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ABSTRACTS OF PUBLICATIONS IN SCIENTIFIC JOURNALS BY OFFICERS OF THE GEOLOGICAL SURVEY OF CANADA IN 1981

RÉSUMÉS DE PUBLICATIONS PAR LES CHERCHEURS DE LA COMMISSION GÉOLOGIQUE DU CANADA POUR 1981

Agterberg, F.P.

CELL-VALUE DISTRIBUTION MODELS IN SPATIAL PATTERN ANALYSIS; in Future Trends in Geomathematics, ed. R.G. Craig and M.L. Labovity, Pion Limited, London, p. 5-28, 1981.

This essay reviews methods of spatial analysis for modelling the shapes of frequency distributions of discrete phenomena measured with respect to cells or blocks of variable size. The frequency distribution of presence-absence data quantified for cells is of interest in several fields of geoscience. These include chemical analysis of rock samples, petrographic modal analysis, geostatistical ore-reserve estimation, litho-stratigraphic correlation of borehole data, geochemical exploration, line-spacing problems in exploration geophysics, drilling for hidden targets, and regional resource estimation.

Agterberg, F.P.

APPLICATION OF IMAGE ANALYSIS AND MULTIVARIATE ANALYSIS TO MINERAL RESOURCE APPRAISAL; Economic Geology, v. 76, p. 1016-1031, 1981.

The quantitative appraisal of the mineral resource of a region can be performed in four stages: collection of information, selection of variables and models, quantification of map patterns and image analysis, and multivariate analysis. The algorithms for stage three may be based on concepts of mathematical morphology. During stage four, probability index maps can be produced for mineral deposits of different types by using a Poisson model or through logistic regression analysis. The estimated probabilities can be integrated for larger areas and combined with size-grade figures derived from sets of known deposits.

Agterberg, F.P.

COMPUTERS AS AN AID IN MINERAL-RESOURCE EVALUATION; in Computer Applications in the Earth Sciences, ed. D.F. Merriam, Plenum Publishing Corporation, p. 43-61, 1981.

Separate flowcharts have been constructed for (1) some computer-based techniques for mineral-resource estimation; (2) different types of input for computer-based mineral-resource estimation and statistical exploration; and (3) quantification and analysis of geoscience map data. Several examples are presented to illustrate the geostatistical modeling of results obtained by image analysis, and the interpretation of probability index maps derived by multivariate statistical analysis of systematically quantified data on the geological framework of a region.

Agterberg, F.P.

GEOCHEMICAL CRUSTAL ABUNDANCE MODELS; Society of Mining Engineers of AIME, Transactions, v. 268, p. 1823-1830, 1981.

It can be useful to model the mean grade values for a metal in mineral deposits containing that metal as representing the extreme value tail of a lognormal frequency distribution for the concentration values of the metal in common rocks of all types. Results for copper and zinc in the Abitibi area of the Canadian Shield are compared to results previously obtained for the Canadian Appalachian region. The lognormal model is also applied to a set of 162 large gold deposits in the Abitibi area. In the second part of the paper, 1311 large and small gold deposits in the Abitibi area are modeled as discrete events. By means of a newly developed spatial clustering model it is possible to predict the variances of random variables for frequencies of deposits in cells of different sizes.

Agterberg, F.P., and **Gradstein, F.M.**

WORKSHOP ON QUANTITATIVE STRATIGRAPHIC CORRELATION TECHNIQUES: OTTAWA, FEBRUARY 1980; Mathematical Geology, v. 13, no. 1, p. 81-91, 1981.

The second workshop of the Canadian working group for project 148 (Quantitative Stratigraphic Correlation Techniques) of the International Geological Correlation Programme (IGCP) was held at the Geological Survey of Canada, Ottawa, Ontario, February 14, 15, 1980. Like the first of these informal meetings which took place at the Bedford Institute of Oceanography, Dartmouth, N.S., August, 27, 28, 1979, the Ottawa Workshop drew over 20 Canadian and U.S. research workers active in the biostratigraphical or geomathematical disciplines. There were eight presentations of research and review which are summarized in sections 1-8 of this note. Additionally, smaller groups of participants worked on specific data sets using computer-based techniques and the meeting served as a platform for extensive discussions for which we should single out Jim Brower of Syracuse University as a source of knowledge. A third workshop will be held in Calgary, Alberta, during Spring, 1981.

Harris, D.P. and **Agterberg, F.P.**

THE APPRAISAL OF MINERAL RESOURCES; Economic Geology, 75th Anniversary Volume, p. 897-938, 1981.

The past decade has been a time of increased awareness of the importance of mineral resources to economic growth and well being, which has resulted in demands for resource appraisals. One result has been the involvement of more

geologists in the activity of appraisal. It is time to examine carefully and critically the use of geoscience in the appraisal of mineral endowment. We must consider some fundamental questions: How well can a geologist estimate undiscovered mineral endowment? How good an estimator can the geologist become, given improvements in science, appropriate methodology, and resource data? Significant improvements in the appraisal of mineral endowment and resources will be severely impeded, if not made impossible, without advances in the three major areas: geology-mineral endowment theory, geological and resource data, and analytical methods. Of these three, the first two may need the greatest improvement. The accuracy by which we can relate geology to mineral endowment, whether by quantification of judgment or by mathematical models, is strongly reflective of how well our data and experience describe relevant geologic processes and endowment. In our opinion, geomathematics is a wide and challenging new field in the earth sciences. Relatively little use has been made of this opportunity because the application of geomathematics is fraught with educational, organizational, and technical difficulties. However, as the usefulness of the statistical methods is demonstrated through successful case history studies, it is likely that increasingly large numbers of geologists will be convinced of the value of this approach and a more widespread usage can be expected.

Aitken, J.D., Ruelle, J.C., and **Cook, D.G.**

COPPER MINERALIZATION NEAR AN INTRA-RAPITAN UNCONFORMITY, NITE COPPER PROSPECT, MACKENZIE MOUNTAINS, NORTHWEST TERRITORIES, CANADA: DISCUSSION; Canadian Journal of Earth Sciences, v. 18, p. 410-413, 1981.

Anderson, T.W.

AGES AND ENVIRONMENTS OF BURIED LOW-LEVEL SEDIMENTS IN LAKE ONTARIO AND THE LAKE LEVEL HISTORY OF THE ONTARIO BASIN; Geological Association of Canada, Annual Meeting 1981, Abstracts, v. 6, p. A-2, 1981.

Several piston cores recovered from Lake Ontario contain buried plant detritus, woody peat, fossiliferous marl, wood and shell bearing sand or sand and gravel layers at depths ranging between 100 and 13 m below present lake level. Sediment records and pollen and macrofossil evidence indicate that these organic and inorganic deposits represent shoreline features of previously existing low-level lake stages in the Lake Ontario basin. Radiocarbon dates on the low-level organic beds range from close to 10 000 years B.P. up to about 5000 years B.P.

Explanation for these low-level deposits rests primarily with the vertical displacement history of the upper St. Lawrence Valley outlet area since retreat of Wisconsinan ice. The earliest low-level sediments accumulated when the Ontario basin was down-tilted in the direction of the outlet. These and younger low-level sediments gradually became submerged by back-flooding water levels as the outlet rebounded isostatically. Submergence of the youngest low-level deposits coincided with the Upper Great Lakes discharge through Lake Erie during the Nipissing stage.

Lake-wide water planes are recognized at 8000 to 10 000 years ago and at approximately 5000 years ago corresponding to stillstands during low-level early Lake Ontario (Admiralty Phase) and the mid-Holocene Hypsithermal interval, respectively.

Hicock, S.R. and **Armstrong, J.E.**

COQUITLAM DRIFT: A PRE-VASHON FRASER GLACIAL FORMATION IN THE FRASER LOWLAND, BRITISH COLUMBIA; Canadian Journal of Earth Sciences, v. 18, p. 1443-1451, 1981.

Coquitlam Drift is formally defined and stratotypes established for it in the Coquitlam – Port Moody area, B.C. It is a Pleistocene formation consisting of till, glaciofluvial, ice-contact, and glaciomarine sediments deposited between 21 700 and 18 700 years BP, during the Fraser Glaciation (late Wisconsin) and prior to the main Vashon glacial maximum at about 14 500 years BP. The drift was deposited in short pulses by valley and peidmont glaciers flucturating into the Fraser Lowland from the Coast Mountains to the north and Cascade Mountains to the east.

Le drift Coquitlam est défini de facon formelle et des stratotypes sont établis pour cette unité dans la région de Coquitlam – Port Moody, en Colombie-Britannique. C'est une formation d'âge Pléistocène composée de till, de dépôts fluvioglaciaires, de dépôts sédimentés au contact de la glace et de sédiments glacio-marins qui se sont accumulés entre 21 700 et 18 700 années avant le présent durant la glaciation Fraser (Wisconsin supérieur) et avant l'avancée glaciaire majeure Vashon d'il y a 14 500 années avant le présent. L'accumulation du drift s'est faite lors de petites pulsations de glaciers de vallée et de piedmont. Ceux-ci, issus des montagnes Côtières au nord et des monts Cascade à l'est, venaient fluctuer dans les basses terres Fraser.

Ballantyne, B., Carter, N.C., Johnson, W.M., and Kalnins, T.

THE BRITISH COLUMBIA REGIONAL GEOCHEMICAL SURVEY: AN OVERVIEW AND EVALUATION; Canadian Mining and Metallurgical Bulletin, v. 74, no. 833, p. 61, 1981.

The Regional Geochemical Survey (RGS) conducted by the British Columbia Ministry of Energy, Mines and Petroleum Resoures is a continuation of a joint federal/provincial geochemical reconnaissance program called the Uranium Reconnaissance Program (URP) initiated in 1976 and continued through 1977 and 1978. During the joint program, eight 1:250,000 map sheet sections of the Province (82E, F, K, L and M and 104P, O and N) were sampled for stream waters and stream sediments with an average sampling density of one sample per 12.5 square kilometers. The water samples were analysed for U, F and pH and the stream sediments for Cu, Pb, Zn, Ag, Mo, Mn, Fe, Ni, Co and U. Samples were also analysed for Sn and W in 82F and K and in 104N, for W in 1040 and P and for Hg in 82F, K and M and 104N. In the last year of the joint program (1978), the provincial government ran a parallel program as part of the Accelerated Mineral Development Program in map sheets 1031 and P and part of 103J and 0. In subsequent years the Ministry has extended the survey into 920 and P in 1979 and 93A and B in 1980. This year 921, J and H were sampled. All programs were based on the specifications designed for the joint federal/provincial URP on the basis of preliminary orientation studies. The sediments for the 1978 and 1979 RGS programs were analysed for Hg, W and As as well as those elements previously listed and Sb was added to the 1980 program.

The data is released generally in the Spring of the year following the sample collection and is available as sample location maps with accompanying data packages for each map sheet or as digital information on computer tapes compatible with a wide range of main frame installations.

A significant portion of the Province has now been covered by this program and some conclusions can be drawn. A statistical evaluation of the data from the duplication in field sampling and subsampling shows that the sampling and analytical specifications result in a good quality of sample and data. The data has been shown to be a useful exploration tool with several new mineral occurrences being found based on anomalies identified by this data.

The quality control built into the program from the sampling program through the analytical stage to the release of data has resulted in a high quality product useful not only for exploration work but also for identifying the level of reliability of the data, for use in regional metallogenic studies and as a data base for land use decisions, future environmental studies and geological interpretations and projections.

Baragar, W.R.A., and Scoates, R.F.J.

THE CIRCUM-SUPERIOR BELT: A PROTEROZOIC PLATE MARGIN?; in Precambrian Plate Tectonics, ed. A. Kroner, Elsevier Scientific Publishing Company, Amsterdam, Chapter 12, 1981.

Nine discrete segments of late Aphebian rocks irregularly distributed around the Archaean Superior Province have sufficient characteristics in common to invite the idea of a Superior craton ringed by a continuous belt of mid-Proterozoic sedimentary and volcanic rocks. On the north side are the Labrador Trough, the Cape Smith Belt, the Belcher Basin, the Sutton Inlier, the Fox River Belt, and the Thompson Nickel Belt; on the south side are the Lake Superior Association (Animikie–Marquette Groups), the Mistassini–Otish Groups, and the Southern Labrador Trough. The bulk of the preserved rocks were probably deposited upon sialic basement as indicated by evidence from the Labrador Trough, Cape Smith Belt, and Lake Superior Association. The earliest deposits in some (Mistassini–Otish, Labrador Trough, the Belcher Basin) and possibly all segments are rift-related continental redbeds, with and without potash-rich basalts. In general the deposits change from mio- to eugeo-synclinal type in passing up in the sequence and outward from the Superior Province, and commonly a major iron formation marks approximately the level of change. Magmatism differs significantly in the two halves of the belt; in the north, ultramafic intrusives and extrusives are a substantial part of the magmatic assemblage, but calc-alkaline rocks are rare; in the south, ultramafic rocks are unknown and calc-alkaline rocks fairly common.

An origin for the Circum-Superior Belt may be postulated which is consistent with a plate-tectonic regime. Stretching of a sialic crust owing to plate motions produced fracturing around a pre-existing stable node, the ancestral Superior Province, followed by necking along the fractures to produce an annular trough in which sediments accumulated. With continued separation, volcanism was initiated at the loci of spreading and volcanic rocks overlapped onto the earlier sediments. Subsequently the southern part of the rift system expanded at the expense of the northern part into an opening ocean and subduction was initiated at the southern continental edge. The northern rift zone ceased activity and eventually closed with the deformation of its contents that we presently see.

Bolton, T.E.

LATE ORDOVICIAN AND EARLY SILURIAN ANTHOZOA OF ANTICOSTI ISLAND, QUÉBEC; in Subcommission on Silurian Stratigraphy, Ordovician-Silurian Boundary Working Group: Field Meeting, Anticosti-Gaspé, Québec 1981, Vol. II: Stratigraphy and Paleontology, ed. P.J. Lespérance, p. 107-135, 1981.

Corals are present throughout Ordovician and Silurian rocks of Anticosti Island; they are the dominant elements of the biostromes and/or bioherms in the upper beds of each formation. Distinct Late Ordovician and Early Silurian coral assemblages are illustrated for the upper Ellis Bay, Becscie, Gun River, Jupiter and Chicotte formations. Only a few taxa range throughout the sequence.

On rencontre des coraux des toutes les roches ordoviciennes et siluriennes de l'île d'Anticosti; ils représentent les éléments dominants des biostromes et biohermes des lits supérieurs de chaque formation. On a illustré des assemblages bien définis de coraux de l'Ordovicien supérieur et du Silurien inférieur, dans les formations supérieures d'Ellis Bay, Bacscie, Gun River, Jupiter et Chicotte. Seuls quelques groupes taxonomiques sont représentés dans toute la succesion.

Bolton, T.E.

EARLY SILURIAN ANTHOZOA OF CHALEURS GROUP, PORT DANIEL-BLACK CAPE REGION, GASPÉ PENINSULA, QUÉBEC; in Subcommission on Silurian Stratigraphy, Ordovician-Silurian Boundary Working Group. Field Meeting, Anticosti-Gaspé, Québec 1981, Vol. II: Stratigraphy and Paleontology, ed. P.J. Lespérance, p. 299-314, 1981.

Four early Silurian (Llandovery) coral assemblages are present in the type region of the Chaleurs Group. The assemblage **Paleofavosites** spp. - **Acidolites clemvillensis** (Parks) occurs in the Clemville Formation; it is overlain by the **Favosites forbesi** Milne-Edwards and Haime - **Heliolites interstinctus** (Linnaeus) - **Alveolites** sp. assemblage in the Anse Cascons Formation. The two upper assemblages are more closely related. The **Syringopora compacta** (Billings) - **Heliolites subtubulatus** (McCoy) - **H. interstinctus** - **Phaulactis** sp. - **Palaeocyclus rotuloides** (Hall) assemblage dominates the lower beds of the Anse à Pierre-Loiselle Formation, and is succeded by **S. compacta** - **Acanthohalysites encrustans** (Buehler) - **Subalveolites depressus** (Parks) - **Palaeocyclus porpita** (Linnaeus) assemblage in the lower beds of the La Vieille Formation. The Wenlock coral **Thecia swinderniana** (Goldfuss) first appears some 100 metres above this upper assemblage.

On rencontre quatre assemblages de coraux du Silurien inférieur (Llandovérien) dans la localité-type du groupe de Chaleurs. L'assemblage à **Paleofavosites** spp. - **Acidolites clemvillensis** (Parks) dans la formation de Clemville, est recouvert par l'assemblage à **Favosites forbesi** Milne-Edwards et Haime - **Heliolites interstinctus** (Linné) - **Alveolites** sp. dans la formation d'Anse Cascons. Ce sont les deux assemblages supérieurs qui présentent les plus grandes

ressemblances. L'assemblage à **Syringopora compacta** (Billings) - **Heliolites subtubulatus** (McCoy) - **H. interstinctus** - **Phaulactis** sp. - **Palaeocyclus rotuloides** (Hall) domine les lits inférieurs de la formation d'Anse à Pierre - Loiselle; il fait place à l'assemblage à **S. compacta** - **Acanthohalysites encrustans** (Buehler) - **Subalveolites depressus** (Parks) - **Palaeocyclus porpita** (Linné) dans les lits inférieurs de la formation de La Vieille. Le corail **Thecia swinderniana** (Goldfuss) du Wenlockien apparait initialement à environ 100 métres au-dessus de cet assemblage supérieur.

Bolton, T.E.

ORDOVICIAN AND SILURIAN BIOSTRATIGRAPHY, ANTICOSTI ISLAND, QUÉBEC; in Subcommission on Silurian Stratigraphy, Ordovician-Silurian Boundary Working Group. Field Meeting, Anticosti-Gaspé, Québec 1981. Vol. II: Stratigraphy and Paleontology, ed. P.J. Lepérance, p. 41-59, 1981.

Anticosti Island is underlain by a continuous sequence of fossiliferous Late Ordovician and Early Silurian rocks, divisible into two Ordovician and four Silurian formations. The composition and biostratigraphic value of many of the macrofossil groups recognized in these formations is discussed and some taxa illustrated: algae, stromaporoids, sponges, echinoderms, bryozoans, brachiopods, gastropods, pelecypods, nautiloids, and trilobites.

Le sous-sol de l'île d'Anticosti contient une succession continue de roches fossilifères de l'Ordovicien supérieur et du Silurien inférieur, que l'on peut subdiviser en deux formations ordoviciennes et quatre formations siluriennes. On étudie la composition et la valeur biostratigraphique d'un grand nombre des groupes de macrofossiles identifiés dans ces formations, et l'on illustre certains groupes taxonomiques: algues, stromatoporoidés, éponges, échinodermes, bryozoaires, brachiopodes, gastéropodes, pélécypodes, nautiloidés et trilobites.

Bonardi, M., Roberts, A.C., and **Sabina, A.P.,** and **Chao, G.Y.**

SODIUM-RICH DACHIARDITE FROM THE FRANCON QUARRY, MONTREAL ISLAND, QUEBEC; Canadian Mineralogist, v. 19, p. 285-289, 1981.

Sodium-rich dachiardite was found in a silicocarbonatite sill exposed in the lower level of the Francon quarry, St-Michel, Montreal Island, Quebec. It occurs as white acicular crystals, monoclinic, elongated [010], forming parallel and divergent aggregates 1 to 2 mm in length. It has a white streak, silky lustre along the cleavage, hardness 4½ and perfect cleavage in two directions parallel to the length of the fibres. Optically transparent, it is biaxial negative, length-fast, with indices of refraction 1.471(1) $\|$ *b*, 1.475(1) ~ $\|$ *a* and 1.476(1) and a measured 2*V* of 52°. The dispersion is $r < v$ moderate, $Z \wedge c \simeq \beta - 90° \simeq 18°$. The measured specific gravity is 2.14(1). The cell parameters are *a* 18.67(1), *b* 7.488(4), *c* 10.282(6) A, β 108.74(8)°, *V* 1361.2 A^3, and the space group is *C*2/*m* (No. 12). Electron-microprobe analyses show that, as to sodium content, the Francon dachiardite compares with that from Tsugawa, Japan. The chemical formula calculated on the basis of 48 oxygen atoms is $(Na_{2.93}K_{0.36}Sr_{0.01}Ca_{0.01})_{\Sigma 3.31}(Si_{20.47}Al_{3.59})_{\Sigma 24.06}O_{48}$ • 12.43 H_2O. With $Z = 1$, the calculated density based on the analytical formula is 2.140 g/cm^3.

On a trouvé une dachiardite riche en sodium dans un sill de silicocarbonatite qui affleure au niveau inférieur de la carrière Francon à St-Michel (île de Montréal, Québec). Ses cristaux blancs, aciculaires monocliniques allongés selon [010], forment des agrégats parallèles ou divergents de 1 à 2 mm de longueur. Elle a une rayure blanche, un éclat soyeux sur le clivage, qui est parfait en deux directions parallèles à l'axe de la fibre, et une dureté de 4½. Optiquement transparente, elle est biaxe négative, à allongement négatif, indices de réfraction 1.471(1) $\|$ *b*, 1.475(1) ~ $\|$ *a*, 1.476(1); 2*V* = 52°; dispersion modérée $r < v$. La densité mesurée est de 2.14(1). Les paramètres reticulaires sont: *a* 18.67(1), *b* 7.488(4), *c* 10.282(6) A, *b* 108.74(8)°, *V* = 1361.2 A^3 et le groupe spatial est *C*2/*m*. D'après les analyses à la microsonde électronique, cette dachiardite ressemble, dans sa teneur en sodium, à celle de Tsugawa (Japon). La formule chimique empirique, $(Na_{2.93}K_{0.36}Sr_{0.01}Ca_{0.01})_{\Sigma 3.31}(Si_{20.47}Al_{3.59})_{\Sigma 24.06}O_{48}$ • 12.43 H_2O (O = 48), donne 2.140 pour la densité calculée (à une molécule par maille).

Bornhold, B.D.

SEDIMENTATION IN THE DOUGLAS CHANNEL FJORD SYSTEM, BRITISH COLUMBIA; Eos, v. 62, no. 45, p. 918.

The Douglas Channel fjord system consists of three major depositional basins, two of which are 400 m deep and contain more than 600 m of unconsolidated sediments. They are separated by a prominent morainal sill more than 900 m thick. The third basin, now completely filled, underlies northern Kitimat Arm and is separated from the other basins by a bedrock sill, presently buried by deltaic sediments.

Seismic profiling, low-frequency echosounding and coring have delineated the following stratigraphic units: tills (?) and glaciomarine sediments; stratified sands and sandy muds; acoustically transparent muds; coarse, gravelly morainal sediments; thin, surficial stratified muds and sandy muds with occasional sand layers; and hummocky, slumped sediments near the Kitimat delta.

Much of the sediment in the fjord was deposited during deglaciation between approximately 13,100 and 11,000 yr. B.P. with the main morainal sill produced by stagnation of the ice at about 12,000 yr. B.P. Deltaic sedimentation near Kitimat began about 9-9500 yr. B.P. followed by deposition of the most recent stratigraphic unit in the basins, stratified muds and sandy muds. These stratified sediments are markedly thicker on the north and west sides of the fjord. It is suggested that this asymmetry is a result of the deflection of the surface plume of sediment laden waters, and possibly also of turbidity currents, by Coriolis force, as has been demonstrated for lakes of comparable dimensions.

Boyle, D.R.

THE ANALYSIS OF FLUORINE IN GEOCHEMICAL EXPLORATION; Journal of Geochemical Exploration, v. 14, p. 175-197, 1981.

Methods of measuring cold-extractable acid-diffusible and total fluorine are described together with a discussion of the ability of each method to attack fluorine-bearing minerals, their respective precisions and the various interferences affecting each technique. These three analytical methods can be used for the detection of a wide variety of mineral deposits containing fluorine. The choice of method

or methods will be governed chiefly by the types of fluorine-bearing minerals associated with mineralization, the predominant type of dispersion in the secondary environment (hydromorphic or mechanical) and the obvious restrictions of cost and time.

For greisens, pegmatites, non-fluorite-bearing disseminated deposits (mainly Nb, Ta, Sn, W, Be) and some placer deposits, cold-extractable methods will be unacceptable since fluorine occurs mainly in minerals resistant to this type of attack (tourmaline, topaz, pyrochlore, micas). The acid-diffusible method will produce adequate anomalies in stream sediments and soils associated with these deposits, only if a significant amount of the fluorine present is contained in the micaceous minerals or apatite. In most cases, the total method should be preferred for detecting these types of deposits. For kimberlites, and serpentinized ultrabasic and basic intrusions, in which fluorine occurs mainly in phlogopite, serpentine, apatite and various weathering products, the determination of cold-extractable and acid-diffusible fluorine will generally give lower anomaly contrasts than the total method. For deposits which contain a large amount of fluorite and/or apatite, such as carbonatites, some mesothermal and epithermal deposits, phosphate deposits and some pegmatite and disseminated deposits, cold-extractable and acid-diffusible methods will produce anomaly contracts in soils and stream sediments similar to the total method.

The application of all three of these analytical methods in an exploration program may be of value in understanding the forms in which fluorine is dispersed.

Boyle, D.R., and **Littlejohn, A.L.**

MINERALOGY, CHEMISTRY AND ENVIRONMENT OF FORMATION OF THE BLIZZARD AND TYEE URANIUM DEPOSITS, SOUTH-CENTRAL BRITISH COLUMBIA; Geological Association of Canada, Annual Meeting 1981, Abstracts, v. 6, p. A-6, 1981.

Uranium mineralization in the Blizzard and Tyee deposits occurs in poorly consolidated Miocene fluvial sediments overlying Tertiary fault and graben structures within the Okanagan Highlands Intrusive Complex. Host sediments consist of basal conglomerates with an overlying sequence of interbedded sandstones, siltstones and mudstones. Ore formation commenced after capping of the fluvial) sediments by Pliocene valley basalts. All of the sedimentary units contain carbonaceous matter in variable states of decomposition. Pyrite, marcasite and clay minerals form the remainder of the authigenic material.

Mineralization is present as uranous (ningyoite) and urayl (saleeite, autunite) phosphates. Ningyoite occurs mainly in association with iron sulphides and organic matter whereas saleeite and autunite may also occur in relatively clean sediments. Ningyolite often occurs as encrustations on saleeite and autunite or as single crystals growing in cleavage cracks of these minerals. A progression from slightly oxidizing to more reducing conditions of formation is indicated, and both the paragenetic data and phase equibria relationships show that the uranyl minerals, saleeite and autunite, are primary minerals. Apart from the ore forming elements U,Ca,Mg and P, only Mo has been introduced during ore formation. Manganese is the only element which has been notably depleted.

These deposits are considered to have formed as a result of infiltration by structurally-controlled, deep-seated groundwaters leaching an intrusive basement complex. Such waters were alkaline before entering the host sediments but uranium precipitation was attained under slightly acid conditions due to oxidation of iron sulphides (Blizzard) and production of soluble organic acids (Tyee). Availability of phosphate and the Ca/Mg ratio of groundwaters also played a major role in ore formation.

Boyle, D.R., Littlejohn, A.L., Roberts, A.C., and Watson, D.M.

NINGYOITE IN URANIUM DEPOSITS OF SOUTH-CENTRAL BRITISH COLUMBIA: FIRST NORTH AMERICAN OCCURRENCE; Canadian Mineralogist, v. 19, p. 325-331, 1981.

Ningyoite has been found in the uranium deposits of southern British Columbia, where it constitutes the major uranous (U^{4+}) phase present. It occurs as accretionary stars, crystal mats and aggregate masses of spindle- or lozenge-shaped crystals that rarely exceed 2 mm in length. Occasionally it is present as single crystals in cleavage cracks of saléeite. The mineral forms in pyritiferous organic-rich fluvial sediments (Tyee deposit) or carbonaceous sandy mudstones (Blizzard deposit). In transmitted light ningyoite is greenish brown and displays a slight pleochroism. Extinction of the spindle-shaped grains is parallel and the mean index of refraction is between 1.60 and 1.70. Ningyoite is orthorhombic a 6.75(1), β 12.00(1), ψ 6.38(1) A, V 516.78 $Å^3$, $Z = 3$, diffraction aspect $C***$. Electron-microprobe analysis failed to detect rare-earth elements in ningyoite from British Columbia. Rare-earth elements were detected in only some ningyoite aggregates from the type locality in Japan. It is proposed that the formula for ningyoite be written $Ca_{2-x}U_x(PO_4)_2 \cdot nH_2O$, where $x \leq 1$. Optimum conditions for the formation of ningyoite are attained when weakly alkaline groundwaters leaching granitic basement complexes and containing high concentrations of U and PO_4 infiltrate pyritiferous, organic-matter-rich sediments.

La ningyoite est l'espèce minérale uranifère (U^{4+}) dominante dans les gîtes d'uranium de la Colombie-Britannique méridionale. On la trouve en accrétions stellaires, en tapis et en agrégats de cristaux fusiformes ou losangiques de longueur généralement inférieure à 2 mm. Parfois on la trouve en cristaux uniques dans les fentes de clivage de la saléeite. La ningyoite a été précipitée dans les sédiments fluviatiles pyritifères et riches en matière organique (gisement Tyee) et dans les boues arénacées carbonacées (gisement Blizzard). En lumire transmise, elle est d'un brun verdâtre, légèrement pléochroique. L'extinction est parallèle, et l'indice moyen de réfraction se situe entre 1.60 et 1.70. La ningyoite est orthorhombique, a 6.75(1), b 12.00(1), c 6.38(1) Å, V 516.78 $Å^3$ pour $Z = 3$; aspect de diffraction $C***$. La microsonde n'a décelé aucune terre rare dans les échantillons canadiens, quoique les terres rares aient été trouvées dans certains agrégats de ningyoite de la localité-type japonaise. Nous proposons la formule $Ca_{2-x}U_x(PO_4)_2 \cdot nH_2O$, $x \leq 1$. La formation de la ningyoite est favorisée par l'infiltration, dans des sédiments riches en matière organique et en pyrite, d'eau légèrement alcaline, enrichie en U et PO_4 par lessivage des complexes granitiques du socle.

Bristow, Q.

TEMPERATURE GRADIENT MEASUREMENTS IN BOREHOLES USING LOW NOISE HIGH RESOLUTION DIGITAL TECHNIQUES; in Ideas and Experiences, Australian Society of Exploration Geophysicists Second Biennial Conference, August, Adelaide, South Australia, 1981.

Equipment described to date for high resolution temperature gradient measurements in boreholes uses thermistor sensors with sophisticated digital resistance

meters providing the analog to digital conversion at the surface. With hundreds or thousands of meters of cable between the thermistor probe and the resistance meter, the problems involved in making high precision measurements are considerable. Some of these problems can be circumvented by digitizing the signal in the probe and transmitting the temperature information up the logging cable in digital form. Commercial equipment currently available which uses this approach offers a maximum precision of the order of ±0.01°C at a sampling interval of 1 second, which is inadequate for high resolution temperature gradient logging.

Continuous temperature logging equipment has been developed at the Geological Survey of Canada which takes advantage of modern technology by using a single integrated circuit voltage-to-frequency converter in the temperature probe to accomplish the analog-to-digital conversion with a sensitivity of 1700 Hz/°C. By measuring the length of time to accumulate 8192 pulses, against a 10 MHz crystal clock at the surface, continuous measurements can be made with a resolution of 10^{-5}°C at intervals of less than 0.4 seconds.

