

The interval of echinoderm debris can be divided into thick 2- to 7-ft (0.6- to 2.1-m) beds of graded skeletal remains lacking shale, and thinner intervals from 1 to 2 ft (0.3 to 0.6 m) thick of graded skeletal remains with interbedded black shale. The echinoderm beds, not present in the subsurface at nearby wells, are probably of local origin. Similar beds of echinoderm debris with graded texture, also of probable local origin, crop out at Powell Creek in the Mackenzie Mountain foothills.

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

MAGNESIUM DISTRIBUTION IN LIVING AND FOSSIL SPECIMENS OF THE ECHINOID PERONELLA LESUEURI AGASSIZ, SHARK BAY, WESTERN AUSTRALIA; *J. Sediment. Petrol.*, v. 44, no. 1, p. 60-69, 1974.

High-magnesian calcite coronal plates from three specimens of the clypeasteroid echinoid Peronella lesueuri Agassiz, collected live from Shark Bay, Western Australia (113°30'E, 25°30'S), were analyzed for magnesium distribution. Electron microprobe spot analyses indicate an average content of 12.8-13.2 mole % MgCO₃. Although this average agrees with X-ray diffraction and atomic absorption analyses completed on the same specimens, point-to-point compositional variations ranging from 10.3 to 17.0 mole % MgCO₃ were detected in electron microprobe work. Thus, some heterogeneity in Mg distribution is indicated: this heterogeneity is not related obviously to either the crystal fabric or the particular coronal plate analyzed. No mineralogical phase with more than 17.0 mole % MgCO₃ was detected.

Coronal plates from 5 Pleistocene specimens (>30,000 years B.P.) of P. lesueuri obtained from the Carbla Oolite at Shark Bay were also analyzed for magnesium distribution. Of more than 400 electron microprobe spot analyses made, about three quarters consist of values of 3.9 mole % MgCO₃ or less, and clearly represent low-magnesian calcite. There are, however, many additional spot analyses in the range 4.0-17.0 mole % MgCO₃, with the majority in the range 4.0-9.0 mole % MgCO₃. These values appear to be derived from minute, Mg-rich zones on the order of 1? micron or less up to 6-7 μ, as determined by beam-scanning photography with the electron microprobe. These zones are interpreted as metastable domains which reflect either no loss (rare), or incomplete loss (relatively common) of Mg from the original skeletal calcite precipitated during the life of the organism, and are believed to indicate inefficiency in the stabilization process by which high-magnesian calcite is eliminated from Peronella lesueuri individuals. The Mg-rich zones suggest, but

do not prove, that *P. lesueurii* calcites have stabilized by loss of magnesium to an aqueous solution while retaining the initial geometry of skeletal elements—the incongruent dissolution described by Land (1967).

The Mg-rich zones could be the location of dolomite nucleation at a later stage in diagenesis, as suggested by Schlanger (1957, 1963), for dolomitization of Mg-rich calcareous algae. Two of the Pleistocene specimens contain dolomite as determined by electron microprobe and X-ray diffraction analysis: the dolomite is interpreted to be of detrital origin.

McCrossan, R. G., and Porter, J. W.

THE GEOLOGY AND PETROLEUM POTENTIAL OF THE CANADIAN SEDIMENTARY BASINS — A SYNTHESIS; in *Can. Soc. Pet. Geol., Mem. 1, 1973.*

The purpose of this work is to relate the principal observations of the various contributors to the volume within a broad background of regional geology and to make an estimation of the Canadian petroleum potential drawing heavily on this basic material. The 38 unmetamorphosed sedimentary basins recognized in this study have been classified into 7 types to provide a framework within which the petroleum potential could be estimated in a uniform manner, and to permit comparison with sedimentary basins of the world. Within the stable region 4 categories of basins are recognized: the craton centre, the craton margin, the craton margin disturbed (the latter lying at the interface with the mobile belt), and the rift or collapse basin. Two types of coastal margin basins are defined: the stable and unstable types. Finally, within the mobile belt are the intermontane basins. Each of these types is geometrically quite distinct as a result of its unique tectonic setting which in turn controls its sedimentological properties. The tectono-sedimentary character of each basin style is related in turn to a limited and characteristic association of types of petroleum occurrence. Those basins of relatively more negative tendency, i. e. the craton margin, rift, and unstable coastal margin types, are of higher petroleum potential because of their particular structural and stratigraphic attributes.

An outline of the geological history of northern North America based on the study of four major stratigraphic sequences within the Phanerozoic serves to outline the evolution of the Canadian basins in time and space. The megasequences of continent-wide distribution were chosen to emphasize the significant tectonic events responsible for the basin formation, particularly with respect to generally accepted concepts of global tectonics.

The estimates of potential are based on a variety of methods but all involve geological analysis. The volumetric method is used to test the reasonableness of the results against other regions of the world. The potential of the various basins varies widely from very low for those of the craton centre to high for those of the unstable coastal margins. These values are shown in a table that displays estimates of oil and gas resources

and sedimentary volumes for all basins as well as a series of calculated parameters for each, such as oil and gas yields per cubic mile, combined yield of oil plus gas equivalent, etc. In addition, a tabular geological description for each basin provides a summary of the documentation for the estimates followed by an aggregate description of each basin type based on the described examples.

Canada has a fairly comfortable conventional petroleum potential (including already discovered oil and gas) estimated at 85 billion barrels of oil and 577 trillion cubic feet of gas occurring within 3.5 million cubic miles of unmetamorphosed sedimentary rock, excluding the continental slopes. The bulk of the future resource lies in geographically remote areas and in areas involving severe logistical problems. No economic studies accompany this work so that it is impossible to say at what price and at what time the supply will be available. It is safe to say, however, that the bulk of it will be obtained only at relatively high cost. It is also fairly apparent that the short term lower cost future supply in the more accessible areas of the country is relatively small, amounting to a little over 6 billion barrels of oil and 55 trillion cubic feet of gas beyond that which has already been discovered. It is evident also that any possibility of major future reserves can lie only in three possible regions large enough volumetrically, or rich enough to contain them: the Mackenzie basin, the Sverdrup basin, and parts of the east coast off-shore area.

McGlynn, J. C., Hanson, G. N., Irving, E., and Park, J. K.

PALEOMAGNETISM AND AGE OF NONACHO GROUP SANDSTONES AND ASSOCIATED SPARROW DIKES, DISTRICT OF MACKENZIE; *Can. J. Earth Sci., v. 11, no. 1, p. 30-42, 1974.*

The Nonacho Group is a folded sequence of sedimentary rocks resting on a crystalline basement of probable Archean age. Both sedimentary and basement rocks are intruded by the Sparrow dikes. Fifty-four samples from 10 dikes have a stable magnetization with mean direction after a.f. cleaning of 131° , $+51^{\circ}$ ($N=10$, $k=50$, $\alpha_{95}=7^{\circ}$) and a corresponding pole at $12^{\circ}N$, $069^{\circ}W$. The presence of reversals and the approximate agreement between dikes and their baked contacts are taken to indicate that the dikes were probably magnetized at the time of intrusion. $^{40}Ar-^{39}Ar$ studies suggest that the probable age of intrusion was about 1700 m. y. The magnetization of the Nonacho sedimentary rocks collected at 12 sites (40 samples) have a mean direction after thermal cleaning of 148° , $+57^{\circ}$ ($N=12$, $k=11$, $\alpha_{95}=14^{\circ}$) without correction for geological dip. The corresponding pole is at $13^{\circ}N$, $086^{\circ}W$. The precision after correction for geological dip is low ($k=3$), so the magnetization is predominantly post-folding. The thermal decay characteristics and the geometry of the directions indicate that the magnetization of the sedimentary rocks was acquired during cooling following a period of mild heating presumably owing to deep burial. This process of secondary

magnetization apparently reached its culmination between about 1700 and 1600 m. y. , and continued with diminishing intensity until about 1400 m. y. These results are used to modify the apparent polar wandering path for the Canadian Shield, so that the path now has a sharp bend (Hairpin 40) at about 1800 m. y. rather than at a 1950 m. y. as previously postulated.

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

AN AUTOMATIC LEAST-SQUARES MULTIMODEL METHOD FOR MAGNETIC INTERPRETATION; Geophysics, v. 38, no. 2, p. 349-358, 1973.

