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ABSTRACTS OF PUBLICATIONS IN SCIENTIFIC JOURNALS BY OFFICERS OF THE GEOLOGICAL SURVEY OF CANADA, APRIL 1976 TO MARCH 1977

RÉSUMÉS DE PUBLICATIONS PAR LES CHERCHEURS DE LA COMMISSION GÉOLOGIQUE DU CANADA PARUES DANS DES REVUES SCIENTIFIQUES AVRIL 1976 À MARS 1977



Energy, Mines and Resources Canada

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#### Abbey, Sydney

DETERMINATIONS OF RARE ALKALIS AND ALKALINE EARTHS IN USGS STANDARD ROCKS; U.S. Geol. Surv. Prof. Paper 840, p. 117-118, 1976.

Results of a series of analyses designed to verify the homogeneity of a group of U.S. Geological Survey reference samples.

#### Abbey, Sydney

TOPICS ON "GEOSTANDARDS" DURING THE INTERAN '76 CONFERENCE ON ANALYSIS OF GEOLOGICAL MATERIALS; Geostandards Newsletter, vol. 1, No. 1, p. 5, 6, 1977.

A technical news report on an international conference held at Prague in August, 1976.

#### Abbey, Sydney

"STANDARD SAMPLES": HOW "STANDARD" ARE THEY?; Geostandards Newsletter, v. 1, p. 39-45, 1977.

A review is presented regarding the problems in the assignment of values for individual components of reference samples of silicate rocks. Possible causes are examined for the disparity of data obtained from contributing laboratories and for the fact that there has been little improvement over the years. Differences between collaborative programmes on rocks and those on ores are emphasized, particularly regarding the imbalance resulting from the inability to maintain adequate control over operations involving so many varied components. A plea is made for more careful interpretation of published values, for more meaningful description of analytical methods used and for more uniform practices in programmes originating in various countries. An argument is presented in favour of tempering statistical treatment with subjective considerations, and several tentative tests are proposed for verifying the validity of derived values.

#### Abbey, Sydney

SY-2, SY-3 AND MRG-1. A REPORT ON THE COLLABORATIVE ANALYSIS OF THREE CANADIAN ROCK SAMPLES FOR USE AS CERTIFIED REFERENCE MATERIALS – SUPPLEMENT 1; CANMET Report 76-36 (1976).

Additional data received since the original report, MRP/MSL 75-132(TR), was prepared, are presented. New recommended values are assigned to several constituents.

# Abbey, Sydney, Gillieson, A.H. and Perrault, Guy

SY-2, SY-3 AND MRG-1. A REPORT ON THE COLLAB-ORATIVE ANALYSIS OF THREE CANADIAN ROCK SAMPLES FOR USE AS CERTIFIED REFERENCE MATERIALS; CANMET Report MRP/MSL 75-132 (TR), 1975.

Analytical data received from many collaborating laboratories are presented, with information on the methods used. Usable values are recommended for most of the major, minor and the more common trace elements. Less certain values are given for many other constituents. The method used in deriving the assigned values is described, and suggestions made for improving available data.

# Agterberg, F.P.

NEW PROBLEMS AT THE INTERFACE BETWEEN GEO-STATISTICS AND GEOLOGY; in Advanced Geostatistics in the Mining Industry, p. 403-421. D. Reidel Publishing Company, Dordrecht-Holland, 1976.

A quantitative theoretical approach is proposed for solving the problem of assigning to unit areas on the map probabilities of existence for hidden objects of a specific type if data are available on known geological features both inside and outside the unit areas. The hidden objects may be punctual deposits of metals or hydrocarbons. In this paper, the theory is developed on the basis of pyritic massive sulphide deposits of a volcanic exhalative origin as occur in the Abitibi area of the Canadian Shield and the Paleozoic rocks of the Canadian Appalachian Region.

#### Agterberg, F.P.

STATISTICAL METHODS FOR REGIONAL RESOURCE APPRAISAL; Can. Min. Metall. Bull., v. 70, p. 1-3, 1977.

The knowledge about the mineral resources in a region ranges from relatively precise ore-reserve estimates for known deposits to probabilistic estimates concerning the speculative resources which may be discovered in future at greater depths and in the less-explored parts of the region. Previously developed probabilistic methods for regional resource evaluation are based on the following two assumptions.

(1) The probability that a specific block of rock, or part of a region close to the topographic surface, contains undiscovered deposits can be estimated by weighting selected geological, geophysical or geochemical parameters for that block. The weights are computed by considering similar environments which are known to contain deposits.

(2) Some of the characteristics of the undiscovered deposits, such as ore tonnages and average grades of metals contained in the ore, can be evaluated by considering probability distributions for known deposit data. These methods were initially applied to Precambrian deposits in the Abitibi Volcanic Belt of the Canadian shield.

Since 1972, statistical methods for quantitative resource evaluation have been applied to the occurrences of the mainly Paleozoic base metal deposits in the Canadian Appalachian Region. The objectives of this project (Project Appalachia) have been discussed by Leech in a paper that introduces 8 papers with results of the exploratory data analysis. Project Appalachia represents an effort to develop and apply methods of combining information and concepts from regional geology, metallogeny and geomathematics for computer-aided regional mineral resource evaluation.

#### McIlreath, Ian and Aitken, J.D.

YOHOLAMINITES (MIDDLE CAMBRIAN), PROBLEMATI-CAL CALCAREOUS SEDIMENT-STABILIZING ORGAN-ISM; Geol. Assoc. Can./Mineral. Assoc. Can., Abstr., v. 1, p. 84, 1976.

Yoholaminites was a calcareous skeletal organism that lived near Middle Cambrian carbonate platform margins now exposed in the Main Ranges of the southern Canadian Rocky Mountains. In the Cathedral Formation, it occurs exclusively in reef-flat lithofacies (peloidal mudstones with fenestral fabric, öoid grainstones, cryptalgal laminites), all of which are dolomitized along with **Yoholaminites**. This facies occurs immediately shelfward of the Cathedral platform margin. Associated organic forms encrusting **Yoholaminites** include algal stromatolite crusts and rare tabular receptaculitids.

Yoholaminites displays various morphologic habits (tabular-encrusting, digitate, domal) and is characterized by a finely laminated, chevron-crenulated macro-structure which now consists of highly ordered, uniformly fine dolomite crystals. Such an ordered structure probably records replacement of a similarly ordered primary structure, such as a sheet-and-pillar arrangement. Yoholaminites is most likely a Middle Cambrian coralline alga, but could it have been instead an ancestor of the stromatoporoids?

# Aitken, J.D., and Long, D.G.F.

HELIKIAN OF MACKENZIE ARC; Geol. Assoc. Can./Mineral. Assoc. Can., Abstr., v. 2, p. 4, 1977.

The entire record of Helikian (presumed Purcell equivalent) deposition in Mackenzie Arc is one of prolonged stable-platform conditions. The oldest unit is shallow-water dolomite hundreds of metres thick. It is succeeded by the coarsening-upward, shallow-water, clastic-dominated megacycle of the Tsezotene and Tigonankweine (Katherine) formations (1200-3100 m). New data reveal the overlying "H5 group" as a stack of five, regional blanket formations totalling up to 1400 m. A basal shallow-water clastic unit (40-70 m) is succeeded by a platform-wide "basinal sequence" (250-620 m) characterized by black shales, nodular limestones, and limestone-shale rhythmites. Stromatolitic reefs up to 300 m high developed in this generally deep-water sequence. Shallowing led to deposition of the "grainstone unit" (99-270 m) characterized by dolomitized, largely öoid grainstones and ending in mud-cracked platy dolomites. The 'grainstone unit" is host to major zinc-lead showings at the RT property. A thick blanket of gypsum (530 m plus) succeeds the grainstones, and may be of deep-water origin. Above it, the "rusty shales" (110-230 m) mark a return to mainly clastic sedimentation. Contrary to earlier speculations, the succeeding Little Dal Formation (150-2000 (?) m) does not bear a facies relationship to the H5, but is yet another regional blanket of shallow-water carbonates and minor clastics. The Redstone River Formation (0-460 m) may be disconformable on the Little Dal, but if so, records resumption of a mixed, shallow-water carbonate-clastic regime, with gypsum. Local conglomerates higher in the Redstone River, above the copper-bearing zone, are rich in parasitized Redstone clasts. Laminated dark limestones succeeded by shallow-water dolomites (laminites) mark the base of the Coppercap Formation (0-300 m), the youngest preserved of the Helikian formations.

#### Annan, A.P. and Davis, J.L.

IMPULSE RADAR SOUNDING IN PERMAFROST; Radio Sci., v. 11, No. 4, p. 383-394, 1976.

A VHF impulse radar system operating on the ground is a viable technique for mapping the near-surface geological structure and electrical properties of permafrost. A fixed antenna configuration transported over the surface yields a reconnaissance map of two-way travel times for subsurface reflectors. Wide-angle reflection and refraction (WARR) sounding determines propagation velocity versus depth when performed in layered areas. To obtain a WARR sounding, one measures travel time versus antenna separation. These techniques were field tested in the Tuktoyaktuk region of the Mackenzie River delta, N.W.T. Data recording was on a graphic display for initial field analysis and on analog magnetic tape for subsequent processing. Reconnaissance surveying has mapped structural features at various depths between 3 and 30 m. The electrical loss of the soils at a site limits the penetration depth. Clays and silts attenuate the radar signal more than sands and gravels. WARR soundings have determined dielectric constant versus depth in layered areas. While impulse radar is useful in delineating geological structure, core drilling is required to determine the geological composition.

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

MESOZOIC MAGNETIC LINEATIONS, THE MAGNETIC QUIET ZONE, AND SEA FLOOR SPREADING IN THE NORTHWEST ATLANTIC; J. Geophys. Res., v. 81, no. 26, 1976.

The magnetic basement topography and associated magnetic anomaly lineation pattern in an area north of the New England seamounts lying between anomaly 31 and the continental margin were examined in light of the Mesozoic sea floor spreading history of the northwest Atlantic. Within the magnetic quiet zone the crust is typically oceanic as far landward as the slope anomaly and exhibits a normally polarized magnetism in the inner quiet zone. Magnetic lineations have been correlated with the Keathley sequence near Bermuda, and, based upon best estimates of the reversal time scale, cross-strike spreading rates are found to be about 1.7 cm  $yr^{-1}$  from -172 m.y. to -136 m.y. and between 0.9 and 1.7 cm yr<sup>-1</sup> from -172 m.y. to -136 m.y. and between 0.9 and 1.0 cm yr<sup>-1</sup> from -136 m.y. to -72 m.y. Landward of the Keathley sequence, magnetic anomalies decrease in amplitude, although the intensity of magnetization of the normally polarized crust exhibits average values. Magnetic observations within a large area of the quiet zone surveyed in detail can be fitted to the basement topography if a Jurassic pole position of normal polarity is assumed. However, three zones trending subparallel to the Keathley lineations require a weak reversely polarized magnetism. These low values of remanent magnetization are attributed to either viscous remanence or contamination of the original crust by widespread volcanic flows or intrusives during periods of predominantly normal magnetic polarity. The normal and reversed polarity sequence resulting from this study is correlated with the sequence obtained from paleomagnetic measurements on land. Trends of isochrons within this relatively limited oceanic area necessitate an alteration in the shape of the ridge axis. A difference in spreading rate and direction is obvious on either side of the New England seamount chain and is discussed with respect to the history of early plate motions in the northwest Atlantic.

#### Blake, Weston, Jr.

GLACIER ICE CORES, CLIMATE, AND CHRONOLOGY AROUND NORTHERN BAFFIN BAY; in Am. Quat. Assoc., Abstr. (4th Biennial Mtd.), p. 20-21, 1976.

Methods of deriving a time scale from glacier ice cores, such as those recovered from Camp Century, Greenland, and from Devon Island, are among the topics discussed by Paterson in his Abstract for this AMQUA session. My contribution is intended to summarize the available chronological evidence from land areas around northern Baffin Bay, because the chronology of events deduced from the ice cores must accommodate the marine and terrestrial record as to when nearby areas were glacierized and when they were ice-free.

Sections exposed in widely separated localities – at Cape Storm, southern Ellesmere Island, on Coburg Island (at the mouth of Jones Sound) and on Saunders Island (northwestern Greenland) – display a similar stratigraphic succession. The oldest Holocene marine strata were deposited close to 9000 radiocarbon years ago, although the postglacial marine incursion may have reached some localities by 10 000 years B.P. Critical dates are: 9330 ± 110 years (GSC-1415; 100.5 m a.s.l.) at Cape Storm, 8940 ± 110 years (GSC-1426; 7 m a.s.l.) on Coburg Island, and 8970 ± 100 years (GSC-2210; 13 m a.s.l.) on Saunders Island. These age determinations are in agreement with others around northern Baffin Bay; e.g., molluscs at Cape Tennyson, southeastern Ellesmere Island, are 9040 ± 90 years old (GSC-1058; 30 m a.s.l.). The fossiliferous strata are underlain by beds, till-like in places, which do not contain marine molluscs; these beds are believed to have been deposited during a glacial episode. Marine molluscs are present beneath the non-fossiliferous units at each site, and on Coburg and Saunders islands the fauna is characterized by the presence of Mytilus edulis L. This mussel, although it now lives in these high latitudes along the Greenland coast, is not known to occur north of Baffin Island in the Canadian Arctic Archipelago. Age determinations indicate that the Mytilus-bearing beds are >38 000 years old (GSC-1425) on Coburg Island and >40 000 years old (GSC-2143) on Saunders Island; the uppermost dated molluscs in the strata underlying the till-like unit at Cape Storm are >34 000 years old (GSC-2209).

Paterson also has cited reasons why changes in the oxygen isotope ratios ( $\delta$ ) with depth cannot be equated directly with changes in temperature. However, the time scale for changes in  $\delta$ , as derived by Dansgaard and coworkers, is in good general agreement with the chronology derived from radiocarbon dating of marine molluscs on nearby coasts:

1. The faunal composition and the nature of the strata above the **Mytilus**-bearing horizons suggest that environmental conditions as favourable as during the Holocene have not existed for a period of time exceeding 40 000 years; the same conclusion is implied by the  $\delta$  record.

2. A pronounced change in  $\delta$  is indicated as having occurred between 13 000 and 10 000 years B.P. The evidence from the marine fauna in no way contradicts the hypothesis that this was a period of warming, during which large volumes of ice were being removed, and that the incursion of the sea onto the existing islands (areas now above sea level) took place between 10 000 and 9000 years ago.

3. In the Camp Century core the maximum values of  $\delta$  during the Holocene occur between 6000 and 5000 years B.P. This coincides with the period, as determined by the distribution of  $^{14}$ C-dated driftwood, during which there was apparently a less extensive cover of sea ice in the Canadian Arctic Archipelago. It is also the time when the ice shelf fringing the northern coast of Ellesmere Island was much less extensive, if in fact it existed at all.

M.N. Cagatay and D.R. Boyle

GEOCHEMICAL PROSPECTING FOR VOLCANOGENIC SULPHIDE DEPOSITS IN THE EASTERN BLACK SEA ORE PROVINCE, TURKEY; 6th Int. Geochem. Expl. Symp., Sydney, Australia, 1976.

Three related types of sulphide mineralization in the Eastern Black Sea volcanic province (Eastern Pontids) of Turkey were studied with a view towards developing geochemical techniques both for their detection and differentiation:

- (a) Zn-Cu-Pb massive sulphide deposits;
- (b) Cu-pyrite stockwork deposits; and
- (c) pyritic impregnation deposits.

Bedrock surveys utilizing samples of the host dacites and overlying basic rocks were effective in outlining various types of primary haloes associated with the sulphide deposits. The most indicative elements are F, Pb, Zn, Cd, Cu, Ag, As and Ba; the dispersion of Hg is restricted, and the element is not a good indicator.

Quantitative evaluation of the clay (kaolinite + montmorillonite + illite-sericite)/feldspar ratio by X-ray methods is useful in detecting the presence and intensity of hydrothermal activity related to sulphide mineralization and also for estimating proximity to mineralization.

On a regional basis the mineral potential of exposed stockwork and impregnation zones can be assessed by their elemental content. Barren impregnation pyritic deposits generally report only anomalous Fe and Cu contents. Cupyrite stockworks with no associated massive sulphides are enriched in Fe, As, and Cu, whereas those accompanying massive sulphides are marked by enrichments of some or all of Fe, As, F, Cu, Pb, Zn, Ag, Cd and Mo.

#### Boyle, R.W., Wanless, R.K., and Stevens, R.D.

SULFUR ISOTOPE INVESTIGATION OF THE BARITE, MANGANESE, AND LEAD-ZINC-COPPER-SILVER DEPOSITS OF THE WALTON-CHEVERIE AREA, NOVA SCOTIA, CANADA; Econ. Geol., v. 71, p. 749-762, 1976.

The consolidated rocks underlying the Walton-Cheverie area are mainly sediments of Lower Carboniferous (Mississippian) and Triassic age. Diabase sills, probably of Triassic age, occur in one place. The Mississippian rocks consist of a lower series of terrestrial fluviatile and lacustrine sediments (Horton Group) and an upper sequence of dominantly marine sediments that include evaporites (Windsor Group). The Triassic sediments are entirely of terrestrial origin. The Mississippian rocks are intricately folded in places, and all are extensively faulted; the Triassic rocks are relatively flat lying and have been faulted in many places. The economic deposits of the area are gypsum and anhydrite in sedimentary beds and epigenetic barite and sulfide bodies.

The sulfur in the sulfates and sulfides of the country rocks and epigenetic deposits exhibits a wide range in  $\delta^{34}S$  composition, from +33.6% to -42.0%. All of the sulfates, including anhydrite and gypsum in the evaporites, barite in epigenetic deposits, and sulfate dissolved in deep circulating brines, near-surface ground waters, and sea water are enriched in  ${}^{34}S$  ( $\delta^{34}S$  range, +33.6% to +5.7%). The pyrite in argillites and shales of the Horton Bluff Formation ranges from +18.3% to -10.9% in  $\delta^{34}S$ ; in the calcareous anhydrite beds of the evaporite formation the pyrite is greatly depleted in  ${}^{34}S$  ( $\delta^{34}S = -18.4\%$ ). Pyrite in the Triassic diabase is also depleted in  ${}^{34}S$  ( $\delta^{34}S = -13.1\%$ ).

The average  $\delta^{34}$ S values for the sulfides and sulfosalts in the Magnet Cove deposit are all negative, ranging from -0.9% to -39.6%. There is a progressive decrease in <sup>34</sup>S with respect to the paragenetic sequence of minerals, the last sulfosalts and sulfides to be crystallized being significantly depleted in <sup>34</sup>S. Disseminated pyrite in certain coalified plant zones has negative  $\delta^{34}$ S values (average -39.6%) whereas that in zones devoid of plant remains has positive  $\delta^{34}$ S values (average +11.6%).

It is concluded that the large massive cryptocrystalline barite body in the Magnet Cove deposit originated mainly by replacement of bedded gypsum and anhydrite ( $Ba^{2+}$  for  $Ca^{2+}$ ) because of similarities in the isotopic composition of the sulfates in the evaporites and in the resultant barite. Other coarsely crystalline barite veins and pods appear to have been deposited from deep circulating brines. The sulfides and sulfosalts in the Magnet Cove deposit appear to have been derived from sulfate in the deep circulating brines by reduction processes, the shift in the isotopic constitution to more negative values being due to these processes which may have been partly aided by bacterial activity.

