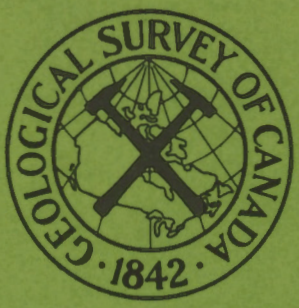

GEOLOGICAL
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DEPARTMENT OF ENERGY,
MINES AND RESOURCES

PAPER 67-4

ABSTRACTS OF PUBLICATIONS IN SCIENTIFIC JOURNALS BY OFFICERS OF THE GEOLOGICAL SURVEY OF CANADA, January 1966 to March 1967.

Compiled by Dervorguilla Snowden

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ABSTRACTS OF PUBLICATIONS IN SCIENTIFIC JOURNALS BY OFFICERS OF THE GEOLOGICAL SURVEY OF CANADA, JANUARY 1966 TO MARCH 1967

This report contains abstracts of 103 papers published by officers of the Geological Survey of Canada in scientific journals and books during the period January 1st, 1966 to March 31st, 1967. 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 the 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 67-3) comprise the total published output of the Geological Survey during this period.

Agterberg, F.P.

MARKOV SCHEMES FOR MULTIVARIATE WELL DATA; Proc. Symposium on Computers in Mining and Exploration, Pennsylvania State University, April 1966, vol. 2, pp. xi-18, 1966.

A method of multivariate analysis by using first-order Markov schemes is discussed. Its purpose is to find one or more linear combinations of the variables which show the strongest serial correlation or 'most' trend. The method is applied to the concentration values for eight elements in the core of two wells penetrating the Swan Hills reef of west-central Alberta. Factor analysis is also applied to these data and the variation patterns for the factor scores are compared to those for the trend factor scores obtained with the help of the method of Markov schemes.

(F.P.A.)

Agterberg, F.P.

THE USE OF MULTIVARIATE MARKOV SCHEMES IN PETROLOGY; J. Geol., vol. 74, No. 5, Part 2, pp. 764-785, 1966.

Multivariate observations in a series may be related to each other by a transition matrix. In this way, systematic variations of the multivariate system with distance or time can be described. From the transition matrix, a trend factor may be extracted which denotes the linear combination of the variates which shows most trend.

The method is applied to two series of major oxide data from the basaltic rocks of Yellowknife, Canada. The trend factor describes a periodical curve suggesting some long-period fluctuations in chemical composition of the basaltic magma.

Agterberg, F.P.

TREND SURFACES WITH AUTOCORRELATED RESIDUALS; Proc. Symposium on Computers in Mining and Exploration, Pennsylvania State University, April 1966, vol. 1, pp. H1-19, 1966.

The technique of surface fitting by the method of least squares is applied to sets of copper assay values from the 425 level of the Whalesback Mine, Newfoundland, Canada. The problem of how many boreholes should be included for solving a quadratic surface is considered. When too many holes are included, the surface may not represent the trend when the pattern is too complex for an exponential polynomial equation of the second degree. With the help of the F-test, it can be decided where the trend equations should be cut off.

If too few holes are included, the trend surface may be poor due to insufficient data. The reliability of a surface is indicated by its 95% confidence interval. Both the F-test and the width of confidence intervals are corrected to account for autocorrelation effects in the residuals.

(F.P.A.)

Agterberg, F.P.

TWO-DIMENSIONAL WEIGHTED MOVING AVERAGE TREND SURFACES FOR ORE VALUATION; a contribution to discussion of paper by D.G. Krige, Proc. Symposium on Mathematical Statistics and Computer Applications in Ore Valuation, Johannesburg, S. Africa, March 1966, pp. 39-45, 1966.

Contains a description of computer techniques used for the statistical analysis of assay values from some Canadian sulphide deposits. The technique of serial correlation and power spectrum analysis are applied to a series of 111 copper values from a drift in the footwall at the 425 level of the Whalesback Mine, near Springdale, Newfoundland. Methods of trend analysis are also discussed.

(F.P.A.)

Aitken, J.D.

MIDDLE CAMBRIAN TO MIDDLE ORDOVICIAN CYCLIC SEDIMENTATION, SOUTHERN ROCKY MOUNTAINS OF ALBERTA; Bull. Can. Petrol. Geol., vol. 14, No. 4, pp. 405-441, 1966.

The stable-shelf succession of the Middle Cambrian to Middle Ordovician of the southern Rockies consists of a limited number of rock-types, predominantly of very shallow-water origin, each of which is repeated many times throughout the succession in a cyclic manner. Eight asymmetrical depositional cycles are represented, each comprising 300 to 2,000 feet of strata and two or more fossil zones. Each of the cycles commences at an abrupt basal contact, and consists of a lower, shaly half-cycle gradationally overlain by a carbonate half-cycle. These cycles in the stratigraphic succession reflect lateral shifts in the positions of the inner detrital, middle

carbonate, and outer detrital facies belts. All formational contacts are drawn at the beginnings or mid-points of depositional cycles.

Rhythmic repetitions of sequences of beds occur within both shaly and carbonate half-cycles, at an estimated frequency of 20 to 50 per cycle. The subcycles vary in character according to stratigraphic and geographic position, but all may be reasonably interpreted as resulting from a sudden increase in water depth and supply of terrigenous sediment, followed by gradual shoaling in clearing waters. The major cycle is interpreted as reflecting a similar sequence of environments, occurring over a much longer period.

Any hypothesis constructed to explain the cyclic deposition must take into account the following:

1. Cycles and subcycles reflect sequences of events parallel in character but different in magnitude and duration.

2. Large areas of the shelf are affected simultaneously.

3. Uplift in the source area, manifested by an increased supply of detritus, coincides with subsidence in the area of deposition, manifested by deeper-water lithofacies.

A "tilting-craton theory" has been constructed to satisfy the above requirements.

Anderson, F.D.

STRUCTURE OF THE BAY D'ESPOIR GROUP, NEWFOUNDLAND; (abst.) Geol. Soc. Am., Program North Eastern Section, Meeting Mar. 16-18, 1967, Boston, Mass., p. 1, 1967.

The Bay d'Espoir Group consists largely of slate and siltstone and their metamorphic equivalents. The strata are of Middle Ordovician (?) age and are best exposed around Bay d'Espoir in southern Newfoundland.

The group occupies four structural zones: (1) A northern zone characterized by highly folded strata with well-developed axial-plane cleavage. The axial planes strike northeast and dip 45-65° NW.; the axes are nearly horizontal. (2) A zone of more intensely folded strata with subhorizontal cleavage. The folds are generally cleavage folds; the axial planes commonly strike northeast and dip gently southeast, and their axes are nearly horizontal. (3) A zone of relatively undisturbed strata with broad open folds. (4) A southern zone of highly faulted and metamorphosed north-dipping strata.

Studies of mesostructures and megastructures show that the group has undergone several stages of deformation, the order of which has probably been: (1) folding; (2) development of subhorizontal cleavage; (3) faulting; (4) folding.

Anderson, T.W., and Terasmae, J.

PALYNOLOGICAL STUDY OF BOTTOM SEDIMENTS IN GEORGIAN BAY, LAKE HURON; Great Lakes Research Division University of Michigan, Pub. No. 15, p. 164, 1966.

A series of surface samples of bottom sediment from precisely located stations has been collected and examined for pollen and spores from central Georgian Bay. The assemblages obtained show a relationship to the surrounding regional vegetation and are different from those obtained from lakes and bogs north and south of Georgian Bay in the boreal and deciduous forest regions, respectively. The dispersal and deposition of pollen in a large body of water requires further study for a satisfactory explanation of pollen deposition, which is necessary for a reliable interpretation of post-glacial pollen diagrams of deep-water sediments in the Great Lakes.

A bottom contour map has been prepared from available sounding data. It indicates the presence of a possible submerged valley system in Georgian Bay and shows that infilling by Pleistocene deposits has been insufficient to significantly obscure the pre-existing bedrock relief.

Armstrong, J.E.

GLACIATION ALONG A MAJOR FIORD VALLEY IN THE COAST MOUNTAINS OF BRITISH COLUMBIA, CANADA; (abst.) Geol. Soc. Am., Program, Ann. Meeting, Nov. 14-16, 1966, San Francisco, Calif., p. 7, 1966.

Four hundred and fifty miles northwest of the United States border a major northerly trending fiord valley transects the Coast Mountains of British Columbia. This fiord valley is more than 120 miles long and varies in width from 3 to 15 miles. It consists of a fiord called Douglas Channel in its southern half and the Kitimat-Terrace valley in its northern half. The withdrawal of the last major Cordilleran ice sheet during Fraser Glaciation from this valley more than 10,800 years B.P. was followed by an invasion of the sea for a minimum distance of 60 miles from the present seacoast at the head of Douglas Channel. Widespread deposits of clays and silts containing marine shells and overlying till crop out up to altitudes of 450 feet.

Shells collected from the late Fraser marine sediments in 3 localities lived about 10,800, 10,400, and 9,900 years B.P. The deposition of these sediments was interrupted in places one or more times by the occupation of at least part of the valley by valley glaciers of late Fraser Glaciation. A valley glacier is represented by a poorly exposed till that was deposited between about 10,800 and 10,400 years B.P. A late stage of this valley glacier or a second valley glacier is represented by widespread glaciofluvial deltaic gravel and sand that was deposited between about 10,400 and 9,900 years B.P. The deltas occur up to altitudes of 750 feet.

The author correlates the late Fraser marine deposits with the Everson Interstade deposits found in the Fraser Lowland on both sides of the United States border. He correlates the deposits attributed to valley glaciers with Sumas Stade deposits of the same area. Correlation with the classical Wisconsin is speculative, but he believes these late Fraser glacial deposits may represent the same climatic event as the Valders of midcontinent.

Armstrong, J.E.

TECTONICS AND MERCURY DEPOSITS IN BRITISH COLUMBIA; in Tectonic History and Mineral Deposits of the Western Cordillera, Can. Inst. Min. Metallurgy, Special vol., No. 8, pp. 341-348, 1966.