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 effect produced by a finite thin plate. Using models generated in this manner, an automatic computer method has been developed at the Geological Survey of Canada for the interpretation of magnetic data. Because the magnetic anomalies produced by the various model shapes are non-linear in parameters of shape and position, it is necessary to use an iterative procedure to obtain the values for the various model parameters which yield a least-squares best-fit anomaly curve to a set of discrete observed data. The interpretation method described in this paper uses the Powell algorithm for this purpose. The procedure can sometimes be made more efficient using a Marquardt modification to the Powell algorithm. Examples of the use of the method are presented for an elongated anomaly in the Moose River basin of the Hudson Bay lowlands in northern Ontario, and for an areally large elliptical anomaly in the Sverdrup basin of the Canadian Arctic Islands.

McGregor, D. C.

LOWER AND MIDDLE DEVONIAN SPORES OF EASTERN GASPÉ, CANADA; I. SYSTEMATICS; Palaeontographica Abt. B, v. 142, no. 1-3, p. 1-77, 1973.

The York River and Battery Point Formations (Gaspé Sandstone Group) and the overlying Malbaie Formation of the Gaspé Bay region of Quebec together comprise about 16,000 feet of strata. The upper 10,000 feet, outcropping on Gaspé Bay, are mainly non-marine. Their precise age has not been known owing to the rarity of marine fossils, which traditionally have been regarded as keys to accurate age determination. However, well preserved spores are abundant throughout the section except in the upper few hundred feet of the Malbaie Formation. They show that the Early to Middle Devonian (Emsian — Eifelian) boundary lies in the upper part of the Battery Point Formation. Full documentation of this conclusion, and discussion of the biostratigraphic and

paleobotanical significance of the spores will be given in Part II of this report.

In Part I, seventy-eight species of spores are described from the York River, Battery Point and Malbaie Formations. Twenty-one species and one variety are new. The diagnosis of the genus Grandispora is emended.

McGregor, D. C.

EARLY DEVONIAN SPORES FROM CENTRAL ELLESMERE ISLAND, CANADIAN ARCTIC; Can. J. Earth Sci., v. 11, p. 70-78, 1974.

The Vendom Fiord Formation near the head of Cañon Fiord, central Ellesmere Island, hitherto thought to be unfossiliferous, contains mid to late Emsian trilete spores. Strata below the Vendom Fiord Formation, separated from it by an unconformity, contain a less diverse assemblage of spores that suggests a mid to late Gedinian age. The spores are the only fossils known from these beds, and the first palynomorphs to be reported from the early Devonian rocks of Ellesmere Island.

McLaren, D. J.

THE SILURIAN DEVONIAN BOUNDARY; Geol. Mag., v. 110, no. 3, p. 302-303, 1973.

McLaren, D. J.

NON RENEWABLE RESOURCES (with contributions by J. C. McGlynn, B. A. Latour, R. M. Proctor and C. J. Yorath) in Science and the North, a seminar on guidelines for scientific activities in Northern Canada 1972; Information Canada Cat. R72-7172.

Miall, A. D.

REGIONAL GEOLOGY OF NORTHERN YUKON; Bull. Can. Pet. Geol., v. 21, no. 1, p. 81-116, 1973.

Structurally the northernmost Yukon is part of the Eastern Cordilleran System, and in many respects it is an eastward extension of Brooks Range and the adjacent structural provinces of northern Alaska. Comparisons may also be made between the geological history of the northern Alaska — northern Yukon region and that of the Canadian Arctic Islands, a fact that has led to some speculation concerning the possible continuity of these two areas throughout much of Phanerozoic time.

This report will deal with British and Barn Mountains, Old Crow Plain and Dave Lord Ridge. Richardson Mountains will not be discussed in detail.

The Ordovician, Silurian and possibly much of the Cambrian are represented east of Dave Lord Ridge

by approximately 10,000 ft of fine-grained clastic sediments, the Road River Formation. Rocks of similar age in British and Barn Mountains and Brooks Range are strongly deformed metasediments (Neruoqpuq "Formation"). Deposition of the Road River Formation took place in a basin named the Richardson Trough, which may have been a southward extension of the Franklinian Geosyncline of the Canadian Arctic Islands.

A major tectonic episode, the Ellesmerian Orogeny, affected northern Yukon, northern Alaska and the Arctic Islands in several separate phases during the Devonian. The Neruoqpuq underwent low-grade regional metamorphism at this time and several granite stocks were emplaced, including that at Mount Sedgwick in British Mountains. Thick syntectonic and post-tectonic clastic wedges were formed nearly everywhere near the present Alaskan and Canadian Arctic coasts, except within the Yukon, as a result of a mid-Devonian pulse of the Ellesmere Orogeny.

Between the Early Mississippian and the Late Triassic the Lisburne Group and the Sadlerochit and Shublik formations were deposited. The Lisburne and Sadlerochit are two of the most important reservoir rocks at Prudhoe Bay. Lisburne sediments, mainly carbonates, are confined (within the report area) to British and Barn Mountains. The Sadlerochit Formation (coarse-grained, porous clastic deposits) is well developed in the Dave Lord Ridge area but is thin or absent in northeastern British Mountains. The Shublik is typically developed in British Mountains.

The principal sediment source area for northern Alaska and northern Yukon during the Cambrian to Jurassic period appears to have been located off the present Arctic Coast and may have been part of the same source area that contributed detritus to the Canadian Arctic Islands region.

Jurassic, Cretaceous and Tertiary sediments are almost exclusively clastic in northern Yukon. They were derived from several sources including an ancestral Brooks Range and Campbell Uplift of the Inuvik area. The Cretaceous marks a major shift in sediment dispersal patterns, particularly in northern Alaska, as a result of large-scale changes in the distribution of land and water masses at this time. These may have been caused by major continental-drift movements in the area of the Arctic Ocean Basin.

A major tectonic episode, the Eureka Orogeny, took place between Middle Cretaceous and Early Tertiary times in northern Yukon (and in Alaska and the Arctic Islands), involving all but the most recent sediments. No igneous activity has been recorded in connection with the Eureka Orogeny in northern Yukon but most of the structural deformation of the post-Devonian rocks dates from this time.

Miall, A. D.

MARKOV CHAIN ANALYSIS APPLIED TO AN ANCIENT ALLUVIAL PLAIN SUCCESSION; *Sedimentology*, v. 20, p. 347-364, 1973.

Markov chain analysis is a comparatively simple statistical technique for the detection of repetitive processes in space or time. Coal measure cyclothems or fluvial fining-upward cycles are good examples of sedimentary successions laid down under the control of Markovian processes.

Analyses of stratigraphic sections commence with a transition count matrix, a two-dimensional array in which all possible vertical lithologic transitions are tabulated. Various probability matrices may be derived from this raw data, and these are then subjected to chi-square tests to determine the presence or absence of the Markov property. This technique is applied to four types of stratigraphic succession which occur in the Devonian rocks of Prince of Wales Island, Arctic Canada.

Norris, A. W.

PALEOZOIC (DEVONIAN) GEOLOGY OF NORTHEASTERN ALBERTA AND NORTHWESTERN SASKATCHEWAN; in Carrigy, M. A., and Kramers, J. W., editors, *Guide to the Athabasca Oil Sands area*, Can. Soc. Pet. Geol. Oil Sands Symposium 1973, Alberta Res., p. 16-61, 12 figs., 2 pls., plus appendix: Measured sections from selected outcrops, by A. W. Norris and S. Carbone, p. 63-76, 1973.

A summary and synthesis of the Paleozoic geology of the Athabasca-Clearwater Rivers outcrop belt is presented, based primarily on detailed reports by Crickmay (1957), Carrigy (1959), Norris (1963) and others, and incorporating more recent published data from many sources. Aside from the presence of saturated oil sands of Early Cretaceous age, this area is of special importance because it is one of the few places along the eastern margin of the Western Canada Sedimentary Basin where Devonian rocks can be examined at the surface.

The erosion of the Clearwater and Athabasca Rivers has partly exposed a wedge of westward-dipping Devonian rocks which nonconformably overlaps the Canadian Shield at Contact Rapids on the Clearwater River, and thickens westward to about 1,160 feet at Fort McMurray. The top of the Devonian succession is an erosion surface overlain by Lower Cretaceous strata that progressively overlap younger Devonian rocks westward. The Devonian succession consists of the La Loche Formation (Eifelian or older); the McLean River, Methy, and Prairie Evaporite Formations (Eifelian and Givetian); the Slave Point Formation (late Givetian); the Waterways Formation subdivided into five members comprising the Firebag, Calumet, Christina, Moberly, and Mildred (early Frasnian); and the Woodbend Group comprising the Cooking Lake, Ireton, and Grosmont Formations (early to late Frasnian). Parts of the Devonian

succession that are not represented in outcrops and are present only in the subsurface comprise the Middle Devonian Prairie Evaporite and Slave Point Formations, and the Upper Devonian Mildred Member of the Waterways Formation and formations of the Woodbend Group.

