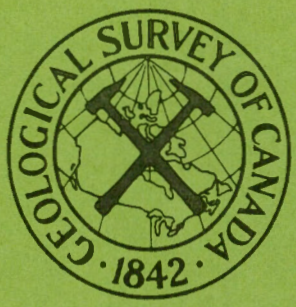

GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

PAPER 69-4

ABSTRACTS OF PUBLICATIONS IN SCIENTIFIC JOURNALS BY OFFICERS OF THE GEOLOGICAL SURVEY OF CANADA APRIL 1968 to MARCH 1969

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IN SCIENTIFIC JOURNALS ABSTRACTS OF PUBLICATIONS

BY OFFICERS OF THE GEOLOGICAL SURVEY OF CANADA

This report contains abstracts of 88 papers published by officers of the Geological Survey of Canada in scientific journals and books during the period 1 April, 1968 to 31 March, 1969. Most of these papers included abstracts, and these have been copied from the published texts; abstracts for the others were prepared by the authors concerned. The abstracts of the papers are arranged alphabetically according to author.

These papers, together with the various Geological Survey memoirs, bulletins, papers, economic geology reports, miscellaneous reports, and maps listed in the Index of Publications of the Geological Survey of Canada (G. S. C. Paper 69-3) comprise the total published output of the Geological Survey during this period.

Agterberg, F. P.

APPLICATION OF TREND ANALYSIS IN THE EVALUATION OF THE WHALESBACK MINE, NEWFOUNDLAND; Can. Inst. Mining Met., Spec. vol. 9, pp. 77-88, 95-96, 1968.

A multiplicative model is discussed for the approximation of the spatial variation of copper in the Whalesback ore deposit near Springdale, Newfoundland. Each observed assay value X is thought to consist of three components: $X = e^{P}.S.N$, where P is a three-dimensional polynomial function. S (signal) represents small-scale gradational fluctuations in copper concentration and N (noise) represents random variations or sampling errors. The trends (systematic patterns of three-dimensional variation) satisfy: $E(X) = \exp(P + 1/2\ s^2)$, where s^2 is the sum of the logarithmic variances for signal and noise. The properties of S and N are determined by the application of the techniques of serial correlation and spectral analysis to series of copper concentration values. The trends, E(X), are determined for blocks of rock that contain several hundreds of sampling points.

Aitken, J. D.

DOCUMENTATION OF THE SUB-CAMBRIAN UNCONFORMITY, ROCKY MOUNTAINS MAIN RANGES, ALBERTA; Can. J. Earth Sci., vol. 6, No. 2, pp. 193-200; 1969.

Much of the existing literature on the base of the Cambrian System in the southern Rocky Mountains tends to de-emphasize the importance of the stratigraphic hiatus represented. Although a sub-Cambrian regional unconformity has been reported by several authors, conclusive evidence of the unconformity has not been published.

This paper documents profound truncation of Miette Group strata of Windermere age at the base of the Gog Group of Early Cambrian age, and

draws attention to several localities at which Precambrian structures are truncated at the base of the Cambrian. The sub-Cambrian unconformity is comparable in style and magnitude to the sub-Devonian unconformity of the same region.

Aumento, F.

THE SPACE GROUP OF PREHNITE; Can. Mineralogist, vol. 9, Pt. 4, 1968.

The space groups of different constituent domains in prehnite crystals from Farmington, Connecticut, were identified by single crystal X-ray diffraction, transmission and replication electron microscopy, and electron diffraction.

A domain with space group P2cm is predominant in both X-ray and electron diffraction patterns. Sub-microscopic interpenetrational polysynthetic twinning of this domain simulates the space group Pncm. The latter can be observed by X-ray diffraction of apparently single macro-crystals, and by electron diffraction on twinned micro-crystals.

A domain with space group P2/n is detectable in minor proportions by X-ray diffraction of macro-crystals, but has yet to be identified by electron diffraction.

Aumento, F.

OCEANS' MINERALS AWAIT EXPLOITATION; Northern Miner, Ann. Rev. No., p. 11, 1968.

Canada, already endowed with some of the richest mineral deposits in the world, will be virtue of her geographical setting, soon be precipitated into the forefront of a new era in mineral exploitation of a magnitude previously undreamed of. Canada's ocean shoreline is more extensive than that of any other nation; the bordering oceans may possess mineral resources which are richer and more abundant than any to be found on the continents.

Aumento, F., and Loncarevic, B. D.

THE MID-ATLANTIC RIDGE NEAR 45°N. III. BALD MOUNTAIN; Can. J. Earth Sci., vol. 6, No. 1, pp. 11-23, 1969.

Metamorphosed and metasomatised basalts, and unmetamorphosed equivalents, were recovered from the steep slopes of Bald Mountain, a north-south elongated seamount lying 60 km west of the Median Rift Valley at 45°N. Block faulting and uplift of the seamount, together with the removal by submarine erosion of extrusives capping the seamount, has resulted in the exposure of the more deep-seated metamorphosed horizons along the fault scarps.

The block-faulted nature of Bald Mountain, indicative of brittle fracturing of the upper crustal layers of the Mid-Atlantic Ridge, may be a result of the low ocean floor spreading rates implied from age determinations and magnetic anomaly patterns at 45°N.

Aumento, F., Wanless, R. K., and Stevens, R. D.

POTASSIUM-ARGON AGES AND SPREADING RATES ON THE MID-ATLANTIC RIDGE AT 45°N.; Science, vol. 161, pp. 1338-1339, 1968.

Potassium-argon dates obtained from extrusives collected on a traverse across the Mid-Atlantic Ridge at 45°N. are consistent with the hypothesis of ocean-floor spreading. The dates suggest a spreading rate in the range of 2.6 to 3.2 cm per year near the axis of the ridge; the rate agrees with that computed from fission-track dating of basalt glasses. Additional data for a basalt collected 62 km west of the axis gives a spreading rate of 0.8 cm per year, which is similar to the rate inferred from magnetic anomaly patterns in the area. Reasons for the difference in calculated spreading rates are discussed.

Baer, A. J.

MODEL OF EVOLUTION OF THE BELLA COOLA-OCEAN FALLS REGION, COAST MOUNTAINS, BRITISH COLUMBIA; Can. J. Earth Sci., vol. 5, pp. 1429-1441, 1968.

Granitic rocks and metavolcanics underlie most of the Coast Mountains of British Columbia between the fifty-second and the fifty-third parallel, about half-way between Vancouver and Prince Rupert. The age of most rocks is unknown. The area has been involved in at least two orogenic cycles. The oldest known supracrustal rocks (Upper Paleozoic?) have been metamorphosed to gneisses, deformed along northeasterly trends, and intruded by granitic plutons, probably early in the Mesozoic Era. These rocks formed the basement of disconformable Mesozoic sediments and volcanics. The basement and its Mesozoic cover were metamorphosed and deformed along northwesterly trends in the early Tertiary. In the late Tertiary (Pliocene?) post-kinematic granites were emplaced and basalts were extruded for a period extending to postglacial times. The model is possibly applicable to all of the Coast Mountains in Canada.

Belyea, H. R., Sanford, B. V., and Hood, P. J.

THE GEOLOGICAL SURVEY OF CANADA AND THE OIL INDUSTRY; in Dusters and Gushers, Pitt Publishing Co. Ltd., Toronto, pp. 99-104, 1968.

Describes the activities of the Geological Survey of Canada and its connection with the Canadian oil industry during a long and important period in the economic development of Canada.

Bik, M. J. J.

MORPHOCLIMATIC OBSERVATIONS ON PRAIRIE MOUNDS; Z. Geomorphologie, vol. 12, pp. 409-469, 1968.

Two mounds with central depressions, named till and silt mounds by Henderson, (1952), prairie mounds by Gravenor (1955), and plains plateaux by Stalker (1960), were subjected to detailed analysis of form, distribution of the stone cover, granulometry and possible provenance of the constituting deposits. Changes of the mound form resulting from a sequence of morphogenetic systems succeeding each other in time, are traced and the parent form reconstructed.

The mounds occur in great numbers and in fields in the Foremost-Cypress Hills area of Alberta.

Common to all mounds, which measure up to 500 feet (183 m) in diameter and up to 30 feet (9 m) in height, is a central depression, surrounded by a rim. The latter is always breached at one and frequently at several spots on the circumference of the mounds. Though the rim is breached, the central depression may be enclosed. More often, however, it is open and the 'armchair' form is more common than the 'doughnut' shape.

The shape of the mounds, prior to partial destruction of the form by exogenetic processes, was one of greater sharpness of the rim, in the descriptive sense similar to a crater and ring wall; the rims consist of till and the apparent saddles in the rim extended to greater depth in the past. The rim outline was more irregular. The deposits found inside the depressions and on the outer slopes are explained from, in part periglacial, colluviation of till from the rims and niveo-aeolian advection of in origin lacustrine deposits. The depression was gradually filled up and the height of the rim reduced. The angle of inclination of the outer bounding slopes was reduced by deposition on the lower slope segments.

Two periglacial climatic phases, interrupted by a period of slope stability are tentatively dated as Earlier and Younger Dryas. The phase of slope stability, dated at about 10,550 radiocarbon years ago, is assigned to the Allerød. After the second periglacial phase soil formation occurred during which clay was removed from A-horizons. An ash layer, which is either synchronous with this soil or post-dates it, is correlated with the Mazama Ash fall (6,600 years B.P.); it marks the beginning of the Xerothermal (Altithermal) Period.

After deposition of the volcanic ash colluviation resumed, indicating further destruction of the mound rims. This final colluvial phase, the dating of which is uncertain, is interrupted by a period during which stone lines were formed. These stones concentrates within the colluvial deposits signify a loss of the finer material only, presumably through rainwash or deflation, from otherwise stable slope deposits. The commonly occurring stone-armour of the mound rim and the upper outer slopes mainly formed during this final colluvial phase.

Boyle, R.W., and Smith, A.Y.

THE EVOLUTION OF TECHNIQUES AND CONCEPTS IN GEOCHEMICAL PROSPECTING; in The Earth Sciences in Canada, editor, E.R.W. Neale, Roy. Soc. Can., Spec. Publ. No. 11, pp. 117-128, 1968.

The history of geochemical prospecting is outlined, beginning with the writings of the early Chinese and mediaeval European workers. The

modern development of the art springs directly from the work in the nineteen thirties of the famous Russian geochemists A. E. Fersman, V. I. Vernadsky, I. I. Ginzburg, and A. P. Vinogradov, and the Scandinavians, V. M. Goldschmidt, S. Palmqvist, and N. Brundin.

The concept of prospecting by geochemical methods was introduced into Canada by H. Lundberg in 1940, but it was not until 1945, when H. V. Warren and his co-workers at the University of British Columbia began their research, that geochemical prospecting methods began to be taken seriously. Other early workers included J. E. Riddell at McGill University who worked initially in Quebec and who later with H. Hawkes, H. Bloom, and J. S. Webb conducted the first large-scale geochemical reconnaissance survey in northern New Brunswick in 1954.

Research in geochemical prospecting by the Geological Survey of Canada began in 1949, when a study of primary haloes associated with gold deposits in the Yellowknife area was undertaken. This has been followed by work on waters and soils in the Yukon; reconnaissance surveys of waters and stream sediments in Nova Scotia and New Brunswick; biogeochemical surveys in a number of metalliferous belts in Canada; and bedrock surveys in Northern Ontario and in carbonate rocks in western Canada. In addition, a number of other projects have been carried out both in the field and in the laboratory, concerned with the development and improvement of geochemical methods and techniques.

Geochemical methods of prospecting have been adopted by industry on an ever increasing scale. From the initial efforts of E. O. Chisholm in 1949, geochemical prospecting methods have grown to be one of the major tools in mineral exploration. Several of the provincial governments have recently carried out regional geochemical studies as an aid to prospecting within their boundaries.

A principal restraint to the expansion of geochemical prospecting in Canada is the lack of training facilities at Canadian universities. Most faculties of geology offer brief courses in applied geochemistry at the undergraduate level; few are undertaking research at the graduate level. As a consequence, research in applied geochemistry in Canada lags behind that of other countries in the western world and far behind the Soviet Union. This situation must be rectified if the full potential of this powerful prospecting tool is to be realized.

Les auteurs retracent dans ses grandes lignes l'histoire de la prospection géochimique depuis le travail des pionniers de la Chine et de l'Europe médiévale. Les travaux effectués entre 1930 et 1940 par les Russes, A. E. Fersman, V. I. Vernadsky, I. I. Ginzburg et A. P. Vinogradov, les Scandinaves, V. M. Goldschmidt, S. Palmqvist et N. Brundin, géochimistes réputés, furent le prélude du développement moderne de cette science.

H. Lundberg a introduit la prospection géochimique au Canada en 1940, mais elle ne fut pas prise au sérieux avant 1945, quand H. V. Warren et ses assistants entreprirent des recherches sur ce type de prospection, à l'Université de la Colombie-Britannique. J. E. Riddell de l'Université McGill, dirigea en 1954, dans le nord du Nouveau-Brunswick, les premiers travaux de reconnaissance géochimique à grande échelle, en compagnie de H. Hawkes et de J. S. Webb, qui firent tous oeuvre de pionniers.

La Commission géologique du Canada a commencé des recherches en prospection géochimique en 1949, par l'étude des halos primaires associés

aux gisements d'or dans la région de Yellowknife. Suivirent des travaux sur les eaux et les sols au Yukon, des études de reconnaissance des eaux et des sédiments fluviaux en Nouvelle-Ecosse et au Nouveau-Brunswick, des examens biochimiques de certaines zones métallifères du Canada, ainsi que des recherches sur la roche de fond, dans le nord de l'Ontario, et des roches carbonatées de l'Ouest canadien. De plus, il a été réalisé un certain nombre de projets portant sur la mise au point des techniques et des méthodes géochimiques.

L'industrie adopte de plus en plus la prospection géochimique. Depuis les recherches effectuées à l'origine par E. O. Chisholm en 1949, la géochimie est devenue un instrument important d'exploration des minéraux. Plusieurs provinces ont récemment entreprises des études géochimiques régionales pour faciliter la prospection à l'intérieur de leurs territoires.

Le progrès de la prospection géochimique au Canada est freiné surtout par la pénurie de moyens de formation dans nos universités. La plupart des départements de géologie n'offrent que des cours très sommaires de géochimie appliquée au niveau du baccalauréat et très peu d'entre eux font de la recherche au niveau post-gradué. En conséquence, dans le domaine de la recherche en géochimie appliquée, le Canada est en retard sur les autres pays occidentaux, et très en retard sur l'Union Soviétique. Il est nécessaire de remédier à cette situation si nous voulons profiter de toutes les possibilités que la géochimie a à offrir en tant que méthode de prospection.

Burk, C. F., Jr.

TOWARDS A NATIONAL SYSTEM FOR GEOSCIENCE DATA; in Oilweek, vol. 19, No. 50, pp. 38-40, 1969.

Inspired by the pioneering efforts and encouraging results of the petroleum industry in utilizing computers for handling its enormous volumes of exploration data, the National Advisory Committee on Research in the Geological Sciences (NACRGS) commissioned a special ad hoc committee of Canadian scientists to develop a concept for a computer-oriented national system for storage and retrieval of geoscience data. Its final report was published in September, 1967 and received widespread Canadian and international distribution, placing Canada in a pre-eminent position in the development of nationally oriented computerized systems for geoscience data. Progress made towards the implementation of this national system is described.