Initial experiments in a thermally stable borehole with a well documented temperature profile indicate that the thermal equivalent noise of the measurement system is of the order of 10^{-4}°C. This permits gradient measurements with a precision of ± 5°C/Km to be made over a depth interval as small as 2 cm. Typical gradients in undisturbed boreholes are from 10 to 30°C/Km and variations of the order of 5 or 10°C/Km over a few centimetres may indicate lithological changes. Data will be presented to demonstrate the application of high resolution temperature gradient logging in hole-to-hole correlation of lithological sequences and in hydrogeological studies.

Buchan, K.L., and **Schwarz, E.J.**

UPLIFT ESTIMATED FROM REMANENT MAGNETIZATION: MUNRO AREA OF SUPERIOR PROVINCE SINCE 2150 MA AGO; Canadian Journal of Earth Sciences, v. 18, p. 1164-1173, 1981.

A method for determining depth of burial from remanent magnetization was applied to three igneous contacts of two different ages in Munro Township of the Superior Province of the Canadian Shield. Sampling profiles perpendicular to the contact of a 2150 Ma diabase dike, one collected in an older (2690 Ma) diabase dike and a second in gabbro country rock, yielded ambient temperatures for the present erosion surface at the time of dike emplacement of 219 ± 23 and 181 ± 7°C, respectively. A third sampling profile perpendicular to a 2690 Ma dike failed to provide a usable magnetic contact zone.

A secondary magnetic component with shallow inclination and easterly declination was detected in individual samples collected from both dikes as well as from the surrounding country rock. Converging remagnetization circles indicate that this component, acquired some time after emplacement of the younger (2150 Ma) dike, has the direction $D = 70°$, $I = -39°$ and corresponding paleopole 39°E, 4°S.

Une méthode pour déterminer la profondeur d'enfouissement à l'aide de l'aimantation rémanente a été appliquée à trois zones de contacts de roches ignées d'âges différents dans le canton Munro de la province du lac Supérieur du Bouclier canadien. Les sections d'échantillonnage sont perpendiculaires au contact d'un dyke de diabase âgé de 2150 Ma, un échantillonnage fait dans un dyke de diabase ancien (2690 Ma) et un deuxième provenant de la roche encaissante gabbroique ont donné comme températures ambiantes pour la surface d'érosion actuelle lors de la mise en place du dyke 219 ± 23 et 181 ± 7°C respectivement. Une troisième section échantillonnée perpendiculairement au dyke âgé de 2690 Ma n'a pu fournir des résultats acceptables de la zone de contact magnétique.

Une composante magnétique secondaire avec une faible inclinaison et une déclinaison vers l'est a été décelé sur des échantillons individuels prélevés dans les deux dykes et également dans la roche encaissante environnante. De cercles de réaimantation convergente indique que cette composante, acquise quelque temps après la mise en place du dyke le plus récent (2150 Ma), possède la direction $D = 70°$, $I = 39°$ avec un paléopole correspondant 39°E, 4°S.

Bujak, J.P., and **Williams, G.L.**

THE EVOLUTION OF DINOFLAGELLATES; Canadian Journal of Botany, v. 59, p. 2077-2087, 1981.

Recent work on modern dinoflagellates indicates that these organisms occupy a critical position in the evolution of life, being intermediate between prokaryotes and eukaryotes. It further suggests that dinoflagellates acquired chloroplasts through symbiosis with ingested autotrophic organisms. Two models have been proposed to explain the development of the cellulosic theca in the Dinophyceae. The first, the plate increase model, is based primarily on observations of living algae, while the second, the plate reduction model, relies mainly on paleontological data. However, neither satisfactorily reconciles both lines of evidence and so the plate fragmentation model is proposed. This postulates that dinoflagellates with two anterior flagella and a wall consisting of two large valves were successful through much of the Paleozoic. A major evolutionary breakthrough occurred in the Triassic with the development of a transverse-longitudinal flagellar arrangement and change in swimming direction. Associated with these modifications was a fragmentation of the valves into numerous polygonal plates. Subsequent evolution emphasized the influence of the two flagellar furrows over the number and arrangement of thecal plates. This led to a decrease in number and stabilization of the thecal plates as seen in modern dinoflagellates.

Cecile, M.P.

MISTY CREEK EMPAYMENT – A MAJOR LOWER PALEOZOIC EXTENSIONAL FEATURE, NORTHERN CANADIAN CORDILLERA; Geological Association of Canada, Annual Meeting 1981, Abstracts, v. 6, p. A-9, 1981.

The Misty Creek Embayment is a 100 x 150 km rectangular "shale" basin forming a prominent northwest-trending embayment into the Mackenzie carbonate platform. This feature is connected with the Selwyn Basin to the southwest across a basin high. Basin strata in the embayment are several orders of magnitude thicker than equivalent carbonate units around the embayment. Basin strata are turbiditic, rhythmic successions of thin-bedded silty limestone and calcareous shale, and thick successions of thin-bedded silty limestone, graphtolitic shale and minor chert. Alkalic volcanic rocks are interstratified with most basin units and are comprised of hyaloclastites, epiclastites, massive and pillowed flows. Flows, dykes and sills are altered and contain scattered large euhedral phlogopite-biotite crystals and microscopic crystals of celsian. The embayment is interpreted as an extensional fault-bounded basis of geometry, linear nature of facies belts and alkalic volcanism.

Christie, R.L.

HISTORY OF STRATIGRAPHIC STUDIES IN THE CANADIAN ARCTIC ISLANDS; in Lexicon of Canadian Stratigraphy, Volume 1, Arctic Archipelago (District of Franklin), ed. R.L. Christie, et al., Canadian Society of Petroleum Geologists, Calgary, p. 1-2, 1981.

An outline of stratigraphic advances in the Arctic Islands, 1824 to the 1970s.

Christie, R.L., and Kerr, J. Wm.

GEOLOGICAL EXPLORATION OF THE CANADIAN ARCTIC ISLANDS; in A Century of Canada's Arctic Islands, 1880-1980, ed. M. Zaslow, Royal Society of Canada, 1981.

Les îles arctiques ont été le centre de nombreuses études géologiques depuis les années 40. Les premiers explorateurs européens en ont rapporté des spécimens de roches et des collections de fossiles, et quelques géologiques s'y sont aventurés vers la fin du XIX^{e} siècle et au début du XX^{e}, mais les expéditions ont depuis connu une surprenante évolution. Alors que les premiers explorateurs devaient habituellement passer l'hiver sur place et se déplacer en traîneaux à chiens, les chercheurs peuvent aujourd'hui, grâce à l'avion et à l'hélicoptère, se livrer à une grande variété de travaux de recherche à l'endroit et à l'époque de l'année qu'ils jugent les plus propices.

The geology of the Arctic Islands is known mainly through field work carried out by the Geological Survey of Canada and by petroleum exploration and university geologists since the 1940s. The geological knowledge aquired prior to that time had been obtained by early explorers and by a few expeditions directed toward geological reconnaissance. The early explorers and geologists typically wintered in the North and carried out field work during the late winter sledging period or by boat during the short summer and fall periods of open water. Transport by steel ship and aircraft in modern times has enabled a great variety of research to advance at an ever-increasing pace.

Christie, R.L., Embry, A.F., and Van Dyck, G.A. (editor)

LEXICON OF CANADIAN STRATIGRAPHY, VOLUME 1; Arctic Archipelago (District of Franklin); Canadian Society of Petroleum Geologists, Calgary, Canada, 1981.

The literature available on the geology of the Canadian Arctic Islands has increased dramatically since 1960 when the Alberta Society of Petroleum Geologists published its "Lexicon of Geologic Names in The Western Canada Sedimentary Basin and Arctic Archipelago". At that time, some 70 formational names were in use; in the 19 years that have elapsed, the number has approximately tripled. Recent field work by the Geological Survey of Canada, by university workers, and by petroleum exploration geologists has resulted in refinement of the understanding of many earlier-named units and in the publication of many new names. The present volume, therefore, updates previously published entries and provides authoritative descriptions of newly named units.

Christie, R.L., Dawes, P.R., **Frisch, T.,** Higgins, A.K., Hurst, J.M., Kerr, J.Wm., and Peel, J.S.

GEOLOGICAL EVIDENCE AGAINST MAJOR DISPLACEMENT IN THE NARES STRAIT; Nature, v. 291, 11 June, p. 478-480, 1981.

Early continental drift[1-3] and later plate tectonic reconstructions[4-14] indicate left lateral (sinistral) movement along Nares Strait of between 10 and 400 km during the Cretaceous-Tertiary. A basic concept in such reconstructions is the substantial part played by seafloor spreading in the origin of Labrador Sea-Baffin Bay. Until recently, geological knowledge of the area adjacent to Nares Strait was insufficient to put tight constraints on displacement along Nares Strait (Fig. 1). Of seven independent lines of evidence from bedrock geology, termed markers, all are consistent with sinistral net displacement of Greenland along Nares Strait of 0-25 km. The three most imprecise markers can be reconciled with maximum movement of 100 km.

This refutes conventional plate tectonic reconstructions which suggest movement of 150 km or more. New mechanisms should now be considered to explain the broad area of oceanic crust in Baffin Bay.

Chung, C.F.

APPLICATION OF THE BUFFON NEEDLE PROBLEM AND ITS EXTENSIONS TO PARALLEL-LINE SEARCH SAMPLING SCHEME; Mathematical Geology, v. 13, no. 5, 1981.

Buffon's needle problem is generalized to a grid of unequally spaced parallel strips and a needle with a preferred orientation. This generalization is useful to determine the spacing of flight lines for locating anomalies by airborne geophysical surveys.

Clague, J.J.

LANDSLIDES AT THE SOUTH END OF KLUANE LAKE, YUKON TERRITORY; Canadian Journal of Earth Sciences, v. 18, no. 5, p. 959-971, 1981.

Landslides are unusually varied and abundant in the Kluane Ranges near the south end of Kluane Lake, Yukon Territory. Selected landslides were investigated to determine the likelihood and probable character of future mass movements in this area, and to gain some understanding of similar but unstudied features elsewhere in the St. Elias Mountains.

Landslides in the study area include slumps and related complex landslides, rockfalls, rockslides, rockfall avalanches, and debris flows. The youngest and most spectacular of the large catastrophic landslides is the Sheep Mountain rockfall avalanche ($5–10 \times 10^{6} m^{3}$), which formed as a result of two separate failures between 500 and 1950 radiocarbon years ago. Much of the low mountain slope southwest of this landslide to near the mouth of Slims River is covered by thick blocky rubble deposited during one or more older catastrophic slope failures. Both the Sheep Mountain landslide and the set of older slope failures to the southwest apparently occurred when Kluane Lake was much smaller than it is today. As the level of the lake rose in response to aggradation accompanying the Neoglacial advance of Kaskawulsh Glacier, distal portions of these landslides were inundated.

Debris flows and debris torrents occur sporadically on fans in the study area. These fans are composed of diamicton and gravel beds separated by loess layers and paleosols. Marker horizons, such as the Slims Soil (Hypsithermal) and White River tephra (ca. 1200 years BP), occur in these sediments and provide evidence that the fans have been active throughout the Holocene.

Contributing factors to landslides in the eastern Kluane Ranges include high seismicity, the presence of steep slopes in pervasively fractured and faulted rocks, an abundance of talus and glacial sediments available for remobilization as debris flows and debris torrents, and the occurrence of intense rainstorms.

Although landslides are ubiquitous in the south Kluane Lake area, most of the large deep-seated bedrock failures are relatively old. Thus the danger posed by future comparable landslides to life and property in the area could be considered to be low. Floods, debris flows, and debris torrents on active alluvial fans and aprons skirting the Kluane Ranges probably are greater potential hazards to economic development of this region.

Copeland, M.J.

A BRIEF OUTLINE OF THE CONTRIBUTIONS OF SOME NINETEENTH AND EARLY TWENTIETH CENTURY PALEONTOLOGISTS AND STRATIGRAPHERS TO THE GEOLOGY OF ANTICOSTI ISLAND AND GASPÉ PENINSULA, QUÉBEC; in Subcommission on Silurian Stratigraphy, Ordovician-Silurian Boundary Working Group. Field Meeting, Anticosti-Gaspé, Québec 1981, Vol. II: Stratigraphy and Paleontology, ed. P.J. Lespérance, p. 1-7, 1981.

Copeland, M.J.

LATEST ORDOVICIAN AND SILURIAN OSTRACODE FAUNAS FROM ANTICOSTI ISLAND, QUÉBEC; in Subcommission on Silurian Stratigraphy, Ordovician-Silurian Boundary Working Group. Field Meeting, Anticosti-Gaspé, Québec 1981, Vol. II: Stratigraphy and Paleontology, ed. P.J. Lespérance, p. 185-195, 1981.

Two well-developed, morphologically and temporally distinct ostracode faunas occur in outcropping strata of Anticosti Island, Québec. There is an abrupt decrease in hollinacean taxa and the termination of the **Jonesites semilunatus** Zone fauna (notably the extinction of the Tetradellidae and Eurychilinidae) near the end of the Ordovician and an equally abrupt establishment of the endemic beyrichiacean zygobolbid fauna early in the Silurian. The intervening latest Ordovician? to earliest Silurian strata on Anticosti Island have failed to yield a diagnostic ostracode fauna that would more precisely define the boundary.

Deux faunes d'ostracodes, bien développées, morphologiquement et temporellement bien définies, apparaissent dans des affleurements rocheux de l'île d'Anticosti au Québec. On observe une brusque réduction des groupes d'Hollinacés et la disparition de la faune de la zone à **Jonesites semilunatus** (en particulier l'extinction des Tetradellidés et Eurychilinidés) vers la fin de l'Ordovicien, puis au début du Silurien l'avènement tout aussi soudain de la faune endémique de Zygobolbidés (Beyrichiacea). Le strates intermédiaires entre le sommet de l'Ordovicien? et la base du Silurien sur l'île d'Anticosti n'ont pas fourni de faune d'ostracodes diagnostique, que permette de définir plus précisément la limite stratigraphique recherchée.

Darnley, A.G.

THE RELATIONSHIP BETWEEN URANIUM DISTRIBUTION AND SOME MAJOR CRUSTAL FEATURES IN CANADA; Mineralogical Magazine, v. 44, p. 425-36, December 1981.

The availability of reconnaissance scale geochemical maps for large areas of Canada enables spatial associations between major crustal structures and surface uranium content to be identified. Maps of the distribution of uranium for an area greater than 2 million km^2 compiled from airborne gamma-ray spectrometry data are supplemented by maps for uranium, based on stream and lake sediment and some bore hole sampling. These are examined in relation to gravity, aeromagnetic and geological maps.

The radioelement distribution can be related in detail to exposed bedrock and surface geology, but in addition there is evidence of the control of uranium distribution by major structural features which are marked by granitoids containing elevated levels of radioelements; several of these granitoids are associated with large negative Bouguer gravity anomalies. The distribution of such granitoids appears to be related to 'megashears', as in the case of the South Mountain batholith in Nova Scotia, or zones of tension. A belt of uranium enrichment, the Athabasca axis which is characterized by uraniferous granitoids with negative Bouguer gravity anomalies and associated tension faulting extends 2500 km northeastward from Edmonton, Alberta to the Melville Peninsula. This structure passes under the Athabasca basin which contains many large uranium deposits. Recent evidence that granitoids enriched in radioelements can provide low-grade heat sources over periods of hundreds of millions of years, capable, in favourable situations of maintaining low-temperature hydrothermal circulation is considered to account for uranium and other mineralization in the basin. It is suggested that the transfer of radio-elements into the crust at the end of the Lower Proterozoic, was a factor in the stabilization of North American craton.

Davies, E.H., Bujak, J.P., and **Williams, G.L.**

LET'S TAKE DINOFLAGELLATES OFF THE SHELF; Geological Survey of Canada, Annual Meeting 1981, Abstracts, v. 6, p. A-13, 1981.

Few would argue that the presence of dinoflagellates generally indicates a marine environment, but is this the best we can do? The distribution of modern dinoflagellates is influenced by a variety of factors, such as temperature, salinity, turbidity and runoff. The difficulty is to develop simplified models to interpret these complex interactions. Add to this the fact that all fossil dinoflagellates are thought to be cysts and it comes as no surprise that their use as environmental indicators is fraught with danger. Despite this, we believe that a combination of imaginative methodology, careful selection of case histories, knowledge of modern and biological processes, and input from the other geological disciplines will make them useful paleo-environmental indicators. In the talk, we shall review a variety of examples relating to the use of dinoflagellates as paleo-environmental indicators.

Dixon, J.

UPPER JURASSIC AND LOWER CRETACEOUS GEOLOGY IN THE SUBSURFACE OF THE MACKENZIE DELTA AREA, NWT; Third International Symposium on Arctic Geology, Canadian Society of Petroleum Geologists, Program and Abstracts, p. 42, 1981.

Over 2500 m of Jurassic and Lower Cretaceous strata are preserved in the Canoe Depression and Kugmallit Trough on the southern edge of the Beaufort-Mackenzie Basin. These depocentres are flanked by several tectonically positive areas, the Eskimo Lakes Arch on the southeast, the Cache Creek Uplift on the west and the Tununuk High on the north. Strata tend to thin towards and over these highs, a result of both erosional and depositional thinning.

The succession can be divided into six depositional-complexes, each complex bounded by major hiatal surfaces. Depositional-complex 1 (Oxfordian to Upper Tithonian, possibly as young as the earliest Berriasian: lower Husky Formation) contains marine strata, predominantly shale and mudstone with a number of thin, coarsening-upward cycles. A single, thick and widespread coarsening-upward unit characterized depositional-complex 2 (Berriasian: upper Husky Formation and Buff sandstone), showing a vertical change from offshore marine muds to barrier island/beach

sands. Depositional-complex 3 (Early Valanginian to ?Middle Hauterivian: Blue-grey Shale, White Sandstone and Coal-bearing Division) contains a vertical succession of marine shale to fluvial sandstone to nearshore and offshore sandstone and shale. This depositional-complex contains rocks partially equivalent to the gas-bearing "Parsons sandstone" at the southern end of the Tuktoyaktuk Peninsula. An unnamed marine shale and the lower part of the Upper Shale-Siltstone Division (?Middle to Early Barremian) comprise depositional-complex 4. Depositional complex 5 (Early Barremian to Aptian: upper part of the Upper Shale-Siltstone Division, Upper Sandstone Division and Atkinson Point Formation) contains marine shale and siltstone in the lower part, and is gradationally overlain by a mostly marine sandstone succession. On part of the Tuktoyaktuk Peninsula coastal fan-delta developed (Atkinson Point Formation). The final depositional-complex (Albian: Arctic Red Formation) is entirely marine shale and mudstone.

The main source area for each of the depositional-complexes was to the south and southeast, but an additional source area to the north has been identified for depositional-complexes 4 and 5.

Dyck, W., and Da Silva, F.G.

THE USE OF PING-PONG BALLS AND LATEX TUBING FOR SAMPLING THE HELIUM CONTENT OF LAKE SEDIMENTS; Journal of Geochemical Exploration, v. 14, p. 41-48, 1981.

Equilibrium between He dissolved in water He inside a ping-pong ball, when confined together inside an airtight container, is reached in 4 days and in about 2 days in the case of 6.4 mm O.D., 0.8 mm wall latex tubing. Ping-pong balls and sections of latex tubing closed at both ends, and filled with air, were left to equilibrate with freshly collected organic lake sediment samples inside closed, completely filled, 467 ml glass jars and then analysed for He.

Using this method two lakes in northern Saskatchewan were found to contain anomalous He in the sediment even though their waters contained atmospheric equilibrium concentrations of He. One lake is known, and the other inferred, to lie over a fracture zone. One is 1 km and the other 1.5 km from known U deposits. However, the source of the excess He is more likely due to upwelling, He-rich groundwaters through fractures, rather than the U deposits.

This lake sediment He method makes possible the detection of fault and fracture zones during the summer when wind and sun have destroyed the thermoclines in lake waters. It would also be useful for detecting subsurface U deposits in porous sedimentary strata and deposits associated with fault and fracture zones.

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

COPPER MINERALIZATION NEAR AN INTRA-RAPITAN UNCONFORMITY, NITE COPPER PROSPECT, MACKENZIE MOUNTAINS, NORTHWEST TERRITORIES, CANADA: REPLY; Canadian Journal of Earth Sciences, v. 18, p. 414-418, 1981.

Eisbacher, G.H., and **Clague, J.J.**

URBAN LANDSLIDES IN THE VICINITY OF VANCOUVER, BRITISH COLUMBIA, WITH SPECIAL REFERENCE TO THE DECEMBER 1979 RAINSTORM; Canadian Geotechnical Journal, v. 18, p. 205-216, 1981.

Historical landslides in the urbanized Vancouver region, southwestern British Columbia, have almost commonly occurred along escarpments within and at the margins of gently rolling upland surfaces underlain by Pleistocene unconsolidated sediments. The most common and most destructive landslides are debris avalanches and debris flows. They are triggered by intense autumn and winter rainstorms, when water infiltrates and saturates the surficial layer of weathered colluvium. After failure the veneer of debris gains momentum and picks up additional soil and uprooted vegetation. Debris avalanches may temporarily block gullies swollen with runoff water, thus changing into rapidly moving debris flows.

A severe rainstorm in December 1979 was accompanied by destructive debris avalanches and debris flows in urban areas in the vicinity of Vancouver. A search of local newspapers and meteorological records back to 1900 indicates that this event was not unique, for at least 26 other comparable storms have triggered landslides in the Vancouver region during this century. Thus it is likely that landslides similar to those of December 1979 will occur repeatedly in the future. The danger of such landslides to life and property will grow if potentially hazardous sites are urbanized without appropriate protective measures.

Historiquement, les glissements de terrain dans la région urbanisée de Vancouver, dans le sud de la Colombie Britannique, se sont généralement produits le long de talus bordant des hautes terres vallonées, formées de sédiments pleistocènes non consolidés. Les glissements les plus courants et les plus destructeurs sont des avalanches et des coulées de debris. Ils sont déclanchés par des pluies torrentielles d'automne et d'hivre, lorsque l'eau s'infiltre et sature la couche superficielle de colluvium altéré. Après rupture, le couvert de debris acquiert de la vitesse et entraîne du sol additionnel et de la végétation déracinée. Les avalanches de debris peuvent bloquer temporairement des ruisseaux gonfiés par les eaux de ruissellement, et se transformer en coulées de debris à mouvement rapide.

Une pluie torrentielle en décembre 1979 a été accompagnée d'avalanches et coulées de debris destructrices dans la région urbaine de Vancouver. Une recherche dans les journaux locaux et les relevés météorologiques depuis 1900 a montré que cet évènement n'était pas unique, puisqu'au moins 26 autres tempêtes de ce type ont déclenché des glissements dans la région de Vancouver depuis le début du siècle. Il est donc probable que des glissements semblables à ceux de décembre 1979 se répètent à l'avenir. Les dommages produits par ces glissements aux propriétés et aux personnes vont augmenter à mesure que des sites dangereux sont urbanisés sans mesure protectrice appropriée.

Emslie, R.F.

EXCEPTIONALLY HIGH GRADE METAPELITIC GNEISSES IN THE RED WINE MOUNTAINS, SOUTHERN LABRADOR; Geological Association of Canada, Annual Meeting 1981, Abstracts, v. 6, p. A-17, 1981.

A south-dipping, fault-bounded, thrust wedge of very high grade metasedimentary and meta-igneous rocks underlies the Red Wine Mountains in the broad tectonic zone south of the Grenville Front. A variety of geothermobarometers suggests metamorphic conditions of $T = 1000 \pm 50°C$, $P_{tot.} = 9 \pm 1 kb$, for the Hope gneiss metapelites. Sapphirine+quartz, stable at peak metamorphic temperatures, was replaced by hypersthene+sillimanite+quartz at slightly lower temperatures. The high oxidation state ($MH > fP_2 >> NNO$) and water fugacities less than a few tens of bars prevented significant partial melting. Rb contents of 103 ± 29 ppm (n=23) in the rocks rule out an earlier extraction of a melt phase.

Metamorphism of these metapelites on a regional scale was caused by widespread and voluminous basic intrusions

that produced a suite of spinel-bearing peridotites, pyroxenites, gabbros, leuconorites, and minor anorthosite. Mineral equilibria within the basic suite confirm the P-T conditions inferred from the metapelites and many assemblages retain a record of their initially higher magmatic temperatures.

The igneous activity and granulite grade metamorphism have an age of about 1660 m.y. (zircon, Rb-Sr whole rock) which seems too young to relate to the Hudsonian Orogeny and more likely records a distinct early Paleohelikian event. The terrane apparently cooled slowly at nearly constant pressure and probably was transported and uplifted to its present structural position by Grenvillian tectonism. This interpretation implies that Grenvillian effects in this region were dominated by tectonism, unaccompanied by significant regional heating. Visible Grenvillian metamorphism primarily reflects dynamic processes that were coupled with retrogression aided by fluid access that accompanied tectonism.

Dunsiger, A.D., Chari, T.R., **Fader, G.B.,** Peters, G.R., Simpkin, P.G., and Zielinski, A.

OCEAN SEDIMENTS—A STUDY RELATING GEOPHYSICAL, GEOTECHNICAL, AND ACOUSTIC PROPERTIES; Canadian Geotechnical Journal, v. 18, p. 492-501, 1981.

A multi-device high density survey of the seafloor was conducted in the outer Placentia Bay area of Newfoundland using the Bedford Institute of Oceanography research ship CSS **Hudson.** The acoustic records obtained from various systems, the seafloor soil samples collected by a piston corer and a grab sampler, and the **in-situ** data from a free-fall penetrometer were all subsequently analyzed. The correlation between the results of these different analyses is examined in this paper.

Une reconnaissance très dense du fond de mer dans la région de la Baie Placentia à Terre Neuve a été réalisée au moyen de divers appareils à partir du navire du recherche CSS **Hudson.** Les relevés accoustiques obtenus à l'aide de différents systèmes, les échantillons de sol du fond de mer prélevés au moyen d'un échantillonneur à piston et d'un "grab sampler" et les données in **situ** fournies par un pénétromètre à chute libre ont été analysés. La corrélation entre les résultats de ces différentes analyses est examinée dans cet article.

Findlay, D.C., Thorpe, R.I., and **Sangster, D.F.**

ASSESSMENT OF THE NON-HYDROCARBON MINERAL POTENTIAL OF THE ARCTIC ISLANDS; in A Century of Canada's Arctic Islands, ed. M. Zaslow, Royal Society of Canada, 23rd Symposium, p. 203-220, 1981.

Enough is known about the geology of the Arctic Islands to make initial judgments of their mineral potential through the application of mineral deposit concepts developed from experience elsewhere. However, reliable judgments are difficult because of gaps in the geological information base, paucity of systematic exploration and the scarcity of documented mineral deposits.

Recently, preliminary assessments of the potential for resources of various metals have been made for the Arctic Islands using the mineral deposit-model analogy approach. Subjective estimates were made of the potential for occurrence of undiscovered deposits and of the probable significance in economic development terms of these predicted but undiscovered deposits.

The main conclusions drawn from these assessments are:

i) parts of the Arctic Archipelago have significant potential for undiscovered lead-zinc, copper-zinc-silver, and to a lesser degree gold and nickel deposits;

ii) large resources of iron are known that have potential for development within the next twenty years;

iii) known uranium occurrences are small and uneconomic and the potential for undiscovered economic deposits seems low;

iv) areas considered to have the greatest potential for undiscovered mineral deposits, particularly lead and zinc are central Baffin Island, North Baffin Rift Zone, Hazen Trough of northern Ellesmere Island and extensions to the Cornwallis Lead-Zinc District.

On possède suffisamment de données sur la géologie des îles arctiques pour en évaluer le potentiel minier à partir de théories sur les gîtes minéraux qui ont été vérifiées ailleurs. Toutefois, ce genre d'évaluation est difficile à effectuer en raison du caractère lacunaire des renseignements géologiques de base, de la rareté des explorations systématiques et du manque de documentation sur les gîtes.

Récemment, les îles arctiques ont fait l'objet d'évaluations préliminaires visant à déterminer la présence de divers métaux à l'aide d'une mise en corrélation des modèles de gîtes minéraux. On a évalué la probabilité de l'existence possible de gîtes non encore découverts et l'incidence de ceux-ci en termes de développement économique.

Voici les principales conclusions de l'étude:

i) il est fort possible que certaines parties de l'Archipel arctique recèlent des dépôts de plomb-zinc, de cuivre-zinc-argent et, il y a quelques chances, des gîtes aurifères et nickélifères;

ii) il existe des gisements de fer qu'il sera possible d'exploiter au cours des vingt prochaines années;

iii) il existe des gîtes d'uranium, mais en faibles quantites et de peu d'utilité sur le plan économique;

iv) le centre et la zone de crevasses dans le nord de la terre de Baffin, et le fossé Hazen dans le nord de l'île Ellesmere, ainsi que des prolongements du district de plomb-zinc de l'île Cornwallis, semblent être les régions les plus riches en plomb et en zinc.

Foscolos, A.E., and Kodama, H.

MINERALOGY AND CHEMISTRY OF ARCTIC DESERT SOILS ON ELLEF RINGNES ISLAND, ARCTIC CANADA; Soil Science Society of America Journal, v. 45, no. 5, p. 987-993, 1981.

Morphological, mineralogical, and chemical characteristics of five soil profiles derived from different parent materials have been studied on the Ellef Ringnes Island, Canadian Arctic Archipelago. The aim was to investigate weathering and pedogenesis of Arctic desert soils.

Morphological, mineralogical, and chemical data of the soil horizons indicate that there is very little soil differentiation between the parent material and the top horizons. However, since the Wisconsin retreat, some 11,000 years ago, bioxidation of pyrite **Thiobacillus ferroxidans** has converted most of the studied soil to acid sulfate soils containing sulfate-bearing minerals such as natrojarosite and gypsum.

Kodama, H., and **Foscolos, A.E.**

OCCURRENCE OF BERTHIERINE IN CANADIAN ARCTIC DESERT SOILS; Canadian Mineralogist, v. 19, p. 279-283, 1981.

Berthierine, an iron-rich trioctahedral 1:1 layer silicate (d_{001} = 7.04 A), is a major component in the A and C horizons of the Jaeger series, an Arctic desert soil, at Ellef Ringnes Island, Northwest Territories. Heating the powder sample to 300°C displaces the 060 reflection from 1.548 to 1.513 A, thus indicating the transformation of the trioctahedral berthierine structure to a dioctahedral one owing to the oxidation of Fe^{2+} to Fe^{3+}. Judging from the *d* value of 060 and the relative intensities of other reflections of the unheated sample, berthierine in the soil is a mixture of monoclinic and orthorhombic polytypes having an intermediate ferrous–ferric composition. Chemical data support the proposed intermediate composition. Although berthierine is highly susceptible to weathering, the severely restricted weathering environment in the Arctic region is the main reason for the rare survival of berthierine in the Jaeger soil.

La berthiérine, phyllosilicate trioctaédrique (1:1) ferrifère (d_{001} = 7.04 A), est un composant principal des unités A et C de la série Jaeger, un sol désertique arctique situé sur l'île Ellef Ringnes (Territoires du Nord-Ouest). On peut déplacer la réflexion 060 de 1.548 à 1.513 A par chauffage à 300°C, ce qui indique la transformation de la structure trioctaédrique de la berthiérine et une autre, dioctaédrique, par oxydation du fer. A la lumière de l'equidistance d_{060} et de l'intensité relative des autres réflexions de l'échantillon non-chauffé, la composition de la berthiérine du sol se situerait entre les termes Fe^{2+} et Fe^{3+} et serait un mélange de polytypes monoclinique et orthorhombique. Les données chimiques confirment cette composition intermédiaire. Quoique la berthiérine soit très sensible à l'altération climatérique, elle persiste dans le sol Jaeger vu l'importance très restreinte du lessivage dans son environnement arctique.