## Brown, P.A.

GEOLOGY OF THE ROSE BLANCHE, PORT AUX BASQUES, AND PART OF THE CODROY MAP SHEETS, SOUTHWEST NEWFOUNDLAND; in Report of Activities, Nfld. Dept. Mines and Energy; Report 76-1, p. 47-55, 1976.

A northeast-striking zone of mylonitisation, the Cape Ray Fault, divides southwest Newfoundland into two totally contrasting geologic terranes. The area to the south of the fault consists of well banded paragneisses and migmatites of the Port aux Basques Gneiss. To the southeast these gneisses are reworked, i.e., further deformed and metamorphosed. Two possibly equivalent sequences of supracrustal rocks, the Harbour le Cou and Bay du Nord groups, are infolded into the gneisses during this reworking. North of the fault the dominant rock type is a megacrystic granite, the Cape Ray Granite. This intrudes a tonalitic gneiss complex, the Long Range Gneiss. Mafic-ultramafic thrust sheets overlie the gneiss and granite.

The Cape Ray Fault is a zone of intense mylonitisation up to 1 km wide. The mylonitisation affects both gneiss complexes. It is, in part, overlain by a sequence of acid volcanics and conglomerates, the Windsor Point Group. Further movements on the fault mildly deform this group.

#### Cawthorn, B. and Brown, P.A.

A MODEL FOR THE FORMATION AND CRYSTALLIZA-TION OF CORUNDUM-NORMATIVE CALC-ALKALINE MAGMAS THROUGH AMPHIBOLE FRACTIONATION; J. Geol., v. 84, p. 467-476, 1976.

 $Calc-alkaline \quad intrusive \quad and \quad extrusive \quad suites \\ frequently \quad show \quad a \quad trend \quad from \quad diopside- \quad to \quad corundum$ normative with increasing SiO<sub>2</sub> which may be explained by the crystallization of hornblende from hydrous magmas. The extent to which normative corundum increases depends in part upon the Na/(Na + K) ratio of the magma. With a ratio greater than 0.6 a large compositional stability field of hornblende is developed, while for lower values mica may crystalize instead of, or as well as, hornblende. As most naturally occurring micas in granitic rocks are corundumnormative, their crystallization will buffer the increase in normative corundum in residual liquids. Garnets are present in some corundum-normative calc-alkaline intrusive and extrusive rocks, and most are thought to crystallize from highly differentiated granitic magmas under crustal pressures. A reaction relation exists once garnet begins to crystallize involving the disappearance of mica and hornblende. As a result garnet occurs in leucocratic rocks such as granites, aplites and pegmatites which are devoid of other ferromagnesian phases.

#### Brown, P.A. and Colman-Sadd, S.P.

HERMITAGE FLEXURE: FIGMENT OR FACT?; Geology, v. 4, p. 561-564, 1976.

Hermitage flexure is the name given by Williams and others to the sinusoidal trend of basement and cover rocks (the eastern crystalline belt) in south-central Newfoundland. These authors postulated that the sinusoidal nature was due to large-scale Acadian folding about a north-south axial surface, and they reiterated this conclusion in later papers. Recent work, however, has shown that the flexure is an internal feature of the eastern crystalline belt and that the curvature of the structures is an original characteristic. Thus, the Hermitage flexure was formed as part of the main Appalachian orogenic event resulting from closure of the proto-Atlantic Ocean rather than as later, large-scale folding.

# Brown, P.A.

#### OPHIOLITES IN SOUTH-WESTERN NEWFOUNDLAND; Nature, v. 264, no. 5588, p. 712-715, 1976.

Ophiolite and ophiolite-related rocks have long been recognised in northern and western Newfoundland. The presence of these rocks has, to a great extent, controlled the plate tectonic models developed for the tectonic evolution of the Newfoundland Appalachians. Such models have been extrapolated through south and south central Newfoundland with little geologic control. I describe here the ophiolites in south-western Newfoundland, discuss their relationship to a cryptic suture, the Cape Ray Fault, and evolve an independent model, which I compare with the model developed for northern and western Newfoundland.

#### Cawthorn, R.G., Strong, D.F., and Brown, P.A.

# ORIGIN OF CORUNDUM-NORMATIVE INTRUSIVE AND EXTRUSIVE MAGMAS; Nature, v. 259, p. 102-104, 1976.

Many intrusive and extrusive calc-alkaline suites show a continuous trend from diopsode-normative basic magma to corundum normative acid magmas, that is, with an increasing SiO<sub>2</sub> content there is an exceptional decrease in the Ca:Al ratio of the magma. A number of explanations have been proposed for these trends, including secondary alteration, vapour phase transfer, assimilation, crustal remelting, hydrous melting of the upper mantle and the fractional crystallisation of a variety of phases. We demonstrate here that corundum-normative magmas can be produced by the fractional crystallisation of a hornblendic amphibole from calc-alkaline magma under moderate water pressure.

#### Brown, P.A.

GEOLOGY OF THE ROSE BLANCHE MAP AREA (110/10), NEWFOUNDLAND; Nfld. Dept. Mines and Energy, Report 76-5, 16 p., 1976.

The Rose Blanche map-area, in the southwest corner of the Central Mobile Belt of Newfoundland, is underlain almost entirely by a high grade metamorphic terrane. The predominant rock type is a coarse grained, high grade, well banded gneiss, the Port aux Basques Gneiss. Other distinctive metamorphic rocks include the tonalitic Long Range Gneiss, which outcrops in the extreme northwestern part of the maparea and is separated from the Port aux Basques Gneiss by a zone of mylonitization, the Cape Ray Fault. The mylonitized zone is overlain locally by metavolcanic and metasedimentary rocks of the Windsor Point Group. In the southeastern part of the area the Port aux Basques Gneiss has been affected by later deformations which resulted in the infolding of a coverrock sequence, the Harbour le Cou Group, into the gneisses. Slates and phyllites of the Bay du Nord Group also occur in this southeastern part of the area and are possible low grade equivalents (locally containing andalusite and cordierite) of the more severely deformed and metamorphosed Harbour le Cou schists (locally sillimanite-bearing). This metamorphic terrane is intruded by six different granitic bodies as well as by pegmatites and quartz veins. The granites vary from the Precambrian pre- or syn-tectonic Port aux Basques Granite to the post-tectonic Carboniferous(?) Isle aux Morts Granite. The pegmatites both crosscut and are conformable with the gneissic banding; some are beryliferous. Quartz veins vary from thin quartz filled fractures to the 50 metre wide Diamond Cove vein. Minor arsenopyrite, sphalerite, chalcopyrite, galena, molybdenite, malachite, and azurite have been reported from some of the veins; trace gold and silver have also been reported from the Diamond Cove vein.

#### Fang, J.H., Robinson, Paul D., Starks, T.H., and Cameron, Alex

GEOSTATISTICAL EVALUATION OF SOME COAL-SEAM CHARACTERISTICS AND THEIR GEOLOGICAL IMPLI-CATIONS; Geol. Soc. Am., Abstr., v. 8, p. 860, 1976.

Kriging is a new geostatistical technique for estimation of geological variables. The method is based on the novel concept of "Regionalized Variables" (R.V.) proposed by Mathron. Kriging allows us to deduce the nature and degree of randomness (or regularity) from the sample data, and to predict the values of geological variables between sample points and mining blocks. The reliability of this method in terms of computational procedures was investigated through simulation studies. We have applied the method to coal sample data from the Pittsburgh seam in Greene County, Pennsylvania. The variograms of sulfur and ash contents, the thicknesses of the seam and the overburden exhibit the "transitive" model characteristic of the sedimentary origin. Calculated directional anisotropies may be related to stream patterns and local structural control. The environments of deposition are reflected in the roof types as well as in the sulfur and ash distribution.

The trend-surface analysis of the coal data has been carried out also to assess the relative merits of the two techniques. It appears that kriging is more advantageous because (1) it is the only technique that explicitly takes into consideration the covariance structure of the spatially distributed data, and (2) it provides a measure of the probable errors associated with estimates of geological variables at each point.

#### Cameron, A.R.

PRINCIPLES OF COAL PETROGRAPHY; Proc. Symp. Coal Evaluation, Oct. 31-Nov. 1, 1974. Alta. Res. Counc. Info. series 76, p. 51, 1976.

A brief description is given of the terminology and methods of coal petrography especially with reference to the maceral composition of coals. As examples of the differences in the physical properties of macerals, data from the literature are shown for density and reflectance. The former varies from less than 1.2 for exinite to more than 1.5 for fusinite in high volatile bituminous coals while the latter has a value of about 0.2 for exinite to over 5.0 for fusinite in coal of the same rank. As the rank of coal increases, differences for these properties diminish and eventually disappear. Corresponding changes in the hydrogén/carbon, oxygen/carbon ratios for the various macerals also are shown. As an example of the petrographic variation between seams, profiles are shown for two Kootenay Formation coal beds; one with a uniform distribution of macerals from roof to pavement, the other with increased amounts of inertinite toward the base. Increases in Hardgrove grindability indices are shown to be related to a decrease in exinite and an increase in vitrinite. Petrographic analysis of a size fraction series shows an enrichment of vitrinite in the finest fraction. The relationship of coal petrography to coke strength (stability factor) is discussed in some detail. The Schapiro and Gray method for predicting stability factors from petrography appears to be less sensitive for western Canadian coals than for Appalachian coals which may be related to the large amounts of semi-inertinite in the former. A modified stability prediction approach, using the data from a limited number of samples, incorporating elements of the Bethlehem Steel method and considering semi-inertinite as reactive, produced somewhat better correlation between predicted and actual stabilities.

#### Cameron, E.M. and Hornbrook, E.H.W.

CURRENT APPROACHES TO GEOCHEMICAL RECON-NAISSANCE FOR URANIUM IN THE CANADIAN SHIELD; Proceedings Int. Symp. Exploration of Uranium Ore Deposits, I.A.E.A./N.E.A. Vienna, 1976, p. 241-266, 1976.

Wide-interval geochemical reconnaissance is currently being carried out over large areas of the Canadian Shield by the Geological Survey of Canada. This work is in support of the federal-provincial Uranium Reconnaissance Program. The paper reviews the methodology employed for this reconnaissance to outline areas of enhanced potential for uranium and other mineral commodities. The generally low relief of the Shield virtually restricts wide-interval reconnaissance to the mobile elements that can travel some distance in solution. The high mobility of uranium, particularly in waters of neutral pH, makes it one of the most suitable types of mineralization for detection. For much of the Shield the most appropriate sampling media are lake sediments and lake waters. Centre-lake sediments are homogeneous, and are readily and economically collected utilizing helicopter support. They provide a good response for uranium and a variety of other indicator elements. Waters collected at the same sample sites are a useful supplement in the search for uranium mineralization, particularly in carbonate terrain. However, because of the very low content of uranium in many Shield waters, they present as yet unresolved problems of analysis and storage. The influence of organic material, iron and manganese on the uranium content of lake sediments are examined. Their scavenging influence has been found to be significant only at their lower concentration levels, particularly for organic matter and iron. For the majority of centre-lake samples the effect is negligible. The choice of sample interval is related to total survey costs, to speed of coverage, and to ability to detect uranium and other types of mineralization. For current G.S.C. programs a sample density of one per five square mile appears optimal. The results are presented as 1:250 000 symbol maps that are prepared largely by computer, and as 1:1 000 000 contoured compilation maps.

# Cameron, G.W., Elliott, B.E., and Richardson, K.A.

EFFECTS OF LINE SPACING ON CONTOURED AIR-BORNE GAMMA-RAY SPECTROMETRY DATA; Proc. Symp. Explor. of Uranium Ore Deposits, I.A.E.A./N.A.E., Vienna, 1976.

A reconnaissance airborne gamma-ray spectrometer survey is usually designed to show the regional surface radioelement distribution pattern and locate broad areas of uranium enrichment. Perhaps the most important parameter to consider for this type of survey is the flight line spacing which will give the desired information most economically.

Airborne gamma-ray spectrometry data of equivalent uranium distribution have been computer contoured into maps to qualitatively illustrate the effect of varying the flight line spacing between 400 metres and 5 kilometres. Data for two coincident surveys with perpendicular flight line directions were also computer contoured. The results demonstrate that reconnaissance survey data, with line spacing as wide as 5.0 km can be contoured to show regional radioelement distribution patterns over the Canadian Precambrian Shield. This line spacing has been adopted for the airborne gamma-ray spectrometric part of Canada's Uranium Reconnaissance Program, a 10-year program designed to collect systematic reconnaissance data for much of Canada.

# Charbonneau, B.W., Killeen, P.G., Carson, J.M., Cameron, G.W., and Richardson, K.A.

THE SIGNIFICANCE OF RADIOELEMENT CONCENTRA-TION MEASUREMENTS MADE BY AIRBORNE GAMMA-RAY SPECTROMETRY OVER THE CANADIAN SHIELD; Proc. Symp. Explor. of Uranium Ore Deposits; I.A.E.A./N.A.E., Vienna, 1976.

Results of airborne gamma-ray spectrometer surveys conducted by the Geological Survey of Canada are presented as maps contoured in units of radioelement concentration and concentration ratios. These contoured values represent the average surface concentrations of the radioelements over areas on the order of several square kilometres. The relationship between this "average surface concentration" and the radioelement concentration in bedrock underlying the area depends on: (1) the percentage of outcrop; (2) the relation between overburden and bedrock radioelement concentration; (3) percentage of marshland or surface water in the area; (4) soil moisture; and (5) density of vegetation. More than 2500 portable gamma-ray spectrometer analyses of outcrop and overburden have been made in the Bancroft, Elliot Lake and Fort Smith areas of the Canadian Precambrian Shield. In the areas examined, the radioelement concentrations in glacial drift reflect the concentrations in the underlying bedrock. Rocks with near-crustal average contents of thorium, uranium and potassium are overlain by glacial drift having approximately the same concentrations. As the concentration in bedrock increases, the concentration in the local overburden also increases, but not to the same extent.

In addition, in situ gamma-ray spectrometry measurements were made at almost 1000 stations within the area of airborne surveys near Mont Laurier and Elliot Lake. These ground measurements were compared with the airborne measurements by averaging the values for all of those ground stations located in the areas between each contour level on airborne maps. Radioelement concentrations in bedrock are considerably higher than corresponding airborne measurements, and this difference between bedrock and airborne values increases at higher radioelement concentrations. Radioelement concentrations in glacial drift are only slightly higher than airborne contour values for the same area. Airborne contour maps of the radioelement ratios give values that are similar to the ratios determined by ground measurements on overburden and outcrop.

#### Collett, L.S.

FUTURE TRENDS IN GEOPHYSICAL MINERAL EXPLORATION; Chap. 12 in World Mineral Supplies, Assessment and Perspective; Elsevier, 1976.

# Poliscuk, V.E. and Cumming, L.M.

GEOLOGY OF THE STRAIT OF BELLE ISLE TUNNEL PROJECT; Can. Min. Metall. Bull., v. 70, p. 82, 1977.

The regional geological setting of the Strait of Belle Isle between Newfoundland and Labrador is that of the margin of a Lower Paleozoic sedimentary basin which is underlain unconformably by Precambrian granitic rocks. The on-shore areas along the Strait have recently been mapped, on the scale 1 inch to 2 miles, by the Geological Survey of Canada.

A detailed seismic reflection survey of the off-shore area, in the narrowest part of the Strait, has revealed 14 normal faults within a distance of 11 miles. These faults show displacements from 50 to 250 feet of the Precambrian surface and the overlying Bradore, Forteau and Hawke Bay formations. These faults trend northeast and are parallel to a regional system of joints. This faulting represents minor displacements at the margin of a sedimentary basin which occurs within a relatively stable area of the continental crust.

Diamond drilling has shown that the surface of the Precambrian-Paleozoic unconformity occurs at a depth of 1547 feet beneath the Newfoundland coast near Flowers Cove. This unconformity is well exposed along the Labrador coast. A proposed 11-mile tunnel beneath the Strait would carry hydroelectric cables for transmission of power from Gull Island, Labrador, to link up with the present Newfoundland power grid. The tunnel would be entered by deep shafts near the Newfoundland and Labrador coasts, at Yankee Point and Pointe Amour respectively.

# Darnley, A.G.

#### THE ADVANTAGES OF STANDARDIZING RADIO-METRIC EXPLORATION MEASUREMENTS, AND HOW TO DO IT; Can. Min. Metall. Bull., v. 70, p. 91-95, 1977.

The fact that there are standard units of mass, distance and time is taken for granted. It is also accepted that the type of instrument used to measure one of these

parameters is irrelevant to the way the measurement is reported. Some geophysical parameters, for example magnetic field strength and gravity, have generally accepted units, the gamma and milligal, which are defined in SI terms. These units are used irrespective of the equipment used to measure them. By contrast, the situation for the measurement of natural radioactivity is, in practice, confused, unsatisfactory and not conducive to efficient exploration. There are at least six different ways of reporting measurements of radioactivity made with different designs of field scintillation counters, and several of these are specific to the particular instrument on which a measurement is made. With gamma-ray spectrometry, the problem is theoretically simpler because the reason for using a spectrometer is to distinguish radioactivity caused by potassium, uranium and thorium. Most instrumentation now on the market is suitable for calibration, so that it is guite possible to report results in terms of the concentration of each of these elements. Unfortunately, this is not done as generally as might be supposed.

The adoption of common measuring units, and standardization of instrumentation to read in terms of these units, has many advantages. Measurements are no longer purely relative, with a limited basis for comparison. Measurements can be gathered in different places at different times with different instruments, and compared systematically. Meaningful compilations can be made. Instrument sensitivities can be established, and malfunctions recognized more readily. There can be greater confidence in identifying small, but possibly significant, differences in the radioactivity of individual lithologies. These benefits can apply equally to ground, airborne and borehole measurements A Consultants Committee of the of radioactivity. International Atomic Energy Agency has recently prepared recommendations on Reporting Methods and Calibration in Uranium Exploration, including the definition of a new unit for the measurement of total (undiscriminated) radioactivity, and procedures for the calibration of all types of ground, airborne and borehole equipment used for the measurement of natural gamma radiation. In part, these procedures follow those already established by the Geological Survey of Canada. Under its new Uranium Program, it is the intention of the Geological Survey to complete, in the near future, the variety of facilities required to permit the implementation of the IAEA recommendations, and to provide as much assistance as possible to encourage their general adoption in Canada.

#### Darnley, A.G.

THE CANADIAN URANIUM RECONNAISSANCE PROGRAM; Int. Conf. World Nuclear Energy – A Status Report; Am. Nuc. Soc. Trans., v. 24, p. 113-114, 1976.

The nuclear power industry, until such time as either breeder or fusion reactors come into service, is dependent on an adequate supply of uranium. The projected growth rate of the industry is such that well before the end of the century uranium demand must be met from reserves as yet undiscovered. There is general concern about the long-term shortage of petroleum, but, in fact, future sources of supply for this commodity are known with considerably greater certainty than is the case for uranium. Most authorities are of the opinion that the world-wide prospects for the future discovery of large supplies of uranium are good, but nobody can be sure where or when they will be discovered, nor what problems may have to be overcome to exploit them. In view of the essential nature of the commodity, and the dire consequences if predictions of future discoveries are not fulfilled, it is understandable that many governments should be taking steps to encourage and facilitate exploration for uranium. Unless the combined efforts of government and industry in the search for new uranium deposits have more success than the average mineral exploration program, many of the problems now being discussed in connection with future

plans for fission power stations may turn out to be of only academic interest. For this reason, all concerned with the nuclear power industry should maintain a keen interest in the steps being taken to ensure adequate uranium supplies.