East-west and south-north columnar and structure cross sections are presented, based mainly on wells drilled along and near the Clearwater and Athabasca Rivers by Bear Oil Company in 1948-49 of which there are published logs. Since 1949 many new wells have been drilled in the area but most of these more recent subsurface data remain unpublished. The Devonian stratigraphic nomenclature of the report area, main faunas, and correlation with other areas are discussed and illustrated in a general way by a figure.

Norris, A. W.

PALEOZOIC (DEVONIAN) GEOLOGY OF NORTH-EASTERN ALBERTA AND NORTHWESTERN SASKATCHEWAN; Alberta Res., Info. series no. 65, p. 15-76, 1973.

Okulitch, A. V.

AGE AND CORRELATION OF THE KOBAN GROUP, MOUNT KOBAN, BRITISH COLUMBIA; Can. J. Earth Sci., v. 10, no. 10, p. 1508-1518, 1973.

The Koban Group, found in south-central British Columbia, consists of highly deformed, low-grade metamorphic rocks derived from a succession of sedimentary and basic volcanic rocks of pre-Cretaceous, likely post-Devonian age. Deformation began in Carboniferous times and recurred with decreasing intensity up to the Tertiary Period. Possible correlative successions are found surrounding Mount Koban. These include possibly late Paleozoic formations west and northwest of Mount Koban, the Carboniferous to Permian Anarchist Group found south of the 49th parallel and east of the Okanagan Valley, the pre-Upper Triassic, possibly Mississippian Chaperon Group west of Vernon, and parts of the Shuswap Metamorphic Complex east of the Okanagan Valley. Prior to deposition of the Koban Group, part of the Shuswap Complex was subjected to deformation, presumably in mid-Paleozoic time.

Owens, E. H.

THE CLEANING OF GRAVEL BEACHES POLLUTED BY OIL; Proc. Thirteenth Coastal Engineering Conf. July 1972, Vancouver, Am. Soc. Civil Eng., N. Y., p. 2549-2555, 1973.

An attempt to clean beaches without the use of dispersants was undertaken in Chedabucto Bay, Nova Scotia, following a spill of Bunker C oil from the tanker "Arrow" in the spring of 1970. Sand beaches account for

less than 2% of the coast of Chedabucto Bay and those which were polluted were cleaned manually using peat moss, rakes and shovels. Most sand beaches can be cleaned with relative ease, as oil does not permeate the sediments, and the angle of sand beaches is generally low so that mechanical methods can be applied without large-scale removal of beach sediments. Oil deposited on gravel beaches permeates below the surface layer and cleaning by mechanical methods involves excavation of beach sediments to depths of one metre or more. This method endangers the stability of a beach, particularly if the sediment supply is limited. Also this method was found to be ineffective in removing all contaminated sediments.

Owens, E. H., and Drapeau, G.

CHANGES IN BEACH PROFILES AT CHEDABUCTO BAY, NOVA SCOTIA, FOLLOWING LARGE-SCALE REMOVAL OF SEDIMENTS; Can. J. Earth Sci., v. 10, no. 8, p. 1226-1232, 1973.

The effects of sediment removal on three beaches have been monitored during a one year period following attempts to clean up an oil spill in Chedabucto Bay, Nova Scotia. Profiles of these beaches are compared with those surveyed on a high energy beach on Crichton Island which was not affected by cleaning operations. It is apparent on beaches affected by cleaning operations that sediments removed from areas beyond the limit of normal wave action have not been replaced. Excessive sediment removal can seriously alter the equilibrium of a beach and this was demonstrated by a 20-m retreat of the beach crest at the eastern end of Indian Cove.

Pelletier, B. R.

A RE-EXAMINATION OF THE USE OF THE SILT/CLAY RATIOS AS INDICATORS OF SEDIMENTARY ENVIRONMENTS: A STUDY FOR STUDENTS; Maritime Seds., v. 9, no. 1, p. 1-12, 1973.

The silt/clay ratio is used as an aid in distinguishing different environments of deposition. Samples were studied from Baffin Bay (marine bay, low energy, shallow to deep); Hudson Bay (marine, epicontinental sea, intermediate energy, shallow to moderate depths); Atlantic Scotian Shelf (marine, open ocean, intermediate to high energy, shallow to moderate depths); Bay of Fundy (marine, tidal embayment, very high energy, shallow to moderate depths); Lake Ontario (non-marine, low energy, shallow to moderate depths). The silt/clay ratio generally decreases with the following: (1) a decrease in mean diameter of sediment, (2) increasing remoteness from shore, (3) increasing water depth, and (4) decreasing hydrodynamic vigour.

Olsen, E., Huebner, J. S., Douglas, J. A. V., and Plant, A. G.

METEORITIC AMPHIBOLES; *Am. Mineral.*, v. 58, p. 869-872, 1973.

The crystal chemistry of richterite found in two new meteorite occurrences, as well as that of the original richterite found occurring in a meteorite, is presented. Microprobe chemical analysis indicates that two of the richterites, from the iron meteorites Wichita County and Canyon Diablo, are not fully fluorinated; however, their a cell parameters suggest they are fully fluorinated. The cell parameters and the chemical analyses are reconciled by postulating that oxygen (O^{2-}) substitutes for hydroxyl (OH^-) on the O(3)-site. The third richterite, from an enstatite chondrite (Abee), shows a and β parameters lower than those for fully fluorinated richterite. This is attributed to Mg distributed on the M(4)-site, as well as full fluorination, suggesting that a partial solid solution between normal fluorichterite ($NaCaNaMg_5Si_8O_{22}F_2$) and Ca-free fluorichterite ($NaMgNaMg_5Si_8O_{22}F_2$) may exist in nature. There is no evidence for structural water in any of these meteoritic amphiboles.

Grieve, R. A. F., and Plant, A. G.

PARTIAL MELTING ON THE LUNAR SURFACE, AS OBSERVED IN GLASS COATED APOLLO 16 SAMPLES; *Proceedings of the Fourth Lunar Science Conference (Supplement 4, Geochim. Cosmochim. Acta)*, v. 1, p. 667-679, 1973.

Apollo 16 samples 64455, 35, a crystalline highland basalt, and 65075, 9, a recrystallized anorthositic gabbro breccia with clasts of gabbroic anorthositic microbreccia, have adhering glass coats and injection veins of highland basalt composition. The coatings represent splashed on impact melted material of similar composition to that of the crystalline rocks and not the fusion products of earlier surfaces of the samples.

Heat supplied by the splash glass has been sufficient to produce zones of partial melting within the crystalline portions of the samples. The analytical data indicate a possible genetic relationship, on a small scale, between anorthositic and Fra Mauro basalt compositions through the low pressure partial melting of materials with highland basalt composition. The partial melts have major element compositions similar to Fra Mauro basalts, but with slightly lower FeO(5.8-9.3), while the residual crystalline materials are relatively anorthositic, being enriched in the plagioclase component. Variation in the degree of melting and the composition of the parent lithologies has produced only minor compositional differences in areas of partial melt within and between samples.

Schreibersite is found with a variety of textures and in all areas of the samples examined. However, the alteration of Fe metal to a rusty component is confined

to the crystalline portions of the samples and is not observed in either the partial melt zones or the glass coatings.

Poole, W. H.

DETRITAL GARNET AND MUSCOVITE IN LATE PRECAMBRIAN SANDSTONE NEAR ST. JOHN'S, NEWFOUNDLAND AND THEIR SIGNIFICANCE: DISCUSSION; *Can. J. Earth Sci.*, v. 10, no. 11, p. 1697-1698, 1973.

Poole, W. H.

STRATIGRAPHIC FRAMEWORK OF VOLCANOGENIC MASSIVE SULPHIDE DEPOSITS, NORTHERN APPALACHIAN OROGEN; *Can. Mining Met. Bull.*, v. 67, no. 742, p. 421, 1974.

Poole, W. H., and Turay, M.

LITHOLOGICAL DESCRIPTION OF ARTIFACTS, COW POINT SITE, NEW BRUNSWICK; Appendix 2 in Sanger, D.: Cow Point, an archaic cemetery in New Brunswick; *Archaeological Survey of Canada, Nat. Mus. Man.*, Paper no. 12, p. 153-174, 1973.

Lithology of 310 rock artifacts was described and several groupings of artifacts of like lithology defined. It was speculated that the unknown quarry sites of most of the artifacts are located in the northeastern Appalachian belt, most probably in eastern Maine and adjacent New Brunswick.

Poole, W. H.