Foscolos, A.E., and **Reinson, G.E.**

RELATIONSHIP BETWEEN CLAY-MINERAL AUTHIGENESIS AND DETRITAL MINERALOGY IN VIKING SANDSTONE, EAST-CENTRAL ALBERTA; Geological Association of Canada, Annual Meeting 1981, Abstracts, v. 6, p. A-18, 1981.

The Viking Formation of east-central Alberta is a shallow-marine shelf deposit containing two prominent laminated to massive, clean sandstone units interbedded with laminated shaley siltstones and bioturbated muddy sandstones. The sandstone units differ markedly with respect to detrital mineralogical composition; one unit is a quartz arenite containing very little feldspar and lithic fragments but with abundance of accessory glauconite whereas the other unit is a lithic-arkosic arenite having a much higher content of feldspar with lithic fragments and a relative paucity of glauconite.

Mechanical analysis of the sandstones indicate that there is a higher percentage of clay minerals in the lithic-arkosic arenite than in the quartz arenites. X-ray and S.E.M. analysis indicate that secondary kaolinite and quartz overgrowths are the main authigenic minerals in the quartz arenites whereas kaolinite with minor quartz overgrowth characterizes the authigenic mineral assemblage in the lithic arkosic arenites. It appears that at a given depth of burial host sandstone mineralogy has a minor control on the type of authigenic clay mineral assemblage.

Campbell, I.H., Coad, P., **Franklin, J.M.,** Gorton, M.P., Scott, S.D., Sowa, J., and Thurston, P.C.

RARE EARTH ELEMENTS IN VOLCANIC ROCKS ASSOCIATED WITH CU-ZN MASSIVE SULPHIDE MINERALIZATION: A PRELIMINARY REPORT; Ontario Geological Survey, Miscellaneous Paper 98, p. 45-53, 1981.

Massive sulphide deposits are closely associated with felsic volcanism. This association is believed to be genetic and forms the cornerstone for most exploration programs, but unfortunately not all felsic volcanic rocks contain ore. It seems likely that ore-bearing felsic volcanic rocks have a different genetic history from barren felsic volcanic rocks and, if this is so, these differences should be reflected in their rare earth element (REE) geochemistry.

A preliminary study of REE in Archean felsic volcanic rocks has shown that those associated with ore have flat REE patterns with well developed Eu anomalies whereas those from barren volcanic rocks have steep REE patterns with weak or absent Eu anomalies. The felsic volcanic rocks associated with ore can be subdivided into two types: tholeiitic and calc-alkaline. Those at the Kam-Kotia, Matagami and South Bay mines are tholeiitic whereas those at the Sturgeon Lake and Golden Grove deposits are calc-alkaline.

The well-developed Eu anomalies in the ore-related felsic volcanic rocks indicate that the melt has undergone a high degree of fractional crystallization en route to the surface, suggesting the existence of a subvolcanic magma chamber below the ore body. We believe that these subvolcanic sills are an integral part of the ore-forming process and are therefore required for the formation of massive sulphide deposits.

The characteristic REE patterns of the ore-associated felsic volcanic rocks should help mining companies in selection of areas for massive sulphide exploration.

Campbell, I.H., Gorton, M.P., Scott, S.D., **Franklin, J.M.,** and Thurston, P.C.

RARE EARTH ELEMENTS AS A GUIDE TO MASSIVE SULFIDE EXPLORATION; Geological Association of Canada, Annual Meeting 1981, Abstracts, v. 6, p. A-8.

Massive sulfide deposits are closely associated with acid volcanism. This association is believed to be genetic and forms the cornerstone for most exploration programs, but unfortunately not all acid volcanics contain ore. It seems likely that ore-bearing acid volcanics have a different genetic history from barren acid volcanics and if this is so, these differences should be reflected in their REE geochemistry.

A preliminary study of REE in Archean acid volcanics has shown that those associated with ore have flat REE patterns with well-developed Eu anomalies whereas those from barren volcanics have steep REE patterns with weak or absent Eu anomalies. The well-developed Eu anomalies in the ore-related acid volcanics indicate that the melt has undergone a high degree of fractional crystalisation en route to the surface, suggesting the existence of a magma chamber below the ore bodies. Significantly, sub-volcanic sills have been located below a number of Canadian massive sulfide deposits and these sub-volcanic sills exhibit the same REE patterns as the ore-bearing acid volcanics. We believe the sub-volcanic sills fed the overlying volcanics and are the heat engines responsible for both the ore deposits and for their associated alteration.

Rhyolites from the Kuroko district in Japan have flat REE patterns similar to the Archean ore-associated acid volcanics. Again the presence of Eu anomalies suggests the existence of a sub-volcanic magma chamber below the Kuroko ore deposits.

Franklin, J.M., Lydon, J.W., and **Sangster, D.F.**

VOLCANIC-ASSOCIATED MASSIVE SULPHIDE DEPOSITS; in 75th Anniversary Volume, ed. Skinner, B.J., Economic Geology, p. 485-627, 1981.

Volcanic-associated massive sulfide deposits are, as a group, predominantly stratiform accumulations of sulfide minerals which formed on or near the sea floor by precipitation near the discharge site of hydrothermal fluids. The enclosing strata have prominent amounts of volcanic rocks, although in some cases the ores themselves may be enclosed in sedimentary rocks. The ores characteristically consist of more than 60 percent sulfide, most of which is pyrite and/or pyrrhotite plus variable amounts of sphalerite, chalcopyrite, or galena. The massive ore may be underlain by Cu-rich vein and disseminated sulfides (the stringer zone) and intensely altered rocks of the alteration pipe. The deposits are characterized by internal metal zoning, the most consistently described of which is a decrease upward and/or outward in Cu/(Cu+Zn+Pb) ratio. This zoning is particularly evident in those deposits which occur above their feeder pipes (e.g., Noranda deposits, Kuroko deposits). In other cases (e.g., Besshi, Kieslager, Bathurst, New Brunswick), the orebodies may be tabular with or without an underlying stringer zone. The massive ores may show evidence of reworking, and in some areas have been displaced, either partially or completely, from this discharge site.

On the basis of metal content, the deposits fall into two distinct groups, a Cu-Zn group and Zn-Pb-Cu group. Many deposits in the Cu-Zn group, such as those in the Canadian Shield and, in part, those of the Scandinavian Caledonides, are contained in compositionally bimodal volcanic sequences; mafic volcanic rocks usually constitute at least 90 percent of the total volcanic complement, but felsic volcanic rocks are generally prominent very near the deposits. The ophiolite-associated Cu-Zn deposits, such as those in Cyprus, Turkey, Newfoundland, and Saudi Arabia, however, are usually at the contact between two pillowed mafic volcanic sequences. The Besshi, Kieslager, and some Fennoscandian Shield deposits are in areas composed of subequal amounts of mafic volcanic and clastic sedimentary rocks.

Deposits of the Zn-Pb-Cu group are in stratigraphic settings dominated either by felsic volcanic rocks, as in the Green Tuff belt of Japan and in Tasmania, or by subequal amounts of felsic volcanic and sedimentary strata, as at Bathurst, New Brunswick, and in the Iberian pyrite belt.

Oxide facies iron-formation, although not ubiquitous, is more commonly associated with the Zn-Pb-Cu deposits. Barite is abundant in some Zn-Pb-Cu deposits but is absent from a majority of the Cu-Zn deposits.

Although the two groups can be distinguished on the basis of their sulfur isotope compositions, this is not the case with lead isotopes. With one exception, the oxygen isotopic compositions of altered rocks that accompany volcanic-associated massive sulfide deposits are lighter than those of the unaltered equivalents. Strontium isotopic compositions of the altered rocks lie between those of primitive magmas and coeval seawater.

Alteration pipes under Zn-Pb-Cu deposits generally have a sericite + quartz core and a chloritic outer zone, whereas alteration pipes under Cu-Zn deposits typically have a chloritic core and sericitic outer zone. Large, semiconformable, regional scale alteration zones underlying many deposits in the Precambrian Shield of Canada and in ophiolite terranes may either enclose or lie below the alteration pipes occurring directly beneath individual deposits.

Although it is generally agreed that the volcanic-associated massive sulfide deposits were formed at or near the discharge sites of submarine hydrothermal systems, there are divergent views on other aspects of their genesis. The immediate source of the ore constituents may be either in the underlying rocks, contemporaneous magmas, or coeval seawater. The balance of the evidence and opinion seems to favor leaching of most of the metal and probably some of the sulfur, from the underlying rocks and derivation of the balance of the sulfur from coeval seawater.

The ore solutions were mobilized by either a convective hydrothermal cell or by a mechanism akin to seismic pumping. The former model postulates that the ore solution was mainly coeval seawater, whereas, in the latter model, the ore solution was mainly connate water which, in turn, originated mainly as trapped seawater. A minor contribution by magmatic or meteoric water is possible in both models.

The discharge sites of the ore fluids were focussed by faults or fractures, which are usually associated with local extensional tectonic activity. Precipitation of sulfides is due to cooling and oxidation brought about by mixing of the ore-forming solution with ambient seawater, or by boiling of the ore solution as it nears the sea floor.

Fulton, R.J.

QUATERNARY GEOLOGY OF CANADA; Geological Association of Canada, Annual Meeting 1981, Abstracts, v. 6, p. A-20, 1981.

The Geological Survey of Canada is planning on revising 'Geology and Economic Minerals of Canada'. One of the eight volumes planned will treat Quaternary geology. This work will form part of the Geological Society of America's Centennial Project "the decade of North American Geology" which ends in 1988.

The Quaternary Volume will consist of two sections; a regional section providing a general description of Quaternary materials, and a summary of Quaternary history; and a topical section providing information on specific aspects of Quaternary geology. Subjects proposed for the topical section are: Quaternary environments, Quaternary crustal dynamics, geomorphologic processes, terrain geochemistry and Quaternary geology in the service of man. Only aspects of the Quaternary which are closely related to geology will be treated and space limitations will require that these be treated briefly (400 p. volume limit).

A surficial materials map of Canada at a scale of 1:5 000 000 will be prepared to accompany this volume. The units will be based on materials rather than stratigraphy but will be grouped into 3 age categories. Some glacial geomorphic features will be shown so that information relative to style of glaciation and nature of ice retreat will be apparent from the map.

Display material will include a map showing the natural Quaternary regions that will serve as the framework for the regional section of the Quaternary Volume, an index map showing surficial mapping coverage of Canada and a proposed legend for the surficial materials map. The purpose of this session is to obtain comments on plans already made and to solicit aid in carrying this work forward.

Gabrielse, H., and **Taylor, G.C.**

GEOLOGICAL MAPS AND CROSS-SECTIONS OF THE CORDILLERA FROM NEAR FORT NELSON, BRITISH COLUMBIA TO GRAVINA ISLAND, SOUTHEASTERN ALASKA; Geological Association of Canada, Annual Meeting 1981, Abstracts, v. 6, p. A-20, 1981.

H. Gabrielse, Geological Survey of Canada, Vancouver, B.C. V6B 1R8 and G.C. Taylor, Geological Survey of Canada, Calgary, Alta. T2L 2A7. The cross-sections show generalized stratigraphic sequences and structural styles in the five major tectonic belts of the Cordillera. Easterly verging structures between the Interior Platform and the Northern Rocky Mountain Trench, probably mainly of early Cretacrous age, effect a minimum shortening of about 55 Km above passive crystalline basement. Basement rocks may be involved, however, in deformation in the region underlain by upper Proterozoic Windermere strata.

The Northern Rocky Mountain Trench, a locus of apparent great dextral movement between mid-Cretaceous and early Tertiary time, separates regions of markedly contrasting stratigraphy and structural style. In the Omineca Belt the earliest and generally dominant structures of late mid-Jurassic to mid-Cretaceous age verge westerly. They are earlier than easterly directed structures that are cut by mid-Cretaceous granitic plutons. Crystalline basement is postulated to be at relatively shallow depths in structural culminations.

In the Intermontane Belt the competent and massive Mesozoic volcanic rocks are block faulted but commonly only gently folded. Sharply dissimilar structural style between the volcanics and highly deformed overlying sedimentary rocks with easterly verging structures indicates a zone of decollement at least locally separates the two assemblages. In general, rocks beneath upper Triassic volcanics are strongly deformed. Indicated ages of deformation in the Intermontane Belt are pre late Triassic, early Jurassic, mid Jurassic and late Cretaceous. The depth and character of basement are unknown.

Late Mesozoic westerly directed structures are evident in the Insular Belt and western part of the Coast Plutonic Complex. Elsewhere, multiple phases of deformation and plutonism have produced a complicated structural style.

Gadd, N.R.

LATE-GLACIAL REGIONAL ICE-FLOW PATTERNS IN EASTERN ONTARIO: REPLY; Canadian Journal of Earth Sciences, v. 18, no. 8, p. 1390-1393, 1981.

Gordey, P.

STRUCTURE SECTION ACROSS SOUTH CENTRAL MACKENZIE MOUNTAINS, N.W.T.; Geological Association of Canada, Annual Meeting 1981, Abstracts, v. 6, p. A-22, 1981.

The Mackenzie Mountains are interpreted as a thin-skinned detachment terrane comprising northwest trending decollement folds and listric thrust faults that are the extension of the northern Rocky Mountain fold and thrust belt. A cross section is presented in which bed lengths are conserved and internal geometric consistency is maintained.

This approach suggests that the significant structural relief of Redstone Plateau resulted from eastward translation of supracrustal rocks across a large pre-existing basement ramp and onto a higher detachment surface that extends beneath the entire deformed belt. Thrust faults bounding the east margin of the plateau are splays from the sole fault and may have originated at the position of the step before significant shortening moved them and the hangingwall assemblage over it and along the flat plateau decollement. Shortening above the detachment east of the plateau is the amount geometrically needed to compensate for overlap beneath the plateau.

Restoration of the structure section to its undeformed length shows that the ramp is coincident with rapid westward thickening of Proterozoic Rapitan Group strata, supporting the concept of pre-Rapitan extension and crustal thinning.

Total shortening across Mackenzie Mountains is about 52 km, very similar to that suggested (55 km) by Gabrielse and Taylor for northern Rocky Mountains.

Gradstein, F.M., and Sheridan, R.E.

DSDP LEG 76, GAS HYDRATES AND THE EARLY HISTORY OF THE ATLANTIC OCEAN; Geological Association of Canada, Annual Meeting 1981, Abstracts, v. 6, p. A-22, 1981.

Leg 76 of the Deep Sea Drilling Project in the western North Atlantic Ocean faced two main objectives: (1) to continuously core in Jurassic strata below reflector D and for the first time reach ocean crust basement in the Jurassic magnetic quiet zone, and (2) to geochemically document gas hydrates.

Continuous coring at Site 534(TD 6632m) in the Blake Bahama basin yielded a detailed ocean basement and overlying sediment record spanning 150 m.y. of ocean history. Fractured and re-cemented oceanic pillow basalt (31.5m) was recovered from below a strong basement seismic reflector which proves normal ocean crusts exists under the Jurassic magnetic quiet zone. Dating the overlying sediments as Early-Middle Callovian revises upward with 10-20 m.y. the timing of early spreading of the Central North Atlantic. 140 meters of Callovian and Oxfordian sediments show a stratigraphic transition from brown-green and black shales to radiolarian rich, green-black silty claystone mixed with redeposited limestone. Sedimentation was hemipelagic, below the Calcium Carbonate Compensation Depth (CCD) for foraminifers, interrupted by contourite and shelf-and slope derived turbidites under fluctuating E_b conditions. The fossil record shows open surface water exchange with Tethys and probably the Pacific, but bottom circulation was at first restricted, leading to organic rich black shales.

Coring to 400 m in the Blake Outer Ridge "contourites" (Site 533) and in situ sampling with the new pressure core barrell quantitatively and qualitatively proved the existence of gas hydrates. Most of the gas is biogenic methane. Temperature measurements agree with the interpretation that the Bottom Simulating Seismic Reflector (BSR) is a phase-change boundary between gas hydrates and normal sediments.

Gradstein, F.M., and **Berggren, W.A.**

FLYSCH-TYPE AGGLUTINATED FORAMINIFERA AND THE MAESTRICHTIAN TO PALEOGENE HISTORY OF THE LABRADOR AND NORTH SEAS; Marine Micropaleontology, v. 6, p. 211-268, 1981.

Virtually identical agglutinated (arenaceous) benthonic foraminiferal assemblages (ca. 30 genera, 45-50 taxa), characteristic of the Alpine–Carpathian flysch basins, occur in the Upper Cretaceous–Paleogene fine-grained clastic (?turbidite) sequences of the East Newfoundland Basin, Labrador Sea and North Sea. The assemblages terminate in both areas in the Late Eocene or Oligocene, although in the central (deepest) part of the North Sea elements of this flysch-type fauna have been observed extending into Lower or Middle Miocene levels.

Independent geological evidence and deep-sea drilling data indicate that these assemblages have an extensive (paleo) bathymetric distribution (~200 m to over 4 km). Therefore, depth alone is not considered a significant factor in their occurrence. A number of interrelated physico-chemical factors at or near the sediment–water interface are believed to account for the observed distribution pattern of these assemblages. These factors include relatively rapid deposition of fine-grained, organic-rich, carbonate-poor clastics under somewhat restricted bottom water circulation in compartmented basins.

A dozen forms appear to be of stratigraphic utility when calibrated against sparse planktonic foraminiferal data and known ranges in flysch basins elsewhere.

Sheridan, R.E., and **Gradstein, F.M.**

EARLY HISTORY OF THE ATLANTIC OCEAN AND GAS HYDRATES IN THE BLAKE OUTER RIDGE RESULTS OF THE DEEP SEA DRILLING PROJECT; Episodes, v. 1981, no. 2, p. 16-22, 1981.

Leg 76 of the international Deep Sea Drilling Project (DSDP) has yielded a plethora of new and exciting scientific data that may revolutionize some concepts in the geological sciences. In this article, the chief scientists of the cruise summarize the remarkable results obtained from continuous and painstaking coring at Site 534 in the Blake Bahama Basin in the Western North Atlantic Ocean – the second deepest hole drilled below the abyssal seafloor, which penetrated the oldest sediments (~155 Ma) yet recovered, and those of Site 533 in the Blake Outer Ridge "contourites", which quantitatively and qualitatively proved the existence of gas hydrates.

Doeven, P.H., and **Gradstein, F.M.**

A QUANTITATIVE NANNOFOSSIL RANGE CHART; Geological Association of Canada, Annual Meeting 1981, Abstracts, v. 6, p. A-15, 1981.

The abundance and diversity of nannofossils in the Upper Cretaceous sediments of the Canadian Atlantic margin makes them ideal for quantitative biostratigraphic studies.

Sixty-four taxa from 10 cored wells were used to erect a statistical zonation. The methods are based on the matrix F of relative frequencies by which stratigraphic events are observed to succeed one another in wells. Four types of events were used: lowest occurrences, sub-bottom, sub-tops and highest occurrences, which were ordered in four optimum stratigraphic sequences. The relative position of the events in these sequences is an average of all the relative positions encountered. The sequences were used to construct a range chart which expresses the ranges between average tops and bottoms and average sub-tops and sub-bottoms. This chart and the eighteenfold zonation based on it compared favourable to subjective, conventional ones in the literature; the sub-top/sub-bottom concept improves biostratigraphic resolution.

Grasty, R.L.

THE INTERPRETATION OF MULTICHANNEL AIRBORNE GAMMA-RAY SPECTRA; Society of Exploration Geophysicists, Technical Program, p. 97, 1981.

In the past few years it has become common practice to record airborne gamma-ray data in several hundred channels covering a broad energy range anywhere between 0 and 3 MeV. At present, little of the information in this multichannel data is being effectively utilized; usually the data are simply converted to three conventional windows, and the full spectrum recording only serves as a monitor of the spectral drift of the system.

In order to make full use of the gamma-ray spectra, the variation in shape of the potassium, uranium, and thorium spectra must be known as a function of the amount of absorbing material between the source of radioactivity and the detector. The shapes of the gamma-ray spectra were derived from measurements on large radioactive concrete calibration pads using plywood sheets as the absorbing material and covered an equivalent range in air from 0 to 112 m. A principal component analysis of the results from the 9 discrete equivalent aircraft altitudes showed that the spectrum of each of the three radioelements was composed essentially of two basic spectra, whose proportions varied in an exponential manner with the amount of absorbing material. With this information, the gamma-ray spectra can readily be synthesized for any particular aircraft altitude.

The most obvious application of these results is in estimating the ground radioelement concentrations by fitting the calculated composite spectra to the observed spectrum. This should in theory provide measurements with reduced errors by virtue of the increased spectral information being utilized. An analysis of airborne data recorded over the U.S. Department of Energy airborne calibration strip at Lake Mead, Colorado and the Geological Survey of Canada calibration strip at Breckenridge, near Ottawa showed that the problem is complicated by the presence of cesium-137 from atomic weapons tests, which emits gamma-radiation at 0.662 MeV and contributes significantly to the gamma-radiation received from the ground. By fitting the calculated and observed spectra above the cesium energy for one-second data, it was found that significant increases in statistical accuracy could be achieved for all three radioelements, the uranium measurement showing the greatest improvement. Over the Lake Mead calibration strip, the standard deviation of all one-second uranium measurements decreased by a factor of approximately 1.4 over the standard 3-window method. To obtain similar increases in accuracy for the 3-window method, it would be necessary to increase the detector volume by a factor of almost two.

The variation in shape of the gamma-ray spectrum may also be used to determine the mass-equivalent of the absorbing material between the source of radioactivity and the detector. This can be achieved by monitoring the build-up of scattered gamma-radiation from potassium-40. From the results of a series of flights at different altitudes over the two calibration strips, it was found that in the range of altitude from 60 to 300 m, the aircraft altitude could be determined to an accuracy of approximately 10 m. Conversely, corrections to the calculated ground concentrations can be made for the presence of any absorbing materials such as trees, inactive overburden or snow.

Finally the two component representation may also allow background atmospheric radiation to be calculated from the shape of the uranium spectrum. Atmospheric bismuth-214 would be expected to have a ratio of the two basic uranium spectral components corresponding to a source near the detector. A source of uranium uniformly distributed in the ground should indicate a source distance equivalent to the aircraft altitude. From the ratio of the two uranium components and a knowledge of the aircraft altitude it should be possible to calculate the proportions of bismuth-214 gamma-rays received from the ground and the air.

Dickson, B.H., Bailey, R.C., and **Grasty, R.L.**

UTILIZING MULTI-CHANNEL AIRBORNE GAMMA-RAY SPECTRA; Canadian Journal of Earth Sciences, v. 18, p. 1793-1801, 1981.

Experimental studies using a large-volume sodium iodide detector system show how the potassium, uranium, and thorium gamma-ray spectra vary with altitude above the ground. The shapes of the spectra were derived from measurements on large radioactive concrete calibration slabs

using plywood sheets to simulate the absorption of the gamma radiation in the air. A mathematical analysis of the data showed that within the range covered by the experiment (0–112 m of air) the spectra of each of the three radio-elements are made up essentially of two spectral components, whose proportions vary with the amount of absorbing material between the source and the detector. With this knowledge, it is shown how all the basic information relating to source–detector distance and source concentration may be extracted from the airborne gamma-ray spectrum.

Des études expérimentales utilisant un système de détection avec grand volume d'iodure de sodium montrent comment les spectres de rayons-gamma du potassium, de l'uranium et du thorium varient avec l'altitude au-dessus du terrain. Les profils des spectres ont été dérivés de mesures effectuées sur de grandes plaques de béton étalonnées et des feuilles en contre-plaqué servaient à simuler l'absorption de la radiation-gamma par l'air. Une analyse mathématique des données a montré que dans les limites des conditions d'expérimentation (0–112 m d'air) les spectres de chacun des trois radioéléments comprennent essentiellement deux composantes spectrales, dont les proportions varient avec la quantité de matériaux d'absorption placés entre la source et le détecteur. Il est montré avec ce renseignement comment on peut extraire d'un relevé aéroporté d'un spectre de rayonnement-gamma toute l'information de base se rapportant à la distance source–détecteur et à la concentration de la source d'émission.

Hacquebard, P.A., Buckley, D.E., and **Vilks, G.**

THE IMPORTANCE OF DETRITAL PARTICLES OF COAL IN TRACING THE PROVENANCE OF SEDIMENTARY ROCKS; Bull. Centres Rech. Explor.-Prod. Elf-Aquitaine, v. 5, no. 2, p. 555-572, 1981.

This paper gives two examples of tracing the provenance of sedimentary rocks from properties of detrital particles of coal contained. The diagnostic coal properties include maceral composition, coal rank as determined by vitrinite reflectance, age determination by means of fossil plant spores and trace element content as determined spectroscopically.

Through these properties the possible source area of coaly fragments present in sediments occurring below the seafloor at two localities in the North Atlantic Ocean have been determined, namely: In Quaternary deposits from the Sohm Abyssal Plain, 760 km east of Bermuda, and in Jurassic sediments from Orphan Knoll, situated 550 km northeast of Newfoundland. The likely provenance of the coaly particles is, respectively, the Sydney coalfield in Nova Scotia, and the coal bearing measures of South Wales or Southern Ireland.

The results permit speculation as to the pre-drift position of Orphan Knoll and also indicate the great distance over which turbidity currents can transport unconsolidated sediments. At the location on the Sohm Abyssal Plain this distance was at least 1 800 km.

L'article présente deux examples de la recherche de la provenance des roches sédimentaires d'après les propriétés des particules détritiques de charbon qui y sont contenues. La diagnose du charbon comprend a composition macérale, le rang déterminé par la réflectance de la vitrinite, l'âge déterminé à l'aide des spores et les éléments trace déterminés par l'analyse spectroscopique.

Grâce à ces indications, une origine possible a pu être déterminée pour les particules de charbon observées dans les dépôts marins de deux localités: d'une part, les dépôts quaternaires de la plaine abyssale de Sohm, à 760 km à l'est des Bermudes et d'autre part, les sédiments jurassiques d'Orphan Knoll, à 550 km au nord-est du Térre-Neuve. La provenance probable des particules de charbon est, respectivement, le bassin bouiller de Sydney, Nouvelle Ecosse, et les dépôts bouillers du Pays de Galles ou de l'Irlande du Sud.

Les résultats permettent de spéculer quant à la position d'Orphan Knoll avant la dérive et sont aussi une indication de la grande distance de transport des sédiments non consolidés par les courants de turbidité. Pour la plaine abyssale de Sohm, cette distance était d'au moins 1 800 km.

Haworth, R.T.

GEOPHYSICAL EXPRESSION OF APPALACHIAN-CALEDONIDE STRUCTURES ON THE CONTINENTAL MARGINS OF THE NORTH ATLANTIC; in Geology of the North Atlantic Borderlands, ed. J.Wm. Kerr and A.J. Fergusson, Canadian Society of Petroleum Geologists, Memoir 7, p. 429-446, 1981.

The offshore extension of the eastern Precambrian margin of the Appalachians (the Avalon Zone) across the Grand Banks of Newfoundland is shown by the extent of arcuate zones of high magnetic anomalies corresponding with volcanic 'ridges' separating basins containing metasedimentary rocks. A similar geophysical pattern occurs in Iberia and France, providing a good correlation with the Avalonian structures when the margins are restored to their relative positions prior to the opening of the Bay of Biscay and the North Atlantic. The linear magnetic pattern of the Avalon Zone is truncated abruptly at its southern edge indicating that the boundary between the Avalon and the Meguma Zones trends almost due east from Cape Breton across the Tail of the Bank. The European landfall of this boundary, expected in southern Spain, is not obvious there. South and west of Newfoundland there is evidence for a northwest-trending fault pattern within the Avalon Zone. Northeast of Newfoundland the abrupt contrast between the gravity and magnetic character of the Avalon Zone and that of Paleozoic units of central Newfoundland indicates that the Avalon Zone boundary extends across the Canadian margin to the western end of the Charlie Fracture Zone. On the European margin, a correlative structural boundary is less obvious, but may cross Porcupine Bank and follow a sinuous path south of Ireland and thence towards Anglesey.

The western Precambrian margin of the Appalachians (the Grenvillian Humber Zone) has a prominent gravity and magnetic gradient associated with it through North America. This boundary extends offshore parallel to the southeastern coast of Labrador until it apparently swings eastward at 53°N. Southwestward trends across Scotland and Ireland, that may be correlative with the Grenville boundary, veer westward towards Rockall Trough indicating that there may be continuity with the eastward-veering Canadian trends, but with little concrete evidence for its continuation across the wide and dissected European margin.

Paleozoic sedimentary and volcanic rocks are well exposed in Newfoundland with slices of an ophiolite suite in the Dunnage Zone representing the remnants of the Paleozoic ocean crust that once separated the Precambrian margins. The subsurface and offshore projections of these oceanic rocks are interpreted to indicate that there was southeastward dipping dubduction of that Paleozoic crust, leading to westward thrusting of the ophiolite suites now seen at Betts Cove, Hare Bay, and Bay of Islands. Following closure of the Paleozoic ocean, east-west trending belts of late Carboniferous faults extended from the Grand Banks in Iberia, and from the Scotian Shelf and Georges Bank into

northwest Africa. The continuity of these belts provides latitudinal control for late Paleozoic paleogeographic reconstructions.

Reactivation of the Precambrian and Paleozoic structures on the Canadian margin is apparent from the confinement of Mesozoic sedimentary basins between structural highs that follow Precambrian trends on the Grand Banks. Vertical displacements of several kolometres between elements of the Canadian and European margins are inferred from seismic refraction data.

Henderson, J.B.

ARCHAEAN BASIN EVOLUTION IN THE SLAVE PROVINCE, CANADA; in Precambrian Plate Tectonics, ed. Kröner, A., Elsevier Scientific Publishing Company, Amsterdam, Chapter 9.

The Slave Province in the northwestern part of the Canadian Shield is a sediment-dominated Archaean "granite-greenstone" terrane underlying an area of about 190,000 km^2. Archaean supracrustal rocks were deposited in a 10 to 15 million year period 2670 Ma ago in a series of small fault-bounded basins that formed due to regional extension of the c. 3 Ga old granitic to tonalitic basement. Several examples of basin margin complexes have been preserved in which the relationship between various supracrustal facies and the sialic basement is evident. The sedimentary fill, which forms by far the greatest proportion of the supracrustal rocks, consists almost entirely of greywacke-mudstone turbidites derived from a mixed felsic volcanic and granitic source. Minor fluvial sandstones and conglomerates occur at the fault-basin margins. Mafic volcanics consisting mainly of massive and pillowed flows and intrusions occur sporadically in narrow linear belts also at the margins of basins. Felsic volcanic complexes occur within, at the margins of and between basins and consist mainly of volcaniclastic deposits that were in part terrestrial. Some form of interactions between hypothetical Archaean plates remote to that part of the ensialic crustal segment now preserved as the Slave Province may be an explanation for the short period of province-wide extension that resulted in the formation of graben-like basins in which the supracrustal rocks were deposited.

Henderson, J.R.

STRUCTURAL ANALYSIS OF SHEATH FOLDS WITH HORIZONTAL X-AXES, NORTHEAST CANADA; Journal of Structural Geology, v. 3, no. 3, p. 203-210, 1981.