The Canadian Uranium Reconnaissance Program, which is funded by the Federal and Provincial governments, has the objectives of providing the mineral industry with high-quality reconnaissance data to indicate those areas of Canada where there is the greatest probability of finding new uranium deposits, and of providing government with nationally consistent systematic data to serve as a base for uranium resource appraisal. By ensuring that data are gathered to high and known standards and are rapidly released after collection, the program is thorough and avoids unnecessary duplication of effort. The approach taken rests on the concept that most of the known uranium deposits in the world occur within, or marginal to regions of the crust containing higher than average amounts of uranium.

The Geological Survey of Canada, which is a branch of the Federal Department of Energy, Mines and Resources, has progressively developed and tested the methods used under Canadian conditions over the past ten years. This work made it possible to provide detailed specifications for work to be performed by contractors. The administrative details of the program owe much to the Canadian Federal-Provincial Aeromagnetic Program which began fifteen years ago.

The principal methods being used for the Uranium Reconnaissance Program are:

1. gamma-ray spectrometry of the land surface, undertaken from an aircraft

2. direct sampling of lake sediments and lake water, using a helicopter for the collection process, with subsequent neutron activation analysis for uranium determination

3. direct sampling of stream sediments and waters for laboratory analysis

4. sampling of water in subsurface aquifers, either from wells or springs.

The methods listed above are those currently in use. However, with the exception of method 4, they are all essentially surface reconnaissance methods. While these are expected to provide useful information over perhaps 66% of Canada's land area, they are not effective in regions where uraniferous rocks are buried beneath genetically unrelated rocks. For areas where there is the possibility of finding deeply buried uranium deposits, more general nonspecific methods of mineral exploration, which respond to some feature associated with the mineralization itself, must be used.

A small but important aspect of the Uranium Reconnaissance Program is the provision of facilities for the standardization and calibration of radiometric measurements. Past exploration work has entailed measurements of a qualitative or, at best, semiquantitative type, which has prevented the compilation and comparison of results obtained in different places at different times. The Geological Survey of Canada is encouraging the exploration fraternity to adopt the recommendations recently published by the International Atomic Energy Agency relating to radiometric standards and calibration, and is providing the physical facilities to enable this to be done. These are available for airborne and ground radiometric equipment and are under construction for borehole equipment.

While government can provide a sound framework from which to start, the detailed work that must follow on the reconnaissance stage of exploration is the responsibility of the mining industry.

# Davidson, A. and McGregor, D.C.

# PALYNOMORPHS INDICATING PERMIAN ROCKS IN ETHIOPIA; Nature, v. 262, p. 371-373, 1976.

Miospores from Karroo strata of Ethiopia provide the first paleontological substantiation of Permian rocks in that country. The fossils occur in the otherwise unfossiliferous Kari and Gilo sandstones of Kefa and Ilubabor provinces, southwestern Ethiopia. It seems likely that much of the apparently thick sedimentary succession mapped as Adigrat Sandstone in western central Ethiopia also may be of Karroo age, rather than Jurassic.

#### Davis, J.L., Scott, W.J., Morey, R.M., and Annan, A.P.

IMPULSE RADAR EXPERIMENTS ON PERMAFROST NEAR TUKTOYAKTUK, NORTHWEST TERRITORIES; Can. J. Earth Sci., v. 13, p. 1584-1590, 1976.

Field trials with a VHF impulse radar have been undertaken in the Tuktoyaktuk, N.W.T. area during the summer of 1973 and the spring seasons of 1974 and 1975. The radar transmits a wavelet with a centre frequency of 110 MHz and a pulse duration of 18 ns. Separate transmitter and receiver antennas were used.

Preliminary interpretation of the data obtained at the Involuted Hill test site indicates that ice/sand interfaces were detected to ranges greater than 30 m. In icy sand, ice lenses separated by 3 m were resolved. Clay-till/ice interfaces were not detected at ranges greater than about 3 m. At other sites near the village of Tuktoyaktuk, sand/clay-till interfaces were detected at ranges greater than 5 m.

Wide angle reflection and refraction sounding yields estimates of reflector depths and propagation velocities. Radar has proven useful in delineating geologic structure, but bore-hole control is required for identification of the geological composition of the structure.

#### Dredge, L.A. and Thom, B.G.

DEVELOPMENT OF A GULLY-FLOW NEAR SEPT-ILES, QUEBEC; Can. J. Earth Sci., v. 13, p. 1145-1151, 1976.

A gully system 2 1/2 km long and 30 m deep has developed on terraces adjacent to the Moisie River, Quebec, in a catastrophic manner following two periods of heavy rainfall. Raised postglacial deltaic sands and silts in which the gully developed were initially deposited in a loose to medium-dense state, and failed by spontaneous liquefaction in 1959 and 1966. Although liquefaction of the sands explains the mechanism of failure, it does not account for the pattern that ensued. The reticulated gully pattern is attributed to piping, which was enhanced by a network of lumber tracks covering the surface of the old delta. This is the first recorded example of sub-aerial gullying induced by catastrophic mass movement in sandy sediments. The location and recurrent development of this gully phenomenon is especially significant since the only road linking the settlements of the Quebec North Shore bridges the Moisie River at this site.

#### Duke, J.M.

DISTRIBUTION OF THE PERIOD FOUR TRANSITION ELEMENTS AMONG OLIVINE, CALCIC CLINO-PYROXENE AND MAFIC SILICATE LIQUID: EXPERI-MENTAL RESULTS; J. Petrol., v. 17, pt. 4, p. 499-521, 1976.

The distribution of  $Ti^{+}$ ,  $V^{3+}$ ,  $Cr^{3+}$ ,  $Mn^{2+}$ , Fe(total),  $Co_2^+$  and  $Ni^{2+}$  among synthetic olivine, calcic clinopyroxene and mafic silicate liquid has been studied between 1125 and 1250°C under anhydrous conditions at 1 bar total pressure. The distribution of iron and magnesium among the three phases was concluded to be independent of temperature and may be described by the two equations

$$\frac{(x^{O})}{\log \frac{Fe}{(x^{O^{T}})}} = 0.198 + 1.30 \log \frac{(x^{Cpx}_{Fe})}{(x^{Cpx}_{Mg})}$$
$$\frac{\log \frac{(x^{Cpx}_{Fe})}{(x^{Cpx}_{Fe})}}{(x^{Cpx}_{Mg})} = -0.564 + 0.755 \log \frac{(x^{L}_{Fe})}{(x^{L}_{Mg})}$$

Titanium and vanadium did not enter olivine in significant amounts. The mean value of the ratio (wt. per cent TiO<sub>2</sub> in Cpx)/(wt. per cent TiO2 in L) was 0.29±0.04 for assemblages in which the liquid had both olivine and hypersthene in the norm but the ratio was greater if the liquid was nepheline normative. Vanadium was concentrated in the pyroxene in some experiments and in the liquid in others, but it was not possible to conclude whether the change in distribution behavior was due to varying temperature or changing liquid composition. Equilibrium partitioning of chromium was not achieved but the results indicate that Cr2O3 was most strongly enriched in clinopyroxene and showed a slight preference for olivine over the liquid. The divalent transition elements were each enriched in olivine relative to clinopyroxene and the degree of enrichment increased in the order predicted by crystal field theory. The mean (wt. per cent oxide in 01)/(wt. per cent oxide in Cpx) ratios were 2.0 for MnO, 2.4 for FeO, 3.9 for CoO and 5.6 for NiO. Manganese was enriched in olivine relative to the liquid and in the liquid relative to the clinopyroxene. Cobalt and nickel were more concentrated in the crystalline phases than in the liquid but the degree of enrichment was markedly less in the experiments in which the liquids were more mafic.

#### Duke, J.M. and Naldrett, A.J.

SULFIDE MINERALOGY OF THE MAIN IRRUPTIVE, SUDBURY, ONTARIO; Can. Mineral., v. 14, p. 450-461, 1976.

Sulfide minerals occur in most rocks of the Main Irruptive but usually constitute less than 0.5 modal per cent. Two textural categories of sulfide occurrence are recognized: 1) magmatic and 2) deuteric or metamorphic. The magmatic sulfide grains are polymineralic and occur interstitially to primary silicate minerals whereas the deuteric or metamorphic sulfides are typically monomineralic grains which are localized in microfractures or are intergrown with secondary silicate minerals. Magmatic sulfides are virtually restricted to the lower units of the Main Irruptive (i.e., the Mafic, Quartz-rich and South Range Norites) but secondary sulfides occur in all units. The magmatic grains typically comprise the assemblage monoclinic pyrrhotite+chalcopyrite ± pentlandite ± pyrite ± magnetite, but most of the pyrite and magnetite in these grains was produced by the secondary alteration of primary pyrrhotite. The chalcopyrite/pentlandite and cobalt/nickel ratios of the magmatic sulfide grains in the Main Irruptive are higher than those characteristic of the Sudbury ores suggesting that the ores segregated from, or at least equilibrated with, a less differentiated magma than that which formed the exposed portion of the Main Irruptive. The solubility of sulfur in the Main Irruptive magma is estimated to be about 600 ppm at 1200°C and it is concluded that the magma was either saturated or slightly undersaturated with sulfur at the time of emplacement.

#### Duke, J.M. and Naldrett, A.J.

ACTIVITY OF NICKEL OXIDE IN SOME SILICATE MELTS; Geol. Assoc. Can./Mineral. Assoc. Can., Abstr., v. 2, p. 16, 1977.

Activity coefficients of NiO dissolved in silicate melts have been calculated from olivine/melt partition

coefficients for Ni which have been determined experimentally or measured in natural phenocryst-groundmass assemblages. NiO, referred to the pure solid standard state, exhibits marked positive deviations from ideal behaviour with the degree of nonideality being greater in less mafic melts. Thus activity coefficients are inferred to be about 2 to 3 in ultramafic (komatiitic) melts, 5 to 15 in basalts and greater than 15 in andesitic liquids. Activity coefficients of NiO in four molten natural igneous rocks have been determined by equilibrating the melts with metallic Ni at 1190°C, log  $f(O_2)$ = -10.4 and 1 atm. total pressure. These experiments yielded activity coefficients of 8 for a basalt, 12 for an andesite, 22 for a dacite, and 28 for a rhyolite.

#### Dyck, W., Jonasson, I.R., and Liard, R.F.

URANIUM PROSPECTING WITH <sup>222</sup>Rn IN FROZEN TER-RAIN; J. Geochem. Explor., v. 5, p. 115-127, 1976.

Published reports show that <sup>222</sup>Rn contents of soil gas can increase under snow-covered or frozen soils. By utilizing these observations and results of field tests described here, it can be stated that U prospecting with <sup>222</sup>Rn in frozen terrain is practicable.

Rn profiles in frozen and snow-covered soils over U mineralization in the Bancroft area of Ontario outlined known radioactive zones more clearly than did scintillometer profiles.

Tests in Gatineau Park, Quebec, in the proximity of a radioactive pegmatite dike showed that lake ice acts as a restrictive barrier to Rn movement from lake waters beneath. Water samples, collected and allowed to freeze in plastic bottles, retained dissolved Rn quite effectively thus permitting sample collection and storage under the most severe winter conditions. Rn sampling of through-ice lake waters is therefore a feasible prospecting tool.

Samples of spring run-off (snow-melt) waters and slushy snow collected from within a known weakly radioactive zone near South March, Ontario, were shown to contain less Rn than found in the same stream waters in the summer. No pronounced Rn degassing event of frozen soils was apparent early in the spring thaw in percolating run-off waters draining from the zone. The usefulness of spring thaw hydrogeochemistry using Rn is discussed.

**Dyck, W.**, Chatterjee, A.K., Gemmell, D.E., and Murricane, K.

WELL WATER TRACE ELEMENT RECONNAISSANCE, EASTERN MARITIME CANADA; J. Geochem. Explor., v. 6, p. 139-162, 1976.

A geochemical survey involving the collection and analysis of about 2000 well water samples from an area of roughly 25,000 km<sup>2</sup> was carried out during the 1975 field season over parts of the Carboniferous basin of eastern Canada. This report describes the results of 1721 regional well sites. Three samples of water were collected from each site and analyzed in four different laboratories for twenty constituents. The distribution and relationships of U, Rn, He, F, CH<sub>4</sub>, Zn, Cu, Pb, Mn, Fe, pH, suspended matter, depth of well, conductivity and alkalinity are described.

The elements U, Rn, He, F, along with conductivity and alkalinity, show systematic regional patterns indicating broad regional belts of element enrichment which are being leached by circulating groundwaters. The close spatial association of these elements over many tens of miles suggests chemical reaction cells or fronts similar to those observed in the uranium mining districts of Colorado and Wyoming in the United States and elsewhere. Their relatively weak character suggests an intermediate cycle in the cyclic enrichment hypothesis believed to be responsible for the formation of epigenetic uranium ore deposits. The heavy elements Zn, Cu, Pb, Mn, and Fe show positive correlation with each other but their spatial distribution is more spotty than that of the uranium elements. Broadly speaking the anomalies of these elements cluster mainly on the southern border of the survey area. Most of the anomalies can be explained in terms of known mineral occurrences.

The most prominent  $CH_4$  anomaly is located south of Moncton and is believed to be due to the old St. Josephs gas and oil field. Several weaker  $CH_4$  anomalies are probably generated by swamps and peat bogs.

# Dyck, Willy

THE USE OF HELIUM IN MINERAL EXPLORATION; J. Geochem. Explor., v. 5, p. 3-20, 1976.

A literature review of the source and occurrence of helium shows that it can, under favorable conditions, lead to the discovery of radioactive ore deposits, oil and gas pools, and fracture zones associated with mineral occurrences.

Analytical results show that anomalous helium is present in groundwaters and near uranium occurrences and thus can aid in the identification of uranium occurrences or prospective target areas for uranium exploration.

# Eisbacher, G.H.

SEDIMENTOLOGY OF THE DEZADEASH FLYSCH AND ITS IMPLICATIONS FOR STRIKE-SLIP FAULTING ALONG THE DEANLI FAULT, YUKON TERRITORY AND ALASKA; Can. J. Earth Sci., v. 13, p. 1495-1513, 1976.

The Dezadeash Formation of Late Jurassic-Early Cretaceous age is a flysch sequence with a thickness of about 3000 m. It consists of turbidites, mass-flow deposits, and argillite. Most of the formation was deposited on a deep-sea fan system fed by an uplifted volcanogenic terrane to the west. Along its western border, the Dezadeash flysch is truncated by the Denali Fault; towards the east, part of the Dezadeash Formation seems to have been metamorphosed into the Kluane Schist.

It is suggested that both the Dezadeash flysch and Kluane Schist have been torn apart by the Denali Fault and that equivalent rock units are found within the Nutzotin Mountains Sequence and the McLaren Metamorphic Belt of Alaska. A dextral displacement of 300 km could account for the present distribution of these units along the Denali Fault. This offset was probably achieved during mid-Tertiary time.

# Frebold, Hans and Poulton, T.P.

HETTANGIAN (LOWER JURASSIC) ROCKS AND FAUNAS, NORTHERN YUKON TERRITORY; Can. J. Earth sci., v. 14, p. 89-101, 1977.

The Lower Jurassic Hettangian Stage is documented with certainty for the first time in the Canadian Arctic. It is represented by a basal Jurassic sandstone unit in the Bonnet Lake area of northern Yukon Territory. The two subzones of the Early Hettangian Planorbis Zone, i.e., the Planorbis Subzone and the Johnstoni Subzone, are indicated by poorly preserved Psiloceras sp. indet. and Psiloceras (Caloceras) cf. P. (C.) johnstoni (J. de C. Sowerby), respectively. The varied but poorly preserved bivalve fauna associated with P. (C.) cf. P. (C.) johnstoni includes Prosogyrotrigonia (?) sp. cf. P. inouyei (Yehara), Cardinia sp. cf. C. hybrida (J. Sowerby), C. sp. aff. C. concinna (J. Sowerby), Pleuromya(?) sp., Meleagrinella (?) sp., Oxytoma (Oxytoma) sp., and Parallelodon (?) sp. The bivalves closely resemble approximately coeval forms described from Japan. The abovementioned faunas are figured as is a specimen of Psiloceras cf. P. erugatum (Phillips), which was previously described from the Hettangian of southern Yukon. Other occurrences of the Hettangian in Canada and Alaska are reviewed.

# Rutter, N.W., Foscolos, A.E., and Hughes, O.L.

CLIMATIC TRENDS DURING THE QUATERNARY IN CENTRAL YUKON BASED UPON PEDOLOGICAL AND GEOMORPHOLOGICAL EVIDENCE; in Proc. Quat. Soils Symp., W.C. Mahaney, ed.

Soils and paleosols were investigated from pre-Reid (early Pleistocene), Reid (Illinoian or early Wisconsinan) and McConnell (classical Wisconsinan) surfaces in central Yukon. Paleosols on the pre-Reid surface indicate that it was subjected to two distinct climates, an initial one which was warm and subhumid with grassland-shrub vegetation and later a more temperate and humid climate characterized by the development of a Luvisol with a red, textural B horizon, in places over 190 cm (75 in.) thick. Subsequently, the climate became colder, resulting in the Reid glaciation. Thermal contraction cracks developed in the pre-Reid deposits beyond the limit of Reid glaciation and were filled with eolian sand, as well as minor silt and clay, to form sand wedges. During the subsequent Reid-McConnell interglacial, a cool, subhumid climate prevailed as evidenced by the Brunisolic characteristics of paleosols on deposits of Reid age. This was followed by a cold period which climaxed with the advent of the McConnell glaciation. Sand wedges also formed in the deposits of the Reid glaciation; the wedges are shallower and narrower than those on the pre-Reid surface, suggesting a shorter cold period. During retreatal stages of the McConnell glaciation, a thin blanket of loess was deposited over McConnell, Reid and pre-Reid surfaces, covering the soils on the Reid and pre-Reid surfaces during post-glacial (holocene) time. Finally, Brunisolic soils developed on the loess blanket and, locally, where the loess is very thin or lacking, on deposits of McConnell age.

# Foscolos, A.E., Powell, T.G., and Gunther, P.R.

CLASSIFICATION OF DIAGENESIS BASED ON MINERALOGICAL, INORGANIC AND ORGANIC GEO-CHEMICAL INDICATORS; Abstr. 29th Meeting Geol. Assoc. Can., 21st Meeting Mineral. Assoc. Can., Edmonton.

In this presentation geochemical and mineralogical changes of argillaceous sediments upon burial from Lower Cretaceous shales from northeast British Columbia, Tertiary rocks of the Mackenzie Delta and Mesozoic and Upper Paleozoic rocks of the Sverdrup Basin are discussed. These changes and the significance of their use for assessing the oil generating potential of clay-rich sedimentary rocks has been put forward.

