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ABSTRACTS OF PUBLICATIONS IN SCIENTIFIC JOURNALS BY OFFICERS OF THE GEOLOGICAL SURVEY OF CANADA, APRIL 1978 TO MARCH 1979

RÉSUMÉS DE PUBLICATIONS PAR LES CHERCHEURS DE LA COMMISSION GÉOLOGIQUE DU CANADA PARUES DANS DES REVUES SCIENTIFIQUES AVRIL 1978 - MARS 1979



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RÉSUMÉS DE PUBLICATIONS PAR LES CHERCHEURS
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Abbey, S. and Govindaraju, K.

ANALYTICAL DATA ON THREE ROCK REFERENCE SAMPLES FROM THE INSTITUTE OF GEOCHEMISTRY, IRKUTSK, USSR; GEOSTANDARDS NEWSLETTER, v. 2, no. 1, p. 15-22, 1978.

Analytical data obtained in our two laboratories on three rock samples from the Institute of Geochemistry, Irkutsk, are reported and compared with "established", "certified" and "uncertain" values. Methods used are described briefly and some comments offered on earlier published information.

Les données analytiques obtenues dans deux laboratoires sur trois roches standards fournies par l'Institut de géochimie d'Irkutsk, sont présentées et comparées avec les valeurs "établies", "certifiées" et "incertaines". Les méthodes analytiques employées sont brièvement rappelées avec quelques commentaires sur les anciennes données publiées.

Abbey, Sydney and **Maxwell, J.A.**

A CRITICAL COMMENT ON: AN INDIRECT METHOD FOR THE SEQUENTIAL DETERMINATION OF SILICON AND PHOSPHORUS IN ROCK ANALYSIS BY ATOMIC ABSORPTION SPECTROMETRY; ANALYTICA CHIMICA ACTA, v. 99, p. 397-398, 1978.

Agterberg, F.P. and **Divi, S.R.**

A STATISTICAL MODEL FOR THE DISTRIBUTION OF COPPER, LEAD, AND ZINC IN THE CANADIAN APPALACHIAN REGION; ECONOMIC GEOLOGY, v. 73, p. 230-245, 1978.

It is assumed that random sampling by means of blocks of constant weight yields lognormally distributed copper, lead, and zinc concentration values in the Canadian Appalachian Region. The cumulative frequencies of the highest values belonging to these distributions are determined by approximation from the average grade values and ore tonnages of all types of sulfide deposits in the region. When the average value of the lognormal distribution for a metal is set equal to this metal's clarke, it is possible to construct a separate lognormal distribution for any observed cumulative frequency value. These different distributions are shown to have approximately the same shape for each metal when the metal grade exceeds 1 percent for Cu, 2 percent for Pb, and 5 percent for Zn, respectively. Application of these lognormal distributions to lower grade material yields estimated frequencies which are significantly larger than the corresponding observed frequencies. It is demonstrated that the fitted lognormal distributions are not sensitive to rather large changes in the assumed weight of the segment of the earth's crust used for control and in the assumed clarke values. This approach may be useful in estimating subeconomic resources.

Agterberg, P.

ANALYSIS OF SPATIAL PATTERNS IN THE EARTH SCIENCES; in D.F. Merriam, Editor: GEOMATHEMATICS: POST, PRESENT AND PROSPECTS; Syracuse University Geology Contribution 5, p. 7-18, 1978.

This paper contains some comments on the role of geomathematics in geoscience and its relationship with mathematical statistics. Examples are given of (a) multivariate analysis, and (b) image analysis of geological map patterns.

Agterberg, F.P. and **Fabbri, A.G.**

STATISTICAL TREATMENT OF TECTONIC AND MINERAL DEPOSIT DATA; Global Tectonics and Metallogeny, v. 1, no. 1, 1978.

This paper contains a brief review of recent work on the statistical treatment of tectonic and mineral deposit data and some suggestions for further work. It also contains a case history study of image processing and subsequent statistical techniques applied to a set of Kuroko deposits in Japan.

Cette publication fait une revue d'études récentes dans le domaine des traitements statistiques de données tectoniques et d'autres sur les gîtes minéraux; elle suggère aussi des travaux futurs. On fait l'analyse d'un groupe de gisements "Kuroko" au Japon en utilisant des techniques de la morphologie mathématique.

Agterberg, F.P.

ESTIMATING THE AVERAGE SIZE OF OBJECTS FROM MEASUREMENTS ON SECTIONS; In. M.A. Romanova and N.A. Sapolov: Research in Mathematical Geology, NAUKA, Leningrad, p. 90-99 (in Russian); 1978.

The paper deals with methods to estimate the moments of size-distributions of spheres from measurements of circular intersections on sections. The spheres are assumed to have centres which are randomly distributed in three-dimensional space. The sections are also located at random.

It is pointed out that the moments of the volume-under-size distribution of the spheres can be readily estimated from the moments of the area-under-size distribution of the circles measured on the section. The resulting estimates are unbiased and robust to errors in the lower tail of the measured size distribution.

Mountjoy, E.W. and **Aitken, J.D.**

MIDDLE CAMBRIAN SNAKE INDIAN FORMATION (NEW) JASPER REGION, ALBERTA; BULLETIN OF CANADIAN PETROLEUM GEOLOGY, v. 26, no. 3, p. 343-361, 1978.

The Snake Indian Formation, named after Snake Indian River, is proposed for an 800 to 2000 ft (244 to 610 m) section of shale containing thinner limestone units that underlies the Eldon (Titkana) Formation and overlies the Gog Group or Hota Formation. This distinctive, recessive-weathering unit occurs throughout much of Jasper National Park and was previously referred to as "map-unit 3." The type section is located on the north spur of Chetamon Mountain 13 mi (21 km) north of Jasper, Alberta. The lithology, paleontology, distribution and correlation are briefly outlined. The Snake Indian contains four Middle Cambrian zones: Plagiura-'Poliella', Albertella, Glossopleura, and lower Bathyuriscus-Elrathina, of which only the latter three have been identified at the type section. Correlative formations in the Bow Valley region are the Mount Whyte, Cathedral and Stephen; in the Mount Robson area, the Chetang and Tatei; and in the subsurface to the northeast, the lower half of the Earlie Formation.

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

MACKENZIE TECTONIC ARC—REFLECTION OF EARLY BASIN CONFIGURATION?; *Geology*, v. 6, p. 626-629, 1978.

Parallelism is demonstrated between the arcuate structure of the Mackenzie Mountains and certain elements in the deformed pile of sedimentary rocks, namely: (1) unrestored zero edges of the younger Proterozoic (Windermere equivalent) succession and its constituent formations, and (2) isopachs of three widely spaced formations in the older Proterozoic (Belt-Purcell equivalent) succession.

The data suggest that the configuration of the northeastern flank of the Proterozoic basin(s), established during the Helikian, preordained the arcuate form of the Mackenzie Mountains.

Hofmann, H.J. and Aitken, J.D.

PRECAMBRIAN BIOTA FROM THE LITTLE DAL GROUP, MACKENZIE MOUNTAINS, NORTHWESTERN CANADA; *Canadian Journal of Earth Sciences*, v. 16, p. 150-166, 1979.

Well preserved Precambrian algal microfossils and megafossils have been recovered in the northern Mackenzie Mountains from several levels and localities in a basinal, limestone-dominated rhythmite formation of the Little Dal Group. The microbiota includes the filaments *Archaeotrichion*, *Taeniatum*, and *Siphonophycus*, and the sphaeromorph acritarchs *Kildinella*, *Trachysphaeridium*, *Nucellosphaeridium*, and *Chuaria circularis*. The megafossils, all of probable algal affinities, comprise large carbonaceous ribbons assigned to the new vendotaenid species *Tawuia dalensis* n.g. n. sp., and the irregular compressions *Moriana?* *antiqua* and *Beltina danai*. The same formation has also yielded a dubiofossil probably representing traces on bedding planes made by small cylindrical, discoid, or spheroidal organisms, questionably referred to *Bergaueria*. The biota suggests a late Helikian to early Hadrynian age (1.1—0.8 Ga) for the Little Dal Group, and adds to the growing body of evidence for the existence of eucaryotic organisms at that time.

On décrit des mégafossiles et microfossiles algaires d'âge précambrien provenant de plusieurs niveaux et localités d'une formation à rythmites calcareuses du groupe de Little Dal dans les monts Mackenzie. La microflore comprend les filaments *Archaeotrichion*, *Traeniatum* et *Siphonophycus*, les Acritarches sphéromorphes *Kildinella*, *Trachysphaeridium*, *Nucellosphaeridium* et *Chuaria circularis*. Les mégafossiles, tous probablement d'affinités algaires, comprennent de grands rubans carbonés de *Tawuia dalensis* n.g. n. sp., appartenant aux Vendotaenidés, et les compressions irrégulières de *Moriana?* *antiqua* et *Beltina danai*. La même formation a livré un dubiofossile qui est rapporté avec doute à *Bergaueria* et qui représente probablement des traces laissées par de petits organismes cylindriques, discoïdes ou sphéroïdes sur des plans de stratification. Le biota suggère un âge néohélikien à paléohadrygien (1.1—0.8 Ga) pour le groupe de Little Dal, et apporte des évidences supplémentaires sur l'existence des eucaryotes à ce moment là.

Balkwill, H.R.

EVOLUTION OF SVERDRUP BASIN, ARCTIC CANADA; *AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS BULLETIN*, v. 62, no. 6, p. 1004-1028, 1978.

Sverdrup basin, a structural depression near the northern margin of the North American craton, contains a succession up to 13,000 m thick of Lower Carboniferous to Tertiary, marine and nonmarine sedimentary rocks, basalt flows, and gabbro dikes and sills.

The basin evolved in five phases: (1) late Paleozoic, when evaporites and marine muds were deposited in the axial region and carbonates and mature sands on the margins; (2) early Mesozoic, when great thicknesses of siltstone and shale accumulated in axial parts of the basin; (3) middle Mesozoic, when terrigenous clastic deposits accumulated slowly; (4) late Mesozoic, when clastic deposits widely overstepped former basin margins; and (5) late Mesozoic-Cenozoic, when the basin underwent three stages of tectonism (Eurekan orogeny).

Some evaporite diapirs in the basin developed halokinetically, beginning probably in the early Mesozoic; others were generated during Tertiary folding and faulting. Mafic volcanism and intrusion occurred episodically at times of basin foundering. Depending on the availability of imported terrigenous detritus, phases of mafic activity (and foundering) were accompanied by widespread marine transgression or by vigorous basin filling.

The thick sedimentary fill masks the fundamental character of the basin. If acutely starved depositional conditions had prevailed through its Paleozoic and Mesozoic history, Sverdrup basin in the latest Cretaceous would have been a small ocean basin with steep sides, a basaltic floor about 3,500 m deep, and a thin succession of deep marine sediments — fundamental attributes of some modern small ocean basins.

Sando, W.J., Bamber, E.W., Armstrong, A.K.

THE ZOOGEOGRAPHY OF NORTH AMERICAN MISSISSIPPIAN CORALS; *Memoires du Bureau de recherches géologiques et minières*; 2nd International Symposium on corals and fossil coral reef, p. 175-184, Paris, 1977.

The distribution of coralliferous facies and the degrees of endemism and generic similarities of Mississippian (early Tournaisian-early Namurian) coral faunas permit recognition of five zoogeographic provinces and five zoogeographic subprovinces in North America: Alaskan province, Pacific Coast province (including Northern and Southern subprovinces), Western Interior province (including Northern, Central and Southern subprovinces), Southeastern province, and Maritime province. Analysis of indices of endemism and similarity suggest the following major conclusions:

1) zoogeographic regions on the periphery of the North American continent (Alaskan, Pacific Coast, and Maritime provinces) had favorable connections for migration to other coralliferous areas of the world, which permitted maximum gene flow,

2) zoogeographic regions in the interior of the North American continent (Western Interior and Southeastern provinces) were relatively isolated genetically and were characterized by coral faunas with low to high endemism throughout Mississippian time,

3) gene flow was highest along continuous shallow water carbonate shelves and was impeded by areas of terrigenous sedimentation and areas of deeper water,

4) similarities between faunas of different zoogeographic regions generally tend to vary inversely with the migration-route distance between these regions, but other factors that affected gene flow modified the distribution patterns significantly.

Bostock, H.H., Currie, K.L. and Wanless, R.K.

THE AGE OF THE ROBERTS ARM GROUP, NORTH-CENTRAL NEWFOUNDLAND; Canadian Journal of Earth Sciences, v. 16, p. 599-606, 1979.

Felsites from the Roberts Arm Group have yielded a Rb-Sr isochron age of 447 ± 7 Ma, with an initial $^{87}\text{Sr}/^{86}\text{Sr}$ of 0.7063, and a genetically related granite pluton has yielded an isochron age of 464 ± 13 Ma, with an initial ratio of 0.7064. The Mansfield Cove oceanic plagiogranite complex, which is in fault contact with the Roberts Arm Group, has yielded a minimum zircon $^{207}\text{Pb}/^{206}\text{Pb}$ age of 594 ± 10 Ma. This plagiogranite, and basaltic rocks of the Hall Hill complex which partly surround it, thus provide a basement of suitable age upon which the Roberts Arm Group may have been deposited. The age of this basement corresponds to that of the opening of the Iapetus Ocean.

The stratigraphic age of the Roberts Arm Group, indicated by these ages, is Middle or possibly Late Ordovician. The volcanics were deposited either before or slightly after the Caradocian black shales of the Notre Dame Bay region. In the former case, Ordovician volcanism around western Notre Dame Bay ceased at about the time of obduction of the allochthons of western Newfoundland. In the latter, volcanism of the Roberts Arm Group marks a north to westward shift of volcanism within the central mobile belt of Newfoundland that occurred in late Middle or early Late Ordovician time. If the Buchans Group is of Silurian age and correlative with the Roberts Arm Group then this lithostratigraphic unit is probably diachronous, younging to the south.

Les roches felsiques du groupe de Roberts Arm ont donné un âge d'isochrone Rb-Sr de 447 ± 7 Ma, avec un rapport initial $^{87}\text{Sr}/^{86}\text{Sr}$ de 0.7063, et un granite qui s'y rattache génétiquement a donné un âge d'isochrone de 464 ± 13 Ma avec un rapport initial de 0.7064. Le complexe de plagiogranite océanique de Mansfield Cove, qui est en contact de faille avec le groupe de Roberts Arm a donné un âge minimum au $^{207}\text{Pb}/^{206}\text{Pb}$ de 594 ± 10 Ma sur des zircons. Ce plagiogranite et les roches basaltiques du complexe de Hall Hill qui l'entourent partiellement fournissent ainsi un socle d'âge adéquat sur lequel le groupe de Roberts Arm a pu se déposer. L'âge de ce socle correspond à celui de l'ouverture de l'océan Iapetus.

L'âge stratigraphique du groupe de Roberts Arm indiqué par ces âges se situe durant l'Ordovicien moyen ou peut-être supérieur. Les roches volcaniques se sont déposées soit avant soit peu après les shales noirs de la région de la baie Notre-Dame au Caradocien. Dans le premier cas, le volcanisme de l'Ordovicien autour de la partie ouest de la baie Notre-Dame a cessé à peu près à l'époque de l'obduction des allochtones de l'ouest de Terre-Neuve. Dans la seconde hypothèse, le volcanisme du groupe de Roberts Arm marque un déplacement du nord vers l'ouest du volcanisme à l'intérieur de la zone mobile de Terre-Neuve à la fin de l'Ordovicien moyen ou au début de l'Ordovicien supérieur. Si le groupe de Buchans est d'âge silurien et corrélatif avec le groupe de Roberts Arm, alors cette unité lithostratigraphique est probablement diachrone, devenant plus jeune vers le sud.

Brassard, R. and Blake, W., Jr.

AN EXTENSIVE SUBFOSSIL DEPOSIT OF THE ARCTIC MOSS APLODON WORMSKIOLDII; Canadian Journal of Botany, v. 56, p. 1852-1859, 1978.

A 2.6-m-thick subfossil peat deposit, composed entirely of the arctic moss *Aplodon wormskioldii*, is described from the Carey Islands, northwestern Greenland ($76^{\circ}44'N$, $73^{\circ}13'W$). Radiocarbon dates indicate that the peat began

forming approximately 6500 years ago and stopped forming some 4500 to 4000 years ago; thus, its growth coincided with the postglacial warm period (Hypsithermal interval). The present-day habitat of *A. wormskioldii*, on dung or otherwise enriched substrates, is difficult to reconcile with its persistence and abundance at a specific site in the high arctic for over two millenia.

Aux îles Carey, au nord-ouest du Groenland ($76^{\circ}44'N$, $73^{\circ}13'W$), on a découvert une accumulation de tourbe de 2.6 m de profondeur, composée entièrement par de la mousse arctique *Aplodon wormskioldii*. Deux datations au radiocarbone indiquent que cette tourbe a été déposée il y a environ 6500 ans avant le présent à 4500-400 ans avant le présent, ce qui correspond à la période postglaciaire la plus favorable (Hypsithermale). L'habitat actuel de cette mousse, qui est restreint aux endroits très enrichis, est difficile à réconcilier avec son abondance et sa persistance à un site spécifique dans l'extrême nord pour à peu près 2000 ans.

Cameron, E.M.

HYDROGEOCHEMICAL METHODS FOR BASE METAL EXPLORATION IN THE NORTHERN CANADIAN SHIELD; Journal of geochemical Exploration, v. 10, p. 219-243, 1978.

The use of lake waters for base metal exploration has been studied in the northern part of the Slave Geological Province of the Canadian Shield. The area is north of the treeline, within the zone of continuous permafrost, and, like most other regions of the Shield, has a high density of small lakes.

A regional sampling of 1218 lakes established that less than 2 ppb ($\mu\text{g/l}$) Zn or Cu is typical of waters from unmineralized terrane. These samples had a median pH of 6.8 and a median specific conductivity of $19.5 \mu\text{mhos}$. Lake waters were also taken from the areas surrounding five massive sulphide occurrences: High Lake, Canoe Lake, Takiyuak Lake, Hackett River and Agricola Lake. In all cases there are unambiguous anomalies for Zn. Anomalies are also present for Cu, but are less intense and extensive. This difference between the two elements is related to the superior mobility of Zn in surface waters and its more consistent presence as a major constituent of massive sulphides.

A water sampling apparatus has been developed and tested on a light turbine helicopter. Using this, thirty sites may be sampled each hour when sampling at a density of 1 site per 2.8 km^2 . Measurement of pH, conductivity and water temperature are recorded in the helicopter during sampling.

A number of factors have been investigated that may influence the utility of lake water sampling for base metal exploration:

1) Seasonal variability, while present to moderate degree, is unlikely to hinder application of the method.

2) For the size of lakes sampled (2 km^2 or less), elements are homogeneously distributed across the lake surface during the ice-free season. During the initial period of break-up there are marked variations in element content around the ice-free lake margin. Sampling during this period may help define the source of metals for anomalous lakes.

3) Study of sample preservation suggests that mobile elements, such as Zn, that are stable in solution within lakes, are also relatively stable when untreated water is stored in plastic bottles.

4) Care must be taken to avoid contamination of the samples, particularly from the bottle.

The areal extent of lake water base metal anomalies appears to be less than equivalent lake sediment anomalies. Thus for wide-interval, regional geochemical reconnaissance, lake sediment sampling is the method of choice. Lake waters are an appropriate medium for detailed exploration of areas of interest, such as volcanic belts. For this application, the principal attractions are rapid sampling rates, and hence low costs, high contrast anomalies, and a uniform sampling medium.

Cecile, M.P. and Campbell, F.H.A.

REGRESSIVE STROMATOLITE REEFS AND ASSOCIATED FACIES, MIDDLE GOULBURN GROUP (LOWER PROTEROZOIC). IN KILOHIGOK BASIN, N.W.T.: AN EXAMPLE OF ENVIRONMENTAL CONTROL OF STROMATOLITE FORM; BULLETIN OF CANADIAN PETROLEUM GEOLOGY, v. 26, no. 2, p. 237-267, 1978.

The Goulburn Group is a thick succession of intracratonic sedimentary rocks deposited within the lower Proterozoic Kilohigok Basin, northwestern Canadian Shield, which have been correlated with strata of the Coronation Geosyncline and the Athapuscow aulacogen. The middle part of the Goulburn Group is comprised of mudstone, carbonate and stromatolitic carbonate rocks and is classified as the 'carbonate-mudstone stratigraphic interval' of the Kilohigok Basin. This interval of sedimentation can be subdivided into early and late stages. The late stage consists of a vertical succession of facies representing: basinal mudstone-dominated and carbonate-dominated environments, a shallow submarine shelf with clastic carbonate and thick mudstones, a complex stromatolite reef and associated stromatolite facies and intertidal-supratidal mudstone. These facies represent a diachronous sequence of once laterally juxtaposed environments which is interpreted to represent a major regression that affected the entire Kilohigok Basin. Stromatolite forms characterize different stratigraphic assemblages that correspond with changes in environmental conditions. Reconstruction of the lateral distribution of a now vertical succession of stromatolitic carbonates shows a basinward to landward pattern of: fore-reef clastics with subtidal stromatolite mounds, reef tract with large subtidal mounds and channeled columns, and a quiet-water back-reef with stromatolite biscuits. Stromatolite elongations are interpreted to define paleo-reef-tract trends.

Becker, A. and Collett, L.S.