Early Proterozoic supracrustal rocks occur below a thick nappe of Archean basement gneiss in the Melville Peninsula where sheath folds are exposed in a wide zone of middle Proterozoic dynamothermal metamorphism. Outcrop patterns of truncated isoclinal sheath folds resemble cylindrical folds except in relatively small areas around the parabolodial caps. Bulk extension axes are parallel to strike in the belt as shown by isoclinal sheath folds with horizontal central axes (X-axes), as well as similarly aligned mullion structure and rotated scapolite prisms. Extension axes converge from northeast to southwest in the apparent flow direction.

Hoffman, P.F.

SHINGLED CRUST IN WOPMAY OROGEN: A PRODUCT OF SIMULTANEOUS THRUSTING AND CONJUGATE TRANSCURRENT FAULTING DURING THE TERMINAL CONTINENTAL COLLISION OF EARLY PROTEROZOIC AGE IN THE BEAR PROVINCE OF THE CANADIAN SHIELD; Geological Association of Canada, Annual Meeting 1981, Abstracts, v. 6, p. A-26, 1981.

Survey of Canada, 588 Booth St., Ottawa, Ontario, K1A 0E4 North-central Wopmay Orogen is broken into overlapping crustal shingles, about 70 km wide, bounded by a network of conjugate transcurrent faults and west-dipping thrusts. The shingle structure post-dates thin-skinned thrusts, metamorphism and plutonism related to a distinctly earlier 1.90 Ga collision. It also post-dates the 1.87 Ga Great Bear continental arc and represents the youngest compressional event in the orogen. Convergence of 9 km can be documented between shingles A and B (see figure) and differential depths of erosion of at least 2-3 km are indicated by metamorphic pressure data. Thrusting appears to be localized where zones of NE-dextral and NW-sinistral faulting meet. Backsliding on the thrusts during post-orogenic extensional tectonism probably produced the graben-like U-bearing basins of Hornby Bay sandstone. Shingle structure, a type of "flake tectonics", is forming today on a larger scale in south-central Asia. Superficially similar fault patterns occur in the Mt. Isa Orogen (Australia) and the Hoggar Shield (NW Africa).

Hood, P.J.

MINERAL EXPLORATION: TRENDS AND DEVELOPMENTS IN 1980; Canadian Mining Journal, v. 102, no. 1, p. 22-60, 1981.

This article reviewed the following topics for the year 1980:

1. General state of mineral exploration business for 1980.
2. Worldwide average costs for airborne geophysical surveys during the period 1974-1980.
3. New capabilities of the airborne geophysical contractors and notable airborne surveys that they carried out in 1980.
4. New commercially-available airborne geophysical instrumentation including data processing and compilation systems.
5. New commercially-available ground geophysical and geochemical instrumentation including new services offered.

In the 1980 review, the characteristics of commercially-available ground scintillation counters and spectrometers were also tabulated.

Hood, P.J.

AEROMAGNETIC GRADIOMETRY: A SUPERIOR GEOLOGICAL MAPPING TOOL FOR MINERAL EXPLORATION PROGRAMS; in SQUID Applications to Geophysics, ed. H. Weinstock and W.C. Overton, Society of Exploration Geophysicists, p. 72-77.

Interest by GSC personnel in aeromagnetic gradiometry dates from the early 1960's when the advent of optical

absorption magnetometers with their much higher sensitivity compared to proton precession magnetometers, made useful gradient measurements feasible. In 1973 it was decided to commence the fabrication of an inboard vertical gradiometer system on the GSC Queenair aeromagnetic survey aircraft. This decision was supported by a theoretical study that demonstrated that the gradients produced by igneous rock formations were measurable by a short base (2m) gradiometer with a 0.01 gamma sensitivity. Considerable effort was subsequently spent on the design and fabrication of the gradiometer system and in devising an automated technique to compile the resultant digital data into map form. In the past 4 years about 20 surveys amounting to some 40,000 line miles, have been carried out in a variety of Precambrian terranes and these demonstrate the improved capability e.g. superior resolution of the gradiometer technique over single sensor surveys. It is abundantly clear that for magnetic surveying applications, the main usefulness of SQUID devices will be in gradiometer configurations.

Iannelli, T.R. and **Jackson, G.D.**

EVOLUTION OF THE LATE PROTEROZOIC BORDEN RIFT BASIN (AULAOCGEN?), NORTHERN BAFFIN ISLAND; Geological Association of Canada, Annual Meeting 1981, Abstracts, v. 6, p. A-28, 1981.

Northern Baffin Island was the site of a late Proterozoic rift basin which received up to 6 km of fluvial to shallow marine sedimentary and volcanic rocks. Its history can be outlined in related stages of structural evolution and sedimentation. The initial Rifting stage was characterized by faulting and deposition of quartzarenites, siltstones, shales, conglomerates and basalt extrusion. Major paleo-currents were directed towards the west and northwest, parallel to the basin axis. This phase was succeeded by a more widespread, semi-stable Downwarping stage during which carbonates eventually extended beyond the trough margins. Tectonic activity resumed in the Collapse stage, when thick redbeds, greywackes, conglomerates and minor carbonates accumulated. Paleocurrents of this stage include southeast directed trends indicating possible flow reversal.

The style of basin evolution can be related to the formation of a mantle plume beneath a continental plate. Doming and extension of the crust caused initial basin formation, sedimentation, volcanism and tectonism (Rifting stage). As the heat source was reduced or removed, there was a relaxation and sagging of the crust (Downwarping stage). Progressive sagging resulted in the collapse of the crustal blocks beneath the basin (Collapse stage), causing mild compression and renewed tectonism. The evolution of the Borden Basin may have been associated with a 1.2 Ga ocean opening event that also influenced the deposition of other late Proterozoic sequences in Arctic Canada and Greenland.

Jansa, L.F.

STORM-DOMINATED SHALLOW MARINE DEPOSITS: THE FERNIE-KOOTENAY (JURASSIC) TRANSITION, SOUTHERN ROCKY MOUNTAINS: DISCUSSION; Canadian Journal of Earth Sciences, v. 18, p. 665-666, 1981.

Jansa, L.F.

MESOZOIC CARBONATE PLATFORMS AND BANKS OF THE EASTERN NORTH AMERICAN MARGIN; in Carbonate Platforms of the Passive-Type Continental Margins, Present and Past, ed. M.B. Cita and W.B.F. Ryan, Marine Geology, v. 44, p. 97-117, 1981.

The Jurassic–Lower Cretaceous carbonate platforms and banks form a discontinuous belt extending over distance of 6000 km from the Grand Banks up to the Bahamas. Six types of carbonate buildups are recognized and document the variability of depositional, paleo-oceanographic and tectonic processes on the eastern North American margin. The composition of the carbonates closely resembles the Recent deposits of the western Great Bahama Bank since oolitic shoals were present near to the shelf edge, and skeletal, peloid wackestones and biomicrites were deposited in the inner part of the platform. Coral-stromatoporoid and sponge bioherms were only rare constituents of the carbonate banks.

The thickness of carbonate buildups progressively increases southward along the margin, attaining a thickness of more than 5 km on the Bahamas. The carbonate platforms also become younger southwards, which is thought to reflect the northward movement of the North American plate of less than 1.5 cm/yr. The carbonate platforms were seeded over the continental basement following the taphrogenic period of plate tectonics.

Building of carbonate ramps which characterized the Early Jurassic, has began during the transitional period between continental rifting and early drift. The second stage in construction of the carbonate platforms and offshore banks proceeded mainly after separation of the continental plates.

Schlee, J.S., and **Jansa, L.F.**

THE PALEOENVIRONMENT AND DEVELOPMENT OF THE EASTERN NORTH AMERICAN CONTINENTAL MARGIN; Oceanologica Acta, Proceedings 26th International Geological Congress, Geology of Continental margins symposium, Paris, July 7-17, 1980, p. 71-80, 1981.

Geophysical studies (multichannel seismic reflection profiles, gravity and magnetic surveys) have been combined with drill hole data so that the major structural elements of the eastern North American continental margin and the seismic stratigraphy of the offshore sedimentary prism can be outlined. The sedimentary basins, trough and platforms are built over a zone of rifted and thinned crust of variable width (20-300 km). Upper Paleozoic and Triassic-Lower Jurassic red beds were deposited in northeast trending grabens that formed prior to or synchronous with rifting (pre- and synrift). During the last synrift phase, Upper Triassic and Lower Jurassic evaporitic sequences were precipitated in a southward encroaching Tethyan seaway. Studies of drill cores on the present shelf indicate that major marine incursions occurred during the Early and Late Middle Jurassic and culminated in the buildup of a series of carbonate platforms and banks that continued to flourish into the Albian on the Eastern Blake Plateau. Off the eastern United States, these banks appear to have formed in the vicinity of the ocean-continent boundary, and may have been associated with secondary volcanic dikes and sills which were emplaced 20-30 m.y. after continental separation. Influxes of terrigenous detritus during the Early to middle Cretaceous broadly prograded the margin as deltaic and mixed inner shelf and nonmarine deposits. A series of marine transgressions in the Late Cretaceous and early Tertiary changed the shelf to a deep-water setting and resulted in the deposition of chalks and marly shale. Major marine regressions in the Oligocene, Miocene and Quaternary contributed to periodic cutback of shelf and slope, exposure of Cretaceous and lower Tertiary strata in submarine canyons, accentuation of the shelf-slope-rise profile, and construction of a broad sedimentary prism beneath the continental rise.

La combinaison des études géophysiques (sismique réflexion multitrace, levés gravimétriques et magnétiques) avec les données des forages permettent de définir les traits structuraux majeurs de la marge continentale du nord-est de l'Amérique et la stratigraphie sismique des dépôts

sédimentaires. Les bassins sédimentaires, fosse et plates-formes, se sont développés sur une zone de rift de largeur variable (20-300 km) où la croûte est amincie. Les couches rouges du Paélozoique supérieur et du Trias-Jurassique inférieur se sont déposées dans des grabens d'orientation NE-SW, crées avant ou pendant la formation du rift. Durant la dernière phase syn-rift, des évaporites du Trias supérieur-Jurassique inférieur ont été précipitées dans un bras de mer, prolongement SW de la Tethys. L'étude des forages effectués sur le plateau continental actuel montre que les principales incursions marines ont eu lieu durant le Jurassique inférieur et moyen tardif, et ont culminé avec le développement de plates-formes et bancs carbonatés qui ont continué à se développer jusqu'à l'Albien sur la partie orientale du plateau de Blake. A l'est des Etats-Unis, ces bancs semblent s'être formés au voisinage de la limite continent-océan, et peuvent avoir été associés avec la mise en place de dikes et sills volcaniques secondaires, 20 à 30 millions d'années après la séparation des continents. La marge a ensuite progradé sous forme de dépôts deltaiques et de plate-forme interne intercalés avec des dépôts non marins, grâce à des apports terrigènes durant le Crétacé inférieur et moyen. Une série de transgressions marines durant le Crétacé supérieur et le Tertiaire inférieur ont fait évoluer la plate-forme vers un milieu plus profond où se sont déposées des craies et des argiles marneuses. Les régressions marines majeures de l'Oligocène, de Miocène et du Quaternaire, ont causé des érosions périodiques du plateau et de la pente, la mise à l'affleurement des couches du Crétacé et du Tertiaire inférieur dans les canyons sous-marins, l'accentuation du profil plateau-pente-glacis et la construction de larges prismes sédimentaires sur le glacis continental.

Kamineni, D.C., Dugal, J.B., and **Simandl, J.**

A STUDY OF ROCK ALTERATION OCCURRING IN THE EYE-DASHWA LAKES PLUTON AND ITS SIGNIFICANCE TO RADIOACTIVE WASTE DISPOSAL; Geological Association of Canada, Annual Meeting 1981, Abstracts, v. 6, p. A-30, 1981.

Investigations of drill core samples from the Eye-Dashwa Lakes pluton, Atikokan, Ontario revealed the presence of various types and degrees of alterations within the rock mass. The alteration can be categorized in terms of mesoscopic physical characters, microscopic secondary mineralogy, plagioclase composition, and bulk rock chemistry. Distinct variations in the chemical and some physical properties of the various altered and unaltered rocks indicate that significant changes have occurred in the altered material.

Close association is found between occurrence of alterations and fracturing. Further associations between the type of infilling, fracture type and fracture size with the degree and volume of alteration were also observed.

The distinct physical and chemical characteristics of altered rocks and their close association with faults and fractures illustrate the need to consider alteration as an important parameter in evaluating crystalline rocks for radioactive waste disposal.

Keen, C.E., and Cordsen, A.

CRUSTAL STRUCTURE, SEISMIC STRATIGRAPHY, AND RIFT PROCESSES OF THE CONTINENTAL MARGIN OFF EASTERN CANADA: OCEAN BOTTOM SEISMIC REFRACTION RESULTS OFF NOVA SCOTIA; Canadian Journal of Earth Sciences, v. 18, p. 1523-1538, 1981.

Two crustal seismic refraction profiles were obtained on the continental margin of eastern Canada. These lines were located on the upper continental rise and on the outer continental shelf off Nova Scotia. A large air gun and explosive charges provided the sound sources, and ocean bottom seismometers were used to receive the signals. The travel time data were analyzed using the tau–*p* extremal inversion method and ray tracing techniques. This analysis allowed velocity–depth models to be constructed that included low-velocity zones and velocity gradients, as well as abrupt velocity contrasts at layer interfaces.

The results show that about 7 km of sediments lies beneath the upper continental rise, beneath which oceanic layers 2 and 3 have been identified. Layer interfaces at depths of 0.39, 1.79, and 2.80 km below the sea floor correspond to strong, regional seismic reflectors, perhaps correlative with horizons A^{μ}, A*, and β. The top of oceanic layer 2 is associated with a velocity of 5.3 km s^{-1} and there is no difficulty in distinguishing between basement and high-velocity sediments in this region.

The crust beneath the outer shelf includes 9–16 km of sediments. A layer with compressional wave velocity of 6.3 km s^{-1} constitutes the main crustal layer, below which the mantle is estimated to lie at total depths of 26–30 km. Within the sediments the velocity–depth model for the upper 5 km agrees well with sonic log velocities measured in deep wells. A seismic stratigraphy for the sediments can be deducted by comparing the refraction result with sonic log velocities and with the regional stratigraphy. The total thickness of the mid-Jurassic and older sediments, not sampled in the wells, is at least 4.5 km. The total thickness of crustal rocks of pre-rift age is between 14 and 21 km, which is significantly thinner than the 35–38 km values measured beneath mainland Nova Scotia in earlier studies. Both the thin crust and the high rate of subsidence during the Early Jurassic are consistent with extention of the lithosphere during initial rifting of this margin in Late Triassic time.

Deux profils crustaux de réfraction ont été enregistrés sur la marge continentale du Canada. Ces lignes de relevé étaient localisées sur le glacis continental supérieur et sur la plate-forme continentale externe de la Nouvelle-Ecosse. Les sources sonores provenaient d'un grand canon à air et de charges explosives et les signaux furent captés par des sismomètres pour fonds océaniques. Les données du temps de propagation ont été analysées en utilisant la méthode d'inversion extrémale *p*–tau et les techniques de traçage de rayons. Cette analyse permet d'élaborer des modèles de vitesse en fonction de la profondeur incluant les zones de faible vitesse et les gradients de vitesse, aussi bien que les contrastes brusques de vitesse aux interfaces des couches.

Les résultats démontrent qu'environ 7 km se sédiments repose sous le glacis continental supérieur, sous lesquels les couches océaniques 3 et 3 furent identifiées. Les interfaces des couches aux profondeurs de 0,39, 1,79 et 2,80 km sous le fond marin correspondent à de puissants réflecteurs sismiques régionaux, probablement reliés aux horizons A^{μ}, A* et β. La partie supérieure de la couche océanique 2 est associée à une vitesse de 5,3 km s^{-1} et il est facile de discerner le socle d'avec les sédiments à vitesse élevée dans cette région.

La croûte sous-jacente à la plate-forme externe comprend de 9 à 16 km de sédiments. Une couche caractérisée par une vitesse de 6,3 km s^{-1} inclut la principale couche crustale, sous laquelle la position du manteau est évaluée à une profoundeur de 26 à 30 km. Dans ces sédiments le modèle de vitesse en fonction de la profondeur pour le 5 km supérieur concorde très bien avec les vitesses de diagraphie sonique mesurées dans des puits profonds. Il est possible d'en déduire la stratigraphie en comparant les résultats de la réfraction avec les vitesses de diagraphie sonique et avec la stratigraphie régionale. L'épaisseur totale

des sédiments du Jurassique moyen ou plus anciens, non échantillonnés dans les puits, est d'au moins 4,5 km. L'épaisseur totale des roches crustales d'âge pré-rift se situe entre 14 et 21 km, laquelle est considérablement plus mince que la valeur de 35 à 38 km mesurée sous la Nouvelle-Ecosse continentale rapportée dans les études antérieures. La faible épaisseur de la croûte et le taux rapide de subsidence durant le Jurassique inférieur concordent avec l'expansion de la lithosphère durant la phase initiale de l'effondrement de cette marge à la fin du Triassique.

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

THINNED AND SUBSIDED CONTINENTAL CRUST ON THE RIFTED MARGIN OF EASTERN CANADA: CRUSTAL STRUCTURE, THERMAL EVOLUTION AND SUBSIDENCE HISTORY; Geophysical Journal of Royal Astronomical Society, v. 65, p. 443-465, 1981.

Seismic refraction measurements were carried out using ocean bottom seismometers over foundered continental crust in Orphan Basin and Flemish Pass, on the continental margin north-east of Newfoundland. Tau–*p* travel time inversion, synthetic seismogram analysis and conventional layered model calculations were applied to the data. The results show that these outer regions of the margin are underlain by thinned continental crust, with a total depth to the M discontinuity of about 22 km. There are two main crustal layers with *P*-velocities of about 6.1 and 7.0 km s^{-1} which appear to be homogenous, and separated by sharp interfaces. These are overlain by a layer in which *P*-velocities are about 5.5 km s^{-1}; this is interpreted to be Precambrian or Palaeozoic basement. Mesozoic and Cenozoic sediments cover the basement rocks, and are over 4 km thick.

The results imply that crustal thinning to about 50 per cent of the original crustal thickness occurred. The gravity anomaly data show that the thin crust has a maximum horizontal extent of about 450 km, from the ocean–continent boundary near Orphan Knoll landward to the outer continental shelf. The subsidence history and thermal evolution of the region was computed, assuming that the observed thinning is produced by horizontal extension of the lithosphere. It is suggested that extension can only satisfy the observed crustal structure and elevation of the margin during the rift phase if more extension took place in the lower lithosphere than in the upper lithosphere. The computed subsidence is compared to the observed subsidence and the total amounts of subsidence are similar. However, the shape of the observed subsidence curves measured in deep exploratory wells differs significantly from the predicted subsidence, assuming cooling began when final continental breakup occurred in the Late Cretaceous. The temperature distribution within the lithosphere due to extension may be related to the flexural rigidity of the plate as a function of both time and position across the margin. Therefore, it is suggested that the response of the lithosphere to sediment loading, and the large amplitude of the gravity 'shelf-edge' anomalies are directly related to the thermal history of the region.

Keen, C.E., Loncarevic, B.D. et al.

"PROGRESS REPORT ON LADLE"; Geophysical Journal, v. 65, p. 263, 1981.

The Lesser Antilles Deep Lithosphere Experiment (LADLE) took place in January and February 1980. An array of 18 Ocean Bottom Seismographs (OBS) was deployed for a month along longitude 61°30'W between the approximate latitudes of Bermuda and the Puerto Rico Outer Ridge.

In addition to eleven explosive charges of weight 1-5 tonnes fired in the southern half of the array, 230 other events were recorded by the southernmost eleven OBS. Twenty-nine earthquakes are seen on one or more OBS, accounting for 61 events, and have been located by a network of Antilles Island stations set up for the experiment. The majority have epicentres close to the Puerto Rico Trench, south-west of the LADLE array. Examples of a number of earthquakes from elsewhere also recorded by the OBS will be shown. The combined shot record section will be presented with a preliminary interpretation.

Keen, C.E. et al. (CANDEL)

LITHOPROBE: GEOSCIENCE STUDIES OF THE THIRD DIMENSION – A CO-ORDINATED NATIONAL GEOSCIENCE PROJECT FOR THE 1980s; by Canadian Committee on the Dynamics and Evolution of the Lithosphere (CANDEL); in Geoscience Canada, v. 8, no. 3, p. 117-125, 1981.

Keen, C.E. et al.

PRELIMINARY RESULTS FROM A THERMO-MECHANICAL MODEL FOR THE EVOLUTION OF ATLANTIC-TYPE CONTINENTAL MARGINS; Oceanological Acta, Proceedings 26th International Geological Congress, Geology of continental margins symposium, Paris, July 7-17, 1980, p. 123-128, 1981.

The geodynamic evolution of rifted continental margins is discussed, based on preliminary results from a thermo-mechanical model. This model uses the temperature distribution predicted by extension of the lithosphere during rifting to derive the mechanical properties of the lithosphere which in turn determine its response to loading by sediments and water. The model predicts the evolution of the marginal sedimentary basin, the configuration of the crust-mantle boundary, and the gravity anomalies, all of which result from extension during rifting and from the isostatic response to loading. The properties are described in general terms and are also shown to compare favourable with observational data on the Nova Scotian continental margin.

L'évolution géodynamique des marges continentales en distenion est étudiée à partir des résultats préliminaires d'un modèle thermo-mécaniue. Ce modèle utilise la distribution de température que l'on peut prévoir à partir de l'extension de la lithosphère pendant la distension, pour en déduire les propriétés mécaniques de la lithosphère, qui déterminent alors la réponse à la charge d'eau et de sédiments. Le modèle prédit l'évolution du bassin sédimentaire marginal, la configuration de la limite croûte-manteau, et les anomalies de gravité, à partir de l'extension pendant la distension et de la réponse isostatique au chargement. Les propriétés sont décrites en termes généraux et s'appliquent favorablement aux données de l'observation de la marge continentale de Nouvelle-Écosse.

Keen, C. et al.

A LARGE APERTURE SEISMIC EXPERIMENT; Eos, v. 62, p. 957, 1981.

Large aperture (>10 km) seismic reflection data are required to probe the lower part of the crust on continental margins, deep ocean bains and the ocean-continental margins, deep ocean basins and the ocean-continent boundary. The wide angle reflections and refractions observed during a large aperture experiment will allow detailed determination of the crustal velocity structure and imaging of deep crustal reflection horizons. During a feasability study across the

continental margin of the U.S. East Coast off New Jersey in June, 1981, Lamont-Doherty Geological Observatory, Woods Hole Oceanographic Institution, the Marine Science Institute of the University of Texas, and the Bedford Institute of Oceanography collected ½1300 km of 144-channel, Common Midpoint (CMP) seismic reflection/refraction data with source-receiver separations from 0.3 to 13.5 km every 150 m along the track. Over most of the track the data quality is good to excellent. In this experiment the CSS DAWSON fired air guns alternately with the FRED H. MOORE, which also recorded all shots with its 3.3 km array. R/V OCEANUS steamed behind the MOORE array and recorded all shots with its 2.4 km array. The individual ships navigated with identical Loran-C units and this data, along with shot and recording times, were logged on all ships with DAWSON also recording ranges to MOORE and OCEANUS. This information will allow us to sort all the seismic data into CMP gathers.

Beaumont, C., **Keen, C.E.,** and Boutilier

A COMPARISON OF FORELAND AND ATLANTIC-TYPE BASINS; Sedimentary Basins Symposium, Royal Society of London, Program and Abstracts, June 1981.

A review of the processes contributing to sedimentary basin subsidence suggests that for certain types of basin, basins that form at rifted continental margins and foreland basins, for example, there is a reasonably good understanding of the relative roles played by thermal and mechanical (flexural) deformation of the lithosphere. These roles, which are primarily dependent on the thermal age of the underlying lithosphere, will be illustrated by a comparison of models of the Alberta Foreland Basin and the Nova Scotian margin.

The Alberta Foreland Basin formed in response to mechanical loading of thermally old, cold, thick lithosphere that had large flexural rigidity and wavelength. That the basin has large long wavelength gravity anomalies, reflecting its departure from local isostatic equilibrium, and shows no evidence of an enhanced geothermal gradient during its subsidence, substantiates this mechanical model.

Conversely, the Scotian Basin formed in response to sediment and water loading of a thermally contracting lithosphere. This lithosphere was, for a large part of the basin's history, thermally young, hot and thin, and, consequently, had small flexural rigidity and wavelength. That the basin has only small relatively short wavelength gravity anomalies and exhibits evidence for a greater than normal geothermal gradient during its early history substantiates this predominantly thermal model.

The opening and closing of ocean basins is marked by the super-position of Atlantic-type marginal basins and foreland basins of which the Scotian Basin and Alberta Foreland Basin can be considered mature type examples. The Appalachian Basin, for example, stores evidence of a complex history of plate rifting and collision. Such sedimentary sequences can, however, be understood in terms of super-imposed immature to mature type basins. It is theoretically possible for such sequences to achieve an overall thickness approaching that of continental crust.

Mudie, P., and **Keen, C.E.**

DINOFLAGELLATE CYSTS IN LATER QUATERNARY MARINE SEDIMENTS, EASTERN CANADA; Tenth Annual Arctic Workshop, INSTAAR, Program and Abstracts, p. 42-43, 1981.

Palynological studies of 150 surface sediment samples from the continental margin of Eastern Canad provide the first data on Holocene dinoflagellate cyst species composition and distribution in the Northwest Atlantic and adjacent Subarctic and Arctic regions. Dinoflagellate cyst (= dinocyst) assemblages were examined in a sample grid extending from the Bay of Fundy (43°N) to Scott Inlet (70°N), including coastal, shelf and upper continental slope environments. Thirty-eight species of Quaternary dinocysts have been identified and tentatively related to motile-stage marine dinoflagellate species reported for phytoplankton surveys off E. Canada and W. Greenland. Analysis of the dinocyst distributions shows that there is a strong correlation between cyst assemblage composition and surface water (0-25 m) temperature-salinity characteristics. It appears that most dinocysts are deposited within about 20 km of their area of motile-stage phytoplankton blooms. Q-mode factor analysis shows that three factors account for most of the variation among the dinocyst assemblages. The spatial distribution of these factors corresponds to Cold Temperature, Subarctic and Arctic marine phytogeographic provinces. The surface distribution data form the basis for determining ecological transfer functions which permit quantitative estimates of ocean surface temperature and salinity conditions from dinocyst assemblages in marine sediment cores. Dinocysts appear to be more sensitive indicators of surface ocean water conditions in neritic regions than planktonic or benthonic foraminifera and the organic-walled dinocyst microfossils are less susceptible to fragmentation and dissolution than fossil diatoms.

The interaction of ocean surface water and terrestrial climate during the past 15,000 years can be demonstrated quantitatively by paleoecological analysis of fossil dinocyst and pollen assemblages in cores of marine sediment from Hamilton Inlet, Makkovik and the Central Labrador Shelf, using Q-mode factor analysis of core-top palynomorph data and ecological transfer functions.

Killeen, P.G.

RADIOMETRIC TECHNIQUES FOR URANIUM BOREHOLE LOGGING: A REVIEW OF THE STATE OF THE ART; in "Ideas and Experiences", Australian Society of Exploration Geophysicists Second Biennial Conference, August, Adelaide, South Australia, p. 21-22, 1981.

Radiometric methods for detecting and measuring the amount of uranium intersected in a borehole have come a long way since geiger muller tubes were first used for gamma-ray logging. Advances in the state-of-the-art have led to the present-day availability of both indirect and direct uranium assaying techniques. These include borehole logging with combination gamma-ray probes containing several detectors of different types, gross count gamma-ray logging with scintillation detectors of different sizes and materials (e.g. NaI, CsI, B.G.O.), and gamma-ray spectrometric logging also with these various types of detectors.

Considerable effort has been devoted to improvements in the application and interpretation of gamma-ray spectrometric methods, including instrument development and construction of calibration facilities. One development has been in the application of high resolution solid-state detectors (such as Ge(Li) and hyperpure germanium). Successive improvements in various methods of detector cooling included the use of liquid nitrogen, solid propane, and more recently a pre-cooled copper heat sink. These high resolution detectors afford a passive but direct uranium determination, bridging the gap between indirect passive and direct active techniques.

Active methods which utilize radioactive sources of various types were developed primarily to obtain a direct uranium measurement, overcoming problems of radioactive disequilibrium which are encountered in some geological environments. Delayed fission neutron (DFN) logging tools actively measure the DFN response of a pulsed neutron

source to uranium in the borehole. Methods of utilizing both pulsed 14 MeV neutron generators, and Californium 252 neutron sources have been developed. Prompt fission neutron (PFN) logging tools which measure the epithermal die-away have also been developed. A method utilizing ^{124}Sb-Be photo-neutron sources for direct uranium measurement has also been tested. A direct uranium measurement based upon X-ray fluorescence has been developed and tested both in model holes and in field boreholes. Although the sample volume is small compared to neutron-based methods, the existing source has an energy low enough to be easily shielded, yet high enough to work in water-filled holes and even through plastic casing. Some of these methods have become routine, while others require further development to become practical field-usable techniques.

Developments in data processing and interpretation methods have led to use of digital time series analysis on gamma-ray logs, and the introduction of inverse filters to deconvolve gamma-ray logs in real time. Thus grade distribution is now plotted in the field even with small portable logging systems.

Even though interpretation is aided greatly by computer modeling, the use of model boreholes is necessary for quantitative uranium determination from borehole measurements. Throughout the world the numbers and types of calibration facilities for uranium borehole logging have increased, for use by all of the above-mentioned techniques. The international proliferation of model holes has led to the discovery of some differnces in standarization and reporting methods for uranium in the models. Factors influencing the assignment of grades to calibration models are presently under investigation along with intercalibration measurements to resolve these problems. The current state of these investigations will be reviewed along with an overview of the state-of-the-art of radiometric logging for uranium.

Lambert, M.B.

VOLCANIC HAZARDS: TYPES AND ASSESSMENT OF RISK; Geological Association of Canada, Annual Meeting, 1981, Abstracts, v. 6, p. A-33, 1981.

The possibility of volcanic eruptions in the Cordillera of British Columbia is real and warrants concern. Several volcanoes known to have erupted during post glacial times probably are enjoying a period of dormancy. Volcanoes of the Garibaldi volcanic belt, which represent a continuation of the same episode of volcanism that formed the stratavolcanoes of the High Cascades to the south, are derived from calc-alkaline magmas which characteristically erupt with great violence. The main hazards related to such volcanoes include lava and pyroclastic flows, violent directed blasts, ash falls, avalanches, debris and mud flows, and floods. Assessment of risk in volcanic areas requires a knowledge of the eruptive history of a volcano, the frequency, magnitude and style of eruptions expected, and the extent of areas affected. Geological mapping and careful stratigraphic studies using techniques of tephrochronology are fundamental to determining the status and behavioural patterns of prehistoric volcanoes.

Lee, P.J.

THE MOST PREDICTABLE SURFACE (MPS) MAPPING METHOD IN PETROLEUM EXPLORATION; Bulletin of Canadian Petroleum Geology, v. 29, no. 2, p. 224-240, 1981.

This paper introduces a numerical procedure for displaying facies configuration and the rate of facies change. The procedure is termed the Most Predictable Surface (MPS) mapping method.