# Foscolos, A.E., Powell, T.G., and Gunther, P.R.

THE USE OF CLAY MINERALS AND INORGANIC AND ORGANIC GEOCHEMICAL INDICATORS FOR EVALU-ATING THE DEGREE OF DIAGENESIS AND OIL GENERATING POTENTIAL OF SHALES; Geochim. Cosmochim. Acta, v. 40, p. 953-966, 1976.

A detailed geochemical study has been made on clay minerals and organic matter from two stratigraphic sequences (Sully-Lepine Series and Buckinghorse Formation) in Lower Cretaceous shales from northeastern British Columbia. The characteristics of the discrete illites, mineralogy and chemistry of the mixed layer clays, organic extract yields and kerogen composition indicate that little diagenesis has occurred in the Sully-Lepine Series whereas extensive diagenesis verging on the anchizone of metamorphism has occurred in the Buckinghorse Formation.

On the basis of this study and the results of other workers, a preliminary classification of diagenesis is proposed. Diagenesis is divided into three stages: eodiagenesis (early), mesodiagenesis (middle) and telodiagenesis (late). The mesodiagenesis stage is divided into two sub-stages. Eodiagenesis corresponds to the zone in which pore water is lost from the shales, little hydrocarbon generation occurs and coals are of lignitous or sub-bituminous types. Mesodiagenesis corresponds to the main phase of oil genesis and coals are of the high volatile to low volatile bituminous type. The first stage of clay dehydration occurs during early mesodiagenesis and the second stage of clay dehydration occurs in late mesodiagenesis. During telodiagenesis, extensive cracking of the organic matter occurs; dry gas is the main hydrocarbon product and coals fall in the semi-anthracite range.

The preliminary classification has been applied to the Lower Cretaceous shales used in this study. The Sully-Lepine Series falls in the eodiagenesis and early mesodiagenesis zones whereas in the Buckinghorse Formation the diagenetic zones range from early mesodiagenesis to telodiagenesis.

Froese, Edgar and Gunter, Avril E.

A NOTE ON THE PYRRHOTITE-SULFUR VAPOR EQUI-LIBRIUM; Econ. Geol., v. 71, p. 1589-1594, 1976.

In the temperature range 600°C to 900°C, the activity coefficients of FeS and S in pyrrhotite may be expressed in terms of a two-constant Margules solution model, with a linear temperature dependence of the excess partial molar free energy at infinite dilution of the two components. The pyrrhotite solid solution exhibits no measurable excess volume of mixing; for this reason, the activity coefficients are independent of pressure. This fact and the simple form of the activity coefficients facilitate the calculation of equilibria involving pyrrhotite at pressures other than one atmosphere.

# Fulton, R.J.

QUATERNARY HISTORY SOUTH-CENTRAL BRITISH COLUMBIA AND CORRELATIONS WITH ADJACENT AREAS; UNESCO Int. Geol. Corr. Prog., Proj. 73-1-24, rep. 3, 1976.

Two nonglacial periods and two glacial periods are recognized in the Quaternary record of south-central British Columbia. The deposits of the oldest nonglacial period are referred to as Westwold sediments and the period during which they were laid down is named the Westwold Interglaciation. This unit is correlated with Puyallup Interglaciation of the Puget Lowland of Washington and the Sangamon Interglaciation of central North America. The oldest glacial deposit, the Okanagan Centre Drift, was deposited during the Okanagan Centre Glaciation, correlated with the Salmon Springs Glaciation of the Puget Lowland and corresponding to the Early Wisconsinan of the Great Lakes -St. Lawrence Valley region. Bessette sediments were deposited during the last nonglacial period, the Olympia Interglaciation. These sediments have radiocarbon dates ranging from 43 000 to 19 100 and hence are correlated with the Middle Wisconsinan of the Great Lakes - St. Lawrence Valley region. Deposits of the last glaciation, the Fraser, are referred to as Kamloops Lake Drift. Parts of south-central British Columbia remained ice free until 19 100 years ago. Deglaciation had begun by 11 000 BP.

The Middle Wisconsinan nonglacial period appears to have been a time during which the Cordilleran Ice Sheet disappeared and Laurentide ice retreated well to the east of its Wisconsin limits. Radiocarbon dates from various parts of western Canada indicate that this nonglacial period began more than 43 800 years ago and lasted until after 25 000 BP.

The extent of Cordilleran and Laurentide ice has varied from glaciation to glaciation. In general where the two sheets have overlapped, the Cordilleran ice reached its maximum and had retreated before the Laurentide reached its limit. During the last glaciation the two ice sheets did not meet in southern Alberta but they probably coalesced in the Athabasca and Peace River Valley areas.

# Gabrielse, H.

ENVIRONMENTS OF CANADIAN CORDILLERA DEPO-SITIONAL BASINS; Am. Assoc. Pet. Geol., Mem. 25, p. 492, 1976.

The stratigraphy of the Canadian Cordillera can be interpreted in terms of stratigraphic assemblages that are unique in distribution, gross lithology, and lateral facies variations. Models of depositional basins in which these assemblages accumulated are essential in exploration for mineral deposits whose distribution is controlled by stratigraphy.

Proterozoic and lower Paleozoic strata in the Cordillera make up an assemblage of clastic and carbonate rocks with minor volcanic rocks. The assemblage appears to represent a continental terrace wedge built along the margin of an earlier Precambrian continent. All units show a distinct polarity of facies distribution and thickness relative to the source area. This assemblage contains most of the known stratiform mineral deposits of gypsum, iron, copper, zinc, and lead in the Cordillera.

The distinctive elements of an Upper Devonian and Lower Mississippian assemblage suggest, at least in the northern Cordillera, the presence of a foredeep and related source areas to the west and northwest. In the southern and eastern parts of the Cordillera, however, the rocks reflect a continuing shelf-platform environment linked to the craton. The mineral potential of these rocks has been considered low, but it needs further study in view of an important zinc-lead deposit in the eastern Selwyn basin.

Distinctive rocks of oceanic character, ranging in age from Mississippian to Middle Triassic, underlie parts of the Cordilleran intermontane belt. They contain asbestos, gold, and some copper in the northern Cordillera, and copper, lead, and zinc on Vancouver Island. However, in general, mineral discoveries, other than those in ultramafic rocks, have been few. In the eastern Cordillera, a shelf environment prevailed.

The association of copper with Late Triassic and Early Jurassic volcanic rocks is well known. The volcanic deposits, together with spatially and temporally associated plutons, are thought to outline a system of evolving island arcs probably roughly coincident with the mapped distribution of these rocks. Between the arcs and the craton, strata were deposited in a marginal basin with little or no evidence of the volcanism that occurred farther west.

The remaining stratigraphic units, ranging in age from Early Jurassic to Cenozoic, are described as successorbasin and foredeep assemblages whose distribution and lithology reflect a close relation to bounding uplifts of metamorphic and plutonic terranes. Because they are a latestage phenomenon in the evolution of the Cordillera, these assemblages have potential for a variety of placer deposits. They also contain all of the known coal reserves of the region.

#### Gadd, N.R.

QUATERNARY STRATIGRAPHY IN SOUTHERN QUEBEC; in Quaternary Stratigraphy of North America; Dowden, Hutchinson and Ross, Inc., Stroudsburg, Pa., U.S.A., p. 37-50, 1976.

Quaternary stratigraphy of the central part of the St. Lawrence Lowland is based on relatively few rockstratigraphic units. The earliest known glaciation is represented by Bécancour Till and its associated varved sediments; collectively these are identified as "early Wisconsin (or older)". The following nonglacial interval is represented by St. Pierre fluvial sand and silt and woody peat beds; the sequence is in erosional contact with underlying Bécancour Till. Radiocarbon datings on peat and wood from the St. Pierre peat beds - >50 000 BP (GSC-1927); 66 500 ± 1600 BP GrN-1711; 65 700 ± 1300 BP GrN-1799 - are interpreted as early Wisconsin (or older?). The end of the St. Pierre Interval is indicated both by a cooling trend in the pollen spectra and by a conformable contact with overlying glacial lake sediments. Glacial Lake Deschaillons, presumably produced by glacial blockage of the St. Lawrence Valley, is the first phase of the main Wisconsin Glaciation of the Lowland. Deschaillons varved sediments were overridden and the uppermost strata were disturbed by the ice that deposited Gentilly Till. The ice remained in the Lowland throughout most of the Wisconsin. Termination of this glaciation is marked by probable expansion of glacial lakes from the Lake Champlain basin into the St. Lawrence Lowland and by the incursion of Champlain Sea. Evidence is contained in sedimentary sequences in which varve-like laminated sediment overlying Gentilly Till grades upwards into fossiliferous strata, both laminated and massive, of Champlain Sea sediments. The time of deglaciation of the St. Lawrence Lowland is gauged by the age of fossil shells in Champlain Sea whose datings, in areas as far west as the Ottawa Valley, range as high as 12 800 ± 220 BP (GSC-1859). A St. Narcisse phase of the Gentilly glacial episode is contemporaneous in part with Champlain Sea. A minimum age for the termination of Champlain Sea in the Ottawa Valley, 10 200 ± 90 BP (GSC-1968), is established by datings on freshwater clams in channel deposits inset in Champlain Sea clay.

Whereas two main glacial events characterize the Wisconsin in the Central Lowland, three glacial events represent the same time interval in the Appalachian areas of southern Quebec. Johnville Till, the representative of the earliest clearly identified glaciation, tentatively is correlated with Bécancour Till of the central Lowland. A nonglacial interval that occurred >54 000 BP (Y-1683) is represented by the Massawippi Formation, which is correlated with the St. Pierre Interval. The Massawippi Interval is followed by a three-unit sequence - Chaudière Till, Gayhurst Formation (lake sediments >20 000 BP (GSC-1137)), Lennoxville Till which is considered to correspond to the deposition of Gentilly Till in the Lowland. Reversal of flow, recorded by miniature crag-and-tail features, striations, and by distribution of boulders, heavy minerals, and some till is a feature of the late phase of Gentilly-Lennoxville Glaciation. Post-Lennoxville events of southernmost Quebec are of the same relative age as Champlain Sea and younger phenomena of the Lowland.

# Gadd, N.R.

GEOLOGY OF LEDA CLAY; in Yatsu, E., Ward, A.J., and Adams, F.: Mass Wasting; Proc. 4th Guelph Symp. on Geomorphology, Geo. Abstracts Ltd., Univ. East Anglia, Norwich, NR4 7TJ, England, p. 137-151, 1976.

In the sequence of events during deglaciation of the St. Lawrence drainage system the first marine submergence occurred along the southern part of the Gulf of St. Lawrence, in the Lake Champlain lowlands and the Ottawa valley. The ice margin fluctuated in the sea over a period of two thousand years before finally retreating northward. Then these regions were uplifted and there was a transition to fresh-water conditions some 10 000 years ago. Only at this time the basin of Lac St-Jean and the north shore of the Gulf of St. Lawrence became ice-free and subject to marine invasion. Following marine submergence Lac St-Jean basin also reverted to fresh-water conditions. In contrast, however, the north shore and Gulf areas east of Quebec city have always been and remain essentially a saltwater environment.

The area of deposition of Leda Clay is subdivided for time-stratigraphic reasons into Champlain Sea (west of Quebec), Laflamme Sea (Lac St-Jean) and "Goldthwait Sea" (east of Quebec). These are convenient subdivisions of the area for geomorphic and geotechnical purposes as well, because within them the Leda Clay deposits have somewhat different physical characteristics and associations that depend on slight differences in environment of deposition and of time.

Primary geologic factors that give Leda Clay its initial susceptibility to mass wastage are mineral composition, distribution, facies variation, age of the clay, and above all, the structure produced by flocculation of sediment in salt water. Other such factors are inherent in the association of the clay with glaciofluvial, glaciomarine and marine sand and gravel. The presence of these coarse sediments beneath, within and overlying marine clay tends to maintain high water table conditions and to provide artesian pressures within the column of sediment. Although the potential for mass wastage is determined by such factors, there is little evidence of actual occurrence of earth movement within the primary marine sediments while they were submerged in the sea, except for minor amounts of intraformational slumping in deltaic facies of Leda Clay.

Post-depositional erosion by waves, currents and mass wastage is responsible for the development of steep slopes, in which slides may occur, and basins or channels into which they might flow. Early stages of erosion occurred in poorly consolidated sediment in the upper part of the basin. Early landslides were broad, shallow and extensively retrogressive, showing a very high degree of liquefaction. Later stages of erosion reached lower sections of the clay deposits which were progressively more consolidated. Such materials were drained over a period of time and therefore were subject to diagenesis involving desiccation, chemical weathering of minerals, and cementation of oxides and carbonates. For these reasons, there is a time-transgressive change from early broad, shallow, high liquefaction slides towards the more recent narrow, steep, relatively low liquefaction slides and simple bank failures. The stage of geomorphic development between these two end members is time-dependent and, therefore, among other influences, it explains some apparent differences in types of landsliding presently occurring in the Champlain Sea, Laflamme Sea and Goldthwait Sea areas.

As freshwater drainage developed in the marine basin, broad fluvial terraces were cut in the Leda Clay. The products of erosion were carried downstream in freshwater and much of the sediment was redeposited as covers of sand and clay of varying thickness. These secondary sediments exist on terraces abandoned as much as 10 000 years ago. They are now being incised by modern streams. The sediments are commonly more resistant to mass wastage than Leda Clay so that they are producing only small bank failures that involve very little liquefaction of the clay.

Some aspects of research being carried out by the Geological Survey of Canada and proposed for future study by the author and colleagues are briefly outlined to illustrate attempts to recognize and document natural geologic conditions related to mass wastage. Hope is expressed that research into geology, engineering and planning will tend to minimize the effects of both natural and artificial development of landslides and other forms of soil failure in Leda Clay and, most important, to minimize human involvement in landslides of disastrous proportions.

# Grasty, R.L.

AIRBORNE GAMMA-RAY SURVEY CALIBRATION IN CANADA; Uranium Geophysical Technical Symposium; U.S. Energy Research Development Administration, Grand Junction, Colo., 1976.

In airborne measurements of natural terrestrial radioactivity for uranium exploration or geological mapping, four channel gamma-ray spectrometers equipped with large volume sodium-iodide detectors are normally used. Calibration constants are required to convert the airborne data to equivalent ground concentrations of potassium, uranium and thorium. The Geological Survey of Canada calibration procedure is described. It consists of first experimentally determining the three spectral stripping coefficients at ground level using large concrete calibration pads of known radioelement concentration. Results from a 6x4, 5x5 and 9x4inch detector are presented which show that the three stripping ratios are essentially the same for all three detectors. The same values are also found for the G.S.C. Skyvan system consisting of twelve 9x4 inch detectors, after problems relating to electronic dead-time were overcome. A comparison of total count measurements and calculated dose rate at the surface of the pads is shown to indicate that there are no problems relating to radon loss from the calibration pads.

An analytical expression is used to calculate the increase with aircraft altitude of the spectral stripping correction that has to be applied to the uranium window due to the build-up of scattered gamma-rays from the thorium decay series. A similar increase with aircraft altitude has also been calculated independently by Lovborg from the Danish Atomic Energy Commission. The two remaining stripping ratios are assumed to retain their ground level value because of the generally high potassium count rate compared to that of uranium and thorium.

The stripped count rates are then converted to the nominal survey altitude using an experimentally measured exponential variation of count rate with aircraft altitude over a uniformly radioactive test strip. The height corrected stripped count rates are then related to equivalent ground concentrations using the results of laboratory analyses on soil samples from the test strip. This calibration procedure is discussed and is shown to be adequate for uniformly radioactive sources whose diameters are greater than about 600 m.

From an analysis of calculated and experimental data for a variety of detectors normally flown in survey operation, the conversion factors relating airborne count rate to equivalent ground concentration are shown to be proportional to detector volume. All other calibration constants (height attenuation coefficients and stripping ratios) are found to be essentially independent of detector dimension provided the same spectrometer window settings are used. A table of these calibration constants for an airborne system with a volume of 3000 cubic inches flown at an elevation of 125 metres will be presented.

Tammenmaa, J., Grasty, R.L., and Peltoniemi, M.

THE REDUCTION OF STATISTICAL NOISE IN AIRBORNE RADIOMETRIC DATA; Can. J. Earth Sci., v. 13, p. 1351-1357, 1976.

An analytical expression for the Fourier energy spectrum of a radioactive point source is found to satisfactorily define that part of the spectrum in which all radiometric features are located. It is shown that the decreased signal-to-noise ratio arising from a shorter measurement time can be regained by the application of a suitable filter, resulting in better ground resolution and less distortion of radiometric anomalies.

#### Haworth, R.T.

APPALACHIAN STRUCTURAL TRENDS NORTHEAST OF NEWFOUNDLAND AS DELINEATED BY DETAILED SEISMIC REFLECTION, MAGNETIC AND GRAVITY SURVEYS; Geol. Soc. Am., Abstr., v. 9, no. 3, p. 273, 1977.

The offshore extensions of the Avalon Platform and Central Mobile Belt of Newfoundland are easily distinguishable on the basis of their gravity and magnetic characteristics. The avalon trends veer from northeast to east across the Grand Banks and establish that the intermediate depth area of the Newfoundland Shelf landward of Orphan Knoll and

Flemish Cap is entirely continental. Pre-drift reconstruction of the North Atlantic indicates structural similarities between the area underlain by Avalon basement and parts of Spain and Brittany. The northeasterly trends associated with Newfoundland's Central Mobile Belt veer north to northwest offshore so that at the latitude of Belle Isle the geological units of Burlington Peninsula lie immediately offshore and the Gander zone trends almost parallel to the continental margin. Some classical correlations of basement features between Scotland and Newfoundland are therefore not supported. The boundary between the divergent trends of the Avalon platform and Central Mobile Belt (the offshore extension of the Hermitage-Dover Fault) appears to have been the locus for development of the Charlie (Gibbs) fracture zone. Core samples of most of the western units with ages from Precambrian through Carboniferous have been recovered offshore, but the Gander zone extension remains unsampled beneath a thick sequence of Coastal Plain sediments.

#### Haworth, R.T. et Lefort, J.P.

ÉTUDE GÉOPHYSIQUE DES FRACTURES DU SOCLE SUBMERGÉ À L'OUEST DE L'EUROPE ET À L'EST DU CANADA – FRACTURATION TARDI-HERCYNIENNE ET CORRÉLATIONS TRANSATLANTIQUES; Réunion annuelle des sciences de la Terre, France, 1977.

L'interprétation géologique des données géophysiques (magnétisme, gravimétrie, sismique) publiées ou non sur les plateaux continentaux Ouest-Européen et Est-Canadien permet de dessiner une carte transatlantique des principales fractures du socle.

Les mégafractures orientées Est-Ouest sont les plus aisées à mettre en évidence ce système parfait d'ailleurs unique sur les Grands Bancs de Terre-Neuve. Ces fractures sont associées lorsque l'on referme l'Atlantique-Nord, selon deux ceintures parallèles aux latitudes 44 et 48°N. La première s'étend à l'Ouest de la zone broyée sud-armoricaine et rejoint Terre-Neuve; la seconde prolonge vers l'Est la faille Cobequid-Chedabucto-Scatarie, elle traverse les bancs de Galice, le Nord de l'Espagne et le Sud de la France. Une troisième ceinture existe peut-être entre la faille Clinton-Newsbury au Nord des U.S.A., le centre de l'Espagne, la Corse et la Sardaigne (lorsque celles-ci sont replacées à l'endroit qu'elles occupaient au Paléozoïque terminal).