MAGNETIC LOSSES IN LUNAR MATERIALS; Earth and Planetary Science Letters, v. 41, p. 139-142, 1978.

Physical constants which define the complex magnetic susceptibility of lunar materials in the frequency domain can be easily determined at frequencies in the vicinity of 1 MHz using a very simple electromagnetic absorption technique. This particular application of absorption measurements derives from the interrelation of the real and imaginary components of the susceptibility of lunar material, and the direct proportionality of the latter component to the power absorbed by the sample when it is exposed to an alternating magnetic field.

The results obtained confirm the validity of the theoretical model of viscous magnetization in lunar material put forward by Hanneken et. al. (1976) and agree very well with data obtained by Stephenson (1971) using an entirely different measurement technique.

Collett, L.S.

INTRODUCTION TO HYDROGEOPHYSICS; in Proceedings, First Canadian National Hydrogeological Conference, in press.

Hydrogeophysics is the application of geophysical techniques to groundwater exploration and water-related investigations. For a geophysical method to work, there must be a physical parameter contrast, eg. electrical resistivity, seismic velocity, density, etc. This physical contrast can usually be related to structural and lithological features in soils and rocks. The electrical resistivity and seismic refraction methods have been most widely used in hydrogeological exploration, and gravity and magnetics to a lesser extent.

The purpose of this paper is to briefly review the state-of-the-art of airborne and surface geophysical methods and their application to hydrogeological investigations. The aim is to provide an introductory guide to the hydrogeologist of how geophysics may be of help to him. Some recent advances in radar sounding and soil moisture determination will be mentioned.

Conaway, J.G. and Killeen, P.G.

QUANTITATIVE URANIUM DETERMINATIONS FROM GAMMA-RAY LOGS BY APPLICATION OF DIGITAL TIME SERIES ANALYSIS; Geophysics, v. 43, no. 6, p. 1204-1221, 1978.

The desired output from a gamma-ray logging system in mining applications is an accurate log of the quantitative distribution of radioelements with depth along the borehole. However, the measured log is not the desired output, but it may be visualized as the desired output modified by a series of low-pass filters of various characteristics. These filters can be related to the distance interval over which each count is made (or the analog ratemeter time constant), the detector length, and the "geologic impulse response" (the response of a point detector to an infinitesimally thin layer of ore of a known grade). In effect, this means that the response due to thin beds is lower than expected, and the resolution will be reduced. An understanding of the nature and properties of these filters will aid in the proper evaluation of the log.

To optimize the accuracy and resolution of quantitative uranium (or other radioelement) determinations, especially in thin beds and complex sequences, it is necessary to keep the counting interval short, and to compensate for the effect of the geologic impulse response. Although the effect of the geologic impulse response may be removed in any of several ways, the use of a simple inverse convolution operator as described here allows the data to be processed on-line, essentially in real time, using a microprocessor or portable minicomputer.

Cranston, R.E. and Murray, J.W.

THE DETERMINATION OF CHROMIUM SPECIES IN NATURAL WATERS; Analytica Chimica Acta, v. 99, p. 275-282, 1978.

A method for the determination of chromium species has been developed and successfully applied to both fresh and sea water samples. The method utilizes pre-concentration of total chromium, chromium (III) and particulate chromium at natural pH with accurate and precise analysis by a single flameless atomic absorption procedure. A minimal blank allows for a reliable detection limit of 0.02 nM, which is sufficient for most natural waters with chromium concentrations in the range 0.01—10 nM. Immediate shipboard preconcentration of the samples minimizes storage problems. The method is simple and rapid; 20 samples can be analysed in duplicate for total chromium, chromium (III) and particulate chromium in one day with routinely available reagents and equipment.

Dixon, J. and McDonald, D.A.

SEDIMENTOLOGY AND PETROLOGY OF THE CAMBRIAN OLD FORT ISLAND AND MOUNT CAP FORMATIONS, NORTHERN INTERIOR PLAINS, N.W.T.; in Display Summaries, C.S.P.G. 1978 Core and Field Sample Conference, A.F. Embry (ed.); Canadian Society of Petroleum Geologists, Calgary Alberta.

Deposition of the Cambrian Old Fort Island and Mount Gap Formations represents a marine transgressive sequence deposited in a semi-enclosed epicontinental basin. The initial transgressive phase is represented by shallow-marine, tidal-deposited quartz arenites of the Old Fort Formation. As coarse detrital supply diminished and the sea deepened, muds and carbonates of the Mount Cap Formation were deposited.

The basal sandstones have been cemented by a variety of minerals, the most common being quartz overgrowths, authigenic clays and dolomite. Original porosity was lost but later decementation, especially the removal of carbonate cements, has produced very porous and permeable horizons. Hydrocarbons (seen as bitumen and/or live oil stain) appear to have migrated into the sandstones after the generation of secondary porosity.

Dixon, J.

A MIDDLE ORDOVICIAN UNCONFORMITY IN THE ARCTIC LOWLANDS: A DISCUSSION; BULLETIN OF CANADIAN PETROLEUM GEOLOGY, v. 26, no. 2, p. 208-217, 1978.

The well-documented Middle Ordovician regional unconformity between the Franklin Mountain and Mount Kindle Formations of the northern Interior Plains (NWT) can be continued into the Arctic Lowlands. Paleontological data exist that suggest Middle Ordovician strata are absent. A sedimentary hiatus is recognized between Lower and Upper Ordovician rocks on Somerset Island and is equated to the Middle Ordovician unconformity of the Interior Plains. A similar sedimentary break, described from Baffin Island, also may be the Middle Ordovician regional unconformity.

Dyck, W. and Tan, B.

SEASONAL VARIATIONS OF HELIUM, RADON, AND URANIUM IN LAKE WATERS NEAR THE KEY LAKE URANIUM DEPOSIT, SASKATCHEWAN; Journal of Geochemical Exploration, v. 10, p. 153-167, 1978.

To test the usefulness of the He method for the detection of buried U ore, a lake-water survey of the Key Lake area was carried out during March 1977 and repeated in June 1977. A set of 87 lake-water samples from 37 sites in eight different lakes were collected from the same sites in each survey. These samples were analyzed for He, Rn, O₂, Eh, pH, conductivity, alkalinity, and U.

In the lakes the highest He concentrations, of nearly four times atmospheric equilibrium concentrations, were obtained during the winter survey. This was under the ice in two bottom lake samples where the sandy overburden extends for some 50 m directly to the ore zone. Radon and U values at these sites were also anomalous, but the highest values of Rn and U were obtained in a shallow lake about 2 km south of the ore zone where concentrations of radioactive boulders occur.

The average net He and Rn contents dropped from 21 standard nanolitres/litre (nl/l) and 25 picocuries/litre (pCi/l) in the winter under the ice to 3 nl/l and 8 pCi/l in the summer, respectively. Average U and conductivity dropped from 2.3 ppb and 15 μ mo/cm to 1.5 ppb and 11 μ mo/cm, respectively, in the same suites of samples. The drop in the

ionic species probably reflects the effect of snow and ice meltwater dilution and the much larger drop in the dissolved He and Rn reflects the combined effects of meltwater dilution, wind turbulence over ice-free lakes, and change in thermal gradients.

The He results must be viewed with guarded optimism until a detailed investigation is completed to ascertain what fraction of the detected He is from the ore, what fraction from basement He that may have found its way into the lakes via the fracture zone in which the one is located, and what effect drilling has had on the He flow into the lakes from the ore zone.

Dyck, W.

THE MOBILITY AND CONCENTRATION OF URANIUM AND ITS DECAY PRODUCTS IN TEMPERATE SURFICIAL ENVIRONMENTS; in Uranium deposits, their mineralogy and origin; short course Handbook 3; M.M. Kimberley ed., Mineralogical Association of Canada, 1978.

Uranium is the most abundant element of the uranium decay series, with an average crustal abundance of about 2.6 ppm. Its high mobility in the surficial environment is due to oxidation to the uranyl ion which forms soluble carbonate complexes. Uranium-decay products generally do not form soluble compounds and so secular disequilibrium of the series is commonly observed. Disequilibrium is almost invariably due to removal of uranium under oxidizing conditions or uranium addition under reducing conditions. Reestablishment of radioactive equilibrium requires time spans of several half-lives of the daughter products. The stable end-products of uranium, i.e. lead and helium, represent the extremes of mobility of the decay products; lead is relatively immobile and helium is able to escape to outer space.

Dyke, A.S.

GLACIAL AND MARINE LIMITS ON SOMERSET ISLAND, NORTHWEST TERRITORIES; in Geological Society of America Abstract with Programs, v. 10, no. 7, p. 394, 1978.

The Somerset Island terrain is both glacial and non-glacial in character. An early glaciation deposited carbonate-bearing till on gneisses (recognized in one place) and widespread shield erratics on carbonate strata. Later 1 m of gneissic grus buried the carbonate till. During a subsequent glaciation ice flowing eastward from beyond the island inundated northern Boothia Peninsula and southern Somerset Is. The ice thinned northward and terminated ca. 20 km inland from the west coast. Two large lobes of western ice, in Creswell and Aston Bays, coalesced with a local ice cap but elsewhere the two ice masses were separated by nunataks. The foreign ice was warm-based; the local ice cap was warm-based near its margin but cold-based in its central region. Lateral meltwater channels record the pattern of recession. In Creswell Bay ice-marginal marine deltas range from 150 to 205 m a.s.l. Driftwood (Siberian Larch?) at 160 m dated >38 000 14 C yr. B.P. Beach ridges rise to 145 m a.s.l. Whole valves of *Hiatella arctica* from the highest ridge are >40 000 yr. old and are probably of Early or Middle Wisconsinan age based on the amino acid racemization. The marine deposits are related to recession of the local ice. The apparent Holocene marine limit has been dated ca. 9200 ± 100 B.P. at 8 localities. The 9200 B.P. shoreline dips eastward, indicating a dominant Late Wisconsinan load to the west. No ice-marginal marine sediments of Holocene age have been found. Furthermore, the Holocene marine gravels overlie weathered bedrock indicating a transgression of a former ice-free area.

Helmstaedt, H., Eisbacher, G.H. and McGregor, J.A.

COPPER MINERALIZATION NEAR AN INTRA-RAPITAN UNCONFORMITY, NITE COPPER PROSPECT, MACKENZIE MOUNTAINS, NORTHWEST TERRITORIES, CANADA; Canadian Journal of Earth Sciences, v. 16, p. 50-59, 1979.

Copper minerals are known from at least five stratigraphic levels above and below an angular unconformity recognized within rocks of the Rapitan Group on and near the Nite copper prospect, Mackenzie Mountains. The main showing on the prospect is structurally controlled and occurs in siliceous dolostone near the top of the folded and faulted Coppercap Formation, directly beneath an unconformity separating two local members of the Sayunei Formation (Rapitan Group). The copper was emplaced in tectonically fractured dolostone, precipitated from solutions that may have descended from copper-bearing conglomerates in the Rapitan Group above the unconformity, or ascended from weakly mineralized carbonates below. Mechanical reworking of older strata-bound copper deposits is indicated by significant copper content in clasts eroded from older rocks of the northeastern Mackenzie Mountains. The ultimate source of copper can probably be sought in basaltic dikes and flows emplaced prior to deposition of Redstone River and Coppercap formations during an early phase of crustal extension in the northern part of the Cordilleran miogeosyncline.

On a reconnu des minéraux du cuivre dans au moins cinq niveaux stratigraphiques au-dessus et au-dessous d'une discordance angulaire observée dans les roches du groupe de Rapitan sur le prospect de cuivre de Nite et dans ses environs dans les monts Mackenzie. L'indice principal de minéralisation du prospect est contrôlé par la structure et se rencontre dans de la dolostone siliceuse près du sommet de la formation faille et plissée de Coppercap, directement en dessous d'une discordance séparant deux membres locaux de la formation de Sayunei (groupe de Rapitan). Le cuivre a été mis en place dans une dolostone tectoniquement fracturée, précipité à partir de solutions qui ont pu descendre des conglomerats riches en cuivre du groupe de Rapitan au-dessus de la discordance ou encore provenir des carbonates faiblement minéralisés en dessous. Le remaniement mécanique d'anciens dépôts de cuivre stratiformes est indiqué par la teneur significative en cuivre dans les galets érodés de roches plus anciennes dans le nord-est des monts Mackenzie. La source ultime du cuivre pourrait probablement se trouver dans les dykes et coulées basaltiques mis en place avant le dépôt des formations de Redstone River et de Coppercap durant une phase initiale d'extension de la croûte dans la partie nord du miogéosynclinal des Cordillères.

Embry, A.F.

A LOOK AT THE BORDEN ISLAND FORMATION; in A.F. Embry, ed., Display Summaries, 1978 CSPG Core and Field Sample Conference, p. 38-43, 1978.

The Borden Island Fm. is a Lower Jurassic sandstone and shale unit which occurs in the western Sverdrup Basin, Arctic Islands. The formation is of current interest because it contains the main reservoir strata in the giant Hecla and Drake gas fields of Melville Island. The base of the Borden Island Fm. is a regional unconformity and the formation overlies strata ranging in age from Lower to Upper Triassic. Three informal members have been recognized within the formation. Member 1, the basal member, consists predominantly of red and grey shale and siltstone with minor sandstone. The member is bounded by unconformities and is Hettangian in age. Member 2 consists of interbedded shale, siltstone and sandstone arranged in coarsening-upward cycles. It too is bounded by unconformities and is Sinemurian in age.

The uppermost member consists of shale, siltstone and very fine grained sandstone with glauconite common. The base of the member is unconformable but the upper contact with the Wilkie Point Fm. is conformable and gradational. The age of the member is Pliensbachian. In summary the Borden Island Fm. consists of two complete sequences and the basal portion of a third. Recognition of the intra-formational unconformities is essential for understanding the complex facies and thickness variations of the formation and for further exploration for hydrocarbons within the formation.

Ermanovics, I., Key, R.M. and Jones, M.T.

THE PALAPYE GROUP, CENTRAL-EASTERN BOTSWANA; Transactions of the Geological Society of South Africa, v. 81, p. 61-73, 1978.

The Palapye Group comprises five formations which from base to top are as follows: Selika, Moeng, Tswapong, Lotsane and Shoshong. The Lotsane and Shoshong formations are chronostratigraphically equivalent and locally there is a gradational contact between the Tswapong and Shoshong formations.

The succession from the Selika to the Lotsane Formation comprises a two-fold sequence of coarse (conglomeratic) to fine (argillaceous) grained sediments. Near the top of the Selika Formation are several manganese horizons while near the base of the Tswapong Formation several pisolithic ironstone horizons are developed.

The Shoshong Formation comprises a basal and discontinuously developed greywacke, followed by a more extensively distributed two-fold succession of quartzite and shale in turn overlain by limestones. Although the age and correlation of the Shoshong Formation has long been problematical, it is suggested that the formation is an upward continuation of the Palapye Group.

The group lies unconformably on rocks of the tectono-metamorphic complex of the southern part of the Limpopo belt. The top of the group is an erosion surface or is unconformably overlain by Karoo strata. The Selika, Moeng, Tswapong and Lotsane formations lie adjacent to and north of the post-tectonic Mahalapye plutonic block from which much of the detritus of the Palapye Group is thought to have been derived. The Shoshong Formation, however, partly surrounds the massive Mahalapye dome which is one of the products of reactivation along the southern edge of the Limpopo Belt at around 2 200 m.y. ago. The development of the sedimentary depository is related to isostatic adjustment of the ancient crust along pre-existing zones of weakness reactivated peripherally to the post-tectonic Mahalapye Granite.

In the east where the Selika Formation contains lava beds, the group is thought to occupy a graben which gradually dies out westwards. During the final stages of deposition of the group the Lotsane and Shoshong formations were laid down in non-graben type depositories. The strata progressively overstep lower Group rocks on to granitic basement westward. As such the Palapye Group is probably a localized stratigraphic succession and cannot yet be correlated on a detailed scale with any other sequence in southern Africa. However, generally, the Palapye Group is part of the pattern of granite/sedimentary basin pairs developed on the Kaapvaal Craton and is probably chronostratigraphically correlatable to the Soutpansberg Group of the northern Transvaal.

Park, R.G. and Ermanovics, I.F.

TECTONIC EVOLUTION OF TWO GREENSTONE BELTS FROM THE SUPERIOR PROVINCE IN MANITOBA; Canadian Journal of Earth Sciences, v. 15, p. 1808-1816, 1978.

The Bigstone Lake and Stevenson Lake greenstone belts are two areas of supracrustal rocks surrounded by quartz diorite to granodiorite plutons and by small patches of tonalitic gneiss interpreted as basement to the greenstone belts. The supracrustal sequence is divided into a lower, mainly volcanic, group correlated with the Hayes River Group of Island Lake and an unconformable upper group with roughly equal proportions of sediments and volcanics correlated with the Island Lake 'Series'. The lower group consists of about 4600 m of basaltic and andesitic pillow lavas with minor greywackes and dacitic volcanics. It is partly replaced at the base by the bordering plutons and cut out at the top by the unconformable upper group, which consists of about 2300 m of greywackes, arkoses, and mudstones above a basal conglomerate containing boulders derived from the lower group and from the basement. A further 2100 m of volcanics overlies these sediments.

The supracrustal rocks show three phases of deformation. The first, F_1 , produced major northeast-southwest and east-west synclines. S_1 foliation was developed under greenschist facies to low amphibolite facies metamorphism. F_2 produced smaller scale steep east-west folds with a crenulation cleavage. Subsequent deformation resulted in chevron folds and conjugate shear belts.

The intrusion of the plutons commenced before the F_1 deformation and partly controlled it, but a further period of plutonic intrusion occurred after F_1 and before F_2 .

The north-south compressive stress prevailing during F_2 and later deformation under waning metamorphism implies that the batholiths in the vicinity of the greenstone belts had completely solidified and that the crust was rigid enough to transmit a uniform stress field. The dominance of east-west structural grain in this part of the Superior Province indicates that these conditions were general.

Les zones de roches vertes de Bigstone Lake et de Stevenson Lake sont deux régions de roches superficielles entourées par des plutons dont la composition varie de diorite quartzifère à des granodiorites et par de petites masses de gneiss tonalistiques interprétées comme le socle des zones de roches vertes. La séquence superficielle se divise en un groupe inférieur, surtout volcanique, mis en corrélation avec le groupe de Hayes River d'Island Lake, et un groupe discordant supérieur avec des proportions à peu près égales de sédiments et de volcaniques mis en corrélation avec la "série" d'Island Lake. Le groupe inférieur comprend environ 4600 m de laves basaltiques et andésitiques en coussins avec des proportions mineures de grauwackes et de volcaniques dacitiques. Ce groupe est partiellement remplacé à la base par les plutons voisins et tronqué au sommet par le groupe discordant supérieur qui comprend environ 2300 m de grauwackes, d'arkoses et de mudstones au-dessus d'un conglomerat basal contenant des blocs originant du groupe inférieur et du socle. Une épaisseur additionnelle de 2100 m de roches volcaniques recouvre ces sédiments.

Les roches superficielles témoignent de trois phases de déformation. La première, F_1 , a produit des synclinaux majeurs nord-est-sud-ouest et est-ouest. La foliation S_1 s'est développée par métamorphisme dont l'intensité a varié du faciès des schistes verts à celui de l'amphibolite. La déformation F_2 a produit à plus petite échelle des plis raides de direction est-ouest avec un faux-clivage. La déformation subséquente a produit des plis en chevrons et des zones de cisaillement conjuguées.

L'intrusion des plutons a débuté avant la déformation F_1 et l'a partiellement contrôlée mais une autre période d'intrusion plutonique s'est produite après F_1 et avant F_2 .

Les contraintes de compression nord-sud qui ont prévalu durant F_2 et la déformation ultérieure à la fin de la période de métamorphisme impliquent que les batholithes dans le voisinage des zones de roches vertes étaient complètement solidifiées et que la croûte était assez rigide pour transmettre un champ de contrainte uniforme. La dominance d'un grain structural est-ouest dans cette partie de la province du Supérieur indique que ces conditions étaient générales.

Jones, D.L. and Fahrig, W.F.

PALEOMAGNETISM AND AGE OF THE ASTON DYKES AND SAVAGE POINT SILLS OF THE BOTHIA UPLIFT, CANADA; Canadian Journal of Earth Sciences, v. 15, p. 1605-1612, 1978.

Oriented samples (107) have been drilled for paleomagnetic studies from diabase sills and dykes on either side of the Boothia Uplift, Canada. Six sites at Savage Point are in sills which intrude the Aston Formation; three, at Whitehead Point, north of Savage Point on the east coast of Prince of Wales Island, are in sills which also intrude these strata. Six sites in the Aston Bay area of Somerset Island are in dykes and a sill which cut the Aston Formation; the former also intrude the Hunting Formation. No meaningful results were obtained from the Whitehead Point samples. Paleomagnetic measurements on the Savage Point samples, together with new K-Ar data, strongly suggest these sills belong to the Mackenzie igneous episode (ca. 1240 Ma). The sill in the Aston Bay area apparently belongs to this episode too, whereas most of the dykes are franklin dykes (ca. 675 Ma). One large dyke was possibly emplaced in Tertiary times. Thus the Aston Formation is older than 1240 Ma and the Hunting Formation is bracketed between 1240 and 675 Ma.