Most of the cinnabar deposits in British Columbia lie along major fault zones in carbonatized rocks. The fault zones provided channelways for carbonate solutions and for later mineralizing solutions both of a deep-seated origin. The carbonatized rocks were good host rocks. The two major deposits, Pinchi Lake and Bralorne Takla occur in altered limestones. Deposits in limestone are not common elsewhere in North America but occur also at Terlingua, Texas. Some of the cinnabar deposits in British Columbia occur in carbonatized serpentines, similar to the larger deposits in California. Most writers state that mercury deposits form at relatively low temperatures and pressures in areas believed to have undergone Tertiary volcanism and restricted erosion. Not much evidence of Tertiary volcanism and of restricted erosion is obvious near the mercury areas in British Columbia except in the Kamloops area, however several writers suggest porphyry dykes found near the Fraser-Yalakom deposits indicate a Tertiary origin for them.

The cinnabar deposits at Pinchi Lake and Bralorne Takla mercury mines were probably deposited from slightly alkaline sulphide hydrothermal solutions modified by mixing with meteoric waters. Most of the orebodies at Pinchi occur in permeable limestone below impervious cap rocks. Many quicksilver deposits in North America occur below impervious caps.

Much of the cinnabar in British Columbia's mercury deposits appears to occupy pre-existing spaces but replacement may have played an important role.

The most obvious geological feature of British Columbia's mercury deposits is their structural control, particularly their relation to major fault zones.

Aumento, F.

MAGMATIC EVOLUTION ON THE MID-ATLANTIC RIDGE; Earth and Planetary Science Letters, vol. 2, No. 3, 1967.

Recent field and experimental evidence is used to produce a model which explains the generation and characteristics of the basalts found on the Mid-Atlantic Ridge.

Multiple cycles of partial melting of the upper mantle, related to tectonic patterns beneath the axis of the Ridge, are thought to generate the different magma types. The sudden stress releases due to faulting on the Median Rift Valley result in considerable partial melting of a pyrolite mantle, which initiates a volcanic cycle with the subsequent extrusion of tholeiitic lava. As the original energy is consumed, the extent of partial melting possible is gradually reduced, so that smaller quantities of magma, progressively enriched in alkalis, are generated. The last extrusions of a volcanic

cycle consist of small quantities of alkaline olivine basalt. Since the magmas extrude onto an actively spreading ocean floor, there results a distribution of the different basalt types which can be correlated to the topographic features of the Median Rift Valley.

Baragar, W.R.A.

GEOCHEMISTRY OF THE YELLOWKNIFE VOLCANIC ROCKS; Can. J. Earth Sci., vol. 3, pp. 9-30, 1966.

Results of rapid-method chemical analyses of samples taken at about 500-ft. stratigraphic intervals through two sections of Yellowknife Group volcanic rocks are presented in graphical and composite form. The Yellowknife section is about 40,000 ft. thick with the base undefined; the Cameron River section, about 45 mi. northeast, is about 7,000 ft. thick and may be complete.

Two aspects of the volcanic chemistry considered are (1) variation in composition with stratigraphic height; (2) bulk composition of the volcanic rocks.

Chemical data of the Yellowknife section define two volcanic cycles in each of which mafic lavas show a small but significant increase in sialic components with stratigraphic height culminating abruptly in acidic layers. The Cameron River section shows a similar but less well-defined trend. Iron-magnesium ratios stage a succession of systematic increases, each persisting for a few thousand stratigraphic feet, but no overall systematic variation. The two types of chemical variation correspond to calc-alkali and tholeiitic differentiation trends respectively. The tholeiitic trend is attributed to fractionation in high-level magma chambers, demonstrated for Yellowknife magma by the Kam Point sill, and the calc-alkali trend to contamination of tholeiitic magma by sialic crust.

Frequency distribution diagrams show Yellowknife volcanic rocks to be similar to Chayes' circumoceanic basalts in TiO_2, CaO, and MgO and to his oceanic basalts in Al_2O_3. The characteristic rock type is basalt.

Becker, A., and Flint, T.R.

A PORTABLE MICROVOLTMETER FOR MEASUREMENT OF 8 H_2 TELLURIC CURRENTS; Proceedings of Electronic and Electrical Measurements and Test Instrument Conference, Ottawa, 1967.

Relative ground resistivity is estimated by measurements of telluric currents using a modular construction, lightweight, operational amplifier system.

Benson, D.G.

THE OROGENIC HISTORY OF NORTHEASTERN MAINLAND NOVA SCOTIA; (abst.), Geol. Soc. Am., Program North Eastern Section, Meeting, Mar. 16-18, 1967, Boston, Mass., pp. 14-15, 1967.

The Taconic and Acadian orogenies and Appalachian and Triassic Disturbances affected the rocks of the area to varying degrees. In Taconian time the Cambro-Ordovician eugeosynclinal sediments and volcanics of the Antigonish Highland were deformed, while the sediments of the Meguma Group were unaffected. Granitic to dioritic bodies were probably emplaced at this time. During the Acadian orogeny, Silurian sediments and volcanics and conformably overlying Lower Devonian sediments, as well as the older rocks of the Antigonish Highland, were deformed, and the Meguma sediments were folded and thrust northward to their present position. Several granite bodies were intruded at a later stage of the Acadian. The major faults of the area developed in the Acadian, but were intermittently active until Middle Carboniferous time. Carboniferous sediments were locally folded and faulted during the Appalachian Disturbance. Diabase dykes were intruded in post-Carboniferous, possibly Triassic time. At both the eastern and western ends of the Carboniferous basin in northeastern Nova Scotia, coarse Triassic sediments were deposited unconformably on older beds. Isolated clay beds, similar to Cretaceous non-marine clays of the Shubenacadie district, suggest the deposition of more extensive Cretaceous beds.

Bhattacharyya, B.K.

A METHOD FOR COMPUTING THE TOTAL MAGNETIZATION VECTOR AND THE DIMENSIONS OF A RECTANGULAR BLOCK-SHAPED BODY FROM MAGNETIC ANOMALIES; Geophysics, vol. 31, No. 1, pp. 74-96, 1966.

In this paper is presented a new method for determining the following parameters of a uniformly magnetized body of rectangular prismatic shape: (i) horizontal dimensions, (ii) depths to the top and bottom of the body, and (iii) intensity and direction of magnetization. Accuracy in the computation of these parameters is highly dependent on the correct location of the center and on the determination of the major and minor axes of the body. An iterative method of calculations is used. This method is considerably aided not only by the second vertical derivative map of the observed total field but also by the total field reduced to the pole and its second vertical derivative map.

The horizontal dimensions are determined by noting the location of the maximum of the odd component of the second vertical derivative about the center of the body. These dimensions are estimated with high accuracy when they are greater than the depth to the top of the body. The remaining unknown parameters of the body are calculated with the help of the first horizontal and vertical derivatives and the total field at the origin in the plane of observation which is directly above the center of the body. The present method also requires the total-field value at the point one-half unit of length above the origin. The factors affecting the accuracy in the calculation of the parameters are discussed in detail.

With the help of high-speed digital computers, this method can be used with great advantage for computation of the above parameters of magnetized bodies giving rise to a number of anomalies over a particular area.

Bhattacharyya, B.K.

CONTINUOUS SPECTRUM OF THE TOTAL-MAGNETIC-FIELD ANOMALY DUE TO A RECTANGULAR PRISMATIC BODY; Geophysics, vol. 31, No. 1, pp. 97-121, 1966.

The Fourier transform of the total-magnetic-field anomaly due to a rectangular prismatic body with arbitrary magnetization yields the two-dimensional spectrum of the anomaly. In the expression for the spectrum the individual effects of the horizontal and vertical dimensions of the body appear as separate factors. Another factor in the expression takes into account the combined influence of the orientation of the magnetization vector and the dip and declination of the earth's magnetic field. The expression for the two-dimensional spectrum is used to obtain analytical formulas of the spectra for magnetic-field values along profiles parallel to the two horizontal axes of the body.

This theoretical study provides a quantitative picture of the shift of the spectrum to the low-frequency end with increase in either depth or horizontal dimension, or in both, of the magnetized body. It has thus been possible to realize the feasibility of a method for separating the effects of near-surface high-amplitude components from those of deep crustal sources in total-field aeromagnetic maps. Separation of these effects is, however, not unique because of spectral overlap between anomalies due to "shallow" and "deep" sources. A detailed discussion has been made about the characteristics of amplitude and phase spectra of anomalies due to prismatic bodies of differing dimensions. The spectra of anomalies seem to be useful in rapid estimation of the dimensions of a body under suitable conditions. The effect of demagnetization on the fields due to prismatic bodies has been ignored in this paper.

Bolton, T.E.

SOME LATE SILURIAN BRYOZOA FROM THE CANADIAN ARCTIC ISLANDS; Palaeontology, vol. 9, Part 3, pp. 517-522, 1966.

One new species of trepostome Diplotrypa franklini, and two species of cyclostome Fistulipora (?) mutabilis Hennig and Cyclotrypa silurica Hennig originally described from the Ludlovian rocks of Gotland are characteristic of the Early Ludlovian shelly faunas scattered throughout the Canadian Arctic Islands.

Boyle, R.W.

GEOCHEMICAL PROSPECTING-RETROSPECT AND PROSPECT; Trans. Can. Inst. Min. Metallurgy, vol. 70, pp. 1-6, 1967.

The concept of using chemical methods in prospecting dates back at least to the middle of the 16th century. Modern methods of geochemical prospecting, however, based on secondary haloes and utilizing trace-element techniques, were first practised in the U.S.S.R. and the Scandinavian countries in the 1930's. After 1945, methods based on soils, stream sediments and vegetation were rapidly developed in the U.S.A., the United Kindom, Canada, France and other countries.

The modern methods of geochemical prospecting owe their rapid development in the 20th century to the following:

1. Recognition of the primary and secondary dispersion haloes and trains that are associated with all mineral deposits.

2. Development of accurate and rapid analytical methods utilizing the spectrograph and the various specific sensitive colorimetric reagents, especially dithizone.

3. Development of polyethylene laboratory ware of all types and the development of resins. This permitted greater freedom of field analyses and reduced the incidence of contamination.