Burk, C. F., Jr.

SUPPLY AND DEMAND OF GEOSCIENCE DATA; in Western Miner, vol. 42, No. 2, pp. 30-36, 1968.

The development of new computer-oriented methods for analyzing geoscience data begs the question: Where will the large volumes of REAL data come from? A qualitative study of the supply and demand situation reveals a great number and variety of sources of geoscience data in Canada and an equally diverse number of users. Because of the variation in data standards used by suppliers of data, a large percentage of data superficially

relevant to particular studies turns out to be useless. Geologists are then forced to obtain their own data first-hand, duplicating previous work. On balance, the demand for geoscience data greatly exceeds the supply, to a large extent because of the standards problem. A computer-oriented National System for storage and retrieval of geological data has been proposed to help increase the supply.

Burk, C.F., Jr.

DATA IN THE EARTH SCIENCES; in The Earth Sciences in Canada, editor, E.R.W. Neale, Roy. Soc. Can., Spec. Publ. No. 11, pp. 75-81, 1968.

Data are defined as any measurements or observations that are reproducible within limits imposed by the user, and may be conceptually separated from more sophisticated levels of information which involve the processing, assessment, and interpretation of data. In most of the earth sciences, the collection and storage of data have tended to be oriented almost exclusively towards individual studies, and thus it has commonly been difficult or impossible to compare data from two or more studies. Attempts to apply computer technology to earth-science problems have emphasized this deficiency and forced scientists to re-examine the nature of their data. As a result, pressures are developing for the use of common minimum standards for recording data. Additional effects of computer technology on earth-science data are the development of more efficient ways of recording data and the improvement of data quality due to 'feedback' between the scientist and the data file.

The rate of data production in the earth sciences appears to be increasing steadily, adding to the large existing backlog. If a significant part of this reservoir could be effectively mobilized by computer technology, the results would conceivably have an almost revolutionary effect on advances in the earth sciences: A large, accessible data base would be available for the testing of theories, hypotheses, and models; the co-ordination and analysis of seemingly unrelated data from a variety of sources could be routinely performed; and a dramatic improvement in the efficiency of mineral exploration could be expected.

As the first step towards mobilizing earth-science data in Canada by the use of computer technology, the National System for Storage and Retrieval of Geological Data has been proposed and certain elements of it have been implemented, most notably the establishment of a national index to geological data.

Les données sont, par définition, des mesures ou observations qu'il est possible de reproduire à l'intérieur de limites imposées et de classer séparément d'autres niveaux plus complexes de l'informatique qui comportent le traitement, l'évaluation et l'interprétation des données. Dans la plupart des sciences de la terre, l'assemblage et la mémorisation des données ayant été orientés presque exclusivement vers des études individuelles, il a été très difficile, voire même impossible, d'établir des comparaisons entre les éléments d'information fournis par différentes études. Des tentatives d'application de la technologie de l'ordination au domaine des sciences de la

terre ont mis en lumière cette déficience et forcé les scientifiques à réexaminer la nature de leurs données. Il en a donc résulté une recherche de normes communes pour l'enregistrement des données. La technologie de l'ordination a permis d'élaborer des moyens plus efficaces d'enregistrer les données et d'enaméliorer la qualité par 'contre-réaction' entre le scientifique et le fichier de l'information.

Le rythme de production des données dans le domaine des sciences de la terre semble croître régulièrement, ce qui enrichit l'ensemble déjà accumulé. Si une bonne partie de cette réserve de données pouvait être utilisée de façon efficace par l'ordinateur, les résultats pourraient avoir des effets importants sur le progrès des sciences de la terre. On pourrait disposer d'un ensemble fondamental, vaste et accessible pour vérifier les théories, les hypothèses et les modèles. Il serait possible de coordonner et d'analyser des informations apparemment étrangères les unes aux autres, provenant de sources diverses. Il pourrait en résulter une amélioration dans l'efficacité de l'exploration minérale.

Le premier pas vers l'utilisation des techniques de l'ordination dans le domaine des sciences de la terre a été fait lorsqu'il a été question d'établir un Système national de mémorisation et de sélection des données géologiques, et certaines mesures ont déjà été prises dans ce sens, notamment l'établissement d'un index national des données géologiques.

Cameron, E.M.

REGIONAL GEOCHEMICAL STUDY OF THE SLAVE POINT CARBONATES, WESTERN CANADA; Can. J. Earth Sci., vol. 6, pp. 247-268, 1969.

A regional geochemical study of the Slave Point Formation from an area of 35,000 square miles in the subsurface of western Canada was made to relate chemical variation to facies change. Core and cutting samples were obtained from ninety wells drilled for petroleum. The Slave Point is a relatively uniform and pure calcitic limestone of Middle Devonian age. A reef facies, dolomitized in places, is developed along the margin of the carbonate shelf with a shale basin. These dolomites produce natural gas from several fields.

R-mode factor analysis methods have been used to help interpret the element distribution. There are slight, but significant chemical differences between limestones occurring close to dolomites and gas discoveries and those limestones distant from these features. The principal differences are a smaller content of magnesium and strontium held in solid solution in the calcites and less clay minerals and pyrite in limestones occurring close to gas discoveries. These differences, which are related to differing conditions during deposition and diagenesis, are used to form a multivariate discriminant function separating the two groups of limestone. This discriminant function is used to classify the different limestone sections. Sphalerite (with galena and quartz) mineralization is a prominent feature of the unit and occurs principally in the dolomites along the margin of the shale basin.

Carson, D. J. T.

METALLOGENY OF VANCOUVER ISLAND; Bull. Can. Inst. Mining Met., vol. 61, No. 671, pp. 274-275, 1968.

Geologically, Vancouver Island is roughly typical of the late Paleozoic (Cache Creek) and younger Western Cordillera. It is well suited to the application of principles relating metal deposition to tectonic history (metallogeny).

The metalliferous deposits of Vancouver Island are best classified on the basis of their metal content, mineralogy, textures, physical forms, host rocks, alteration and, where applicable, related intrusions.

The classes of syngenetic eugeosynclinal deposits on Vancouver Island include the ferruginous and manganiferous cherts of the Sicker group and the cupriferous basic volcanic rocks and vanadiferous sedimentary rocks of the Karmutsen formation. Nickel-copper in Mesozoic(?) peridotite is also syngenetic. None of the deposits of these classes is known to be economic.

Massive zinc-copper-lead sulphide deposits include Lynx (Western Mines) and Twin 'J'. They occur in the Sicker group and are in 'shear zones' which are probably tightly folded incompetent cherty tuff horizons in which axial-plane cleavage approximates schistosity. They have no obvious relationship to intrusions. The metals may be syngenetic and may have been concentrated by migration to favourable structures during subsequent periods of deformation.

Iron and copper skarn deposits are numerous. Most are erratic, but some, such as Brynnor and Coast Copper, have been mined.

Most skarn deposits are related to intrusions of the main orogenic stage which occurred in mid to early-late Jurassic. These intrusions are stocks and batholiths ranging in composition from gabbro to quartz monzonite. During emplacement, they greatly deformed their host rocks, especially limestone, and skarn deposits are in the deformed rocks near intrusive tongues and apophyses.

Nearly all the skarn deposits are related to late Triassic limestone (Quatsino formation) rather than the early Permian limestone of the Sicker group. As suggested by previous authors, this may be due to the fact that the former limestone is more abundant and that it is underlain by the Karmutsen formation, which contributed iron (and copper) to the rising intrusions. An additional factor may have been lithostatic pressure, which in mid to early-late Jurassic was lower at the Quatsino formation than at the Sicker limestone. This enabled the ascending intrusions to spread laterally as tongues and apophyses in the plastic limestone, once they had breached the surface of the competent Karmutsen volcanics. Thus, the ascent of many intrusions was halted at the Quatsino formation, allowing reaction with limestone to yield skarn deposits.

Molybdenum-copper-bearing quartz veins and stockwroks are related to potassic intrusions which were emplaced during the Jurassic orogeny and in the early Tertiary. Several have been explored, but none is known to be economic.

Gold-quartz, porphyry copper, arsenic-carbonate and copper-arsenic-quartz deposits occur in linear belts of Tertiary intrusive activity which probably coincide with zones of Tertiary faulting. The porphyry copper and many gold-quartz deposits are within and adjacent to subvolcanic(?).

Tertiary quartz diorite – dacite porphyry – breccia intrusive complexes. Most arsenic and copper-arsenic deposits are in close proximity to sills and laccoliths of Tertiary dacite porphyry intruding the Nanaimo group. Past production has occurred from some gold-quartz veins, mainly those at Zeballos, and from the copper-arsenic deposit of Mt. Washington Copper.

Other classes of known or probable Tertiary deposits include copper related to Sooke gabbro (e.g., Sunro Mine), and mercury and alunite. None of these is currently mined.

Chamberlain, J. A.

GEOCHEMICAL FACTORS INFLUENCING THE FORMATION OF NICKEL SULPHIDE DEPOSITS ASSOCIATED WITH ULTRAMAFIC ROCKS; Bull. Can. Inst. Mining Met., vol. 61, No. 671, p. 297, 1968.

The total nickel content of most of the world's non-lateritized ultramafic rocks ranges between 0.1 and 0.3 per cent, and averages about 0.2 per cent. Such nickel values are approximately 25 times the crustal average, and represent tantalizingly high concentrations. One cubic mile of typical peridotite, for example, contains 2.5 million tons of nickel metal, an amount 10 times greater than Canada's entire current annual production.

The great bulk of the nickel in typical sulphide-deficient ultramafic rocks is held in the silicate structure of the mineral olivine or its principal alteration product, serpentine. The remaining nickel is partitioned variably between other silicates, oxides or minute grains of sulphide or native metal. The total sulphur content of most ultramafic bodies is of the same order of magnitude as the nickel; that is, about 0.2 per cent, which appears to be close to the limit of sulphur solubility in the silicate fraction of these rocks. For a given set of conditions in a cooling magma, sulphide minerals will segregate in appreciable amounts only where the sulphur solubility is exceeded. In such cases, which are relatively rare, the strong sulfophile character of iron and nickel (and to a less extent, copper) cause these metals to become enriched in the sulphide fraction. A corresponding depletion of nickel in the host silicates is difficult to confirm because of its vast dispersion in these rocks. Thus, sulphur rather than nickel is the critical element in the development of nickel orebodies associated with ultramafic rocks. Any geochemical evidence that provides an indication of sulphur abundance during primary cooling of ultramafic bodies should therefore be of direct importance in assessing the economic potential of a given pluton.

Theoretical considerations suggest that high sulphur fugacities in a cooling magma would tend to (1) form sulphide assemblages in which pyrite is a stable phase and (2) produce sulphide fractions having relatively high nickel:copper ratios. The applicability of these indicators seems confirmed by comparisons of the sulphides in producing nickel mines with those in most nickel 'occurrences'.

Cumming, L. M.

DEVONIAN OF CANADIAN APPALACHIANS AND NEW ENGLAND STATES; Intern. Symp. on the Devonian system: Alberta Soc. Petrol. Geologists, vol. 1, pp. 1041-1055, 1968.

Belts of Devonian granitic rocks, having radiometric ages of 405-360 m.y., occupy the central core of the entire region. This Acadian orogeny was the major event in the structural development of the eastern part of the Appalachian fold system.

Lower Devonian volcanic rocks (chiefly rhyolite flows, welded tuffs and associated sediments) are widespread throughout the central granitic terrain. The Kineo volcanic sequence of Maine and west-central New Brunswick is Emsian in age (between Onondaga and Oriskany). This volcanic facies changes to a Lower Devonian carbonate facies which characterizes the Gaspé-Connecticut synclinorium. Sedimentary iron formations with a Rhenish faunal facies (Torbrook Formation, Nova Scotia) and carbonates with interbeds of fine-grained pyroclastics (Cape Bon Ami Formation – host rock for copper sulphides at Murdockville, Québec) reflect stability of the Lower Devonian sedimentary environment both north and south of the Lower Devonian volcanic activity.

The first pulse of the Acadian orogeny, dated as pre-Early Givetian, is bracketed locally in Maine between the Chapman and Mapleton sandstones. Continued Lower and Middle Devonian subsidence and sedimentation allowed flysch (e.g. Fortin Formation) and molasse (e.g. Gaspé Sandstone Group) to accumulate in successor basins along the northern flank of the central granitic terrain.

Post-orogenic Upper Devonian clastic sediments blanketed the Acadian folded zone. Remnants of these clastics are now preserved in several widely separated regions, e.g., south-central Newfoundland (Terrenceville Formation), southern New Brunswick (Perry Formation), and southern Gaspé Peninsula (Escuminac and Fleurant formations).

Paleontologically the region is classic ground for study of Devonian plants (Psilophyton from Gaspé) and Devonian fish (Bothriolepis from Chaleur Bay). Brachiopod, ostracod and plant-microspore zones have recently been established in New Brunswick and Gaspé. Fossiliferous limestone blocks, remnants of platform carbonates deposited near the northwestward limit of the Lower Devonian marine transgression, occur as subsidence breccia-blocks in the Cretaceous intrusive at Ile Ste Hélène, in the St. Lawrence River at Montreal.

Cumming, L. M.

ST. GEORGE-TABLE HEAD DISCONFORMITY AND ZINC MINERALIZATION, WESTERN NEWFOUNDLAND; Can. Mining Met. Bull., vol. 61, pp. 721-725, 1968.

The contact between dolomite of the St. George Formation (Cambro-Ordovician) and limestone of the overlying Table Head Formation (Middle Ordovician) is a regional disconformity. This is best illustrated from exposures on Pointe Riche Peninsula, near Table Point, and along Port

au Port Bay. The contact occurs along 180 miles of the west coast of Newfoundland from St. John Island in the north to the western part of Port au Port Peninsula in the south. A disconformity of the same age occurs between the Romaine and Mingan formations on the north side of the Gulf of St. Lawrence.

Dolomitic beds beneath the disconformity locally contain concentrations of base-metal sulphides. Sphalerite occurs in dolomite pseudobreccias of the St. George Formation at Zinc Lake, 7 miles northeast of Daniels Harbour. The western Newfoundland Lower-Middle Ordovician regional disconformity is interpreted as having originated on and near the edge of a broad platform, and to have provided an important regional geological control in the localization of zinc mineralization.

Cumming, L. M.

ORDOVICIAN OF HUDSON BAY LOWLANDS; (abstr.) Geol. Soc. Am., Program, Ann. Meeting, Nov. 11-13, 1968, Mexico City, pp. 66-67, 1968.

Ordovician strata occur in two outcrop belts each with different facies along the south and southwestern side of the Hudson Platform.

Limestone and minor sandstone form a continuous belt, 840 miles long, extending from the North Knife River of Manitoba to the Kenogami River of Ontario. The belt is from 10 to 40 miles wide and is truncated in the south by a major fault scarp. This remarkably uniform Ordovician outcrop belt represents the southern and western margins of the Hudson Bay and Moose River basins. Ordovician stratigraphic units within this belt are the Bad Cache Rapids Group and the Churchill River Group. The thickness of Ordovician strata varies, from southwest to northeast, from a few feet at the wedge-edge to over 600 feet in the subsurface. The average composite Ordovician section in the northern part of the outcrop belt is 300 feet.