On a obtenu par forage 107 échantillons orientés pour études paléomagnétiques dans les sills et les dykes de diabase de part et d'autre du soulèvement de Boothia, Canada. Six localités à Savage Point sont dans des sills qui recoupent la formation d'Aston; trois localités, à Whitehead Point, au nord de Savage Point sur la côte est de l'île de Prince de Galles, sont dans des sills qui aussi recoupent ces strates. Six localités dans la région d'Aston Bay sur l'île de Somerset sont dans des dykes et un sill qui coupent la formation d'Aston; les dykes pénètrent aussi la formation de Hunting. On n'a obtenu aucun résultat significatif des échantillons de Whitehead Point. Les mesures paléomagnétiques sur les échantillons de Savage Point en plus des données K-Ar nouvelles, suggèrent fortement que les sills appartiennent à l'épisode intrusif de Mackenzie (environ 1240 Ma). Le sill dans la région d'Aston Bay appartient apparemment à cet épisode aussi, alors que la plupart des dykes sont des dykes de Franklin (environ 675 Ma). Un gros dyke a probablement été mis en place au Tertiaire. Ainsi, la formation d'Aston serait plus ancienne que 1240 Ma et la formation de Hunting daterait de la période entre 1240 et 675 Ma.

Frisch, T. and Thorsteinsson, R.

HAUGHTON ASTROBLEME: A MID-CENOZOIC IMPACT CRATER, DEVON ISLAND, CANADIAN ARCTIC ARCHIPELAGO; Arctic, v. 31, pt. 2, p. 107-124, 1978.

Haughton Astrobleme is a nearly circular impact crater with a diameter of about 16 km and a central uplift in Devon Island. Bedrock exposed in the crater comprised the following mainly carbonate Lower Ordovician to Upper Silurian formations in order upward: Eleanor River, Bay Fiord, Thumb Mountain, Irene Bay and Allen Bay. The Eleanor River Formation in the centre of the crater is raised

about 480 m above its normal stratigraphic position outside the crater. The much shattered and faulted lower Paleozoic rocks within the crater contrast markedly with the subhorizontal surrounding strata. The Allen Bay Formation constitutes surface exposure around all but the easternmost part of the crater's border where the Thumb Mountain and Irene Bay Formations are exposed. Also exposed in the crater are two newly recognized, and as yet unnamed, formations: a polymict impact breccia that overlies the lower Paleozoic rocks with marked angular unconformity and crops out over about a quarter of the area of the crater; and a unit of lake sediments near the western border of the crater that lies disconformably on the impact breccia and with angular unconformity on the lower Paleozoic rocks.

The impact breccia is composed chiefly of carbonate rocks, but locally contains clasts of Precambrian crystalline basement from a depth estimated to be at least 1700 m. The basement clasts show varying degrees of shock metamorphism, the highest being that displayed by rocks with vesicular, flow-banded feldspar or quartz glass. Coesite has been identified in a sample of gneiss.

The lake sediments are interpreted as an infilling of the crater that occurred shortly after impact. On the basis of fossils, these sediments are dated as Miocene or, possibly, Pliocene. From this and other evidence, it is concluded that the impact took place in the Miocene or Pliocene.

"Haughton Astrobleme" est un cratère quasi-circulaire, causé par un impact; il a un diamètre d'environ 16 km avec un mamelon central et se situe dans l'île Devon: Les affleurements du cratère sont datés de l'Ordovicien au Silurien supérieur: les formations carbonatées représentées sont dans l'ordre "Eleanor River, Bay Fiord, Thumb Mountain, Irene Bay et Allen Bay." La formation Eleanor River au centre du cratère est montée d'environ 480 mètres au-dessus de sa position stratigraphique normale, en dehors du cratère. Les roches les plus brisées et faillées du Paléozoïque inférieur, à l'intérieur du cratère, font un contraste marquant avec les bancs sub-horizontaux qui les entourent. La formation d'Allen Bay représente les affleurements entourant l'ensemble mais ce sont des affleurements des formations "Thumb Mountain" et "Irene Bay" que l'on observe sur la bordure la plus orientale du cratère. De plus, deux formations nouvelles et pas encore "baptisées" ont été reconnues dans le cratère: une brèche d'impact polygénique qui repose sur les roches du Paléozoïque inférieur en discordance angulaire accusée, dans environ un quart de la surface du cratère; un affleurement de sédiments lacustres près de la bordure ouest du cratère, reposant en discordance sur la brèche d'impact et avec une discordance angulaire sur les roches du Paléozoïque inférieur.

La brèche d'impact est composée principalement de roches carbonatées mais localement contient des clastiques du socle cristallin pré-cambrien, situé à au moins 1700 mètres de profondeur. Les clastiques du socle montrent des degrés variés de métamorphisme de contact, le plus haut degré étant représenté par des roches à feldspaths zonés ou à verre quartzitique. La coesite a été identifiée dans un échantillon de gneiss.

Les sédiments lacustres sont interprétés comme un remplissage du cratère qui se serait situé rapidement après l'impact. Au vu des fossiles, ces sédiments sont datés du Miocène ou peut-être du Pliocène. De cette constatation et d'autres indices, on a conclu que l'impact s'est situé au Miocène ou au Pliocène.

Fulton, J. and Smith, G.W.

LATE PLEISTOCENE STRATIGRAPHY OF SOUTH-CENTRAL BRITISH COLUMBIA; Canadian Journal of Earth Sciences, v. 15, p. 971-980, 1978.

The late Pleistocene deposits of south-central British Columbia record two major glacial and two major nonglacial periods of deposition. The oldest recognized Pleistocene deposits, called Westwold Sediments, were deposited during a nonglacial interval more than 60 000 years ago. Little information is available on the climate of this period, but permafrost may have been present at one time during final stages of deposition of Westwold Sediments. The latter part of this nonglacial period is probably correlative with the early Wisconsin Substage of the Great Lakes - St. Lawrence Valley area. However, deposition of the Westwold Sediments may have begun during the Sangamon Interglacial.

Okanagan Centre Drift is the name applied to sediments deposited during the glaciation that followed deposition of Westwold Sediments. Okanagan centre Drift is known to be older than 43 800 years BP and probably is older than 51 000. It is considered to correlate with an early Wisconsin glacial period.

Bessette Sediments were deposited during the last major nonglacial period, which is south-central British Columbia persisted from at least 43 800 years BP (possibly more than 51 000) to about 19 000 years BP. This episode corresponds to Olympia Interglaciation of the Pacific Coast region and the mid-Wisconsin Substage of the Great Lakes - St. Lawrence Valley area. During parts of Olympia Interglaciation the climate was probably as warm as the present-day climate in the interior of British Columbia. Information from coastal regions indicates that there may have been periods of cooler and moister climate.

Kamloops Lake Drift was deposited during the last major glaciation of south-central British Columbia. Ice occupied lowland areas from approximately 19 000 to 10 000 years BP. This period corresponds approximately to the Fraser Glaciation of the Pacific Coast region and the late Wisconsin Substage of central and eastern parts of North America.

Les dépôts de la fin du Pléistocène dans le centre sud de la Colombie-Britannique enregistrent deux périodes majeures de dépôt glaciaire et deux périodes majeures de dépôts non glaciaire. Les dépôts les plus anciens du Pléistocène, les sédiments de Westwold, se sont déposés durant un intervalle non glaciaire il y a plus de 60 000 ans. Il y a peu d'information disponible sur le climat à cette période, mais le pergélisol a pu être présent durant un certain temps au cours des derniers stades de dépôt des sédiments de Westwold. La dernière partie de cette phase non glaciaire est probablement corrélatrice des dépôts du Wisconsin inférieur de la région des Grands-Lacs et de la vallée du Saint-Laurent. Toutefois, le dépôt des sédiments de Westwold peut avoir débuté durant l'interglaciaire du Sangamon.

Le drift de l'Okanagan Centre est le non qu'on donne aux sédiments déposés durant la glaciation qui a suivi le dépôt des sédiments de Westwold. Ce drift est plus ancien que 43 800 ans avant le présent et peut-être plus ancien que 51 000 ans. On considère qu'il est corrélatif avec la période glaciaire du début du Wisconsin.

Les sédiments de Bessette se sont déposés durant la dernière période non glaciaire majeure qui a persisté dans le centre sud de la Colombie-Britannique entre 43 800 ans avant le présent (possiblement 51 000 ans) et il y a environ 19 000 ans. Cet épisode correspond à l'interglaciaire d'Olympia de la région de la Côte du Pacifique et au Wisconsin moyen de la région des Grands-Lacs et de la vallée du Saint-Laurent. Durant des intervalles de l'interglaciaire d'Olympia, le climat

a été probablement aussi doux qu'actuellement à l'intérieur de la Colombie-Britannique. L'information provenant des régions côtières indique qu'il a pu y avoir des périodes de climat plus froid et plus humide.

Le drift de Kamloops Lakes s'est déposé durant la dernière glaciation majeure du centre sud de la Colombie-Britannique. La glace a occupé les basses-terres d'environ 19 000 à 10 000 ans avant le présent. Cette période correspond approximativement à la glaciation de Fraser dans la région de la Côte du Pacifique et à la fin du Wisconsin dans le centre et l'est de l'Amérique du Nord.

Garrett, R.G.

AN ABUNDANCE MODEL RESOURCE APPRAISAL FOR SOME CANADIAN COMMODITIES; *Mathematical Geology*, v. 10, no. 5, 1978.

An abundance model resource appraisal has been undertaken for 10 mineral commodities in Canada: nickel, copper, zinc, lead, molybdenum, uranium, silver, gold, chromium, and tin. The purpose of the appraisal was to investigate the applicability of the model to the Canadian situation. Resource appraisals for the first 6 of the commodities studied have been published following deposit modeling studies. For many other commodities there are inadequate data to carry out deposit modeling appraisals. The demonstration of the relevance of the abundance model to Canada would allow its application in such cases. The data presented in this paper indicate that the approximate relation, resource (short tons) = abundance (%) $\times 10^{10}$, holds true for all commodities studied except chromium and tin. As the resources versus abundances relationship observed on a global scale is observable in Canada, it is concluded that Canada is a sufficiently large fraction (~ 7%) of the earth's continental crust to represent a valid sample of that crust. Canada appears to be relatively well endowed with resources of copper, molybdenum, lead, and zinc, and poorly endowed with chromium and tin. It is proposed that the intersection of national boundaries with the boundaries of the world's metallogenic provinces is of greater importance than the intensity of past search, a feature that has been suggested in other studies. If these areas overlap, a nation may be self sufficient in a commodity; if they do not, the nation must import, or find a nationally available substitute. The sources of information used in the appraisal are outlined together with an analysis of the problems encountered and the time requirements.

Whitehead, R.E.S. and Goodfellow, W.D.

GEOCHEMISTRY OF VOLCANIC ROCKS FROM THE TETAGOUCHE GROUP, BATHURST, NEW BRUNSWICK, CANADA; *Canadian Journal of Earth Sciences*, v. 15, p. 207-219, 1978.

The volcanic rocks of the Tetagouche Group are predominantly dacitic to rhyolitic pyroclastics and lavas; mafic alkaline and tholeiitic volcanic rocks are less abundant. Lavas representing the intermediate range (such as andesites) are uncommon.

As a consequence of intense Na_2O and K_2O metasomatism, the mafic volcanic rocks have been classified on the basis of relatively immobile elements such as Ti, Y, Zr, Nb, Ni and Cr.

By reference to volcanic suites described elsewhere for varying geologic and tectonic environments, the Tetagouche group appears to represent two geologic environments. It is proposed that the deposition of tholeiitic and alkaline basalts accompanied the rifting associated with the opening of the Proto-Atlantic, which began during Hadrynian times.

However the calc-alkaline felsic volcanic rocks were deposited on the top of the basaltic sequence along a mature island arc system that developed with the closing of the Proto-Atlantic during Middle Ordovician time.

Les roches volcaniques du groupe de Tetagouche se composent surtout de laves et de pyroclastiques dacitiques à rhyolitiques; les roches volcaniques alcalines et tholéïtiques sont moins abondantes. Les laves représentant le domaine intermédiaire (comme les andésites) sont peu communes.

A cause du métasomatisme intense et de la mobilisation de Na_2O et de K_2O , on a classifié les roches volcaniques mafiques en se basant sur leur teneur en éléments relativement immobiles tels Ti, Y, Zr, Nb, Ni et Cr.

Par comparaison avec des séquences volcaniques décrites pour d'autres régions dans des contextes géologiques et tectoniques variés, le groupe de Tetagouche semble appartenir à deux milieux géologiques. On propose que le dépôt des basaltes alcalins et tholéïtiques a accompagné la dislocation associée à l'ouverture du Proto-Atlantique laquelle a débuté au cours de l'Hadrynién. Toutefois, les roches volcaniques calc-alcalines felsiques se sont déposées au sommet de la séquence basaltique le long d'un système d'arc insulaire parvenu à maturité et qui semble s'être développé lors de la fermeture du Proto-Atlantique au cours de l'Ordovicien moyen.

Whitehead, R.E.S. and Goodfellow, W.D.

GEOCHEMISTRY OF VOLCANIC ROCKS FROM THE TETAGOUCHE GROUP, BATHURST, NEW BRUNSWICK, CANADA: Reply; *Canadian Journal of Earth Sciences*, v. 15, p. 1681-1683, 1978.

Grant, D.R.

GLACIAL STYLE AND ICE LIMITS, THE QUATERNARY STRATIGRAPHIC RECORD, AND CHANGES OF LAND AND OCEAN LEVEL IN THE ATLANTIC PROVINCES, CANADA; *Géographie physique et Quaternaire*, v. 31, no. 3-4, p. 247-260, 1977.

Evidence from scattered stratigraphic sections, from the relationship of a sequence of ice flow indicators to a raised interglacial marine platform, together with the limits of freshly glaciated terrain against weathered bedrock areas, indicates that late Wisconsinan glaciers spread weakly toward, and in many areas not beyond, the present coast. These were fed by a complex of small ice caps located on broad lowlands and uplands. The limiting factor was the deep submarine channels that transect the region. Thus, Laurentide ice was limited to northern Gulf of St. Lawrence. With this pattern of centripetal flow toward the Gulf, large areas remained unglacierized. There is now better geological corroboration of Fernald's hypothesis of nunatak botanic refugia, though there was, perhaps during early Wisconsinan time, grounded ice in the Gulf and an outlet glacier in Laurentian Channel. Raised postglacial shorelines fit the model, with a general tilt toward the main shield ice sheet, but with two broad domes reflecting the ice complexes over New Brunswick and Newfoundland. Older emerged and submerged shorelines beyond the glacial limit complicate the pattern. At present northern regions are still rebounding while a zone of subsidence is migrating inland from the continental margin.

Un certain nombre de faits prouvent que les glaciers, à la fin du Wisconsinien, se sont éoulés vers les côtes actuelles, et dans plusieurs cas, ne sont pas allés au-delà: les coupes stratigraphiques, les liens entre une série d'indicateurs de l'écoulement glaciaire et la plate forme marine interglaciaire relevée, ainsi que les rapports entre les limites

des dernières régions englacées et les régions dont la roche en place a été altérée. Ces glaciers étaient nourris par un ensemble de petites calottes localisées sur de vastes étendues. Toutefois, les profonds chenaux qui entaillent la région, en ont empêché l'extension. Le glacier laurentidien s'est donc confiné au nord du golfe du Saint-Laurent. Ce mouvement centripète vers le golfe a d'ailleurs épargné de vastes secteurs. Les données géologiques appuient maintenant davantage l'hypothèse de Fernald au sujet des refuges biologiques des nunataks, bien qu'au début du Wisconsinien, une calotte et un glacier émissaire aient occupé le golfe et le chenal laurentien. Les lignes de rivages soulevés postglaciaires sont conformes au modèle d'ensemble, avec un relèvement différentiel davantage marqué vers le glacier laurentidien mais également avec la présence de deux larges dômes associés aux calottes du Nouveau-Brunswick et de Terre-Neuve. Toutefois des littoraux plus anciens, émergés et immergés, au-delà de la limite glaciaire, compliquent ce plan. Au nord, les régions se relèvent encore, alors qu'une zone de subsidence se déplace vers l'intérieur des terres.

Grant, D.R.

SYNOPSIS OF QUATERNARY CRUSTAL DELEVELLING AND SEA-LEVEL CHANGE IN ATLANTIC CANADA; *in Abstract Volume, Symposium on Earth Rheology and Late Cenozoic isostatic movements*; Geological Institute, Stockholm University Sweden, 1977.

In this segment of the continental margin, 1000 km wide and 1500 km long, Mesozoic and Cenozoic shelf strata record a slow epeirogenic sinking at 5-10 m/my that has been greatly modulated by effects of recent glaciations. An important datum for comparing the isostatic delevelling of Wisconsinan stadials, and for assessing modern crustal disequilibrium is the +2 m to +6 m emerged intertidal rock platform cut during the last interglacial, that is widely preserved at the seaward periphery, but tilted up slightly toward the north. Late Wisconsinan glaciers comprised two icecap complexes that were contiguous with the Laurentide ice sheet but were separated by Gulf of St. Lawrence inland sea. Postglacial marine limit thus takes the form of two ridges rising northward from 0-150 m toward the main ice load. Local negative slopes occur in Newfoundland fiords and larger calving bays. However, such raised marine features, best exemplified by ice-marginal deltas, are found only in the northern half of the region. To the south where ice was thinner, late-glacial shorelines have been drowned mainly by custatic submergence. In extraglacial areas, submerged terraces at various depths from 20-120 m may mark either stadial custatic minima, subsequently differentially uplifted, or interstadial eustatic maxima. As well, older strandlines occur as much as twice as high (up to 70 m) above certain uplifted fossiliferous Late Wisconsinan glacial deltas. These are leached and cemented, and are probably related to earlier, more extensive glaciations. The general pattern of emergence thus reflects not only ice load and ice margin, but date and rate of retreat. Interpretation is complicated by subsequent differential subsidence that has locally reduced the original emergence by up to 40 m. This occurred mainly during the Holocene, and is known from the date and depth of forest beds buried by intertidal mud. Over the past several millenia the average rate of 30 cm per century continues unabated judging by archeologic and geodetic measurements. This renewed transgression is probably due to the collapse of a migrating glacier crustal forebulge. To summarize the variation in the interplay of eustatic recovery and isostatic uplift, a series of curves has been constructed to illustrate the local change of relative sea-level. This change ranges from essentially continuous emergence or submergence from north to south across the region, in a way that is broadly analogous to the situation in northwestern Europe.

Grant, D.R.

LATE WISCONSINAN ICE LIMITS AND GLACIAL STYLE IN THE ATLANTIC PROVINCES, CANADA; *in Abstracts, 10th INQUA Congress*, p. 174, 1977.

Based on new and re-interpreted evidence from two areas – northern Nova Scotia and western Newfoundland – the chronology and extent of glacial stades since the last interglaciation is reconstructed for the region based on a 3-phase sequence of ice-flow indicators and from 3 altitudinal zones of differential weathering, and the relation of the inferred ice expansions to dated inter-till organic beds and to a prominent emerged marine platform apparently dating from the last interglaciation. The limit of the last glacial stade is marked by "fresh" glacial landforms juxtaposed against at least two distinctive higher or more distal zones of subdued (soliflucted) moraine, and felsenmeer or grus with minor tors. Flow features and moraines show that ice spread seaward from a complex of upland centres, deploying around numerous coastal highland nunataks, to terminate a short distance off-shore as a calving or moraine-building margin at depths of 100 to 200 m. Late Wisconsinan retreat was inland of the present coast by 13 000 yr BP. For comparison only a few small coastal areas were deglaciated during a middle Wisconsinan interstadial \sim 38 000 yr BP, whereas during an earlier interstadial more than 50 000 yr BP most of the area was ice free judging by several organic beds. During earlier stades, ice caps had a similar disposition, except for two that were located on the continental shelf and flowed northward over Cape Breton Island and southeast Newfoundland. Drowned cirques off northern Newfoundland may date from this phase. Initially however, glacierization culminated as an ice flood that filled the Gulf and Laurentian Channel and overrode the region. Similarly, postglacial submergence, hitherto regarded solely as Late Wisconsinan with anomalies, may differentiate into separate events of varying extent and reach. In essence, the style of glacierization involves a complex of upland ice caps peripheral to the Gulf of St. Lawrence inland sea, sustained at low elevation independently of the Laurentide shield ice sheet, presumably because of the reversed easterly onshore circulation simulated by CLIMAP. This model of centripetal flow both from an inland ice sheet and from outlying ice caps toward a central ice-free enclave resembles the interplay of British and Fennoscandian ice across the North Sea. In view of this analogue and the apparent response of both glacier domains to North Atlantic circulation, a better correlation of glacial events is developing with northwest Europe than with middle North America.

Grant, D.R.

HOLOCENE CRUSTAL ADJUSTMENTS, SOUTHEASTERN ATLANTIC REGION, CANADA; *in Abstract Volume, Symposium on Recent Crustal Movements* Palo Alto, California, 1977.