La répartition des trajectoires de raccourcissement montre que les deux ceintures principales ont réagi différemment devant les mêmes contraintes au Carbonifère terminal.

Ces corrélations permettent de proposer des repères précis pour une meilleure reconstitution des continents avant l'ouverture actuelle de l'Atlantique-Nord.

#### Haworth, R.T. et Lefort, J.P.

L'ARC IBÉRO-ARMORICAIN: UNE STRUCTURE PRÉCAMBRIENNE DE LA PLATEFORME AVALONIENNE; Réunion annuelle des sciences de la Terre, France, 1977.

Les levés géophysiques effectués sur le plateau continental situé à l'Est du Canada montrent qu'il existe au niveau des Grands Bancs de Terre-Neuve des rides magnétiques et gravimétriques continues dont certaines atteignent plus de 500 kilomètres de long; ces rides sont interrompues au Sud par un accident magnétique majeur: le "collector anomaly"; au Nord, elles ne se prolongent pas au delà du contact entre la ceinture mobile appalachienne et la plate-forme avalonienne (rive Sud du Iapetus). Rien n'indique pourtant que le matériel magnétique soit partout d'âge antécambrien; il peut en effet tout aussi bien s'agir (comme à l'Est du Nouveau Brunswick) de roches basiques dont la mise en place est liée à la distension du Iapetus, d'arcs volcaniques qui (comme en Avalon) dateraient de l'Hadrynien, ou même d'arcs volcaniques d'âge paléozoïque puisque l'on sait que dans cette région le Iapetus s'est refermé à la suite d'une subduction vers le Sud-Est. Seule la "forme" de rides est, avec certitude, précambrienne, des structures de cet âge pouvant guider par la suite la mise en place d'intrusions plus jeunes. Lorsque l'on referme l'Atlantique-Nord actuel, on constate une homothétie parfaite entre ces structures et l'arc Ibéro-armoricain; on peut considérer que cette homothétie n'est pas fortuite puisque l'on sait que les faciès sédimentaires du Paléozoïque inférieur espagnol dessinent des arcs et que ceux-ci reflètent le contrôle d'un socle précambrien. L'arcature ibéro-armoricaine serait ainsi une structure d'âge précambrien appartenant à la plate-forme avalonienne. Un serrage de certains de ces arcs à l'époque hercynienne n'est pas incompatible avec notre modèle.

#### Haworth, R.T.

THE CONTINENTAL CRUST NORTHEAST OF NEWFOUNDLAND AND ITS ANCESTRAL RELATION-SHIP TO THE CHARLIE FRACTURE ZONE; Nature, v. 266, p. 246-249, 1977.

Continental edges that are matched in precontinental drift reconstructions have generally been defined by an isobath. When the isobath chosen is too shallow, isolated bathymetric highs within the 'oceanic' area are interpreted as continental fragments that may consequently be moved at will to fill any gaps in the reconstruction. Orphan Knoll (which had a history of uplift, erosion and subsidence) and Flemish Cap are two such fragments for which lateral movements across the northeast Newfoundland shelf have been invoked. Detailed bathymetric, magnetic and gravity surveys have confirmed that the entire intermediate depth area of the northeast Newfoundland Shelf inshore of Orphan Knoll and Flemish Cap is continental in nature thereby invalidating reconstructions which assume otherwise. I show here that the offshore extension of the Hermitage-Dover fault in Newfoundland provided the line of weakness along which the Charlie transform fault developed.

#### Herd, R.K., Chandler, F.W., and Ermanovics, I.F.

WEATHERING OF ARCHEAN GRANITOID ROCKS, ISLAND LAKE, MANITOBA; Geol. Assoc. Can./Mineral. Assoc. Can., Abstr., v. 1, p. 72, 1976.

The Island Lake greenstone belt of eastern Manitoba contains the mainly volcanic Hayes River Group overlain by the clastic sedimentary Island Lake Series. Felsic plutonites were previously thought only to postdate these supracrustals but on Cochrane Bay, an altered micaceous rind discovered on a quartz diorite pluton is overlain by conglomerate of the Island Lake Series. Further, on the western extension of the greenstone belt, east of Willow Lake, a 100 m thick altered and fractured zone caps quartz diorite and underlies boulder conglomerate (of the Island Lake Series?). These altered zones have the field appearance of non-oxidised regolith.

Many clasts in conglomerate of the Island Lake Series are lithologically similar to the quartz diorites and to volcanics of the Hayes River Group. Therefore, erosion and weathering of both may have contributed detritus to the Island Lake Series.

# Hornbrook, E.H.W.

GEOCHEMICAL RECONNAISSANCE FOR URANIUM UTILIZING LAKES OF THE CANADIAN SHIELD; in Sask. Geol. Soc., Spec. Publ. 3, 1976.

Lake sediments and/or lake water geochemical reconnaissance surveys have been carried out in the Canadian Shield by the Geological Survey of Canada, Provincial governments, the mineral exploration industry and various universities and research institutions over the last several years. At the Geological Survey of Canada, in support of the Federal-Provincial Uranium Reconnaissance Program, utilization of Shield lakes has evolved to the point where centre-lake bottom sediment and/or surface lake water are routinely collected over thousands of square miles of Canadian Shield.

Sufficient orientation, reconnaissance and follow-up surveys have been, or are about to be, completed to permit an examination of the effectiveness of lakes as a source of sample media for uranium reconnaissance.

In this paper, the objectives, methodology and effectiveness of lake sediment and water surveys are briefly described and relevant studies are discussed.

These data show that uranium contents of centrelake bottom sediment and surface lake water provide meaningful information on the concentration and distribution of uranium in the Canadian Shield for exploration or resource appraisal.

#### Irvine, J.A. and Williams, G.D.

A COMPUTER-ASSISTED NATIONAL COAL INVEN-TORY; Can. Min. Metall. Bull., v. 70, p. 68, 1977.

In 1972, a cooperative program to map and estimate the quantity of Tertiary coal resources in southern Saskatchewan was initiated by the federal and Saskatchewan governments. More than 700 exploratory boreholes were drilled over a two-year period, and data were obtained from other organizations on an additional 2000 boreholes in the area. Stratigraphic data and data on each coal seam penetrated in the boreholes, along with technical and location data for each borehole, were stored in a computer data base for convenience of retrieval, modification and manipulation. Correlation of stratigraphic units, including coal zones and individual seams, was done manually.

Programs and program packages were developed or adapted to:

(1) select borehole information defined by variable retrieval parameters from the data base;

(2) calculate derived information, such as overburden ratios, cumulative net coal thicknesses, mean weighted center of gravity of coal seams in each borehole, etc., from the selected data;

(3) produce posting maps of either selected data or calculated information in various combinations at variable scales on a plotter or CRT display;

(4) produce contoured structure, isopach or ratio maps, and perspective diagrams as appropriate, utilizing plotter or CRT display;

(5) calculate and categorize quantities of coal in place within user-defined "mineability-economic-reliability" limits.

The emphasis in computer utilization was placed on geological credibility of the results and ease of operation by relatively untrained geological personnel, resulting in extensive use of interactive methods. The single most important benefit derived from using computer-assisted procedures is the ability to produce new maps and quantity estimates rapidly and inexpensively as a result of availability of new data or/and changes in external criteria which impose economic or mineability constraints.

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

ELECTROMAGNETIC PROPAGATION CHARACTER-ISTICS OF ROCKS; in the Physics and Chemistry of Minerals and Rocks; Ed. R.G. Strens, p. 279-296. John Wiley & Sons, N.Y., 1976.

# Katsube, T.J.

ELECTRICAL PROPERTIES OF ROCKS; In "Induced Polarization for Exploration Geologists and Geophysicists", p. 15-44; University of Arizona Geophysical Society and the University of Arizona, 1977.

# Kerr, J.Wm.

GEOLOGY OF OUTSTANDING ARCTIC AERIAL PHOTO-GRAPHS; 3. MARGIN OF SVERDRUP BASIN, LYALL RIVER, DEVON ISLAND; Bull. Can. Pet. Geol., v. 24, No. 2, p. 139-153, 1976.

An outstanding aerial photograph of northern Grinnell Peninsula, Devon Island is reproduced with a geological interpretation. The area was occupied by three successive depositional basins: the Franklinian Miogeosyncline, the Arctic Platform and the Sverdrup Basin. Remnants of all three are preserved. The exposed section is more than 3300 m (11 000 ft.) thick, including 12 Ordovician to Cretaceous map units and six unconformity surfaces.

Three major deformations produced two intersecting structural trends. The Cornwallis Fold Belt developed first, with deformation ending in Late Devonian time. Its northerly trend was rejuvenated and influenced all younger structures.

The Ellesmerian Orogeny occurred between Late Devonian and mid-Pennsylvanian time and included two phases. The first phase included a southward compression that put an east-west overprinting on northern parts of the Cornwallis Fold Belt. It apparently occurred before deposition of the Mississippian Emma Fiord Formation. This is a shaly and coaly transitional unit representing the earliest stages of the Sverdrup Basin. It apparently filled topographic lows in a fresh-water lake, as subsidence followed the first phase of folding.

The second phase of the Ellesmerian Orogeny was contemporaneous with marked regional downwarping that developed the Sverdrup Basin. The phase was marked at Lyall River by folding and faulting near the zone of flexure. The topographic relief created provided coarse conglomerate to the contemporaneous Canyon Fiord Formation.

A narrow east-trending, furrow-shaped high within the Sverdrup Basin was emergent through Canyon Fiord deposition. South of this high and largely cut off from the main basin was the narrow Lyall River Embayment of the Sverdrup Basin. The early history of the Sverdrup Basin was influenced greatly by pre-existing structure. The flexure that produced the basin caused an abrupt increase in the northward plunge of the Cornwallis Fold Belt.

Numerous normal faults exposed in the area probably were active in the Cretaceous-Tertiary Eurekan Orogeny. They were controlled by older structures.

#### Kerr, J.Wm., McLaren, D.J., and Thorsteinsson, R.

CANADIAN ARCTIC ARCHIPELAGO; in The Silurian-Devonian Boundary, IUGS Series A, No. 5, p. 281-288. Stuttgart, 1977.

The boundary between the Silurian and Devonian systems in the Archipelago is transitional and not represented by a hiatus. Graptolitic rocks occur in the outer parts of the Franklinian Geosyncline on Melville, Bathurst, Cornwallis, Baillie Hamilton, Devon and Ellesmere Islands. Shelly facies occurs in the inner parts of the Franklinian Geosyncline and the adjoining Arctic Platform, on Victoria, Stefansson, Cornwallis, Devon and Ellesmere Islands. Three important sections that include the boundary occur on Twilight Creek on Bathurst Island, Washington Point on Baillie Hamilton Island, and western Prince of Wales Island. Faunas of Pridolian and Gedinnian ages are commonly abundant, well preserved and diverse. Monograptus cf. uniformis, Icriodus waschmidti, and Warburgella rugulosa canadensis mark the basal Devonian in the graptolitic sequence. Ostracoderms are common in the full range of contrasting facies and invariably associated with marine invertebrates. Although widespread, sections embracing the boundary can only be reached conveniently by aircraft from Resolute Bay on Cornwallis Island.

# Killeen, P.G. and Bristow, Q.

URANIUM EXPLORATION BY BOREHOLE GAMMA-RAY SPECTROMETRY USING OFF-THE-SHELF INSTRU-MENTATION; Proc. Symp. Explor. for Uranium ore deposits; I.A.E.A., Vienna, 1976.

During the 1975 summer field season, two Canadian manufacturers offered borehole gamma-ray spectrometric equipment which was essentially a modified version of their portable instrument designed for surface measurement. The operation of both portable gamma-ray spectrometry systems was tested in boreholes at locations near Ottawa, Elliot Lake, and the Bancroft area. The off-the-shelf instruments, interfaces, borehole probes, cables, winches, recorders, and associated equipment are described and compared. Methods of operation, and of calibration, their relative advantages and disadvantages, and results of borehole measurements are given for both sets of equipment.

In addition, 1024 channel gamma-ray energy spectra from the three available borehole probes with Nal(Tl) crystals of sizes  $3/4 \ge 2$  in.,  $3/4 \ge 3$  in., and  $1 \ge 3$  in., were recorded in the laboratory. The low efficiency of such crystals for high energy gamma-rays is readily apparent from these spectra, and also from spectra recorded in the boreholes in the Bancroft area. Sample recordings of K, U, Th and total count logs were made in the same hole with the three probes, for comparison. An attempt is made to give an appreciation of the problems involved, typical count rates to be expected, and suggestions are made for future modifications in equipment and technique to overcome some of the difficulties encountered.

# King, L.H.

RELICT ICEBERG FURROWS ON THE LAURENTIAN CHANNEL AND WESTERN GRAND BANKS; Can. J. Earth Sci., v. 13, p. 1082-1092, 1976.

#### Kurfurst, P.J.

ULTRASONIC WAVE MEASUREMENTS ON FROZEN SOILS AT PERMAFROST TEMPERATURES; Can. J. Earth Sci., v. 13, p. 1571-1576, 1976.

An ultrasonic pulse technique was used in the laboratory to measure compressional and shear wave velocities on frozen soil samples with various ice contents. Measurements were made on a variety of samples, which differed in type of material, geographical location, and ice content, at temperatures ranging from -7 to +1°C. Three series of tests were run on specimens from the Norman Wells, Fort Good Hope, and Eureka areas, Northwest Territories. The first series of specimens was tested under uniaxial stress conditions, whereas the measurements for the second and third series were done under triaxial stress conditions. The results measured on samples from the Norman Wells and Eureka areas were compared with the results obtained from shallow seismic profiles shot in the field at the sampled drill sites at the time of drilling. The values of field velocities lie within the range of laboratory measurements, and therefore prove that the laboratory tests provide a measure of control in the interpretation of seismic records.

# Latour, B.A.

COAL RESOURCES OF CANADIAN CORDILLERA – SUMMARY; Am. Assoc. Pet. Geol., Mem. 25, p. 105 ff, 1976.

Coal deposits of various ages and ranks are widely distributed throughout the Canadian Cordillera. Although

separated from the Pacific Ocean by about 350 mi (563 km) of rugged mountainous terrain, the coal deposits of the eastern part of the region are of considerable significance to the Circum-Pacific area.

The current production from all other coal deposits in this region is sufficient only to meet local domestic needs, although some deposits have undergone extensive exploitation in the past. In view of the current, rapidly changing energy situation, some of these deposits may become more significant. In particular, the Hat Creek and Groundhog coalfields of British Columbia appear to have potential.

Jurassic, Early Cretaceous, Late Cretaceous, and Tertiary coal occurs in the Canadian Cordillera. There is no general pattern of age distribution but, for descriptive convenience, the region is grouped into three north-south geographic belts. The eastern belt extends from Fernie northward to Peace River, the central belt includes the area from Princeton coalfield northward through British Columbia to Dawson in the Yukon, and the western belt comprises Vancouver Island and Queen Charlotte Islands.

All ranks of coal are present; rank generally increases with the age of the coal. Sulfur in most of the coal is consistently less than 1%, except in Comox coalfield on Vancouver Island, where the sulfur content ranges up to 2%.

The only known deposits of high-quality metallurgical coal in the Canadian Cordillera are located in the eastern belt. Because the deposits are extensive and the demand for this type of coal has been high over the past few years, they are the most actively exploited deposits in the Cordillera; in 1973 production rose to about 11 million short tons (10 million MT). This coal was all shipped to Japan and represented about 15% of that country's metallurgical coal requirements. The total coal tonnage produced in 1973 from the central belt was only about 25 000 short tons (23 000 MT), and there was no production from the western belt.

#### Hutcheon, Ian, Gunter, Avril E., and LeCheminant, A.N.

SERENDIBITE FROM PENRHYN GROUP MARBLE, MELVILLE PENINSULA, DISTRICT OF FRANKLIN; Can. Mineral., v. 15, p. 108-112, 1977.

Serendibite occurs in skarn which formed between Aphebian Penrhyn Group marble and granite on the Melville Peninsula, District of Franklin. The mineral is triclinic and the parameters of the reduced cell are a 9.513, b 10.001, c 8.622Å α95.85°, β114.70°, γ64.28°, V=668.27Å<sup>3</sup>. Microprobe analysis gave (wt. %) SiO<sub>2</sub> 20.85, Al<sub>2</sub>O<sub>3</sub> 40.20, FeO (total iron) 3.48, MgO 12.71, CaO 17.11 (B2O3 not determined). The optical properties of the mineral for Nan are:  $2VY=81^{\circ}$ ,  $\alpha$  1.700 (pale blue-green),  $\beta$  1.703 (pale yellow),  $\gamma$  1.706 (moderate blue); axial r>v, inclined and horizontal dispersion. Serendibite is associated with fassaite, uvite-rich tourmaline, clinozoisite, spinel, and calcite. Comparison with other occurrences suggests that the stability field of serendibite may be restricted to silica-undersaturated bulk compositions.

#### Maxwell, J.A.

SAMPLING AND SAMPLE PREPARATION AT THE GEOLOGICAL SURVEY OF CANADA – THE WHAT, WHY, AND HOW; in National Bureau of Standards, Sp. Pub. 422, 1976.

The landmass of Canada, with half of its 4 million square miles underlain by the Precambrian Canadian Shield, encompasses most of the main geological regions of North America, and presents the geoscientist with a wide diversity of geological terrains of varying degrees of complexity, economic interest and inaccessibility.

Among the chief concerns of the Geological Survey of Canada is that of providing a comprehensive inventory and

understanding of the geological framework through its extensive field and laboratory studies, with emphasis upon those regions having high potential for the occurrence of additional economic mineral deposits.

Many factors influence the nature of a sampling program, which may vary from the taking of single "grab" specimens to the collection of large numbers of samples on the basis of a sampling pattern laid out according to a statistically devised plan, but the primary consideration is always to obtain a sample that will yield the best answer to the question being asked. Rocks, minerals, stream and lake sediments, soils, glacial deposits, water samples from lakes, streams, springs, muskeg and other sources, all of these have their use as a source of compositional, petrographic, isotopic, mineralogical, textural and other information.

Because of the often unique nature of a sample, the difficulty of obtaining additional samples, the succeeding extensive and frequently costly work to be done on the prepared material, and the conclusions that will be derived from the resulting data, it is of paramount importance that the sample be correctly prepared. Again, various factors must be considered in the choice of method to be used, but the overriding concern must be to ensure that the sample prepared for study is truly representative of the sample submitted.

# Mayr, Ulrich

MIDDLE SILURIAN REEFS IN SOUTHERN PEARY LAND, NORTH GREENLAND; Bull. Can. Pet. Geol., v. 24, No. 3, p. 440-449, 1976.

The Ordovician and Silurian rocks of the Canadian Arctic Archipelago and northern Greenland are characterized by a facies change from carbonates to fine-grained clastics – a facies change that may be traced from the Yukon Territory through the Canadian Arctic Archipelago to northeastern Greenland. In the central part of southern Peary Land on northern Greenland, small reefs formed during Middle and part of Late Silurian time. These reefs have a lateral shale equivalent and are the youngest carbonates of an extensive carbonate shelf which was subsequently covered by siltstone. The largest reefs have an estimated thickness of 1500 ft. (450 m). Paleogeographic and paleoecological conditions for these reefs may have been similar to those that exist at present on the Queensland and Sahul shelves of Australia.