Arkosic sandstone, calcareous sandstone, and shale comprise a smaller Ordovician outcrop belt, 30 miles long, near the southeastern extremity of the Hudson Bay Lowlands. These strata grade into dolomite, 300 feet thick, toward central Moose River Basin.

In the Moose River Basin and along the southwestern edge of the Hudson Bay Basin, Archean crystalline rocks form the basement, and Ordovician strata are the oldest Paleozoic rocks. However, where Proterozoic sedimentary rocks are present (that is, at Churchill and at Sutton Lake), Silurian carbonates overlap onto Proterozoic basement ridges, and Ordovician strata are locally missing.

Currie, K. L.

VARIATIONS IN THE HAFNIUM/ZIRCONIUM RATIO OF HIGH GRADE METAMORPHIC ROCKS FROM SOUTHEASTERN ONTARIO, CANADA; Earth and Planetary Sci. Letters, North-Holland Publishing Co., vol. 4, pp. 299-304, 1968.

The zirconium content is inversely proportional to the hafnium/zirconium ratio in metamorphic rocks surrounding metasomatic granitoid bodies. The zirconium content reaches a maximum in a narrow border just outside the boundaries of the granitoid rocks. Experiments are described to show that such behaviour cannot result from movement of solutions, but could be the result of diffusional transport of material toward the granitoid rocks in a fluid medium.

Currie, K. L.

ON THE SOLUBILITY OF ALBITE IN SUPERCRITICAL WATER IN THE RANGE 400 to 600°C and 750 to 3,500 BARS; Am. J. Sci., vol. 266, pp. 321-341, 1968.

The results of 64 determinations of the solubility of albite by a dynamic method are reported. The departures from equilibrium were experimentally evaluated. The solute, up to 0.3 per cent by weight, is not isochemical with albite at any pressure or temperature in the range examined. The size and type of departures from isochemistry depend on pressure, temperature, and the rate of collection of the solutions. The solubility of albite in supercritical water can be quantitatively described by equations derived for non-ideal reaction mixtures. Qualitative calculations indicate that solutions may play an important petrologic role in regions surrounding dehydrating rock masses.

Currie, K. L.

A NOTE ON SHOCK METAMORPHISM IN THE CARSWELL CIRCULAR STRUCTURE, SASKATCHEWAN; in Shock metamorphism of natural materials, B.M. French and N.M. Short, editors, pp. 379-383, 1968.

Deformation lamellae on quartz and isotropic material are found in pre-Proterozoic granite, whereas the overlying Proterozoic sandstone shows no shock features. The structure formed during the early Paleozoic. Hence the shock features are not due to shockwaves propagated downward and outward, but probably to stresses directed upward.

Currie, K. L.

THE GEOCHEMISTRY OF SOME LARGE CANADIAN CRATERS; Nature, vol. 218, pp. 457-460, 1968.

It is shown that the average chemical composition of volcanic rocks from the Clearwater, Manicouagan and Carswell craters differs from the average composition of the country rocks by being richer in potassium, magnesium and heavy metals, and poorer in silica. Sampling plans are discussed, together with consideration of the evaluation of analytical errors. It is concluded that the volcanic rocks consist of a plutonic source magma, contaminated by large scale assimilation of country rocks.

Currie, K. L.

MISTASTIN LAKE, LABRADOR: A NEW CANADIAN CRATER; Nature, vol. 220, No. 5169, pp. 776-777, 1968.

Mistastin Lake (55°52'N., 63°22'W.) occupies an elliptical, east-northeast trending depression, approximately 11 by 7 miles in size, cut into moderately rugged, barren hills of pre-Cambrian granitoid and anorthositic rocks. The presence of a butte of flat lying volcanic rocks at the western end of the lake (radiometric age 202 million years), and the presence of a horseshoe-shaped central island of pre-Cambrian rocks, displaying shock metamorphism shows that a new crater of the type of the Clearwater Lakes and Manicouagan has been discovered. This hypothesis has been confirmed by field mapping.

Dyck, Willy

RADON-222 EMANATIONS FROM A URANIUM DEPOSIT; Econ. Geol., vol. 63, pp. 288-289, 1968.

In order to investigate the possibility of using radon for prospecting for uranium, soil gas samples were collected above a uranium deposit in the Bancroft, Ontario area and analysed for radon-222. Good correspondence between the gamma-ray intensity and the radon concentration across the deposit was observed. Furthermore, 90 per cent of the radon values were greater than two times background, whereas only 40 per cent of the gamma-ray values were greater than two times background.

Dyck, Willy, and Smith, A. Y.

THE USE OF RADON-222 IN SURFACE WATERS IN GEOCHEMICAL PROSPECTING FOR URANIUM; Quart. Color. School Mines, vol. 64 (1), pp. 223-236, 1969.

As part of a geochemical prospecting study of uranium, a feasibility test on the use of radon-222 in surface waters was carried out during the latter part of 1967. The radon-222 and uranium contents of some 150 surface samples from 140 sample sites in the Bancroft, Ontario, and Ottawa-Hull districts were found to vary from 0 to 2200 pc/l and 0 to 47 ppb. respectively. A difference was observed between the radon content of lakes and ponds (0 to 262 pc/l, some of the higher values being near uranium mining operations) and that of creeks and streams (0 to 2200 pc/l). No such variation was noted in the case of uranium. Although the correlation between radon and uranium values in the waters was marginal, the results indicated gross aereal correlation between radon or uranium content of surface waters and uraniferous areas.

Spot tests in winter indicated that radon levels in lake waters under the ice increase as expected, but remain more or less constant in creeks. Uranium levels on the other hand, remain more or less constant in lakes, but decrease noticably in creeks.

The low cost and simplicity of the radon method suggest considerable potential as a preliminary reconnaissance geochemical prospecting method. Tests over larger areas and in more detail are indicated.

Dyck, Willy, and Smith, A. Y.

THE USE OF RADON-222 IN SURFACE WATERS IN GEOCHEMICAL PROSPECTING FOR URANIUM; Can. Mining J., pp. 100-103, 1968.

The increased demand for uranium has resulted in renewed efforts to develop new prospecting methods. As part of a geochemical prospecting study of uranium, a feasibility test on the use of radon-222 in surface waters was carried out. During the latter part of August 1967, 59 samples of surface waters (lakes, ponds and streams) were collected in the Bancroft, Ontario area, covering approximately 100 square miles. Another 78 samples were collected during September 1967, from the Ottawa-Hull and surrounding areas. Approximately 30 of these samples came from a 50-square-mile area in the southern half of the Gatineau Hills in the Gatineau National Park, where uranium minerals are known to occur but not in economic amount. The remaining samples were collected from the Ottawa Valley.

The samples were collected from the surface and near the shore of lakes and creeks in one litre plastic bottles. Ease of access determined the sampling sites. Radon analyses were carried out as soon as possible to avoid undue loss of radon through the walls and caps of the bottles on prolonged standing. The radon concentration was measured by degassing the waters, collecting the gas and measuring its alpha activity in a ZnS cell. The uranium content of these waters was also measured using a fluorometric technique.

The radon content of surface waters varied from 0 to 2,200 pc/l (picocuries/litre) while the uranium content varied from 0 to 47 ppb (part/billion). A difference was observed between the radon content of lakes and ponds (0 to 262 pc/l, some of the higher values being near uranium mining operations) and that of creeks and streams (0 to 2,200 pc/l). No such variation was noted in the case of uranium. The higher radon content in creeks is probably due to the closer contact of the water with bedrock source. At the time of the season when these results were obtained precipitation was at a minimum and hence the creeks were probably spring fed.

Although no clear correlation between radon and uranium values in the waters was observed, the results indicated gross aereal correlation between radon or uranium content of surface waters and uraniferous areas. This seemingly contradictory phenomena must be due to the different physico-chemical properties of the two elements.

The low cost and simplicity of the radon method suggest considerable potential as a preliminary reconnaissance geochemical prospecting method. Further tests over much larger areas are indicated.

Donato[1], R. J., and Hobson, George D.

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

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[1] National Research Council, Ottawa, Ontario.

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

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

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

Fleischer, R. L.[1], Viertl, J. R. M.[1], Price, P. B.[1], and Aumento, F.

MID-ATLANTIC RIDGE: AGE AND SPREADING RATES; Science, vol. 161, pp. 1339-1342, 1968.

Fission-track dating of basaltic glass from the Mid-Atlantic Ridge gives results which are consistent with the proposal of ocean-floor spreading. Solidification ages from ~10,000 years to ~300,000 years were measured. Correlation is also possible between the magnetic anomaly patterns over the Crest Mountains at 45°N. and the geochronology of the outcropping basalts. Renewed volcanic activity well removed from the axis of the Mid-Atlantic Ridge has been demonstrated to have taken place in recent times.

Fraser, J. A., and Tremblay, L. P.

CORRELATION OF PROTEROZOIC STRATA IN THE NORTHWESTERN CANADIAN SHIELD; Can. J. Earth Sci., vol. 6, pp. 1-9, 1969.

The Epworth and Goulburn Groups comprise the lowermost sequences of the Proterozoic strata exposed near the northern margins of the Slave (structural) Province of the Canadian Shield. Each group is at least 4,600 m thick and underlies a distinct and separate area of not less than 13,000 sq. km.

The many features common to the two groups indicate that they are correlative: (1) each lies unconformably on an Archean basement; (2) each is overlain unconformably and successively by kaolinitic sandstone, by dolomite, and by Coppermine River Group basalt and sediments; (3) each has argillite and quartzite near the base, interbedded argillite and limestone in the upper

[1] General Electric Research and Development Center, Schenectady, New York.

parts, and sandstone at the top; (4) each exhibits features characteristic of deposition in shallow water; (5) both occupy similar structural basins and show the same style of folding and faulting; (6) both are traversed by gabbro dykes and sills of similar age.

Field relationships among the Proterozoic strata and the relation these strata bear to intrusive granite, dikes, and sills of known radiogenic age, define the Epworth and Goulburn Groups as of Aphebian age.

Fulton, R. J.

OLYMPIA INTERGLACIATION, PURCELL TRENCH, BRITISH COLUMBIA; Geol. Soc. Am. Bull., vol. 79, pp. 1075-1080, 1968.

Radiocarbon dates from a conformable sequence of nonglacial deposits indicate that the Purcell Trench was not occupied by ice from at least 43,800 years B. P. until after 25,840 years B. P. This interval coincides with the Olympia Interglaciation. The nonglacial deposits are overlain by till and consist of flood-plain deposits containing wood, peat, and a layer of volcanic ash. These sediments were deposited on a strongly developed paleosol which overlies a second till. Radiocarbon dates from outside the immediate study area are cited as proof that the ice, which deposited the top till, did not advance over the area until after 20,000 years B. P. and had retreated from the Purcell Trench prior to 10,000 years B. P.

Gabrielse, H.

LOWER CAMBRIAN STRATA AND BASE METALS; Western Miner, vol. 42, No. 2, pp. 22-28, 1968.

Lower Cambrian and(?) Eocambrian strata appear to be the most important host rocks for base-metal deposits in the part of the Northern Cordillera covered by this report. This relationship is significant for future exploration and for consideration in concepts of ore genesis.

Garrett, R. G., and Nichol, Ian

FACTOR ANALYSIS AS AN AID IN THE INTERPRETATION OF REGIONAL GEOCHEMICAL STREAM SEDIMENT DATA; Quart. Color. School Mines, vol. 64 (1), pp. 245-264, 1969.

Interpretation of regional geochemical survey data requires consideration of the effects of bedrock geochemistry, weathering and other secondary factors tending to modify the bedrock-soil-stream sediment relationship. Visual interpretation of complex multi-element data may only serve to recognise the obvious features leaving subtle though significant aspects undetected. Where the relationship of the minor element contents to the local environment is obscure, factor analysis can be used for identifying the dominant geochemical controls of the data. It is then possible to express the

overall data in terms of these principal geochemical associations, thus providing a method for separating the minor element variations related to different geochemical causes and hence permitting a more thorough interpretation.

Godby, E.A.[1], Hood, P.J., and Bower, M.E.

AEROMAGNETIC PROFILES ACROSS THE REYKJANES RIDGE SOUTHWEST OF ICELAND; J. Geophys. Res., vol. 73, pp. 7637-7649, 1968.

Six low-level aeromagnetic profiles were obtained across the Reykjanes ridge southwest of Iceland during 1967. The 1,300 km long profiles spaced about 100 km apart were flown at right angles to the mid-Atlantic ridge between the Greenland and European continental shelves. The magnetic anomalies have an excellent symmetry about the crest of the ridge, and the symmetry extends from the Greenland continental slope to about the 2,000 m contour on the European side. A quantitative interpretation of the results indicates that the intensity of magnetization (J) of the rock producing the axial anomaly is about 0.013 emu/cc. A plot of the average J over 20 km also shows excellent symmetry about the ridge axis, and the known geomagnetic polarity epochs have associated maxima and minima in the J plot. There appear to be 23 polarity epochs in 480 km, so that the average length of an epoch is 2.1 m.y. if a constant spreading rate of 1 cm/yr is assumed. A power spectral analysis shows a major peak at 40 km, which is about the length of a complete reversal cycle. Digital filtering was, therefore, performed to separate the anomalies due to epochs and those due to events. There are 61 reversals of the magnetic field in 500 km that are resolvable in the profiles. The magnetic anomaly pattern has a minimum amplitude and a maximum wavelength at points 260 km on either side of the ridge axes. The amplitude and wavelength are approximately symmetrical for distances of 160 km on either side of these 260 km points. Two possible explanations of this symmetry are offered: (1) If it is assumed, as was suggested by Menard, that the thickness of the second layer is directly proportional to the spreading rate, both the change in anomaly wavelength and amplitude can be explained by a symmetrical 2:1 change in spreading rate. (2) The double axes of symmetry are the locus of two dormant ridges that were active in the middle Tertiary and migrated away from one another because the material between them could not itself migrate. Any continental crustal remnants would tend to be trapped between the double-ridge system. When the two active ridges were approximately 320 km apart, they and possibly the Labrador Sea ridge became dormant. The present stage of single-ridge ocean-floor spreading began about 10 m.y. ago, and the unconformity between the two systems occurs at 100 km, where Ewing and Ewing have demonstrated that a discontinuity in the sediment thickness exists.

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[1] National Aeronautical Establishment, Ottawa, Ontario.

Gross, G. A., Little, H. W., Chamberlain, J. A., and Robinson, S. C.

GUIDELINES TO PROSPECTING; Can. Mining J., May, pp. 49-57, 1968.

A panel discussion held at the 1968 Annual Meeting of the Prospectors and Developers Association, which included the following talks: (1) A geological program for developing guidelines, by G. A. Gross; (2) favourable geological environments for uranium prospecting, by H. W. Little; (3) some geochemical factors in nickel exploration, by J. A. Chamberlain, and (4) some general guidelines for prospecting, by S. C. Robinson.

Gross, G. A.

DETAILED SURVEY TABULATES BILLIONS OF TONS OF IRON; Northern Miner, Ann. Rev. No., p. 51, 1968.