A variety of tectonic mechanisms are deforming this segment of the continental margin. Epeirogenic subsidence of 5-10 m per million years is known from the age and depth of marker horizons in the Mesozoic-Cenozoic sedimentary pile that forms the continental shelf. Recently, this imperceptible tilting has been glacio-tectonically modulated directly by large perturbations of crustal load, and indirectly by fluctuations of sea-level position. Retreat of glaciers during the last 15 000 years caused most areas to rebound isostatically at rates that climaxed at 5 m per century and decreased exponentially to zero as shown by datings of raised tilted shorelines, except in northern areas where emergence continues. This upwarp includes minor re-adjustments related to eustatic sea-level rise, geoidal/gravitational sea-level fall and hydro-isostatic compensation. Regionally the deformation appears as a smooth warping but obviously involves,

perhaps in large part, local discrete faulting as suggested by innumerable examples of closely-spaced, systematic, step-wise, parallel, vertical, dislocations of glaciated surfaces. Subsequently, however, a broad zone of subsidence has been sweeping inland, probably as the effect of a glacier-marginal crustal forebulge. The rate of migration is unknown, but the collapse is occurring at 0.3 m per century as proven by forests drowned and buried by accreting estuarine salt marshes. Geodetic levelling reveals considerable local variation ($\pm 50\%$) in this general pattern of sinking, perhaps reflecting real topography of the bulge. A notable feature of uncertain affiliation is a raised marine marker horizon that has been offset postglacially in several places, with a throw of at least 10 m along one of the major ancient fault zones.

Hacquebard, P.A. and Avery, M.P.

APPRAISAL OF COAL SEAM QUALITY IN BOREHOLES USING SIDEWALL CORE SAMPLES; Geological Association of Canada/Geological Society of America, Abstracts with Program, v. 10, no. 7, p. 414, 1978.

In the offshore coal drilling program at Sydney, Nova Scotia, the coal seam intersections have been sampled with a series of sidewall cores spaced at intervals of 3 - 6 cm. Position of the cores relative to the seam section was verified with the density and gamma ray logs. Proximate and maceral analyses were carried out on composite samples in 15 cm increments.

The reliability of the sidewall sampling method has been tested on 1.8 - 3 m thick intersections of the Harbour seam in three wells. This was done by (1) a comparison with analytical results from conventional core obtained at the same intersection, and (2) a study of the variability in coal petrographic profiles between wells and in relation to the known pattern previously determined for the seam in the coalfield.

Results show that the sidewall core technique can provide representative and reliable seam data on coal quality and petrography, but not as precise with regard to positioning within the seam section as conventional cores.

Beckering, A.R. and Hacquebard, P.A.

OFFSHORE DRILLING TECHNIQUES AND GEOLOGICAL INTERPRETATION OF RESULTS OBTAINED IN THE SYDNEY COAL BASIN, NOVA SCOTIA; Canadian Institute of Mining and Metallurgy, v. 71, no. 791, p. 118, 1978.

Coal mining at Sydney has been carried out for nearly two hundred years and the remaining resources lie nearly all beneath the Atlantic Ocean, because all seams dip seaward. To explore these resources required an offshore drilling program, which was carried out in 1977 by the drillship GLOMAR CONCEPTION, owned and operated by Global Marine, Inc. of Los Angeles, California. The project was undertaken for the Nova Scotia Department of Mines under the joint federal-provincial coal exploration program.

The majority of the equipment and procedures used for this program are standard to the offshore oil and gas drilling industry. Because of its unique nature, however, changes were made to enable some operations to be performed more simply and expeditiously.

The technical part of the paper describes equipment, techniques and procedures used by GLOMAR CONCEPTION, and her performance during drilling operations of six wells in the offshore area.

The wells explored three reserve areas, namely (1) Lingan-No. 26, (2) Donkin and (3) Morien Bay. These areas were selected in relation to accessibility of mining from

shore outside old workings or downdip from operating mines. The six wells varied in depth from 1,253 to 3,622 feet, with a total footage of 13,201 feet.

In areas (1) and (2) the program was most successful, in that some 150 million tons of "measured" and 765 million tons of "indicated" coal resources were delineated in four seams. However, at Morien Bay no mineable deposit was found, because of structural complications that were confirmed by an offshore seismic survey.

The geological part of the paper discusses: (1) rationale of well-site selection; (2) seam correlations; (3) thickness and partings of coal intersections as deduced from electro logs and sidewall cores; (4) coal quality with regard to ash, sulphur and reflectance; and (5) method and assurance of calculated coal resources in the Sydney submarine areas.

Haworth, R.T. and Lefort, J.P.

GEOPHYSICAL EVIDENCE FOR THE EXTENT OF THE AVALON ZONE IN ATLANTIC CANADA; Canadian Journal of Earth Sciences, v. 16, p. 552-567, 1979.

Precambrian volcanic rocks exposed in structural highs of the Avalon zone of Newfoundland are marked by high magnetic anomalies whose continuity offshore permits recognition of the extent of the Avalon zone, particularly on the Grand Banks. South of Newfoundland and in the Gulf of St. Lawrence, where the magnetic pattern is less well defined, the Avalon platform can also be recognized by the existence of seismic velocities of the order of 6.6 km s^{-1} , which are apparently associated with volcanic rocks. The magnetic Collector Anomaly running eastwards from Cape Breton across the southern Grand Banks is the southern limit of these Avalonian markers, while the northern boundary follows a serrated path (the offsets apparently caused by a series of northwest-trending faults) from the Belle Isle Fault in New Brunswick to the Hermitage and Dover Faults in Newfoundland, thence to the western end of the Charlie Fracture zone. These Avalonian boundaries provide markers for the constraint of pre-drift continental reconstructions.

Les roches volcaniques du Précambrien exposées dans les zones de surélévation de la zone d'Avalon à Terre-Neuve sont marquées par de fortes anomalies magnétiques dont la continuité au large permet de reconnaître l'extension de la zone d'Avalon, en particulier sur les Grands Bancs. Au sud de Terre-Neuve et dans le golfe du Saint-Laurent où la signature magnétique est moins bien définie, on peut aussi reconnaître la plate-forme d'Avalon par l'existence de vitesses sismiques de l'ordre de 6.6 km/s qui semblent associées aux roches volcaniques. L'anomalie magnétique de Collector qui s'étend à l'est depuis le Cap Breton à travers les Grands Bancs est la limite sud de ces indicateurs de l'Avalon, alors qu'au nord la limite suit un chemin dentelé (les décrochements étant probablement causés par une série de failles de direction nord-ouest) à partir de la faille de Belle-Isle au Nouveau-Brunswick jusqu'aux failles de Hermitage et de Dover à Terre-Neuve, donc jusqu'à la limite ouest de la zone de fractures de Charlie. Ces limites de l'Avalon fournissent des bornes pour restreindre les reconstructions continentales d'avant la dérive.

Fyson, W.K., Herd, R.K. and Ermanovics, I.F.

DIAPIRIC STRUCTURES AND REGIONAL COMPRESSION IN AN ARCHEAN GREENSTONE BELT, ISLAND LAKE, MANITOBA; Canadian Journal of Earth Sciences; v. 15, p. 1817-1825, 1978.

The sequence of structures affecting rocks of the Island Lake greenstone belt suggests a progression from structures attributable to emplacement of granitic plutons to those that are of regional extent. Early homoclines (D_0 deformation) and

isoclinal folds (D_1) are overturned or face away from marginal plutons which partly truncate the folds. Granitic offshoots display an S_1 foliation. Syn- D_1 emplacement of the granite is implied, and the pattern of homoclines and folds is consistent with deformation due to diapiric uplift.

Later upright folds (D_2) and a widespread subvertical schistosity S_2 trend eastward throughout most of the region. S_2 passes with little deflection into the granites. D_1 folds are rotated towards S_2 and clasts and volcanic vesicles are flattened, except within a zone of low strain extending 15 km east-west between two plutons. Evidently during D_2 deformation the plutons acted as relatively rigid massifs between which a large 'pressure shadow' developed in response to regional north-south compression.

La séquence des structures affectant les roches de la zone de roches vertes d'Island Lake suggère une progression de structures attribuables à la mise en place de plutons granitiques à celles qui sont d'extension régionale. Les homoclines précoce (déformation D_0) et les plis isoclinaux (D_1) sont renversés ou s'éloignent des plutons marginaux qui tronquent partiellement les plis. Les apophyses de granite possèdent une foliation S_1 . La mise en place de granite en même temps que les plis D_1 est implicite et la configuration des homoclines et des plis est compatible avec la déformation causée par le soulèvement diapirique.

Les plis tardifs verticaux (D_2) et la schistosité S_2 subverticale répandue ont une direction est dans presque toute la région. S_2 passe avec une faible déflexion dans les granites. Les plis D_1 ont subi une rotation vers S_2 et les débris et vésicules volcaniques sont aplatis, excepté dans une zone de faible déformation qui s'étend sur 15 km d'est en ouest entre les deux plutons. Selon toute évidence, durant la déformation D_2 , les plutons ont agi comme des massifs relativement rigides entre lesquels une vaste zone non soumise aux pressions s'est développée en réponse à la compression régionale nord-sud.

Hood, P.J.

MINERAL EXPLORATION: TRENDS AND DEVELOPMENTS IN 1978; Canadian Mining Journal. v. 100, no. 1, p. 28-69, 1979.

This article reviewed the following topics for the year 1978:

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

In addition in the review for 1978, the characteristics of commercially-available resistivity equipment were tabulated together with airborne electromagnetic survey systems offered for purchase or as a contract service.

Hunter, J.A., Neave, K.G., MacAulay, H.A. and Hobson, G.D.

INTERPRETATION OF SUB-SEABOTTOM PERMAFROST IN THE BEAUFORT SEA BY SEISMIC METHODS. PART I. SEISMIC REFRACTION METHODS; in Proceedings, 3rd International Conference on Permafrost, v. 1, 1978.

The cocurrence and distribution of ice-bonded permafrost beneath the sea floor of the Beaufort Sea Shelf have been mapped by seismic techniques. The data for the maps comes primarily from refraction arrivals on front ends of unprocessed marine reflection records supplied to us by the oil industry. High seismic velocities, indicative of ice-bonded

permafrost, are observed east of 135°W from the shoreline out to 90 m water depth. A thin discontinuous upper layer appears to overly a continuous thicker (greater than 30 m) horizon. West of 135°W, there is a zone of anomalous seismic velocities which are intermediate between the velocity for unfrozen sediments and the velocity for ice-saturated sediments (greater than 2.5 km/sec). This zone can be explained as an occurrence of partially ice-bonded permafrost, or alternatively, as gas-hydrate bonded sediments.

On a fait appel à des méthodes sismiques pour cartographier les zones de pergélisol lié par la glace, et sa répartition, au-dessous du fond marin du plateau de la mer de Beaufort. Les données qui ont servi à établir les cartes proviennent essentiellement des signaux frontaux de réfraction, qui figurent sur les enregistrements non traités de sismique-réflexion marine, que nous a fournis l'industrie pétrolière. On observe à l'est de 135°W, entre le rivage et 90 mètres de profondeur d'eau, des vitesses sismiques élevées qui indiquent la présence d'un pergélisol lié par la glace. Il semble qu'une mince couche supérieure discontinue recouvre un horizon continu plus épais (supérieur à 30 mètres). À l'ouest de 135°W, il existe une zone de vitesses sismiques anormales, intermédiaires entre la vitesse caractéristique des sédiments non gelés, et la vitesse caractéristique des sédiments saturés en glace (supérieure à 2.5 km/s). On peut expliquer la présence de cette zone par la présence d'un pergélisol partiellement lié par la glace, ou bien par la présence de sédiments liés par des hydrates gazeux.

Hunter, J.A., Neave, K.G., MacAulay, H.A. and Hobson, G.D.

INTERPRETATION OF SUB-SEABOTTOM PERMAFROST IN THE BEAUFORT SEA BY SEISMIC METHODS. PART II. ESTIMATING THE THICKNESS OF THE HIGH-VELOCITY LAYER; in Proceedings, 3rd International Conference on Permafrost, v. 1, 1978.

A study of thickness determination methods for high-velocity layers has been conducted to determine the potential of mapping thickness of permafrost under the Beaufort Sea Shelf. For thin, shallow, high-velocity layers, a method described by J.H. Rosenbaum, using attenuation measurements of refracted energy, has been successful. For thicker layers, a dispersion method based on modal propagation (discussed by Rosenbaum) and a technique based on discrete reflections from the base of the layer have been tried; however, strong modes developed in the low-velocity layer above the ice-bonded section adding considerable noise to the records. The low signal-to-noise ratio on the unprocessed records makes measurement of thickness unreliable. Signal enhancement processing may retrieve the thickness information from the records.

On a effectué une étude des méthodes de détermination de la puissance des couches caractérisées par une vitesse élevée de propagation des ondes sismiques, pour déterminer dans quelle mesure il est possible de cartographier l'épaisseur du pergélisol sous-marin du plateau continental de la mer de Beaufort. Une méthode décrite par J.H. Rosenbaum, qui a utilisé des mesures de l'atténuation de l'énergie réfractée, a donné des résultats concluants pour les couches peu profondes, caractérisées par une vitesse élevée. Pour les couches plus épaisses, on a essayé une méthode de dispersion basée sur la propagation modale (étudiée par Rosenbaum), et une technique basée sur des réflexions discrètes à partir de la base des couches; cependant, de forts signaux se sont produits dans la couche de faible vitesse située au-dessus de la tranche liée par la glace, qui a introduit un bruit considérable dans les enregistrements. Le faible rapport signal-bruit sur les enregistrements non traités rend les mesures de puissance des

couches peu sûres. L'amplification automatique des signaux peut aider à obtenir sur les enregistrements des renseignements relatifs à la puissance des couches.

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

ALKALINE SNOWFALLS IN OTTAWA AND WINNIPEG, CANADA; *Atmospheric Environment*, v. 12, p. 1169-1174, 1978.

The first snowfall of the winter 1974-75 in Ottawa, Canada revealed what is interpreted as the influence of a cement industry in the centre of the National Capital Region. Snow pH values of less than 6 were found outside the city limits. Values systematically increased to over pH 9.0 in the centre of the city. The alkaline samples contained anomalous concentrations of Ca and Mg. In 1975-76, snow samples collected in the most alkaline area of 1974-75, had normal pH values of 6 or less. Between the two collection periods, a large cement plant operation located in the centre of the 1974-75 pattern, had ceased operations. This fact, in conjunction with the Ca and Mg concentrations in the 1974-75 samples, and the occurrence of alkaline snow collected during the winters of 1975-76 and 1976-77 in an area of presently operating cement plants in Winnipeg, support the contention that the alkaline snowfall in Ottawa was related to the cement plant's former operations.

Jackson, K.S., Jonasson, I.R. and Skippen, G.B.

THE NATURE OF METALS-SEDIMENT-WATER INTERACTIONS IN FRESHWATER BODIES, WITH EMPHASIS ON THE ROLE OF ORGANIC MATTER; *Earth-Science Reviews*, v. 14, p. 97-146, 1978.

A review with 227 references of the title subject is presented. It is divided into two main sections, viz., nature and properties of humic matter, and water-metal-sediment interactions.

The first section deals with the essential properties of organic matter which occurs naturally in drainage sediments and waters. Discussion of the basic molecular structure of humic and fulvic acids is followed by some details of the chemical nature of functional groups within these structures which are important in metal-ion adsorption and complexing reactions which these materials can undergo. Information is also presented for colloidal and polyelectrolyte properties, complexation properties, and finally a summary discussion of metal-ion-humic-acid, metal-ion-fulvic-acid stability constants for both single ligand and mixed ligand systems completes the section.

The second section comprises discussions of some specific aspects of interactions between metals, sediments and waters, including metal and organic speciation studies; sorption interactions between organic matter, clays and humic acids; chemical reaction between humic acids, heavy-metal minerals, clays and other silicate minerals; metal-ion adsorption-desorption studies, oxidation-reduction reactions between metal ions and humic acids; effects of sulphide ion on some of the above interactions and finally a summary of some relevant field geochemical dispersion studies.

This second section describes both laboratory and field studies for each aspect.

Keen, C.E.

THERMAL HISTORY AND SUBSIDENCE OF RIFTED CONTINENTAL MARGINS-EVIDENCE FROM WELLS ON THE NOVA SCOTIAN AND LABRADOR SHELVES; *Canadian Journal of Earth Sciences*, v. 16, p. 505-522, 1979.

The subsidence histories of the Labrador and Nova Scotian rifted continental margins have been determined from biostratigraphic data for 11 deep exploratory wells off Nova Scotia, for five wells off Labrador, for three wells northeast of Newfoundland, and for one well off the northeast coast of the United States of America. The components of subsidence, due to sediment loading, and when possible due to loading by changes in eustatic sea level, were removed leaving that part of the subsidence, the tectonic subsidence, caused by cooling of the lithosphere or by other deep seated processes. The thermal cooling model theoretically predicts a linear relationship between tectonic subsidence and $t^{1/2}$, where t is the time since subsidence began. This relationship should be obeyed during the first tens of Ma of subsidence. The slope of this curve depends upon the temperature to which the crust and upper mantle were heated during the initial rifting stage and can be used to derive the temperature-time history within the sediments, the present temperature distribution, and geothermal gradient. The data show that the observed subsidence curves behave in accordance with the thermal cooling model, at least during the first 80 Ma after subsidence began and obey the equation $y = 300(\pm 80)t^{1/2}$ m, where y is the tectonic subsidence. The slopes of the subsidence curves are similar for the Labrador Shelf, the Nova Scotian Shelf, and the shelf off the northeastern U.S.A. More rapid and variable subsidence occurs northeast of Newfoundland and this may be associated, in a way yet to be established, with the anomalous founded continental crust near the Orphan Knoll and Flemish Cap micro-continents which lie close to this area. After about 80 Ma, the subsidence appears to depart from the linear $t^{1/2}$ law in a manner similar to the subsidence curves for oceanic crust, but this is not well established by the data. The present temperatures and temperature gradients computed using the slope of the subsidence curves show good agreement with measured values; geothermal gradients of $17.5^{\circ}\text{C km}^{-1}$ and $26^{\circ}\text{C km}^{-1}$ are calculated off Nova Scotia and Labrador respectively, and mean values of about $23^{\circ}\text{C km}^{-1}$ are observed. The computed temperature-time history within the sediments was used to estimate values of vitrinite reflectance, an indicator of the degree of organic metamorphism. These values show reasonable agreement with the measured values and suggest that only the Upper Jurassic and Lower Cretaceous sediments off Nova Scotia and the Paleocene sediments off Labrador are sufficiently mature to be good sources of petroleum. The linear $t^{1/2}$ behaviour of the subsidence, and the good agreement between predicted and observed temperatures support the contention that cooling is largely responsible for the observed tectonic subsidence. The similarity of results from different areas suggests that the usefulness of the method is not restricted to a particular geographical area and may be applied to other rifted continental margins. Comparisons between the subsidence rates, thermal histories, and crustal structure at rifted margins on a worldwide scale may provide insights concerning the processes controlling their development. The temperature-time histories of the sediments estimated from the subsidence may be useful in establishing the potential of a rifted margin area for petroleum generation when little other information is available.

On a déterminé les histoires d'affaissement des bordures continentales effondrées du Labrador et de Nouvelle-Écosse à partir de données biostratigraphiques dans 11 forages d'exploration profonds au large de la Nouvelle-Écosse, cinq forages au large du Labrador, trois forages au nord-est de Terre-Neuve et un forage au nord-est de la côte américaine. Les composantes de l'affaissement causées par l'accumulation de sédiments et, lorsque c'est possible, par les charges résultant des variations eustatiques des niveaux marins ont été soustraites pour laisser cette portion de l'affaissement, l'affaissement tectonique, qui résulte du refroidissement de la

lithosphère ou d'autres processus agissant en profondeur. Le modèle thermique de refroidissement prédit une relation linéaire théorique entre l'affaissement tectonique et $t^{1/2}$, où t est le temps écoulé depuis que l'affaissement a débuté. Cette relation devrait être valide durant les premières dizaines de Ma d'affaissement. La pente de cette courbe dépend de la température à laquelle se sont élevés la croûte et le manteau supérieur durant le stade initial de faillage et on peut l'utiliser pour établir l'évolution de la température en fonction du temps dans les sédiments, la distribution actuelle des températures et le gradient géothermique. Les données montrent que les courbes d'affaissement observées se comportent comme le prédit le modèle théorique de refroidissement, au moins durant les premiers 80 Ma après le début de l'affaissement et obéissent à l'équation $y = 300(\pm 80)t^{1/2}$ m, où y est l'affaissement tectonique. Les pentes des courbes d'affaissement sont semblables pour les plate-formes du Labrador, de Nouvelle-Écosse et du nord-est des États-Unis. On observe un affaissement plus rapide et plus variable au nord-est de Terre-Neuve et ceci pourrait être associé, d'une façon qui reste à expliquer, à l'anomalie dans la croûte continentale effondrée près des micro-continentaux d'Orphan Knoll et de Flemish Cap qu'on retrouve près de cette région. Après environ 80 Ma, l'affaissement semble s'éloigner de la loi linéaire $t^{1/2}$ de façon semblable aux courbes d'affaissement pour les croûtes océaniques mais ceci n'est pas bien établi par les données qu'on possède. Les températures et gradients de température actuels calculés en utilisant la pente des courbes d'affaissement s'accordent bien avec les valeurs mesurées; on a calculé des gradients géothermiques de $17.5^{\circ}\text{C km}^{-1}$ et de $26^{\circ}\text{C km}^{-1}$ au large de la Nouvelle-Écosse et du Labrador respectivement alors qu'on observe des valeurs moyennes de $23^{\circ}\text{C km}^{-1}$. On a utilisé l'évolution de la température en fonction du temps calculée pour les sédiments pour estimer les valeurs de réflectance de la vitrinite, un indicateur du degré de métamorphisme organique. Ces valeurs montrent un accord raisonnable avec les valeurs mesurées et suggèrent que seulement les sédiments du Jurassique supérieur et du Crétacé inférieur au large de la Nouvelle-Écosse et les sédiments du Paléocène au large du Labrador sont suffisamment matures pour être de bonnes sources de pétrole. Le comportement linéaire $t^{1/2}$ de l'affaissement et la bonne concordance entre les températures observées et prédictes supportent l'hypothèse que le refroidissement est en grande partie responsable de l'affaissement tectonique observé. La similitude des résultats dans deux régions différentes suggère que l'utilité de la méthode n'est pas restreinte à une région géographique donnée et qu'elle pourrait s'appliquer à d'autres bordures continentales effondrées. Les comparaisons entre les taux d'affaissement, les histoires thermiques et la structure de la croûte aux bordures effondrées sur une base mondiale pourraient donner des indications sur les processus qui contrôlent leur développement. L'évolution des températures en fonction du temps dans les sédiments estimée à partir de l'affaissement peut être utile pour établir le potentiel d'une région de bordure effondrée pour la génération du pétrole quand il y a peu d'information disponible d'autres sources.