The Beaverhill Lake Group and Nisku Formation of the Western Canada Basin were analyzed as examples to demonstrate the use of MPS mapping in subsurface facies analysis. The facies variants of the Beaverhill Lake Group suggest anomalies that would have helped explorationists pinpoint areas for intensive geophysical surveys. The paleotopography of the Nisku Formation outlines areas favourable for the developments of fore-, barrier, or patch reefs. The MPS method could, therefore, have led to geological and geophysical exploration in the areas of interest.

Lewis, C.F.M., and Barrie, J.V.

GEOLOGICAL EVIDENCE OF ICEBERG GROUNDINGS AND RELATED SEAFLOOR PROCESSES IN THE HIBERNIA DISCOVERY AREA OF GRAND BANK, NEWFOUNDLAND; Proceedings of Symposium on Production and Transportation Systems for the Hibernia Discovery, St. John's, Feb. 16-18, 1981.

Interpretation of the northeastern area of Grand Bank seabed based on high resolution seismic reflection profiles; side scan sonar imagery; bottom photography, sample and current metering; and engineering boreholes generally supports the surficial geology model of Fader and King (1981) and shows further evidence that the Hibernia area seabed is subject to iceberg scouring and intermittent sediment transport. Thin discontinuous sand and gravel unconformably overlies Tertiary semiconsolidated siltstone and sandstone. A lag gravel terrace, probably related to late Wisconsin low sea level occurs between 100-110 metres on the northeast Grand Bank margin. Alternating sand bars and lag gravels parallel the slope contours above the terrace. Below it a thin continuous fine sand facies partially buries a degraded relict iceberg furrowed surface. Sand waves, megaripples and wave-induced ripples indicate intermittent sediment transport in shallower water on and above the terrace. The Tertiary unconformity appears to be over-consolidated probably due to erosion, subareal exposure and desiccation during periods of glacial low sea levels.

A sparse population of relatively fresh looking ice scours comprising linear and curvilinear furrows and circular pits occurs throughout the region and is believed to represent the cumulated record of iceberg impacts within the past 10,000 years (Holocene) when late Wisconsin low sea level had risen sufficiently to allow icebergs to drift onto the Bank. Ice scour depths, widths, and ice-related seabed disturbance range from 0 to 6.5 metres, 3 to 124 metres, and 0 to 15% respectively. The extreme value distribution predicts, for example, one scour 2.7 m deep or deeper in a survey line 100 km long between water depths of 100 and 150 metres. Between 140 and 70 metres water depth on the margin of the Bank there is an upslope decrease in scour depths, widths, abundance and seabed disturbance. This is thought to arise as a result of a decrease in iceberg size and flux toward the Grand Bank margin away from the major iceberg source – the main branch of the Labrador current flowing around the northeast corner of Grand Bank. Scour depths may also be limited in shoaler water by the occurrence of the over-consolidated Tertiary unconformity near the seabed surface and by intermittent sedimentary infilling.

Lydon, J.W.

CONTRIBUTED DISCUSSION (P. 101-103) in Goldie, R. and Bottrill, T.G. "Seminar on sea floor hydrothermal systems", Geoscience Canada, v. 8, p. 93-104, 1981.

A comparison of the modern submarine hydrothermal activity and sulphide precipitation on the East Pacific Rise (EPR) at 21°N with the geological characteristics and genetic models of volcanic associated massive sulphide deposits

indicates that there are fundamental differences in the two situations. Both heat flow models and the chemistry of the EPR hydrothermal solutions indicate that the modern situation results from convective hydrothermal flow, whereas the strong stratigraphic control, absence of a sufficient heat source in some examples and the chemistry of the deposits themselves, suggests that hydrothermal flow due to a mechanism akin to seismic pumping is more probable for the ancient ore deposit situation. Other contrasting features between the two situations include the quantity of the sulphide precipitate, textures of the ore minerals and the architecture of the deposits.

MacLean, B., Falconer, R.K.H., and Levy, E.M.

GEOLOGICAL, GEOPHYSICAL AND CHEMICAL EVIDENCE FOR NATURAL SEEPAGE OF PETROLEUM OFF THE NORTHEAST COAST OF BAFFIN ISLAND; Bulletin of Canadian Petroleum Geology, v. 29, no. 1, p. 75-95, 1981.

Chemical, geological and geophysical studies indicate that surface slicks and oil and gas bubbles erupting at the sea surface off northeastern Baffin Island originate from natural seepage of petroleum from the seabed. The continental shelf in this area is cut by two deep submarine troughs that extend seaward from the mouths of the fjords at Scott Inlet and Buchan Gulf. Anomalies in petroleum residue concentrations have been found in the surface microlayer, water column, and unconsolidated sea-floor sediments in both the Scott and Buchan Trough areas. Bedrock samples indicate that the stratigraphic succession includes marine rocks of Late Cretaceous and Tertiary ages. Reflection seismic data indicate that older sedimentary rocks may also be represented. Free-air gravity, seismic and magnetic data suggest a thicker sedimentary section at Scott than at Buchan. The most continuous seep is at the outer part of Scott Trough, where seepage apparently originates with strata flanking a basement high near the south wall. Seepage at other localities may be more sporadic.

Ryall, P.J.C., Fowler, G.A., and **Manchester, K.S.**

AN ELECTRIC ROCK CORE DRILL FOR DEEP OCEAN USE; 13th Annual Offshore Technology Conference, p. 123-128, 1981.

The recovery of accurately located, oriented rock samples from the sea bed and near subsurface in the deep ocean cannot be readily achieved using existing techniques. For operation on the continental shelf (1000 ft. water depth) an underwater electric drill has been developed at the Bedford Institute of Oceanography. The drill, which is powered and controlled from an unanchored surface vessel, is capable of driving a 20-ft. long diamond drill barrel, using a modified screw feed mechanism, into the bottom to take a 1-inch diameter core.

This paper reviews the design of the original drill and its subsequent development for deep ocean work. From its inception the drill has been powered and handled using a two-cable system which severely limited its depth capability. To alleviate this restriction the two-line system has been replaced by a contrahelically armoured triaxial cable. Power is transmitted at 2300 volts while signals from the drill are multiplexed and superimposed on the power lines. In addition the drill rig itself has been redesigned to allow operation on slopes up to 30° which may easily be encountered on oceanic ridges, the primary area of application.

The earlier version of the drill has been used extensively for geological reconnaissance on the shelf off Canada's East Coast. Cores have been recovered from various rock types while operating in a wide range of weather conditions. The new version has been used successfully on the Mid-Atlantic Ridge in June 1980 with core recovered in 10 to 11 attempts in water depths to 800 m. The use of the system will be extended to operating depth of 3500 m within the year.

In addition to bedrock reconnaissance and other scientific sampling the drill should find application in site surveys for projects such as the laying of deep-water pipelines and cables. Other tools, such as the vibrocorer will also be operated on the new power system.

Hughes, O.L., Harington, C.R., Janssens, J.A., **Matthews, J.V.,** Jr., Morlan, R.E., Rutter, N.W., and Schweger, C.E.

UPPER PLEISTOCENE STRATIGRAPHY, PALEOECOLOGY, AND ARCHAEOLOGY OF THE NORTHERN YUKON INTERIOR, EASTERN BERINGIA 1. BONNET PLUME BASIN; Arctic, v. 34, no. 4, p. 329-365, 1981.

New stratigraphic and chronometric data show that Bonnet Plume Basin, in northeastern Yukon Territory, was glaciated in late Wisconsinan time rather than during an earlier advance of Laurentide ice. This conclusion has important ramifications not only for the interpretation of all-time glacial limits farther north along the Richardson Mountains but also for non-glaciated basins in the Porcupine drainage to the northwest. The late Wisconsinan glacial episode in Bonnet Plume Basin is here named the Hungry Creek advance after the principal Quaternary section in the basin. Sediments beneath the till at Hungry Creek have produced well-preserved pollen, plant macrofossils, insects, and a few vertebrate remains. The plant and invertebrate fossils provide a detailed, if temporally restricted, record of a portion of the mid-Wisconsinan interstadial, while the vertebrate fossils include the oldest Yukon specimen of the Yukon wild ass. Some of the mid-Wisconsinan sediments have also yielded distinctive chert flakes that represent either a previously unreported product of natural fracturing or a by-product of stone tool manufacture by human residents of Bonnet Plume Basin.

In addition to presenting new data on these diverse but interrelated topics, this paper serves an an introduction to a series of reports that will treat in turn the Upper Pleistocene record of Bluefish, Old Crow, and Bell basins, respectively.

De nouvelles données stratigraphiques et chronométriques indiquent que le bassin de Bonnet Plume situé au nord-est du Yukon était glaciaire au Wisconsin supérieur plutôt que lors de la crue antérieur de glace laurentienne. Les conséquences entraîne la révision des interprétations des limites glaciaires maximales en bordure des montagnes Richardson plus au nord et en bassin non glaciaire au reseau hydrographique de la Porcupine au nord-ouest. La phase supérieure du Wisconsin dans le bassin de Bonnet Plume est connue ici comme la crue de Hungry Creek, d'après la section quaternaire principale du bassin. Les dépôts sous l'alluvion glaciaire à Hungry Creek ont produit des spécimens fossiles bien préservés de grains de pollen, de plantes, d'insectes et de quelques restes de vertébrés. Les fossiles de plantes et d'invertébrés indiquent, de façon très détaillée mais peu étendu dans le temps, de l'interstade mi-Wisconsin, tandis que les fossiles de vertébrés comprennent le plus vieux spécimen connu au Yukon de l'âne sauvage du Yukon. Certains des sédiments de la phase mi-Wisconsin ont aussi fourni des éclats particuliers de chert qui indiquent soit une formation de fissures non décrites jusqu'ici, soit un sous-produit de la fabrication d'outils de pierre par des résidents humains de bassin de Bonnet Plume. En plus de présenter de nouvelles données sur ces thèmes diversifiés mais connexes, ce texte sert d'introduction

à une série de rapports qui traiteront respectivement du Pléistocène supérieur dans les bassins de la Bluefish, de la Old Crow et de la Bell.

Johnson, W.M., and **Maxwell, J.A.**

ROCK AND MINERAL ANALYSIS; Second Edition, A Wiley-Interscience Publication, John Wiley & Sons, 1981.

This second edition of Rock and Mineral Analysis is, like the first, intended to be a laboratory reference book which will provide the practising analyst with an up-to-date treatment of the problems associated with the analysis of geological materials. The prediction made in the preface to the first edition, that there would be a rapid evolution of methods incorporating instrumental techniques has been realized with, if anything, an acceleration in the anticipated rate of change, and this revision reflects the dramatic developments of the last decade.

The organization of the book has altered but not its attention to details of specific analytical methodology. This revised edition is intended to complement the first edition in that it describes in some detail the instrumental analysis of rocks and minerals (chiefly by atomic absorption spectroscopy (AAS) and X-ray fluorescence spectroscopy (XRF)), whereas the previous emphasis was very largely on the classical "wet" methods. At the same time, however, this edition is intended to be complete in itself and material from the early chapters of the first edition has been included, albeit in a revised and updated form. Special attention has been given to the consideration of new advances in sampling theory, and the discussions of standard reference materials and of sample decomposition techniques have been significantly expanded.

McGregor, D.C.

SPORES AND THE MIDDLE—UPPER DEVONIAN BOUNDARY; Review of Palaeobotany and Palynology, v. 34, p. 25-47, 1981.

The stratigraphic levels most favoured for the Middle—Upper Devonian boundary fall approximately within the range of the ammonoid **Pharciceras lunulicosta** Zone, i.e. from the Middle **varcus** Subzone to the base of the Lower **asymmetricus** Zone of the conodont scale. Spore data that are potentially useful for recognition of the boundary within this range have been correlated with conodont zones in marine facies in the Boulonnais region of France. A vast amount of information on spores from Middle—Upper Devonian boundary strata has accumulated in the European U.S.S.R., where the boundary is taken at a somewhat lower level. Late Givetian and early Frasnian continental strata of Melville Island in the Canadian Arctic contain species present in the Boulonnais or the European U.S.S.R., as well as species common to both regions. **Diatomozonotriletes** spp., **Rhabdosporites langii, Samarisporites triangulatus, Contagisporites optivus, Archaeoperisaccus timanicus, Chelinospora concinna** and **Ancyrospora langii,** among others, may be useful for correlating the boundary as eventually defined. The stratigraphic ranges of most of these taxa show only limited agreement interregionally at present, probably owing at least in part to problems of spore nomenclature and taxonomy, and an insufficiency of spore reference sequences keyed to faunal zones. Nevertheless, individual species of spores, and especially assemblages of species, have much potential for delimiting and correlating the Middle—Upper Devonian boundary in both marine and continental facies.

McLaren, P.

AN INTERPRETATION OF TRENDS IN GRAIN SIZE MEASURES; Journal of Sedimentary Petrology, v. 51, no. 2, p. 611-624, 1981.

The mean grain size, sorting, and skewness of a sedimentary deposit are dependent on the sediment grain size distribution of its source and the sedimentary processes of i) winnowing (erosion), ii) selective deposition of the grain size distribution in transport, and iii) total deposition of the sediment in transport. If a source sediment undergoes erosion, and the resultant sediment in transport is deposited completely, the deposit must be finer, better sorted, and more negatively skewed than the source. This trend is referred to as Case I. The lag remaining after erosion, on the other hand, must be coarser, better sorted, and more positively skewed (Case II). If sediment in transport undergoes selective deposition, the resultant deposit can either be finer (Case IIIA) or coarser Case IIIB) than the source, but the sorting will be better and the skew more positive.

Although exceptions to these trends may occur, they suggest that comparison of one sediment must be made with another for the proper identification of the sedimentary process, and therefore it is not possible for a single grain-size distribution to identify the depositional environment. The trends also suggest that the skewness of a grain-size distribution has been widely misinterpreted and implies neither the truncation of one of the tails nor the mixing of more than one mode. Rather, a skewed sediment is the natural result of the sedimentary process.

In a system of related environments, these trends can be used to identify both the probable source and the probable deposit and, by inference, the net sediment transport paths among sedimentary deposits. Such an analysis provides a rapid understanding of the sedimentary processes, identifies patterns of erosion and accretion, and may suggest transport processes.

McLaren, P.

RIVER AND SUSPENDED SEDIMENT DISCHARGE INTO BYAM CHANNEL, QUEEN ELIZABETH ISLANDS, NORTHWEST TERRITORIES, CANADA; Arctic, v. 34, no. 2, p. 141-146, 1981.

During 1974, a stream from a small drainage basin (117 km^2) on the east coast of Melville Island discharged approximately 1.63×10^7 m^3 water containing 7.08×10^7 kg suspended sediment. Because nearby basins show hydrological similarity, these data can be extrapolated to provide an indication of the total suspended sediment discharge into the adjacent channels. The results suggest that much of this sediment is not deposited in the channels; rather it is incorporated into the active delta fronts or possibly transported out of Byam Channel above a pycnocline.

The values agree well with a hydrological study on nearby Bathurst Island where predicted discharge values for both runoff and suspended sediment are within an order of magnitude of those measured. Recent attention has focussed on the Mecham River which flows into Bridport Inlet, the site of a proposed LNG terminal which is to be situated on an active delta front. Values extrapolated from this study indicate that design criteria must consider typical runoffs of 1.2×20^8 m^3 with peak mean daily discharges in excess of 9.0×10^6 m^3/day and suspended sediment loads of 5.0×10^8 kg/year.

McLaren, P.

COASTAL GEOLOGY AND OIL SPILLS; Episodes, v. 1981, no. 3, 1981.

The catastrophic effects of accidental oil spills warrant scientific concern and coordinated interdisciplinary research on an international scale. Geological input is fundamental, not only in assessing the susceptibility of coastal environments to oil pollution, but in establishing rational contingency plans to cope with potential spills and blow-outs.

McLaren, P., Barrie, W.B., and Sempels, J.M., 1981

GEOMORPHOLOGY – 1980 STUDY RESULTS; (BIOS) Baffin Island Oil Spill Project Working Report 80-7, 200 p., 1981.

Cape Hatt, a small peninsula that protrudes into Eclipse Sound at the north end of Baffin Island is the site for an experimental oil spill to take place in the summer of 1981. Three small bays are required: one as a control; a second to study the effects of oil spilled on the surface and allowed to impinge the shoreline; and a third to use an oil-dispersant mix for comparison with the oil-only experiment.

The chosen site contains at least 13 bays potentially suitable for the experiments. Analyses of data from baseline studies in 1980 has resulted in selection of 3 suitable bays (bays 9, 10 and 11). Geomorphic and sedimentologic criteria indicate that the processes of winds, waves and ice action are greatest in bay 10 and least in bay 11. On the assumptions that cross-contamination must be minimal and longevity of the oil in the environment is desirable to ensure reasonable and measurable detrimental effects, we suggest that bay 10 should be used for control, bay 11 for the oil-dispersant mix and bay 9 for the oil-only experiments.

McMechan, M.E.

THE MIDDLE PROTEROZOIC PURCELL SUPERGROUP IN THE SOUTHWESTERN ROCKY AND SOUTHEASTERN PURCELL MOUNTAINS, BRITISH COLUMBIA AND THE INITIATION OF THE CORDILLERAN MIOGEOCLINE, SOUTHERN CANADA AND ADJACENT UNITED STATES; Bulletin of Canadian Petroleum Geology, v. 29, no. 4, 1981.

Purcell Supergroup strata exposed in the southeastern Purcell and southwestern Rocky Mountains comprise a turbidite sequence (Aldridge Formation) gradationally overlain by shallow water deposits. The lower member of the Kitchener Formation represents a transition from intertidal and shallow subtidal clastic sedimentation in the Creston Formation to the shallow subtidal shelf facies of the upper member. Varicoloured siltite and argillite of the Van Creek Formation mark the return to shallow water clastic sedimentation. They are abruptly overlain by volcanic rocks and shallow water clastic sediments of the Nicol Creek Formation. Stromatolitic dolomite and quartzite of the Sheppard Formation conformably to disconformably overlie the Nicol Creek Formation. The siltite and argillite comprising the Gateway Formation are interpreted as lagoonal deposits. The overlying subaerial quartzites of the Phillips Formation form a north- and westward thinning marker unit. The Roosville Formation, which forms the top of the Purcell succession, has been removed by pre-Devonian erosion over much of the area.

The shallow water deposits comprising the Creston through Phillips Formations can be subdivided into three composite stratigraphic units that are recognized throughout the northern Belt-Purcell basin. Thickness variations in the lower two units outline a northtrending basin margin that is deflected more than 200 km westward near 49°N latitude. The rectilinear shape can be ascribed to deeply rooted block faults developed during continental rifting. This shape governed the later development of a major structural reentrant in the Rocky Mountain thrust and fold belt. Thickness variations in the upper unit record the evolution of epeirogenic structures that apparently controlled the distribution of volcanic rocks within the Belt-Percell basin. A reevaluation of middle and upper Belt-Purcell correlations indicates that the hypothesis of a 'dome' which was supposed to have formd during deposition of the lower Missoula Group was based on incorrect correlation.

McNeil, D.H. and Caldwell, W.G.E.

CRETACEOUS ROCKS AND THEIR FORAMINIFERA IN THE MANITOBA ESCARPMENT; Geological Association of Canada, Special Paper 21, 439 p., 25 plates, 1981.

In the Manitoba escarpment, the Cretaceous System consists of approximately 600 m of sand, clay, shale, various kinds of calcareous shale, and subordinate amounts of limestone, including calcarenite. The current nomenclature of the formations needs considerable revision to take cognizance of the logical and practical divisions of the systemic sequence, the stratigraphic refinement now achievable, and the regional context of the sequence. The divisions to be adopted are, in ascending order, the Swan River Formation: The Ashville Formation, divided into the Skull Creek Shale, Newcastle Sandstone, Westgate (newly proposed), and Belle Fourche Shale Members; the Favel Formation, comprising the Keld and Assinboine Members, which respectively contain the newly named Laurier Limestone Beds and Marco Calcarenite; the Modern Shale; the Niobrara Formation, divided into an informally named calcareous shale member and a chalky member; the Pierre Shale, comprising the Gammon Ferruginous, Pembina, Millwood, and Odanah Members, and an unnamed member; and the Boissevain Formation.

An array of foraminiferal assemblages, some of them the most diverse and rich yet described from Albian to Maestrichtian rocks in any limited segment of the Canadian Western Interior basin, are present in the Manitoba escarpment. Among one hundred and ninety species, representative of eighty-six genera and thirty families, more than ninety have not been recorded hitherto from the Western Interior of Canada. Description and illustration of the Foraminifera is vital to the establishment of a sound biostratigraphic system applicable across the Canadian Great Plains. Application of the Canadian Western Interior foraminiferal zonal scheme to the Cretaceous rocks of the Manitoba escarpment completes eastward extension of the scheme and establishes the presence of ten zones and six subzones; the oldest zone is the Late Albian **Haplophragmoides gigas** Zone, the youngest the Late Campanian **Haplophragmoides fraseri** Zone. The zones are dated in terms of the international stages by integration with the molluscan zones of the Western Interior basin. Ammonite and bivalve collections from the escarpment contain numerous species which are new to Canada but well known from the United States, thus providing important links with the widely accepted ammonite zonal sequence estalished in that country. Where zonal molluscs are lacking, ages may be inferred with varying degrees of certainty by extension of the foraminiferal zones westward into Saskatchewan or southward into the Western Interior of the United States, where many of the zones are clearly expressed in ammonite-bearing sequences.

Dans l'escarpement du Manitoba, le système crétacé comprend environ 600 mètres de sables, d'argilles, de schiste, de schistes calcaires variés, et de quantités moindres de

calcaire, y compris le calcarénite. La nomenclature des formations dans lesquelles ces typés de roches sont couramment inclus a besoin de revue générale afin de mettre à point les divisions logiques et pratiques de la suite, la précision stratigraphique qui est maintenant possible, et la contexte régional de la suite. Les divisions qui seront acceptées sont, en ordre ascendant, la Formation de Swan River; la Formation d'Ashville, qui compte le Schiste de Skull Creek, le Gré de Newcastle, les Membres de Westgate (nouveau) et du Schiste de Belle Fourche; la Formation de Favel, qui compte les Membres de Keld et d'Assiniboine qui contiennent respectivement les Lits de Calcaire de Laurier (nouveau) et le Calcarénite de Marco (nouveau); la Schiste de Morden; la Formation de Niobrara, divisée non-formellement en un membre de schiste calcaire et en un membre crayeux; le Schiste de Pierre, qui comprend les Membres de Gammon Feruginous, de Pembina, de Millwood, et d'Odanah; ainsi qu'un membre sans nom; et la Formation de Boissevain.

Plusieurs assemblages de foraminifères sont présents dans l'escarpement du Manitoba, parmi lesquels se trouvent quelques uns des plus variés et des plus riches décrits jusqu'ici des roches albiennes et maestrichtiennes d'aucune section limitée du bassin de l'Intérieur Ouest du Canada. Des cent quatre-vingt-dix espèces, dont quatre-vingt-six genres et trente familles, plus de quatre-vingt-dix n'ont pas encore été rapportées de l'Intérieur Ouest du Canada. La description et l'illustration de ces foraminifères sont étroitement liées a l'établissement d'un système biostratigraphique qui s'appliquerait partout dans les Grandes Plaines canadiennes. L'application du système zonal de foraminifères de l'Intérieur Ouest du Canada aux roches crétacées de l'escarpement du Manitoba complète l'extension vers l'est de ce système et démontre la présence de dix zones et dix sous-zones; la zone la plus âgée est la zone de **Haplophragmoides gigas** de l'Albien supérieur, et la plus jeune est la Zone de **Haplophragmoides fraseri** du Campanien supérieur. Les zones sont rapportées aux étages internationaux par leur intégration aux zones de mollusques du Bassin de l'Intérieur Ouest. Les collections d'ammonites et de bivalves de l'escarpement comprennent plusieurs espèces nouvelles dans le Canada, mais déjà bien connues aux États-Unis, fournissant ainsi des liens importants avec la séquence zonale américaine d'ammonites déjà bien acceptée. Où des mollusques manquent, les datations peuvent ètre impliquées avec plus ou moins de certitude en rapportant les zones de foraminifères vers l'ouest dans le Saskatchewan, ou vers le sud dans l'Intérieur Ouest américaine où plusieurs de ces zones sont bien exprimées dans des suites contenant des ammonites.

Meijer Drees, N.C. and Mhyr, D.W.

THE UPPER CRETACEOUS MILK RIVER AND LEA PARK FORMATIONS IN SOUTHEASTERN ALBERTA; Bulletin of Canadian petroleum Geology, v. 29, no. 1, p. 42-74, 1981.

An estimated 141.5 billion m^3 (5 trillion ft^3) of recoverable gas are present in the subsurface of southeastern Alberta and southwestern Saskatchewan in the Upper Cretaceous Lea Park Formation. The gas is present in a sandy shale unit for which the name Alderson member is proposed. The Alderson Member is of shallow-marine origin and is transitional between a sandy, nearshore, foreshore, shore and backshore facies (the Eagle and Milk River Formations) and a marine, offshore shale facies (the Lea Park Formation). The Milk River and Eagle Formations respectively outcrop in southern Alberta and northern and central Montana. The Lea Park shale is widely distributed in the subsurface of central Alberta and southeastern Saskatchewan.

The Alderson Member is about 85 m (280 ft) thick consists of thinly, lenticularly interbedded, bioturbated, silty shale and laminated, in places bioturbated, very fine grained sandstone. The two lithologies form a sedimentological unit which resembles the "parallel laminated to burrowed sets" present in Recent sublittoral sediments.

Good porosity and permeability are restricted to the thin, laminated sandstone beds that form the lower part of the "parallel laminated to burrowed sets," and to thin, lenticular sandstone beds, that are scattered throughout the lower part of the Alderson Member. In the area marginal to the depositional limit of the Virgelle Member of the Milk River Formation, the laminated sandstone beds in the upper part of the Alderson Member increase in number and thickness and comprise up to 30 or 40 per cent of the interval. However, the sandstone beds become progressively more bioturbated toward the top of the member and permeability decreases. Discontinuous zones of partly silicified siderite nodules, pebbles and bentonitic shale beds are present in the Alderson Member.

The southeastern Alberta Milk River Gas Pool and two gas pools in Saskatchewan produce from the Alderson Member on the flanks and crest of the Bow Island Arch. The gas pools occur downdip from a freshwater aquifer (the Virgelle sandstone) which is connected with the present-day Milk River.

Miller, A.R. and **Le Cheminant, A.N.**

URANIUM METALLOGENY OF PROTEROZOIC BASINS, CENTRAL DISTRICT OF KEEWATIN, N.W.T.; Saskatoon Uranium Geology Symposium Sept. 8-12, 1981, CIM Geology Division, Field Tours Booklet, p. 12-13, 1981.

In the Churchill structural province, central District of Keewatin and adjacent areas in the District of Mackenzie, uranium mineralization can be linked to northeasterly trending Proterozoic basins reflecting several different sedimentary and tectonic environments. The oldest Proterozoic basins contain early Aphebian shelf and continental psammitic, pelitic and carbonate-bearing metasediments. Stratabound uranium mineralization within greenschist facies pelitic-psammitic metasediments is associated with the metallic assemblage Cu+Pb+Mo+Fe ± Co ± As.

Dubawnt Group continental sedimentary and volcanic rocks fill structural depressions whose evolution was controlled by late Aphebian to Paleohelikian extension (about 1.9-1.7 Ga). Uranium occurrences have been recognized within each formation of the Dubawnt Group and in crosscutting syenitic and granitic stocks and plutons.

Metals associated with numerous epigenetic fracture-controlled uranium occurrences include: Cu+Pb+Mo ± Ag ± Zn, Cu+Pb, Cu and Cu+Se+Au+Ag. Stratabound epigenetic uranium mineralization within red clastic sequences are associated with Cu+Pb ± Ag and Cu+V. Disseminated syngenetic Th+U+ rare earth element-bearing refractory phases in bostonitic dyke swarms and related stocks crystallized from highly differentiated alkalic magmas. U+Cu mineralization is located in the contact aureole and marginal phases of a composite alkalic pluton. U-Pb isotopic studies of pitchblendes from fracture-controlled and disseminated occurrences yield discordant ages between 1.8-1.7 Ga.

Helikian conglomerate, sandstone and siltstone of the Thelon Formation were deposited in a large complex basin, Thelon Basin, which lies principally to the west and northwest of the older basins. This formation, interpreted to comprise both fluvial and marine facies, rests unconformably on a diverse granitoid intrusive and gneiss complex, Aphebian metasediments and late Aphebian-Paleohelikian sediments and volcanics. Helikian unconformity-type mineralization,

exemplified by the Lone Gull prospect, is characterized by vein and disseminated pitchblende-coffinite within white mica, clay and Mg-chlorite alteration envelopes. Mineralization is localized by major fault zones. In another association, uranium anomalies are present within phosphate-impregnated basement units near the Helikian unconformity and within phosphate-rich Thelon Formation sandstones and conglomerates. The U+P association may result from either continental or marine environments.

Monger, J.W.H. and Price, R.A.

EVOLUTION OF THE CANADIAN CORDILLERA; Geological Association of Canada, Annual Meeting, 1981, Abstracts, v. 6, p. A-40, 1981.

The Canadian Cordillera is a collision orogen formed by accretion of allochthonous terranes to the North American continent by convergent and transform plate motions. The only part of the Cordillera that is identified as always having been in physical continuity with North America is the wedge of sedimentary rock (Miogeocline) in the Rocky Mountain Belt and parts of the Omineca Crystalline Belt. Marine volcanogenic (eugeoclinal) strata form a collage of allochthonous terranes that differ in history and place of origin, but coalesced with one another and the western margins of North America mainly in Mesozoic time. The collage comprises two large composite terranes (I,II) made up of smaller, originally independent elements (E,Q,Cc,St, and W,A) that coalesced prior to emplacement in their present locations, and a number of smaller ones (Br,Ca,Pa,O). I probably accreted to North America between mid-Jurassic and mid-Cretacrous time, and II between Early Cretaceous and early Tertiary time. The Omineca Cyrstalline Belt and Coast Plutonic Complex appear to have formed, at least in part from accretion of I and II as these belts are coincident, respectively, with the boundaries between I and the ancient margin of North America and between I and II, and much of the metamorphism and granitic intrusion in the belts occurred during the time of collisions as deduced from stratigraphic and structural evidence.

Mott, R.J., Anderson, T.W., and **Matthews, J.V., Jr.**

LATE-GLACIAL PALEOENVIRONMENTS OF SITES BORDERING THE CHAMPLAIN SEA BASED ON POLLEN AND MACROFOSSIL EVIDENCE; Quaternary Paleoclimate, ed. W.C. Mahaney, GeoAbstracts, Norwich, England, p. 129-171, 1981.

Organic deposits at two sites in Quebec which bordered the Champlain Sea at different times in the past, namely, 11,050 ± 130 years BP (QU-448) and 10,100 ± 150 years BP (GSC-2200), yielded pollen, seeds, leaves, wood and insect remains that indicate distinctly different palaeoenvironments prevailed at these times. At the older site, in the Quebec City area, a lens of organic debris in sandy shore gravels, possibly a lagoonal environment, accumulated when the sea was at an elevation 144 m above present sea level. Pollen analysis shows an Arctic tundra assemblage dominated by Gramineae, **Oxyria digyna** and **Salix** sp. along with several herbaceous types such as **Senecio congestus, Armeria maritima** and others in lesser amounts. Tree pollen is present in negligible amounts. Leaves of **Dryas integrifolia** are present along with abundant leaves and fruits of **Salix hebacea** and seeds of such Arctic tundra types as **Oxyria digyna, Armeria maritima, Cerastium** cf. **alpinum, Silene acaulis** var. **exscapa,** several species of **Potentilla, Carex** and others. These fossils, plus those of tundra and northern taiga beetles (e.g.; **Amara alpina** Payk., **Pterostichus haematopus** Dej. and **Helophorus arcticus** Brown), suggest a climate considerably colder than at present in the region.