A 1,500-word review paper with 2 tables and one figure.

Hacquebard, Peter A., and Donaldson, J. Roger

COAL METAMORPHISM AND HYDROCARBON POTENTIAL IN THE UPPER PALAEOZOIC OF EASTERN CANADA; (abstr.) Geol. Soc. Am., Program, Ann. Meeting, Nov. 11-13, 1968, Mexico City, p. 124, 1968.

Coal rank is used to measure the degree of organic metamorphism and to evaluate the hydrocarbon potential, using the principles of the 'carbon ratio' theory. The rank is determined on true coal seams and small coaly fragments in clastic sediments by measuring the vitrinite reflectance. Most of the areas of deposition and nearly all terrestrial formations could thus be examined.

Within the Fundy Basin the surface bedrock shows considerable variation in regional metamorphism. A high zone, above the hydrocarbon 'deadline', extends across northern Nova Scotia, from eastern Cape Breton Island to New Brunswick. Low rank areas, below the deadline, occur in the Cumberland sub-basin, including Prince Edward Island, in the Moncton sub-basin, and in eastern New Brunswick.

The coalification is largely postorogenic, and a good correlation exists between rank and depth of overburden. In the higher-rank coals the increase in rank can be measured accurately by the reflectance. An average increase of 0.05 per cent R_o per 100 m depth (equal to a loss of 1.3 per cent volatile matter) has been recorded. This can be equated with a geothermal gradient of 46 m per degree centigrade. In the lower rank coals (above 36 per cent volatile matter), the reflectance indicates only the approximate position on the coalification band, and precise rank predictions at depth cannot be made from surface observations. However, on suitable borehole samples, rank changes can be measured and the position of the hydrocarbon deadline determined. The thickness of potential strata has thus been determined in several areas.

Harris, D. C., Jambor, J. L., Lachance, G. R., and Thorpe, R. I.

TINTINAITE[1], THE ANTIMONY ANALOGUE OF KOBELLITE; Can. Mineralogist, vol. 9, Pt. 3, 1968.

Re-examination of kobellite, a Pb-Bi-Sb sulphosalt, from the type locality, Hvena, Sweden, and from three new North American localities has led to a redefinition of the mineral and the discovery of its new antimony analogue. Electron probe analyses show that a solid solution series is present and extends from the high bismuth member to the pure antimony end-member. The ideal formula for the kobellite series is $5PbS \cdot 4(X)_2S_3$ where X is Bi and/or Sb.

The structural cell is orthorhombic with space group Pnnm. The unit-cell dimensions, as determined by Nuffield (1948) for kobellite with approximately 70 per cent Bi, are a = 22.62, b = 34.08, c = 4.02 Å, while those of the pure antimony member from Tintina, Yukon, are a = 22.30, b = 34.00, c = 4.04 Å. Densities of the minerals in the series increase from 5.47 for the antimony end-member to 6.99 for the bismuth end-member.

It is proposed that the name kobellite be retained for minerals in the series having Bi:Sb = >1:1, and that antimony-rich members (Bi:Sb = < 1:1) be assigned the new name tintinaite.

Henderson, E. P.

PATTERNED GROUND IN SOUTHEASTERN NEWFOUNDLAND; Can. J. Earth Science, vol. 5, No. 6, pp. 1443-1453, 1968.

Patterned ground is present and active on the Avalon Peninsula of Newfoundland, though in the main it is restricted to higher exposed areas of the southern half of that peninsula. The patterned ground forms resemble types previously considered confined, if a low elevations, to more northerly latitudes. Also, a permafrost base had been assumed necessary for construction of certain of the structures, but there presently is no permafrost anywhere on the Avalon Peninsula. Formation of the patterned ground was caused largely by low summer temperatures, general thinness or absence of snow cover in winter, and a strongly maritime climate. Those factors, where combined with sparse vegetation and a hard till underlying the frost-churned soils, can produce most typical patterned ground forms.

Presence of such well-developed features on the Avalon Peninsula indicates that fossil frost structures elsewhere should not everywhere be assumed to indicate much more severe climate, perhaps with permafrost, in the past. They may merely indicate an earlier, intensely maritime-type climate with a moderate winter, but a low mean, annual temperature.

Hobson, George D.

SEDIMENTARY SEISMIC SURVEYS OVER THE WATER AND LOWLANDS (OF HUDSON BAY); in Science, History and Hudson Bay, C. S. Beals and D. A. Shenstone, editors, vol. 2, pp. 615-628, 1968.

1 The name has been approved by the Commission on new minerals and mineral names, I. M. A.

Conventional refraction seismic surveys were undertaken by the Department of Energy, Mines and Resources (then Mines and Technical Surveys) in the Hudson Bay basin to determine the thickness and attitude of the sedimentary rocks underlying the waters of the Bay and the Lowland areas. A thickness of approximately 6,600 feet of sediments is calculated to be present in the centre of the Bay. Sediments of Mesozoic age overlie Paleozoic formations on the basis of seismic velocities. These younger formations show evidence of considerable structure within the sedimentary section.

Hood, Peter J.

MINERAL EXPLORATION: TRENDS AND DEVELOPMENTS IN 1968; Can. Mining J., vol. 90, No. 2, pp. 157-180, 1969.

This article reviewed the following topics for the year 1968:

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

In addition, the specifications of the following airborne geophysical surveys offered by Canadian companies as a contract service were tabulated:

(1) Aeromagnetic
(2) Combined aeromagnetic/electromagnetic
(3) Airborne radiometric

Hood, Peter J.

WORLD EXPENDITURES IN MINING GEOPHYSICS DURING 1967; Can. Inst. Mining Met. Bull., vol. 61, No. 680, pp. 1453-1459, 1968.

Data on world-wide geophysical activity in mining exploration programs are collected annually by the Society of Exploration Geophysicists' Geophysical Activity Committee as part of a continuing service to the industry. The data are obtained by sending out questionnaires to all organizations which are known to be carrying out mining geophysical work; the organizations canvassed include mining companies, contractors, government departments and universities. The questionnaire is divided into three sections; namely, ground methods, airborne methods and research. The data compiled from the questionnaires show that world-wide utilization of mining geophysical methods reached a new high in 1967 with total expenditures of (U.S.) $32,323,240. This was divided as follows: ground methods, $18,106,785; airborne methods, $10,123,405; and research, $4,093,050. For the ground

methods, most money was spent on the induced polarization technique ($5,681,780); electromagnetic methods were second in reported expenditures ($2,010,900). The total reported geophysical line mileage flown was 1,275,072 line miles, with aeromagnetic surveying being the most popular airborne method. The total amount spent on aeromagnetic surveys was $5,832,564 for 895,420 line miles. This gives an average cost of (U.S.) $6.50 per line mile.

Hood, Peter J., and Kellogg, William C.[1]

GEOPHYSICAL ACTIVITY IN 1967 APPLIED TO MINING EXPLORATION; Geophys., vol. 33, pp. 903-910, 1968.

Data on world-wide geophysical activity in mining exploration programs is collected annually by the SEG Geophysical Activity Committee as part of a continuing service to the industry. The data is obtained by sending out questionnaires to all organizations which are known to be carrying out mining geophysical work; the organizations canvassed include mining companies, contractors, government departments and universities. The questionnaire is divided into three sections, namely ground methods, airborne methods, and research. The data compiled from the questionnaires shows that world-wide utilization of mining geophysical methods reached a new high in 1967 with total expenditures of U.S. $32,323,240. This was divided as follows: ground methods - $18,106,785; airborne methods - $10,123,405; and research $4,093,050. For the ground methods, most money was spent on the induced-polarization technique ($5,681,780); electromagnetic methods were second in reported expenditure ($2,010,900). Total reported geophysical line-mileage flown was 1,275,072 line-miles, with aeromagnetic surveying being the most popular airborne method. Total amount spent on aeromagnetic surveys was $5,832,564 for 895,420 line-miles. This gives an average cost for aeromagnetic surveys of $6.50 per line-mile.

Hopkins, W.S.

SUBSURFACE MIOCENE ROCKS, BRITISH COLUMBIA-WASHINGTON, A PALYNOLOGICAL INVESTIGATION; Geol. Soc. Am. Bull., vol. 79, pp. 763-768, 1968.

Subsurface Miocene sedimentary rocks have been recognized in the Whatcom basin of southwestern British Columbia and northwestern Washington in two deep exploratory wells using palynological techniques.

The flora is characteristic of a warm temperate to temperate climate and probably represents three basic assemblages; (1) warm temperate, probably growing on the basin lowland, (2) temperate, probably growing on uplands on the basin margin, and (3) a much smaller assemblage characteristic of somewhat higher elevations and, therefore, probably well back from the basin margins.

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[1] Lockwood, Kessler and Barlett, Inc., Pasadena, California.

Howie, R. D.

STONY CREEK GAS AND OIL FIELD, NEW BRUNSWICK; in Natural Gases of North America, Am. Assoc. Petrol. Geologists, Mem. No. 9, vol. 2, p. 1819, 1968.

The Stony Creek gas and oil field, about 9 miles south of Moncton, New Brunswick, is the only productive field in Canada east of the province of Ontario. Production is from deltaic sandstone beds in the Albert Formation of Mississippian age. The field has an area of only 1,830 acres and is on the gently dipping north limb of the Weldon syncline.

Howie, R. D., and Hill, J. V.[1]

EXPLORATION - EASTERN CANADA, LAKE ERIE ACTIVITY HIGHLIGHTS 1967; in Canadian Petroleum, pp. 63, 64, 67, 1968.

Gas and oil production in Eastern Canada declined slightly during the year. Gas production in 1967 was 14,366,311 Mcf, a decrease of 1,271,487 Mcf, with the oil production at 1,248,642 bbl, a decrease of 81,975 bbl.

In southwestern Ontario, both exploration and development drilling indicated a slight increase in activity. From 1966 to 1967, exploration drilling increased from 56 tests to 68, and development drilling from 62 wells to 67, respectively. However, total footage drilled in 1967 was about 3 per cent less than in 1966, indicating a shift to shallower drilling in the eastern part of the area. Only six Cambrian wells were drilled, compared with 19 the previous year.

The exploratory drilling resulted in 14 gas discoveries all Silurian. No new oil discoveries were made.

Offshore activity in Lake Erie was very strong in 1967. The Ontario portion of the lake, 3,108,045 acres, was completely leased. Thirty-two wells were drilled, resulting in seven gas discoveries in the lake.

In the Hudson Bay lowlands, both industry and government geological and geophysical parties carried out 37 crew months. An exploratory hole was completed to the Precambrian.

Industry activity in Quebec consisted of 10.5 crew months. The Quebec government reported 20 crew months of geological surveying in the sedimentary area of the province.

In the Atlantic region, four exploratory tests were reported from New Brunswick. Both oil and gas production from the Stoney Creek field show a considerable increase over the previous year. The increased production is probably due to secondary recovery operations.

Principal interest in eastern Canada again this year was focused on the offshore prospects in the Maritimes. Offshore holdings increased from 169,543,939 acres in 1966 to 240,219,468 acres in 1967. Industry carried out 24 crew months of geophysical work and completed one deep test on Sable Island. This island is on the continental shelf approximately 180 miles southeast of Halifax.

In 1968 we anticipated that activity in eastern Canada will increase slightly over 1967.

[1] Union Gas Co. of Canada Ltd., Chatham, Ontario.

Howie, R. D., and Hill, J. V. [1]

DEVELOPMENTS IN EASTERN CANADA IN 1967; Am. Assoc. Petrol. Geologists Bull., vol. 52, No. 6, pp. 927-939, 1968.

Gas and oil production in Eastern Canada declined slightly during the year. Gas production in 1967 was 14, 366, 311 Mcf, a decrease of 1, 271, 487 Mcf. Oil production was 1, 248, 642 bbl, a decrease of 81, 975 bbl.

In southwestern Ontario, both exploratory and development drilling increased slightly. From 1966 to 1967, exploratory drilling increased from 56 tests to 68, and development drilling from 62 wells to 67. However, total footage drilled in 1967 was about 3 per cent less than in 1966, indicating a shift to shallower drilling in the eastern part of the area. Only 6 Cambrian wells were drilled, compared with 19 in 1966.

Exploratory drilling resulted in 14 gas discoveries, all Silurian. No oil discoveries were made.

Activity offshore in Lake Erie was very strong in 1967. The Ontario part of the lake, 3, 108, 045 acres, was completely leased. Thirty-two wells were drilled in the lake resulting in 7 gas discoveries.

In the Hudson Bay lowlands, industry and government completed 37 crew-months of geologic and geophysical work. An exploratory hole was completed to the Precambrian.

Industry activity in Quebec consisted of 10.5 crew-months. The Quebec government reported 20 crew months of geologic surveying in the sedimentary area of the province.

In the Atlantic region, 4 exploratory tests were reported from New Brunswick. Both oil and gas production from the Stoney Creek field showed a considerable increase from 1966. Secondary-recovery operations probably account for the increased production.

Principal interest in Eastern Canada again this year was on offshore prospects in the Maritimes. Offshore holdings increased from 169, 543, 939 acres in 1966 to 240, 219, 468 acres in 1967. Industry completed 24 crew-months of geophysical work and 1 deep test on Sable Island. This island is on the continental shelf approximately 180 miles southeast of Halifax, Nova Scotia.

In 1968 it is anticipated that activity in Eastern Canada will increase slightly from 1967.

Hutchison, W. W.

PLUTONISM IN THE PRINCE RUPERT-TERRACE AREA, NORTHERN COAST MOUNTAINS, BRITISH COLUMBIA, CANADA. PART 1. THE METAMORPHIC FRAMEWORK; (abstr.) Geol. Soc. Am., Cordilleran Section, Program, 64th Ann. Meeting, p. 66, 1968.

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[1] Union Gas Co. of Canada Ltd., Chatham, Ontario.

Investigation of an area of about 5,000 square miles in coastal British Columbia at its boundary with Alaska has revealed an extensive region of metamorphic and plutonic rocks. The oldest rocks (pre-Permian?) underlie a broad, northwest-trending, central migmatite zone. Critical mineral associations are sillimanite-muscovite, sillimanite-potash feldspar, and, locally, sillimanite-cordierite-potash feldspar. The metasedimentary rocks (Mesozoic and older?), which are most common in the western part of the area, display a progressive increase in metamorphism from greenschist facies in the west to the kyanite subfacies of the amphibolite facies in the east. Sedimentary rocks (Upper Jurassic-Lower Cretaceous) in the eastern part of the area are metamorphosed only along contacts with plutonic rock. Major areas on the outer islands and the mainland are underlain by plutonic rock.

The dominant regional structural grain trends northwest and is characterized by steep dips. An older east-northeast trend with associated recumbent folds is present in the northeast part of the area.

The regional metamorphism can be bracketed between the Barrovian and the Idahoan Facies Series; relatively low temperature-high pressure and high temperature-low pressure assemblages have not been recognized in the regionally metamorphosed rocks.

Some plutons, which were probably an integral part of the early metamorphic framework, have apparently continued to move out of their environment while metamorphism waned and have in places deformed the pre-existing fabric.