Sullivan, K.D. and Keen, C.E.

ON THE NATURE OF THE CRUST IN THE VICINITY OF THE SOUTHEAST NEWFOUNDLAND RIDGE; Canadian Journal of Earth Sciences, v. 15, p. 1462-1471, 1978.

This paper presents new seismic reflection, refraction, gravity, and magnetic data bearing on the nature of the crust in the vicinity of the Newfoundland Ridge and the J-anomaly Ridge, immediately south of the Grand Banks. This area experienced a complicated plate tectonic history being the focal point for interactions of the North American, African, and Iberian plates. New data have recently been published

for this region and conflicting interpretations have been offered in relation to the oceanic or continental origin of the crust there. The data presented here show that the seismic structure and the most reasonable models for the magnetic anomalies are more consistent with an oceanic origin. The trends and offsets in the magnetic lineations and possible differences in subsidence, north and south of the Newfoundland Ridge, are discussed in relation to possible modes of formation of this feature. It is proposed that similar subsidence histories since mid-Cretaceous time on the Grand Banks and J-anomaly Ridge are related to a similarity in the thermal history of the lithosphere beneath these areas, as the ridge crest migrated eastwards, and do not require the same type of crust to underlie both areas.

Cet article présente de nouvelles données de réflexion et de réfraction sismiques, de gravité et de magnétisme sur la nature de la croûte dans le voisinage de la crête de Terre-Neuve et de la crête de l'anomalie-J, immédiatement au sud des Grands-Bancs. Cette région a subi une histoire compliquée de tectonique de plaques parce qu'elle est au foyer d'interaction des plaques nord-américaine, africaine et ibérique. De nouvelles données ont été publiées récemment pour cette région et il existe des interprétations contradictoires quant à l'origine océanique ou continentale de la croûte en cet endroit. Les données qu'on présente ici montrent que la structure sismique et les modèles magnétiques les plus plausibles pour les anomalies magnétiques s'accordent mieux avec une origine océanique. On discute les motifs et les décrochements dans les linéations magnétiques et les différences possibles de subsidence, au nord et au sud de la crête de Terre-Neuve, en relation avec les modes possibles de formation de cette crête. On propose que la similitude des histoires de subsidence depuis le Crétacé moyen, sur les Grands-Bancs et sur l'anomalie-J, s'explique par une similitude dans l'histoire thermique de la lithosphère sous ces régions, au moment où les crêtes se déplaçaient vers l'est, et on n'a pas besoin de postuler que le même type de croûte existait en dessous des deux régions.

Kerr, J.Wm.

CORNWALLIS LEAD - ZINC DISTRICT; MISSISSIPPI VALLEY - TYPE DEPOSITS CONTROLLED BY STRATIGRAPHY AND TECTONICS; Canadian Journal of Earth Sciences, v. 15, p. 460, 1978.

Callahan's suggestion of an alternate interpretation of the lead-zinc deposits is appreciated. Its validity depends on there being a regional unconformity older than any known at present. For four reasons it appears that this is not the case.

Kerr, J.Wm.

CORNWALLIS LEAD-ZINC DISTRICT; MISSISSIPPI VALLEY-TYPE DEPOSITS CONTROLLED BY STRATIGRAPHY AND TECTONICS: Reply II; Canadian Journal of Earth Sciences, v. 16, p. 615-617, 1979.

Killeen, P.G. and Conaway, J.G.

NEW FACILITIES FOR CALIBRATING GAMMA-RAY SPECTROMETRIC LOGGING AND SURFACE EXPLORATION EQUIPMENT; Canadian Mining and Metallurgical Bulletin, May, 1978.

Proper calibration of portable gamma-ray spectrometers and spectrometric logging equipment is essential if they are to be used for accurate quantitative determinations of radioelement concentrations. In the case of both types of equipment, it is necessary to determine the system calibration constants (stripping factors and sensitivities). In the case of borehole logging equipment, it is

further necessary to determine the system response characteristics if the data are to be computer processed to improve the accuracy and resolution of the logs.

Facilities are now available near Ottawa for the complete calibration of portable gamma-ray spectrometers and spectrometric logging equipment, in addition to already existing facilities for calibrating airborne gamma-ray spectrometers. Limited additional facilities are also available or planned in several other areas of Canada.

Klassen, R.W.

A UNIQUE STRATIGRAPHIC RECORD OF LATE TERTIARY-QUATERNARY EVENTS IN SOUTHEASTERN YUKON; *Canadian Journal of Earth Sciences*, v. 15, p. 1884-1886, 1978.

A succession of fluvial sediments with minor coal, basaltic lava, five tills, and fossiliferous intertill sediments exposed along the Liard River where it crosses the Liard Plain provides a remarkably continuous record of geologic-climatic events in this region. The coal bearing sediments and lava were previously described and interpreted as Tertiary-Quaternary in age. The Quaternary sediments record four major intervals of glaciation and three nonglacial intervals not previously recognized in this region.

Une succession de sédiments fluviaux contenant du charbon, de laves basaltiques, de cinq tills et de sédiments intertills fossilières exposés le long de la rivière Liard à travers la plaine de Liard fournissent un registre remarquablement continu des événements climatiques et géologiques de cette région. On interprète comme datant de la fin du Tertiaire les sédiments contenant du charbon et les laves. On reconnaît quatre épisodes majeurs de glaciation et trois intervalles interglaciaires dans les sédiments du Quaternaire.

Lambert, M.B.

VOLCANOES; Douglas and McIntyre, Vancouver B.C., 64 p. 1978.

A well illustrated, descriptive book designed for the general reader.

Long, D.G.F.

DEPOSITIONAL ENVIRONMENTS OF A THICK PROTEROZOIC SANDSTONE: THE (HURONIAN) MISSISSAGI FORMATION OF ONTARIO, CANADA; *Canadian Journal of Earth Sciences*, v. 15, p. 190-206, 1978.

The Mississagi Formation is a thick (up to 3.4 km) Proterozoic arenite sequence that forms part of the Huronian (lower Aphebian \approx 2.2-2.5 Ga) succession of the north shore of Lake Huron, Ontario. The formation is characterized by planar and to a lesser extent trough cross-stratified medium to coarse feldspathic arenites, with only minor amounts of argillite and conglomerate. Although the formation lacks any regular systematic cyclicity, both thinning upward and fining upward sequences can be recognized in some sections. Paleocurrent roses for individual outcrops are typically unimodal, although some bimodal distributions are recognized. The bulk of the formation is interpreted to be the result of deposition in a fluvial environment, principally from bed load and mixed load streams. These rivers were probably marked by a braided stream pattern in which channels were characterized by intermediate to low sinuosities and high width to depth ratios. Regional paleocurrent and petrographic trends sand south from the Sault Ste. Marie - Elliot Lake region to meet a second,

southwesterly flowing system originating in the Cobalt Plain. These systems met in the southern Huronian area, from where the coalescing river systems flowed south.

La formation de Mississagi est une séquence d'arenite épaisse (jusqu'à 3.4 km) du Protérozoïque qui forme une partie de la succession de l'Huronien (Apébien inférieur, \approx 2.2-2.5 Ga) sur la rive nord du lac Huron, en Ontario. La formation se caractérise par des arenites feldspathiques de granulométrie moyenne à grossière en lits planaires et jusqu'à un certain point avec stratification croisée en auge et par des quantités mineures d'argilite et de conglomerat. Bien que la formation manque de cyclicité systématique régulière, on reconnaît dans certaines sections des séquences qui s'amincissent et deviennent plus fines vers le haut. Les rosettes de paléocourants pour des affleurements individuels sont typiquement unimodales, bien qu'on reconnaîsse quelques distributions bimodales. On interprète le plus gros de la formation comme le résultat de dépôt dans un milieu fluviatile de matériaux provenant de la charge de fond et de la charge mixte des cours d'eau. Ces rivières possédaient probablement un réseau anastomosé de chenaux qui se caractérisaient par des sinuosités intermédiaires à faibles et des rapports largeur/profondeur élevés. Les paléocourants régionaux et les tendances pétrographiques indiquent que deux systèmes fluviaux majeurs existeront. Un système fluvial s'écoulait vers l'est et le sud en provenance de la région de Sault-Ste-Marie - Elliot Lake à la rencontre d'un second système s'écoulant vers le sud ouest avec sa source dans la plaine de Cobalt. Ces systèmes fluviaux confluaient dans le sud de la région huronienne pour ensuite couler vers le sud.

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

DISPERSION OF CROSS-STRATIFICATION AS A POTENTIAL TOOL IN THE INTERPRETATION OF PROTEROZOIC ARENITES; *Journal of Sedimentary Petrology*, v. 48, no. 3, p. 857-862, 1978.

The distribution of values of dispersion of cross-stratification (measured as variance, at outcrop level) in Proterozoic rocks can be compared directly with patterns obtained from published descriptions of Phanerozoic rocks of more certain origin in order to augment environmental interpretations of the older sequences. Fluvial patterns show characteristic peaks below a variance of 4000; marine sequences show a broad distribution of values with characteristic peaks above 4000. Patterns obtained from aeolian deposits and (?) marine deposits in which unidirectional currents were important are difficult to distinguish from fluvial patterns. Hence, in Proterozoic arenite sequences, the observed distribution of variance values should be used only in conjunction with other environmental indicators.

Long, D.G.F.

PROTEROZOIC STREAM DEPOSITS: SOME PROBLEMS OF RECOGNITION AND INTERPRETATION OF ANCIENT SANDY FLUVIAL SYSTEMS; in FLUVIAL SEDIMENTOLOGY, A. D. MIALL, ED.; Canadian Society of Petroleum Geology Memoir 5, p. 313-341, 1978.

Fluvial deposits of Proterozoic age (\sim 2.5 - 0.6 Ga) have been reported from several continents. They include the products of deposition in alluvial fan, braided stream and possibly meandering stream environments. The braided stream deposits include both conglomeratic and non-conglomeratic sequences. Many of the non-conglomeratic, sandy, fluvial deposits, which may be several kilometres thick, are characterized by a paucity of fine-grained clastic material, whether as matrix or as associated mudrocks. In many cases,

thick arenaceous sequences of Proterozoic age have been interpreted as fluvial by some authors and non-fluvial by others, with little conclusive evidence of either interpretation. Fossils are generally unavailable as evidence, except perhaps in the uppermost Proterozoic. Even stromatolites, where present, may have developed in nonmarine settings. Differentiation may in some cases be achieved by examination of grain size characteristics, in association with the type, scale and abundance of sedimentary structures, their directional attributes and vertical and lateral associations. Other criteria include sand-body geometry, lithofacies association, petrology and, in some examples, colour. A comparison can be made between Proterozoic and Phanerozoic fluvial environments, although the absence of vegetation must have had profound effects on the style of deposition in Proterozoic fluvial systems. The paucity of fines in many Proterozoic fluvial systems can be related to differences in hydraulic regime, dominance of bedload type streams, the extreme vulnerability of overbank flood deposits to atler fluvial and aeolian erosion, and possibly to removal of fines from the fluvial systems as wash load.

Maurice, Y.T. and Coker, W.B.

METHODS OF INTERPRETATION AND FOLLOW-UP OF RECONNAISSANCE LAKE SEDIMENT DATA IN THE NORTHERN CANADIAN SHIELD; in 7th International Geochemical Exploration Symposium; Association of Exploration Geochemists, 1978.

The Canadian Federal-Provincial Uranium Reconnaissance Program begun in 1975 has surveyed some 160,000 square miles ($414,000 \text{ km}^2$) of the Canadian Shield utilizing center-lake sediment and water sampling at a density of one sample per 13 km^2 . In order to assess these data, in terms of their usefulness to the mineral industry as a regional exploration tool, and also to recommend methods of interpretation and follow-up, two detailed programs were carried out in 1976. One program was conducted in the Nonacho Lake area, south of the East Arm of Great Slave Lake, and the other, in northwestern Manitoba along the postulated extension of the Wollaston fold belt.

The paper first discusses methods of interpreting the reconnaissance lake sediment data. These are varied and range from the examination of simple features such as element concentrations and areal extent of the anomalies, to assessing the significance of element associations and performing multivariate statistical analyses. By means of these interpretive procedures areas were selected for field follow-up, and the second part of the paper examines the methodology adopted and some results obtained during this phase. The application of such techniques as detailed lake water, lake sediment, stream and spring geochemistry, overburden geochemistry, lithogeochemistry, and ground and airborne radiometric techniques in follow-up operations are critically assessed in terms of specific surficial and bedrock conditions.

MacLean, B., Falconer, R.K.H. and Clarke, D.B.

TERTIARY BASALTS OF WESTERN DAVIS STRAIT: BEDROCK CORE SAMPLES AND GEOPHYSICAL DATA; Canadian Journal of Earth Sciences, v. 15, p. 773-780, 1978.

Short bedrock cores of basalt were recovered at two localities on the Baffin Island shelf, 33 and 89 km southeast of Cape Dyer. The volcanic rocks underlying these sites have a surface extent of some 8000 km^2 as outlined by seismic reflection and magnetic anomaly profiles. Similar rocks are inferred to occur at two smaller offshore areas

south of the main area. The offshore occurrences are both more continuous and much larger than the onshore basalt areas of eastern Baffin Island

The core samples appear to have been cut from single flows consisting of fine-grained microporphitic basalts with olivine as the principal phenocryst phase. Although having distinct differences from one another in terms of texture and degree of alteration, the samples from the three drill stations bear similarities to the Baffin Island basalts that suggest a close petrogenetic relationship may exist between the onshore and offshore basalts. However, in contrast to the subaqueously erupted volcanic breccias of onshore Baffin Island and West Greenland the offshore samples contain little evidence of glass, suggesting the possibility that the latter may have been erupted in a subaerial environment.

On a prélevé de carottes de faible longueur dans des basaltes à deux localités sur la plate-forme de l'île de Baffin à 33 et 89 km au sud-est de Cape Dyer. Les roches volcaniques dans cette région ont une extension latérale de quelques 8000 km^2 comme l'indique l'étude des profils de sismique-réflexion et des anomalies magnétiques. On suppose que des roches semblables se retrouvent dans deux petites zones marines au sud de la région principale. La distribution des basaltes au large est à la fois continue et beaucoup plus vaste que les affleurements de basalte sur le littoral est de l'île de Baffin.

Les carottes semblent provenir de coulées individuelles consistant en basaltes à grains fins microporphyriques avec l'olivine comme phase phénocristalline principale. Bien qu'il existe des différences assez nettes entre les échantillons en termes de texture et de degré d'altération, les échantillons des trois stations de forage ont des affinités avec les basaltes de l'île de Baffin qui suggèrent qu'une relation pétrogénétique puisse exister entre les basaltes du littoral et ceux du large. Toutefois, par contraste avec les brèches volcaniques provenant d'éruption sous l'eau qu'on retrouve actuellement dans l'île de Baffin et à l'ouest du Groenland, les échantillons du large contiennent peu d'évidence de verre volcanique, ce qui supporte la possibilité que ces basaltes ont pu avoir une éruption subaérienne.

McGregor, D.C. and Narbonne, G.M.

UPPER SILURIAN TRILETE SPORES AND OTHER MICROFOSSILS FROM THE READ BAY FORMATION, CORNWALLIS ISLAND, CANADIAN ARCTIC; Canadian Journal of Earth Sciences, v. 15, p. 1292-1303, 1978.

A diverse palynomorph assemblage of trilete spores, tetrads, acritarchs, chitinozoans, scolecodonts, and fragments of arthropods, ?hydrozoans, ?graptolites, and possibly nematophytalean and vascular plants occurs 20 m above the base of member B of the Read Bay Formation at the type section on eastern Cornwallis Island, District of Franklin. This assemblage, here described briefly, is late Ludlow according to faunas above and below. The palynomorphs, other fossils, and stratigraphic framework indicate that the shales of member B were deposited in a sheltered near-shore marine environment. One new species of trilete spores, *Retusotriletes chartulatus* McGregor, is erected.

Un assemblage palynomorphe diversifié de spores trilètes, de tétrares, d'acritarches, de chitinozoaires, de scolécodontes, et des fragments d'arthropodes, d'hydrozoaires?, de graptolites? et possiblement de plantes nématophytaleennes et vasculaires se retrouve à 20 m au-dessus de la base du membre B de la formation de Read Bay dans sa coupe-type dans l'est de l'île de Cornwallis, district de Franklin. Cet assemblage qu'on décrit ici brièvement date de la fin du Ludlovien selon les faunes observées au-dessus et en dessous. Les palynomorphes,

d'autres fossiles et le cadre stratigraphique indiquent que les shales du membre B se sont déposés dans un milieu marin abrité, près du littoral. On érige une nouvelle espèce de sporetrilete, *Retusotriletes chartulatus*, McGregor.

McLean, J.R.

DEPOSITIONAL ENVIRONMENTS OF CRETACEOUS-TERTIARY COAL, ALBERTA FOOTHILLS; in Display Summaries, C.S.P.G. 1978 Core and Field Sample Conference; A.F. Embry (ed.) Canadian Society of Petroleum Geologists, Calgary, Alberta, p. 59-63, 1978.

Coal seams of commercial interest in Western Canada are confined to the molasse deposits which infilled the foreland basin synchronously with the tectonic development of the Rocky Mountains. Depositional environments favourable to peat accumulation - deltas, coastal plains and alluvial plains - and progressive subsidence, essential to peat preservation, are characteristic of molasse basins. Examples from the Lower Cretaceous and Tertiary sequences in the Alberta Foothills illustrate vertical sedimentary sequences generated by delta plain and alluvial plain depositional environments.

McLean, J.R. and Jerzykiewicz, T.

CYCPLICITY, TECTONICS AND COAL: SOME ASPECTS OF FLUVIAL SEDIMENTOLOGY IN THE BRAZEAU-PASKAPOO FORMATIONS, COAL VALLEY AREA, ALBERTA, CANADA; In FLUVIAL SEDIMENTOLOGY, A. D. MIAIL, ED.; Canadian Society of Petroleum Geology Memoir 5, p. 441-468, 1978.

The Upper Cretaceous - lower Tertiary Brazeau-Paskapoo Formations in the central Foothills of Alberta encompass an estimated thickness of 3600 m of nonmarine sediments of alluvial plain origin. They were deposited in a foreland, or molasse, basin accompanying orogeny in the Cordillera to the southwest.

Three orders of cyclicity are observed: (1) first order cycles representing mappable lithostratigraphic units; (2) second order cycles representing successive recurrences of fluvial channels at a particular location; and (3) third order cycles representing high- and low-energy overbank deposits on a flood plain.

The main allocyclic control on sedimentation was tectonics. Progressive, but sporadic, encroachment of the thrust belt of the Rocky Mountains on the foreland basin produced sporadic loading and subsidence by isostatic compensation. Coarser members of first order cycles reflect major thrust loading events that initially produced maximum aggradation on the southwestern flank of the foreland basin and then was transmitted progressively eastward. Continued subsidence due to sediment loading produced further aggradation but at a reduced rate, resulting in the finer members of first order cycles which are characterized by a greater proportion of overbank to channel deposits. Second order cycles are predominantly of autocyclic origin but with an allocyclic override. Third order cycles are entirely autocyclic.

Rapid marine transgressions are related to rapid (10^4 - 10^5 years) thrust loading and widespread subsidence of a flexurally rigid lithosphere. Slower transgressions are a function of sediment starving at the coastal plain by preferential sedimentation at the proximal edge of the foreland basin, or by creation of local base levels.

Calculated rates of deposition suggest that long periods of nondeposition must have occurred.

Modern river classifications appear to be inadequate for application to ancient fluvial systems because they lack the perspective of time. Present models for ancient fluvial sequence interpretation are premature and often misleading.

Channel sands, interspersed with various thicknesses of overbank deposits, have characteristics of both braided and meandering rivers, suggesting that both of these morphological types were present. Many channel deposits, composed of horizontally stratified, coarse-grained sandstones, are interpreted to have a flood origin.

The inferred tectonic - sedimentation framework for the Brazeau-Paskapoo sequence is analogous in many respects to the modern Indogangetic Plain of northern India and Bangladesh.

Thick coal deposits are of alluvial plain origin and are associated with a climatic change and widespread floral extinction at the Cretaceous-Tertiary transition. They also coincide with a major orogenic event producing widespread subsidence and marine transgression.