STRATIGRAPHIC FRAMEWORK OF VOLCANOGENIC MASSIVE SULPHIDE DEPOSITS, NORTHERN APPALACHIAN OROGENY; Abstracts from "A Special Symposium on Metavolcanic Massive Sulphides with Reference to the Northern Appalachians"; sponsored by the Adams Club (Graduate Geology Students' Society of McGill University), November 30, 1973; in *Can. Mining Met. Bull.*, v. 67, no. 742, Feb., 1974.

Rampton, V. N., and Walcott, R. I.

GRAVITY PROFILES ACROSS ICE-CORED TOPOGRAPHY; *Can. J. Earth Sci.*, v. 11, p. 110-122, 1974.

Gravity profiling at five different sites in an area of ice-cored topography indicates the usefulness of the technique as a method for the detection of ground ice and for estimating the thickness of the excess ice.

Bouguer anomaly profiles using a density of 2.0 Mgm^{-3} provide a quick method of assessing the relative amount of ice along a profile, the thickness of ice and the elevation being inversely proportional to the Bouguer anomaly value along each profile. The average amount of excess ice in the topography along the profiles is obtained by removing linear trends, obtaining the Bouguer density of the topography, and calculating the proportion of frozen saturated sediment and ice required to produce this density. Variations in thickness of the body are obtained from significant gravity residuals. Finally, models are given to show the distribution of the excess ice with the aid of supplementary information. The above technique is unable to detect changes in the amount of excess ice that have a linear trend over the complete profile or a uniform slab of ice underlying the complete profile. A model for a pingo is constructed using stacked concentric cylinders. Geologic data from the region indicate that all models give reliable estimates of the amount of excess ice and probable thermokarst subsidence if the area were thawed.

Rampton, V. N.

THE HISTORY OF THERMOKARST IN THE MACKENZIE-BEAUFORT REGION, NORTHWEST TERRITORIES, CANADA; Abstracts, 9th Cong. Int. Union Quat. Res. (INQUA), p. 299, 1973.

The Mackenzie-Beaufort region, lying adjacent to the southern Beaufort Sea (Arctic Ocean) between latitudes 68° and 70°N , is characterized by an extensive plain having thick unconsolidated deposits, thick permafrost, an abundance of massive ground ice and ice-rich sediments, and numerous thermokarst basins, both drained and containing lakes. Most of the area was glaciated at some time beyond the range of C^{14} dating, presumably in early Wisconsin time. Dates on basal deposits in the thermokarst basins generally range between 12,000 and 8000 B. P. with the majority lying between 10,000 and 9000 B. P. Melting was probably initiated at this time because of climatic warming and thickening of the active layer: icy sediments were subjected to temperatures above freezing for the first time. Palynological studies by Ritchie (Ritchie and Hare, 1971) and paleontological studies by Kuc (Fyles *et al.*, 1972) indicate that indeed temperatures rose to near present values along the southern coast of the Beaufort Sea around 11,500 B. P. and that by 8500 B. P. temperatures were significantly above their present values.

The nature and thickness of the sediments - coluvium overlain by lacustrine deposits - in the thermo-

karst basins indicate that initiation of the basins probably resulted from a small pond developing on the landscape, but that expansion of the basin was mainly through ground ice slumping. In this process, massive ground ice or ice-rich sediments exposed on a slope melt back rapidly with the overlying and enclosed sediments sliding to the base of the steep slope; the supersaturated sediments at the base of the steep slope are supersaturated and flow further downslope; and wave action erodes the mud-flow debris and redistributes the material over the lake floor. As the lake expands, the permafrost table degrades below the lake and further thermokarst subsidence may occur due to the melting of ice at depth.

Although some active ice slumps are present around lakes today, the expansion of thermokarst basins seems relatively slow. Only along the coast where wave action can remove the mud-flow debris is thermokarst rapidly melting out massive ice and ice-rich sediments. The slowness of basin expansion probably follows from two factors: (1) Most massive icy beds and icy sediments vulnerable to ice slumping have been melted; (2) The regional climate cooled between 5500 B. P. and 4000 B. P. (Ritchie and Hare, 1971).

The large number of drained thermokarst basins in the region result from a number of factors: (1) lacustrine basins have coalesced, in some cases with the sea; (2) the development of an integrated drainage system has continued with less interference from slumping. It is ironic that the final stage in this cycle of ground ice formation, thermokarst development, and lake drainage, is the re-establishment of permafrost and ground ice in the drained basins.

Prakash, A., Rashid, M. A., Jensen, A., and Subba Rao, D. V.

INFLUENCE OF HUMIC SUBSTANCES ON THE GROWTH OF MARINE PHYTOPLANKTON: DIATOMS; *Limnol. Oceanogr.*, v. 18, p. 516-524, 1973.

Humic and fulvic acids extracted from decomposed residues of two littoral marine algae, Laminaria digitata and Fucus vesiculosus, and from mangrove leachates, stimulated the growth of a number of marine diatoms. This stimulatory effect was dependent on the concentration as well as the molecular size of the humic additive. Low molecular size fractions at low concentrations generated the maximum growth responses, as evidenced by increased cell yield, growth rate, chlorophyll concentration, and radiocarbon assimilation.

Rashid, M. A., and Leonard, J. D.

MODIFICATIONS IN THE SOLUBILITY AND PRECIPITATION BEHAVIOR OF VARIOUS METALS AS A RESULT OF THEIR INTERACTION WITH SEDIMENTARY HUMIC ACID; Chem. Geol., v. 11, p. 89-97, 1973.

The sedimentary humic acid or its acid-hydrolysate, consisting of various amino acids, was found effective in dissolving unusually large quantities of metals (up to 682 mg/g of organic matter) from their insoluble salts. The presence of humic acid in the reaction media which had favourable conditions for the precipitation of metals as carbonates, hydroxides or sulphides, prevented the formation of insoluble metal salts. Infrared analysis suggests that the metals added to various anionic systems and humic acid do not react with the anion. The most likely mechanism of reaction appears to be a complex formation between metals and organic matter which keeps the metal in solution.

The enhanced solubility and consequent decrease in precipitation of metals under the influence of humic compounds, as evidenced in these studies should play a leading role in the accumulation of metals in sedimentary deposits.

Rimsaite, J.

APPLICATION OF MICAS TO THE STUDY OF THE AGE AND GENESIS OF MINERAL DEPOSITS; Abstracts, II Cong. Latinoamericano de Geologia; p. 76, 1973.

Micas are common rock-forming minerals and they also occur in diverse ore deposits. The following mica-ore assemblages have been studied: Li-biotite - uraninite; biotite - muscovite - fuchsite - zirconian Cr-spinel - Ni-sulphides; Ni-geothite - biotite - spinel - Co-Ni-sulphides; biotite - chlorite - Cu-Pb-Zn-sulphides; biotite - magnetite and biotite - hematite replacements; pyrochlore - mica; sericite - chlorite - gold, and Li-micas from Be-Li-Nb-Ta pegmatites and hydrothermal molybdenite deposits.

The Marlartic - Val d'Or mining area in Quebec has been chosen to illustrate the application of micas to the study of the age and genesis of light metal and heavy metal deposits. The mining area is in the Superior Province of the Canadian Shield. The Cu-Ni deposits occur in the older metamorphosed basic rocks and in biotite-hornblende gneisses. The molybdenite, beryl, pollucite, spodumene and lepidolite with minor uranophane and columbite-tantalite occur in Be-Li pegmatites transecting the younger granodiorite-adamellite batholith. The biotite, phlogopite and several types of amphibole

are associated with Cu-Ni sulphides. The replacement of silicates by sulphides is usually associated with alteration of mica and change in composition of amphibole. By determining the chemical composition and isotopic ages of the fresh and altered micas and amphiboles, the chemical environment and period of the replacement of silicates by ore minerals are inferred.

The adjacent Li pegmatites contain primary and secondary micas, overgrown on the Li-Be ore minerals. Chemical analyses of the micas and host minerals provide data on geochemical evolution of the pegmatite and on repeated remobilizations of rubidium, lithium, fluorine and sodium during the main pegmatitic and hydrothermal stages, and during late albitization. Isotopic ages of the primary and secondary micas and associated feldspars provide data on the age relationships between the host rocks, on K-Rb-Na metasomatism and on periods of crystallization of the pegmatitic and hydrothermal ore minerals. The heterogeneous nature of Li micas is attributed to repeated Li-Rb-F activities which resulted in the crystallization of as many as five generations of Li-Al micas in a single flake.

Rimsaite, J.

EFFECT OF Rb-METASOMATISM ON Rb/Sr AND $^{87}\text{Sr}/^{86}\text{Sr}$ RATIOS IN PEGMATITIC MINERALS AND HOST ROCKS; Abstracts, II Cong. Latinoamericano de Geologia; p. 77-78, 1973.