4. Development of gas chromatography. This permitted the rapid and accurate determination of hydrocarbons in petroleum prospecting.

Future research in geochemical prospecting should be focused on the following tasks:

1. Definition of geochemical provinces and their relation to mineral deposits.

2. Development of methods for discovering large low-grade deposits.

3. Development of methods for discovering deeply buried deposits.

4. Further development of methods to outline primary haloes.

5. Elucidation and formulation of techniques to relate the size and intensity of anomalies to the grade of the deposits.

6. Development and refinement of biogeochemical methods, especially those based on indicator plants, chlorotic or toxic effects, and microbiological techniques.

7. Definition of the types of primary and secondary haloes associated with accumulations of oil and gas.

Boyle, R.W.

ORIGIN OF THE GOLD AND SILVER IN THE GOLD DEPOSITS OF THE MEGUMA SERIES, NOVA SCOTIA; Can. Mineralogist, vol. 8, Part 5, p. 662, 1966.

The gold deposits of the Meguma Series of Nova Scotia are of the 'Bendigo type' and occur mainly in quartz saddle reefs, angulars, and veins on the crests and flanks of anticlines and synclines composed of slates, argillites, quartzites, and greywackes. Most of the deposits favour incompetent slate beds.

Geochemically the deposits represent major concentrations of SiO_2, Fe, S, As, Au, and Ag. A few, as at West Gore, are greatly enriched in antimony, and others contain tungsten combined as scheelite. The principal minerals are quartz, pyrite, and arsenopyrite, with minor amounts of chalcopyrite, galena, sphalerite, and scheelite. At West Gore, stibnite is abundant. Most of the gold and silver occur as the native gold-silver alloy. The average grade of the deposits mined to date is about 0.35 oz. Au/ton. The Au/Ag ratio of deposits varies considerably but generally falls in the range 4 to 20.

The slates and some of the quartzites and greywackes of the Meguma Series are greatly enriched in sulphur and arsenic, bound mainly in pyrite, arsenopyrite, and pyrrhotite. The slates tend to carry mainly pyrite and pyrrhotite; arsenopyrite is often concentrated in greywacke but also occurs in the slates. Some beds carry up to 3% sulphur and up to 2% arsenic along strike for distances measured in miles. Such an extensive distribution of sulphur and arsenic suggests that the two elements are of sedimentary origin, deposited in a reducing environment in the Meguma sea.

Sedimentary pyrite and arsenopyrite separated from the slates and quartzites are enriched in gold and silver. The pyrite in places averages 0.15 ppm Au and 1.2 ppm Ag; the arsenopyrite averages 2.0 ppm Au and 0.5 ppm Ag. There is a definite tendency for gold to follow arsenic and to be concentrated in arsenopyrite.

The research on the gold deposits to date suggests that the sulphide-bearing Meguma rocks are the source of the gold, silver, and arsenic. During their folding and metamorphism dilatant zones appeared on the crests of anticlines, along the limbs of the folds, in dragfolded slates, and in small angular faults and fractures. These constituted low chemical potential zones which drew in from the sedimentary country rocks – silica, sulphur, arsenic, iron, gold, silver and the other elements in the gold-quartz deposits.

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

MINERALOGY, GEOCHEMISTRY, AND ORIGIN OF THE MAGNET COVE BARITE-SULPHIDE DEPOSIT, WALTON, NOVA SCOTIA; Trans. Can. Inst. Min. Metallurgy, vol. 69, pp. 394-413, 1966.

The Magnet Cove barite-sulphide deposit is a raking pipe-like body that replaced and partly filled a large brecciated zone at the junction of two faults at the contact between sedimentary rocks of the Horton and Windsor Groups of Mississippian age.

The principal minerals in the deposit are siderite, barite, hematite, pyrite, marcasite, galena, sphalerite, chalcopyrite, tennantite, proustite, pearceite, acanthite and stromeyerite. The mineral assemblage and textural relationships indicate that the minerals were deposited from low-temperature solutions. The source of the elements in the deposit is believed to be the enclosing sedimentary rocks, with connate or groundwaters as the transporting medium, and solubility products as the governing factor controlling the abundance and order of deposition of the minerals.

Boyle, R.W., and Dass, A.S. [1]

GEOCHEMICAL PROSPECTING FOR SILVER DEPOSITS AT COBALT, ONTARIO; Can. Min. J., vol. 88, No. 4, p. 139, 1967.

Research in geochemical prospecting methods, including analyses of wall rocks in the vicinity of the silver veins, analyses of soils, tills, and glacial clay on traverses across the veins, analyses of stream, spring, and underground waters and their precipitates, and scintillometer surveys on traverses across the veins both underground and on the surface were carried out in the Cobalt area of Ontario during June, July, and August, 1966. The analytical work was done in the field utilizing field colorimetric and spectrographic laboratories.

The rocks, soils, tills, glacial clays, and precipitates from springs and underground waters were analyzed for Cu, Pb, Zn, Ag, Ni, Co, Mo, Hg, As, Sb, and Mn, and the stream, spring, well, and drill-hole waters were analyzed for total heavy metals (mainly zinc), nickel, and cobalt in the field. The Eh, pH, and temperature of the spring, ground, and stream waters were also determined at each sample point, and samples of water were obtained for precise analyses of Pb, Zn, Cd, Cu, As, Sb, Ag, Ni, Co, Mn, and Fe in the laboratories in Ottawa. Some 2,461 samples of rock, soil, till, and spring precipitates were analyzed for the elements noted above, and 360 samples of water were analyzed for total heavy metals, nickel, and cobalt in the field and for the elements noted above in Ottawa.

The following conclusions on the various surveys seem warranted. Further details are given in Geological Survey of Canada Paper 66-46.

1. Analyses of clay and derived soils are not effective for prospecting for silver veins in the Cobalt area.

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[1] Carleton University, Ottawa

2. Analyses of till and derived soils should be effective for prospecting for silver veins in the Cobalt area. The A horizon gives the best response, (3) but in some places the B horizon also responds favourably, especially where the till is relatively shallow. The C horizon is generally not suitable except where samples are taken close to bedrock. The best indicator elements in the till and derived soils are Ag, As, Sb, and Mn. Nickel and cobalt are also effective in some areas, and mercury may be useful in a few places.

3. Analyses of both drill core samples and rock chips indicate the presence of veins and vein clusters. In the Cobalt sediments the dispersion of Ag, As, Sb, Ni, Co, Mn, and Hg outward from the veins is broad, and veins may be indicated as far as 100 feet away by these elements. A somewhat similar pattern is present for silver veins in Keewatin greenstones, but the dispersion is generally more restricted. In the diabase the dispersion is narrow and veins are indicated only a few feet away by a rise in Ag, As, Ni, and Co.

4. Scintillometer surveys proved negative for locating veins, suggesting that this method is not applicable for soils, till, glacial clay, or rock in the Cobalt area.

5. The water analyses are difficult to interpret in terms of geochemical prospecting for silver veins. The groundwaters have pH's ranging from 3.0 to 9.6 and contain variable amounts of dissolved HCO_3 and SO_4. In general the spring and drill-hole waters in the vicinity of silver veins are enriched in Zn, Cu, Ag, Co, Ni, As, and Sb. The content of these elements increases with increase in the acidity of the water. Cobalt is much more mobile in the waters than nickel. The general conclusion seems valid that water analyses may be useful in locating areas in which silver deposits occur but they cannot be expected to pinpoint individual deposits.

6. The natural iron and manganese precipitates at the orifices of springs and drill-holes are greatly enriched in Cu, Pb, Zn, Ag, Co, Ni, As, and Sb in the vicinity of known silver deposits. Similar precipitates well removed from known silver deposits have normal contents of these elements.

7. Great care must be taken in the Cobalt area in using geochemical prospecting methods because of the large amount of contamination present from old mine dumps, trenches, and domestic refuse.

From an academic viewpoint consideration should be given to the possibility that the sedimentary interflow bands and certain volcanic flows in the Keewatin assemblage are the source of the Ag, Cu, Pb, Zn, Ni, Co, As, and Sb in the silver deposits. These sedimentary and volcanic rocks are greatly enriched in the ore elements compared with the Nipissing diabase, Cobalt sediments, and granites. The rich silver veins may represent an "extract" derived by diffusion from the metal-rich interflow sediments and volcanic flows.

Burk, C.F. Jr., and Ediger, N.M.[1]

COLLATING EXPLORATION DATA; Oilweek, vol. 17, No. 39, pp. 16, 18-19, 1966.

Available geological data on the non-associated gas pools of Western Canada were compiled and processed for computer storage as a pilot project of the Committee on Storage and Retrieval of Geological Data in Canada. The project was designed to partially evaluate recommendations for a proposed national file of geological data on fossil fuels deposits. Difficulty was encountered in compiling even elementary data for many of the 610 pools studied and data on other factors are commonly recorded in a variety of ways. The need for nationally recognized standards was thus emphasized.

A few simple analyses of the data were made: 1) Generalized distribution maps of gas reserves in Devonian, Mississippian (mainly), and Mesozoic rocks, respectively, 2) Azimuth of maximum dimension of Devonian, Mississippian and Cretaceous pools, respectively, 3) Listing of pools by structural province and reserves, and 4) Listing of pools by date of discovery. The writers believe that a complete file on oil and gas pools would provide the basis for a better understanding of the geological controls that govern the occurrence of known deposits, and thereby contribute to the discovery of future reserves.

[1] The British American Oil Co. Ltd.

Cabri, L.J., and Traill, R.J.

NEW PALLADIUM MINERALS FROM NORIL'SK, WESTERN SIBERIA; Can. Mineralogist, vol. 8, Part 5, pp. 541-550, 1966.

Two new palladium minerals from Noril'sk, Pd_3Pb and Pd(Bi, Pb), are described. Pd_3Pb is cubic, with $a_o = 4.02_5$ Å, and with space group Pm3m. It is white in reflected light, and has a high reflectivity, which varies from about 60 to 67% over the wavelength range of 4500 to 6560 Å. The mean Vickers Hardness Number for a 15g. load is 279. Pd(Bi, Pb) is anisotropic; colours are grey to pale brown in oil. An estimate of the Vickers Hardness Number, using the pseudo-Becke line, indicated a value somewhere between 201 and 276 for a 50g. load.