McNeil, D.H.

GEOLOGICAL SETTING, STRATIGRAPHY, AND FORAMINIFERA OF THE LATE CRETACEOUS PIERRE SHALE IN THE MANITOBA ESCARPMENT; Geological Association of Canada, Mineralogical Association of Canada, Geological Society of America, 1978. Joint Annual Meeting, Abstracts with Programs, v. 10, no. 7, p. 454, 1978.

The Cretaceous System in the Manitoba escarpment comprises some 600 m of sand, clay, shale, chalk-speckled shale, chalky shale, marlstone, and subordinate amounts of limestone, including calcarenite. The sequence variously contains lithofacies of the early, intermediate, and late stages of the Greenhorn, Niobrara, Claggett, and Bearpaw cycles of marine sedimentation. As such, the sequence stands as a unique record of Cretaceous mid-basinal deposition in the Canadian Western Interior.

The Pierre Shale, at 400 m thick, forms a major part of that sequence and shows many of its distinguishing characteristics. Five members comprise the formation in the Manitoba escarpment; they are the Gammon Ferruginous, Pembina, Millwood, Odanah, and an unnamed member. The Millwood Member and its partial equivalent, the Gregory Member in North Dakota, record a southeastward facies change from silty clay to calcareous shale to marlstone and chalk. This facies distribution establishes the proximity of the Manitoba escarpment to the axis of the Western Interior basin during Campanian time.

The Pierre Shale was yielded approximately 100 foraminiferal species. Four assemblage zones of the foraminiferal zonal scheme for the prairie provinces have been differentiated; the oldest is the early Campanian *Trochammina ribstonensis* Zone, the youngest is the late Campanian-early Maestrichtian *Haplaphragmoides fraseri* Zone. The assemblages are rich in agglutinated and calcareous benthonic species but include rare planktonic species. Many of the species are cosmopolitan in Campanian-Maestrichtian sequences; some are of chronostratigraphic importance. The relationships of the assemblages together with lithological data collectively suggest or substantiate a variety of significant stratigraphic interpretations.

Meijer Drees, N.C.

REGRESSIVE SEDIMENTARY SEQUENCES IN THE FUNERAL AND BEAR ROCK FORMATIONS; in Display Summaries, C.S.P.G. 1978 Core and Field Sample Conference, A.F. Embry (ed.); Canadian Society of Petroleum Geologists, Calgary, Alberta, 1978.

In the subsurface of the Mackenzie Plain (Northwest Territories, Canada), the facies transitional between the Bear Rock Formation (dolostone and anhydrite) and the Funeral Formation (limestone and shale) consists of a repetition of regressive sequences composed of shale grading upward to carbonate or carbonate grading upward to anhydrite. The sequences are up to 6 m thick and are marked at the base by a sharp contact that is commonly overlain by a thin fossiliferous bed containing mud pebbles. It is possible to correlate the sequences composed of carbonate and shale with the sequences composed of carbonate and anhydrite and it appears that both are tidal deposits. The sedimentary structures preserved in the anhydritic beds indicate that a substantial amount of anhydrite accumulated as a sulphate mud in shallow subtidal, lagoonal and "low energy-intertidal" environments.

Miall, A.D. and Gibling, M.R.

THE SILURO-DEVONIAN CLASTIC WEDGE OF SOMERSET ISLAND, ARCTIC CANADA, AND SOME REGIONAL PALEOGEOGRAPHIC IMPLICATIONS; *Sedimentary Geology*, v. 21, p. 85-127, 1978.

Upper Silurian and Lower Devonian rocks on Somerset Island were derived from Boothia Uplift, a linear tectonic belt that underwent a pronounced period of positive movement commencing in the Pridolian. The lower part of the clastic wedge is a succession of predominantly intertidal to supratidal dolomite and siltstone 150-400 m thick (Somerset Island Formation). Markov analysis documents the presence of tidal cycles in these rocks. The succession changes eastward, away from the uplift, into subtidal marine limestone indistinguishable from that of the underlying Read Bay Formation. The Somerset Island Formation grades vertically and laterally westward into alluvial deposits of the Peel Sound Formation, which consists of red sandstone of braided river and possibly eolian origin, and two fanglomerate members. A variety of fluvial fining-upward and thinning-upward cycle types has been documented by Markov analysis of a lower sand member of the formation. The Peel Sound reaches a maximum thickness of 600 m in northern Somerset Island.

Paleocurrent analysis of crossbedding indicates eastward transport directions in the fluvial rocks, except for cosets of very large scale crossbeds (up to 6 m thick) in the northwestern part of the island, which indicate northwesterly flow. The large sets are interpreted as the deposits of eolian dunes, or of sand waves in a large trunk river which carried clastic detritus northward, parallel to Boothia Uplift.

The Peel Sound Formation and its lateral facies equivalents on Prince of Wales Island, west of Boothia Uplift, contain coarser conglomerates and a higher sandstone/carbonate ratio, indicating deposition under higher energy conditions than are thought to have prevailed in Somerset Island. Relief may have been greater and depositional slope steeper in the west, an asymmetry in Boothia Uplift that is reflected in the present-day structural style of a narrow zone of tilting and reverse faulting in the west, and a broad zone of gentle folding and normal faulting in the east. The similarity in structural and stratigraphic asymmetry indicates a genetic link, which is further suggested by the presence of syndepositional folds and unconformities at a few localities within the clastic wedge.

An estimate of the volume of sediment removed from Boothia Uplift indicates that approximately one third can be accounted for in the present clastic wedge on either side of the Uplift. Either the Lower Paleozoic formations were attenuated over the Uplift, or rivers such as the hypothetical trunk river were effective in the dispersal of material beyond the region of the clastic wedge.

Miall, A.D.

TECTONIC SETTING AND SYNDEPOSITIONAL DEFORMATION OF MOLASSE AND OTHER NONMARINE-PARALIC SEDIMENTARY BASINS; *Canadian Journal of Earth Sciences*, v. 15, p. 1613-1632, 1978.

Molasse is a distinctive sedimentary facies consisting of alluvial and shallow marine deposits derived from source areas undergoing rapid uplift and erosion. The characteristic setting of molasse is within or adjacent to fold belts, and most molasse basins can be classified as foreland basin (external) or intermontane (internal) in type. Thick alluvial and shallow marine sequences in cratonic settings (e.g., taphrogenic troughs) have been classified as molasse by some workers, but this is not generally accepted.

Most molasse is synorogenic, and the interdependence of sedimentation and tectonism results in structural and stratigraphic complexity. Intermontane basins generally are tensional in origin and are bounded by high angle (commonly normal) faults. Facies distributions adjacent to each fault depend on relative rates of differential movement, erosion, and sedimentation; accelerated source area uplift causes segmentation and progradation of alluvial fans and generates coarsening-upward sedimentary cycles. Complications are introduced if tectonism occurs in discrete pulses and if basins enlarge themselves along systems of stepped faults.

Basins of compressional origin, such as those in a foreland setting, show a greater variety of internal complexity. Facies belts and trends of maximum thickness move progressively out from the core of the fold belt in response to a migration of the zone of active deformation. Conversely, broad structural warps may develop in response to a locally increased sedimentary load, such as a major delta. Folds or thrust faults growing within the basin cause local thinning or unconformable relationships, and may breach the surface so as to isolate parts of the alluvial plain as a synorogenic intermontane basin. Uplift of the fold belt may be discontinuous, causing the generation of stacked sedimentary megacycles. Basin margins commonly are characterized by intraformational angular unconformities and syndepositional folds.

Rates of alluvial sedimentation and tectonic movement measured in modern environments are one to two orders of magnitude higher than rates deduced from ancient nonmarine sequences. This lends support to the idea that much sedimentation may be very episodic in nature, but it could also imply that alluvial sequences are deposited much more rapidly than current interpretations of the ancient record would imply, based as they are on relatively crude dating techniques. Only in some wrench-fault basins do calculated sedimentation rates compare with those measured in modern environments.

La molasse est un faciès sédimentaire distinct comprenant des dépôts alluviaux et marins peu profonds qui proviennent de régions sources soumises à un soulèvement et une érosion rapides. La mise en place caractéristique des molasses se fait à l'intérieur ou à proximité des zones plissées et on peut classifier la plupart des bassins de molasses comme des types de bassins d'avant-pays (externe) ou intermontagneux (interne). Certains auteurs ont classé d'épaisses séquences alluviales ou marines peu profondes dans un milieu cratonique (par exemple, les fosses taphrogéniques) comme des molasses, mais ceci n'est généralement pas accepté.

La plupart des molasses sont synorogéniques et l'interdépendance de la sédimentation et du tectonisme aboutit à une complexité structurale et stratigraphique. Les bassins intermontagneux ont en général une origine en

extension et sont limités par des failles à fort pendage (souvent des failles normales). La distribution des faciès à proximité de chaque faille dépend des taux relatifs de mouvements différentiels, d'érosion et de sédimentation; une accélération du soulèvement de la région source provoque la segmentation et la progradation des cônes d'alluvions et engendre des cycles sédimentaires négatifs. On observe des complications lorsque le tectonisme se produit par pulsations discontinues et si les bassins s'agrandissent le long de systèmes de failles en escalier.

Les bassins dont l'origine est en compression, comme ceux d'un avant-pays, montrent une plus grande variété de complexité interne. Les ceintures de faciès et les directions d'épaisseurs maximales vont en s'éloignant progressivement du noyau de la zone plissée en réponse à la migration de la zone de déformation active. De même, de grands ploisements structuraux peuvent se développer sous l'accroissement local de la charge sédimentaire comme c'est le cas dans un delta majeur. Les plis et les failles de chevauchement qui se développent à l'intérieur du bassin causent un amincissement local ou des relations discordantes et peuvent traverser la surface pour isoler des portions de la plaine alluviale comme dans le cas d'un bassin intermontagneux synorogénique. Le soulèvement de la zone plissée peut être discontinu, engendrant ainsi l'empilement de mégacycles sédimentaires. Les bordures de bassin se caractérisent communément par des discordances intraformationnelles angulaires et par des plis synsédimentaires.

Les taux de sédimentation alluviale et de mouvement tectonique dans des milieux récents sont d'un à deux ordres de grandeur plus élevés que les taux déduits pour les séquences non marines anciennes. Ceci supporte l'idée qu'une grande partie de la sédimentation pourrait être de nature très épisodique mais pourrait aussi impliquer que les séquences alluviales se sont déposées beaucoup plus rapidement que les interprétations courantes des dépôts anciens le laissent supposer, puisqu'elles sont basées sur des techniques de datation primitives. Il y a seulement dans certains bassins limités par des failles verticales de décrochement que les taux de sédimentation calculés se comparent à ceux qu'on mesure sans les milieux récents.

Miall, A.D.

FLUVIAL SEDIMENTOLOGY: AN HISTORICAL REVIEW; in FLUVIAL SEDIMENTOLOGY, A.D. Miall, ed., Canadian Society of Petroleum Geology Memoir 5, p. 1-47, 1978.

Naturalists have been aware of the importance of rivers as depositional agents since the time of Herodotus and Aristotle although, until the mid-nineteenth century, there was a tendency to attribute "diluvial gravels" to the action of "The Deluge". Modern sedimentological concepts began with Lyell in 1830, and owe much to the subsequent work of Sorby, Walther, Gilbert, Barrell and Grabau. In the twentieth century sedimentological studies became highly specialized, with a resultant partial breakdown in communication between specialist groups. Six main themes can be traced: descriptive fluvial geomorphology, quantitative geomorphology (the study of hydraulic relationships), sediment transport and textural studies, bedforms and paleocurrents, facies studies, and paleohydraulics.

Modern concepts of fluvial sedimentary processes can be traced back to the detailed work of Fisk on the Mississippi River during and following the Second World War, the development of the flow regime concept by Simons and Richardson and of facies models by Allen. These and other developments are reviewed, and it is shown how the other papers in this book contribute to the overall development of fluvial sedimentology.

Miall, A.D.

LITHOFACIES TYPES AND VERTICAL PROFILE MODELS IN BRAIDED RIVER DEPOSITS: a summary; in Fluvial Sedimentology, A.D. Miall, ed., Canadian Society of Petroleum Geology Memoir 5, p. 599-604, 1978.

This article serves as an introduction to the papers dealing with braided river deposits in this volume.

A lithofacies code erected earlier by the writer is expanded to include matrix-supported gravel, low-angle cross stratified sand, erosion surfaces with intraclast conglomerates, and massive mud deposits.

The four vertical profile models erected by the writer are expanded to six. A new model, the "Trollheim type" is proposed, to include gravelly deposits characterized by abundant debris flows. The Donjek sequence type is restricted to gravel-dominated cyclic deposits and a new model, the "South Saskatchewan type", is erected for sand dominated cyclic deposits. The Scott, Platte and Bijou Creek models remain essentially unchanged.

Miall, A.D., Kerr, J.W. and Gibling, M.R.

THE SOMERSET ISLAND FORMATION: AN UPPER SILURIAN TO ?LOWER DEVONIAN INTERTIDAL/SUPRATIDAL SUCCESSION, BOOTHIA UPLIFT REGION, ARCTIC CANADA; Canadian Journal of Earth Sciences, v. 15, p. 181-189, 1978.

The Somerset Island Formation of Somerset Island is a newly defined unit consisting of interbedded fine-grained, grey, planar-laminated dolomite and limestone, grey mottled limestone and dolomite, red quartzose siltstone and red dolosiltite. It forms a transitional unit between the limestone and dolomite of the underlying Read Bay Formation and the sandstone and conglomerate of the overlying Peel Sound Formation, and ranges in thickness from 150 to more than 400 m. The formation was formed predominantly in intertidal and supratidal environments and forms the lowest part of a regressive sequence that culminates in boulder conglomerates of alluvial fan origin in the Peel Sound Formation. The Somerset Island Formation is predominantly Pridolian in age, but may include some strata of Ludlovian and Gedinnian age.

The regressive sequence reflects a major pulse of the Cornwallis Disturbance of Boothia Uplift. A similar sequence occurs in Prince of Wales Island, although the lower part of the succession there contains conglomerate and sandstone, rock types that are absent in Somerset Island. These rocks are formally assigned to the Lower Peel Sound Formation but are of similar age to the Somerset Island Formation of the type area.

Rocks of similar facies to the Somerset Island Formation of Somerset Island comprise the upper member of the Drake Bay Formation on Russell Island and Member D of the Read Bay Formation on Cornwallis Island. The latter unit is younger than the Somerset Island Formation, reflecting a later commencement of regression in that area.

La formation de Somerset Island sur l'île de Somerset est une unité nouvellement définie qui comprend des calcaires et des dolomies interlités, à grain fin, gris, avec laminations planaires, des calcaires et dolomies tachetés gris, un siltstone quartzeux rouge et une dolosiltite rouge. Elle forme une transition entre les calcaires et dolomies de la formation sous-jacente de Read Bay et les grès et conglomérats de la formation de Peel Sound au-dessus. Son épaisseur varie de 150 à plus de 400 m. La formation s'est déposée surtout en milieu intertidal et supratidal et forme la partie inférieure d'une séquence régressive qui culmine en conglomérats de blocs ayant pour origine un cône d'alluvion dans la formation

de Peel Sound. La formation de Somerset Island date surtout du Pridolien mais pourrait inclure quelques strates du Ludlovien et du Gédinnien.

La séquence régressive reflète une pulsation majeure de la dislocation de Cornwallis dans le soulèvement de Boothia. On rencontre une séquence similaire dans l'île du Prince de Galles, quoique la parti inférieure de la séquence en cet endroit contienne des grès et des conglomérats, types de roches qui sont absents dans l'île de Somerset. On assigne formellement ces roches à la partie inférieure de la formation de Peel Sound mais elles sont de même âge que la formation de Somerset Island de la région type.

Des roches de faciès semblables à celles de la formation de Somerset Island sur l'île de Somerset comprennent le membre supérieur de la formation de Drake Bay sur l'île de Russell et le membre D de la formation de Read Bay sur l'île de Cornwallis. Cette dernière unité est plus récente que la formation de Somerset Island, reflétant ainsi un début de régression plus tardif dans cette région.

Monger, J.W.H., Richards, T.A. and Paterson, I.A.

THE HINTERLAND BELT OF THE CANADIAN CORDILLERA: NEW DATA FROM NORTHERN AND CENTRAL BRITISH COLUMBIA; Canadian Journal of Earth Sciences, v. 15, p. 823-830, 1978.

The Omineca Crystalline Belt of the Canadian Cordillera is flanked on the west by the Hinterland Belt, characterized by folds and faults that show predominant westward directed tectonic transport. Rocks involved in northern and central British Columbia comprise the Cache Creek Group and, to the west, various Permian, Triassic and Jurassic units. The structures in this belt record three major episodes of deformation. Earliest folds in the Cache Creek Group probably reflect latest Triassic deformation and cannot be related to the Hinterland Belt for they trend obliquely to it. In northern and central British Columbia the Hinterland Belt as a structural entity was produced by probable latest Jurassic or earliest Cretaceous deformation. Major east-dipping thrust and reverse faults, associated locally with folds and schist terranes, bring Cache Creek strata over and against coeval and younger rocks to the west. This belt was later disrupted by strike-slip faults in Late Cretaceous - Early Tertiary time.

La zone cristalline d'Omineca dans la Cordillère canadienne est flanquée à l'ouest par la zone de Hinterland, caractérisée par des plissements et des failles indiquant un transport tectonique dirigé vers l'ouest. Les roches qu'on rencontre dans le nord et le centre de la Colombie-Britannique comprennent le groupe de Cache Creek et, à l'ouest, différentes unités datant du Permien, du Trias et du Jurassique. Les structures de cette zone ont enregistré trois épisodes majeurs de déformation. Les plissements les plus anciens ne se reconnaissent que dans le groupe de Cache Creek et reflètent probablement la déformation à la toute fin du Trias. Dans le nord et le centre de la Colombie-Britannique, la zone de Hinterland comme entité structurale s'est produite par déformation à la fin du Jurassique ou au début du Crétacé. Des failles inverses majeures et des failles de chevauchement avec pendage à l'est, associées localement avec des plissements et des étendues de schistes, ont porté les strates du Cache Creek au-dessus ou en contact avec des roches contemporaines ou plus jeunes à l'ouest. Plus tard cette zone a été disloquée par des failles à rejet horizontal à la fin du Crétacé et au début du Tertiaire.

Mott, R.J.

POPULUS IN LATE-PLEISTOCENE POLLEN SPECTRA; Canadian Journal of Botany, v. 56, p. 1021-1031, 1978.

Populus profiles in pollen diagrams have often been ignored or given little attention because of problems with identification and preservation. Modern surface spectra aid in the interpretation of fossil assemblages, but exact modern analogues have not been found. Recent studies from several localities in Canada have revealed peaks in **Populus** pollen in late-Pleistocene and (or) early-Holocene spectra, and relative and absolute frequencies indicate that **Populus** may have played a significant role in the transition from tundra to forested conditions.

Mott, R.J. and Farley-Gill, L.D.

A LATE-QUATERNARY POLLEN PROFILE FROM WOODSTOCK, ONTARIO; Canadian Journal of Earth Sciences, v. 15, p. 1101-1111, 1978.

Maplehurst Lake, situated in a former interlobate zone that was deglaciated relatively early compared to adjacent areas of southern Ontario, provides one of the more complete pollen records for the region.

Five radiocarbon dates allow determination of sedimentation rates and hence pollen influx rates. Both relative percentage and pollen influx values outline a vegetational history that began prior to 12 000 years BP with a herb pollen zone representative of tundra conditions. This was followed by invasion of spruce that culminated in a spruce woodland environment which peaked about 11 200 years BP and then declined, to be replaced, beginning about 9500 years BP, by a closed mixed conifer-hardwood forest dominated by pine species. Hemlock replaced pine as the most abundant coniferous species about 7200 years BP. Hardwoods completely dominated the forest after 6400 years BP and beech, maple, oak, elm, and ash were prominent, associated with a wide variety of other deciduous genera. The deciduous hardwood forest prevailed without major change until recent times when the forests were largely removed for agriculture. Ragweed, grasses, and other weed taxa indicative of agricultural activity characterize the pollen spectra of this most recent interval. This sequence of events parallels those found at sites throughout the great Lakes region, New England and Maritime Canada and adds to the knowledge of migration rates, succession, chronology, and climate of northeastern North America.

Le lac Maplehurst, situé dans une ancienne zone interlobaire qui a été déglaçée relativement tôt par rapport aux régions adjacentes du sud de l'Ontario, fournit un des registres polliniques les plus complets pour la région.

Cinq datations au radiocarbone permettent de déterminer les taux de sédimentation et par conséquent le taux d'accumulation du pollen. Les pourcentages relatifs et les valeurs d'influx pollinique délimitent une histoire de la végétation qui a débuté plus de 12 000 ans avant le présent avec une zone de pollen herbacé représentative de conditions de toundra. Cette période a été suivie d'une invasion d'épinettes qui a culminé en un environnement de forêt d'épinette il y a environ 11 200 ans et qui a décliné ensuite pour être remplacée à partir d'il y a environ 9500 ans par une forêt mixte de conifères et de bois durs dominée par les espèces de pin. La pruche a remplacé le pin comme conifère le plus abondant il y a environ 7200 ans. Les bois durs dominent complètement la forêt après 6400 avant le présent et le hêtre, l'érable, le chêne, l'orme et le frêne étaient abondants en association avec une grande variété d'autres genres de feuillus. La forêt de feuillus a prévalu sans changement majeur jusqu'à récemment alors que la forêt a

fait place à l'agriculture. L'ambroisie, les herbes et d'autres taxons de mauvaises herbes indicatrices d'activité agricole caractérisent les spectres polliniques de l'intervalle le plus récent. Cette séquence d'événements est en parallèle avec celles qu'on observe en d'autres sites partout dans la région des Grands-Lacs, la Nouvelle-Angleterre et les Maritimes canadiennes et ajoute à l'information sur les taux de migration, la succession, la chronologie et le climat du nord-est de l'Amérique du Nord.