The younger site, near Montreal, is at a much lower elevation (43 m) and the organic debris is associated with marine clays, or reworked marine clays, that were possibly deposited where a stream debouched into the sea. Marine clay with shells underlies the debris layer and non-marine clay with wood overlies it. Tree pollen characterizes the spectrum at this site and only minor amounts of herbaceous pollen are present. **Picea** and **Pinus** pollen are abundant along with a large percentage of **Quercus** and smaller amounts of several other tree genera. **Abies balsamea** wood was found within the debris layer. Needles and seeds of **Picea** cf. **mariana,** needles, cones and seeds of **Larix laricina,** and a fruit of **Betula papyrifera** attest to the proximity of these trees. A variety of seeds refer to shrubs and herbs characteristics of a boreal forest habitat. In addition, fragments of certain weevils and scolytid beetles suggest a coniferous forest, and except for several ground-beetles, most of the fossils represent species that live in the area today. The species that do not are presently found in the Gaspé region or, as in the case of **Amara hyperborea** Dej., across all of Quebec but 200 km north of the site. Thus all the evidence indicates a somewhat colder climate than the present but not nearly as cold as at the other site.

Comparison with pollen profiles from the St. Lawrence lowlands and southern Quebec allows reconstruction of the vegetation and climate of this region in late-glacial times.

Mwenifumbo, C.J.

INTERPRETATION OF MISE-A-LA-MASSE DATA; 51st Annual Society of Exploration Geophysicists, Technical Program and Abstracts, 1981.

The mise-a-la-masse method of electrical prospecting is used when a conductive mineralized zone has already been located. A current electrode is placed directly in the mineralized zone and the resulting potential field is mapped either on the surface or in drillholes. The potential field distribution reflects the size, shape, and orientation of the mineralization. A number of case histories describing the successful application of the mise-a-la-masse technique in base metal exploration have been reported in the literature. Interpretation of field data has, however, been mainly qualitative and has been based on the assumption that a uniformly conductive body, surrounded by a homogeneous resistive host rock, is energized. There has been very little work done to obtain either theoretical or experimental data on the method to aid in interpretation of the field data. The interpretation of mise-a-la-masse data based on analog scale modeling and computer numerical modeling is presented.

Norford, B.S.

REVIEW OF POTENTIAL STRATOTYPE SECTIONS FOR THE CAMBRIAN-ORDOVICIAN BOUNDARY IN CANADA; in Short Papers for the Second International Symposium on the Cambrian System, United States Geological Survey, Open File Report 81-743, p. 152-155, 1981.

Areas of special interest include Mount Wilson and Wilcox Pass, southwestern Alberta; Grey Peak, northeastern British Columbia, the Nahanni Map-area, westernmost Mackenzie; Peel River Canyon, Yukon; Saint John, New Brunswick; and western Newfoundland. The well exposed sections of Broom Point and Cow Head in western Newfoundland contain both indigenous and transported faunas and have excellent potential for the integration of zonal schemes based on graptolites, trilobites and conodonts.

Barnes, C.R., **Norford, B.S.**, and Skevington, D.

THE ORDOVICIAN SYSTEM IN CANADA CORRELATION CHART AND EXPLANATORY TEXT; International Union of Geological Sciences, Publication 8, 1981.

A correlation chart documents and correlates Ordovician rocks within Canada. Biostratigraphic correlations are achieved mainly with conodonts, graptolites and shelly fossils using established international zonal schemes, but difficulties are presented concerning the biostratigraphic and chronostratigraphic classifications. Eighty-eight regional successions illustrate Canadian Ordovician successions, each of these stratigraphic columns is documented by literature references and most are accompanied by explanatory notes.

Norris, D.K.

TRANSFORM, CONTRACTION AND EXTENSION FAULTS IN THE NORTHERN CORDILLERA OF CANADA - THEIR SPATIAL AND TEMPORAL RELATIONSHIPS SINCE MID-CRETACIOUS TIME; Cordilleran Section, Geological Association of Canada, Programme and Abstracts, p. 29, 1981.

The northern Cordillera of Canada comprises that segment of the Cordilleran Orogen north of Latitude 60°N and east of the 141st Meridian. Transform, contraction and extension zones, trending from northwest to northeast, have all played major roles in the tectonic evolution of the region since mid-Cretaceous time. Key zones include the Omineca Belt, Fraser-Tintina-Kobuk System, Rapid Depression, Kaltag Fault, Brooks Range Thrust Belt, and Denali and Fairweather Faults. Collectively they contain progressive spatial and temporal relationships important to the understanding of the allochthonous, compressed and extended terranes of the orogen from northern California to western Alaska.

More than 175 km of telescoping on contraction faults in the Omineca Belt took place in the mid-Cretaceous. It was followed by up to 190 km of dextral slip in the Fraser-Tintina-Kobuk System in the early Late Cretaceous with concurrent extension in the Rapid Depression. In the Paleocene, horizontal displacement on the Kaltag Fault offset the Fraser-Tintina-Kobuk System by about 100 km in conjunction with regional, systematic, right and left hand en echelon folding in the Mackenzie and Ogilvie Mountains, and generation of the Romanzof Orocline. The Kobuk segment was rendered inactive. Contemporaneously, the eastern Cordillera of southern Canada was telescoped up to 200 km on major contraction faults. In the Eocene and Oligocene more than 250 km of dextral slip took place on the new Fraser-Tintina-Kaltag System in conjunction with extension in the southeastern Cordillera of Canada and, at about the same time, with large scale contraction faulting in the Brooks Range Thrust Belt. The general progression of transfer of dextral slip from east to west, that is from an older to younger transform zone, continued with activation of the Denali Fault and horizontal displacement of an estimated 350 km in the Eocene, and an additional 40 km since that time. More than 100 km of dextral slip has taken place on the Fairweather Fault System, the outermost dextral transform zone in the northern Cordillera, during the past 10 Ma. On structural and stratigraphic grounds, therefore, on the order of 1000 km of dextral slip can be accounted for altogether along the western margin of the North American Plate, far short of that implied from paleomagnetic evidence.

Data on timing of faulting in support of the above displacement arguments suggest alteration in direction of compression from north to northeast with a half-period of between 20 and 30 Ma since the mid-Cretaceous which may be explained by systematic variations in obliquity of subduction beneath the curvilinear margin of the North American Plate and/or variations in rate of relative motion of the North American and Pacific Plates. There were corresponding changes in direction of transform, contraction and extension faulting.

Norris, D.K.

STRUCTURAL EVOLUTION OF THE CORDILLERAN FOLDBELT AND FORELAND OF NORTHERN CANADA AND ITS RELATION TO HYDROCARBON MATURATION AND ENTRAPMENT; Third International Symposium on Arctic Geology, Canadian Society of Petroleum Geologists, p. 96, 1981.

Norris, D.K. and **Yorath, C.J.**

THE NORTH AMERICAN PLATE FROM THE ARCTIC ARCHIPELAGO TO THE ROMANZOF MOUNTAINS; in Volume 5, The Arctic Ocean of the Ocean Basins and Margins, ed. A.E.M. Nairn et al., Plenum Press, Chapter 3, 1981.

Nowland, G.S.

STRATIGRAPHY AND CONODONT FAUNAS OF THE LOWER AND MIDDLE ORDOVICIAN ROMAINE AND MINGAN FORMATIONS, MINGAN ISLANDS, QUEBEC; Maritime Sediments and Atlantic Geology, v. 17, p. 67, 1981.

Nowlan, G.S.

LATE ORDOVICIAN CONODONTS FROM THE GASPE PENINSULA, QUEBEC; Geological Society of America, Abstracts with Program, v. 13, p. 311, 1981.

Thick sections of Upper Ordovician sediments have been collected for conodonts from the eastern, central and western part of the southern Gaspé Peninsula. In the east the White Head Formation (750 m) is exposed. The lower part (360 m) comprises thin bedded calcilutite and shale and 43 of 50 samples have yielded about 2,000 conodont elements. The fauna is dominated by **Amorphognathus ordovicicus, Gamachignathus ensifer, Oulodus rohneri, Phragmodus undatus** and simple cone taxa. The fauna is similar to that known from the Late Ordovician upper Vauréal and lower Ellis Bay formations of Anticosti Island. This unit is overlain by a unit of mudstone (28 m) which is devoid of conodonts but bears a Hirnantian brachiopod fauna. This occurrence, together with conodont evidence from Anticosti and Gaspé provides correlation between European and North American Midcontinent sequences in the Late Ordovician. The upper part of the White Head is of Llandovery age.

The Matapedia Group has been collected in the central and western parts of the southern Gaspé Peninsula. It is thin (110 m) in some central sections (these are devoid of conodonts) but may be as much as 3,000 m thick. In the Matapedia Valley the group is complexly deformed and compilation of a stratigraphic section is difficult; it comprises alternating calcareous siltstone and mudstone with shale and rare limestone. Conodonts have been obtained from 27 of 129 samples and the most common taxa (in order of decreasing abundance) are: **Aphelognathus** spp., **Gamachignathus ensifer, Panderodus** spp., **A. ordovicicus**?, **Icriodella superba** and **Periodon** sp. The fauna is of mixed

provincial aspect in contrast to the midcontinent fauna of the White Head, but is of similar Late Ordovician, Ashgill age based upon **G. ensifer.**

Nowlan, G.S.

LATE ORDOVICIAN - EARLY SILURIAN CONODONT BIOSTRATIGRAPHY OF THE GASPÉ PENINSULA - A PRELIMINARY REPORT; Subcommission on Silurian Stratigraphy, Ordovician-Silurian Boundary Working Group. Field Meeting, Anticosti-Gaspé, Québec 1981, Vol. II: Stratigraphy and Paleontology, ed. P.J. Lespérance, p. 257-291, 1981.

Examination of over 6,000 conodont specimens from 310 samples of Upper Ordovician and Lower Silurian strata of the Gaspé Peninsula has resulted in the recognition of several previously established conodont faunas and zones. The apparently deep-water sediments of the Matapedia Group and the more 'platformal' sediments of the Chaleurs Group have been collected.

The Matapedia Group in its type area is of almost entirely Late Ordovician age, bearing conodont elements assignable to Fauna 13 as well as some species previously known only from the North Atlantic Province. No Silurian conodonts have been recovered from the Matapedia Group in its type area. The White Head Formation at Percé is regarded as part of the Matapedia Group and contains elements of Fauna 12 at its base; these are succeeded by components of Fauna 13 including **Gamachignathus ensifer** which range up to the base of a mudstone unit bearing a typical Hirnantian fauna. Thus a broad correlation is effected between late Ashgill strata of Europe and Late Ordovician strata of North America. The upper part of the White Head Formation yields only sparsely but the faunas recovered indicate an early to late (C_5) Llandovery age. Conodonts are absent from the interval spanning the Ordovician - Silurian boundary.

The Clemville Formation at the base of the Chaleurs Group contains a Llandovery A brachiopod fauna and has also yielded a rich conodont fauna. Elements of the lowest Silurian **Oulodus? nathani** Zone of Anticosti Island are present together with forms assignable to the **Icriodella discreta - I. deflecta** Assemblage Zone of Britain. The overlying Weir Formation yields **I. deflecta** and forms assignable to **I.** aff. **I. malvernensis** suggestive of a Fronian (C_{1-2}) age. Collections from the middle part of the succeeding Anse Cascon Formation contain specimens assignable to **Icriodella inconstans** and **Ozarkodina gulletensis?** which indicate a Telychian (C_5) age, correlation with the **Icriodella inconstans** Assemblage Zone of Britain and approximately with the **Pterospathodus celloni** Zone as recognized in Europe and North America. Diverse conodont faunas from the overlying Anse à Pierre-Loiselle Formation include **Apsidognathus tuberculatus** and **Pterospathodus pennatus** indicative of a late Llandovery (Telychian, C_{5-6}) age. Elements of **Pterospathodus amorphognathoides** occur in the lower part of the La Vieille Formation; this zonal indicator spans the Llandovery - Wenlock boundary. Samples from the upper part of the La Vieille Yield **Ozarkodina confluens** indicating a Wenlock or younger age. The overlying Gascons Formation was not examined but megafossils indicate a Ludlow age suggesting circumstantially that the upper part of the La Vieille may be confined to Wenlock. The Llandovery - Wenlock boundary lies within the La Vieille Formation but cannot be defined accurately on the basis of conodonts at present.

Grâce à l'examen de plus de 6,000 spécimens de conodontes provenant de 310 échantillons prélevés dans des strates de l'Ordovicien supérieur et du Silurien inférieur de la péninsule de Gaspé, on a identifié plusieurs faunes de conodontes et zones à conodontes déjà établies. On a aussi recueilli des échantillons de sédiments du groupe de Matapédia, apparemment formés en eau profonde, et de sédiments du groupe de Chaleurs Bay, plus typiques d'une plate-forme.

Dans sa région-type, la groupe de Matapédia date presque entièrement de l'Ordovicien supérieur, et contient des éléments de conodontes attribuables à la faune 13, ainsi que certaines espèces jusque là seulement connues par des spécimens de la province Nord-Atlantique. Dans la région-type du groupe de Matapédia, on n'a encore recueilli aucun conodonte silurien appartenant à ce groupe. A Percé, la formation de White Head, considérée comme une partie du groupe de Matapédia, contient à sa base des éléments de la faune 12; ceux-ci sont suivis d'éléments de la faune 13, en particulier **Gamachignathus ensifer,** qui atteint la base d'une unité à mudstones contenant une faune hirnantienne (Hirnantian) typique. Ainsi, on peut établir une corrélation sommaire entre les strates de l'Ashgillien supérieur en Europe, et les strates de l'Ordovicien Supérieur en Amérique du Nord. Quant à la portion supérieure de la formation de White Head, les fossiles n'y sont pas abondants, mais les faunes que l'on y a trouvées permettent de la placer dans le Llandovérien inférieur à supérieur (C_5). Les conodontes sont absents de l'intervalle qui couvre la limite entre l'Ordovicien et le Silurien.

A la base du groupe de Chaleurs Bay, la formation de Clemville contient une faune de brachiopodes du Llandovérien A et a aussi fourni une riche faune de conodontes. On y trouve des éléments de la zone à **Oulodus? nathani,** de l'étage le plus bas du Silurien, sur l'île d'Anticosti, en même temps que des formes attribuables à la zone caractérisée par l'assemblage **Icriodella discreta-I. deflecta** en Grande-Bretagne. La formation sous-jacente de Weir a fourni **I. deflecta** et des formes attribuables à **I.** aff. **I. malvernensis;** elle correspondrait donc au Fronien (C_{1-2}). Parmi les spécimens recueillis dans la partie médiane de la formation sous-jacente d'Anse Cascon, on trouve des spécimens attribuables à **Icriodella inconstans** et **Ozarkodina gulletensis**? qui correspondent au Télychien (C_5), et indiquent une corrélation avec la zone britannique caractérisée par l'essemblage à **Icriodella inconstans,** et approximativement, avec la zone à **Pterospathodus celloni,** telle qu'identifiée en Europe et en Amérique du Nord. Diverses faunes de conodontes de la formation sous-jacente d'Anse à Pierre-Loiselle contiennent **Apsidognathus tuberculatus** et **Pterospathodus pennatus;** cette formation correspond donc au Llandovérien supérieur (Telychien, C_{5-6}). Dans la partie inférieure de la Formation de la Vieille, on rencontre des éléments de **Pterospathodus amorphognathoides:** cet indicateur zonal couvre la limite du Llandovérien-Wenlockien. Des échantillons de la portion supérieure de la Formation de la Vieille contenaient **Ozarkodina confluens,** ce qui indiquerait une appartenance au Wenlockien ou à un étage plus récent. On n'a pas examiné la formation sous-jacente de Gascons, mais des mégafossiles indiquant le Ludlowien suggèrent incidemment que la partie supérieure de la Formation de la Vieille pourrait bien se limiter au Wenlockien. La limite entre le Llandoverien et le Wenlockien se situe dans la Formation de la Vieille, mais ne peut encore être définie avec précision d'après l'étude des conodontes.

Okulitch, A.V.

THE SHUSWAP METAMORPHIC COMPLEX: ITS ROLE IN CORDILLERAN TECTONISM; Geological Association of Canada, Annual Meeting 1981, Abstracts, v. 6, p. A-44, 1981.

The Shuswap Complex consists of three terranes, each with unique stratigraphy and orogenic evolution, separated by major faults of diverse nature and having in common only a post-late Mesozoic tectonic history. The Monashee Terrane, exposed in the domal nappes of Frenchman Cap and Thor-Odin, is a para-autochthonous part of the North American craton which contains limited evidence of Mesozoic orogenesis and which was rapidly uplifted during the Paleogene. The Monashee Decollement, a warped mylonite zone interpreted as a regional thrust fault active through the Middle Jurassic to Late Cretaceous, separates this terrane from the Shuswap Terrane which is equivalent to the late Proterozoic to early Mesozoic Kootenay Arc and Cariboo Mtns. fold belt. The Okanagan Terrane, straddling the 49th parallel from the Okanagan Valley to the Kootenay Arc, contains the exhumed roots of a Mesozoic magmatic arc built upon North American continental and transitional crust that includes obducted(?) late Paleozoic exotic assemblages. The Eastern Cordillera is best viewed as an Alpine orogen formed by westward drift of North America into a continent of accreted elements. Response of continental crust, attenuated during two episodes of Proterozoic rifting, and its bordering sedimentary prism to westward underthrusting of the craton and simultaneous collision with an accreted collage of continental mass, was first to restore attenuated crust to about its original configuration while deforming westernmost parts of the bordering prism (Jurassic events in the Shuswap and Okanagan Terranes) and second to thrust restored crust, the deformed prism and platformal strataeastward (Late Cretaceous-Paleocene movement of the three terranes and formation of the foreland fold and thrust belt). Reduction of westward underthrusting led to ascendancy of transcurrent faulting in response to northward drift of the Pacific plate, crustal extension primarily in the Okanagan Terrane and final (10 km?) uplift of cratonic massifs.

Orchard, M.J.

UPPER PALEOZOIC CONODONT DISTRIBUTION IN THE CANADIAN WESTERN CORDILLERA: A SYNOPSIS; Geological Association of Canada, Annual Meeting 1981, Abstracts, v. 6, p. A-45, 1981.

Carboniferous and Permian conodonts are widespread in the Canadian Western Cordillera and provide a means of dating and correlating strongly disrupted and frequently metamorphosed rock sequences. Mississippian records are mostly confined to eastern areas: Kinderhookian **Siphonodella** -, Osagian **Eotaphrus** -, Visean **Mestognathus** and Chesterian **Gnathodus** - bearing faunas are conspicuous; in North America **Mestognathus** has only previously been recorded from Nova Scotia. Early Pennsylvanian **Idiognathodus** and **Idiognathoides** - bearing faunas have been recovered from the Whitehorse Trough and from the Cariboo region. Mid-late Pennsylvanian conodonts from the latter area include distinctive species of **Neognathodus, Gondolella** and **Streptognathodus,** some of which occur within limestones in the Cache Creek Terrane. **Idiognathodus** and **Gondolella** are also known from western coastal regions. Early and late Permian conodont faunas from Cache Creek are generally dominated by **Gondolella.** Early Permian conodont from Kamloops include **Hindeodus, Diplognathodus, Sweetognathus,** rare **Gondollella** and, unexpectedly, **'Adetognathus';** almost identical faunas have also been found in the Chilliwack Group. Younger Permian **Neostreptognathodus** faunas are widespread in 'Stikinia' and occur also in the St. Elias Mountains. The youngest Permian conodonts may occur as a reworked constituent in an early Triassic fauna from Marble Canyon, near Cache Creek.

Percival, J.A.

REGIONAL VARIATION OF METAMORPHIC CONDITIONS IN ARCHEAN GRANULITES OF THE KAPUSKASING STRUCTURAL ZONE, ONTARIO; Geological Association of Canada, Mineralogical Association of Canada, Canadian Geophysical Union, Abstracts, v. 6, p. A-46, 1981.

The Kapuskasing structural zone is characterized by high-pressure granulite mineralogy in mafic rocks (garnet(GT)- clinopyroxene(CPX)- hornblende(HB)-plagioclase(PG)- quartz(QZ)- tonalite veinlets(TON) ±orthopyroxene(OPX)); paragneiss is GT-biotite(BT)-PG-QZ-TON ± K-feldspar; dioritic gneiss is HB-BT-PG-QZ ± OPX ± CPX ± TON and anorthositic rocks are HB-PG ± GT ± OPX ± CPX. OPX is present in three discrete zones up to 2 x 25 km.

Paleotemperature, pressure and water activity were determined at 60 locations within a 3000 km^2 area. T estimates by Fe-Mg partitioning between GT-CPX (Ellis-Green calibration) are generally ~700°C in agreement with the inferred presence of partial melts (TON) and are within 20°C of GT-BT (Ferry-Spear calibration) estimates for the same rock. Combined results indicate thermal maxima of >800°C superimposed on 700°C isotherms with minima in the 600°C range. GT-OPX, GT-PG-QZ-sillimanite and anorthite-tschermakite-QZ barometry indicate that total P was in the 4-10 kb range. A 6 kb isobar separates the SW corner of the zone from the remainder. Water activity, determined on GT-CPX-HB-PG-QZ assemblages to be in the 0.1-0.7 range, shows no regular variation on the regional scale.

High-T isotherms do not generally coincide with OPX zones and an apparent thermal low (<650°C) in migmatitic rocks must reflect retrograde Fe-Mg exchange in thermometers. Anhydrous and anatectic layers in gneiss are folded and P-T indicator pairs may thus record post-folding rather than peak metamorphic conditions.

Percival, J.A. and Coe, K.

PARALLEL EVOLUTION OF ARCHAEAN LOW- AND HIGH-GRADE TERRANE: A VIEW BASED ON RELATIONSHIPS BETWEEN THE ABITIBI, WAWA AND KAPUSKASING BELTS; Precambrian Research, v. 14, p. 315-331.

The Kapuskasing structural zone (KSZ) is a region of high-grade Archaean gneiss transverse to the regional east—west structural trends of the adjacent lower-grade Abitibi, Wawa and Quetico belts. The structural zone is made up of granulite and amphibolite facies paragneiss, tonalitic gneiss and anorthosite-suite gneiss, whereas adjacent regions are metavolcanic—metasedimentary belts, with gneissic and plutonic components. Foliations in the KSZ strike northeast and dip moderately northwest. To account for the development of contrasting lithological, structural and metamorphic characteristics in adjacent areas, a unique Archaean history is postulated for the KSZ. Psammitic sedimentary rocks, possibly deposited in a fault-bounded basin, were intruded by anorthosite which may have had its

eruptive equivalents in the tholeiitic volcanic rocks in the adjacent Abitibi belt. During the Kenoran orogeny the KSZ was metamorphosed and intruded at infrastructural levels while low-grade regions outside underwent sub-greenschist to amphibolite metamorphism at higher levels. Late ductile shear in the KSZ reoriented gneissic structural elements into northeast directions. Proterozoic fault movements juxtaposed low and high-grade regions.

Piper, D.J.W. and Panagos, A.G.

GROWTH PATTERNS OF THE ACHELOOS AND EVINOS DELTAS, WESTERN GREECE; Sedimentary Geology, v. 28, p. 111-132, 1981.

Alam, M. and **Piper, D.J.W.**

DETRITAL MINERALOGY AND PETROLOGY OF DEEP-WATER CONTINENTAL MARGIN SEDIMENTS OFF NEWFOUNDLAND; Canadian Journal of Earth Sciences, v. 18, p. 1336-1345, 1981.

Seventeen long piston cores have been examined from the continental slope and rise off the Grand Banks and from nearby seamounts. Most cores penetrate Holocene and late Wisconsinan sediment. Four main facies groups are distinguished: A—red terrigenous sediment; B—gray terrigenous sediment (including turbidite sands); C—calcareous (mostly biogenic) sediment; and D—diatomaceous sediment. Facies C and D characterize the Holocene and interstadials; facies A and B were developed during stadials.

Three suites of ice-rafted debris are distinguished: (i) a metamorphic-dominated suite, derived either from Greenland and Baffin Island or from local Labrador and Newfoundland ice; (ii) a carbonate-dominated suite, derived from the Arctic Islands; and (iii) a red sandstone – siltstone suite, derived from the Gulf of St. Lawrence and its environs.

Three heavy mineral assemblages are recognized: on the Grand Banks slope—pyroxene, opaques, amphiboles, and garnet; in Flemish Pass—opaques, pyroxene, garnet, and tourmaline; and on the western Grand Banks rise—opaques, pyroxene, tourmaline, and garnet.

In the biogenic facies C and D, which have slower rates of sedimentation and more ice-rafting corresponding to high stands of sea level, there is little geographic variation in clay mineral assemblage, with montmorillonitic minerals dominant. In the terrigenous facies A and B, which accumulated during glacio-eustatic lower sea-level stands, there is considerable geographic variation, suggesting derivation from local sources on the shelf through wave or glacial erosion.

Dix-sept échantillons prélevés avec un carottier à piston ont été examinés en provenance du talus continental et du glacis des Grands Bancs, et des guyots environnants. La plupart des carottes pénètrent les sédiments d'âge Holocène et Wisconsin inférieur. Quatre principaux groupes de faciès sont identifiés: A—à sédiment rouge terrigène; B—à sédiment gris terrigène (incluant des sables de courant de turbidité); C—à sédiment calcaire (généralement d'origin biologique; et D—à sédiment à diatomées. Les faciès C et D sont caractéristiques de l'Holocène et des interstadiaires; les faciès A et B se sont développés pendant les stadiaires.

Trois séquences de matériaux transportés par les glaces sont reconnus: (i) une séquence à prédominance métamorphique, provenant du Groënland et de la terre de Baffin ou de glaces locales du Labrador ou de Terre-Neuve; (ii) une séquence riche en carbonate dérivées des iles de l'Arctique; (iii) une séquence de grès-siltstone rouge, en provenance du golfe du St-Laurent et de ses environs.

Trois assemblages de minéraux lourds sont reconnus. Sur le talus de Grands Bancs: pyroxène, opaques, amphiboles et grenat; dans la passe Flemish: opaques, pyroxène, grenat et tourmaline; et sur le côté ouest du glacis des Grands Bancs: opaques, pyroxène, tourmaline et grenat.

Dans les faciès d'origine biologique (C et D), caractéristés par un taux moindre de sédimentation et d'un plus grand transport par la glace correspondant aux périodes des hauts niveaux de la mer, il y a peu de variation géographique dans l'assemblage des minéraux argileux, avec prédominance des minéraux du type montmorillonite. Dans les faciès terrigènes (A et B) qui se sont accumulés durant les périodes persistantes glacio-eustatiques de niveau de mer abaissé, il se présente une variation géographique considérable suggérant une origine provenant de sources locales sur la plate forme par l'action des vagues et de l'érosion glaciaire.

Robertson, P.B. and **Plant, A.G.**

SHOCK METAMORPHISM IN SILLIMANITE FROM THE HAUGHTON IMPACT STRUCTURE, DEVON ISLAND, CANADA; Contributions to Mineralogy and Petrology, v. 78, p. 12-20, 1981.

Clasts of shocked garnet-sillimanite gneisses comprise a minor fraction of the allochthonous breccia at the Haughton impact structure. Refractive indices of the diaplectic and fused components of the gneisses, and reduced specific gravity indicate shock pressures from 35 to 55 ± 5 GPa and effective post-shock temperatures from 500° to 1,000°C in a suite of selected samples.

Sillimanites remain birefringent but display several effects of shock metamorphism. Shock-produced planar features and planar fractures are highly developed; optic axial angle ($2V_\gamma$) increases from near normal (26°) to over 80° within a sample; there is a reduction in optical relief and a development of a pale brown colouring which generally deepens in shade as shock level increases. There is no unambiguous evidence, optically or from X-ray investigation, of a high-pressure Al_2SiO_5 polymorph of breakdown to mullite and silica. The highly shocked sillimanites have anomalous K_2O contents from 0.11% to 0.92%. Potassium appears to substitute for aluminum and, to a lesser degree, for iron while retaining sillimanite stoichiometry, and the amount of substitution generally reflects increased shock level. The source of the contributed potassium is the coexisting shock-fused feldspar glass. The glass of each sample is derived primarily from melted alkali feldspar with a minor and varied admixture from the breakdown of mafic minerals. The glasses are depleted in K_2O, although Na_2O is unaffected, and the extent of depletion can be correlated with the increased K_2O content of the associated sillimanite. The incorporation of potassium in shocked sillimanites is a function of both degree of shock deformation and availability of potassium from other coexisting shocked phases. It is speculated that the brown colouration is a function of ferrous iron content and may reflect post-crater thermal history rather than shock level.

Rimsaite, J.

MOBILIZATION AND MIGRATION OF URANIUM AND RARE-EARTH ELEMENTS(REE) IN NATURAL ENVIRONMENTS IN RELATION TO SITE SELECTION FACTORS FOR REDEPOSITORIES OF RADIONUCLIDE WASTES; Geological Association of Canada, Annual Meeting, Abstracts, v. 6, p. A-49, 1981.

Various geological formations, including granite, gneiss and clay, have been considered as sites for storage and disposal of high-level and alpha-bearing wastes. The author proposes for consideration, on the basis of her own research, some modifications observed in natural radioactive rocks, which could occur in geological formations supposedly suitable for disposal of radioactive wastes. Such modifications may develop as a result of secondary thermal and mechanical effects after the emplacement of the radionuclide waste. These modifications are: (1) decomposition of U-and REE-bearing minerals (uraninite, pyrochlore, allanite, phosphates) in natural rocks due to radiation and alteration. Similar processes could result from alterations caused by solidified high-level and alpha-bearing wastes; (2) increased porosity and permeability of radioactive rocks develops as a result of increased interstitial spaces and fractures due to radiation damage; (3) secondary U-and REE-bearing compounds migrate and recrystallize as 1 to 50 micron-thick coatings and films on and in fractures within rock-forming minerals; (4) the U-and REE-bearing fracture fillings are commonly associated with phyllosilicates, hydrous iron oxides and carbonates. Secondary electron images of the fractures provide evidence of recurring mobilization of various components and their interaction in fractures as a result of progressive alteration of the host rock and on fluctuating availability, pH and chemical composition of circulating aqueous solutions; these phenomena cause structural changes in the rocks; (5) secondary radioactive and radiogenic minerals in interstices and fractures cause disintegration and crumbling (reduced strength) of apparently dry radioactive rocks (containing equivalent 0.2 wt.%U) and such "weak zones" may facilitate the escape of radionclides. All these modifications should be taken into account when selecting sites for disposal of radionuclide waste.

Rimsaite, J.

NEOFORMATION OF SECONDARY RADIOACTIVE MINERALS RESULTING FROM NATURAL INTERACTION OF PRIMARY U, Th, REE MINERALS, WATER AND HOST ROCKS; in 7th International Clay Conference, Association International pour l'Étude des Argiles, Abstracts, p. 245, 1981.

Because of their potential properties to fix, and thus delay possible migration of, radionclides from the geologic nuclear waste repository sites, swelling clays have been considered for the use as the backfill barrier around containers of nuclear wastes.