Cameron, A.R., and Babu, S.K.[1]

PETROGRAPHY OF A 50-FOOT-THICK SEAM, THE CROWSNEST COALFIELD, BRITISH COLUMBIA, CANADA; (abst.) Geol. Soc. Am., Program, Ann. Meeting, Nov. 14-16, 1966, San Francisco, Calif., pp. 34-35, 1966.

Three column and channel samples of a 50-foot-thick, low-volatile bituminous seam from Natal in the Crowsnest area, British Columbia, were studied petrographically. The seam is near the base of the Kootenay formation of Jurassic and Cretaceous (?) age. The petrography is expressed in terms of macerals and microlithotypes. Only parts of the seam are well banded, yet considerable vertical variation is apparent from the

[1] Department of Applied Geology, University of Saugor, India.

microscopic data. On the basis of these data the seam was divided into 12 petrographically different intervals. These intervals can be traced from sample to sample although they show considerable lateral variations. The seam is characterized by high contents of the opaque macerals, particularly fusinite and semifusinite. The combined total of these two macerals ranges from 20 to more than 40 per cent between intervals in the same column sample. Reflectance data were determined on the vitrinite of each interval, and within the same column sample mean reflectances in oil range from 1.33 to 1.50. A 10-12-foot-thick section in the upper half of the seam appears to have the best coking properties.

Cameron, A.R., and Botham, J.C.

PETROGRAPHY AND CARBONIZATION CHARACTERISTICS OF SOME WESTERN CANADIAN COALS; in Coal Science, Advances in Chemistry Series 55, edited by R.E. Gould, published by American Chemical Society, pp. 564-576, 1966.

Petrographic and carbonization studies were carried out on samples from two seams in the Crowsnest Pass area of British Columbia. Swelling was measured by the free swelling index test and fluidity by the Gieseler test; strength measurements were made on coke from the 500 lb. capacity, movable-wall test oven. Petrography is expressed in both macerals and microlithotypes. Of interest is the somewhat anomalous distribution of the fusinitic constituents in the size fractions of one of the seams examined. Fluidity correlates better with the content of the microlithotype vitrite than with the total vitrinite. Calculated stability factors on six cokes suggest that a textural variety of vitrinite, described as mylonitized or pitted, has a deleterious effect on coke strength.

Cameron, E.M.

EVALUATION OF SAMPLING AND ANALYTICAL METHODS FOR THE REGIONAL GEOCHEMICAL STUDY OF A SUBSURFACE CARBONATE FORMATION; J. Sediment. Petrol., vol. 36, No. 3, pp. 755-763, 1966.

A regional geochemical study of the carbonate Slave Point Formation from a wide area of the subsurface of Western Canada was made in an attempt to relate chemical variation to facies change. Both core and drill cuttings from petroleum wells were used as samples. The resulting data showed that chemical variation was subtle enough that a knowledge of sampling and analytical errors was essential for the proper interpretation of the data.

This paper is an attempt to evaluate such errors by examining the effects of within-station variation, selective sampling during drilling, contamination, and analytical error. These various factors, which bias or add variance to the data, do not affect all elements equally. Least affected are the elements that are carried principally in solid solution within the dominant carbonate mineral of the rock. Therefore, for the Slave Point Formation, these elements are more reliable as indicators of facies change than are those elements that are held in the terrigenous fraction or within secondary minerals.

Campbell, R.B.

TECTONICS OF SOUTH-CENTRAL CORDILLERA OF BRITISH COLUMBIA; in Tectonic History and Mineral Deposits of the Western Cordillera, Can. Inst. Min. Metallurgy, Special vol. No. 8, pp. 61-71, 1966.

The south-central belt lies between the eastern and Coast Mountain belts and extends from the 49th to the 54th parallel. Rocks within it range from late Paleozoic to Recent.

Rocks of a widespread late Paleozoic eugeosynclinal assemblage rest apparently unconformably on strata of the eastern belt. These rocks were deformed and intruded by ultramafic rocks prior to late Triassic.

In late Triassic deposition of definite marine Mesozoic strata began. During the Mesozoic the seaway, originally widespread, gradually contracted until, by late Jurassic, it was a long trough or series of troughs along the eastern margin of the present Coast Mountains. In this trough late Jurassic and early Cretaceous marine clastics were deposited over an earlier Mesozoic eugeosynclinal assemblage. The emerging areas during this time were partly controlled by fault movements. They also marked the sites of granitic intrusions which began in late Triassic or early Jurassic and culminated in late Cretaceous and early Tertiary.

During late early and late Cretaceous non-marine sediments and volcanics were deposited roughly along the site of the early Cretaceous marine strata.

Little evidence favours a single widespread orogeny after mid-Triassic. The rocks seem to have been deformed by intermittent fault movement and locally by intrusions. Disconformities were produced by continual shifting of strand lines and of the centres of depositional basins.

During Paleocene and Eocene non-marine volcanics and sediments were deposited in many small basins formed upon all older rocks. These were accompanied by granitic and syenitic intrusions. Flood basalts poured out in the Miocene and Pliocene in the central part of the belt and finally basalts extruded locally in Pleistocene and Recent time.

Chamberlain, J.A.

HEAZLEWOODITE AND AWARUITE IN SERPENTINITES OF THE EASTERN TOWNSHIPS, QUEBEC; Can. Mineralogist, vol. 8, Part 4, pp. 519-527, 1966.

Most serpentinites in the Eastern Townships region of Quebec contain, along with magnetite, minute quantities of heazlewoodite and awaruite. These nickel rich-minerals were not observed together in the same zones. The apparent antipathy is probably due to fluctuating sulphur-oxygen activities in various parts of the "system" during serpentinization of the original dunites and peridotites.

(J.A.C.)

Chamberlain, J.A.

SULFIDES IN THE MUSKOX INTRUSION; Can. J. Earth Sci., vol. 4, pp. 105-151, 1967.

The Muskox intrusion is a layered, dominantly ultramafic pluton, in northern Canada. Sulfide phases belonging to the Ni-Cu-Fe-S system are concentrated along its margins and in chromite-rich horizons within its central layered series. They are sparsely disseminated through the rest of the intrusion, except in a core zone, which is almost barren of sulfides.

The primary sulfide assemblages in the layered series range from nickel-rich at the base, through copper-rich at intermediate levels, to iron-rich near the roof. Nickel: copper ratios in the sulfides vary sympathetically with those of the host silicates. A similar but inverted sequence of sulfide assemblages occurs in the marginal zone. This and textural evidence indicate that the disseminated sulfides in the main body of the intrusion formed by segregation of sulfides from intercumulous magma and that they crystallized in equilibrium with their respective host silicates. The ultimate origin of the sulfur is not known. Sulfides in the upper part of the layered series and upper border zone appear to have formed by late replacement of the host rocks at temperatures below 675°C.

The concentration of sulfides along the intrusive contacts, and in adjacent wallrocks, developed during the primary cooling cycle by a process of desulfidization of the Muskox magma. Sulfide transfer in these locations was controlled primarily by the temperature gradient, not by gravity settling of a separate sulfide fluid.

During subsequent serpentinization of the intrusion, the introduced fluid phase became progressively more oxygen depleted. The effect was most pronounced in the central regions, where primary sulfides ultimately decomposed to form native metals. Sulfur so released migrated as H_2S to more peripheral parts of the intrusion, where it entered into various reactions with primary sulfides, oxides, and silicates.

Separate processes thus operated to achieve desulfidization and desulfurization at magmatic and submagmatic temperatures, respectively, of the main body of the intrusion and to favor development of sulfide-enriched zones towards its margins.

Sulfides in both the Muskox feeder dyke and the diabase dykes of the area are disseminated relatively uniformly through these rocks. These sulfides appear to have crystallized in situ and show no obvious zoning relationships.

Copeland, M.J.

SOME LEPERDITIID OSTRACODA FROM THE RICHARDSON MOUNTAINS, NORTHERN YUKON TERRITORY; Proc. Geol. Assoc. Can., vol. 17, pp. 43-51, 1966.

Study of Ordovician and Silurian faunas from Yukon Territory has revealed numerous well-preserved ostracods. Of these, specimens of the Leperditicopida are the most distinctive element.

Cumming, L. M.

ST. GEORGE-TABLE HEAD DISCONFORMITY, WESTERN NEWFOUNDLAND; Bull. Can. Inst. Min. Metallurgy, vol. 60, No. 658, p. 154, 1967.

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 on the north side of the Gulf of St. Lawrence between the Romain and Mingan Formations. This Lower-Middle Ordovician regional disconformity is interpreted as having originated on and near the edge of a broad platform. The platform acted as a single structural unit during subsidence-sedimentation and uplift-erosion. Dolomites beneath the disconformity locally contain concentrations of base-metal sulphides. Sphalerite occurs in dolomite pseudobreccias of the St. George Formation at Zinc Lake (the Leitch property), 7 miles northeast of Daniels Harbour. Petroliferous dolomitized algal biostromes occur beneath the disconformity near Port aux Choix. Oil shale occurs on the St. George erosional surface at Aguathuna – in a channel filling composed of bituminous Table Head limestone.

Currie, K.L.

SHOCK METAMORPHISM IN THE CARSWELL CIRCULAR STRUCTURE, SASKATCHEWAN, CANADA; Nature, vol. 213, No. 5071, pp. 56-57, 1967.

Shock metamorphism occurs in a basement outlier, but not in the overlying Athabasca sandstone. Glass-rich breccia presumably formed by the shock metamorphism cuts the Athabasca Formation. The shock impedance of the sandstone and basement complex are virtually identical up to 300 kilobars. Therefore, the shock metamorphism cannot have resulted from the propagation of a shock wave through the Athabasca into the basement. This conclusion refutes an origin by meteorite impact for this structure and suggests either (a) shock processes can be generated endogenetically, or (b) processes other than shock can produce shock metamorphism.