#### McLaren, Digby J.

THE SILURIAN-DEVONIAN BOUNDARY COMMITTEE. A FINAL REPORT; in The Silurian-Devonian Boundary, IUGS Ser. A, no. 5, p. 1-34, Stuttgart.

The Silurian-Devonian Boundary Committee of the Commission on Stratigraphy, International Union of Geological Sciences, was constituted in Copenhagen in 1960. In Montreal in 1972, the Committee presented a final report to the Commission on Stratigraphy with recommendations for a type area, a type section, and an horizon within the type section, which defined the boundary between the Silurian and Devonian Systems. The recommendations of the Committee were accepted by the Commission on Stratigraphy. Acceptance of the horizon recommended by the Committee was widespread even before the final decision was ratified. Concurrently with this acceptance was the realization that a stratotype was required from which correlation might be made to other sequences. Groups of most use at the time such as stratotype was chosen include graptolites, conodonts, trilobites, and brachiopods. Definition, in itself, is not a scientific activity, but a necessary prerequisite of scientific discussion. A boundary defined in a continuous sedimentary sequence questions certain assumptions implicit in the idea of a "typical fauna" for the Silurian or Devonian. Similarly strongly held views on lithological changes at the boundary and priority of definition were modified in arriving at a universally acceptable definition. Boundary definition is greatly facilitated by widespread although not universal acceptance of the principle of defining stratigraphic units by stratotypes and boundaries by boundary stratotypes. Definition of stratigraphic horizons by species-defined zones is believed to be less accurate and inherently unstable.

#### Miall, A.D.

POST-PALEOZOIC GEOLOGY OF BANKS, PRINCE PATRICK AND EGLINTON ISLANDS, ARCTIC CANADA; Can. Soc. Pet. Geol., Mem. 5, p. 557-587, 1975.

Pennsylvanian to Early Jurassic sediments underlie part of Prince Patrick Island but are absent on Banks Island. From Early Jurassic through Early Tertiary time the Banks-Prince Patrick area underwent fairly continuous sedimentation. A slower subsidence rate than in the Mackenzie Delta and Sverdrup Basin depocentres gave rise to correspondingly smaller sediment thickness.

A late Early Jurassic marine transgression covered most of Prince Patrick Island and Eglinton Graben and probably filled much of Banks Basin. Thick sands and shales resulted (Wilkie Point and Mould Bay formations). In the Aptian, uplift and block faulting caused a regression and created local troughs in which fluvial sediments accumulated (Isachsen Formation). Sediment was derived from the craton and from local fault-bounded uplifts (?including Storkerson Uplift). Vertical sequences of sedimentary structures demonstrate stream rejuvenation and shifting channel patterns, both thought to have been caused by continued syndepositional fault movement.

Succeeding argillaceous and silty beds (Christopher Formation) reflect an Albian marine transgression. A Late Albian shoreline sand facies developed in Eglinton and northern Banks Island (Hassel Formation) and an Early Cenomanian regression followed. Marine sedimentation may have continued in Big River Basin, while mild erosion ensued elsewhere in the report area. Renewed, eastward transgression commenced in the Turonian but did not reach eastern Banks until Late Campanian time. Prince Patrick Island remained uplifted until the Late Tertiary.

Silty shale accumulated in the Banks area during the Late Cretaceous (Kanguk Formation). A Campanian shore-face sand facies developed on the flanks of Storkerson and Cape Crozier uplifts, while extrusive volcanism may have occurred in the vicinity of western Banks Island.

Fault rejuvenation and differential uplift from Maastrichtian through Eocene time caused deltaic wedges to prograde from Storkerson Uplift and the craton into Banks and big River basins (Eureka Sound Formation). Fourier analysis of gamma ray logs shows that coarsening upward clastic cycles therein thicken with present basin depth, indicating a Tertiary origin for the present structural configurations.

Uplift and erosion during the Oligocene was followed by subsidence of present offshore areas and commencement of a major deltaic phase which continued to the present. Beaufort Formation is part of this assemblage, which thickens seaward to several thousands of feet.

# Miall, A.D.

SEDIMENTARY STRUCTURES AND PALEOCURRENTS IN A TERTIARY DELTAIC SUCCESSION, NORTHERN BANKS BASIN, ARCTIC CANADA; Can. J. Earth Sci., v. 13, p. 1422-1432, 1976.

The Eureka Sound Formation of northern Banks Basin is a deltaic unit of Paleocene to Eocene age. A basal member of shale, approximately 100 m thick, passes vertically and, in part, laterally into a succession of sand, silt, shale, and lignitic coal approximately 1000 m thick, which is referred to as the cyclic member because of the abundance of coarsening-upward cycles, averaging 7.4 m in thickness.

Sand beds in the cyclic member can be divided into four lithofacies: (1) A facies dominated by medium- to largescale planar crossbedding, formed by channel processes, including lateral point bar accretion, in the delta plain environment. (2) A predominance of medium-scale trough and (minor) planar crossbeds, formed by migrating dunes in distributary mouth bar sands. (3) A predominance of smallscale ripple-marks, formed by low energy, unimodal currents in distal distributary mouth sands. (4) A lack of current structures, indicating quiet-water, interdeltaic and prodeltaic deposition. The distribution of these four facies outlines a series of small lobate deltas.

Paleocurrent data suggest a pattern of radiating distributaries within each delta lobe. Directional variance, when analyzed at various levels of the sedimentary structure hierarchy, provides information regarding channel sinuosity and enables comparisons to be made with other deltaic deposits. High variance for the directions of the distributaries is consistent with a fluvially dominated delta.

#### Miall, A.D.

PALAEOCURRENT AND PALAEOHYDROLOGIC ANALYSIS OF SOME VERTICAL PROFILES THROUGH A CRETACEOUS BRAIDED STREAM DEPOSIT, BANKS ISLAND, ARCTIC CANADA; Sedimentology, v. 23, p. 459-483, 1976.

A study of directional variability has been carried out on five vertical profiles containing a total of approximately 195 superimposed planar crossbed sets. The latter are interpreted as the deposits of braid bars. Detailed measurements on one set revealed within-set variance of 93. Within river tract, between-bar variance was obtained by calculating a ten-point moving average for each profile, and subtracting the actual azimuth at each point from the moving average value. Variance at this level is 980, which compares closely with data obtained from modern braided streams. Variability in the moving average azimuth is interpreted as the result of meander migration in the entire channel system. Sinuosity can be estimated from this variability, using a geometrical approximation. It ranges from 1.03 to 1.13.

Changes in stream competency with time are indicated by vertical changes in directional variance and set thickness. When accompanied by changes in mean azimuth, as in one of the present five profiles, the data suggest successive deposition by two distinct stream systems.

A Markov chain analysis of the data sequence indicates a weak memory effect. Short sequences of bar deposits were formed by streams which varied little in orientation, and these are separated from one another by sequences showing random directional fluctuation.

The hydrology of the Isachsen rivers was investigated using Schumm's empirical relationships for modern rivers. Owing to inherent uncertainties in these relationships and a wide margin of error in the input data (principally associated with estimates of depth and width of the Isachsen streams), the results have a validity only at the order-of-magnitude level. Individual Isachsen rivers are estimated to have had drainage areas of between 5000 and 30 000 km<sup>2</sup>; this information is of use in reconstructions of palaeogeography and tectonic history.

#### Nassichuk, W.W. and Hodgkinson, K.A.

SCAPHOPODS FROM THE PERMIAN ASSISTANCE FORMATION, CANADIAN ARCTIC ARCHIPELAGO; J.Paleontol., v. 50, no. 6, p. 1150-1156, 1976.

A new species of the dentaliid scaphopod **Prodentalium** Young, 1942 is described from strata near the top of the Assistance Formation on Grinnell Peninsula, Devon Island. **Prodentalium belcheri** n. sp. is the only scaphopod described from the upper Paleozoic of Arctic Canada and through its direct association with a variety of ammonoids, brachiopods, elasmobranchs and other fossils can be dated rather precisely as late Early Permian (Roadian).

# Norris, D.K.

THE NORTH AMERICAN CORDILLERA IN CANADA NORTH AND EAST OF THE TINTINA FAULT; 25th Int. Geol. Cong., Abstr., v. 3, p. 690-692, 1976.

The North American Cordillera in Canada north and east of the Tintina Fault comprises the outer part of the Columbian Orogen north of Latitude 60°. It consists of two fundamentally distinct sectors separated by the Kaltag Fault Zone. North of the zone the foreland is Beaufort Shelf, on the southern rim of Canada Basin. South of it the foreland comprises the Interior Platform and the Canadian Shield.

The rock succession in this part of the North American Cordillera is in the form of an eastward- and northward-tapering sedimentary wedge, ranging in age from Proterozoic to Paleogene, and comprising two superposed, genetically and compositionally distinct, stratigraphic assemblages. The lower, Proterozoic to Lower Cretaceous miogeoclinal and eugeoclinal assemblage, is the continuation of the relatively undeformed foreland sequence of the Interior Platform and Beaufort Shelf; and the upper, Lower Cretaceous to Paleogene exogeoclinal assemblage, is the synand post-orogenic suite of rocks derived from the deformed and uplifted regions farther into the Cordilleran Orogenic System.

The wedge also can be divided geographically into two stratigraphically different regions. The Mackenzie Mountains are characterized by a relatively simple, layered succession in which individual formations persist over great distances along as well as across the strike. West and north of there, however, many formations lack this lateral continuity either because of facies changes, or nondeposition, or because of differential erosion at the multiplicity of unconformities within the stratigraphic succession.

Several discrete tectonic elements make up the region. They can be identified by particular structural and stratigraphic attributes such as trend and curvature of the long dimension of the element, fold and fault type, and continuity of formations along and across the element. Collectively, the elements comprise a complex part of the Cordilleran Foldbelt whose structural development and consequent tectonic style contrast markedly with those of the southern Rocky Mountains and Foothills of Canada. Bundles of right- and left-hand, en echelon, cylindrical to conical folds, most commonly with axial surfaces vertical to slightly inclined either toward or away from the foreland, are cut by longitudinal, high-angle reverse faults. They are interrupted by two arrays of right-lateral strike-slip faults, along some strands of which activity is as old as the mid-Proterozoic. Rare recumbent and isoclinal folds are confined largely to the eugeoclinal assemblage of the core zone of the Mackenzie Arc. Thrust faults are localized for the most part in the Kandik Thrust Belt and along the southwest flank of Romanzof Uplift. In both regions, they are limited not only in number but also in amount of stratigraphic separation.

Many unconformities within this complex of tectonic elements attest to a long, regionally episodic history of tectonism ranging from the Precambrian to the Tertiary. Although commonly they are disconformities, locally the unconformities are spectacularly angular, as seen for example in and adjacent to the Richardson Anticlinorium, to the Aklavik Arch Complex, and to Barn and Romanzof Uplift. Of the plethora of tectonic episodes which affected the northern part of the Columbian Orogen, that in the Tertiary appears to have been most widespread and masks to varying degrees earlier deformations.

The horizontal shortening of the sedimentary succession, consequent upon the climatic Tertiary orogenv. measured between the Tintina Fault and the western margin of the Interior Platform across the north-trending arm of the Ogilvie Deflection, is approximately 15 per cent. This degree of shortening persists around the Mackenzie Arc well into the northern Rocky Mountains and Foothills. There, in the vicinity of Latitude 56° North, where the Peace River heads into the Columbia Orogen, high-angle reverse faults begin to give way southward to thrust faults with concomitant increase in the amount of horizontal shortening. In association with the thrusts, the folds develop a decided asymmetry with their axial surfaces characteristically dipping westward. At Latitude 49° North (the International Boundary with the United States of America), moreover, the shortening of the sedimentary section between the Rocky Mountain Trench and the eastern margin of the Foothills would appear to reach a maximum value of approximately 60 per cent, or about four times greater than in the corresponding part of the foldbelt at the Ogilvie Deflections.

Two arrays of right-lateral strike-slip faults played a fundamental role in the structural development of the Cordilleran Foldbelt north of Latitude 60°. The Richardson Fault Array, traceable from Beaufort Shelf southward to the Mackenzie Arc, was demonstrably active from the Precambrian to the Tertiary. The Kaltag Fault Zone, extending for more than 1200 km from Norton Sound in western Alaska to the southern rim of Canada Basin (approximately the length of the surface trace of the Alpine Fault across North and South Islands, New Zealand), was active at least in the mid-Cretaceous. Vertical displacements on both fault systems localized and controlled the direction, shape and extent of important, narrow depositional sites, the former, the early and middle Paleozoic Road River Trough, and the latter, the late Early Cretaceous flysch trough between Barn and Cache Creek Uplifts.

The Kaltag Fault Zone, in addition, played a singular role in the tectonic history of the North American Plate. In Alaska it offsets the Tintina-Kobuk Fault Zone right laterally about 200 km and in Canada it turns sharply seaward to dissipate this displacement as oblique slip among the several components of the Rapid Fault Array. Beneath Mackenzie Delta the more easterly strands merge with the Richardson Fault Array on the seaward flank of the Aklavik Arch Complex and attenuate their displacements northeastward as a family of down-to basin faults on Beaufort Shelf.

The many Phanerozoic rock units which are common to contiguous parts of the Cordilleran and Innuitian Foldbelts suggest parallel development and physical continuity of depositional basins and environments. There are no data, on the other hand, to suggest physical continuity of structures between the two foldbelts even though their tectonic histories are somewhat analogous. If there is a connection between the lower Paleozoic mobile belts of northern Yukon Territory and the Arctic Islands, it lies now or lay at one time in the past, beneath the present Beaufort Sea. An unbroken, circum-arctic Paleozoic mobile belt is, therefore, yet to be demonstrated for the North American Plate.

Moreover, many of the spectactularly arcuate fold and fault bundles of the Cordilleran Foldbelt are manifestly not oroclines. After collision and suturing of the North American and Eurasian Plates in the Early Cretaceous, it would appear that some of the continued westward drift of the North American Plate was taken up through right-lateral displacement in the Kaltag Fault Zone. Concurrently, there may have been buckling of large-scale structures and mountain belts closer to the suture, in western Alaska and adjacent Chukotka. True oroclines, if they exist at all in the northern Cordilleran Foldbelt, appear to be confined to those buckles. Dence, M.R., Grieve, R.A.F., and Plant, A.G.

APOLLO 17 GREY BRECCIAS AND CRUSTAL COMPOSI-TION IN THE SERENITATIS BASIN REGION; Proc. Lunar Sci. Conf. 7th, p. 1821-1832, 1976.

Apollo 17 grey breccias, as represented by 73235 and 73215, are texturally and compositionally similar mixtures of two clast-rich lithologies: coherent, very fine grained, dark matrix breccia and more porous, light matrix breccia. Clast populations are of lunar highland type and comprise generally unshocked microbreccias and other rocks and abundant mineral fragments. A notable clast group confined to dark matrix breccia includes millimetre-sized plagioclase grains which, although largely recrystallized, show evidence of shock metamorphism at pressures of 15-40 GPa. It is proposed that the breccias consist of primary Serenitatis ejecta, texturally modified by secondary impact mixing. When applied to a model of the Serenitatis impact event unshocked clasts are interpreted as samples of the upper 25 km of the lunar crust, with the coarser grained, shocked, plagioclase-rich clasts as material excavated from the lower crust. The dark matrix is considered to be a shock-melted mixture of almost the entire 60 km crust near the point of impact. That the dark matrix is equivalent to a compositional mixture of the enclosed clasts is supported by microprobe analyses which show it to be closely similar to bulk analyses. Its low K Fra Mauro composition can be approximated by a mixture of highland lithic rock types in the proportions 65% anorthosite and anorthositic gabbro, 17% gabbro, 17% troctolite and 1% granite. Its normative mineralogy is slightly more mafic than the compositional model proposed by Taylor (1975) for the upper 60 km of the crust.

# Poulton, T.P.

DISTRIBUTION AND SIGNIFICANCE OF TRIGONID BIVALVES IN THE MESOZOIC OF CANADA; Geol. Assoc. Can., Vancouver, 1977. Abstr., v. 2, p. 42.

Bivalves of the family Trigoniidae Lamarck are an important element of many of the Late Triassic through Cretaceous faunas of western Canada, and they occur rarely in the Lower Jurassic faunas of the Canadian Arctic. Most species appear to be useful for recognition of biostratigraphic intervals to approximately the level of one or two stages, and identifications of many genera permit somewhat coarser biostratigraphic determinations.

Most Late Triassic species are radially costate and represent the genera Minetrigonia and Myophorigonia. A few other poorly understood species are present also. The pre-Middle Toarcian Early Jurassic species represent Prosogyrotrigonia (?), Frenguelliella, Jaworskiella, Psilotrigonia, Vaugonia, and Trigonia. Middle Toarcian through Oxfordian species dominantly represent Myophorella, Trigonia, and Vaugonia, with less numerous species of Orthotrigonia (?), Scaphotrigonia and Anditrigonia. Trigoniids occur rarely in Kimmeridgian through Valanginian rocks in Canada, where species of Buchia are abundant instead. Species of Myophorella (Steinmanella), Apiotrigonia, Quoiecchia and a new genus occur in the Hauterivian and Barremian stages. Aptian species are rare and poorly known. Younger Cretaceous species mainly represent Myophorella (Steinmanella) and P. (Pterotrigonia). Apiotrigonia, Heterotrigonia, and the same new genus as occurs in older bed, are also present locally in Albian rocks. The genus Yaadia Crickmay is taken to be a junior synonym of Myophorella (Steinmanella) Crickmay.

The Canadian trigoniids are almost entirely endemic. The closest affinities of pre-Middle Toarcian species are with circum-Pacific species. Younger species resemble 'Tethyan' and northwest European forms.

# Robertson, K.R. and Rashid, M.A.

# EFFECT OF SOLUTIONS OF HUMIC COMPOUNDS ON CONCRETE; J. Am. Concrete Inst., Oct. 1976, p. 577-580.

The corrosive effect of humic acid on portland cement concrete was investigated with a 10 ppm concentration of organic matter under conditions simulating fresh and salt water environments. Calcium, the most abundant cation in concrete, was released in the fresh and salt water systems containing humic additions at maximum concentrations of 28 and 96 ppm, respectively. The corresponding controls which were devoid of organic matter contained significantly lower calcium concentrations. The solubility of calcium increased rapidly within the first 4 days of experimental exposure and then leveled off.

It was also observed at the end of the experimental period of 15 days that the organic matter formed a protective coating on the surface of the concrete blocks. Considering the concentration of calcium in portland cement concrete the quantity released in the reaction media constituted only a minor fraction of the total solid mass of concrete blocks. Moreover the formation of organic coating on the surface of the concrete appears to have a protective effect from further corrosion. It is therefore concluded that humic compounds present in aquatic or sedimentary environments do not exert any long term adverse effect on concrete structures, but on the contrary may provide a protective coating.

#### Richardson, K.A.

CANADA'S URANIUM RECONNAISSANCE PROGRAM; Uranium Geophysical Symp., U.S. Energy Research and Development Administration, Grand Junction, Colo., 1976.