The purpose of this paper is to discuss and illustrate secondary fine-grained radioactive mineral aggregates and colloform crusts that form under natural hydrous environmental conditions in alteration haloes around uranium deposits. Knowledge of behaviours of U, Th, REE and other elements released from the primary source in and around uranium deposits can be applied to predict behaviours of radionuclides in man-made geologic waste repositories.

Three groups of processes, studied using a scanning electron microscope in backscattered electron images and in spectra obtained by an energy dispersive spectrometer, are proposed for discussion:

(1) natural decomposition of rock-forming and associated radioactive ore and accessory minerals, such as uraninite, uranothorite, allanite, pyrochlore, apatite, monazite, xenotime, tourmaline, zircon, sulphides and carbonates;

(2) mobilization, migration and redeposition of U, Th, REE, Zr, radiogenic lead and other elements along fractures;

(3) neoformation of autunite, torbernite, phosphuranylite, coffinite, boltwoodite, kasolite, uranophane, bayleyite, ruthefordite, liebigite, masuyite, anglesite, wulfenite and complex unidentified U, Th, P, REE and Zr compounds in clays and in fractures of hydrated rock-forming minerals.

The mobilized radionuclides can be fixed by several processes, namely by adsorption, by complexing with other ions and by entering and capture in the interlayer of swelling mixed-layer clays and hydrated layer silicates.

These observations on natural behaviours of radioactive and radiogenic materials could be applied in evaluating rock formations and planning preventive measures for nuclear waste disposal sites.

Roberts, A.C., Ansell, H.G., and Dunn, P.J.

COMANCHEITE, A NEW MERCURY OXYCHLORIDE-BROMIDE FROM TERLINGUA, TEXAS; Canadian Mineralogist, v. 19, p. 393-396, 1981.

Comancheite is a new mercury oxychloride-bromide mineral from the Mariposa mine, Terlingua district, Texas. Associated minerals are calcite goethite, hematite and quartz. Comancheite occurs as anhedral crystalline masses and as stellate groups of acicular crystals, elongate parallel to *c*, averaging 80 µm long and 3 to 4 µm wide. Masses are red with an orange-yellow streak and have a resinous lustre; crystals are orange-red to yellow, vitreous and translucent to transparent. Comancheite is brittle with fair cleavage parallel to {001} and {110}, has a Mohs hardness of 2 and does not fluoresce in ultraviolet light. Optically, comancheite exhibits parallel extinction and is length-fast with all indices of refraction between 1.78 and 1.79. The measured density is 7.7(4); calculated density is 8.0 Mg m^{-3}. Electron-microprobe analysis yielded the chemical formula $Hg_{13.00}(Cl_{4.51}Br_{3.50})_{\Sigma 8.01}O_{9.07}$, calculated on Hg = 13. The ideal formula is $Hg_{13}(Cl,Br)_8O_9$. Comancheite is orthorhombic, space group *Pnnm* or *Pnn*2, *a* 18.41(1), *b* 21.64(1), *c* 6.677(2) A and *Z* = 4. The strongest seven reflections of the X-ray powder pattern (*d* A, *I* on a ten-point scale) are: 5.68(7), 5.42(6), 2.878(8), 2.710(5), 2.669(10), 2.457(5) and 1.415(5).

La comanchéite, nouvelle espèce minérale de la mine Mariposa, district de Terlingua (Texas), est un oxychlorure–bromure de mercure. En association avec calcite, goethite, hématite et quartz, elle se présente en amas xénomorphes et en groupes radiés de cristaux aciculaires allongés selon *c*, de dimensions 80 x 3-4 µm. Les échantillons massifs sont rouges, à rayure jaune orange et éclat résineux: les cristaux passent du rouge-orange au jaune, ils ont l'éclat vitreux et sont translucides à transparents. La comanchétite est fragile, avec clivage

assez net suivant {001} et {110}; elle possède une dureté Mohs de 2 et ne montre aucune fluorescence en lumière ultraviolette. Extinction parallèle, allongement positif. Les indices de réfraction se situent entre 1.78 et 1.79. Densité mesurée 7.7(4), calculée 8.0. A la microsonde électronique, on trouve la formule $Hg_{13}(Cl_{4.51}Br_{3.50})_{\Sigma 8.01}O_{9.07}$, d'où la formule idéalisée $Hg_{13}(Cl,Br)_8O_9$. La comanchéite est orthorhombique, groupe spatial *Pnnm* ou *Pnn*2, *a* 18.41(1), *b* 21.64(1), *c* 6.677(2) A, *Z* = 4. Les sept raies les plus intenses du cliché de poudre (*d* (A), *I* sur échelle de 10) sont: 5.68(7), 5.42(6), 2.878(8), 2.710(5), 2.669(10), 2.457(5) et 1.415(5).

Roscoe, S.M.

TEMPORAL AND OTHER FACTORS AFFECTING DEPOSITION OF URANIFEROUS CONGLOMERATES; in Genesis of Uranium and Gold Bearing Precambrian Pebble Conglomerates, ed. F.C. Armstrong; United States Geological Survey, Professional Paper 1161-W, 17p., 1981.

Uraniferous, auriferous, pyritic quartz-pebble conglomerates, unknown in strata less than 2.3 billion years old, are considered preoxyatmoversion analogues of black-sand placers common in younger terrestrial sediments. Radioactive conglomerates in Huronian rocks near Elliot Lake, and others, are within the most proximal facies of once-extensive sheets of terrigenous clastics derived from soil mantles and chemically mature colluvium that covered Archean protocontinents weathered under an atmosphere that lacked free oxygen.

The initial entrapment of quartz-gravel-bearing grits in Elliot Lake Group, as well as subsequent deposition, deformation, and preservation of Huronian rocks, was governed by the development of tectonically unstable conditions in an epicontinental sector of the Superior Craton. Warping of the southerly inclined paleoslope, adjustments along old fractures, and eruptions of basalt were accompanied by deposition of coarse clastic wedges or alluvial fans atop soil-mantled Archean basement rocks, weathered Huronian basalt flows, and finer grained sands that flanked or overlay other gritty conglomerate-bearing lenses.

Successions resembling the Huronian Supergroup are found west of Hudson Bay, in Wyoming, and in central Quebec, suggesting that tectonic traps for coarse clastics with pyritic conglomerates developed extensively around a more stable core of the Archean protocontinent about 2.5 billion years ago. Comparable tectonic conditions developed earlier in South Africa, where bankets occur in strata 2.8 to 2.3 billion years old. Possibilities of discovering other occurrences of this type in North American rocks older than 2.6 billion years are remote, but one occurrence in Quebec may be in this category. Favourable areas are the Huronian Supergroup, other remnants of Paleoaphebian strata (2.6 to 2.3 billion years), and highly metamorphosed equivalents of these. Many of these remnants are buried under more extensively preserved younger Proterozoic strata, but the Paleoaphebian rocks should not be regarded as basal phases of the Proterozoic tectonostratigraphic units.

Ruzicka, V.

SOME METALLOGENIC FEATURES OF THE HURONIAN AND POST-HURONIAN URANIFEROUS CONGLOMERATES; in Genesis of Uranium- and Gold-bearing Precambrian Quartz-pebble Conglomerates, United States Geological survey, Professional Paper 1161-V, p. V1-V8, 1981.

Two genetic types of uraniferous conglomerates can be distinguished: (1) those with syngenetic mineralization, and (2) those with epigenetic mineralization.

Uraniferous conglomerates with syngenetic mineralization are restricted to lower Proterozoic sediments, such as those in the Huronian Supergroup in Canada. It is postulated that deposits with this type of mineralization can occur only in regions where above-normal concentrations of radioelements and uranium minerals were present in the source rocks.

Liberation of uranium minerals, their transportation to the site of deposition, and their deposition along with other heavy minerals took place under oxygen-deficient conditions but at a time when primitive organisms existed.

The depositional environment was near volcanic centres; excessive sulphur, a product of volcanic and post-volcanic activity, apparently caused sulphurization of some minerals and of hydrocarbon, the latter derived from organic and possibly inorganic material.

Concentration of uranium minerals during transportation and deposition was governed by hydraulic and hydrodynamic conditions.

The sedimentary syngenetic origin of uranium mineralization may be illustrated by a portion of an ore deposit that corresponds to a complete cycle of sedimentation. The cycle starts with deposition of coarse grains of quartz, continues with the deposition of a mixture of finer grains of quartz and pyrite with distinct graded bedding, is followed by deposition of monazite and brannerite, and ends with deposition of fragmented fine grains of uraninite embedded in sulphur-rich hydrocarbon. The bed containing hydrocarbon and uraninite is locally depressed by impact of an exotic pebble of quartz. This situation apparently testifies to the fact that the carbonaceous material is a product of algal mats that existed in quiet times between cycles of sedimentation. The succeeding cycle again starts with the deposition of coarse grains of quartz.

Preservation of uranium mineralization during and after diagenesis was possible owing to reducing conditions of the depositional environment.

Uraniferous conglomerates with epigenetic mineralization are localized in regions containing rocks with higher contents of uranium. Primary concentration of uranium minerals in these source rocks can also be syngenetic.

Transportation of uranium from the site of original liberation to the site of deposition was apparently mainly in solutions and in refractory minerals by hydraulic action. Mobilization of uranium from the source rocks and its redistribution were governed by hydrodynamic gradients related to erosional, tectonic, magmatic, or metamorphic processes in the Earth's crust. The conglomerate beds apparently served as channels for penetration of uranium-bearing fluids.

Deposition of uranium took place by one or more epigenetic processes: adsorption, complexing, precipitation, or redox changes according to the degrees of solubility and stability of uranium compounds.

The mineralization in this type of deposit has been preserved beneath the zone of oxidation.

Evidence of these mentioned features is based upon studies on the Huronian uraniferous conglomerate from Elliot Lake, Canada, and on the late Precambrian and Paleozoic radioactive conglomerates from the eastern Ural Mountains and Enisey Crest region, U.S.S.R.

St-Onge, M.R.

"NORMAL" AND "INVERTED" METAMORPHIC ISOGRADS AND THEIR RELATION TO SYNTECTONIC PROTEROZOIC BATHOLITHS IN THE WOPMAY OROGEN, NORTHWEST TERRITORIES, CANADA; Tectonophysics, v. 76, p. 295-316, 1981.

Three progressive metamorphic suites are developed in pelitic rocks of the northern Wopmay Orogen. Two suites are related to the Hepburn Batholith and one to the Wentzel Batholith. All three suites are cut by post-metamorphic wrench faults, some of which have significant vertical displacement. The structural relief so provided reveals that medium- and high-grade isograds associated with the Hepburn Batholith dip inward towards the batholith and are thus "hot-side-up". Isograds associated with the Wentzel Batholith dip away from the batholith and are thus "hot-side-down". It is concluded that Hepburn Batholith has the form of the flattened funnel fed from depth, and that Wentzel Batholith is the arched roof of an intrusive complex of unknown shape at depth.

Bjorlykke, A., and **Sangster, D.F.**

AN OVERVIEW OF SANDSTONE LEAD DEPOSITS AND THEIR RELATION TO RED-BED COPPER AND CARBONATE-HOSTED LEAD-ZINC DEPOSITS; in 75th Anniversary Volume, Economic Geology, p. 179-213, 1981.

Deposits of galena occurring as disseminations in basal quartzitic sandstones constitute a distinct and characteristic deposit type. By world standards they are relatively minor yet they constitute an important resource in some countries.

Host rocks to the deposits are basal quartzitic sandstones deposited in low latitude positions on a sialic basement. In several areas, the basement is anomalously rich in lead relative to average granite. Depositional environments range from continental to shallow marine.

The deposits are characteristically low grade, lead dominant, pyrite free, and silver poor. A common feature is a high-grade core surrounded by a lower grade halo. If present, zinc occurs in a position strigraphically higher than the lead.

Galena cements sand grains, with the higher grades occurring in originally more porous zones. Silica, commonly chalcedonic in the younger deposits, is the next most common cement.

The preferred genetic model involves transport of metals laterally from adjacent basement highs through permeable channels in sandstones to an environment with a sufficiently high H_2S content to precipitate galena and minor amounts of other sulfides.

From a comparison of several features of these deposits with those of two other major intracratonic, sediment-hosted, base metal deposit types (red-bed copper and carbonate-hosted lead-zinc), it is concluded that these three deposit types are not only clearly separate entitles in terms of their tectonic and sedimentary environments but were probably formed at different stages of continental evolution.

Schafer, C.T., Cole, F.E., and **Carter, L.**

BATHYAL ZONE BENTHIC FORAMINIFERAL GENERA OFF NORTHEAST NEWFOUNDLAND; Journal of Foraminiferal Research, v. 11, no. 4, p. 296-313, 1981.

About 35% of the bathyal zone foraminiferal genera observed on the northeast Newfoundland slope and rise, whether arenaceous (43 genera) or calcareous (63), have an average absolute abundance per genus of greater than one specimen per cubic cm of wet sediment (FN). **Trochammina** is the most abundant and most ubiquitous arenaceous taxon. First occurrences of deep water arenaceous genera are especially evident in middle to lower slope and continental rise environments. **Ammobaculites, karreriella** and **Reophax** are among the arenaceous genera that are associated with a base-of-slope to rise (2,000-3,000 m) contour current factor. **Astrammina, Hormosina** and **Saccorhiza** appear to be most related to middle slope, low energy, fine substrate conditions.

Mean absolute abundance for the total number of calcareous genera is 2.5/cc of wet sediment, compared to 1.5 for the arenaceous taxa. The relatively high calcareous specimen abundance is especially evident on the lower slope and on the upper continental rise. Profiles of the total number of specimens per unit volume of wet sediment suggest dilution of tests by sediment on the middle slope and concentration of tests below the core of the Western Boundary Undercurrent (WBU). **Epistominella** is the most abundant calcareous genus and occurs in about 53% of the samples. Generally, calcareous genera that occur in more than 90% of the samples are confined to the 1.8 to 32.3 average FN interval, suggesting a comparatively ubiquitous distribution for the well represented forms.

Elphidium shows a distinctive relationship to middle slope and base-of-slope environments that are characterized by a relatively high clay concentration. The distribution of this genus suggests that the low energy middle slope (1,500 m) environment may serve as a depositional "sink" for passively-transported specimens of this taxon. Benthic environments that are associated with contour current processes on the lower slope and upper rise are characterized by **Hoeglundina, Melonis, Nonion, Lenticulina, Astacolus, Gyroidina, Oridorsalis, Pullenia,** and **Quinqueloculina,** and by comparatively dense living populations.

Many calcareous and arenaceous genera observed on the Newfoundland slope appear to have their peak distributions in relatively deep water compared to equivalent Gulf of Mexico taxa.

Scott, J.S.

THE ROLE AND DEVELOPMENT OF ENGINEERING GEOLOGY IN THE GEOLOGICAL SURVEY OF CANADA; Geological Society of America, 94th Annual Meeting, Absracts with Programs, v. 13, no. 7, 1981.

The Geological Survey of Canada, founded in 1842, is one of Canada's oldest scientific institutions. Throughout its history the survey has been subject to many organizational changes, occasioned by changing economic and political imperatives. Despite institutional changes the primary mission of the Geological Survey has remained the provision of scientific information on the geology and related economic mineral deposits and energy resources of the nation.

To the extent that engineering geology constitutes the application of geological knowledge and expertise to the resolution of engineering problems the Geological Survey has always contributed to this field. These contributions have been mainly; response to external requests for information and services, provision of geological information of direct application for planning and engineering purposes, support of university research and direct investigation of natural hazards.

The Survey's record of contributions to engineering geology parallels the economic and social development of the country as exemplified by early surveys of railway routes in the 19th and early 20th centuries, the search for road-building aggregates occasioned by increasing use of the automobile in the 1920's, examination of geological conditions for major engineering works that have accompanied the nation's growth.

In the years following World War II the role of engineering geology became more clearly identified with the mission of the Survey. Recent activities have included the evaluation of permafrost terrain for pipeline routes, geotechnical problems asociated with offshore hydrocarbon development and evaluation of the concept of disposal of high-level radioactive waste in igneous rocks and other geological formations.

Sen Gupta, J.G.

DETERMINATION OF YTTRIUM AND RARE-EARTH ELEMENTS IN ROCKS BY GRAPHITE-FURNACE ATOMIC-ABSORPTION SPECTROMETRY; Talanta, v. 28, p. 31-36.

With the use of synthetic solutions and several international standard reference materials a method has been developed for determining traces of Y, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb and Lu in rocks by electrothermal atomization in a pyrolytically-coated graphite furnace. Depending on the element, the sensitivity is of the order of 10^{-9}-10^{-12} g at 2500°. To avoid matrix interferences the lanthanides are separated from the common elements by co-precipitation with calcium and iron as carriers. The data for Canadian reference rock Sy-2 (syenite), U.S.G.S. reference rocks W-2 (diabase), DNC-1 (diabase) and BIR-1 (basalt), and South African reference rock NIM-18/69 (carbonatite) obtained by graphite-furnace atomization are compared with the values obtained by flame atomic-absorption. The results are in good agreement with literature values.

Sinclair, W.D., Cathro, R.J., and Jensen, E.M.

THE CASH PORPHYRY COPPER-MOLYBDENUM DEPOSIT, DAWSON RANGE, YUKON TERRITORY; Canadian Mining and Metallurgical Bulletin, v. 74, no. 833, p. 67-76, 1981.

The Cash is one of the largest porphyry copper-molybdenum deposits found in Yukon to date. It is 80 km northwest of Carmacks, within the unglaciated portion of the Dawson Range, and is associated with the Big Creek fault, an important tectonic feature. Part of the mineralized zone is blanketed by up to 70 m of alluvial drift. The remainder is covered by a relatively thin residual soil layer. The mineralized zone, however, was not detected by conventional stream-sediment sampling because pathfinder elements, such as Cu and Mo, have not been geochemically dispersed into the main drainage system. The deposit was discovered by a combination of soil analysis and inspection of rock fragments from small pits.

Twenty widely spaced, shallow drill holes have outlined an area over 2700 m long and 550 to over 1000 m wide that grades more than 0.1% copper equivalent (% CuE = % Cu + (5 x % MoS_2)). Two smaller zones grading over 0.4% copper equivalent occur within the larger area. The limits of the widest end of the deposit have not been delineated.

The Cash deposit is fairly typical of high-level, calc-alkaline porphyry copper-molydenum occurrences in the Canadian Cordillera (cf. CIM Special Volume 15) and is representative of most prospects in the Dawson Range. It is associated genetically with a subvolcanic complex of small, irregular stocks and dykes of feldspar porphyry and related breccias of Late Cretaceous age. Copper and molybdenum sulphides occur along fractures, in quartz veinlets and disseminated in feldspar porphyry and in older metasedimentary and intrusive rocks. Higher-grade zones of copper and molybdenum have associated potassic alteration. Phyllic alteration is, in part, superimposed on potassic alteration. Argillic alteration occurs locally.

This paper describes the history of the discovery and the geochemical and geophysical characteristics, together with the regional geology, and the nature and distribution of the host rocks, hypogene mineralization and hydrothermal alteration.

Souther, J.G.

QUATERNARY VOLCANISM IN THE STIKINE REGION OF NORTHWESTERN B.C. AND POTENTIAL HAZARDS FROM FUTURE ERUPTIONS; Geological Association of Canada, Annual Meeting 1981, Abstracts, v. 6, p. A-52, 1981.

The Stikine Volcanic Belt is defined by over 50 Quaternary volcanic centres that are scattered along a broad, north-northwesterly trending zone that extends from the Aiyansh Flow, near Terrace, across the Stikine region of northwestern B.C. and into the southern Yukon. Most of the volcanoes are small basaltic cinder cones from which one or more thin flows have issued. However, the belt includes three large volcanic complexes; Level Mtn., Mt. Edziza, and Hoodoo Mtn. each of which has a long, complex history of activity that includes the eruption of intermediate to acid lava and pyroclastic deposits in addition to basalt.

The Stikine region is sparsely settled and, prior to completion of the Cassiar-Stewart highway in 1973, it was not traversed by any major transportation corridors. However, the proposed construction of hydroelectric installations on the Stikine and Iskut Rivers has focused attention on the possible impact that future eruptions might have on dams, reservoirs, powerhouses, transmission lines, and access roads as well as the risk to existing and future communities.

An assessment of risk, based on past events, indicates that the Stikine sites would not have suffered any significant damage from past eruptions of Mt. Edziza or adjacent satellite cones. However, the intervening valley of Klastline R. has been repeatedly dammed by flows that may have triggered floods in Stikine valley downstream from the proposed damsites. The proposed Iskut R. damsite is adjacent to a basaltic cinder cone that erupted a sufficiently large volume of lava to have caused severe damage to the site. The cone has been dormant for 14,000 years and, because none of the other isolated centres in the region show evidence of reactivation the risk here is slight.

Struik, L.C.

A RE-EXAMINATION OF THE TYPE AREA OF THE DEVONO-MISSISSIPPIAN CARIBOO OROGENY, CENTRAL BRITISH COLUMBIA; Canadian Journal of Earth Science, v. 18, p. 1767-1775, 1981.

Three tectonostratigraphic successions are established from remapping of the area near Barkerville and Cariboo River. The first, of Late Proterozoic to Cambrian sediments, was deposited on the shallow to moderately deep platformal shelf west of and derived from the exposed North American craton. The second is an unconformably overlying Ordovician to Permian sequence of sedimentary and volcanic rocks representing a basinal environment with periodic highs. These packages of sediments were deposited on the North American craton and its western transitional extensions. The third succession, composed of oceanic chert and basalt of the Permo-Pennsylvanian Antler Formation, was thrust eastward over the other two during the early Mesozoic. The three successions were folded, faulted, and metamorphosed during the mid-Mesozoic Columbian Orogeny. The Devono-Mississippian Cariboo Orogeny, which was thought to have affected all of the first sequence and part of the second, could not be documented in its type locality. The geology of

the Barkerville-Cariboo River area has many similarities with that of Selwyn Basin and Cassiar platform of northern British Columbia and Yukon.

Trois successions tectonostratigraphiques sont établies suite à une reprise de la cartographie de la région près de Barkerville et de la rivière Cariboo. La première est composée de sédiments du Protérozoique supérieur à Cambrien et fut déposée sur la plateforme peu à modérément profonde du plateau continental à l'ouest du craton nord américain exposé et lequel a fourni les sédiments. La deuxième est une séquence discordante sus-jacente ordovicienne à permienne de roches sédimentaires et volcaniques qui représentent un environnement de bassin avec des points culminants périodiques. Ces ensembles de sédiments furent déposés sur le craton nord américain et sur les zones de transition se prolongeant vers l'ouest. La troisième succession est composée de chert océanique et de basalte de la formation Antler d'âge Permo-Pennsylvanien qui a chevauché vers l'est au-dessus des deux autres durant le Mésozoique inférieur. Les trois successions ont été plissées, faillées et métamorphisées pendant l'orogénie colombienne au Mésozoique moyen. L'orogénie Cariboo d'âge Dévono-Mississipien, laquelle semble avoir affecté la totalité de la première séquence et une partie de la deuxième, ne fournit aucun renseignement relié à la localité type. La géologie de la région Barkerville-rivière Cariboo présente plusieurs similitudes avec celle du bassin Selwyn et de la plateforme Cassiar du nord de la Colombie Britannique et au Yukon.

Srivastva, S.P., Falconer, R.K.H., and **MacLean, B.**

LABRADOR SEA, DAVIS STRAIT, BAFFIN BAY: GEOLOGY AND GEOPHYSICS – A REVIEW; in Geology of the North Atlantic Borderlands, ed. J.Wm. Kerr and A.J. Fergusson, Canadian Society of Petroleum Geologists, Memoir 7, p. 333-398, 1981.

The structural developments of the Labrador Sea, Davis Strait and Baffin Bay as obtained from the combined analysis of geological and geophysical measurements are reviewed. Compilation of magnetic and gravity data show that well developed magnetic lineations and a prominent gravity low, coincident with the rift valley of the extinct Labrador Sea Ridge, are present in the southern and central Labrador Sea. In the northern Labrador Sea and magnetic anomalies are subdued in amplitude and the coincidence of the gravity low with the rift valley is obscured by complexities in the basement topography. These have been interpreted as arising from the obliqueness of spreading in this region. In Baffin Bay a similar but smaller amplitude gravity low is also found to be coincident with a rift valley feature and has been interpreted as the northward continuation of the extinct Labrador Sea Ridge. Sufficient reflection seismic data are not available throughout Baffin Bay to delineate such a feature there. The gravity low in Baffin Bay lies at a small angle to magnetic lineations in the central region of the Bay, indicating presence of one or several small fracture zones. Compilation of gravity, magnetic and seismic reflection data in Davis Strait show presence of a prominent basement high oriented northeast-southwest. The high is flanked by thick sediments on landward sides.

These and other geological observations compiled from the deep exploratory wells drilled on the Labrador and Greenland shelves are interpreted as being in accord with the sea-floor spreading hypothesis for the Labrador Sea and Baffin Bay regions. Problems associated with the hypothesis that these regions were formed by the foundering and subsidence of continental crust are discussed and it is shown such as hypothesis is not consistent with the overall development of the North Atlantic as a whole and implies large scale internal deformation of the Greenland and North American plates. The subsidence history of the Labrador Shelf obtained from the exploratory wells, correlates well with different episodes of spreading in the Labrador Sea. Micropaleontological studies of the Labrador Shelf wells show that the late Cretaceous-Eocene widespread marine transgression coincided with the opening phase of the Labrador Sea. Deepest conditions existed in the Eocene and a broad shelf marine regression occurred in the Oligocene with the cessation of spreading in the Labrador Sea-Baffin Bay region.

Occurrence of older (Berriasian-Hauterivian) basalt on the Labrador Shelf and younger (Turonian) basalt farther to the north on the Greenland Shelf agrees with a progressive opening from south to north. A later change in the mode of spreading in the Labrador Sea-Baffin Bay regions agrees with the widespread occurrence of Paleocene volcanics inland and offshore in Davis Strait.

Syvitski, J.P.M. and Murray, J.W.

PARTICLE INTERACTION IN FJORD SUSPENDED SEDIMENT; Marine Geology, v. 39, p. 215-242.

Glacial flour enters the surface layer of Howe Sound, a fjord in southwestern British Columbia, as a sediment plume which moves quickly down inlet while gradually mixing with the sea water. Flocculation occurs in the lower, brackish waters of the surface layer, although mixing and diffusion are the dominant processes for sediment to enter the marine water. Once in the underlying marine water, zooplankton pelletization and biologic agglomeration of inorganic floccules predominate. This generates a response, in the order of days, between the two layers in terms of sedimentation of particulate matter.

Most particles settling in the fjord environment fall as: (1) sand and silt grains containing attached clay particles; (2) clay clasts possibly related to river mudballs; (3) mineral-bearing fecal pellets from pelagic zooplankton; (4) large-grain inorganic and colloidal floccules; and (5) in-organic–biogenic agglomerates.

Analysis of sediment trap data has led to the following conclusions: (1) water turbidity cannot be used to infer the downward flux of particles; (2) size distributions of sediment deposited on the sea-bed are a function of non-lognormal size distributions from particles composing sub-laminae.

Syvitski, J.P.M. and van Evergingen, D.A.

EVALUATION OF THE GEOLOGIC PHENOMENON OF SAND FLOTATION: A FIELD AND EXPERIMENTAL APPROACH; Journal of Sedimentary Petrology, v. 51, no. 4, p. 1315-1322, 1981.

The floating of sediment is a viable mechanism for moving relatively large amounts of sediment in low energy environments. The tidal flats of Boundary Bay, within the Fraser Delta complex, are an excellent example. The local consequences of flotation are the homogenization of grain size on the flats and high sedimentation rates in the flora zones. The necessary parameters (field and laboratory) for the calculation of the flotation load are discussed herein.

The presence of floating sediment indicates that three factors are ideal: 1) proper atmospheric conditions (no fog or precipitation); 2) rising water with intact surface tension (no surface turbulence); and 3) appropriate floatable sediment for the incoming water velocity. The appropriateness of the floating sediment is a function of grain size, grain shape, grain surface texture and surface coating, and grain density. The presence of clays mixed in with the coarser sediment will adversely affect the floatibility of the coarser sediment.

Taylor, F.C.

PRECAMBRIAN GEOLOGY OF THE CANADIAN NORTH ATLANTIC BORDERLANDS; Canadian Society of Petroleum Geologists, Memoir, v. 9, p. 11-30.

Precambrian rocks extend 3300 km from central Ellesmere Island to the Strait of Belle Isle and form parts of three structural provinces, which are from north to south, the Churchill, Nain, and Grenville. The Churchill Province is composed primarily of gneissic granitic rocks, some of which are of Archean age and were deformed and metamorphosed during the Kenoran Orogeny (~2500 Ma). Aphebian supracrustal rocks unconformably overlie these gneissic rocks and form at least three fold belts, the Committee, Foxe and Dorset, all of which were deposited in the Baffin Geosyncline. These and the older rocks were deformed, metamorphosed, and intruded by granitic rocks during the Hudsonian Orogeny (~1750 Ma). At that time the major structural elements now present were established. Grabens in northern Baffin Island, that probably began to form in Aphebian time, were filled in Neohelikian time with rocks that comprise the Borden Plate. Elements of the Thule Group were deposited in eastern Ellesmere Island as a result of similar tectonism. Block faulting occurred intermittently into the Cenozoic so that present coastal outlines, particularly in Baffin Island, are fault-controlled and were not formed by Precambrian structures.

The Nain Province is composed chiefly of Archean rocks, of which a few were metamorphosed, deformed, and intruded 3600 Ma ago. The major deformation, metamorphism, and intrusion of this province occurred during the Kenoran Orogeny. In Aphebian time supracrustal rocks of the Ramah, Mugford, and Snyder Groups were deposited unconformably in the Archean rocks. These supracrustal rocks, which may also be part of the Baffin Geosyncline, were deformed and metamorphosed during the Hudsonian Orogeny. In the Makkovik Subprovince, in the southern part of the Nain Province, the Aillik Group was also deposited in Aphebian time, and deformed, metamorphosed, and intruded during the Hudsonian Orogeny. Post-tectonic batholiths of anorthosite and adamellite were emplaced in Paleohelikian time during the Elsonian Event (~1400 Ma) in the Nain Province and also in the Grenville Province to the south.

The Grenville Province is composed of gneisses, many of undetermined age and origin, as the Grenvillian Orogeny (~1000 Ma) destroyed evidence of most earlier events. This orogeny also metamorphosed the anorthosite and adamellite intrusive rocks. In Hadrynian time sedimentation occurred in a few fault-controlled areas in southern Labrador.

Archean rocks of Labrador and Aphebian supracrustal rocks of the Foxe Fold Belt correlate well with those in West Greenland. Aphebian rocks of the Committee Fold Belt and associated rocks probably also are present in Greenland.

Teskey, D.J.

THE APPLICATION OF DATA PROCESSING TECHNIQUES IN THE INTERPRETATION OF TOTAL FIELD AND VERTICAL GRADIENT AEROMAGNETIC DATA FROM THE ATHABASCA AREA OF NORTHERN SASKATCHEWAN; Geological Association of Canada, Annual Meeting 1981, Abstracts, v. 6, p. A-55, 1981.