(K.L.C.)

Dreimanis, A.[1], Terasmae, J., and McKenzie, G.D.[1]

THE PORT TALBOT INTERSTADE OF THE WISCONSIN GLACIATION; Can. J. Earth Sci., vol. 3, pp. 305-325, 1966.

The Port Talbot interstade is a cool, long, nonglacial interval separating the Early from the Late or Main Wisconsin in the Lake Erie

[1] Geology Department, University of Western Ontario, London, Ontario.

region. Recent test borings at its type locality, lithologic and palynologic investigations of the cores, and new radiocarbon dates suggest that this interval was considerably longer than previously assumed. It began more than 48,000 years before present (B.P.) and ended, if the Plum Point interval is included, 24,000 years B.P.

The entire nonglacial interval comprises two relatively warm episodes, with boreal climate (Port Talbot I and II), separated by a brief glacial readvance that reached Lake Erie from the north; 100 varves were deposited during this readvance. Another similar readvance separates the Port Talbot I beds from the Plum Point (?) sands and silts. Pine (Pinus) and spruce (Picea) pollen predominate throughout the section, with relative abundance oak (Quercus) in the Port Talbot I green clay. The pollen assemblages are dissimilar from those of the Sangamon interglacial or postglacial in southern Ontario.

L'interstadiaire Port Talbot est un long intervalle froid non glaciaire qui sépare le premier épisode glaciaire de l'épisode glaciaire principal du Wisconsin dans la région du lac Érié. De récents sondages effectués à la localité type des dépôts interstadiaire Port Talbot, des études lithologiques et palynologiques des carottes, ainsi que de nouvelles analyses de radiocarbone portent à croire que cet intervalle est beaucoup plus long qu'on ne l'avait cru jusqu'ici. Celui-ci a débuté 48,000 ans avant nos jours et se termina, si l'on inclut l'intervalle Plum Point, il y a 24,000 ans avant nos jours.

Dans sa totalité, l'intervalle non glaciaire comprend deux épisodes climatiques (Port Talbot I et II) relativement chauds, permettant aux espèces forestières de type boréal de croître. Ces deux épisodes ont été séparés par une brève avancée glaciaire qui venue du nord atteint le lac Érié; une centaine de varves furent déposées au cours de cette avancée. Une avancée semblable sépare les dépôts Port Talbot I du Plum Point.

Des pollens de pin (Pinus) et d'épinette (Picea) predominent dans toute la section, avec une abondance relative de pollens de chêne (Quercus) trouvés dans la glaise verdâtre de Port Talbot I. Les assemblages de pollens diffèrent de ceux de période interglaciaire Sangamon ou de la période postglaciaire au sud de l'Ontario.

Dyck, W.

SECULAR VARIATIONS IN THE ^{14}C CONCENTRATION OF DOUGLAS FIR TREE RINGS; Can. J. Earth Sci., vol. 3, pp. 1-7, 1966.

Measurement of the ^{14}C concentration in a Douglas fir from Vancouver Island indicate a maximum variation of 44% during the past 1,100 years. The magnitude and trend of these variations are similar to those observed by de Vries (1958) in oak from Germany and by Willis et al. (1960) in sequoias from California, confirming earlier observations that atmospheric mixing of CO_2 takes place rapidly on a large scale.

^{14}C measurements of successive annual growth rings from the piths of two firs (346 years and 1,142 years old) show no variations beyond those attributable to the statistical counting error of $\pm$ 6%. Thus, cyclic

variations in sunspot activity and (or) climate, if present during these intervals, did not affect the ^{14}C concentration in the biosphere appreciably.

A mechanism, based on a climate-sensitive carbon pumping rate of the biosphere coupled with the temperature-dependent oceanic CO_2 content is postulated to explain, qualitatively, the observed short-term (150 years or less) and long-term (1,000 years or more) ^{14}C variations in the land biosphere. Short-term fluctuations are directly proportional to temperature because variations in the carbon fixation rate lead to a pulsating CO_2 content of the atmosphere. Long-term changes are inversely proportional to temperature because large quantities of carbon, normally stored in deeper regions of the ocean, are exchanged between biosphere and hydrosphere.

Dyck, W., Lowdon, J.A., Fyles, J.G., and Blake, W., Jr.

GEOLOGICAL SURVEY OF CANADA RADIOCARBON DATES V; Radiocarbon, vol. 8, pp. 96-127, 1966. (Also reprinted as Geol. Surv. Can. Paper 66-48.)

One hundred and ten radiocarbon age determinations made by the Geological Survey of Canada Radiocarbon Dating Laboratory, mostly between December 1964 and November 1965, are presented. They are on specimens from the following parts of Canada: Nova Scotia (7); Prince Edward Island (1); Quebec (4); Ontario (18); Manitoba (4); Alberta (4); British Columbia (21); Yukon (14); N.W.T.-mainland (14); N.W.T.-Arctic Islands (23). The results of dating organic and inorganic fractions of bone are summarized; age determinations on the organic (collagen) fraction are considerably more reliable than those on the inorganic fraction. Further tests for contamination of marine and freshwater shells, and of peats from permafrost areas, are also tabulated; in all cases where finite ages were obtained there was good agreement between the different fractions of shell material and between the more soluble (organic) and less soluble (inorganic) fractions of peat.

Eade, K.E., Fahrig, W.F., and Maxwell, J.A.

COMPOSITION OF CRYSTALLINE SHIELD ROCKS AND FRACTIONATING EFFECTS OF REGIONAL METAMORPHISM; Nature, vol. 211, No. 5055, pp. 1245-1249, 1966.

A study of the composition of crystalline shield rocks in a 200,000 square mile area of New Quebec indicates minor but significant differences between rocks of the amphibolite and granulite metamorphic facies as a result of the removal of some constituents from the granulite zone. The potassium content of rocks of the hornblende granulite facies is lower than in adjacent rocks of the amphibolite facies, suggesting that significant fractionation of this heat-producing element occurs during deep-seated regional metamorphism. There are differences between the average composition of this area of continental shield crystalline surface rocks and previously published average compositions for surface shield rocks. Because this region probably represents a deeper crustal level, these differences reflect a chemical zoning of the crust resulting from the transport of low temperature constituents to higher crustal levels.

Eisbacher, G.H., and Kelley, D.G.

TECTONIC STUDIES IN THE COBEQUID MOUNTAINS, NOVA SCOTIA; Maritime Sediments, vol. 2, No. 4, pp. 180-183, 1966.

A brief outline is presented on analyses of structures along the "Cobequid Fault" and their relationship to deformation patterns within the pre-Carboniferous Cobequid rock complex. The fault is right-lateral, with a strong strike-slip component. Similar displacement vectors are associated deformation within the Cobequid complex. Statistical studies of fractured phenoclasts in Carboniferous conglomerate close to the "Cobequid Fault" led to construction of NW-SE compressive axes.

Fortescue, J.A.C.

GEOCHEMICAL PROSPECTING, CASE HISTORIES AND EXPLORATION ARCHITECTURE; National Advisory Committee on Research in the Geological Sciences, Abstracts and Program Symposium on Geochemical Prospecting, Ottawa, April 20-22, 1966, p. 15.

The application of geochemical prospecting methods in Canada has frequently been criticised because results obtained by a given method in one area are considerably more reliable than results obtained by the application of the same method in a second area. In this paper the role that case histories can play in recording the scope and limitations of geochemical methods in Canada is discussed. The need for a simple, but generally accepted, terminology for the description of geological, geophysical and geochemical components of an exploration program is stressed and one set of terminology for this purpose is described under the heading of "Exploration Architecture".

Fortescue, J.A.C.

THE ROLE OF GEOCHEMISTRY IN EXPLORATION ARCHITECTURE; Bull. Can. Inst. Min. Metallurgy, vol. 60, No. 657, pp. 50-53, 1967.

During the past decade, geochemical prospecting methods have become important in Canadian mineral exploration. The object of this paper is to discuss the role of geochemical methods in a typical mineral exploration program involving parallel geological and geophysical methods applied at different degrees of intensity. Particular attention is given to the description of the degree of development of geochemical prospecting under different kinds of local conditions.

Fortescue, J.A.C., and Hornbrook, E.H.W.

A PROGRESS REPORT ON BIOGEOCHEMICAL PROSPECTING RESEARCH AT THE GEOLOGICAL SURVEY OF CANADA; National Advisory Committee on Research in the Geological Sciences, Abstracts and Program Symposium on Geochemical Prospecting, Ottawa, April 20-22, 1966, p. 16.

During the past three years, the foundations have been laid for a long term biogeochemical prospecting research program at the Geological Survey of Canada. A review of the literature on biogeochemical prospecting

methods tried in Canada prior to 1962 revealed that the method was in the experimental stage of development, and that there was a need for systematic studies of the morphology and geochemistry of vegetation near mineral deposits, in order to determine the scope of biogeochemical and geobotanical prospecting methods under Canadian conditions. It was considered advantageous to carry out research in the vicinity of known but undisturbed mineral deposits, so that the results of biogeochemical and geobotanical investigations could be interpreted in terms of parallel geological and geophysical studies carried out at the same level of intensity (the followup level).

The practical aspects of the biogeochemical prospecting research program have involved setting up a moveable biogeochemical laboratory unit housed in two specially designed trailers. Besides having drying and sample preparation facilities, the laboratory is equipped with an optical spectrograph and ancillary equipment and will include an atomic absorption spectrophotometer in the near future. The unit was specifically designed to carry out research on biogeochemical and geobotanical investigations at the followup level of detail which involves large numbers of chemical determinations on large numbers of samples of different materials. In order to achieve this a systematic approach was adopted to the organization of planning, sample collection, chemical analysis, and the mechanical processing and plotting of results.

In addition to the setting up of the laboratory, progress has been made in the setting up of greenhouse experiments in biogeochemistry. Preliminary experiments have shown that it is feasible to grow small trees and cuttings under controlled conditions in the greenhouse on the roof of the Geological Survey building in Ottawa. Feasibility experiments have already been made using known amounts of minor elements, a radioactive tracer, and artificial mixtures of common isotopes.