In 1975 Canada embarked on a 10-year, 25 million dollar Uranium Reconnaissance Program with the objective of providing the mineral industry with high quality reconnaissance data to indicate those areas of Canada where there is the greatest possibility of finding new uranium deposits, and of providing the Government with nationally consistent, systematic data to serve as a base for uranium resource appraisal.

The program involves high sensitivity airborne gamma-ray spectrometry over areas of low relief with some outcrop, regional geochemistry in mountainous terrain and in areas of extensive overburden, and hydrogeochemistry in flat lying sedimentary basins.

The Geological Survey of Canada has been involved in development of methods of airborne gamma-ray spectrometry over the past 2 decades. This work progressed from modest small scale experiments to extensive test surveys in several areas containing known uranium mineralization, and demonstrated the general suitability of the method for rapid and efficient coverage of large areas. This operational experience made possible the preparation of detailed specifications for the execution of the work by contractors to a common national standard.

The Uranium Reconnaissance Program specifications call for a spectrometer system with not less than 50 000 cubic centimeters of sodium iodide detector, flown at 125 meter terrain clearance and 200 kilometers per hour. Equipment is calibrated using the Geological Survey of Canada facilities at Ottawa, and results are presented as computer plotted contour maps and profiles in units of radioelement concentration.

The Uranium Reconnaissance Program is based on the concept that most uranium deposits are geologically related to and occur within or marginal to regions of the crust containing higher than average amounts of uranium and airborne spectrometer surveys' with widely spaced flight lines are adequate to delineate three regions of high uranium concentration. Airborne gamma-ray spectrometric coverage of Canada at present, including work done by the Geological Survey of Canada prior to the Uranium Reconnaissance Program, work done in 1975, and work being completed in the 1976 season, amounts to approximately 935 000 km<sup>2</sup> flown with 5 km line spacing, and an additional 800 000 km<sup>2</sup> of advance reconnaissance work in the Northwest Territories which was flown in 1975 with 25 km line spacing in order to assign priorities for later coverage with the standard 5 km line spacing.

# Ridler, R.H.

VOLCANIC STRATIGRAPHY AND METALLOGENY OF THE RANKIN-ENNADAI BELT, DISTRICT OF KEEWATIN, N.W.T.; Geol. Assoc. Can., Sp. Paper 14, p. 659-660, 1976.

#### Rimsaite, J.Y.H.

PROGRESSIVE ALTERATION OF PITCHBLENDE IN AN OXIDATION ZONE OF URANIUM DEPOSITS; 25th Int. Geol. Cong., Abstr., v. 2, p. 594-595, 1976.

Transition of "black uranium ore" to "red uranium ore" and their associated host rocks were studied using XRD, optical, DTA-TG, chemical and electron microprobe methods on samples collected from uranium deposits, south of Lake Athabasca in Northern Saskatchewan, Canada. General geology of the areas of these deposits has been described by Little et al. (1972, 23rd Int. Geol. Congr. Excursion C-67 Guidebook), Knipping (1974, IAEA-SM-183/38, in Formation of uranium ore deposits) and Wallis (1971, Saskat. Dept. Mines Res., Rep. 137).

The purpose of this study is to determine the amount of uranium, lead and associated elements removed from pitchblende and coexisting minerals during their alteration in the oxidation zone, and their mode of redeposition as secondary mineralis. The alteration of host rocks preceding uranium mineralization and the alteration of pitchblende before oxidation are briefly discussed and are illustrated by selected chemical analyses and electron microprobe analyses showing chemical trends during progressive alteration.

1. Alteration of siliceous meta-sediments before mineralization involved argillization of plagioclase partial alteration of potassium feldspar, transformation of biotite to chlorite and muscovite with the liberation of Si, Ti, Fe and alkalis, and the crystallization of secondary oxides, such as "geothite", anatase and quartz. Silicification of minerals and rocks is prominent. In addition, vugs filled with dolomite and minor amphibole, garnet, green and brown tourmaline, apatite and zircon are common.

2. Minerals and their alteration in the "black uranium ore" preceding extensive oxidation. The "black ore" consists of three varieties of massive, fractured pitchblende: (a) relatively pure Pb-bearing U-oxide; (b) impure Pb-bearing U-oxide; and (c) impure Pb-depleted U-oxide. The associated minerals are sooty pitchblende, coffinite, poorly crystalized U-bearing clay minerals, non-radioactive poorly-crystallized clay minerals and altered detrital grains of minerals from the host rock. The processes involved during alterations include the removal of boron from tourmaline and of U and Pb from pitchblende, and the replacement of pitchblende by clay minerals in part as coffinite and as a component in uranium-bearing clay minerals. Part of the removed Pb crystallizes as galena.

3. Replacement of "black uranium ore" by "red ore" in the oxidation zone and incorporation of released ions into secondary radioactive minerals. In the oxidation zone, which coincides with the ground water level, the host rocks are stained red with iron oxides and contain traces of U and Pb. They are made up of abundant quartz and chloritic clays with

local concentrations of fine-grained white tourmaline aggregates. The contact of the ore with the host rock within the oxidation zone consists of a narrow black-greenish-white transition zone a few centimetres in width. This transition zone is composed of glauconite-chlorite-vermiculite clays impregnated by U-C compounds, including "thucholite", and locally silicified. Within the transition zone, the greyishblack U-C clays are partly replaced by white clays containing abundant guartz and mixed-layer phyllosilicates which expand to 29 A after glyceration. The grey U-C impregnated clays contain dominant ferrous iron, and the white replacing clays have predominantly ferric iron, implying that in this narrow transition zone the reduced and oxidized minerals coexist in different parageneses. The above transition zone passes into a multicoloured zone containing red, orange, yellow and green secondary uranium minerals which constitute the "red uranium ore". About 50% of the minerals in this zone are poorly crystallized and produce broad, weak and unidentifiable X-ray patterns. Because these fine-grained aggregates are not strictly monomineralic, due to replacements and alterations, minerals identified in X-ray diffraction patterns are written in guotation marks. The secondary U-minerals are commonly intergrown with calcite, gypsum, quartz and clays; their chemical compositions differ from the ideal formulae.

The early stage of pseudomorphic replacement of pure pitchblende by Pb-Si-rich pitchblende is followed by crystallization of "kasolite" and powdery "becquerelitemasuyite", and involves considerable hydration, additions to Pb and Si, and depletion of U. These Pb-rich U-aggregates are surrounded and partly replaced by bleached montmorillonite clays containing abundant quartz.

The late stages of alteration involve removal of lead, addition of silica and calcium, and gradual replacement of "kasolite" and "masuvite" by uranophane which in turn is replaced by white clay. The released ions from radioactive and non-radioactive minerals react with one another within montmorillonitic clays to yield "vein uranophane", "uranophane" globules and radiating aggregates which grade into "sklodowskite", "boltwoodite", an unidentified U-Ti-RE compound, and "zippeite". All these secondary minerals postdate crystallization of montmorillonitic clays and contain very little or no lead.

Results of the study on progressive alteration of minerals and removal and redeposition of ions confirm previous observations of differential behaviour of uranium and lead released from euxenite. The uranium released from pitchblende forms several generations of secondary uranium minerals, the earlier-formed ones being enriched in lead and the late-formed ones impoverished in lead. Uranium-bearing minerals associated with carbon compounds, sulphides and carbonates contain less lead than the red uranium-bearing silicates and oxides from the oxidation zone. Part of the lead in Pb-rich minerals is probably radiogenic. Isotopic studies could determine the origins of the Pb and U in the finegrained minerals of the oxidation zone.

#### Roddick, J.

SUMMARY OF THE COAST PLUTONIC COMPLEX OF BRITISH COLUMBIA; Geol. Soc. Am., Abstr., v. 8, no. 3, p. 405, 1976.

The Coast Plutonic Complex, 1700 km by 96 km, is dominated by intermediate and basic plutonic rocks. The flanking strata consist mainly of Mesozoic volcanic and sedimentary rocks, although Paleozoic rocks occur locally. The Complex consists of a core of migmatite and gneisses flanked by a matrix of foliated intermediate and basic (locally migmatitic) plutonic rock with minor zones of schist. Within this matrix are discrete and partly discrete plutons of various sizes within the range of composition of the matrix. The granitoid rocks are commonly heterogeneous. As areas of clear massive plutonic rock are much less common than might be implied by the term Coast Range batholith, Coast Plutonic Complex is preferred. Diorites and dioritic migmatites lie on the west with acid gneisses to the east. Although K-feldspar is more abundant to the east, there is no distinct quartz diorite line; some quartz monzonite plutons occur in the western zone. The Coast Plutonic Complex contains a large amount of diorite and basic quartz diorite. Rocks more acid than mid-quartz monzonite are rare. The two most common rock types, quartz diorite and granodiorite, as well as the granitoid gneisses, have average chemical compositions that are equivalent to tholeiitic andesite (average series), rather than to calc-alkaline andesite.

The main period of plutonism in the Coast Mountains began in the late Triassic but most was concentrated in the Cretaceous and Eocene. In the eastern part of the belt, K-Ar ages are mainly in the 43-50 m.y. range; to the west they are transitional between the eastern section and early Cretaceous on the western shore.

#### Ruzicka, V.

URANIUM RESOURCES EVALUATION MODEL AS AN EXPLORATION TOOL; Proc. Symp. Explor. for uranium ore deposits; I.A.E.A./N.A.E., Vienna, 1976.

Evaluation of uranium resources, as conducted by the Uranium Resources Evaluation Section of the Geological Survey of Canada, comprises operations analogous with those performed during the preparatory stages of uranium exploration. The uranium resources evaluation model, simulating the estimation process, can be divided into four steps. The first step includes definition of major areas and "unit subdivisions" for which geological data are gathered, coded, computerized and retrieved. Selection of these areas and "unit subdivisions" is based on a preliminary appraisal of their favourability for uranium mineralization. The second step includes analyses of the data, definition of factors controlling uranium mineralization, classification of uranium occurrences into genetic types, and final delineation of favourable areas; this step corresponds to the selection of targets for uranium exploration. The third step includes geological field work; it is equivalent to geological reconnaissance in exploration. The fourth step comprises computation of resources; the preliminary evaluation techniques in the exploration are, as a rule, analogous with the simplest methods employed in the resource evaluation. The uranium resources evaluation model can be conceptually applied for decision-making during exploration or for formulation of exploration strategy using the quantified data as weighting factors.

# Ruzicka, V.

GEOLOGICAL FAVOURABILITY FOR VARIOUS TYPES OF URANIUM DEPOSITS IN CANADA; Geol. Assoc. Can./Mineral. Assoc. Can.; Abstr., v. 1, p. 38, 1976.

Metallogenic processes leading to formation of economic uranium deposits are closely related to petrogenetic processes. According to the relationship between those two groups of geologic features, i.e. uranium deposits and rocks, and according to kinds of processes involved, several genetic types of uranium deposits can be distinguished. The conceptual model simulating processes leading to formation of syngenetic conglomeratic deposits postulates granitic source terranes, oxygen-deficient environment, extensive drainage system, source of excessive sulphur, etc. The genetic model of veins and related types of uranium deposits postulates such prerequisites as penetration of uranium-bearing solutions from oxidizing to reducing environments, presence of unconformities, favourable lithostratigraphic units, etc. Although no economic uranium deposits in sandstones are known in Canada yet, there are indications of this type of mineralization in some Phanerozoic basins containing continental sandstones, where geochemical conditions suitable for generation of uranium-bearing fluids, Redox front in permeable environments and lithological and/or structural traps occur. A genetic model simulating uranium mineralization in granitic-pegmatitic rocks postulates magmatic differentiation as the important ore-forming process, but the deposits may be modified by supergene enrichment or by segregation of uranium mineralization by metamorphism. The remaining types of uranium deposits are either of syngenetic or of epigenetic origin. Favourability of their immediate environments depends upon their location within individual uranium-bearing metallogenic provinces, and upon the mobility-stability equilibria of uranium in them.

#### Sangster, D.F.

POSSIBLE ORIGINS OF LEAD IN VOLCANOGENIC MASSIVE SULPHIDE DEPOSITS OF CAL-ALKALINE AFFILIATION; Geol. Assoc. Can., Sp. Paper 14, 1976.

# Scott, W.J. and Hunter, J.A.

APPLICATIONS OF GEOPHYSICAL TECHNIQUES IN PERMAFROST REGIONS; Can. J. Earth Sci., v. 14, p. 117-127, 1977.

This paper reports the results of some recent geophysical experiments carried out in the Arctic with a variety of methods. In the Beaufort Sea, seismic refraction profiles obtained with both source and receivers on the seabottom indicate the presence of discontinuous nearbottom high-velocity (4200 m/s) material interpreted to be presently aggrading permafrost. Spring-time resistivity soundings taken through the ice in Kugmallit Bay, Beaufort Sea, show the top of permafrost at about 50 m below the bottom. Even for 5-km spreads, the base of permafrost was not observed.

Off the southeast coast of Melville Island, refraction seismic profiles shot on the seabottom and resistivity soundings made through summer ice yielded data which correlate with known sub-bottom geology, but which gave no clear indication of either presence or absence of permafrost.

Seismic and resistivity measurements made at a number of control sites in the Arctic Islands yielded typical velocities of 3500 m/s and resistivities of  $1 \times 10^6$  ohm-m for ice-saturated sands. Some correlation was observed between seismic velocity and moisture contents in the range from 10% to 40%.

Seismic and resistivity results in IOL Lake at the Involuted Hill test site, Tuktoyaktuk Peninsula, suggest the absence of permafrost under some parts of the lake bottom. On the hill itself, seismic up-hole shooting and VLF resistivity profiling give interpretations of ice distribution which correlate well with drill control. Gamma-gamma logs taken in some of the drill holes correlate well with ice content logged during drilling.

#### Sen Gupta, J.G.

DETERMINATION OF LANTHANIDES AND YTTRIUM IN ROCKS AND MINERALS BY ATOMIC-ABSORPTION AND FLAME-EMISSION SPECTROMETRY; Talanta, v. 23, p. 343-348, 1976.

The sensitivity of atomic-absorption and flameemission determination of lanthanides and yttrium is improved by a factor of 2-5 when an absolute ethanol solution of the perchlorate of the metal (instead of an aqueous solution) is aspirated into a nitrous oxide-acetylene flame. Based on this, a method has been developed for accurate determination of small amounts of certain rare earths and yttrium. Lanthanum (1%) is used as a spectroscopic buffer to eliminate interferences and to enhance the sensitivities in certain determinations. Where the use of lanthanum is not practicable because of interferences (such as in the determination of praseodymium and samarium by flame emission), sodium (2000 ppm) is used as the spectroscopic buffer. Studies with synthetic solutions indicate that yttrium and most lanthanides can be directly determined in minerals without any chemical separation. With rock samples it is necessary to preconcentrate the traces of the rare earths by fluoride or oxalate precipitation with calcium as the carrier, followed by removal of calcium by hydroxide precipitation using mg amounts of iron as the carrier. The method developed has been applied to the determination of certain lanthanides and yttrium in a variety of rocks, including the Canadian reference rocks, syenites SY-1, SY-2 and SY-3, and some minerals such as britholite, cenosite, chevkinite, allanite, apatite and sphene.

### Sinha, A.K. and Frisch, Thomas

WHOLE-ROCK Rb/Sr AND ZIRCON U/Pb AGES OF METAMORPHIC ROCKS FROM NORTHERN ELLESMERE ISLAND, CANADIAN ARCTIC ARCHIPELAGO. II. THE CAPE COLUMBIA COMPLEX; Can. J. Earth Sci., v. 13, p. 774-780, 1976.

Although not clearly separable on field and petrographic criteria, the gneisses of the Cape Columbia Complex, one of the two major crystalline terrains in the Northern Ellesmere Fold Belt, fall into two Rb/Sr age groups: nine samples define an isochron corresponding to an age of  $1083 \pm 18$  m.y.,  $Sr_0 = 0.7057$ , while six samples show more scatter at  $512 \pm 90$  m.y.,  $Sr_0 = 0.7189$ . Zircons from two gneisses have  $^{207}$  Pb/ $^{206}$ Pb, i.e. minimum, ages of 926 and 980 m.y. These data are interpreted as indicating that the rocks were recrystallized in the amphibolite facies about 1000 m.y. ago; little significance is attached to the younger Rb/Sr age. However, the possibility that the rocks are orthogneisses emplaced about 1000 m.y. ago, cannot be excluded. In any event, the Cape Columbia Complex becomes the latest addition to the growing list of occurrences of 900-1200 m.y.-old ('Grenville-Sveco-Norwegian') rocks in the North Atlantic craton and environs.

#### Sinha, A.K.

INFLUENCE OF ALTITUDE AND DISPLACEMENT CURRENTS ON PLANE-WAVE EM FIELDS; Geophysics, v. 42, no. 1, p. 77-91, 1977.

Airborne electromagnetic mapping by wavetilt measurement is especially suitable for highly resistive strata like the permafrost terrains of northern Canada. A theoretical study has been made on the influence of the altitude of the aircraft and displacement currents on the measured wave tilt values over a range of frequency from VLF (very low frequency) to BCB (broadcast band).

A computer modeling study has shown that the effects of displacement currents cannot be ignored over resistive ground if the frequency is greater than 100 kHz. The altitude effect is significant beyond 2 m for medium frequencies and resistive ground. The phase of the wavetilt is almost always more sensitive to these factors than the amplitude. When the top layer is thicker than three skin depths in that layer, the effects of lower layers on the wavetilt is negligible. It is also apparent that before attempting to interpret wavetilt data over a layered medium, one should carefully determine the nature of the source field.

The results are readily applied to the Barringer Ephase System, an airborne EM technique which measures the quadrature part of the wavetilt at three frequencies from VLF to BCB range. If the effects of altitude and displacement currents are ignored, the calculated apparent resistivities from E-phase data will be much less than the true resistivities, even for moderately resistive ground. A graphical technique is presented for correctly estimating the resistivity values from two-frequency E-phase measurements when the electrical constants are not frequency dependent.

### Sinha, A.K.

DETERMINATION OF GROUND CONSTANTS OF PERMAFROST TERRAINS BY AN ELECTROMAGNETIC METHOD; Can. J. Earth Sci., v. 13, p. 429-441, 1976.

The generalized solution of the scattering of electromagnetic fields by an **n**-layer earth in the presence of oscillating magnetic dipoles carrying harmonic currents has been obtained. The solutions are valid for all frequency ranges and for arbitrary parameters of the **n**-layer earth. The results have been expressed in terms of six infinite integrals, four of which depend on the transverse electric modes and the rest on the transverse magnetic modes. These solutions have been used to obtain the generalized expressions for the mutual coupling ratios for five coil systems, most often used in the geophysical industry.

Using the solutions, a study has been made on the relative performance of the five coil systems for mapping permafrost terrains by multifrequency techniques, assuming the earth to be a homogeneous lossy dielectric, which may be a valid model in winter. It has been observed that the responses in all five coil systems are quite similar, but the magnitude of the response is largest in the horizontal coplanar system. A graphical technique of obtaining the resistivity and dielectric constant of the ground from the mutual coupling ratios has also been described. The results would be useful for designing portable multifrequency e.m. dipole systems for the detection and delineation of permafrost at high latitudes. The inclined, parallel, null-coupled system comes next in order of preference for the mapping of permafrost terrain, followed by the vertical coplanar and the perpendicular systems.