Morrow, D.W., Krouse, H.R., Ghent, E.D., Taylor, G.C. and Dawson, K.R.

A HYPOTHESIS CONCERNING THE ORIGIN OF BARITE IN DEVONIAN CARBONATE ROCKS OF NORTHEASTERN BRITISH COLUMBIA; Canadian Journal of Earth Sciences, v. 15, p. 1391-1406, 1978.

The sulphur isotope ratios of barite in many syngenetic barite deposits are shown to be approximately the same as those of the seawater from which they were deposited. Although the stratiform replacement barite-fluorite deposits of northeast British Columbia are epigenetic, their barite sulphur isotope ratios ($\delta^{34}\text{S}$) of +24.2 to +30.1‰ may indicate a late Middle Devonian time of mineralization if the sulphur in these deposits was derived from seawater.

A model for barite mineralization is proposed in which mixing of euxinic (i.e., reducing) seawater with meteoric groundwater near the seaward edge of a large coastal aquifer, similar to the present-day Floridan Aquifer, caused solution of the shelf carbonates and induced low-temperature precipitation of barite in the resultant solution cavities. The extensive solution collapse that accompanied mineralization, and the coarse crystallinity and low manganese content (<65 ppm) of the barite in northeastern British Columbia support this interpretation. The postulated Devonian paleoaquifer in northeastern British Columbia coincided with the regional distribution of solution-collapse breccias in the Stone Formation dolomite. The karsted upper surface of the Sulphur Point Formation may have been the landward recharge area for this aquifer.

The variation in the mole percent SrSO_4 along barite blades suggests that during precipitation there were changes in the rate of circulation of the mineralizing solution. In some places up to 30% of the barium in solution may have been precipitated. The $\delta^{34}\text{S}$ values of later formed, strontium-enriched barites tend to be lower suggesting an isotope effect during crystallization favouring ^{34}S in the crystalline phase.

On montre que les rapports d'isotopes de soufre dans la barite de plusieurs dépôts syngénétiques de barite sont à peu près les mêmes que ceux de l'eau de mer à partir de laquelle ils ont précipité. Bien que les dépôts de barite-fluorite stratiformes de remplacement dans le nord-est de la Colombie-Britannique soient épigénétiques, les rapports d'isotopes de soufre dans la barite ($\delta^{34}\text{S}$) de +24.2 à +30.1‰ peuvent indiquer une minéralisation date de la fin du Dévonien moyen et que le soufre dans ces dépôts avait son origine dans l'eau de mer.

On propose un modèle de minéralisation de la barite dans lequel le mélange d'eau de mer euxinique (c'est-à-dire réductrice) avec l'eau souterraine météorique près de la limite marine dans un immense aquifère côtier, semblable à l'aquifère de Floride actuel, a amené la mise en solution des carbonates de la plate-forme et a favorisé la précipitation à basse température de barite dans les cavités de dissolution. La dissolution et l'effondrement extensif qui a accompagné la minéralisation, la cristallinité grossière et la faible teneur en manganèse (<65 ppm) de la barite du nord-est de la Colombie-Britannique supportent cette interprétation. Le paléoaquifère du Dévonien dont on postule l'existence dans le nord-est de la Colombie-Britannique a coïncidé avec la distribution

générale des brèches d'effondrement et de remplissage dans la dolomie de la formation de Stone. La surface supérieure karstifiée de la formation de Sulphur Point a pu être la source terrestre d'alimentation de cet aquifère.

La variation de mole pour cent de SrSO_4 , le long des lames de barite suggère que durant la précipitation, il y avait des changements dans le taux de circulation de la solution minéralisatrice. En certains endroits, jusqu'à 30% de baryum en solution a pu être précipité. Les valeurs de $\delta^{34}\text{S}$ pour les barites formées tardivement et enrichies en strontium tendent à être plus faibles, ce qui suggère un effet isotopique durant la cristallisation favorisant l'accumulation de ^{34}S dans la phase cristalline.

Morrow, D.W. and Mayers, I.R.

SIMULATION OF LIMESTONE DIAGENESIS-A MODEL BASED ON STRONTIUM DEPLETION: REPLY; Canadian Journal of Earth Sciences, v. 15, p. 1685-1687, 1978.

FÅHRAEUS, L.E. and Nowlan, G.S.

FRANCONIAN (LATE CAMBRIAN) TO EARLY CHAMPLAINIAN (MIDDLE ORDOVICIAN) CONODONTS FROM THE COW HEAD GROUP, WESTERN NEWFOUNDLAND; Journal of Paleontology, v. 52, no. 2, p. 444-471, 1978.

Twelve multielement conodont species and 17 residual form species are reported from the Late Cambrian-Early Ordovician Cow Head Group of western Newfoundland. One new monotypic genus is described on the basis of one new species, *Macerodus dianae*. Two new subfamilies are proposed, *Drepanodontinae* and *Drepanoistodinae*. The recovered Late Cambrian and earliest Ordovician (Tremadocian) conodonts are typical of the North American Midcontinent Province whereas the Arenigian (? and earliest Llanvirnian) taxa are typical of the North Atlantic Province. Detailed correlations with western European chronostratigraphic units are proposed. Only a very poor correlation can be made with the conodont zones established in the North American midwest, emphasizing the difficulty of establishing correlation between cratonic and extra-cratonic conodont faunas.

Nowlan, G.S. and Barnes, C.S.

LATE ORDOVICIAN CONODONTS FROM THE VAUREAL FORMATION, ANTICOSTI ISLAND, QUEBEC; Geological Society of America, Abstracts with Program, v. 10, no. 5, p. 235, 1978.

During the late Ordovician and Early Silurian, a considerable thickness of strata accumulated in the Anticosti Basin, Quebec. At least 350 m of argillaceous limestone and shale of the Vaureal Fm. is exposed and subsurface data indicate a total thickness of about 1000 m. The Vaureal Fm. is underlain by Upper Ordovician black shale (Macasty Fm.) and overlain by argillaceous limestones and shales (Ellis Bay Fm.). Graptolites from three wells indicate that the lower (subsurface) part lies within the *Dicellograptus complanatus* Zone and younger faunas suggest a post-Ashgillian, pre-Llandovery age (Riva, 1969). Shelly fossils indicate a Richmondian age (Twenhofel, 1928; Bolton, 1971).

Over 40,000 conodont elements have been recovered from 100 samples from a composite section of the Vaureal Fm. The diverse fauna includes representatives of thirteen multielement genera and is dominated (50-60%) by *Drepanoistodus suberectus* and *Panderodus gracilis*. Several well known Upper Ordovician species are present throughout the sequence, including *Amorphognathus ordovicicus*, *Belodina profunda*, *Phragmodus undatus*, *Plectodina tenuis*,

Plegagnathus dartoni and species of *Aphelognathus* and *Oulodus*. A key species, "*Prioniodus ferrarius?*", is present in low abundance, first appearing about 50 m above the base of the exposed Vaureal Fm. This species is known only from latest Ordovician strata in Missouri and East Germany. Only minor variations in faunal composition are present throughout the exposed formation. The fauna represents a mixture of elements that characterized eastern and western Midcontinent subprovinces earlier in the Cincinnati together with a few North Atlantic Province representatives.

Henderson, J.R. and Okulitch, A.V.

THE NATURE OF POLYPHASE DEFORMATION IN FOXE FOLD BELT, NORTHWEST TERRITORIES, CANADA; Geological Association of Canada/Geological Society of American, Abstracts with Program, v. 10, no. 7, p. 419, 1978.

Late penetrative deformation of Aphebian Penrhyn Group paragneisses and Archean granitoid basement gneisses involved horizontal elongation parallel to the strike of Foxe Fold Belt on Melville Peninsula. Buckling of early recumbent-fold hinges formed paraboloidal folds flattened in the horizontal plane with central axes parallel to the strike of the belt. An inhomogeneous pure shear strain describes late deformation: horizontal shortening along a northwest-southeast λ_3 direction caused buckling and transposition of early linear elements into stable positions parallel to λ_1 . Variably-verging, open-to-tight late folds suggest shortening occurred also along the vertical λ_2 direction; axes of late folds generally parallel λ_1 . Buckled early-fold hinges indicate values for $\sqrt{\lambda_1/\lambda_3}$ from 70 to 300. Upper-amphibolite grade, post-kinematic recrystallization of the rocks took place about 1750 Ma ago.

The late strain nearly obscures an earlier deformational history characterized by emplacement of several km-thick basement gneiss sheets over thousands of km of Aphebian rocks: Archean basement allochthons cover Aphebian supracrustal rocks on the north, south and east margins of Foxe Fold Belt; in the southwest end, basement gneisses core early recumbent anticlines and intrude overlying paragneisses. The north margin of Foxe Fold Belt parallels the hinge of an enormous recumbent syncline; much of the belt on Melville Peninsula is exposed in windows eroded through the basement gneisses on the upper limb of the fold.

Jackson, D.E., Lenz, A.C. and Pedder, A.E.H.

LATE SILURIAN AND EARLY DEVONIAN GRAPTOLITE, BRACHIOPOD AND CORAL FAUNAS FROM NORTHWESTERN AND ARCTIC CANADA; Geological Association of Canada Special Paper 17, p. 159, 1978.

Emphasis of this paper is biostratigraphic, and illustrations (Pls. 1-4, graptolites; 5-14, brachiopods and two trilobites; 15-44 rugose corals) are arranged by faunas and regions, not zoological affinities. Age estimations primarily are based on graptolites and conodonts in Pragian and earlier strata, and on conodonts and a goniatite occurrence in later strata. Ages are argued as much as possible in terms of the European Hercynian magnafacies stages.

Twelve formally defined graptolite zones are recognized in shale facies: *nilssoni*, *leintwardinensis primus* Zones (Ludlovian), *formosus*, *bugensis*, *chelmiensis*, *bouceki*, *transgrediens*, *angustidens* Zones (Pridolian), *uniformis* *uniformis*, *hercynicus* Zones (Lochkovian), *thomasi* and *yukonensis* Zones (Pragian). The zone of *Monograptus thomasi* is new.

Brachiopods are assigned to six informal assemblages: *Conchidium* Fauna (Ludlovian), *Cryptatrypa triangularis*

Fauna (Pridolian), *Gypidula pelagica* Fauna (early Lochkovian), *Spirigerina supramarginallis* Fauna (late Lochkovian), *Davidsoniatripala johnsoni* Fauna (middle to late Pragian) and *Sieberella-Nymphorhynchia pseudolivonica* Fauna (early Zlichovian). Brachiopod occurrences are strongly affected by facies. Generally speaking, in the northern Cordillera they: (1) are more abundant in thin bedded carbonates and shales west of the Mackenzie Arch than in massive shallow water limestones and dolostones to the east, (2) increase in size from Pridolian to Pragian, then decrease, which is interpreted as being due to shallowing followed by deepening conditions. Most of the well known Lochkovian to Pragian brachiopods of Royal creek, Yukon Territory, probably lived at moderate depths, comparable to the communities of small species in Nevada.

Corals figured are referred to 11 units, which take their names either from associated conodonts, or from their stratigraphic occurrence between conodont or graptolite faunas. In ascending order with approximate stage assignments these are: index associates (early Pridolian), post *bugensis* and pre *transgrediens praecipius* Fauna, and *confluens* & associates (middle Pridolian), post *index* and pre *hesperius* Fauna (late Pridolian), *hesperius* associates (early Lochkovian), post *hesperius* and pre *pesavis* Fauna (middle Lochkovian), *pesavis* associates (late Lochkovian), late *sulcatus* associates (late Pragian), *dehiscens* associates (early Zlichovian), aff. *perbonus* associates (late Zlichovian) and *serotinus* associates (Dalejan). In Prongs and Royal Creeks areas, where the best dated coral faunas are mostly allochthonous in debris flows, migrations caused by minor transgressive/recessive cycles considerably affected the composition of coral faunas. Several forms present have no known ancestors or descendants in other local faunas. Halysitids are not known in Pridolian or later faunas and Lower Devonian heliolitids are extremely rare in the region. Coral provinciality was most marked in Pridolian time, when Yukon faunas were still entirely Silurian, while arctic faunas included obvious Devonian forerunners, and in late Pragian to early Zlichovian time, when the Yukon and arctic faunas continued to be of Old World Faunal Realm aspect, while contemporaneous faunas in Nevada appear to have included forms developed from Eastern North America's Realm species. The following taxa are described: *Ogilvilasma discors* gen. & sp. n., *Werneckelasma multiseptata* gen. & sp. n., *Spongonaria guttata* sp. n., and *Windelasma werneckensis* gen. & sp. n.

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

DIAGENESIS OF ORGANIC MATTER AND FINE CLAY MINERALS: A COMPARATIVE STUDY; *Geochemica et Cosmochimica Acta*, v. 42, p. 1181-1197, 1978.

A geochemical study has been made of fine clay minerals and organic matter in subsurface shale samples from the Canadian Northwest Territories. The mixed layer clays comprise smectite-vermiculite-illite but are transformed during thermal diagenesis to a pseudo-quaternary system (smectite-vermiculite-illite-chlorite) by incorporation of amorphous inorganic material. The first clay dehydration occurs prior to hydrocarbon generation and is accompanied by adsorption of K^+ and substitution of Al^{3+} for Si^{4+} in the clay lattice. Vermiculite is an intermediary in the transformation of smectite to illite and in the presence of Ca^{2+} ions delays the second dehydration step to the zone where cracking of liquid hydrocarbons to gas occurs.

Hydrocarbon generation commences at a vitrinite reflectance level of $\approx 0.5\% R_o$ maximum in both amorphous and woody-herbaceous organic matter but does not reach a significant level in the latter case until reflectance levels of $0.7\% R_o$ maximum. The pristane to phytane ratio and

portion of n-alkanes and acyclic isoprenoids increase during hydrocarbon generation from woody-herbaceous organic matter. Anomalous hydrocarbon yields from certain samples are attributed to high concentrations of plant resins. Destructions of liquid hydrocarbons by cracking commences at a reflectance level of 1.0% R_o maximum and is essentially complete by a reflectance level of 1.4% R_o maximum. The proportion of n-alkanes in the saturates decreases during cracking of the liquid hydrocarbons.

Deroo, G. and Powell, T.G.

THE OIL SANDS DEPOSITS OF ALBERTA: THEIR ORIGIN AND GEOCHEMICAL HISTORY; in O.P. Strausz, and Lown, E.M., eds.; Oil Sand and Oil Shale Chemistry, Verlag Chemie, p. 11-32, 1978.

A geochemical study has been made of the heavy oils in eastern Alberta and their relationship to the conventional oils in the central part of the Alberta Basin. The heavy oil deposits and the heavy conventional oils of eastern Alberta resemble the conventional oils in Lower Cretaceous (Mannville) reservoirs in the central part of the basin and as such differ in origin from the Devonian oils. They are, however, relatively less mature than the contemporaneous oils to the west. Although their relative immaturity can partially account for their heavy character, secondary processes such as biodegradation, water washing, secondary migration of light components and possibly some inorganic oxidation result in the concentration of heavy ends with the ultimate formation of solid bitumen.

Purcell, L.P., Rashid, M.A. and Hardy, I.A.

HYDROCARBON GEOCHEMISTRY OF THE SCOTIAN BASIN; in Proceedings, 10th Annual Offshore Technology Conference, v. 1, 1978.

The Sable and Abenaki Subbasins, within the Scotian Basin, have accumulated Mesozoic and Cenozoic rocks in excess of 12,000 m (40,000 ft). No major unconformity is recognized. The present temperatures therefore are believed to be the maximum, and threshold levels required for the generation of hydrocarbons appear to have been reached in the Cretaceous.

The organic carbon content is sufficient (1 to 3 percent) to have generated significant amounts of hydrocarbons, but the organic-matter type (dominantly terrestrial) and the time/temperature relationship appears responsible for the absence of good source rocks.

Organic-matter coloration and type, light gas analyses, and C_{15+} extract data all suggest the Sable and Abenaki subbasins are thermally immature. This has created a thick marginally mature zone above the mature level that is characterized by shows of gas, condensate, and light oils, a situation that does not conform to the usual hydrocarbon sequence of immature dry gas, mature liquids followed by overmature condensate and eventually dry gas again. Thus the occurrence of condensates, in particular, above the mature zone, is in contrast to the normal sequence of hydrocarbon occurrence observed in mature petroleum provinces.

Pelletier, B.R.

THE ENVIRONMENT OF SEDIMENTATION ON THE SOUTHEASTERN BEAUFORT SHELF, CANADA; Proceedings of the 10th International Sedimentological Congress, Jerusalem, Israel, July 9-14, 1978.

Three physiographic features dominate the sea floor: (1) the continental shelf, extending 100 km offshore at 100-m depths; (2) the continental slope, falling to 2000 m about 500 km offshore in the southern Canada Basin; (3) the V-shaped Mackenzie Canyon, transecting both slope and shelf with the headward portion lying 30 km from the Mackenzie River delta. Lesser but abundant seabed features include: diapirs (mud intrusions), pingos (ice-cored mounds), and ice-scorch marks (grooves and related ridges caused by moving and impinging ice keels).

Sediment discharged from the Mackenzie River is seen as a plume on satellite photographs. The plume moves seaward about 30 km, partly to the west and north but mainly to the east because the currents are influenced by the Coriolis force. Along the coast, islands and headlands with their associated bars and spits are the sites of vigorous erosion and arenaceous sedimentation. Further offshore fine sediments move westerly from the eastern part of the shelf. This suggests that ocean currents, perhaps in winter, move westerly in this area. As a result fine sediments are accumulating in the central area of the shelf and Mackenzie Canyon, and are being augmented by direct sedimentary increments from the Mackenzie River.

Silt/clay ratios indicate occurrences of hydrodynamic energy gradients consistent with directions of sediment transport, in that high ratios are associated with greater energy. On this basis, three major hydrodynamic environments were determined: (1) the coastal and deltaic area (excluding beaches), and portions of the eastern shelf area, characterized by moderate energy and deposits of silt and sand; (2) the next seaward inshore area paralleling the coast, generally, but transecting the shelf in both eastern and western portions; it is a region of low energy and contains predominately silty deposits; (3) the area seaward of the second environmental one, extending from the 10-m isobath in the southerly region and including Mackenzie Canyon and immediately adjacent shelf areas to east and west. This central shelf area is one of low vigour and contains mainly clay and very fine silts. Sediments may move down the continental slope due to mass movement such as slumping or turbidity flows.

Coarse sediments are present on the western and most easterly portions of the shelf; in the western part, deposition from ice-rafting appears to be most significant whereas in the eastern part, erosion exposing relict deposits of fluvial and coastal sediments is suggested. Generally most relict shelf deposits are being buried by sediments discharged from the Mackenzie River.

Rashid, M.A.

THE INFLUENCE OF A SALT DOME ON THE DIAGENESIS OF ORGANIC MATTER IN THE JEANNE D'ARC SUBBASIN OF THE NORTHEAST GRAND BANKS OF NEWFOUNDLAND; Organic Geochemistry, v. 1, p. 67-77, 1978.

This study elucidates the geothermal influence of a salt dome on the diagenesis of organic matter present in sedimentary sequences directly overlying the salt strata. Despite similarities in geological setting, geochemical characteristics in sedimentary column and proximity of location (~ 3 km), the exploratory wells Adolphus 2-k-41 and D-50 drilled on the crest and flank of a salt dome respectively, show considerable differences in the quantitative and qualitative distribution of hydrocarbons. The well drilled on the crest of the salt dome tested oil of 31 API gravity. The concentrations of gaseous (C_1-C_4) and heavy (C_{15+}) hydrocarbons of this well were several times higher than those found in the corresponding sequences of a flank well. The coloration studies of isolated kerogen and gas

chromatographic investigations of hydrocarbons suggest that the organic matter present in Adolphus 2-k-41 has undergone a greater degree of thermal alteration than that of D-50. The heat radiating from the salt strata is believed to be responsible for the early diagenesis of the organic matter.

Rimsaite, J.

APPLICATION OF MINERALOGY TO THE STUDY OF MULTI-STAGE URANIUM MINERALIZATION IN REMOBILIZED URANIUM DEPOSITS, SASKATCHEWAN; in Short course in uranium deposits: their mineralogy and origin; Mineralogical Association of Canada, p. 402, 1978.

Mineralogical research provides the following data essential for the interpretation of radioactive anomalies as well as for evaluation and characterization of multi-stage mineralization of remobilized uranium deposits in northern Saskatchewan:

- a. Identification and interpretation of the complex mineralogy of the ore and host rocks;
- b. Paragenetic relationships between uranium-bearing ore minerals and groundmass minerals;
- c. Changing chemical and physical properties of the ore minerals and associated rock-forming minerals during superimposed alterations as a result of changing environmental conditions;
- d. Chemical and structural relationship between primary and secondary ore minerals;
- e. Mineralogical evidences of several periods of remobilization and redeposition of the mobilized uranium and radiogenic lead; and
- f. Selection of minerals for age dating of multi-stage mineralizations and alterations that have recurred during a time period of at least 1800 million years.