Studies of chemically analysed feldspars and micas, and of their host rocks, indicate that potassium-bearing minerals are favourable hosts for rubidium and unfavourable hosts for strontium. Thus, in common crystalline rocks, the rubidium occurs in potassic minerals and the strontium in Ca-Na-minerals.

To test this observation, pegmatitic minerals and host rocks were chosen for the study of Sr and Rb isotope distribution in an area affected by K, Na and Rb metasomatism. It was found that secondary micas formed during the late pegmatitic-hydrothermal stage of high Rb-activity contain very little or no common Sr. Micas and microcline formed during the main pegmatitic stage of high K-Be-Li-activity, which also affected the host rocks of the pegmatite, contain a few ppm common Sr; and the "old" Ca-Na-feldspar contains the most abundant common strontium. Plots of $^{87}\text{Sr}/^{86}\text{Sr}$ vs $^{87}\text{Rb}/^{86}\text{Sr}$ constructed from isotopic data obtained in the pegmatitic minerals and related rocks show five different slopes resulting from the increased quantity of K and Rb. The steepness of the slope increases with the increasing Rb-content and decreasing common Sr-content of rock-forming minerals.

Rimsaite, J.

ORIGIN OF JAROSITE AND NICKELIFEROUS GOETHITE IN THE OXIDATION ZONE OF A CANADIAN NICKEL DEPOSIT; Prog. Abstr., p. 62, Clay Minerals Society - 10th Meeting; 22nd Annual Clay Minerals Conference, 1973.

Jarosite and nickeliferous goethite are hydrous oxidation products of Fe, Ni-sulphides and biotite formed in the oxidation zone of a nickel deposit. The replacement mechanism of the primary biotite by goethite and reactions between ions released from partly-decomposed Fe, Ni-sulphides and biotite were studied by electron probe microanalyses in thin-polished sections. Two phases of decomposition and of replacement were distinguished.

During the first phase, the biotite consists of alternating fresh and altered bands, the latter being coated by Fe-hydroxide plates. Gradual replacement of biotite by iron-rich hydroxides takes place along basal cleavage planes and on the surface of the mica flake. Electron probe microanalyses of fresh and altered bands of the biotite indicate increased nickel contents and the following losses of oxides from the altered bands: ca 80% K_2O and Na_2O ; 50% SiO_2 , MgO and TiO_2 ; and 25% Al_2O_3 and Cr_2O_3 .

The second phase involves reactions between sulphur, iron and nickel released from Fe, Ni-sulphides, environmental water, and potassium released from the biotite, resulting in replacement of altered biotite bands by Ni-goethite and precipitation of jarosite in fractures of relatively fresh remnant biotite. The jarosite retains the potassium released from altered portions of the mica. Electron probe scanning pictures indicate higher concentrations of nickel (8%) adjacent to decomposed biotite.

It is suggested that high pH on the surface and along (001) fractures of the mica due to released potassium provided favourable environment for precipitation of iron and nickel and crystallization of nickeliferous goethite. Trends of reactions and losses of protons from the interlayer and tetrahedral and octahedral layers of the biotite with increasing degree of its decomposition are illustrated by series of X-ray scanning pictures and in a diagram.

Ross, D. I., and Henderson, G.

NEW GEOPHYSICAL DATA ON THE CONTINENTAL SHELF OF CENTRAL AND NORTHERN WEST GREENLAND; Can. J. Earth Sci., v. 10, p. 485, 1973.

Recent geophysical work on the continental shelf of central and northern West Greenland has enabled the known onshore geology of the West Greenland Basin to be extended into the offshore region and the major graben running the length of the continental shelf in Melville Bugt

to be defined in some detail. Two zones are observed within the offshore extension of the West Greenland Tertiary basalts. The eastern zone corresponds to dipping basalts at shallow depth similar to those occurring onshore on Hareøen, outermost Nûgssuaq, Ubekendt Ejland, and southwestern Svartenhuk. The more westerly zone corresponds to subhorizontal to horizontal basalts whose top occurs at a depth of up to 1 km, the depth increasing towards the west and south. In the upper part of this offshore sequence the basalts are believed to be interlayered with Tertiary sediments. The Melville Bugt graben is shown to be a major continuous feature parallel to the coast of northwestern Greenland with sediment thicknesses of 7-10km. The graben is believed to have been formed at the time of initial rifting of Canada and Greenland.

Sanford, B. V., and Norris, A. W.

THE HUDSON PLATFORM; in Can. Soc. Pet. Geol., Mem. 5, 1973.

The Hudson Platform embraces an area of 375,000 square miles of which the greater part (235,000 square miles) is covered by water of Hudson and James Bays. It is represented onshore in the south by the Hudson Bay Lowlands (125,000 square miles) and in the north by the Southampton Plain (15,000 square miles).

Two Phanerozoic sedimentary basins are present within the Hudson Platform: the Moose River Basin in the southern part of the Hudson Bay Lowlands, and the Hudson Bay Basin of which only a small part is exposed in the northern Lowlands and on Southampton, Coats and Mansel Islands. The two basins are separated by a northeast trending positive area, the Cape Henrietta Maria Arch, where Archean and Proterozoic rocks are exposed in several inliers which are surrounded by a thin veneer of Silurian rocks.

In the Moose River Basin, Ordovician, Silurian, Devonian and Lower Cretaceous rocks are present and these have a total thickness of about 2,500 feet in the central part of the basin. In the Hudson Bay Basin rocks of Ordovician, Silurian and Devonian ages are represented in the Hudson Bay Lowlands, and rocks of Ordovician and Silurian ages are present on Southampton, Coats and Mansel Islands. The total succession in the water-covered central part of the latter basin is estimated by geophysical studies to be about 6,000 feet thick.

Ordovician rocks within the Hudson Platform underlie an area of about 360,000 square miles and have a volume of about 55,000 cubic miles. Three types of exploration targets are worthy of consideration: (1) unconformity traps, (2) fault traps, and (3) biohermal structures. Estimated possible potential of these rocks is 550 million barrels of oil and 3.3 trillion cubic feet of gas, assuming a yield of 10,000 barrels per cubic mile of sedimentary rocks.

Silurian rocks underlie an area of about 331,000 square miles and have a volume of 98,000 cubic miles.

Biohermal structures in the Attawapiskat Formation are the main target both in the onshore and offshore regions. Assuming an arbitrary yield of 15,000 barrels of oil per cubic mile of sediment, Silurian rocks have a potential of 1.4 billion barrels of oil and 8.4 trillion cubic feet of gas.

Devonian rocks underlie an area of about 90,000 square miles and have a volume of 16,000 cubic miles. The more promising of these rocks are the Moose River, Murray Island and Williams Island Formations which are coeval and lithologically similar to producing carbonate reservoirs in the Michigan Basin. Estimated possible potential is 320 million barrels of oil and 1.9 trillion cubic feet of gas, assuming an arbitrary yield of 20,000 barrels of oil per cubic mile of sedimentary rocks.

The two basins of the Hudson Platform are compared with the productive Michigan Basin, pointing out gross similarities and differences. In addition, the more promising as well as the adverse geological factors affecting the petroleum possibilities of the Hudson Platform are discussed.

Schwartz, E. J.

MAGNETIC CHARACTERISTICS OF MASSIVE SULFIDE ORE BODIES NEAR SUDBURY, CANADA; *Can. J. Earth Sci.*, v. 10, no. 12, p. 1735-1743, 1973.

Scott, W. J., and Fraser, D. C.

DRILLING OF EM ANOMALIES CAUSED BY OVERBURDEN; *Can. Mining Met. Bull.*, v. 66, no. 735, p. 72-77, 1973.

Airborne electromagnetic surveys were flown during 1965 in the Moose River area of Ontario. The systems used were INPUT Mark II and the Canadian Aero Otter. Anomalies indicated by both systems were located on the ground with vertical-loop EM. Two such anomalies were drilled, with no explanation being found in the bed-rock geology. Subsequent seismic, resistivity and gravity surveys indicated that the sources of these anomalies lay in the overburden.

Current work in the similar geological environment of the Winisk River area has shown that comparable AEM anomalies can still be misleading. The lesson to be learned from these experiences is that additional geophysical work can help to resolve doubtful cases before drilling decisions are made.

Sen Gupta, J. G.

A REVIEW OF THE METHODS FOR THE DETERMINATION OF THE PLATINUM GROUP METALS, SILVER, AND GOLD BY ATOMIC-ABSORPTION SPECTROSCOPY; *Miner. Sci. Eng.*, v. 5, no. 3, 1973.