The surface distribution of metamorphic facies is asymmetrical about a northwest-trending axis. This asymmetry is defined by a broad western zone of greenschist facies rocks, a central zone of amphibolite facies, and a narrow eastern zone of greenschist regional-contact metamorphism, or local-contact metamorphism, or both. The greatest vertical uplift was in the central belt of mobile metamorphic-plutonic rocks, and the greatest relative movement was along its eastern margin.

Hutchison, W. W.

PLUTONISM IN THE PRINCE RUPERT-TERRACE AREA, NORTHERN COAST MOUNTAINS, BRITISH COLUMBIA, CANADA. PART 2. PLUTONIC ROCKS; (abstr.) Geol. Soc. Am., Cordilleran Section, Program, 64th Ann. Meeting, p. 67, 1968.

There are at least three major types of plutons in this area. The first is essentially 'tadpole' shaped in plan, with an apparently intrusive 'head' and a migmatitic 'tail'. Variation in outcrop patterns may be related to different stages in development, or levels within a pluton, or both. In the second type, the plutonic rock concordantly occupies the core of westerly directed recumbent structures, yet clearly displays intrusive relationships along the eastern margin of the steeper-dipping 'root zone'. This type is in part similar to the migmatite nappes described by Haller (1955). The third type displays sharp contacts, characteristic of late- or post-tectonic intrusives.

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

granite are rare. Interplutonic contacts are commonly gradational, but generally the more acidic plutonic rocks are younger than the more basic. Times of emplacement of most plutons are unknown. Late Cretaceous to early Tertiary K/Ar ages have been obtained from various plutons (one of which cuts Lower Cretaceous strata), and probably indicate only the minimum age of final emplacement.

Intrusive contact relationships, and textures compatible with emplacement of a partly magmatic rock, and synneusis twins of plagioclase are found only in the eastern zone of one of the nappelike plutons and in a few stocks. Elsewhere, flow structures, healing of faults, dislocation of migmatite screens, protoclastic textures, zoning of plagioclase, and locally the mineral assemblages themselves suggest the rock was not magmatic during the final major phases of movement, yet flowed in a manner analogous to a glacier or salt dome.

Jambor, J. L.

NEW LEAD SULFANTIMONIDES FROM MADOC, ONTARIO. PART 3 – SYNTHESES, PARAGENESIS, ORIGIN; Can. Mineralogist, vol. 9, Pt. 4, 1968.

At least eleven artificial sulfosalts have been prepared by heating various mixtures of galena, stibnite, and orpiment in closed tubes. Among these are the new Madoc sulfosalts playfairite, madocite, guettardite, and two lead sulfantimonides which have no mineral counterparts.

From oldest to youngest, the depositional sequence at Madoc is sulfides, arsenic-rich sulfosalts, and antimony-rich and copper-bearing sulfosalts. Precipitation of the Pb-Sb-As sulfosalts initially followed a trend of decreasing activity of As_2S_3 and probably terminated with increasing activity of Sb_2S_3 in the system. The observed paragenesis is believed to have resulted principally from the greater solubility of arsenic as compared to antimony, with temperature effects becoming a more important control toward the terminal stages of deposition.

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

A PRELIMINARY INVESTIGATION OF CHLOROPHYLL DEGRADATION PRODUCTS IN THE SEDIMENTS OF LAKES ERIE AND ONTARIO; Proc. 11th Conf. Great Lakes Res. 1968, Intern. Assoc. Great Lakes Res., Milwaukee, Wisconsin, pp. 206-229, 1968.

Thirty seven surface sediment samples from lakes Erie and Ontario have been examined for acetone-soluble chlorophyll degradation products, from stations generally distributed along the axes of the two Lakes. Determinations were made for chlorophylls, pheophytins, organic carbon, carbonate carbon, Eh, pH and particle size distribution.

Sub-environments within each lake were recognized on the basis of bathymetry, sediment particle size distribution, clay mineral content and mud thickness. Total chlorophylls (chlorophylls a and b) ranged in concentration from 0 to 30 ppm dry weight of sediment in the two Lakes. Total

pheophytin (pheophytins a and b) concentrations of 0 to 192 ppm dry weight of sediment were found, with the pheophytin concentrations along the axis of Lake Erie being generally greater than along the axis of Lake Ontario. Calculations showed that the phytoplankton chlorophylls are 93 to 100 per cent decomposed before settling on the bottom. The pheophytins decomposed an average of 70 per cent with burial in the sediment to a depth of 5 cm, whereas the organic carbon decomposed an average of 33 per cent under the same conditions. Percent organic carbon ranged from 0.23 to 3.60 in Lake Erie sediments and 1.90 to 5.00 in Lake Ontario sediments. The pheophytin concentration paralleled the organic carbon content and both varied with the clay content of the sediments. The generally lower values of organic carbon in Lake Erie are attributed to dilution of the sediments with coarser non-clay particles.

Kindle, E. D.

VARIETY IS KEYNOTE OF COPPERMINE DEPOSITS; Northern Miner, Ann. Rev. No., Nov. 28, pp. 65, 72, 1968.

The 1967-1968 staking rush to Coppermine River area has brought attention to the presence there of a great variety of copper deposits most of which occur in Proterozoic basalt flows. Chalcocite and bornite are the important sulphides, pyrite is rarely found. The copper sulphides occur in quartz veins, calcite veins, datolite-prehnite veins, shear veins, shatter zone replacements, sheared zone replacements, carbonated shear zones, amygdaloidal flow tops and flow top breccia fillings and replacements and as disseminations in diabase dykes (porphyry coppers). Native copper occurs as fine disseminations in massive basalts and sometimes as thin sheets or nuggets near the erosion surface in the veins. Some nodules of chalcocite and hematite occur in one place in sandstone on the west bank of Coppermine River.

Larochelle, A.

PALEOMAGNETISM OF THE MONTEREGIAN HILLS: NEW RESULTS; J. Geophys. Res., vol. 73, p. 3239, 1968.

Paleomagnetic directions were obtained for 74 stably and homogeneously magnetized cores drilled at 16 sites on 4 of a group of 8 basic intrusive plugs located in southeast Quebec and known as the Monteregian Hills. A statistical analysis of these data shows that the mean directions (regardless of polarity) of magnetization of the 4 sampled bodies were not significantly distinct after the cores were 'cleaned' in an alternating field of 250 oe. The circle of confidence about the mean of the 16 site means (each given unit weight) has a radius, α_{95}, of 3.8 degrees. Because of the high precision of these data it is proposed that they supersede a set of data obtained from the same series of rocks and published 5 years ago. The 74 directions yielded a paleomagnetic pole at 171.2°W., 69.9°N. This pole position is in remarkably good agreement with the poles derived from 6 different areas in North America and at present regarded as reliable estimates for the Cretaceous

period. The high coherency of the Cretaceous poles so far estimated from North American rocks strongly supports the view that the earth's magnetic field was dipolar at that time.

Lee, Hulbert A.

TYRRELL SEA; in The Encyclopedia of Geomorphology, R.W. Fairbridge, editor, pp. 1179-1181, 1968.

Tyrrell Sea is the name given to an inland sea that existed during and following deglaciation of Hudson Bay basin. It reached its maximum extent 7,000 or 8,000 years ago. Hudson Bay is a relict of the Tyrrell Sea.

The sea extended from latitude 50-66° N., excluding Foxe Channel, and arbitrarily ended at the boundary between the districts of Keewatin and Franklin. Longitude is from 75-97° W.

This region lies within the central zone of the maximum Wisconsin Laurentide ice sheet; it was greatly downwarped during the period of ice occupation, was flooded during ice recession, and later was partly emerged as upwarping progressed. The Tyrrell Sea came into being when Atlantic water penetrated through Hudson Strait into the Hudson Bay Area. The marine waters soon divided the shrunken Wisconsin Laurentide ice sheet into two, or more, separate ice caps, one to the west and one to the east of Hudson Bay.

The limit of the Tyrrell Sea is found at an elevation of about 120-180 m (400-600 feet) above present sea level west of Hudson Bay, compared with about 250-275 m (800-900 feet) east of the Bay. The emergence curve of the upwarped land is similar to that given for the Gulf of Bothnia region in Sweden by Magnusson, G. Lundqvist and Granlund and by J. Lundqvist.

The transgressive phase of the Tyrrell Sea is shown by the trends of 'DeGeer moraines'. Regional trend of the ridges is remarkably linear, typical for ice calving into water. The trend is northerly on both the west and the east sides of Hudson Bay, and it shows the orientation of the transgressive strandlines of the Tyrrell Sea.

Silt and clay were deposited in the Tyrrell Sea during both its transgressive and its regressive phases. The maximum recorded thickness is 56 m (185 feet) measured in a drillhole section at Fort-George where the silt and clay unit lies between alluvial sand at the top and bedrock at the base. Environments of deposition for the silt and clay include a basin of restricted circulation and a basin with good circulation.

Gravel, sand and boulder facies were formed during regression of the Tyrrell Sea by wave action on hill slopes. Large areas of the former sea floor, however, are not covered by sediments but are bare bedrock.

Ages of 7,875± 200 and 7,280± 50 years were obtained on shells south of Hudson Bay (Hughes, 1965), and an age of 6,975 ± 250 years was obtained on shells from west of Hudson Bay. Dates are not yet available for the east coast of Hudson Bay.

Lee, Hulbert A.

QUATERNARY GEOLOGY, PART 1, CHAPTER 9; in Science, History and Hudson Bay, C. S. Beals and D. A. Shenstone, editors, vol. 2, pp. 503-543, 1968.

This chapter on Quaternary geology of Hudson Bay summarizes the existing state of knowledge in 1965 on: (a) the chronology of the Quaternary ice-sheets west, south and southeast of Hudson Bay, (b) marine inundation during and after deglaciation, (c) interpretation of raised shorelines in terms of glacial loading and isostatic rebound, and (d) the sediments and landforms of the present nonglacial period.

The distribution of nonglacial sediments underlying till is shown for the area around the southern part of Hudson Bay. It can be said that there was not only a nonglacial interval immediately preceding the Wisconsin Laurentide glaciation in the Hudson Bay region, but that there were probably similar nonglacial intervals between still earlier glaciations.

The Tyrrell Sea is a major stratigraphic marker around Hudson Bay. This sea is discussed in terms of its paleogeography, sedimentation, and radiocarbon dating. The early phase of the sea had a major influence on the ice sheet, and caused a division of the Laurentide ice sheet into several parts during the final deglaciation of Mainland Canada. These late remnant ice masses were responsible for the glacial landforms now seen around Hudson Bay.

Time-distance profiles are drawn for an area near Fort-George to Kanaapuscow southeast of Hudson Bay, and for the area of Tavani to Ennadia west of Hudson Bay. These profiles show the chronology and deposits of the ice-recession, the marine inundation, glacial lakes, and terrestrial materials, for those regions.

Extensive dune fields are prominent in the region east and south of Hudson Bay. The important factors of dune building were strong winds at a time of reduced soil cohesion, commonly in late winter to early spring. Most of the dunes can be classified into three separate types; the parabolic dune, the transverse dune and the wind pit or furrow. Dunes are of lesser importance in those regions west and north of Hudson Bay.

An important factor in frost action at the land surface is the presence or absence of permafrost. The permafrost boundaries are shown and a number of examples are given. Bogs, generally of the string type, and muskeg are extensively developed in regions south of Hudson Bay. The string bogs, characterized by lines of organic matter separated by open water, give way to a dominance of palsa bogs with raised mounds of organic matter and ice layers, in Ungava north of about 55° 30'N. latitude. Here permafrost may play a role in development.

An appendix is given to illustrate those types of ice-flow features present around Hudson Bay. Their relative merits are discussed, as a means of determining the former direction and sense of glacial flow at any one site.

General references are selected, 34 in all, to give the reader an introduction to each of the many aspects of the Quaternary geology around Hudson Bay.

Lewis, C. F. M., and Tovell, Walter, M.[1]

BATHYMETRY AND BOTTOM DEPOSITS AT THE ENTRANCE TO GEORGIAN BAY NORTH OF BRUCE PENINSULA, ONTARIO; (abstr.) 11th Conf. Great Lakes Res. 1968, Spec. Rept. No. 3, Milwaukee, Wisconsin, pp. 65-66, 1968.

Investigations of bottom deposits were initiated by the late R. E. Deane to obtain a better understanding of present sedimentary processes and the relationships between water levels in the Georgian Bay and Huron basins during the low-level Lake Stanley phase of Lake Huron. Detailed bathymetry and a reconnaissance map of sediment distribution were prepared from SCUBA dive observations made by Deane in 1965, grab and core samples collected in 1967 and from the echograms and charts of a recent survey of the area provided by the Canadian Hydrographic Service.

The Niagara escarpment continues north from Bruce Peninsula to Fitzwilliam and Manitoulin Islands and constitutes an area of rugged relief. Extensive bank areas with water depths up to 100 feet surround numerous islands. Pitted limestone and dolomite bedrock is commonly exposed at surface; in places it is grooved. Large areas are overlain with patchy glacial deposits and local lows are commonly filled with boulders, rippled sands or eroded varved clay. These areas are apparently non-depositional and have undergone erosion. Fine-grained sediments occur elsewhere in lows or on flanks of the Huron and Georgian Bay basins where water depths exceed 120 feet. Sediments in the basin south of Flowerpot Island characteristically grade upwards from grey clay to oxidized silty sand at surface.

Re-entrants into the escarpment from the east occur south of Flowerpot Island and south of James Island. A shallow deep extends into the area north of Cove Island from the west. No deep channels connecting the Huron and Georgian Bay basins were found. The basins are completely separated below 100 feet water depth except for one well-defined channel with a sill elevation at about 460 feet asl. (120 feet water depth) passing eastward from Lake Huron north of Cove Island thence northward east of Lucas Island. From Yeo Island it swings northeastward and occurs as a steep-walled bedrock gorge with thalweg depths in excess of 200 feet. Silty clay or silty sand sediments locally impregnated with plant detritus overlie till or laminated red clay in this area.

Considerations of regional events place the low-level Lake Stanley episode at about 10,000 years B. P. Post-glacial crustal rebound adjustments, based on time-uplift diagrams derived mainly from Lake Algonquin and Nipissing Great Lakes isobase data, were applied at several critical localities. These suggest that the North Bay outlet may have been sufficiently depressed 10,000 years to drain Georgian Bay slightly below Lake Stanley level. Lake Stanley at about 300 feet asl. may have been controlled and drained by two outlets – the Yeo Island channel and the low country north of Manitoulin Island between Little Current and Whitefish Falls. Differential uplift soon caused Lake Stanley's discharge north of Manitoulin Island to be diverted through the Yeo Island channel and later caused water levels in the Huron and Georgian Bay basins to become confluent by raising the North Bay outlet. Aside from the Yeo Island channel no critical evidence relating to the above hypothesis has been recognized yet within the Georgian Bay sediment record.

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[1] Royal Ontario Museum, Toronto, Ontario.

Little, H. W., and Smith, A. Y.

TECHNIQUES CURRENTLY USED IN URANIUM PROSPECTING IN CANADA; in Symposium on the use of nuclear techniques in the prospecting and development of mineral resources, Lima, Peru, Nov. 4-8, 1968, Trans. Intern. Atomic Energy Agency, Vienna, 1969.