The assessment, characterization and exploitation of a uranium deposit is difficult without pertinent mineralogical background data.

Rimsaite, J.

NATURAL AMORPHOUS MATERIALS AND PROCEDURES FOR THEIR IDENTIFICATION; in Book of Summaries, 6th International Clay Conference, Oxford, July, 1978, p. 657; 1978.

Comparative optical and XRD studies of partly argillized and thermally altered rocks revealed the presence of amorphous phases that may easily be overlooked on XRD patterns. The amorphous or poorly crystalline materials include either the major constituents or the accessory minerals and discrete particles dispersed in a rock that form during the following processes:

- 1: precipitation of colloidal substances in fractures and voids in clay;
- 2: hydration and argillization of primary igneous and metamorphic minerals;
- 3: transition of hydrous minerals to anhydrous phases; and
- 4: structural damage as a result of radiation.

Examples of poorly crystalline and structurally disordered materials that cannot be identified by X-rays, pertaining to the above four processes are as follows:

1a: fine-grained crusts and stains of siliceous goethite in fractures and as mineral coatings, locally containing adsorbed Cr, Mn, Mo, Ni, Pb, Ti and U compounds that may account for unusual chemical composition of clays;

1b: minute specks of disintegrating titanium and rare earths oxides dispersed in residual clay;

1c: amorphous oxygenated hydrocarbons, including 'thucholite' containing adsorbed ions;

2a: fine-grained argillite replacing partly argillized cloudy feldspars;

2b: discoloured flakes pseudomorphic after biotite consisting dominantly of amorphous silica in oxisols;

3a: transition of muscovite and phlogopite to anhydrous glassy phases in natural environments and in laboratory experiments;

3b: transition of hydrous alumina to anhydrous alumina phases;

3c: transition of hydrous uranium-bearing silicates to anhydrous, amorphous phases;

4a: phyllosilicates and other minerals in high grade uranium ore;

4b: uraniferous phyllosilicates.

These amorphous and poorly crystalline substances can be identified and studied by combining optical, DTA, TG, XRD and electron microprobe methods.

Ruzicka, V.

1978: Phanerozoic uranium deposits and occurrences in Europe and Eastern North America; in Uranium deposits, their mineralogy and origin ed. by M.M. Kimberley, Short Course Handbook, v. 3, Mineralogical Association of Canada, 1978.

Uranium deposits in Europe occur (in descending order of importance) in the Hercynian, Alpine and Caledonian orogenic belts. They are classified into types as follows:

1. Vein type and related deposits;
 - 1.1. Intragranitic veins;
 - 1.2. Veins and disseminations in peribatholithic shale, schist or paragneiss (Iberian type),
2. Sedimentary deposits;
 - 2.1. Sandstone and related deposits,
 - 2.2. Uraniferous shale,
3. Volcanogenic and effusive-sedimentary deposits;
4. Sedimentary metamorphic deposits;
5. Magmatic and anatetic deposits.

Conceptual models based on uranium deposition in Europe are applicable to exploration in similar geological environments in eastern North America. The Appalachian orogen contains several potentially favourable rock types for similar uranium deposits, e.g. intragranitic veins, peribatholithic shale, carbonaceous sandstone and pelite, volcanic, contact - metamorphic rocks and magmatic-anatetic zones.

Sangster, D.F.

ISOTOPIC STUDIES OF ORE-LEADS OF THE CIRCUM-KISSEYNEW VOLCANIC BELT OF MANITOBA AND SASKATCHEWAN; Canadian Journal of Earth Sciences, v. 15, p. 112-1121, 1978.

Volcanic rocks, distributed to the north, west and south of the Kisseynew gneissic belt in Manitoba and Saskatchewan, define a crescent-shaped belt herein informally referred to as the 'circum-Kisseynew volcanic belt'. Field relationships lead to the conclusion that the flanking volcanics are correlative with, and grade basinward to, greywackes and shales.

Nearly 30 volcanogenic massive sulfide deposits, interpreted as coeval with their host rocks, are distributed throughout the circum-Kisseynew volcanic belt. Lead isotopic abundances in a representative number of these deposits are, apart from 204-error, relatively homogeneous in composition and model lead ages determined from these isotopic ratios fall, for the most part, between 1700 and 1900 Ma. This is regarded as good evidence that the circum-Kisseynew volcanic belt, as well as its greywacke equivalent, is largely Aphelian in age.

Model lead ages for sulfide deposits from the entire circum-Kisseynew volcanic belt, with one exception, agree well with recent Rb-Sr and U-Pb age determinations from the southern portion of the belt. Reasons for the exception, in the Hanson Lake area, are discussed in some detail.

Les roches volcaniques distribuées au nord, à l'ouest et au sud de la zone des gneiss de Kisseynew au Manitoba et en Saskatchewan définissent une zone en forme de croissant qu'on désigne ici sous le nom de "ceinture volcanique circum-Kisseynew." Les associations de terrain mènent à la conclusion que les roches volcaniques de bordure sont corrélatives avec les grauwackes et les shales du bassin et que leur contact est gradationnel.

Environ 30 dépôts volcanogéniques de sulfures massifs, interprétés comme datant de la même époque que leurs roches hôtes, se retrouvent dans la ceinture volcanique circum-Kisseynew. Les abondances isotopiques de plomb dans un nombre représentatif de ces dépôts, en compensant pour l'erreur sur le ^{204}Pb , sont relativement homogènes et les âges au plomb déterminés sur modèle à partir des rapports isotopiques tombent pour la plupart dans l'intervalle de 1700 à 1900 Ma. On considère ceci comme une bonne preuve que la zone volcanique circum-Kisseynew, de même que son équivalent de grauwacke, appartient surtout à l'Aphébien.

Les âges au plomb sur modèle pour les dépôts de sulfures de la zone volcanique entière sont, à une exception près, conformes aux déterminations récentes d'âges au Rb-Sr et au U-Pb pour la portion sud de la zone. On discute en certain détail les causes de l'exception dans la région de Hanson Lake.

Slaney, V.R.

A STUDY OF AIRBORNE GAMMA-RAY SPECTROMETRY FOR GEOLOGICAL MAPPING; Proceedings, 12th International Symposium on Remote Sensing of Environment, v. 3, 1978.

Airborne gamma-radiation surveys are not easily correlated with published geological maps. This is particularly true in the swampy, glaciated terrain of the northwestern Precambrian Shield, with its numerous lakes. To investigate the applicability of such surveys as aids in geological mapping, high sensitivity gamma-ray data were collected over 8000 km² in the Hearne Lake area of the Northwest Territories of Canada. Hearne Lake itself lies 75 km southeast of Yellowknife. The area chosen had been mapped geologically at a scale of 1:125,000. Rocks are exposed in about 60% of the region, the remaining area consisting of water and overburden of glacial origin.

The high sensitivity gamma-ray survey was flown at a nominal height of 120 m above ground with a line spacing of 2.5 km and at an average speed of 190 km/hr. The spectrometer had three channels to measure ground concentrations of potassium, uranium and thorium, and one broader total count channel to measure overall ground radioactivity.

Twelve flight lines were selected as test lines, since they crossed most of the major rock types known to exist in the area. Colour air-photographs were used to identify outcrops of each rock type and the distribution of overburden, swamp and water. Since each individual intrusion was regarded as a separate lithologic unit, there were 24 of these units within the area of the test lines but only 17 of them were sufficiently exposed to provide reliable radiation signatures. The average and standard deviation of the potassium, uranium and thorium contents, as well as that of total radioactivity, were calculated for those measurements taken over outcrop. Similar calculations were performed on the three radioelement ratios; uranium/thorium, uranium/potassium and thorium/potassium.

Using a maximum likelihood technique, it was found that by grouping the seventeen lithologic units into nine rock classes, approximately 80 percent of the 1730 airborne measurements within the test lines could be correctly identified. A test was introduced to confirm that each classified data point lies within the normal population bounds of its class. Because of this test, 2 more classes were identified. Water is also represented as a separate class. In studying individual radiometric parameters, the total count channel was found to reflect best the geology, followed by the potassium and thorium channels. Only minimal classification success was obtained utilizing the uranium channel and the uranium/thorium ratio, due to their relatively large standard deviations in all rock classes.

When the classification procedure was extended to the whole survey area, many rock units were found to have quite variable radiation patterns. In a few cases, similar rocks, located in different parts of the area, were found to have different radiometric signatures. Zones of anomalous high radioactivity were often found to cross lithological boundaries and may be considered useful indicators for uranium exploration.

The study shows that airborne gamma-ray data can be analyzed and displayed in a simple format to provide both mapping and exploration geologists with information not readily obtainable from the original data. The technique described appears to be most usefully applied to areas where outcrop is extensive. Further studies are needed in areas where overburden obscures the lithology.

Swan, Davis., Clague, J.J. and Luternauer, J.L.

GRAIN-SIZE STATISTICS I: EVALUATION OF THE FOLK AND WARD GRAPHIC MEASURES; Journal of Sedimentary Petrology, v. 48, no. 3, p. 863-878, 1978.

The study investigates the effectiveness of graphic statistical parameters as descriptors of grain-size distributions. Grain-size distributions which cannot be described adequately using the graphic technique are isolated by comparing the graphic parameters to moment measures calculated for the ungrouped weight frequency data from hypothetical samples consisting of randomly generated "grains" of known size, shape, and density.

Differences between graphic and ungrouped mean are insignificant, except for highly skewed distributions. Ungrouped standard deviations generally are larger than their graphic counterparts; the disparity is greatest for medium sorted samples which have long "tails" in the finest or coarsest 5% of the distribution. The respective skewness and kurtosis values are only weakly related, indicating that the graphic measures respond erratically to significant deviations from normality in grain-size distributions. Transformed graphic and ungrouped kurtosis values ($kurtosis / (kurtosis + 1)$) are more strongly related than the corresponding nontransformed parameters. From these

relationships it is concluded that classification schemes of sediment types should make use of graphic parameters only if the range in values of statistical parameters is large enough so that the limitations of the graphic technique do not significantly affect the classification units.

It is also established that (a) obtaining data at intervals finer than whole phi is not justified if graphic statistical parameters are to be used, (b) gaussian (probability) interpolations between known points on a cumulative curve and extrapolations beyond the ends of the distribution are required in the calculation of graphic parameters by computers (published computer programs employ linear interpolations and extrapolations), and (c) ungrouped parameters calculated using weight and number frequency are unrelated.

Taylor, R.B.

THE OCCURRENCE OF GROUNDED ICE RIDGES AND SHORE ICE PILING ALONG THE NORTHERN COAST OF SOMERSET ISLAND, N.W.T.; Arctic, v. 31, no. 2. p. 133-149, 1978.

Massive shore ice piles and grounded ice ridges up to 30 m high were examined along the northern coast of Somerset Island between 1973 and 1976. The ice ridges, composed of 1 to 2 m thick ice blocks and occasionally thicker multi-year ice blocks, occurred most frequently along the north and west shores of capes and headlands. 'Cape Fisher' was the site of shore ice piling during each of the four years and one set of ice piles, built 15-60 m inland existed three years. Effects of grounded ice ridges on nearshore morphology were minimal but ice-push features were observed as much as 185 m inland across the beach.

On a observé des amoncellements de glace littorale et des murs de glace "enracinés" pouvant atteindre 30 m de hauteur, sur la côte Nord de l'Île de Somerset, entre les années 1973 et 1976. Les murs de glace étaient formés de blocs de glace, de 1 à 2 m d'épaisseur, parfois plus quand il s'agissait de glace de plusieurs années; on les a rencontrés surtout le long des rivages du Nord et à l'Ouest de caps et promontoires. Pendant ces 4 ans d'observation, les amoncellements de glace littorale se situaient à cap Fisher; un amoncellement de glaces construisait une butte de 15 à 60 m pendant 3 ans. Les effets de ces murs de glace "enracinés" sur la morphologie proche du littoral, étaient très réduits mais des témoins de poussée de glace étaient observés sur la plage avec une taille atteignant 185 m (pingos).

Macqueen, R.W. and Thompson, R.I.

CARBONATE-HOSTED LEAD-ZINC OCCURRENCES IN NORTHEASTERN BRITISH COLUMBIA WITH EMPHASIS ON THE ROBB LAKE DEPOSIT; Canadian Journal of Earth Sciences, v. 15, p. 1737-1762, 1978.

In the Rocky Mountains of northeastern British Columbia, a Lower and Middle Devonian platform carbonate succession of six formations and \approx 1500 m total thickness gives way laterally north and west to shales, siltstones, and carbonaceous limestones of the Besa River Formation, of deeper water origin. Promising mineralization, dominantly sphalerite with some galena, is located in carbonates near the platform margin, within the Muncho-McConnel-Stone, Pine Point - Sulphur Point, and Slave Point Formations. Mineralization is not obviously related to structure, unconformities, or evaporite solution. Sphalerite and galena are closely associated with white sparry dolomite and commonly accompanied by quartz and thermally altered reservoir bitumen. Sulphur isotope ratios of galena and sphalerite range from +5.0 to +17.5 $\delta^{34}\text{S}$ ‰ consistent with a reduced sulphate or petroleum-derived hydrogen sulphide source for sulphur.

At Robb Lake, mineralization occurs within broadly conformable breccias in the Stone, Muncho-McConnell interval; sparry dolomite forms the breccia matrix; and bitumen is common although rare elsewhere in the interval. Maximum paleotemperatures of host carbonates at Robb Lake appear to have been about 200-230°C, as determined by bitumen characteristics, fluid inclusion filling temperatures in quartz, and illite crystallinity from illite in Besa River Formation shales. The Paleozoic and Mesozoic sedimentary section in the region suggests that the Middle Devonian of the Robb Lake area reached a maximum burial depth of about 5 km during mid-Cretaceous time. Physical proximity of bitumen and sulphide mineral deposits suggests that similar processes were involved in petroleum maturation-migration, and metallic mineral precipitation. Besa River shales are seen as probable sources for both petroleum and metals; sulphide sources appear to have been hydrogen sulphide generated within carbonate host rocks. A genetic association of petroleum and metals implies that mineralization took place relatively late (?early Mesozoic), and under deep subsurface conditions.

Ground preparation in the form of brecciation and fracturing is problematical; at Robb Lake it maybe a consequence of hydraulic fracturing due to high pore pressures generated by dewatering of the fine clastic facies that envelope the host dolomites. A better knowledge of time of origin of these deposits will contribute greatly to an understanding of their genesis. Meanwhile, consideration of the burial and thermal history of the host rocks offers a useful framework within which the mineral deposits and their genesis may be assessed.

Dans les montagnes Rocheuses du nord-est de la Colombie-Britannique, une succession de six formations calcaires datant du Dévonien inférieur et moyen et formant une plate-forme dont l'épaisseur totale est d'environ 1500 m fait place latéralement vers le nord et l'ouest aux shales, siltstones et calcaires carbonatés de la formation de Besa River, déposée à l'origine en eau plus profonde. On retrouve une minéralisation prometteuse comprenant surtout de la sphalerite et un peu de galène dans les carbonates en bordure de la plate-forme dans les formations de Muncho-McConnel-Stone, de Pine Point - Sulphur Point et de Slave Point. Selon toute évidence, la minéralisation ne semble pas liée à la structure, aux discordances ou aux solutions d'évaporites. La sphalerite et la galène sont étroitement associée à la dolomite spathique blanche et s'accompagnent souvent de quartz et de bitume d'un réservoir altéré thermiquement. Les rapports des isotopes de soufre dans la galène et la sphalerite sont de +5.0 à +17.5 $\delta^{34}\text{S}$ ‰, ce qui est compatible avec une source de soufre provenant de la réduction des sulfates ou du sulfure d'hydrogène dérivé du pétrole.

A Robe Lake, la minéralisation se rencontre dans de larges brèches concordantes dans l'intervalle de Stone, Muncho-McConnell; la dolomite spathique forme la matrice des brèches et le bitume y est commun quoique rare ailleurs dans l'intervalle. Les paléotempératures maximum des carbonates hôtes à Robb Lake semblent voir été d'environ 200-230°C, d'après les caractéristiques du bitume, les températures de remplissage d'inclusions fluides dans le quartz et la cristallinité de l'illite dans l'illite des shales de la formation de Besa River. La coupe sédimentaire du Paléozoïque et du Mésozoïque dans la région suggère que le Dévonien moyen de la région de Robb Lake a atteint une profondeur d'enfouissement maximum de 5 km au milieu du Crétacé. La proximité physique du bitume et des dépôts de sulfures suggère que des processus similaires sont responsables de la maturation-migration du pétrole et la précipitation des minéraux métalliques. On considère les shales de Besa River comme des sources probables à la fois pour le pétrole et pour les métaux; la source des sulfures

semble avoir été le sulfure d'hydrogène engendré dans les roches hôtes carbonatées. Une association génétique du pétrole et des métaux implique que la minéralisation s'est effectuée relativement tard (?début du Mésozoïque) et dans des conditions d'enfouissement à grande profondeur.

La formation de brèches et de fractures dans le terrain pose un problème; à Robb Lake, c'est peut-être une conséquence de la fracturation hydraulique causée par les hautes pressions interstitielles engendrées par la consolidation des roches à faciès clastiques fins entourant les dolomites hôtes. Une meilleure connaissance du temps d'origine de ces dépôts contribuera grandement à la compréhension de leur genèse. Entre-temps, la considération de l'histoire thermique et de l'enfouissement des roches hôtes offre un cadre utile dans lequel on peut étudier les dépôts minéraux et leur genèse.

Tozer, E.T.

REVIEW OF THE LOWER TRIASSIC AMMONOID SUCCESSION AND ITS BEARING ON CHRONOSTRATIGRAPHIC NOMENCLATURE; Veröffentlichung des Österreichischen Nationalkomitees für das International geological Correlation Programme Project Nr. 73/I/4. Triassic of the Tethys Realm; Schriftenreihe des Erdwissenschaftlichen Kommissionen Österreichische Akademie der Wissenschaften, Bd. 4. p. 21-36; 1978;

The relationship between proposed schemes for subdividing the Lower Triassic with events in the ammonoid history is reviewed. Several schemes based on sequences in Asia are compared with one in North America where four Stages (Griesbachian, Dienerian, Smithian, Spathian, in ascending order) are recognized. None appears to be wholly satisfactory for International use. For this purpose a division of the Lower Triassic (Scythian) Series into three Stages is suggested. For the earliest stage Griesbachian is appropriate, for the latest, Spathian. The middle Stage, for which no name is available, is equivalent to the Dienerian and Smithian combined. No name is proposed at present. Definition of the Permian-Triassic boundary at the base of the Griesbachian is recommended. Proposals to place the boundary at higher levels are also mentioned.

Kennedy, D.J., Barnes, C.R. and Uyeno, T.T.

A MIDDLE ORDOVICIAN CONODONT FAUNULE FROM THE TETAGOUCHE GROUP, CAMEL BACK MOUNTAIN, NEW BRUNSWICK; Canadian Journal of Earth Sciences, v. 16, p. 540-551, 1979.

The Tegagouche Group is a 10 000 m geosynclinal sequence of slates, greywackes, rhyolite tuffs, and greenstones underlying parts of northern New Brunswick. It hosts the well-known stratabound massive sulphide deposits of the Bathurst-Newcastle mining area. Few fossils have been found in the group and its age is poorly known. More than 890 conodonts have been recovered from a locality near Camel Back Mountain in the Metabasalt unit. *Coelocerodontus? lacrimosus* and *Protopanderodus liripinus* are described as new species. The faunule contains species indicative of the *Prioniodis alobatus* Subzone of the *Amorphognathus tvaerensis* Zone and is the first record of the subzone in North America. The subzone equates with the middle Caradocian (approximately the Soudleyan Stage) or late Wildernessian Stage of the Middle Ordovician Epoch. During this interval the Proto-Atlantic Ocean is considered to have been undergoing closure, hence recent interpretations that regard the Metabasalt unit as forming during an earlier phase of opening must be reexamined.

Le groupe de Tetagouche est une séquence géosynclinale de 10 000 m comprenant des ardoises, des grauwackes, des tufs rhyolitiques et des roches vertes qu'on retrouve en profondeur en plusieurs endroits du nord du Nouveau-Brunswick. Le groupe renferme les dépôts stratiformes de sulfures massifs de la région minière de Bathurst-Newcastle. On a trouvé peu de fossiles dans le groupe et son âge est mal établi. On a trouvé au-delà de 890 conodontes dans une localité près de Camel Back Mountain dans l'unité de métabasalte. On décrit *Coelocerodontus? lacrimosus* et *Protopanderodus liripinus* comme de nouvelles espèces. La faunule comprend des espèces indicatrices de la sous-zone *Prioniodis alobatus* de la zone *Amorphognathus tvaerensis* et c'est la première occurrence de cette sous-zone en Amérique du Nord. La sous-zone et en corrélation avec le Caradocien moyen (approximativement l'étage de Soudley) ou l'étage du Wilderness supérieur de l'Ordovicien moyen. Durant cet intervalle, on pense que l'océan proto-Atlantique s'est refermé et ainsi on doit réexaminer les interprétations récentes qui regardent l'unité de métabasalte comme s'étant formé durant une phase plus ancienne d'ouverture.