A review of the atomic-absorption methods for the determination of the noble metals in various materials

developed during the past fourteen years is presented. The means to overcome interferences from the matrix elements in aqueous and non-aqueous solutions and to improve the sensitivity of determination, as well as sample treatment (decomposition, separation, etc.), are thoroughly discussed with references to published materials. Applications of the methods to the determination of individual noble metals in specific materials, together with the operating parameters, are presented.

Aumento, F., and Souther, J. G.

FISSION-TRACK DATING OF LATE TERTIARY AND QUATERNARY VOLCANIC GLASS FROM THE MOUNT EDZIZA VOLCANO, BRITISH COLUMBIA; *Can. J. Earth Sci.*, v. 10, no. 7, p. 1156-1163, 1973.

Seventeen specimens of Pliocene to Recent volcanic glass from Mount Edziza, British Columbia, were dated by the fission-track method. Results agree well with paleomagnetic, potassium-argon, carbon-14, and stratigraphic data, offering accurate dates with closer limits of confidence than can be obtained by other methods.

The age data supports the petrological evidence for three principal stages of activity, each beginning with eruption of basalt and culminating with eruption of more acid magma.

Cochrane, N. A., and Srivastava, S. P.

TIDAL INFLUENCE ON ELECTRIC AND MAGNETIC FIELDS RECORDED AT COASTAL SITES IN NOVA SCOTIA, CANADA; *J. Atmos. Ter. Physics*, v. 36, p. 49-59, 1974.

Large M_2 period (12-42-hr) periodicities in the terrestrial electric field at Morden and Dartmouth, Nova Scotia are ascribed to ocean tidal dynamos in the Bay of Fundy and Atlantic Ocean, respectively. Theoretical models permit crude estimates of gross earth conductivity from observed tidal electric amplitudes in the Fundy region. Similar tidal influences are not clearly resolved in magnetic recordings along the Atlantic coastline compared to simultaneous recordings 500 km inland. Possible D component magnetic gradients associated with the Bay of Fundy dynamo are also undetectable in a short stretch of simultaneous recording between Morden and Dartmouth.

Srivastava, S. P.

INTERPRETATION OF GRAVITY AND MAGNETIC MEASUREMENTS ACROSS THE CONTINENTAL MARGIN OF BRITISH COLUMBIA, CANADA; *Can. J. Earth Sci.*, v. 10, no. 11, p. 1664-1677, 1973.

Contoured free air and Bouguer gravity and magnetic anomaly have been produced for the continental

margin off the west coast of Canada from sixteen new profiles and previous data. Models produced from gravity, magnetic, and seismic reflection data indicate a deepening of the oceanic basement towards the continent off Vancouver Island. These results, along with folding and faulting of the large thickness of sediments at the base of the slope, indicate that there is present or very recent subduction in this area. In contrast, off the Queen Charlotte Islands, the basement is nearly horizontal and faulting is predominant, probably representing strike-slip motion along the Queen Charlotte Fault.

Elvers, D., Srivastava, S. P., Potter, K., Morley, J., and Sidel, D.

ASYMMETRIC SPREADING ACROSS THE JUAN DE FUCA AND GORDA RISES AS OBTAINED FROM A DETAILED MAGNETIC SURVEY; *Earth Planet. Sci. Lett.*, v. 20, p. 211-219, 1973.

Marine magnetic data collected along 37 east-west lines off the Washington and Oregon coast between 42°N and 48°N westward to 144°W have been interpreted. Our interpretation shows that decrease in the offsets of the anomalies across the Surveyor fracture zone and the presence of undisturbed north-south lineations east of it are the result of continuous asymmetric spreading along the Surveyor fracture zone. The survey has delineated the extension of the Blanco fracture zone north-westward to about 133°W. Movement along the Blanco fracture zone was initiated about 15 million years ago. The undisturbed north-south trend of the magnetic anomalies between latitudes 42°N and 48°N and longitudes 133°W and 136°W is interpreted as the interval (22 to 15 my) during which the Juan de Fuca and Gorda rises were one continuous structure. West of 137° the Surveyor, Sedna and three minor fracture zones are mapped.

Stalker, A. MacS.

A REVISED INTERPRETATION OF A SECTION OF HOLOCENE LAKE SEDIMENT FROM THE RIDING MOUNTAIN AREA OF MANITOBA; *Geol. Assoc. Can. Proc.*, v. 25, p. 27-33, 1973.

The importance of pollen studies to our understanding of the postglacial history of the Canadian Prairies has prompted the writer to re-interpret the information obtained by J. C. Ritchie during his 1969 study of absolute pollen frequencies in E Lake, in the Riding Mountain area of Manitoba. That study was based on the premise that the sedimentation rate in the lake had remained relatively constant during the last 11,000 years. A review of the information shows, on the other hand, that the rate of sedimentation varied widely; this strongly affects the conclusions reached about rates of pollen fall and climatic changes. Absolute pollen frequencies based on this revised sedimentation rate indicate that there were two climatic 'deteriorations' during that time, separated

by the Hypsithermal Episode. The last climatic 'deterioration', between 2300 and 250 radiocarbon years B. P., corresponds to the Neoglacial Episode. The older 'deterioration', which was severe but short, spanned the interval from 7800 to 7200 years ago. Differences in the pollen ratios indicate that the two 'deteriorations' had some dissimilarities in climate.

This is only one example of a number of reported occurrences of climatic 'deterioration', or even of glacier readvance, between 8,000 and 6,500 radiocarbon years ago.

Stalker, A. MacS.

CORRELATION AND CHRONOLOGY OF CORDILLERAN AND LAURENTIDE GLACIATIONS IN SOUTHWESTERN ALBERTA, CANADA; Abstracts, 9th Int. Cong. Int. Union Quat. Res. (INQUA), 1973.

The Foothills and Plains of southwestern Alberta were the scene, during the Pleistocene epoch, of successive and often overlapping advances of Cordilleran and Laurentide glaciers. The Cordilleran glaciers flowed east and northeast down valleys in the Rocky Mountains to, and in some instances far onto, the Plains, while the more massive Laurentide ice sheets spread into the region from the north or east. The deposits of the Cordilleran and Laurentide glaciers, which have very different lithologies, interfinger in the Foothills and western Plains. However, several of the Laurentide advances and some of the smaller Cordilleran ones did not reach this region, traces of others have been obliterated, and so the cross-section of Figure 1 is very incomplete.

Pleistocene events in Alberta are probably best displayed along the Crownsnest Valley, in the Mountains and Foothills, and in the Oldman Valley on the Plains. Figure 1 is based on four river exposures in those valleys, from Kipp Bluff (E. ½ of sec. 18, tp. 9, rge. 22, W. 4th mer.) on the Plains, past Brocket Bluff near the edge of the Foothills (NW. ¼ of sec. 27, tp. 7, rge. 28, W. 4th mer.), to Cowley (S. ½ of sec. 2, tp. 7, rge. 1, W. 5th mer.) and Triforks (NE. ¼ of sec. 2, tp. 7, rge. 1, W. 5th mer.) Bluffs well inside the Foothills. This is a distance of 60 miles (100 km).

Stacy, H. R., and Grant, D. R.

TIDAL MUDS REVEAL MINERAL CURIOSITY; *Can. Geog. J.*, v. 88, no. 1, p. 36-38, 1974.

Rare double-ended forms of calcite occur in tidal mud near Fort Beauséjour at the head of Bay of Fundy. They are rhombohedral in cross-section, with corrugated surfaces and serrated edges, and have a hard shell with a granular interior. Provisionally named 'fundylites' as a popular and local descriptive term, they occur as individuals up to 4 inches long, and as intergrowths, in saltmarsh mud 40 feet below high tide. The mud buries a submerged forest dated at 4010 yr. B. P.

Fundylites are thought to be authigenic growths, perhaps localized by conditions related to the subjacent peat and to the karst that is developing in the underlying carbonate rocks. Similar growths are described from scattered occurrences abroad.

Hogarth, D. D., Steacy, H. R., Semenov, E. I., Proshchenko, E. G., Kazakova, M. E., and Kataeva, Z. T.

NEW OCCURRENCES AND DATA FOR SPENCITE;
Can. Mineral., v. 12, p. 66-71, 1973.

Spencite is described from two new occurrences in Ontario: a pyroxene-rich layer within a calcite-fluorite vein-dyke (Cardiff property) and a pyroxene — and amphibole — rich pegmatite (Faraday mine). All spencites are metamict but after heating to 900°C in air, are recrystallized to an apatite (britholite) phase and a fluorite (CeO₂) phase. The physical properties vary considerably but for convenience spencites have been divided into three groups: Spencite I (S.G. = 3.05-3.08, n = 1.620-1.630), Spencite II (S.G. = 3.27-3.40, n = 1.670-1.685) and Spencite III (S.G. = 3.27-3.81, n = 1.711-1.713). These properties reflect characteristics in lanthanide composition with Spencite I being the most yttric (Y maximum), and Spencite III being the most ceric (Ce maximum) and forming a link with tritomite. Allanite is commonly associated with spencite and may, in part, be derived from it by addition of Si and Al and release of B. Because of leaching of constituents, spencite does not yield a rational formula but its origin from hellandite is considered possible.