The sequence of existing practice in the search for uranium deposits in Canada begins with the establishment of a factual classification of types of uranium deposits and the criteria for recognition of the geological environment favourable to each type. The next step is the careful appraisal of geological maps and reports to determine regions and, more specifically, rock formations in which these criteria exist. Guidelines in the selection of such areas were given in a recent Geological Survey paper by S. M. Roscoe.

In most areas, once a favourable region or formation is selected, initial field investigation is preceded by an airborne scintillometer or airborne gamma-ray spectrometer survey. Detailed geological mapping is usually done, particularly by the larger companies, with special attention to the cause of anomalies. The form of geological studies is dependant on the type of uranium deposit; in the Elliot Lake area sedimentological studies comprise the main guidelines in the search for ore whereas structural interpretation is the keynote in such areas as Uranium City.

Detailed scintillometer grid surveys on the ground are used subsequently to pinpoint the targets to be surface trenched or diamond drilled. The drilling pattern is also governed by the type of deposit. Down-hole scintillometer probes are used to extrapolate data obtained by more costly chemical assays.

Research is being conducted, both by private industry and by the Geological Survey of Canada, into improved design and sensitivity of airborne gamma ray spectrometry, and airborne magnetometers. The Geological Survey is testing AFMAG equipment and plans to cover the Uranium City area, where pitchblende-bearing veins are in or close to faults.

Geochemical research is being undertaken on the behaviour of uranium ions in stream sediments, in soils, and in surface waters, relative to their use in prospecting for uranium deposits. Recent analyses for radon in surface waters has shown a closer relationship between radon anomalies and uranium deposits than uranium anomalies in surface waters. Radon has also been used successfully to trace dykes that are covered by glacial overburden. Both uranium content of stream sediments and radon content of surface waters are being used by prospectors and companies as tools in uranium prospecting.

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

GEOLOGICAL SURVEY OF CANADA, RADIOCARBON DATES VII; Radiocarbon, vol. 10, pp. 207-245, 1968. (Also reprinted as Geol. Surv. Can., Paper 68-2 B)

One hundred and forty-two radiocarbon age determinations on geologic samples made by the Geological Survey of Canada Radiocarbon Dating Laboratory are reported. They are on samples from various parts of

Canada as follows: Newfoundland and Labrador (2); Nova Scotia (6); Prince Edward Island (3); New Brunswick (1); Quebec (8); Ontario (17); Manitoba (7); Saskatchewan (2); Alberta (18); British Columbia (23); Yukon (17); Northwest Territories – mainland (8); Northwest Territories – Arctic Islands (30). Further tests on bone samples show that the collagen fraction yields a reliable date, but the inorganic part of the bone does not. Additional tests for contamination of both marine and freshwater shells show good agreement between different fractions in all cases where finite ages were obtained. The ages of the carbonate in marl samples is considerably older than that of the included organic matter in two cases; in a third case, where the date on the organic matter is older than that on the inorganic fraction, both dates appear too old in a regional context.

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

GEOLOGICAL SURVEY OF CANADA RADIOCARBON DATES VIII; Radiocarbon, vol. 2, pp. 22-24, 1969. (Also reprinted as Geol. Surv. Can., Paper 69-2 B.)

Fifty-six radiocarbon age determinations on archeologic samples made by the Geological Survey of Canada Radiocarbon Dating Laboratory are reported. They are on samples from various areas as follows: Newfoundland (2); Quebec (3); Ontario (11); Alberta (3); British Columbia (19); Yukon (4); Northwest Territories-Arctic Islands (12); Alaska (2). Dates on corn are consistently younger than dates on wood charcoal from identical cultural layers. This is due to isotopic fractionation in corn. Also, because of fluctuations in the C^{14} content in the atmosphere, very young radiocarbon dates (i.e., less than 500 years) must be treated with caution. Often archeologic evidence, such as ceramic seriation, provides a more accurate means of distinguishing between cultural horizons.

Macqueen, R. W.

MISSISSIPPIAN SEDIMENTS OF ARABIAN GULF TYPE, ALBERTA ROCKY MOUNTAINS AND FOOTHILLS, CANADA; (abstr.) Geol. Soc. Am., 21st Ann. Meeting, Rocky M. Sect., p. 50, 1968.

Outcrop studies in the Alberta Rocky Mountains and Foothills have delineated a lateral succession of sedimentary carbonate rock assemblages which compares closely with the sequence of recent sediments found along the south side of the Arabian Gulf. These lithic assemblages comprise the Mississippian Shunda Formation and laterally equivalent beds of the Livingstone Formation and are distributed across a belt which was about 60 miles wide before thrusting. From Foothills to western Front Ranges, the assemblages grade from microcrystalline dolomites and solution breccias, to micritic 'birdseye' limestones and microcrystalline dolomites, to micritic and argillaceous limestones, to coarse-grained oölitic and skeletal limestones, to very coarse grained skeletal limestones, to medium- or fine-grained slightly argillaceous skeletal limestones. Both the lateral succession and the types of lithic changes noted are consistent with the former presence

of sedimentary environments varying from evaporitic supratidal sabkhas and littoral carbonate flats in the Foothills to open-marine, relatively deep-water, offshore fine-grained skeletal sand environments in the western Front Ranges. The comparable seaward succession of Recent environments in the Arabian Gulf is: supratidal, dolomite-rich evaporitic sabkhas; tidal flats fringed by agal mats; quiet-water lime-mud lagoons; barrier oölitic and skeletal sand shoals and flats; and open marine skeletal sands decreasing in grain size seaward. In contrast to the modern setting, the ancient setting apparently had: (a) sub-environments, especially lagoons and sabkhas, which were areally larger, (b) sabkhas which were sites of more complete dolomitization, (c) few algal mats, and (d) lagoons which locally received large amounts of terrigenous silt and clay.

Macqueen, R. W., and Bamber, E. W.

STRATIGRAPHY AND FACIES RELATIONSHIPS OF THE UPPER MISSISSIPPIAN MOUNT HEAD FORMATION, ROCKY MOUNTAINS AND FOOTHILLS, SOUTHWESTERN ALBERTA; Bull. Can. Petrol. Geol., vol. 16, No. 3, pp. 225-287, 1968.

The widespread Meramecian Mount Head Formation (Rundle Group) consists of approximately 500 to 1,000 feet of limestones and dolomites, with local shales, sandstones, siltstones, and solution breccias, all of shallow marine origin. In the eastern ranges the formation contains six members – the Wileman, Baril, Salter, Loomis, Marston, and Carnarvon (Douglas, 1958) – which are clearly recognizable from the southern Livingstone Range near Crowsnest Pass to the eastern Fairholme Range in the Bow Valley, north of which they lose their distinctive character.

The non-skeletal limestone, solution breccia, and dolomite of the lower four members, which accumulated in shallow shoals, lagoons, and supratidal sabkhas, change facies westward into skeletal limestones of the Livingstone Formation, which were derived from widespread echinoderm-bryozoan shoals. This facies change begins with the Wileman and Baril to the east and progresses westward through the overlying Salter and Loomis. The dolomites and micritic limestones of the overlying Marston and Carnarvon Members, which originated in lagoons and sabkhas, pass westward into the barrier shoal and open marine skeletal and micritic limestones and calcareous shales of the Opal Member (new name). Only the upper part of the Carnarvon Member extends to the west where it overlies the Opal, and represents a return to widespread lagoonal conditions. Correlations across these facies changes are supported by the stratigraphic distribution of four assemblages of corals and brachiopods.

Macqueen, R. W., and Sandberg, C. A. [1]

CORRELATION OF OUTCROPPING DEVONIAN-MISSISSIPPIAN CLASTIC UNITS, ALBERTA AND MONTANA; (abstr.) Geol. Soc. Am., 21st Ann. Meeting, Rocky M. Sect., pp. 50-51, 1968.

[1] United States Geological Survey, Denver, Colorado.

The Exshaw Formation of the Alberta Rocky Mountains and Foothills unconformably overlies the Devonian Palliser Formation and is overlain by the Mississippian Banff Formation. The Exshaw Formation generally comprises a lower black carbonaceous shale and an upper dark-yellowish-orange calcareous siltstone. The shale thickens westward from a few feet in the Foothills to more than 150 feet in the western ranges; whereas, the siltstone thickens eastward from about 10 feet in the western ranges to 127 feet at the type section of the Exshaw Formation. As previously defined, the Exshaw Formation included only the lower part of the siltstone, but, as here redefined, it includes all of the siltstone because no part is lithologically separable. The siltstone is a widespread, easily mapped, homogeneous unit that is gradational with the underlying shale of the Exshaw Formation but is overlain sharply (disconformably?) by yellowish-grey calcareous shale of the Banff Formation.

The Sappington Member of the Three Forks Formation in Montana comprises a lower black carbonaceous shale and an upper sequence of mainly dark-yellowish-orange calcareous siltstone. The lower shale is continuous with that of the Exshaw Formation in Alberta; the upper siltstone sequence is closely comparable and probably correlative to that of the Exshaw Formation.

Recent studies of conodonts and spores indicate that the base of the Sappington Member is very late Devonian (lower to V) and that the Devonian-Mississippian boundary is high in the overlying siltstone. If the Exshaw Formation and Sappington Member are chronologic as well as lithologic equivalents, the Devonian-Mississippian boundary also is within the upper siltstone of the Exshaw Formation.

McCrossan, R. G.

AN ANALYSIS OF SIZE FREQUENCY DISTRIBUTION OF OIL AND GAS RESERVES OF WESTERN CANADA; Can. J. Earth Sci., vol. 6, No. 2, pp. 201-211, 1969.

Both the oil and gas reserves of Western Canada are log-normally distributed. If the total reserves are separated into groups made up of single types of occurrence, these all display log-normal distributions as well. The parametres of the distributions vary considerably for different groups of genetically related accumulations. Many of the distributions also appear to be heterogeneous, showing distinct bimodality. Several hypotheses can be offered to explain this. For instance, the reserves of the group of smaller sized pools may be under-estimated for lack of sufficient information; secondly, geologically unlike types of pools may be grouped together. If the former is the case, an estimate can be made of the additional oil and gas in aggregate that may be undeveloped in the smaller under-estimated pools. The degree of bimodality may also indicate the maturity of an exploration play. Other possibilities are also considered. The distribution curves for the total reserves show only a generalized picture and obscure the characteristics of the individual distributions of the several types of oil or gas accumulations.

McGrath, P. H.

AN INTERPRETATION OF THE MIRAMICHI BAY MAGNETIC ANOMALY, NEW BRUNSWICK; in Maritime sediments, vol. 4, No. 1, pp. 11-13, 1968.

A quantitative interpretation of the prominent magnetic anomaly centered over the northern half of Miramichi Bay (Geol. Suv. Can., Aeromagnetic Map 805 G, Chatham, New Brunswick, Sheet 21 P/3) is presented. This anomaly is caused by either a sedimentary-basic volcanic sequence or by basic intrusives, such as a dike swarm. The top of this disturbing zone is situated at a depth of 6,000 feet. Resting unconformably above this zone is a 6,000 foot thick section of Carboniferous sediments.

McGrath, P. H., and Hall, Donald H.[1]

CRUSTAL STRUCTURE IN NORTHWESTERN ONTARIO: REGIONAL MAGNETIC ANOMALIES; Can. J. Earth Sci., vol. 6, No. 1, pp. 101-107, 1969.

A regional aeromagnetic map, portraying the regional magnetic anomaly system in Northwestern Ontario west of longitude 92° W. and south of latitude 55° N. and extending westward into Manitoba to longitude 97° W. (with an additional block bounded by latitudes 54° N. and 56° N. and longitudes 97° W. and 102° W.) is presented. The map was prepared by multiple application of a two-dimensional smoothing operator applied to data digitized at 3 km intervals from the 1-inch-to-1-mile aeromagnetic map series published by the Geological Survey of Canada. Comparison was made with previous maps overlapping on portions of the area, which had been made by various techniques, including Fourier analysis, fitting of 6th-order polynomials, and photographic reduction. The general features of the anomaly system were found to be similar for all of these techniques. The regional anomaly system is found to be related in some cases to the thickness of the upper crustal layer (defined as lying above the Intermediate seismic discontinuity) and to structure within it, but not to the lower crustal layer or to the upper mantle.

McLaren, D. J.

PALEONTOLOGY IN CANADA; in Developments, trends and outlooks in Paleontology by R. C. Moore and others, J. Paleontology, vol. 42, No. 6, pp. 1334-1335, 1968.

The most significant achievements of paleontology in Canada have been in biostratigraphy. Since the war it has fallen to paleontologists from Government, University, and Industry, to carry out rigorous stratigraphic, and biochronologic investigations in the vast and, until 20 years ago, virtually unknown regions of the West, Northwest, and Arctic. It is a remarkable vindication of the methods of biochronology that accurate time scales have

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been erected for most geologic periods, and difficulties in long-range correlations have been reduced to minor chronologic subdivisions. Restudy of earlier known regions in the East has allowed greater refinements and new concepts in correlation.

Major advances include: (1) discovery of microfossils in the Precambrian Gunflint Chert on Lake Superior; (2) extension of Cambrian trilobite zonation in both North American and Atlantic Provinces into new regions; (3) start of a redescription of the Burgess Shale fauna; (4) accurate zonation using benthonic organisms in Ordovician and Silurian formations of the Cordillera, accompanied by local correlation with graptolite zones of the shale sequence and thus with the standard succession; (5) graptolite zonation of the Lower Devonian and correlation of graptolite assemblages with shelly faunas; (6) coral-brachiopod zonation of Middle and Upper Devonian strata in the West and Arctic and correlation with ammonoid and conodont standard sequences; (7) fusulinacean and ammonoid zonation in the Cordillera and Arctic in Carboniferous and Permian deposits; (8) discovery and zonation of the most complete sequence of marine Triassic faunas in the world in the Cordillera and Arctic, with subdivision of the Lower Triassic into four new stages of demonstrable world-wide significance; (9) extension of European and Greenland ammonite zonation to the Jurassic of the West and Arctic in order to effect detailed stratigraphic analyses; and (10) demonstration of the extent of principal marine faunal realms in the Cretaceous and detailed zonation of the period by ammonites and certain bivalves.

Outstanding discoveries include: (11) a unique sequence of Upper Ordovician to Lower Devonian graptolites preserved in three dimensions in Arctic Islands; (12) marine pelagic ostracoderms ranging from early Wenlockian to Early Devonian in Arctic Islands; and (13) rich faunas of graptolites, brachiopods, corals, and conodonts in continuous succession across the Silurian-Devonian boundary in Yukon.

Ecological studies have been mainly confined to reef distribution and development, and this field is open for the future. The challenge to come lies in describing the enormous and diverse faunas that were collected during major phases of exploration, the further refinement of zonation, and greater emphasis on newer fields, especially in micropaleontology, including conodonts, acritarchs, spores, and pollen.

Mulligan, R.

METALLOGENY OF THE CASSIAR BATHOLITH, YUKON AND BRITISH COLUMBIA; Bull. Can. Inst. Mining Met., vol. 61, No. 671, p. 274, 1968.