Digital techniques including continuation, filtering and modelling of the potential fields have been used to estimate the dimensions and depth of magnetic sources in the Athabasca area of Northern Saskatchewan. By placing suitable restrictions on the source parameters, information on the structure of the basement can be inferred which is of great benefit in the exploration for economic uranium deposits in the area. An additional aid to the analysis of structure in this area is the one:one million scale total field aeromagnetic map that has been digitally compiled by the Geological Survey of Canada from the older analogue one inch: one mile series. Presentation of the data at this scale, after subtraction of the International Geomagnetic Reference Field helps to bring perspective to the more detailed anlaysis.

Thompson, R.I.

THE NATURE AND SIGNIFICANCE OF LARGE 'BLIND' THRUSTS WITHIN THE NORTHERN ROCKY MOUNTAINS OF CANADA; in Thrust and Nappe Tectonics, The Geological Society of London, Special Volume, p. 449-462, 1981.

The northern Canadian Rocky Mountains comprise a rugged, structurally complex Foothills subprovince of large amplitude box an chevron folds, and a structurally diverse Rocky Mountain subprovince in which large mappable thrusts are rare. The boundary between them is, in some regions, defined by the unfaulted E-dipping limbs of an **en echelon** sequence of large mountain-front anticlines. The lack of thrusts, especially along the mountain front, contrast with the well exposed linearly continuous thrusts of the Front Ranges structural subprovince within the southern Rocky Mountains, and leads to the impression that little lateral deplacement has occurred.

Where deep cross-cutting valley erosion combines with increased fold plunge, it is apparent that the frontal anticlines are, in reality, large allochthonous sheets displaced many kilometres eastward relative to the craton on flat thrusts that separate Ordovician shales from underlying Devonian and Mississippian shales. The faults can be traced, in some places, eastward to the mountain front where they cut abruptly through the thick hanging wall successions of carbonate rocks; however, they cannot be mapped further eastward into surface exposures ecause they terminate within a décollement zone of Devonian and Mississippian shales, where the displacement on them is transfomed into disharmonic folds and tectonic thickening of overlying units.

The Devonian and Mississippian shale succession is interpreted as a fundamental décollement zone of regional extent that separates a lower structural level of thrust-faulted carbonate rocks from an upper structural level characterized by folded late Palaeozoic and Mesozoic units. The shortening represented by Foothills folds is interpreted to equal the amount of shortening on 'blind' thrusts beneath the western margin of the Foothills structural subprovince.

A structural reinterpretation across the Muskwa Anticlinorium using the blind thrust interpretation demonstrates that the mountain-front Tuchodi Anticline may represent a large allochthonous thrust sheet folded over a large step in the blind thrust on which it was transported.

The northern Rocky Mountains, narrower and less foreshortened than the southern Rocky Mountains, are interpreted as a thin-skinned tectonic regime similar to but orogenically less mature than the southern Rocky Mountains.

Thorpe, R.I.

PRELIMINARY PLAN FOR ORE DEPOSITS CONTRIBUTIONS TO VOLUMES ON CANADIAN GEOLOGY AND ORE DEPOSITS; Geological Association of Canada, Annual Meeting 1981, Abstracts, v. 6, p. A-55, 1981.

The explosion of knowledge on the geology and mineral deposits of Canada since preparation of the 5th edition of "Geology and Economic Minerals of Canada", published by the G.S.C. in 1970, dictates a different approach for the

next one. As currently planned, the former single volume will be superseded by about nine, to be published during 1986-88. Volumes of the new edition will stand on their own, but will also form part of a centennial series by the Geological Society of America.

Planning is at an early stage as to how best to marshall and integrate information on the mineral deposits of the country into the five main regional volumes. Mineral deposits coordinators will be chosen to work in conjunction with regional geology coordinatos on these volumes. One of their responsibilities will be to solicit deposit descriptions, mining camp descriptions, or regional metallogenic summaries from the most knowledgeable people. Because geologists and their employers in the mining industry, governments and universities will be called upon to achieve the best scientific product, I take this opportunity as mineral deposits coordinator, in the planning stage, to solicit your comments.

One volume devoted to mineral deposits/resourcs is also planned to enable presentation of interregional comparisons, summaries of general deposit characteristics, metallogenic synthesis, and the best contemporary genetic models for major Canadian deposit types.

The need for an up-to-date and comprehensive account of Canada's mineral deposits and resources is abundantly obvious. I hope we can work together to take advantage of the present opportunity to significantly advance national, as well as broad regional, documentation of Canadian mineral deposits.

Thorpe, R.I., Guha, J. and Cimon, J.

EVIDENCE FROM LEAD ISOTOPES REGARDING THE GENESIS OF ORE DEPOSITS IN THE CHIBOUGAMAU REGION, QUEBEC; Canadian Journal of Earth Sciences, v. 18, no. 4, p. 708-723, 1981.

Twenty-three lead isotope analyses are reported for massive sulfide deposits, the main copper-gold shear zone deposits in anorthosite of the Doré Lake complex, and and two gold deposits, all in Archean terrane, in the Chibougamau district. Five analyses were also obtained for lead occurrences in Proterozoic carbonate sediments in the Mistassini Basin.

Galenas from the Coniagas and Lemoine deposits of volcanogenic massive sulfide type, from the Taché Lake deposit of possibly the same type, from the Norbeau and Ayrhart gold properties, and one from within the Opemiska mine, have Archean compositions. Of these, the Lemoine, Norbeau, and Opemiska mine galenas are slightly younger than the others or were contaminated during later deformation and (or) metamorphism.

Analyses for the main Cu-Au deposits generally form a cluster, although the spread in $^{206}Pb/^{204}Pb$ ratios is significant and three analyses for the Copper Rand deposit, in particular, are distinct from data for the other deposits. One interpretation is that the data, in combination with the Archean analyses, define a secondary isochron reflecting a primary age of Archean deposits and rocks at 2735-2800 Ma and a secondary event, including genesis of the Cu-Au ores, at 2240-2160 Ma. Additional evidence for a metamorphic-plutonic(?) event at about 2200 Ma has been provided by previous paleomagnetic studies. One galena from the Opemiska deposit appears to have had uranogenic lead added at 1735-2075 Ma. Three analyses of galena fom the Campbell (Merrill) pit are anomalous or indicate they were formed at 162-300 Ma, and it is suggested they may have resulted from multiple episodic additions of ambient rock lead to galena originally deposited at about 2200 Ma.

Two new analyses, together with four older values, for Mistassini Basin lead occurrences define a possible secondary isochron that may indicate an integrated source age of 2655 or 2940 Ma at mineralization ages of 2100 and 1700 Ma, respectively. This secondary isochron is very poorly defined because three other new analyses plot above the line.

This study suggests that further geochronological investigation of the Cu-Au orebodies, and of felsic dykes that occur in many cases in close spatial association with them, should be undertaken.

Vingt-trois analyses d'isotopes de plomb ont été effectuées sur des gîtes de sulfures masifs, sur les principales minéralisations filoniennes du type Cu-Au associées aux zones de cisaillement dans l'anorthosite du complexe du Lac Doré et sur deux gîtes d'or, tous situés dans les terrains archéens du district minier de Chibougamau. Cinq analyses pour le plomb ont également été faites dans des sédiments protérozoiques du type carbonate dans le bassin de Mistassini.

Les galènes des gisements du type sulfures massifs volcanogéniques de Coniagas et de Lemoine, celles du gisement du Lac Taché, possiblement du même type, celles des camps miniers aurifères de Norbeau et d'Ayrhart et une galène provenant de la mine Opemiska, ont toutes des compositions archéennes. Parmi celles-ci, les galènes de Lemoine, de Norbeau et celles de la mine Opemiska sont légèrement plus jeunes que les autres, ou bien elles ont été contaminées au cours d'un stade de déformation et (ou) métamorphisme subséquent.

Les analyses pour les principaux gîtes du type Cu-Au sont généralement groupées, malgré une dispersion significative du rapport $^{206}Pb/^{204}Pb$. Les résultats de trois analyses du gisement de Copper Rand se distinguent particulièrement de ceux des autres gisements. Il est possible d'interpréter ces données combinées avec les analyses archéennes de définissant un isochrone secondaire représentant un âge primaire des gîtes archéens et des roches associées de 2735 à 2800 Ma et un événement secondaire comportant la mise en place des minéralisations Cu-Au de 2240 à 2160 Ma. Des études paléomagnétiques antérieures suggèrent également un événement métamorphique-plutonique(?) à environ 2200 Ma. Il apparaît qu'une des galènes du gisement d'Opemiska contient du plomb uranogène qui lui a été ajouté entre 1735 et 2075 Ma. Trois analyses de galènes de la fosse de Campbell (Merrill) sont anomales et indiquent des âges compris entre 162 et 300 Ma. Il est possible qu'elles résultent d'additions répétées et épisodiques de plomb provenant de la roche environnante à une galène formée à l'origine, il y a environ 2200 Ma.

Deux nouvelles analyses de plomb en plus de quatre autres plus anciennes en provenance du bassin de Mistassini définissent possiblement un isochrone secondaire qui pourrait indiquer un âge de couru intégré de 2655 ou 2940 Ma pour des âges de minéralisation respectifs de 2100 et 1700 Ma. Cet isochrone secondaire est très mal défini du fait que trois autre nouvelles analyses tombent au-dessus de la ligne.

Cette étude devrait susciter d'autres travaux géochronologiques sur des gisements de type Cu-Au et sur les dykes felsiques qui sont souvent en étroite relation spatiale avec ces derniers.

Tipper, H.W.

OFFSET OF AN UPPER PLIENSBACHIAN GEOGRAPHIC ZONATION IN THE NORTH AMERICAN CORDILLERA BY TRANSCURRENT MOVEMENT; Canadian Journal of Earth Sciences, v. 18, p. 1788-1792, 1981.

The north to south climatic zonation of upper Pliensbachian ammonites known in Europe has been recognized in the North American Cordillera. This simple geographic arrangement has been disrupted by northwest trending dextral transcurrent faults. With further

documentation and amount of offset of these zones should provide a measure of the amount of movement on these faults since Pliensbachian time and further document and allochthoneity of the western part of the Cordillera.

La zonation climatique nord et sud des ammonites du Pliensbachien supérieur connue en Europe a été identifiée dans la Cordillère de l'Amérique du Nord. Cet arrangement géographique simple a été interrompu par des failles de décrochement dextre de direction nord-ouest. Plus de rensiengmenents sur la distance du déplacement de ces zones permettraient de mesurer la grandeur du mouvement de ces failles depuis le temps Pliensbachien et d'être mieux informé sur la nature allochtone de la partie ouest de la Cordillère.

Uyeno, T.T. and Barnes, C.R.

A SUMMARY OF LOWER SILURIAN CONODONT BIOSTRATIGRAPHY OF THE JUPITER AND CHICOTTE FORMATIONS, ANTICOSTI ISLAND, QUÉBEC; Subcommission on Silurian Stratigraphy, Ordovician-Silurian Boundary Working Group. Field Meeting, Anticosti-Gaspé, Quéec 1981, Vol. II: Stratigraphy and Paleontology, ed. P.J. Lespérance, p. 173-184.

The Jupiter and Chicotte Formations, respectively 145 m and 23-33 m thick (Bolton 1972), represent the youngest Silurian units on Anticosti Island. With the exception of informal member 2 (Bolton 1972) of the Jupiter, they were sampled at 2-m intervals along their main sections. Fifty-nine samples, averaging 2.0 kg in weight, yielded 5100 disjunct conodont elements. The Anticosti conodonts can be confidently assigned to the zonation established by Aldridge (1972) based on strata at the Welsh Borderland, U.K. Thus the sample from 10 m above the base of member 7 of the Jupiter Formation is in the highest part of the **discreta-deflecta** Zone (C_2, Fronian age). The remainder of the Jupiter, up to 2 m below the top of the formation, is assignable to the **staurognathoides** Zone (C_2 to C_4, Fronian to early Telychian). In the Anticosti succession, this zone can be further subdivided into two informal units: the lower **staurognathoides** fauna (C_2, mid-Fronian) and the higher **Ozarkodina** n. sp. B fauna (C_{3-4}, late Fronian-early Telychian), with the separation occurring about 17 m above the base of member 4. The interval including the uppermost 2 m of the Jupiter and up to 24 m above the base of the Chicotte Formation, belongs to the **inconstans** Zone (C_5, Telychian). The **celloni** Zone of Walliser (1964) probably represents an upper part of this zone. The **amorphognathoides** Zone (C_6, late Telychian-early Wenlock) is present in the sample from 24 m above the base of the Chicotte. Although the zone straddles the Llandovery-Wenlock boundary, the stratigraphic position of this sample suggests that it is probably still of late Telychian age. Two of Cooper's (1980) Datum Planes are represented: the **Distomdus staurognathoides** Datum in member 1 of the Jupiter Formation, and the **Pterospathodus amorphognathoides** Datum in the Chicotte Formation.

Les formations Jupiter et Chicotte, dont l'épaisseur est de 145 m et de 23 à 33 m respectivement (Bolton, 1972), sont les unités siluriennes le plus récentes de l'île d'Anticosti. A l'exception du terme 2 officieux (Bolton, 1972) de la formation Jupiter, elles ont été échantillonnées sur des intervalles de 2 mètres de long de leurs sections principales. Cinquante-neuf échantillons, en moyenne de 2 kg chacun, ont donné 5100 corps disjoints de conodontes. Les conodontes d'Anticosti sont assignés aux zones établies par Aldridge (1972), qui sont fondées sur des strates de la bordure du pays de Galles (Royaume-Uni). Ainsi, l'échantillon prélevé à 10 m au-dessus de la base du terme 1 de la formation Jupiter est la partie la plus haute de la zone de **discreta-deflecta** (C_2, Fronien). Le reste de la formation, jusqu'à 2 mètres du sommet, fait partie de la zone de **staurognathoides** (C_2 à C_4, Fronien – base du Telychien). Dans la succession Anticosti, cette zone peut être subdivisée en deux unités officieuses: la faune **staurognathoides** inférieure (C_2, milieu du Fronien) et la faune **Ozarkodina** nou. esp. B supérieure (C_{3-4}, fin du Fronien – base du Telychien); la séparation a lieu à environ 17 mètres au-dessus de la base du terme 4. L'intervalle comprenant les deux derniers mètres de la formation Jupiter et les 24 premiers mètres de la formation Chicotte appartient à la zone d'**inconstans** (C_5, Telychien). La zone de **celloni** de Walliser (1964) est probablement une partie supérieure de cette zone. La zone d'**amorphognathoides** (C_6, fin du Telychien – base du Wenlockien), est présente dans l'échantillon à 24 mètres au-dessus de la base de la formation Chicotte. Bien que la zone coiffe la limite valentienne-wenlockienne, la position stratigraphique de l'échantillon laisse supposer qu'il date de la fin du Telychien. Deux niveaux de référence de Cooper sont représentés: le niveau de **Distomodus staurognathoides** dans le terme 1 de la formation Jupiter et le niveau de **Pterospathodus amorphognathoides** dans la formation Chicotte.

Vilks, G.

SCIENCE AND TECHNOLOGY: BRIDGING THE FRONTIERS; Geoscience Canada, v. 8, no. 3, p. 126-128, 1981.

Vilks, G.

LATE GLACIAL-POSTGLACIAL FORAMINIFERAL BOUNDARY IN SEDIMENTS OF EASTERN CANADA, DENMARK AND NORWAY; Geoscience Canada, v. 8, no. 2, p. 48-55, 1981.

Sediments in cores collected from the Scotian and Labrador shelves contain a faunal discontinuity where older benthic foraminiferal assemblages dominated by **Elphidium excavatum** f. **clavata** change to more diverse present day continental shelf assemblages. A similar change is found in Late Quaternary borings in Denmark (Jutland) and in the Oslofjord area of Norway. The ^{14}C age of the faunal break varies from 10,000 years B.P. in the European sediments to 13,000 years B.P. on the Scotian Shelf and 15,000 years B.P. on the Labrador Shelf.

The present day oceanographic setting along the coasts of Norway, Denmark and eastern Canada was established when the glacial ice retreated inland. The dominance of **E. excavatum** f. **clavata** in the older sediments is related to diluted and cold coastal waters during the time when continental ice was ablating on the inner shelf. The disappearance of **E. excavatum** f. **clavata** therefore can be used to estimate the Late Glacial.

Vincent, J-S.

L'ÎLE DE BANKS: UN PARADIS POUR L'ÉTUDE DES GLACIATIONS QUATERNAIRES; Geos, v. 10, no. 1, p. 18-21, 1981.

L'île de Banks, située à l'extrémité sud-ouest de l'archipel Arctique canadien, est un désert polaire où une longue séquence d'événements quaternaires est enregistrée. Des calottes laurentidiennes, venant de centres de dispersions au sud-est, ont atteint leur limite d'extension sur l'île de Banks au moins en trois occasions. L'histoire des trois glaciations et des périodes interglaciaires est résumée.

Banks Island, situated at the southwestern extremity of the Canadian Arctic Archipelago, is a polar desert where a long sequence of Quaternary events are recorded in the sediments. Laurentide ice sheets, spreading from dispersal centres to the southeast, reached their maximum extent on Banks Island on at least three occasions. The story of the three glaciations and of the intervening interglacial periods is summarized.

Vincent, J-S.

LES LACS GLACIAIRES DE L'ÎLE DE BANKS, ARCTIQUE CANADIEN; Résumés des communications, Annales de l'ACFAS, v. 48, p. 105, 1981.

La cartographie des formations superficielles de l'îles de Banks a permis de reconnaître l'existence de douze lacs glaciaires. Ceux-ci sont associés à l'un ou l'autre des trois glaciers continentaux qui ont atteint leur limite d'extension sur l'île au Quaternaire. Les lacs ont soit été piégés dans des régions non glaciées sises à la brodure des inlandsis ou ils se sont étendus sur des régions novellement librérées des glaces. Les lacs Egina et Storkerson ont inondé des surfaces du nord-ouest lors du retrait des glaces au cours de la plus ancienne Glaciation de Banks. Les lacs Parker et Dissection ont submergé des régions non glaciées du plateau du nord-est lors de la Glaciation de Thomsen antérieure au dernier interglaciare. Au cours du Stade de M'Clure de la Glaciation d'Amundsen (Wisconsinien inférieur), huit lacs ont été piégés dans des vallées en bordure des lobes de Thesiger, de Prince of Wales et de Prince Alfred qui étaient ancrés dans les bras de mer entourant l'île. Les lacs glaciaires ont fourni, en se basant sur leur localisation et sur celles de leurs exutoires, des renseignements sur le mode de déglaciation et sur la direction de retrait des glaces. Dans le cas des lacs associés au Stade de M'Clure, les liens entre ceux-ci et les divers lobes glaciaires ont permis de démontrer qu'il y avait correspondance d'âge entre les lobes de Thesiger, de Prince of Wales et de Prince Alfred.

Hardy, L. and **Vincent, J-S.**

LAST DEGLACIATION AND PROGLACIAL WATER BODIES IN JAMES BAY BASIN, QUÉBEC; Geological Society of America, Northeastern Section 1981, Annual Meeting, Bangor, Abstracts with Programs, v. 13, no. 3, p. 136, 1981.

The Québec portion of the James Bay Basin has an area of 350 000 km^2. It includes a 150 km wide flat lying belt of lowlands and an outer zone of hills reaching 700-800 m. During the deglaciation of the southern part of the basin, the Labrador sector of the Laurentide ice-sheet became divided along a north-northwest trending line where the Harricana Interlobate Moraine was built. The two residual ice caps, called New Québec and Hudson ice-sheets, retreated northeasterly and northwesterly in contact with the waters of glacial Lake Ojibway which reached altitudes of up to 500 m. In the deepest part of the lake, an ice-shelf was formed at the margin of the Hudson ice-sheet. Between 8200 and 7900 years BP, the ice-shelf grew and advanced rapidly as many as three times, and deposited the Cochrane Till. The retreat of the New Québec ice was broken by short halts and by a longer standstill shown by the Sakami Moraine. This end moraine is 630 km long and stretches between Lake Mistassini and Great Whale River on Hudson Bay. It marks the position of the New Québec ice front during the drainage of Lake Ojibway and the concurrent invasion by Tyrrell Sea. Marine limit is located at an elevation of 290 m east of James Bay and 198 m south of it. Post-Sakami ice retreat proceeded in contact with the marine waters and is detailed by the presence of multitudes of De Geer moraines. The drainage of Lake Ojibway, the marine invasion and the Sakami standstill are dated 7900 ^{14}C years BP. Much evidence, from the James Bay Basin area, can be presented to support the multi-dome model for the Laurentide ice-sheet.

Hillaire-Marcel, C., Occhietti, S., and **Vincent, J-S.**

SAKAMI MORAINE, QUÉBEC: A 500-KM-LONG MORAINE WITHOUT CLIMATIC CONTROL; Geology, v. 9, no. 5, p. 210-214, 1981.

The Laurentide ice sheet in eastern Canada disintegrated step by step, as evidenced by several morainic complexes. Although commonly interpreted as reflecting climatic evidents, it seems probable that the disintegration simply related to changes in the dynamics of the ice margin, without climatic control. From the example of the Late Glacial Sakami moraine in Quebec, formed during the drainage of Lake Ojibway into the Tyrrell Sea, the concept of a "re-equilibration moraine," already briefly proposed, is developed. The construction of such a moraine implies a stabilization of the ice front when the glacier margin, previously floating or calving in a lacustrine or marine basin, is suddenly grounded because of topographic blocking or abrupt drop of water level due to drainage. The glacial retreat then pauses until the equilibrium profile of the ice is restored, and a morainic accumulation can form during the halt.

Wade, J.A.

GEOLOGY OF THE CANADIAN ATLANTIC MARGIN ROM GEORGES BANK TO THE GRAND BANKS; in Geology of the North Atlantic Borderlands; ed. J.Wm Kerr and A.J. Fergusson, Canadian Society of Petroleum Geologists Memoir 7, p. 447-460.

Pre-drift reconstruction of continental plates around the North Atlantic, based on the geology of adjacent margins, indicates that: the Essaouira Basin was opposite the Scotian basin; the Rif area of Morocco was southwest of the Newfoundland Ridge; and Iberia lay south of the Flemish Cap east of the Grand Banks. During early Mesozoic time, tensional stresses preceding continental breakup resulted in the development of northeast-southwest trending taphrogenic basins along the southern flank of the Appalachian Orogen. Initial sedimentation consisted of continental clasts followed by salt which was deposited from carbonate and sulphate depleted brines from the Tethys.

Following the initiation of sea-floor spreading between the North American and African plates, at about 170 m.y., a normal marine regime was established and along the Canadian margin a thick shelf edge carbonate bank developed simultaneously wih back bank clastics and deeper water shales. A tectonic pulse, associated with the separation of the European and North American plates in Late Jurassic to Early Cretaceous time resulted in uplift of a large salient southeast of Newfoundland. During the same time a regional regression resulted in the development of a series of delta systems along the northeast margin of North America. The Late Cretaceous eustatic rise of sea level resulted in the deposition of a thick transgressive clastic wedge. The transgression culminated in the early Tertiary. A subsequent predominantly regressive cycle deposited an upward coarsening, prograding clastic sequence which constructed the present day continental shelves of Atlantic Canada.

Wanless, R.K., Poole, W.H., King, L.H., and **Fader, G.B.**

FLEMISH CAP GRANODIORITE: AGE AND CORRELATION; Geological Society of America, Northeastern Section, 16th Annual Meeting, Abstracts with Programs, v. 13, no. 13, p. 183, 1981.

Flemish Cap, the submarine easternmost extension of North America, off the Grand Banks of Newfoundland consists of a basement of granodiorite and some siltstone and dacite, rimmed by unconformably overlying, undeformed to weakly deformed, probably Cretaceous and younger sediments. The basement rocks were sampled by eight short drill cores. Flemish Cap granodiorite is a normal hornblende-biotite granodiorite, undeformed and only slightly altered except in one locality. Two cores consist of aphanitic dacite and laminated cherty volcanic siltstone cut by prehnite-calcite-quartz stringers (cf Conception Group); their structural relations to the granodiorite are unknown.

Hornblende from fresh granodiorite yielded a K-Ar age of 657 ± 29 Ma and from altered granodiorite 619 ± 34 and 505 ± 48 Ma. Tests indicated no incorporated excess radiogenic argon. The zircon data from the 657-Ma core are moderately discordant and do not define a unique chord. Chords drawn from the extremes of the 657 ± 29 Ma hornblende age to the zero intercept age enclose four of the five zircon data points. A least squares fit yields upper and lower intercept ages of 856 and 278 Ma respectively.

The Flemish Cap granodiorite is thus significantly older than the 610-Ma Holyrood granite of eastern Avalon Peninsula but its age is uncertain. Basement rocks of the Flemish Cap are lithologically like some Hadrynian rocks of Avalon Peninsula.

Yorath, C.J. and Chase, R.L.

TECTONIC HISTORY OF THE QUEEN CHARLOTTE ISLANDS AND ADJACENT AREAS–A MODEL; Canadian Journal of Earth Science, v. 18, p. 1717-1739, 1981.

The region including Queen Charlotte Islands, Hecate Strait, and Queen Charlotte Sound is underlain by two allochthonous terranes, Wrangellia and the Alexander terrane. The suture between them occurs in central Graham Island and cenral Hecate Strait and is coincident with the traces of the Sandpit and Rennell Sound fault zones, each of which developed in response to crustal rifting in Queen Charlotte Sound during mid-Tertiary time.

The stratigraphic succession comprises four tectonic assemblages. (1) The allochthonous assemblages comprise Paleozoic rocks of the Alexander terrane and Upper Traissic and Jurassic rocks of Wrangellia, which on the basis of paleomagnetic and biogeographical data are clearly exotic. The distribution of these terranes beneath Queen Charlotte Sound and Hecate Strait is supported by geophysical information and subsurface data obtained from offshore wells. (2) The suture assemblage is represented by extremely coarse conglomerates, massive graywackes, and turbidites of Early Cretaceous age, and possibly by Upper Jurassic plutons. (3) The post-suture assemblage is expressed by the tripartite succession of the mid- to Upper Cretaceous Queen Charlotte Group whose middle component, the Honna Formation, comprises polymictic conglomerates that may have resulted from the final accretion of the amalgamated crustal fragments of the Alexander Terrane and Wrangellia to the continental margin. (4) The rift assemblage is expressed by mid- to upper Tertiary volcanics, epizonal plutons, and terrigenous clastics. Rifting is believed to have occurred in Queen Charlotte Sound above a mantle plume and resulted in crustal attenuation through development of listric, crustal-penetrative normal faults, and concurrent extrusion of subaerial volcanics and emplacement of high-level plutons. The attenuation caused northward motion of the Queen Charlotte Islands along the Louscoone Inlet – Sandspit fault zone and subsidence in Queen Charlotte Sound where Lower Miocene marine sediments were deposited within the rift zone. Later, additional rifting in southern Hecate Strait resulted in the reactivation of the old suture zone, manifest as the Rennell Sound fault zone. Concurrent with continued terrigenous deposition and volcanism, the Queen Charlotte Islands moved northwesterly along the Rennell Sound Fault, which disrupted the earlier fault trend. The final rotation of the islands to their modern position was accomplished through left-lateral motion along the Beresford Bay and Langara Faults.

La région incluant les îles Queen Charlotte, le détroit Hecate et le bras de mer Queen Charlotte est formée de deux types de terrains allochtones, Wrangellia et Alexander. La suture tectonique entre les deux passe par le centre de l'île Graham et le centre du détroit Hecate et elle coincide avec les traces des zones de failles Sandspit et du bras Rennell, chaque faille s'étant formée par ajustement de la croûte lors du développement du fossé d'effondrement dans le bras Queen Charlotte durant le temps Tertiaire moyen.

La succession stratigraphique comprend quatre assemblages tectoniques. (1) Les assemblages allochtones qui incluent les roches paléozoiques des terrains Alexander et des roches du Triassique supérieur et du Jurassique du Wrangellia, qui en se référant aux données paléomagnétiques et biogéographiques sont nettement allochtones. La distribution de ces terrains sous-jacents au bras Queen Charlotte et au détroit Hecate est confirmée par un revelé géophysique et des données de subsurface obtenues à partir de forages au large du rivage. (2) L'assemblage de la suture tectonique est repésenté par des conglomérats extrémement grossiers, des graywackes massives et des turbidites d'âge Crétacé inférieur et possiblement par des plutons du Jurasique supérieur. (3) L'assemblage postérieur à la suture tectonique comprend une succession tripartie du groupe Queen Charlotte du Crétacé moyen à supérieur et dont la constituante du milieu est la formation Honna, cette dernière étant composée de conglomérats polygéniques qui ont pu se former par accrétion des fragments crustaux amalgamés des terrains Alexander et Wrangellia de la marge continentale. (4) L'assemblage du fossé d'effondrement comprend des roches volcaniques du Tertiaire moyen à supérieur, des plutons épizonaux et des sédiments clastiques terrigènes. La formation du fossé d'effondrement semble être apparue dans le bras Queen Charlotte au-dessus d'un panache dans le manteau et il en résulta une atténuation crustale due au développement de failles normales pénétratives listriques dans la croûte, et des extrusions concourantes de matériaux volcaniques subaériens et une mise en place de plutons surélevés. L'atténuation a provoqué le déplacement vers le nord des îles Queen Charlotte de long du petit bras Lousconne – la zone de faille Sandspit et la subsidence dans le bras Queen Charlotte où des sédiments marins du Miocène inférieur furent déposés à l'intérieur de l'aire d'effondrement. Plus tard, un effondrement additionnel dans le sud du détroit Hecate a suscité une réactivation de l'ancienne zone de suture tectonique, manifestement représentée par la zone de faille du bras Rennell. Concouramment à la déposition de sédiments terrigènes et au volcanisme, les îles Queen Charlotte se sont déplacées vers le nord-ouest le long de la faille du bras Rennell, ce qui changea la direction antérieure de la faille. La rotation finale des îles dans leur position actuelle a été réalisée à l'aide d'un mouvement latéral gauche le long des failles de la baie Beresford et Langara.

Yorath, C.J., Woodsworth, G.J., Snovely, P.D. Jr., and Chase, R.L.

THREE STRUCTURE SECTIONS ACROSS THE PACIFIC CONTINENTAL MARGIN; Geological Association of Canada, Annual Meeting 1981, Abstracts, v. 6, p. A-63, 1981.

Three structure-sections across the Canadian Pacific continental margin will be displayed:

1. Yalakon Fault to Juan de Fuca Ridge.

The principal features of this section include:

(A) Wrangellia. This allochthonous terrane, comprising upper Paleozoic to Upper Jurassic arc volcanics and sediments, oceanic tholiites and calcareous sedimentary rocks accreted to the continental margin in late Mesozoic time. In the Coast Mountains it is intruded by Jurassic to Tertiary granite-diorite complexes.

(B) Overlying Wrangellia on its western flank is a wedge of Tertiary clastics which enclose a detached slab of oceanic crust.

2. Northern Vancouver Island continental margin.

A complex association of association of Jurassic to Tertiary gabbros, diorites, slope-trench deposits and calc-alkaline volcanics is displayed as a subduction complex above the modern descending oceanic plate.

3. Hecate Strait – Queen Charlotte Sound.

This section crosses the locus of Late Jurassic to Early Cretaceous suture between Wrangellia and the Alexander Terrane and extends through a mid Tertiary rift zone in Queen Charlotte Sound. The locus of suture is coincident with the mid Tertiary Rennell Sound Fault. Crustal penetrative listric normal faults developed above a mantle plume in Queen Charlotte Sound resulting in rift basins and the disruption of western Wrangellia to form the modern Queen Charlotte Islands.