Szabo, B. J., Stalker, A. MacS., and Churcher, C. S.

URANIUM-SERIES AGES OF SOME QUATERNARY DEPOSITS NEAR MEDICINE HAT, ALBERTA, CANADA; Can. J. Earth Sci., v. 10, p. 1464-1469, 1973.

²³⁰Th and ²³¹Pa dates were obtained on 10 bone samples from Quaternary deposits near Medicine Hat, Alberta. The youngest date so obtained (9500 ± 1500 years) agrees reasonably well with a radiocarbon date (11,200 ± 200 years) from the same site. In addition, where samples were collected from more than one bed at the same bluff the results are in the correct chronological order. A Sangamon bed containing chipped stones, thought to be artifacts, gave a date of 72,000 ± 6000 years, which is acceptable, though at the younger end of the previously estimated age range of between 200,000 and 70,000 years for the bed.

In general, however, the results reveal large discrepancies with the estimated ages of the beds that yielded the bones. Although several causes for the discrepancies are possible, in two or three instances the uranium-series dates themselves appear to be incorrect, and the other dates must be treated with caution.

Taylor, F. C., and Baer, A. J.

PIEMONTE-BEARING EXPLOSION BRECCIA IN ARCHEAN ROCKS, LABRADOR, NEWFOUNDLAND; Can. J. Earth Sci., v. 10, p. 1397-1402, 1973.

An explosion breccia, 4 km east of Hopedale, Labrador, occurs in Archean migmatite forming part of the Hopedale Gneiss. The breccia, 105 by 60 m, consists of angular to well-rounded fragments compositionally similar to the country rock. Extensive development of piemontite and epidote is characteristic of the breccia. Two narrow mafic dikes post-date and fill fractures in the breccia. An electron probe analysis of piemontite and epidote shows the former contains 1.86% Mn₂O₃ and the latter 0.21%. A genesis of the breccia involving fluidization with subsequent development of piemontite by hydrothermal activity is suggested.

Thorpe, R. I., and Sangster, D. F.

AN INTEGRATED MODEL FOR LEAD ISOTOPIC EVOLUTION FOR SAMPLES FROM THE CANADIAN SHIELD: DISCUSSION; Can. J. Earth Sci., v. 10, p. 1693-1696, 1973.

Ozard, Slawson and Russell (C. J. E. S., 10, p. 529-537) obtained six dates for important events in the evolution of the Canadian Shield from simultaneous consideration of seven anomalous lead lines and three secondary rock lead isochrons.

In our discussion of their paper the nature of these events is questioned, as well as their use of a single growth curve for a reference. The ages for the Noranda, Quemont and Flin Flon deposits that are implicit in the results of Ozard *et al.* are discussed in the light of other geochronological data. Geological models are suggested for the two-stage evolution of anomalous lead lines (secondary isochrons). A plea is made for better descriptions of analyzed samples and for more specific geological interpretation of events during the evolutionary history of the lead.

Thorpe, R. I., and Harris, D. C.

MATTAGAMITE AND TELLURANTIMONY, TWO NEW TELLURIDE MINERALS FROM MATTAGAMI LAKE MINE, MATAGAMI AREA, QUEBEC; Can. Mineral., v. 12, p. 55-60, 1973.

Mattagamite is a new mineral with the composition Co_{0.54}Fe_{0.37}Te_{2.00}. The name is for the locality and is to be applied to the end member CoTe₂. The analyzed material is a ferroan mattagamite. The mineral is orthorhombic; the unit-cell for CoTe₂ is a 5.31, b 6.31, c 3.89 Å whereas for FeTe₂ (frobergite) it is a 5.29, b 6.27, c 3.86 Å. The strongest lines on the x-ray power pattern are 3.31(3), 2.805(10), 2.703(8), 2.066(6), 1.843(4), 1.583(3), 1.514(2), 1.354(2) Å. The mineral occurs as equidimensional grains (110 microns

or less) isolated in altaite and as irregular rims (<30 microns) on pyrrhotite and chalcopyrite in contact with altaite. Under reflected light the mineral is violet, particularly in contrast to the pink of cobaltite. Anisotropism is weak, varying from a pinkish violet to greyish violet. Reflectance measurements at 470, 546, 589 and 650 nm gave 53.1, 51.4, 51.7 and 52.7%. Micro-indentation hardness values are 383, 404 kg/mm² for a 25 g load and 630 kg/mm² for a 15 g load.

Tellurantimony is a new mineral with the composition Sb_{1.91}Te₃. The name is for the composition, Sb₂-Te₃, in analogy with tellurbismuth, Bi₂Te₃, with which it is isostructural. The mineral is hexagonal ($\bar{R}3m$); the unit-cell is a 4.258; c 30.516 Å. The strongest lines on the x -ray powder pattern are 3.156(10), 2.348(7), 2.129(8), 1.980(7), 1.767(6), 1.577(5), 1.468(4), 1.359(5) Å. The mineral occurs in altaite as lath-shaped crystals up to 175 microns wide and 350 microns long, but more frequently as laths up to 40 microns wide. Under reflected light the mineral shows weak pleochroism with colours from pink to cream. Anisotropism is moderate, varying from pink to dark grey. Reflectance measurements at 470, 546, 589 and 650 nm gave 65.1, 63.6, 63.8 and 63.7%. Micro-indentation hardness values range from 39.6-61.3 (av. 49.8) kg/mm² with a 25 g load.

Subsequent to the initial study, an antimonian mattagamite and an unknown Ag-Sb telluride were identified. The antimonian mattagamite occurs rimming pyrrhotite in contact with altaite and contains up to 29.5 weight per cent antimony. The antimony content has been found to vary inversely with iron. The unknown telluride occurs as a 15 micron bleb along an altaite-pyrrhotite grain boundary. Microprobe analysis gave a formula of Ag_{0.9}Sb_{1.0}Te_{2.0}.

Thorpe, R.I., and Little, H.W.

THE AGE OF SULFIDE MINERALIZATION AT ROSSLAND, BRITISH COLUMBIA; *Ec. Geol.*, v. 68, p. 1337-1346, 1973. (Discussion)

R.I. Thorpe and H.W. Little questioned the conclusions of a paper on the above subject that was published by J. T. Fyles, J. E. Harkal, and the late W. H. White in *Economic Geology* in January, 1973. The principal objection was to the Tertiary age assigned to the mineralization and to virtually all the intrusive rocks of the camp, based largely upon K-Ar age determinations. Thorpe and Little were of the opinion that the older rocks were up-dated by intrusion of the nearby Coryell batholith. A different interpretation also was suggested for the geological relationships observed, and a genetic relation of the veins to the Juro-Cretaceous Nelson intrusions was favoured.

Thorsteinsson, R.

DERMAL ELEMENTS OF A NEW LOWER VERTEBRATE FROM MIDDLE SILURIAN (UPPER WENLOCKIAN) ROCKS OF THE CANADIAN ARCTIC ARCHIPELAGO; *Palaeontographica Abt. A*, v. 143, no. 1-6, p. 51-57, 1973.

Harington, C. R., Tipper, H.W., and Mott, R. J.

MAMMOTH FROM BABINE LAKE, BRITISH COLUMBIA; *Can. J. Earth Sci.*, v. 11, p. 285-303, 1974.

Remains of a partially articulate mammoth skeleton were exposed during stripping operations at a mining site on Babine Lake, central British Columbia. The bones lay in silty pond deposits in a bedrock depression, and were overlain by a thin layer of gravel and a thick layer of glacial till. Although no molar teeth were found, limb proportions show that the specimen was a large mammoth, like the Columbian mammoth (*Mammuthus* cf. *M. columbi*). Two radiocarbon dates of 42,900 ± 1860 yr B. P. and 43,800 ± 1830 yr B. P. on wood from the silty fossiliferous layer, and another of 34,000 ± 690 yr B. P. on mammoth bone suggest that the animal sank in sticky pond deposits and died there. Paleobotanical evidence indicates that, during this part of the Olympia Interglaciation, the vegetation near Babine Lake was similar to present shrub tundra just beyond the treeline in northern Canada.

Frebold, H., and Tipper, H.W.