The granite core of the Cassiar Mountains in the western Cordilleran region of northern British Columbia breaks up near the Yukon boundary into a number of segments following diverse structural trends. At that latitude also, the east boundary of the western Cordilleran region veers abruptly northeastward from its northwesterly course along the Rocky Mountain Trench. The area is one of great structural complexity and numerous and varied mineral deposits.

The bedded rocks are mainly Proterozoic to Permian sediments with volcanic greenstones prominent in Devono-Mississippian and Permian

sequences. They are regionally metamorphosed in places west of the main Cassiar batholith. Permian and Mesozoic sedimentary and volcanic rocks underlie the southwesternmost part of the area. The intrusive rocks range from ultramafic to granitic in composition. The larger plutonic bodies are chiefly granodiorite or quartz-monzonite, with muscovitic, miarolitic and pegmatitic granite phases prominent in some segments. One granitic pluton contains tourmaline. Diorite forms the border zones of some granitoid plutons and makes up small satellitic bodies. Ultramafic rocks intrude the Devono-Mississippian and Permian greenstones. The distribution of the bedded rocks is determined partly by major fold patterns but in large part by a complex network of faults. Some faults cut the large granitic bodies, and one large fault zone forms the west limit of the main Cassiar batholith for more than 50 miles.

Asbestos deposits, in addition to the Cassiar asbestos mine, occur in ultramafic bodies intruding Devono-Mississippian greenstone, and a few small chromite, nickel and copper showings are associated with these rocks. Lead-zinc-silver veins and replacements are numerous in Lower Cambrian limestone along the east flank of the Cassiar batholith. Another group is emplaced in younger skarn west of the batholith, and one deposit is associated with a dioritic body. Gold- and silver-bearing quartz-tetrahedrite veins occur in a greenstone belt east of the Cassiar batholith and probably contributed to the gold placers of McDame Creek. Molybdenite-quartz-greisen veins are common along the east flank of the Cassiar batholith. Tungsten occurs as wolframite in one of these, and as scheelite in skarns farther west. Beryl occurs in pegmatites, in a quartz stockwork in granite and in one quartz-greisen-molybdenite vein. The beryllium mineral helvite is found in one fluorite-bearing magnetite skarn. Fluorite also forms small deposits elsewhere. Cassiterite is a constituent of wolframite-quartz-greisen veins and of some small tourmaline-quartz veins. Tin is a minor component of garnet, epidote and ferroactinolite in one group of silicate skarns, and is concentrated in two magnetite-rich skarns. Tin is present also in many of the lead-zinc-silver deposits, and amounts to more than a tenth of one per cent in places.

Mulligan, R., and Jambor, J. L.

TIN-BEARING SILICATES FROM SKARN IN THE CASSIAR DISTRICT, NORTHERN BRITISH COLUMBIA; Can. Mineralogist, vol. 9, Pt. 3, 1968.

Two skarns in the Cassiar District of northern British Columbia are characterized by the presence of up to 0.9 per cent SnO_2 in a unique iron-rich silicate assemblage of andradite, epidote, ferroactinolite, and hedenbergite. No normal tin minerals are present, and indications are that tin is principally in the lattice of garnet and epidote, probably as Sn^{4+} substituting Fe^{3+}.

Nichol, Ian, Garrett, R. G., and Webb, J. S.

THE ROLE OF SOME STATISTICAL AND MATHEMATICAL METHODS IN THE INTERPRETATION OF REGIONAL GEOCHEMICAL DATA; Econ. Geol., vol. 64, pp. 204-220, 1969.

Interpretation of regional geochemical survey data requires consideration of the effects of bedrock geochemistry and the influence of weathering and other secondary factors tending to modify the bedrock-soil-stream sediment relationship. Visual interpretation of complex multi-element data may only serve to recognize the more obvious geochemical patterns leaving subtle though significant features undetected. In areas of simple geochemistry exemplified by the Basement Complex of Sierra Leone, trend surface and rolling mean analysis can be used to portray trends in metal distribution and to focus attention on local areas where the data deviate significantly from the trend. Similarly, in areas of complex geology and geochemistry, factor-vector analysis is applicable as a method of determining and delineating patterns of variation in the trace element composition as a whole which may then be correlated with the geology, secondary environment or some other causal factor.

Norford, B. S., and Steele, Miriam H.

THE ORDOVICIAN TRIMERELLID BRACHIOPOD EODINOBOLUS FROM SOUTHEAST ONTARIO; Paleontology, vol. 12, pp. 161-171, 1969.

Obolus canadensis Billings, Obolellina magnifica Billings, and Dinobolus erectus Wilson are redescribed. The species are Wilderness (early Caradoc) in age. Rowell recently assigned all three species to Eodinobolus and chose Obolellina magnifica as the type species. The internal structures of the three species are described from silicified material. A hypothesis is presented for the mechanics of the opening and closing of the shell and requires articulation about a poorly defined hinge that is analogous in its position to that of the Class Articulata.

Procter, Richard M., and MacAuley, George

MISSISSIPPIAN OF WESTERN CANADA AND WILLISTON BASIN; Am. Assoc. Petrol. Geologists Bull., vol. 52, pp. 1956-1968, 1968.

Mississippian sedimentary rocks within the western Canada and Williston basin region are predominantly shallow-water marine deposits; carbonate rocks predominate on the south and argillaceous content increases northward. In most of the area, sedimentation was nearly continuous from Devonian into Pennsylvanian time. The terminal phase of Mississippian deposition was dominated by terrigenous clastics throughout the area. The original depositional extent was far greater than the area of sedimentary rocks remaining today; a significant part of the present Precambrian shield probably

was covered by Mississippian sediments. Westward thickening in the disturbed belt indicates an approach to geosynclinal conditions postulated for the Cordilleran area.

Deep erosion at the end of Paleozoic time led to the partial separation and more complete preservation of Mississippian rocks in three distinct areas: the Williston basin, southern Alberta, and northern Alberta-British Columbia. Laramide tectonics created a fourth distinct area in the Rocky Mountains. Within each area, different nomenclature and independent interpretations of basinal history have been developed. Major barriers to the complete understanding of Mississippian sedimentation have been the tendency to regard each region as a depositional entity and failure to recognize that the presently known sedimentary rocks represent only a part of their original depositional extent. Partial coincidence of these pseudogeologic provinces with political boundaries has further hindered the development of broader regional concepts.

Within this region, Mississippian sedimentary rocks contain recoverable hydrocarbon reserves in excess of 2 billion bbl of oil and 15 trillion cu feet of gas, which are present in four types of trap. Unconformity traps, containing the largest reserves, are in southern Alberta and along the northeast flank of the Williston basin. Two other types of trap important in the Williston basin are features formed by the combined effects of salt solution and erosion, and tectonic folds. Production also is found in overthrust structures along the eastern margin of the Cordillera in southern Alberta.

Reinhardt, E. W.

PHASE RELATIONS IN CORDIERITE-BEARING GNEISSES FROM THE GANANOQUE AREA, ONTARIO ; Can. J. Earth Sci., vol. 5, pp. 455-482, 1968.

Phase relations among sillimanite, cordierite, garnet, biotite, and hypersthene from regionally metamorphosed pelitic gneisses were determined from petrographic studies and the chemical compositions of 46 ferromagnesian minerals and 18 bulk rocks. The compatible mineral associations including quartz, feldspar, and opaque oxides are cordierite-sillimanite, cordierite-garnet-sillimanite, cordierite-garnet-biotite, cordierite-garnet-hypersthene, cordierite-biotite-hypersthene, cordierite-biotite, garnet-biotite, garnet-biotite-hypersthene, and biotite-hypersthene. The assemblages were graphically analyzed using A-F-M diagrams derived from compatibility tetrahedra by successive projections through the common phases quartz, alkali feldspar, plagioclase, magnetite, and ilmenite; this results in the subtraction of excess components such that A = Al_2O_3-K_2O-Na_2O-CaO, F = FeO-Fe_2O_3-TiO_2, and M = MgO. Variations in the positions of the three-phase triangles defined by cordierite, garnet, and biotite in the A-F-M system are due to systematic variations of F:M ratios for these minerals and reveal that the external conditions of metamorphism were variable over the rock sequence studied. Partitioning of elements among coexisting minerals and field evidence indicate that equilibrium was reached at constant temperature in the gneisses around Gananoque Lake; possible variations in load pressure were inadequate to cause the observed variations in F/M. A correlation between the $Fe^{+2}/(Fe^{+2} + Mg)$ of coexisting ferromagnesian silicates

and the oxidation ratios ($2Fe_2O_3/(2Fe_2O_3 + FeO)$) of respective rocks suggests that the mineralogical variations in F/M are a function of oxygen partial pressure. Increased oxygen pressures would give rise to magnetite at the expense of the ferromagnesian silicates, which would consequently become enriched in the magnesium end-members. It is further proposed that the equilibrium partial pressures of oxygen and water were interdependent in any small volume of pelitic gneiss during metamorphism, and that P_{H_2O} was the independent variable.

Rimsaite, J.

NATURAL AND LABORATORY FUSED PHLOGOPITE; (abstr.) 6th Gen. Meeting, Prague, Symp. I. 'Sheet Silicates', Intern. Mineral Assoc., p. 32, 1968.

Natural occurrence of partly fused phlogopite in an eclogite nodule from a basic rock prompted present study of thermal stability and other chemical and physical properties of mica. The partly fused phlogopite: $(Al_{.03}Ti_{.23}Fe'''_{.24}Fe''_{.74}Mg_{4.37}Mn_{.004})$ $(Si_{6.16}Al_{1.84})$ O_{20} $(OH_{3.12}F_{.18}O_{.35})$ $(K_{1.73}Na_{.15})$ has a deficient hydroxyl group and contains glassy particles that concentrate mainly along fractures and margins. Samples heated at 6° per min. retain glass inclusions to the temperature of final dehydration, fusion and recrystallization at ca 1150° C. Samples heated 50 hours at 970° C also recrystallize, and glass particles disappear with decomposition of mica.

Properties of partly fused mica and of its host rock are compared with those of other similar micas from basic and calcic rocks. Dehydration-oxidation phenomena are discussed as a function of losses of hydrogen and water from the hydroxyl group under various experimental conditions. It is concluded that thermal stability of mica is a function of its hydroxyl, fluorine and iron contents, and that naturally occurring partly fused mica provides some data on the conditions of crystallization and cooling of its host rock.

Rimsaitę, J.

GEOCHEMISTRY, MINERALOGY AND PETROLOGY OF POLY-MICA ROCKS; Proc. 23rd Intern. Geol. Congr., vol. 6, pp. 45-66, 1968.

Geochemical, mineralogical and petrological studies of biotite-muscovite and poly-mica rocks were initiated because of diverse isotopic age results obtained on various associated micas. Results of the present report are based on the writer's petrographic study of several hundred rocks and on mineralogical study of coexisting micas. The distinction of different micas from the same rock is made on the basis of differences in size, colour, type and paragenetic relations. Phlogopite-biotite, biotite-muscovite and muscovite-lepidolite assemblages are discussed in relation to the type of host rock. Pegmatites are considered as coarse-grained residual rocks, and paragenetically different early and late pegmatitic micas are chosen to demonstrate changes in their composition as a result of changing conditions during the sequence of crystallization. Examples are given of concordant and

discordant isotopic ages of coexisting micas, and interpretations are made on the basis of homogeneity and degree of alteration of the host rock.

It is concluded that: (1) a close relationship exists between the mica type and conditions of crystallization; (2) coexisting phlogopite-biotite and biotite-muscovite pairs are stable under rare favourable conditions, the earlier-crystallized mica usually alters or recrystallizes during crystallization of the late mica; (3) the late mica is more stable during postcrystallizational alteration than the early mica; (4) the compositional range of biotite that coexists with muscovite is narrow, being wider in biotites from metamorphic rocks than that in biotites from magmatic rocks; (5) the muscovite remains stable during crystallization of sericite under hydrothermal and low-metamorphic conditions, whereas the biotite alters along with associated plagioclase.

Rimsaite, J.

MICAS AND ASSOCIATED MINERALS FROM TWO LI-PEGMATITES; Can. Mineralogist, vol. 9, Pt. 4, p. 580, 1968.

Micas from Li-pegmatites were chosen for the study of the distribution of certain elements between the micas and their host minerals and inclusions in order to learn about the chemical evolution of the pegmatites and the genesis of micas.

Microcline, cleavelandite, spodumene and beryl are the hosts of muscovite and lepidolite in the Val d'Or pegmatite of the Superior Province. Three principal types of mica occur in this pegmatite: phlogopite along the margins, and muscovite and lepidolite in the centre. Micas overgrowing spodumenes are different: green spodumene is host to a greenish muscovite that contains four cations in the octahedral co-ordination $(K_{1.8}Na_{0.1})$ $(Al_{3.5}, Fe'''_{0.3}.Fe''_{0.1}, Li_{0.2})$ $(Si_{6.1}, Al_{1.9})$ O_{20} $(OH_{3.49}, F_{.05})$, whereas pink spodumene is host to a pink Li-mica that contains five cations in the octahedral co-ordination $(K_{1.7}, Rb_{0.1}, Na, Ca, Cs_{0.1})$ $(Al_{2.9}.Fe'''_{0.1}.Mn_{0.1}, Li_{1.9})$ $(Si_{6.7}, Al_{1.3})$ O_{20} $(OH_{2.4}, F_{1.7})$. Micas enclosed in beryl and in fractures of cleavelandite resemble Li-micas from the pink spodumene in chemical composition, but contain different quantities of Zn and Ni.

On the basis of increasing quantities of fluorine, lithium, rubidium, manganese and silica, the following sequence of crystallization of micas is suggested: (1) phlogopite; (2) coarse muscovite; (3) muscovite overgrowing green spodumene; (4) Li-mica overgrowing pink spodumene and lepidolite in cleavelandite fractures and (5) Li-mica overgrowing beryl. Three modes of occurrence of micas were observed in a Li-pegmatite in the Leduc Mine, in the Grenville Province: (1) fine-grained biotite in surrounding gneisses; (2) biotite sheets along the fractures of pink peristerite from the pegmatite margins and (3) Li-mica enclosed in amazonite containing inclusions of tourmaline. The biotites are similar in chemical composition, but the biotite from the peristerite fractures contains more silica, fluorine and lithium. The Li-mica contains the highest quantities of manganese, lithium, fluorite and silica, much adsorbed water, and almost six cations in the octahedral co-ordination. $(K_{1.8}, Na, Rb_{0.1})$ $(Al_{2.0}Fe''_{0.2}, Mn_{0.5}, Li_{3.1})$ $(Si_{7.1}.Al_{0.9})$ $O_{19.5}$ $(OH_{1.7}, F_{3.2})$.

Micas contain higher concentrations of the following elements than their hosts: K (except microcline), Li (except spodumene), Rb, Cs, Fe, Mn, Ni and Zn.

Ruffman, A. S., Hobson, George D., and Keen, M. J.

A SEISMIC STUDY OF THE CRUST AND MANTLE BENEATH THE BAY; in Science, History and Hudson Bay, C. S. Beals and D. A. Shenstone, editors, vol. 2, pp. 629-642, 1969.