# Stalker, A.MacS.

INDICATIONS OF WISCONSIN AND EARLIER MAN FROM THE SOUTHWEST CANADIAN PRAIRIES; N.Y. Acad. Sci., Ann., v. 288, 1976.

The Taber Child is the most direct evidence for presence of man on the Canadian Prairies before retreat of the last Wisconsin glacier. It consists of the skull and some other bones from a four month old child, found in alluvial sand some 60 feet below prairie level at a fresh exposure along Oldman River just north of Taber, Alberta. Because the sand beds lay beneath a Classical Wisconsin till, the child is at least early Classical Wisconsin in age. Further, the bones compare in mineralization and preservation to Mid Wisconsin or perhaps Younger Wisconsin bones recovered from near Medicine Hat, to the east. Elsewhere the unit that contained them yielded radiocarbon dates of 36 000 and >49 000 years. At the Reservoir Gully Site in Medicine Hat, Alberta, intertill beds of probable Midclassical Wisconsin age contain fractured cherts that do not appear to have formed naturally. Because these beds are no older than those that contained the Taber Child, and perhaps substantially younger, the fracturing could well have been done by man. In addition, older sites near Medicine Hat, and possible others in Saskatchewan, have yielded fractured and flaked cherts that appear to need presence of man for their creation. These sites are in late Sangamon beds, and probably between 120 000 and 80 000 years old. Both Reservoir Gully and the Sangamon Sites contain abundant, scattered bones from animals well suited to support a human population.

### Stalker, A.MacS.

QUATERNARY STRATIGRAPHY OF THE SOUTH-WESTERN CANADIAN PRAIRIES; from Quaternary Stratigraphy at North America, ed. W.C. Mahaney; Dowden, Hutchison & Ross Inc., Stroudsberg, P.A., 1976.

Quaternary sections are magnificently displayed along the valleys of the South Saskatchewan River System, in the southwestern Canadian Prairies. These sections, along with vertebrate fossils collected from some 40 sites, have enabled the preparation of a composite stratigraphic column for the Quaternary of the region. This paper deals mostly with the Laurentide part of this column, which is better known than the Cordilleran sequence. The vertebrate paleontology chronology is used, although its use of certain time terms has not, in the past, always corresponded directly with their use by the glacial geologist.

Some deeply weathered Cordilleran till, found near the mountain front, may represent an extensive, early, Cordilleran glaciation. It has not been adequately investigated. In addition, much of the late Pliocene and early Pleistocene Saskatchewan gravels and sands, a unit found beneath the lowest till in buried valleys on the plains, may be outwash from such early Cordilleran glaciers. If so, these tills and gravels give the first indication of Cenozoic glaciation for the region.

The Wellsch Valley Site, north of Swift Current in Saskatchewan, gives the first sign of Laurentide glaciation. Here stones brought by glaciers from the Canadian Shield are found in deposits containing late Blancan and early Irvingtonian vertebrate fossils, and these deposits are probably of Nebraskan or Aftonian age.

At Wascana Creek, near Regina, Pearlette type 0 ash, with an apparent Kansan age of between 600 000 and 700 000 years, overlies at least two till sheets. The relation of these tills to the four that overlie the fossil bed at Wellsch Valley is unknown; however, the unit containing the ash is probably of much the same age as the Saskatchewan gravels and sands at Medicine Hat, which contain an extensive, late Kansan, vertebrate fauna. As these are the oldest surficial deposits found at Medicine Hat, southern Alberta appears to have escaped the early Laurentide glaciers that covered the Regina-Wellsch Valley region.

At Medicine Hat, after a hiatus of unknown duration, a thick section of silt, sand, and clay was deposited over the Saskatchewan gravels and sands. These stream and pond deposits contain a Yarmouthian vertebrate fauna near their base. They are overlain by tills of Illinoian age, which in turn are overlain by Sangamon alluvium. This alluvium includes the most intensively studied beds at Medicine Hat, and it has produced an abundant, varied and most interesting fauna. Some four Wisconsin tills, separated by beds of sand and gravel, overlie it. The highest of these Wisconsin intertill units contains abundant vertebrate fossils, the bottom unit a more restricted fauna.

Laurentide tills and Cordilleran deposits interfinger west of Lethbridge. Unhappily, Pleistocene vertebrate fossils are rare there, and only a tentative correlation between that section and the Laurentide sequence at Medicine Hat is possible.

MacLeod, N.S., Tiffin, D.L., Snavely, P.D., Jr., and Currie, R.G.

GEOLOGIC INTERPRETATION OF MAGNETIC AND GRAVITY ANOMALIES IN THE STRAIT OF JUAN DE FUCA, U.S.-CANADA.

A gravity and magnetic survey of the Strait of Juan de Fuca and adjacent Pacific continental shelf was conducted to define the tectonic framework in this 20 to 35 km wide seaway and its relation to that of Vancouver Island and the Olympic Peninsula. The offshore extensions of large onshore faults are delineated by linear magnetic and gravity anomalies. One of these, the Leech River fault of southern Vancouver Island, marks the northern limit of oceanic-type basaltic basement present in western Washington and Oregon. This fault probably continues southeastward from Vancouver Island across the Strait to near the northeastern coast of the Olympic Peninsula, and westward across the strait to the continental shelf off Cape Flattery. The Calawah fault, which extends northwestward from near Cape Flattery onto the Pacific shelf, terminates the Leech River fault. Northwest of the Leech River fault on the shelf, the Calawah fault probably is the contact between oceanic and continental crustal types. The gravity and magnetic data also indicate the location of folds, other faults, and areas of shallow basement rocks.

#### Tozer, E.T.

DEFINITIONS AND LIMITS OF TRIASSIC STAGES AND SUBSTAGES; SUGGESTIONS PROMPTED BY COMPARI-SONS BETWEEN NORTH AMERICA AND THE ALPINE-MEDITERRANEAN REGIONS; in Oesterreichische akademie der wissenschaften. Schriftenreihe der Erdwissenschaftlichen Kommissionen, Bd. 2, p. 195-206.

#### Vilks, Gustavs and Rashid, M.A.

POST-GLACIAL PALEO-OCEANOGRAPHY OF EMERALD BASIN, SCOTIAN SHELF; Can. J. Earth Sci., v. 13, p. 1256-1267, 1976.

Two sediment cores taken from Emerald Basin, Nova Scotia are discussed in terms of organic geochemistry and foraminifera. The analytical results are used to infer changes in the marine environment in Emerald Basin during the last 15 000 y.

The fine sediments contained relatively low amounts of organic carbon, plant pigments, sulphides with respect to total sulphur, and only background values of methane. The data indicate that the bottom of the Basin has been well oxygenated since the Late Wisconsin, including the times of lowest sea level. The foraminiferal assemblages varied from estuarine-nearshore fauna in the older sediments to the outer shelf-normal marine faunas in the surface sediments. Planktonic foraminifera were found in all levels of the cores.

The faunal evidence indicates that during the Late Wisconsin sea-level minimum and the period of glacial waning, the bottom salinities of the Basin were in the order of 20 . Emerald Basin was connected to the ocean via a wide but shallow sill that allowed the exchange of Basin waters with only relatively diluted surface waters of the ocean.

#### Vilks, G.

FORAMINIFERA OF AN ICE-SCOURED NEARSHORE ZONE IN THE CANADIAN ARCTIC; Ist. Int. Symp. on Benthonic Foraminifera of Continental Margin. Part A. Ecology and Biology; Marit. Sediments, Spec. Publ. 1, p. 267-277, 1976.

Benthonic foraminifera were studied in 19 cores collected by SCUBA divers in Byam Channel in the Canadian Arctic Archipelago. The divers observed that the nearshore Byam Channel sea floor was considerably modified by ice scouring. The three most dominant species in the first 10 cm of core were identified as **Spiroplectammina biformis**, **Textularia torquata**, and **Trochammina nana**, which are typical of the nearshore waters surrounding the Queen Elizabeth Islands. In the first 2 cm of core the ratio of calcareous to arenaceous species increases at localities closer to the Viscount Melville Sound. In the subsurface layers (2 to 5 cm) calcareous species occur in significantly greater numbers than in the surface layer throughout the study area. A distinctive subsurface layer in most of the cores may indicate that ice scouring normally does not overturn the sediment. The increasing abundance of calcareous species with depth in the cores suggests that Byam Channel once had longer open-water seasons than it does today.

#### Vilks, Gustavs

COMPARISON OF GLOBOROTALIA PACHYDERMA (EHRENBERG) IN THE WATER COLUMN AND SEDIMENTS OF THE CANADIAN ARCTIC; J. Foram. Res., v. 5, no. 4, p. 313-325, 1975.

Planktonic foraminifera were collected from the water column and sediments of the Beaufort Sea and the Northwest Passage of the Canadian Arctic Archipelago at 175 The mean maximum diameter of specimens localities. collected in the sediment is significantly larger (238 microns) in comparison to specimens collected in the water column (197 microns). The specimens from sediments also have significantly larger mean numbers of chambers per test (11) in comparison to 9 for the living population. These results indicate that in the Arctic environment the preservation is selective towards the larger and older Globorotalia pachyderma. The preserved assemblage of variants contains significantly larger percentages of specimens with 4 chambers in the last whorl and in the quadrate growth stage. By comparing the living and fossil assemblages, a minimum average loss of 80 percent is estimated as due to dissolution or destruction by predators. The normal form tests and tests from a highly productive population with short turnover periods may suffer a much greater destruction and consequently leave very little evidence in the sediments.

Surface textures of preserved specimens are not significantly different from the surface textures of encrusted specimens from the water column, indicating that in the Arctic environment the addition of calcite to the test terminates with the death of the individual.

#### Wall, J.H.

MARGINAL MARINE FORAMINIFERA FROM THE LATE CRETACEOUS BEARPAW-HORSESHOE CANYON TRAN-SITION, SOUTHERN ALBERTA, CANADA; J. Foram. Res., v. 6, no. 3, p. 193-201, 1976.

An entirely agglutinated foraminiferal fauna of late Campanian age is found at three levels of the transition between the Bearpaw and Horseshoe Canyon Formations in the Canadian Pacific Oil and Gas Strathmore well, southern Alberta. The generic composition and very low diversities of the assemblages favor the interpretation of a salt marsh environment over that of a hyposaline lagoon or shallow shelf. One species each of Miliammina, Ammotium, Trochammina, Verneuilinoides, and Eggerella are described, none of which is proposed as new.

Wall, J.H., Caldwell, W.G.E., North, B.R., and Stelck, C.R.

A FORAMINIFERAL ZONAL SCHEME FOR THE CRETACEOUS SYSTEM IN THE INTERIOR PLAINS OF CANADA; Geol. Assoc. Can., 1976 Ann. Mtg., Edmonton, Alberta; Abstr., v. 1, p. 45.

The Cretaceous sediments underlying the Interior Plains of Canada accumulated in a northerly segment of the vast seaway that flooded the Western Interior basin of North America. Shallow and temperate, the waters supported rich foraminiferal and molluscan faunas and permitted their migration between what are now the Arctic and Gulf coasts.

Most foraminiferal faunas are mixtures of arenaceous and calcareous benthonic elements; two are dominated by pelagic elements. In the last two decades, these faunas have been used in different parts of the plains to establish more than twenty-five zones. Enough now is known about the faunas to propose a zonal scheme for the plains as a whole and to relate it to the more refined scheme based on ammonites.

Both epeirogenic and orogenic movements caused continual and, at times, rapid changes in geography, which are recorded in facies variations, diachronism, and disconformities. Not surprisingly, therefore, only some foraminiferal zones maintain their consistency across the entire plains; others have relatively local distributions or display changes in composition laterally. For example, the oldest zones are largely confined to northern Alberta, where they represent deposits of the boreal arm of the Western Interior seaway as it encroached southward in Albian time; the youngest zones are best developed in Saskatchewan, where open-marine conditions prevailed in Campanian-Maestrichtian time, although one of them, representing the peak transgression of mid-Bearpaw time, can be traced into the Rocky Mountain foothills. Zones of latest Albian, early Turonian, and early Santonian ages are most consistent and widespread, and these correspond to times when the Western Interior seaway was most expanded.

Duedall, Iver W., Dayal, Ramesh, and Willey, Joan D.

THE PARTIAL MOLAL VOLUME OF SILICIC ACID IN 0.725*M* NaCl; Geochim. Cosmochim. Acta, v. 40, p. 1185-1189, 1976.

The partial molal volume (V) of silicic acid in 0.725 m NaCl at 20°C has been calculated from (1) direct volume changes due to the dissolution of anhydrous sodium silicate and (2) some literature values for the partial molal volumes of NaOH and water.  $V_{Si}(OH)_4$ , uncorrected for electrostriction effects, was found to be  $53 \pm 2$  ml mole<sup>-1</sup>.  $V_{Si}(OH)_4$ , corrected for volume changes due to solvent electrostriction by charged Si species, was estimated to be in the range 58-62 ml mole<sup>-1</sup>; this range is 7-11 ml mole<sup>-1</sup> greater than the  $V_{Si}(OH)_4$  calculated from Willey's (Mar. Chem. 2. 239-250, 1974) solubility data obtained from the dissolution, in seawater, of amorphous silica subjected to hydrostatic pressure. Our  $V_{Si}(OH)_4$  does, however, agree within experimental error with the  $V_{Si}(OH)_4$  calculated from Jones and Pytkowicz's (Bull. Soc. Roy. Sci. Liege 42, 118-120, 1973) data for the solubility of amorphous silica in seawater at high pressure and is nearly in agreement with Willey's (Ph.D. thesis, Dalhousie University, 1975) solubility data for amorphous silica in 0.6 m NaCl.

# Willey, Joan D.

GEOCHEMISTRY AND ENVIRONMENTAL IMPLICA-TIONS OF THE SURFICIAL SEDIMENTS IN NORTHERN PLACENTIA BAY, NEWFOUNDLAND; Can. J. Earth Sci., v. 13, p. 1393-1410, 1976.

Three chemically distinct sediment types, as defined by factor analysis, occur in northern Placentia Bay; these correspond to the muds, the sands, and the amodal sediments (tills) in this area. Factors that control the sediment geochemistry in Placentia Bay are: the organic-rich fraction, the clay-size fraction, the calcium carbonate fraction, the iron-containing fraction, the non-clay-size aluminous minerals, and the silica-rich fraction. The relative importance of these factors in controlling sediment chemistry is different in each sediment type. The trace metal concentrations and associations are also different in the three sediment types.

The weak acid leachable fractions of the metals investigated are derived primarily from the organic material, the clay-size fraction, and the calcium carbonate, even in the sands where these three fractions are only a small part of the sediment. The non-leachable fractions of the metals are controlled by the organic material and by minerals such as feldspars and micas. The average concentrations of the major components and of the trace metals, and the factors that control these concentrations, are not significantly different in Long Harbour sediments (after five years of operation of the phosphorous plant there) compared with similar sediments in Placentia Bay. The association of Pb in Long Harbour sediments may be different than in other areas.

# Woodsworth, G.J., Pearson, David E., and Sinclair, A.J.

METAL DISTRIBUTION PATTERNS ACROSS THE EASTERN FLANK OF THE COAST PLUTONIC COMPLEX, SOUTH-CENTRAL BRITISH COLUMBIA; Econ. Geol., v. 72, p. 170-183, 1977.

Machine-plotted maps of metal distributions, combined with field work, indicate the presence of a previously unrecognized regional zoning pattern in the Taseko Lakes and Pemberton map-areas. Mineral deposits occur in well-defined camps, the most productive of which has been the Bridge River gold camp. A distinctive asymmetric metal and mineral zoning pattern occurs in the Bridge River district. Two elongate, northwesterly trending centers of gold-bearing vein deposits lie within a larger area characterized by antimony minerals. The antimony zone is succeeded to the northeast by a mercury zone. This pattern is explained by mineral deposition under a regional thermal gradient decreasing outward from the eastern margin of the Coast Plutonic Complex, implying that mineralization occurred during or shortly after final cooling of the eastern margin of the Coast Plutonic Complex about 50 m.y. ago.

Porphyry deposits occur in geographically separate areas from most vein deposits. Porphyry mineralization occurred during the Late Cretaceous, early Tertiary, and Miocene. Copper-molybdenum-gold porphyry deposits characterize the first two events, whereas porphyry molybdenum deposits formed during the Miocene. Principal movements along the Yalakom fault predated mineral deposition in the Bridge River camp. Late Tertiary porphyry molybdenum deposits appear genetically related to Cascade volcanism rather than to plutonism of the Coast Plutonic Complex.

# Young, G.M. and Long, D.G.F.

ICE-WEDGE CASTS FROM THE HURONIAN RAMSAY LAKE FORMATION (> 2,300 m.y. OLD) NEAR ESPANOLA, ONTARIO, CANADA; Palaeogeogr., Palaeoclimatol., Palaeoecol., v. 19, p. 191-200, 1976.

Two structures interpreted as ice-wedge casts occur in the lower Huronian Ramsay Lake Formation of the north

shore of Agnew Lake, north of Espanola, Ontario. They are the oldest known examples of such structures. By analogy with presently forming ice-wedges, they suggest a cold, humid, subaerial environment, lending support to the glacial origin of the Ramsay Lake Formation, and by inference, of other similar mixtites in the lower Huronian sequence of the Agnew Lake area. If the many mixtites present in the lower Huronian of this region are in fact tillites, then a relatively frigid regime can also be postulated for mixtite-free lower Huronian rocks (including uraniferous conglomerates) in other parts of the Huronian outcrop belt.

#### Young, G.M. and Long, D.G.F.

STROMATOLITES AND BASIN ANALYSIS: AN EXAMPLE FROM THE UPPER PROTEROZOIC OF NORTHWESTERN CANADA; Palaeogeog., Palaeoclimatol., Palaeoecol., v. 19, p. 303-318, 1976.

Stromatolites have been used for inter-basinal biostratigraphic correlation, rock-stratigraphic correlation within individual sedimentary basins and for palaeoecological studies of various kinds. In the northern part of Victoria Island stromatolites are abundant in the uppermost part of the Glenelg Formation, which is the lowest unit of the upper Proterozoic Shaler Group. Measureable attributes of these stromatolites include elongate mounds, intermound channel fillings, ridges and grooves, elongate columns and inclined columns. In a widespread stromatolitic bank that forms the upper part of the Glenelg Formation, and also in stromatolites of the overlying Reynolds Point Formation, several of these features show a preferred orientation in a northeasterly direction. Herringbone cross-beds in associated sandy oolitic limestones show a northeast-southwest bimodalbipolar distribution that is probably related to tidal activity. This similarity of directional features suggests that the stromatolite orientations are also likely to have been tidally influenced. If each stromatolitic bank were deposited diachronously then the northeasterly preferred orientation may be explained as being due to tidal currents active at a migrating shoreline that trended in a northwest-southeast direction. Alternatively, if, in the absence of metazoan competitors, the stromatolite builders contemporaneously occupied a large part of the basin floor, their northeasterly orientation may reflect tidal currents parallel to the length of an elongate embayment of the Precambrian sea, analogous in many ways to the present-day Persian Gulf. Such an interpretation, involving parallelism between coastline and elongate stromatolites, would differ from those of most earlier reports, in which elongate stromatolites have generally been assumed to have been oriented normal to the ancient shoreline.