Much attention has been given to the selection of field areas for systematic biogeochemical and geobotanical studies as well as to the details of laying out line and plot types of sampling programs. These methods have been developed in the course of four field investigations – two near mineral deposits, and two away from such deposits. The control experiments were carried out in a peat bog near Ottawa and in the Moose River area of northern Ontario. The experimental investigations near mineral deposits were carried out at a property near Silvermine, Cape Breton Island, and in the vicinity of the Texas Gulf Sulphur deposit near Timmins.

The experience gained in all these aspects of the biogeochemical prospecting research program will be referred to in this brief paper; a more detailed account will appear in a progress report which should be published before the end of 1966.

Gabrielse, H.

TECTONIC EVOLUTION OF THE NORTHERN CANADIAN CORDILLERA; Can. J. Earth Sci., vol. 4, pp. 271-298, 1967.

A tectonic framework that was established in the northern and eastern parts of the northern Canadian Cordillera in the late Proterozoic persisted generally until mid-Devonian time. Late Palaeozoic deposition was strongly influenced by a late Devonian and/or early Mississippian orogeny, which

produced coarse clastic sediments in the northern and western parts of the region, and by a late Pennsylvanian (?) orogeny evident in northern Yukon. The Cassiar and Coast geanticlines were established at least by late Triassic time and controlled the distribution and character of Mesozoic strata southwest of Tintina and Rocky Mountain Trenches.

Metamorphism and granitic intrusion were concentrated along Cassiar and Coast geanticlines. During the Mesozoic and early Tertiary, plutonic activity appears to have occurred at intervals of about 30 million years and was accompanied generally by deformation and development of regional unconformities.

Crustal shortening has been much less in Mackenzie Mountains than in southern Rocky Mountains; a marked change in structural style of the eastern Cordillera occurs near Liard River. Many phases of deformation and intrusion have affected rocks in the southwestern part of the region; their differentiation is as yet incomplete.

Gadd, N.R.

PATTERN OF GLACIAL RECESSION IN SOUTHEASTERN QUEBEC; (abst.), Geol. Soc. Am., Program North Eastern Section, Meeting Mar. 16-18, 1967, Boston, Mass., pp. 28-29, 1967.

Data on distribution of moraines and other ice marginal features and on organic sediments between Lake Champlain and Riviere du Loup indicate that a series of southwest-trending moraines was built prior to 12,600 years B.P. as the Wisconsin ice margin retreated across Appalachian regions of southeastern Quebec. Deep lobation in Lake Champlain basin is indicated. A continental ice-sheet centered on the Laurentian highland, actively flowing southeastward, abutted against southwesterly trending ridges of Appalachian hills and penetrated northwesterly trending valleys as lobations that locally dammed glacial lakes. Stream erosion of ponded glacial sediments provides one possible explanation of occurrence of erratics north and northwest of potential sources that was earlier interpreted as evidence of northward flow from the Appalachian highland; a westerly component of early southwesterly glacial flow may also have brought erratics north of potential sources.

Observations near the International boundary northeast of Lake Champlain allow extension of the Highland Front morainic system and suggest possible correlation with moraines in northern New York.

Invasion of St. Lawrence lowland regions by Champlain Sea probably involved expansion of glacial lakes from Lake Champlain basin northward and eastward, possibly as far as Drummondville, before their waters merged with sea water that simultaneously extended southwestward as a wedge between the ice margin and the Appalachian highland. A series of radiocarbon dates at and near Mont St. Hilaire date ice recession from the Highland Front moraine and bracket the age of Champlain Sea maximum between about 11,400 and 12,500 B.P.

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

AEROMAGNETIC RECONNAISSANCE OF THE LABRADOR SEA; J. Geophys. Res., vol. 71, No. 2, pp. 511-516, 1966.

A total of 12 low-level aeromagnetic profiles across the Labrador Sea were recorded with digitized rubidium-vapor and fluxgate magnetometers. The resultant data are presented in the form of profiles with the regional gradient removed. There is good correlation between the anomalies on adjacent flight lines in a number of places, and the area may be divided into two zones having anomalous magnetic signatures. These zones can be followed through the central part of the Labrador Sea and are generally flanked by areas of lesser magnetic relief. The more westerly zone strikes toward Hudson Strait and appears to die out at about 59°N. The presence of the magnetic zones, marine seismic results, and the fact that five earthquakes are known to have occurred in the area between the zones are reasonably good evidence for the existence of an active buried median ridge in the Labrador Sea.

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[1] National Aeronautical Establishment, Nat. Res. Council, Ottawa, Canada.

Goodwin, A.M.

ARCHEAN VOLCANIC BELTS; Can. Geophys. Bull., vol. 19, p. 181, 1966.

Eight Archean volcanic-rich "greenstone" segments distributed across the southern part of the Superior Province have been studied. Some 2,500 sequentially arranged, chemically analyzed volcanic components with supporting stratigraphic information, provide substantial insight into the form, pattern and composition of Archean volcanic rocks.

Individual Archean volcanic-rich piles or accumulations commonly contain generalized mafic-to-felsic stratigraphic sequences in which predominant lower tholeiitic basalt is overlain by increasingly felsic components. Individual mafic-to-felsic sequences range from 15,000 to 25,000 feet thick. One complete mafic-to-felsic sequence together with mafic capping commonly constitutes a volcanic pile. However, some piles contain two or more superimposed mafic to felsic sequences. The total stratigraphic sequence of a pile is commonly 20,000 to 40,000 feet thick. Tholeiitic basalt is the dominant volcanic component. Andesite, dacite, rhyodacite and rhyolite, the other common volcanic components, are generally present in that order of decreasing abundance. With rare exceptions, these volcanic components belong to the calc-alkaline suite typical of active orogenic belts at continental margins. In exception, minor alkalic volcanic components are present locally in the southernmost Archean volcanic-rich belts of the Superior Province. These are restricted as far as known to narrow zones at the top of normal calc-alkaline volcanic assemblages.

Goodwin, A.M.

GROWTH AND MINERALIZATION OF THE CANADIAN SHIELD; Bull. Can. Inst. Min. Metallurgy, vol. 60, No. 658, p. 154, 1967.

Archean crustal history was dominated by the growth and aggregation of discrete protocontinents. Remnants of four protocontinents are recognized in the Canadian Shield. The protocontinents exhibit random to sub-linear basin distribution patterns, the product of an unstable pre-geosynclinal stage of crustal development.

Aggregation and consolidation of the protocontinents resulted in a single cratonic mass which dominated Proterozoic history. The attainment of crustal stability by this means led to the development of stable platforms and primitive geosynclines which are the salient features of this early geosynclinal stage of crustal development.

Mineral zoning in the Canadian Shield in general and in the Superior protocontinent in particular reflects this pattern of protocontinental growth. The core-to-periphery trend of mineralization within an Archean protocontinent is from simple gold-silver mineralization to complex base metal sulphide-gold mineralization. The Proterozoic belts, in turn, are characterized by complex sulph-arsenide accumulations and widespread uranium and iron deposits.

Mineral patterns of the Canadian Shield, sequentially arranged, are viewed as integral facets of a unidirectional continuum of crustal evolution. This evolution was in the direction of increasing crustal thickness and mass with attendant stability. Thus the thin, small, unstable Archean protocontinents resulted in simple, direct igneous-sedimentary mineralization. In contrast, the relatively thick, large, stable crustal mass of Proterozoic time experienced complex igneous-sedimentary mineralization, the product of numerous interdependent crustal variables.

Considering the Canadian Shield at large, the mineral deposits represent integral parts of a growing continent. Accordingly, patient and systematic unravelling of the Precambrian record serves both economic and scientific ends.

Goodwin, A.M.

THE RELATIONSHIP OF MINERALIZATION TO STRATIGRAPHY IN THE MICHIPICOTEN AREA, ONTARIO; Geol. Assoc. Can., Special Paper No. 3, Precambrian Symposium, p. 57, 1966.

The Michipicoten area, situated 150 miles north of Sault Ste. Marie in the northeast corner of the Lake Superior region, has produced twenty-seven million tons of iron ore valued at $182 million, and 189,000 ounces of gold and 18,000 ounces of silver from 857,000 tons milled together valued at $6.4 million since the start of mining operations in 1899.

The iron ore is associated with extensive bands of iron-formation which directly overlie several large masses of acidic pyroclastic rocks. The iron-formations are indicated to be products of subaqueous chemical

depositions during extended periods of exhalative activities that accompanied and followed explosive eruption and accumulation of the great acidic tuff breccia masses.

Most gold and base metal occurrences, including all deposits of note, are intimately associated with acidic porphyry stocks which are, in turn, situated within or marginal to the large acidic tuff breccia masses. Representative chemical analyses of the acidic porphyry stocks and nearby acidic extrusive tuff breccia masses indicate close chemical similarity of the acidic intrusive and extrusive rocks.

Geologic relations in the Michipicoten area indicate a common igneous origin for the acidic extrusive masses, the acidic porphyry stocks, and the iron, gold and base metal mineralization. Rock and metal components are ascribed to common generative processes related to a parent magma. From this parent source, Michipicoten metals migrated to their present sites largely by way of sub-volcanic and volcanic routes.

Goodwin, A. M.

VOLCANIC STUDIES IN THE BIRCH-UCHI LAKES AREA OF ONTARIO; Ont. Dept. Mines, Miscellaneous Paper MP. 6, 1967.

Detailed stratigraphic studies in the Birch-Uchi Lakes area of northwestern Ontario have shown that volcanic components are arranged in superimposed sequences or cycles. Each cycle displays a progression from predominantly basic effusives below to predominantly acid to intermediate extrusives above. Sedimentary rocks are preferentially associated with the acid to intermediate extrusive phases. Parts of two volcanic cycles are present.

The average stratigraphic thickness of the volcanic rocks present is 31,000 feet. The original volcanic-sedimentary pile was probably in the order of 40,000 feet. The present lithologic content of the volcanic-sedimentary pile of this area is estimated to be: basalt – 47 per cent; andesite and dacite – 23 per cent; rhyodacite and rhyolite – 10 per cent; sedimentary rocks – 9 per cent; gabbro-peridotite – 8 per cent; and granite – 3 per cent.