This paper presents a preliminary account of a study of the crust and mantle of the earth underlying the Hudson Bay basin. The survey was conducted during August, 1965 and involved 9 University and Government seismic parties. Charges were detonated on the bottom of the Bay on a pre-arranged schedule. The thickness of the crust has been determined using the time-term approach over an east-west line from Churchill to the Ottawa Islands and on a line from the centre of the Bay to Chesterfield Inlet. The crust varies in thickness between 26 and 43 km.

Rutter, Nathaniel W.

A METHOD OF PREDICTING SOIL EROSION IN THE ROCKY MOUNTAIN FOREST RESERVE, ALBERTA, CANADA; (abstr.) Program, 1968 G. S. A. Rocky M. Sect. Ann. Meeting, Bozeman, Montana, p. 70, 1968.

Forest personnel concerned with watershed management in the Rocky Mountain Forest Reserve were interested in obtaining a method of predicting water erosion of potential logging areas that could be utilized by a non-erosion expert. A system was devised whereby a worker could establish qualitatively, the gross erosion hazard of a naturally occurring exposed soil in the Forest Reserve by airphoto interpretation and a reconnaissance study in the field. The steps involve determining the type and lithology of surficial deposits present, and the relative importance of certain internal and external erosion factors.

Infiltration rate, grain size characteristics, carbonate cement content, and the binding strength of silt and clay are considered the important inherent soil properties to evaluate. On the basis of these properties the least erodible soils include glacial outwash, alluvial fan and floodplain deposits, talus, and carbonate cemented till with a high percentage of gravel-sized material. The most erodible soils are lake, pond, and muskeg deposits, soil derived from bedrock, and till composed of a high percentage of silt and clay. Soils of intermediate erodibility are certain varieties of till and colluvium.

The ratings of soils based on inherent factors are evaluated with important external factors such as slope steepness and precipitation. The conclusion is reached that in the Rocky Mountain Forest Reserve, soils offer a low overall erosion risk. Only exposed soils with high silt and clay content on steep slopes offer any extensive erosion problems.

Sabina, Ann P., Jambor, J. L., and Plant, A. G.

WELOGANITE, A NEW STRONTIUM ZIRCONIUM CARBONATE FROM MONTREAL ISLAND, CANADA; Can. Mineralogist, vol. 9, Pt. 4, pp. 468-477, 1968.

Weloganite occurs in an alkalic sill which has intruded Ordovician limestone at St-Michel, Montreal Island, Quebec. Chemical analysis of the new mineral gave SrO 41.0, ZrO_2 19.4, CO_2 32.2, H_2O 6.6, sum 99.2, corresponding to $Sr_5Zr_2C_{9.3}H_{9.3}O_{32.2}$, ideally $Sr_5Zr_2C_9H_8O_{31}$.

Weloganite is trigonal, space group $P3_1, 2$, hexagonal dimensions a = 8.96, c = 18.06Å, D_m = 3.22, D_c = 3.26 for Z = 2. The strongest lines of the X-ray powder pattern are 2.81Å (10), 4.35 (9), 2.59 (7), 2.227 (7), 2.009 (7). The mineral occurs predominantly as yellow crystals which are roughly hexagonal in outline and typically irregular in width.

Sangster, D. F.

RELATIVE SULPHUR ISOTOPE ABUNDANCES OF ANCIENT SEAS AND STRATA-BOUND SULPHIDE DEPOSITS; Proc., Geol. Assoc. Can., vol. 19, pp. 79-91, 1968.

The principles used by Thode and Monster to deduce the origin of petroleum sulphur are applied to strata-bound sulphide deposits. Average sulphur isotopic compositions of sixty-six sulphide bodies occurring in rocks ranging in age from Precambrian to Tertiary are compared with isotopic compositions of contemporaneous sea-water sulphate. The orebodies are classified as being of either 'sedimentary' or 'volcanic' type depending on host rock lithology; in both types, a parallel variation exists between the isotopic compositions of strata-bound sulphide deposits and ancient seas throughout geologic time. Sulphide minerals are depleted in S^{34} relative to sea-water sulphate whereas coexisting barite gangue is slightly enriched in S^{34}.

In the 'sedimentary type', the average fractionation factor is 11.7 per mil with respect to parental sea-water sulphate; 'volcanic type' deposits show an average fractionation factor of 17.5 per mil. In trend direction, range and magnitude, close agreement exists between the average isotopic fractionation in the deposits and that produced by bacterial action.

The data support the theory that all of the sulphur in 'sedimentary' strata-bound deposits and probably a significant portion of the sulphur in 'volcanic type' strata-bound deposits was derived from contemporaneous sea-water sulphate and was reduced to sulphide by bacterial action. The slightly greater depletion of S^{34} in sulphides of the 'volcanic type' orebodies probably resulted from the incorporation of isotopically light volanic sulphur at the time of their formation.

Sangster, D. F.

SOME CHEMICAL FEATURES OF LEAD-ZINC DEPOSITS IN CARBONATE ROCKS; Bull. Can. Inst. Mining Met., vol. 61, No. 671, p. 274, 1968.

The major chemical features of lead-zinc deposits in carbonate rocks, considered as a group, can be expressed in terms of the two 'systems': Cu-Pb-Zn and Pb-Zn-Ag. In the Cu-Pb-Zn 'systems', the ores are markedly bimodal in terms of the Zn/Zn + Pb ratio and are characteristically copper-poor relative to lead and zinc. In the Pb-Zn-Ag 'system', ores from carbonate-host lead-zinc deposits are generally very low in silver, except for those few orebodies which produce by-product copper and/or contain polymetallic minerals.

Host-rock carbonate from three selected Canadian deposits, ranging in size from sub-economic occurrences to multi-million-ton orebodies, have been analyzed for trace amounts of Cu, Pb and Zn. These studies show that, as the size of the deposit increases, the Cu:Pb:Zn ratio in the host-rock carbonate approaches that of the ore.

Trace element contents of sphalerite from four selected Canadian deposits are presented as Fe-Mn-Cd, Ag-Cu-As and Cr-Ni-Co ratios. Sphalerite from one of these deposits, which field studies show has more 'hydrothermal features' than the other three, is distinguished by its relative enrichment in Mn, Ag and Ni.

Schytt, V.[1], Hoppe, G.[1], Blake, W. Jr., and Crosswald, M. G.[2]

THE EXTENT OF THE WÜRM GLACIATION IN THE EUROPEAN ARCTIC; A preliminary report about the Stockholm University Svalbard Expedition 1966; Publ. No. 79, Intern. Assoc. Sci. Hydrol., I. U. G. G. (Gen. Assembly of Bern., 1967), Comm. of Snow and Ice, pp. 207-216, 1968. Also published in Russian in Proceedings of the USSR Academy of Sciences, Geograph. Ser., No. 5, pp. 56-68, 1968.

In the light of the increased knowledge of the Antarctic ice sheet it now seems possible that the last ice sheet in northwest Europe was not split up into separate sheets over Scandinavia, the British Isles and the Spitsbergen archipelago but was rather one continuous sheet covering the very shallow North Sea and Barents Sea.

This hypothetical 'super ice sheet' has been studied by the Department of Physical Geography, Stockholm University.

Approximately 6,500 years ago great quantities of pumice drifted ashore along the northern coasts of Svalbard (on Vestspitsbergen and Nordaustlandet particularly) and the 'pumice level' then established has been found to rise from 5 m above sea level at the north end of Hinlopenstretet to just over 20 m at Finn Malmgrenfjorden (on the north coast of Nordaustlandet) and to 28 m at Wilhelmöya (in southern Hinlopen). Systematic studies of the height of the pumice level have given a very reliable map of the land uplift during the last 6,500 years, and C^{14} datings of wood, whale bones and shells from several places in Vestpitsbergen, Nordaustlandet, Kong Karls Land, Barentsöya and Hopen have shown that the rate of uplift in the areas, near the edge of the continental shelf was very high about 10,000 years ago and then

[1] Department of Physical Geography, University of Stockholm, Stockholm, Sweden.

[2] Institute of Geography, Academy of Sciences, Moscow, U.S.S.R.

slowed down very rapidly, whereas this rate has been nearly constant over the last 7,000 years in King Karls Land and Hopen, far away from the edge.

This is tentatively interpreted as evidence of a thick ice sheet over at least the northern Barents Sea.

A la lumière des connaissances croissantes de la couche de glace couvrant l'Antarctique, il semble maintenant possible que la dernière couverture de glace de l'Europe du Nord-Ouest n'a pas été déposée en couches distinctes en Scandinavie, dans les îles Britanniques et sur l'archipel du Spitzberg, mais qu'elle constituait plutôt une couverture continue couvrant les mers peu profondes du Nord et de Barents.

Cette hypothétique couverture supérieure de glace a été étudiée par le Département de Géographie Physique de l'Université de Stockholm.

Il y a approximativement 6,500 ans, de grandes quantités de pierre ponce furent poussées au rivage des côtes nord de Svalbard (particulièrement sur le Vestspitsbergen et le Nordaustlandet) et la couche de pierre ponce alors établie a été trouvée s'élever à 5 m au-dessus du niveau de la mer à l'extrémité nord du Hinlopenstretet jusqu'à 20 m à Finn Malmgrenfjorden (sur la côte nord de Nordaustlandet) et jusqu'à 28 m à Wilhelmöya (dans le Hinlopen du Sud). Les études systématiques de la hauteur de cette couche de pierre ponce a fourni une carte du relèvement du sol au cours des dernières 6,500 années et des déterminations d'âge (à l'aide de C_{14}) de bois, de fanons de baleine et de coquillages de différents endroits du Vestspitsbergen, Nordaustlandet, Kong Karls Land, Barentsöya et Hopen, ont montré que le taux du soulèvement dans les régions près de l'angle de la glace flottante continentale était très élevé il y a environ 10,000 ans, mais se ralentit alors rapidement, tandis que ce taux fut à peu près constant au cours des 7,000 dernières années dans le Kong Karls Land et Hopen, très loin de l'angle en question.

Ceci est tentativement interprété comme une preuve de l'existence d'une couche épaisse de glace sur au moins la partie Nord de la mer de Barents.

Sen Gupta, J. G.

DETERMINATION OF FLUORINE IN SILICATE AND PHOSPHATE ROCKS, MICAS AND STONY METEORITES; Anal. Chim. Acta, vol. 42, pp. 119-125, 1968.

By making certain modifications to a published procedure for fluorine in rocks, it has been possible to improve stability and extend the range of the method. The modified method has been successfully applied to silicate and phosphate rocks, micas, glass and stony meteorites containing from 60 ppm to 8 per cent fluorine. Some precautions are recommended for reliable determination of chlorine.

Sen Gupta, J. G.

DETERMINATION OF MICROGRAM AMOUNTS OF THE SIX PLATINUM GROUP METALS IN IRON AND STONY METEORITES; Anal. Chim. Acta, vol. 42, pp. 481-488, 1968.

Microgram amounts of the 6 platinum-group metals in 5 stony and 3 iron meteorites were determined spectrophotometrically after perchloric acid decomposition and ion-exchange separation. The accuracy of the determinations of osmium, ruthenium and platinum was improved by the use of more sensitive procedures; arsenazo-III was used for the determination of palladium in presence of platinum, rhodium and iridium. The data for platinum-group metals thus obtained are compared with published data obtained by neutron activation and spectrographic methods for the same meteorites or for other meteorites of the same class. With a few exceptions, the agreement between the new data and published data is satisfactory.

Stalker, A. M.

GEOLOGY OF THE TERRACES AT COCHRANE, ALBERTA; Can. J. Earth Sci., vol. 5, pp. 1455-1466, 1968.

The prominent terraces north of Bow River at Cochrane, Alberta, divide readily into an upper and a lower set. The three terraces of the upper set represent deltas built into lakes ponded in front of Laurentide ice. They were constructed between 19,000 and 15,000 years ago, when Classical Wisconsin glaciation was near its maximum. Due to the inhospitable conditions then prevailing, these upper terraces contain few or no fossils. During a warm interstade that followed, the glaciers shrank and Bow River deepened and enlarged its valley until ice readvance, about 12,000 years ago, stopped this phase of erosion. Before the glaciers in the Bow and its tributary valleys again retreated, more than 10,000 years ago, Bow River had deposited vast quantities of fill in its valley. Since then, the river has carved the five lower terraces from that fill and from the underlying bedrock.

The valley fill is here named 'Bighill Creek Formation'. It is a valuable source of gravel and sand, and a prolific supplier of vertebrate fossils. Most of the latter come from a sand unit, here called 'Clarke Pit Member', which extends throughout much of the formation. Radiocarbon dates indicate that the member is about 11,000 years old.

Stott, D. F., Gibson, D. W., and Ollerenshaw, N. C.

MESOZOIC AND CENOZOIC ROCKS BETWEEN BOW AND BRAZEAU RIVERS, ALBERTA; Alta. Soc. Petrol. Geologists, Guidebook, 16th Ann. Field Conf., pp. 67-105, 1968.

Lithology, age relationships, and depositional environments of the Mesozoic and Cenozoic successions are reviewed briefly. The relationships of Triassic marine and evaporitic sediments between Banff and Jasper are shown by columnar sections. Several schematic diagrams illustrate the facies relationships of the Cretaceous sandstones and shales in the Nordegg region.

Taylor, F. C., and Dence, M. R.[1]

A PROBABLE METEORITE ORIGIN FOR MISTASTIN LAKE, LABRADOR; Can. J. Earth Sci., vol. 6, pp. 39-45, 1969.

Mistastin Lake, Labrador, latitude 55°53'N., longitude 63°18'W., is a roughly circular lake with a large central island lying in a marked depression. A meteorite impact origin is indicated by shock metamorphism features and fracturing of anorthosite and adamellite on the central island and of inclusions in flat-lying igneous rocks on the western shore. The crater had an original diameter of about 20 km and an age, by whole-rock K-Ar determination, of 202 ± 25 m.y.

Trettin, H. P.

A PALEOZOIC-TERTIARY FOLD BELT IN NORTHERNMOST ELLESMERE ISLAND ALIGNED WITH THE LOMONOSOV RIDGE; Geol. Soc. Am. Bull., vol. 80, pp. 143-148, 1969.

A south-trending belt of sialic Paleozoic rocks on the northern coast of Ellesmere Island lines up with the Lomonosov Ridge. It was deformed (1) in Middle Ordovician or earlier time; (2) between the Late Silurian and the Middle Pennsylvanian, and (3) in the Tertiary. The Paleozoic movements elevated terrane continuous with the Lomonosov Ridge relative to terrane on the east, but the Tertiary movements did not cause such relative uplift. About 40 km inland, the south-trending orogen terminates against east-trending structures, that conform with the predominant structural grain of northern Ellesmere Island. The zone of structural intersection, marked by Early Devonian (or older) ultrabasic intrusions and a Tertiary graben, was repeatedly a site of crustal extension.

Whitmore, D. R. E., and Liberty, B. A.

BEDROCK AND MINERAL DEPOSITS; in Science, History and Hudson Bay, C. S. Beals and D. A. Shenstone, editors, vol. 2, Pt. 2, pp. 543-557, 1968.

This forms a chapter of the two-volume book on Hudson Bay, and describes the relationship of the Precambrian, Paleozoic and Cretaceous rocks of the area and their possible and actual mineral deposits, including the Rankin Inlet Nickel Mine.

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[1] Dominion Observatory, Ottawa, Canada.