UPPER BAJOCIAN - LOWER BATHONIAN AMMONITE FAUNA AND STRATIGRAPHY OF SMITHERS AREA, BRITISH COLUMBIA; *Can. J. Earth Sci.*, v. 10, p. 1109-1131, 1973.

In the Smithers area of British Columbia, faunas are recognized below the beds with *Lilloettia*, *Kepplerites*, and other characteristic Lower Callovian ammonites. The upper one includes *Arctocephalites* (*Cranoccephalites*) *costidensus* Imlay, *Parareineckia* cf. *P. shelikofana* (Imlay), *P.* cf. *P. hickersonensis* Imlay, *Cobbanites talkeetnanus* Imlay, *Epizigzagicerus evolutum* Frebold n. gen. n. sp., and *Morrisiceras?* *dubium* Frebold. This fauna is equivalent in age to a similar fauna in southern Alaska described by Imlay, and is assigned to the Lower Bathonian. The next older fauna includes *Megasphaeroceras?* aff. *M. rotundum* Imlay, *Epizigzagicerus crassum* Frebold n. gen. n. sp. *Zemistephanus* sp. indet., and *Cobbanites talkeetnanus* Imlay. The age is Bajocian, possibly Late Bajocian. Below are beds with pelecypods of uncertain, probably Bajocian age. The upper and middle faunas are new for British Columbia and other parts of Canada.

Trettin, H. P.

EARLY PALEOZOIC EVOLUTION OF NORTHERN PARTS OF CANADIAN ARCTIC ARCHIPELAGO; Arctic Geology, Mem. 19 (publ. Am. Assoc. Pet. Geol.) 1973.

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 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 a stable carbonate platform.

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.); and (3) late Middle Ordovician to Middle Silurian deep-water deposition of flysch type (greywacke, shale, etc.).

The trough must have formed by subsidence of the continental crust rather than by sea-floor spreading, because the deep-water strata lie on shallow-water strata and not on volcanic rocks. The trough, which was separated from subaerial parts of the geanticline by a shelf on which carbonate, clastic, and volcanic materials 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, which was basement controlled, 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.

Anthony, E. H., and Vilks, G.

ASKING MICROORGANISMS TO CLASSIFY THEIR ENVIRONMENT; Estuarine Microbial Ecology; L. Harold Stevenson and R. R. Colwell, ed., p. 269-280, University of South Carolina Press, 1973.

It is proposed that association analysis of certain members of a biota is a useful technique for the classification of environment. The technique may also provide means for ecologically useful classification of the organisms concerned. As an example, counts of species of foraminifera from 75 samples of sediment from East Bay, Mackenzie King Island in the Canadian Arctic were converted to a matrix of presence-absence data. These were submitted to both normal and inverse association analysis. The results were compared with observations made at the time the survey was carried out.

Walker, D. A., and Vilks, G.

SPINAL ULTRASTRUCTURE OF THE PLANKTONIC FORAMINIFERS HASTIGERINA THOMSON AND GLOBIGERINELLA CUSHMAN; J. Foram. Res., v. 3, no. 4, p. 196-198, 1973.

Scanning electron microscopy of the planktonic foraminifer Hastigerina pelagica (d'Orbigny) has revealed the presence of spinal barbs along each of the edges of the triradial spines. These structures were lacking on all Globigerinella aequilateralis (Brady) specimens examined, suggesting that the genus Globigerinella Cushman is valid and not a junior synonym of Hastigerina Thomson.

Vilks, G., and Walker, D. A.

MORPHOLOGY OF ORBULINA UNIVERSA D'ORBIGNY IN RELATION TO OTHER SPINOSE PLANKTONIC FORAMINIFERA; J. Foram. Res., v. 4, no. 1, p. 1-8, 1974.

The adult phenotype of the planktonic foraminifera Orbulina universa contains two seemingly unrelated forms: the inner trochospiral and the outer spherical. To demonstrate the relationship of this species to other planktonic foraminifera, scanning electron micrographs were studied on specimens collected in surface waters of the Atlantic and Pacific Oceans and the Caribbean Sea.

Most trochospiral forms of Orbulina contain supplementary secondary apertures, therefore the species is not related to Globigerina d'Orbigny as maintained by several authors. All specimens possess triradial spines, which are different from any species of the genus Globigerinoides, indicating a basic difference between the two genera. Hastigerina Thomson and Globigerinella Cushman also contain triradial spines, but these genera are planispiral and therefore different from O. universa.

It is suggested that morphology of spines should reflect variations in genetic codes and therefore is useful for the classification of spinose planktonic foraminifera. The micromorphology of Orbulina universa is distinct from the other forms of planktonic foraminifera and therefore it is a valid taxon.

Yorath, C. J.

GEOLOGY OF BEAUFORT — MACKENZIE BASINS AND EASTERN PART OF NORTHERN INTERIOR PLAINS; *Am. Assoc. Pet. Geol., Mem.* 19, p. 41-47, 1973.

Young, F. G., Campbell, R. B., and Poulton, T. P.

THE WINDERMERE SUPERGROUP OF THE SOUTH-EASTERN CANADIAN CORDILLERA; in *Belt Symposium*, v. 1, 1973 (publ. Dept. Geol. Univ. Idaho, Idaho Bur. Mines Geol.).

The Windermere Supergroup and the unconformably underlying Purcell (=Belt) Supergroup comprise the two major late Precambrian sedimentary assemblages of the Canadian Cordillera. The Windermere Supergroup embraces those groups and formations which lie between the Purcell Supergroup below and Lower Cambrian or slightly older quartzite above. Near inferred Windermere source areas (east and southeast) the upper contact is unconformable; elsewhere it is conformable.

In the southeastern Canadian Cordillera the Windermere can be subdivided into six lithologic divisions that correspond to all or parts of formations and groups. In the southeast the Toby Formation and the Irene Volcanics comprise the relatively local diamictite and volcanic divisions, respectively. The Toby reflects largely local derivation from the underlying Purcell. Much more widespread are the four overlying divisions. From oldest to youngest these are: 1) the grit division of largely impure quartz, sandstone and shale in which some features of turbidites are characteristic; 2) the slate division suggesting deposition in deep, quiet euxinic conditions; 3) the carbonate division implying shallow water conditions with the development of carbonate banks and "off bank" deposition; 4) the upper clastic division of shale, sandstone and carbonate deposited during a marine transgression. Windermere deposition concluded during partial regression of the sea and subaerial erosion of the marginal parts of the depositional basin. The main source area of Windermere sediments was the Precambrian Shield including the ancestral Peace River Arch. Purcell rocks uplifted in "Montania" also provided an important source.

Windermere sedimentation provides little evidence in support of the concept of deposition in a developing continental rift.

Young, F. G.

MESOZOIC EPICONTINENTAL, FLYSCHOID AND MOLASSOID DEPOSITIONAL PHASES OF YUKON'S NORTH SLOPE; in *Proc. Symp. Geol. Can. Arctic*, May 1973, Saskatoon, 1973, publ. Can. Soc. Pet. Geol. — Geol. Assoc. Can.

The Jurassic and Cretaceous sedimentary record of Yukon's north slope consists of discrete, successive, epicontinental, flyschoid and molassoid clastic phases. Each is characterized by its facies associations, thickness variability, sandstone petrography, and inferred tectonic setting.

During the Jurassic and Early Cretaceous, until the Albian Stage, epicontinental marine sandstone and mudstone were evenly deposited over a large area of northern Yukon. Widespread deltaic lobes and sand-bar complexes suggest that the sea was generally shallow. Typically, the sandstones are nearly pure quartz and contain less than 5% chert or feldspar. Their mineral maturity, as well as facies trends and paleocurrent structures, indicate derivation from the craton to the southeast.

Restructuring of the tectonic framework in early Albian time resulted in a marine trough which received 15,000 feet (4,600 metres) of shale, siltstone, turbiditic sandstone, and conglomerate from a rising western highland. The trough axis runs from the Arctic coast southward through the headwaters of Blow and Bell Rivers. This flyschoid clastic wedge rapidly becomes thinner toward the east where phosphatic iron carbonate accumulated on a restricted shelf. The flyschoid clastics are very immature and extremely variable in composition. Some sandstones are enriched in chert, others in andesitic or slaty fragments. The trough was deformed and uplifted in the early Upper Cretaceous, leaving restricted hypersaline basins near Mackenzie Delta.

In Maestrichtian time rejuvenated highlands shed detritus northward, resulting in 7,000 feet (2,150 metres) of molassoid alluvial, deltaic, littoral and marine deposits of sandstone, conglomerate, mudstone and coal under the present coastal plain. The sandstones are relatively uniform in composition and contain quartz, chert and feldspar, as well as sedimentary, metamorphic and volcanic lithoclasts.