Basalt, the dominant volcanic component and present mainly in effusive forms, is of general tholeiitic character. Andesite, dacite, rhyodacite and rhyolite, present mainly in pyroclastic forms, are of the calc-alkalic suite. The average chemical compositions of the volcanic components and of the stratigraphic divisions of the volcanic pile are consistent with a theory of derivation by differentiation of a single, tholeiitic, parent magma.

Gold occurrences in the area are preferentially distributed with respect to the volcanic succession; stratigraphically, most occurrences are located in the upper acid part of the Lower volcanic cycle; lithologically, most occurrences are associated with interbanded rhyolite-dacite pyroclastics and andesite-basalt lava flows; structurally, most gold-bearing quartz veins either lie at the contact of enclosing volcanic units or occupy cross-cutting fractures in a narrow stratigraphic range of lithologic units.

A common magmatic derivation for the gold and enclosing volcanic rocks is advocated. The preferential distribution of the gold deposits with respect to the volcanic succession may express related emplacement histories. Possible methods of gold emplacement are considered. Similar stratigraphic studies in other Archean greenstone belts are desirable.

Gross, G.A.[1]

IRON DEPOSITS EXAMINED IN SOVIET UNION; Skillings' Mining Review, vol. 56, No. 10, p. 1, 1967.

This paper gives brief description of iron ore deposits and mining operations visited in the Krivoy Rog and Kursk Magnetic Anomaly areas where more than 70% of the iron ore in the Soviet Union is produced. Other major types of iron ore occurrences studied in the course of a seven week scientific liaison visit in 1966 are noted.

(G.A.G.)

Gross, G.A.

PRINCIPAL TYPES OF IRON-FORMATION AND DERIVED ORES; Bull. Can. Inst. Min. Metallurgy, vol. 59, No. 646, pp. 150-153, 1966.

Nearly 90 per cent of the iron ore produced in Canada is derived from iron-formation or bedded iron deposits. About 70 per cent of this consists of concentrates obtained from iron-formation; another 20 per cent was formed by natural enrichment processes.

Four principal varieties of iron-formation are recognized – the Algoma, Superior, Clinton and Minette types. Differences in their geology, mineralogy, chemical composition and environment of deposition are of special significance in their evaluation as ore.

The properties of the ores, including grade, beneficiation qualities and minor element content in taconites, metataconites and naturally enriched ores, reflect characteristics of the primary stratigraphic units from which they are derived. A detailed description of the stratigraphic facies is essential for efficient utilization of these source beds.

Gross, G.A.

THE ORIGIN OF HIGH GRADE IRON DEPOSITS ON BAFFIN ISLAND, N.W.T.; Can. Min. J., vol. 87, No. 4, pp. 111-114, 1966.

High grade iron deposits discovered near the north end of Baffin Island are of special geological importance because of the exceptional high grade and structural quality of the hematite and magnetite ore and the unusual sequence of geological events which produced them. They occur in Archaean rocks composed of acid and basic metavolcanics, iron-formation and metasediments infolded and faulted within a granitoid massif intruded by

[1] See also page 59.

basic and ultrabasic rocks. A distinctive feature in the Algoma type iron-formation is the occurrence of beds of nearly pure magnetite and occasionally hematite which range in thickness from a few inches to tens of feet that are interlayered with the thinly laminated quartz magnetite beds.

Potential ore zones are described which contain more than one hundred million tons of material with an average iron content of more than 68% iron and less than 1% silica. It is concluded that protore iron-formation originally rich in iron oxide were enriched during Early Precambrian time by natural processes which leached silica and oxidized iron prior to a later period of metamorphism which reached amphibolite rank. Enriched zones in the iron-formations extend to depths greater than one thousand feet and formation of high grade ore may have been widespread throughout the region.

Hobson, G.D.

G.S.C. SURVEYS GULF AREA; Oilweek, vol. 17, No. 27, pp. 54-56, 1966.

The Geological Survey of Canada has been engaged in a reconnaissance program of seismic refraction surveys in the Gulf of St. Lawrence with the intention of extending onshore geology to offshore regions by geophysical methods to result in a geological map of the eastern Canadian Maritime region with the water removed. Refraction techniques only have been used.

Two sections are presented; one is located over the Orpheus gravity anomaly southeast of Cape Breton Island while the other extends from Cheticamp, Nova Scotia to Tracadie, New Brunswick. Over the Orpheus anomaly, step delays of approximately 70 milli-seconds have been observed leading to an interpretation of a graben infilled with at least 10,000 feet of sediments. Two faults are suggested at the extremities of the other line with possibly 18,000 feet of sediment present beneath the centre of the line. No attempt has been made to label the various velocity layers as geologic formations.

Hood, P.J.

FLEMISH CAP, GALICIA BANK, AND CONTINENTAL DRIFT; Earth and Planetary Science Letters, vol. 1, pp. 205-208, 1966.

It is proposed that a geophysical study be carried out of a strip about 250 miles wide stretching between Grand Banks of Newfoundland and the Galicia Bank off Spain. The primary objective would be to demonstrate that there is a two-sided symmetry about the axis of the Mid-Atlantic Ridge in the physical properties (e.g. remanent magnetization) and dimensions of the geological formations underlying the ocean floor. If this symmetry can be demonstrated to exist in the North Atlantic Ocean then the case for ocean-floor spreading (and presumably continental drift) will be greatly strengthened.

Hood, P.J.

MINERAL EXPLORATION: TRENDS AND DEVELOPMENTS IN 1965; Can. Min. J., vol. 87, No. 2, pp. 171-185, 1966.

MINERAL EXPLORATION: TRENDS AND DEVELOPMENTS IN 1966; Can. Min. J., vol. 88, No. 2, pp. 217-240, 1967.

These articles reviewed the following topics for the years 1965 and 1966:

(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 the 1966 review article the characteristics of the various ground geophysical equipments manufactured in North America were summarized in tabular form. The tables were as follows:

(1) Induced Polarization equipment.
(2) Horizontal-loop EM equipment.
(3) Vertical-loop EM equipment.
(4) Other types of EM equipment.
(5) Resistivity equipment.
(6) Self-potential equipment.
(7) Gravimeters.
(8) Magnetometers.
(9) Susceptibility meters.
(10) Radiometric equipment.
(11) Shallow refraction seismic equipment.
(12) Drill-hole geophysical equipment.

(P.J.H.)

Hood, P.J.

SHIP AND AIRBORNE MAGNETOMETER RESULTS FROM THE SCOTIAN SHELF, GRAND BANKS AND FLEMISH CAP; Maritime Sediments, vol. 2, No. 1, pp. 15-19, 1966.

Since 1958 the Geological Survey of Canada has been carrying out magnetic surveys over the continental shelves of eastern Canada. The objective of these surveys is to aid the geological study of the continental shelves, and particularly to outline areas of thick sediments which might be oil-bearing for further study.

This paper presents some hitherto unpublished sea magnetometer results from the eastern Scotian Shelf and the Grand Banks of Newfoundland together with results obtained during magnetic airborne detector (MAD) surveys carried out in co-operation with the National Aeronautical Establishment and the RCAF.

The first area discussed is the 1961 sea magnetometer survey of the eastern Scotian Shelf by CSS Kapuskasing and includes the area in the vicinity of Sable Island. The eastern limit of the Cambro-Ordovician Meguma Group and enclosed Devonian granites may be inferred from the magnetic pattern. Of particular interest is a zone of relatively flat magnetics extending eastwards from Chedabucto Bay in an area where Loncarevic has reported a negative gravity anomaly. The formations underlying Chedabucto Bay are most probably Carboniferous sedimentary rocks and are bounded on the south by a fault contact with the Meguma Group.

Results of the aeromagnetic surveys include a discussion of a circular magnetic low surrounded by a halo of magnetic highs – a pattern similar to that produced by a Devonian granite intrusion on the mainland.

The sea magnetometer map from the CSS Baffin 1963 survey of the Great Bank of Newfoundland is in striking contrast to those from the Scotia Shelf. A line of isolated anomalies, having amplitudes in excess of 1,000 gammas, parallel the southwest edge of the continental shelf, and one anomaly in particular appears to have been produced by a rock formation having a remanent magnetism vector aligned in a direction quite different from the present earth's field direction. Depth determinations carried out on the anomalies indicate that the thickness of sediments in the area is between 14,000 and 20,000 feet.

Results from a single traverse across the Grand Banks showed a distinct 400-gamma anomaly associated with the edge of the continental shelf at the Tail of the Great Bank. A series of sharp shallow-source anomalies was recorded over the Flemish Cap; this feature appears to have a negatively-polarized core whose longer horizontal dimension is oriented in a NNW-SSE direction. It is suggested that the Flemish Cap may be composed of oceanic basaltic material, Cretaceous or younger in age.

Hood, P.J., and Bower, Margaret

AEROMAGNETIC SURVEY OF THE SCOTIAN SHELF SOUTHEAST OF HALIFAX, NOVA SCOTIA; Geol. Assoc. Can. and Min. Assoc. Can., Technical Program, 1966 Ann. Meetings, Halifax, Nova Scotia, pp. 40-42, 1966.

Approximately 30,000 line miles of total intensity aeromagnetic data were obtained over the continental shelf southeast of Halifax, Nova Scotia, during the 1962 field season. The magnetometer used was an AN/ASQ-8 magnetic airborne detector modified by the National Aeronautical Establishment to meet the requirements of magnetic surveying by the addition of a current feedback servo and digital output circuitry.

On display during the GAC-MAC meeting are some of the resultant Scotian Shelf aeromagnetic maps, in which a new format for the aeromagnetic surveys of water-covered areas has been used. On the published maps, the aeromagnetic contours are printed in red using a 10-gamma contour interval, and all other lines are printed in a light grey. The survey flight lines are the straight, solid lines running north-northwest across the

map, so that the RCAF Argus aircraft, in which the digital magnetometer was installed, actually flew along the "purple" lines of the Decca Navigation Chain 7. The "green" Decca lines, used to position the aircraft along the "purple" Decca lines, are shown as dashed lines. The bathymetry has also been printed on the map using a contour interval of 25 feet, and the track of the ship, which obtained the echo-sounder profiles, is shown by the dashes on the bathymetric contours themselves. Hence the control for both the aeromagnetic and the bathymetric data is clearly indicated on the map. It is thus possible, in carrying out subsequent geophysical or geological investigations, to position survey ships with respect to a given geological feature deduced from the magnetic data by using the Decca co-ordinates appearing on the aeromagnetic map. Also, in preparing a smaller scale compilation map, the aeromagnetic contours may be readily separated by photographic means from the rest of the data because they are a different colour.

In the northern part of the area surveyed the Cambro-Ordovician Meguma Group of slates (Halifax Formation) and quartzitic greywackes (Goldenville Formation) produces a characteristic pattern of linear magnetic contours which parallel the coastline. The Halifax Formation has much more pronounced magnetic properties than the Goldenville Formation. A number of distinct circular lows are also to be found on the maps in this area which are most probably Devonian granite intrusions such as occur on the mainland of Nova Scotia. It is obvious that the granites have a very low intensity of magnetization and thus contain an extremely low percentage of magnetite. The anomalies at the edge of the granites appear to have been produced by the intrusions and form magnetic aureoles around the Devonian granites. The most obvious explanation for this phenomenon is that the natural remanent magnetization of the country rock has been considerably increased by its being heated at the time of the intrusion of the granites through the Curie point of the constituent magnetic minerals, and then acquiring an augmented intensity of magnetization by subsequent cooling in the earth's magnetic field. In addition contact metamorphism of the country rock may have produced some magnetite. There are a number of examples of this phenomenon elsewhere in Nova Scotia and it seems to be a diagnostic feature of granites that where they intrude formations already possessing significant magnetic properties, i.e. contain about one-half per cent magnetite or more, then the anomalies at the margins of the intrusion will usually be enhanced by an increased intensity of remanent magnetization. The features could also be expected to have concomitant negative gravity anomalies associated with them because of the low density of granite.

Farther to the south the amplitudes of the magnetic anomalies decrease and their wavelength increases because of the increased depth to the magnetic basement.

A number of faults have been inferred from displacements in the aeromagnetic contours. Most of their landward extensions appear on the G.S.C. maps of mainland Nova Scotia resulting from the geological fieldwork of E.R. Faribault during the early part of this century. One of these faults appears to pass along the North West Arm of Halifax Harbour. The Meguma Carboniferous contact has also been deduced from the aeromagnetic contours. The Meguma Group appears to continue underneath the Carboniferous and terminates in the southern part of the survey area. Depth determinations carried out on individual anomalies are in general agreement with those

obtained by Lamont Geological Observatory during their 1950 refraction seismic survey. However, it is felt that the case for a basement ridge immediately north of the edge of the continental shelf has not been proven conclusively by Lamont's seismic survey results. Actually there is evidence from the magnetic survey of a ridge striking in a northeasterly direction but depth determinations indicate that it is approximately 20,000 feet subsurface, which is twice the depth calculated by Lamont. Moreover, seismic surveys by the Dalhousie Group in the Sable Island area indicate that any such ridge must lie to the south of the island. It would thus be worthwhile to carry out additional geophysical surveys in the area to resolve the question. There is a possibility that the line of northeast-striking magnetic anomalies, which the magnetic maps of the Sable Island Bank area show to continue to the east, are due to Triassic basaltic intrusions such as occur on the south shore of the Bay of Fundy. J.I. Marlowe of the Bedford Institute of Oceanography has collected bottom samples containing basaltic fragments from the Gully which he feels may be of Triassic age. A prominent line of magnetic highs and lows occurs on the continental slope and probably is the start of the typical linear magnetic pattern associated with the oceanic crust.

Some special processing techniques have been applied to the digital data and an example is presented showing the resultant magnetic signatures extending across the Scotian Shelf. Included on the profile are the total intensity of the earth's magnetic field (with the regional gradient removed), a high-frequency digitally filtered trace, a low frequency filtered second derivative magnetic trace together with the underlying bathymetric contour and interpreted geological cross-section. The high frequency filter is designed to enhance the magnetic effects of the near-surface sediments, whereas the low frequency second derivative signature discriminates against shallow causative bodies and augments the anomalies due to more deeply buried sources such as the crystalline basement. Thus the edge of the Meguma may be inferred from the second derivative trace, and this interpretation is supported by the fact that the characteristic pattern of linear magnetic contours which parallels the coastline terminates at the same location.

Howie, R.D., and Cumming, L.M.

BASEMENT GRABEN BENEATH MIRAMICHI BAY; Geol. Assoc. Can. and Min. Assoc. Can., Technical Program, 1966 Ann. Meetings, Halifax, Nova Scotia, p. 20, 1966.

Structure of the Precarboniferous basement beneath Miramichi Bay is a graben-like trough which extends northeast beneath the Gulf of St. Lawrence. A Bouguer anomaly of -300 milligals centered 30 miles offshore and 70 miles east of Bathurst, plus offshore aeromagnetic trend lines show this structure to be 65 miles long with an estimated width of 10-15 miles.

A refraction profile (from Tracadie to Cheticamp) crosses the northwest margin of the structure 20 miles from Tracadie. There, the depression of the Precarboniferous basement is shown by the horizontal change in seismic velocity from 5.9 to 5.3 km/sec. A depth determination from an aeromagnetic anomaly indicates that beneath Miramichi Bay the trough-floor lies at a depth of -10,000 feet. Analogy with late stage structures on stabilized platforms suggests that the trough-floor is nearly flat and that infilling sediments, to the level of the present New Brunswick shelf, are Carboniferous clastics and evaporites.

Hutchison, W.W.

TWO STAGES OF DECREPITATION OF MICAS; Can. Mineralogist, vol. 8, Part 4, pp. 437-460, 1966.

This investigation has revealed that biotite, muscovite, lepidolite, zinnwaldite and some phlogopites on being heated to 1,000°C decrepitate in two distinct stages. The lower temperature stage has a sharp peak rate in the range of 305°-340°C for all the micas examined. This stage, which was never exhibited by chlorite, is related to the rapid loss of an extremely small amount of water from the micas. A more vigorous stage of decrepitation starts in the range 550°-750°C and rises to a peak in the range 600°-1,000°C. The temperature of the peak rate and the character of the decrepitation appear to be dependent, in part, on the species of the mica. From heating stage observations, weight loss measurements, chemical analyses and the measurements of the gas pressure over mica during heating, it appears that this stage is mainly caused by the partial loss of lattice water during heating.

Hutchison, W.W., and Roddick, J.A.

SPECIFIC GRAVITY OF PLUTONIC ROCKS IN THE NORTHERN COAST MOUNTAINS OF BRITISH COLUMBIA; (abst.) Geol. Soc. Am., Program Cordilleran Section, Meeting Mar. 22-25, Santa Barbara, Calif., 1967.

In connection with the Geological Survey's Coast Mountains Project specific gravity determinations were made on more than 5,800 uncrushed rock specimens from an area of about 20,000 square miles between lats. 52° and 55°N. This paper concerns about 3,000 specimens (averaging 700 gm) of plutonic rock. The average specific gravity of the more common types of plutonic rock are as follows: biotite granite, 2.63, (23 specimens); biotite-quartz monzonite, 2.64, (195); bio-hbl quartz monzonite, 2.65, (59); hbl-bio quartz monzonite, 2.68, (53); biotite-granodiorite, 2.67, (198); bio-hbl granodiorite, 2.69, (271); hbl-bio granodiorite, 2.72, (417); hornblende granodiorite, 2.71, (74); biotite-quartz diorite, 2.70, (135); bio-hbl quartz diorite, 2.74, (254); hbl-bio quartz diorite, 2.76, (631); hornblende-quartz diorite, 2.77, (95); bio-hbl diorite, 2.78, (32); hbl-bio diorite, 2.81, (195); hornblende diorite, 2.84, (110); gabbro, 3.03, (72). Average specific gravity for the above plutonic rocks is 2.74. The specific gravities for individual specimens range from 2.56 (hornblende granodiorite) to 3.21 (gabbro).

In general, specific gravity increases with decrease in K-feldspar content, increase in mafic mineral content, and increase in hornblende-biotite ratio.

When reasonable care is taken in specimen selection and weighing procedure, specific gravity determinations are reproducible to 0.005 accuracy. Small specimens and insufficient presoaking are the important sources of error.

The specific gravity determinations were made in the field and, in conjunction with staining of specimens for K-feldspar content, were of considerable value in classifying plutonic rocks, and consequently, of raising the standard of initial mapping of plutonic terrane. Differences within, and between, plutons which may otherwise be missed or not apparent until extensive petrographic work has been done, can be recognized in the field. Anomalous specific gravities are useful in bringing attention to rocks containing miarolitic cavities or unusual minerals.

Jackson, G.D.

GEOLOGY AND MINERAL POSSIBILITIES OF THE MARY RIVER REGION, NORTHERN BAFFIN ISLAND; Can. Min. J., vol. 87, No. 6, pp. 57-61, 1966.

About 4,000 feet of metamorphosed sediments and volcanics - "Mary River Group" - occur as remnant pods and belts in a metamorphic terrain that falls within the hornblende hornfels facies and the almandine amphibolite facies. The "Mary River Group" has undergone at least two periods of major deformation accompanied by granitic intrusions and the formation of migmatites and hybrid gneisses. All ultrabasic and most basic intrusions were emplaced prior to the last major orogeny about 1,700 m.y. ago. The "Mary River Group" and its associated intrusions are similar to some of the Precambrian rocks on Melville Peninsula and in northern Baffin Island. Northwesterly trending, late Proterozoic diabase dykes have been emplaced along, and parallel to, regional fault zones.

Approximately 1,000 feet of horizontal to gently folded and block faulted Ordovician-Silurian strata overlie the Precambrian rocks along a major unconformity. Thin lenses of quartzite, possibly of late Proterozoic age, outcrop along the Palaeozoic-Precambrian contact.

Large deposits of magnetite-hematite occur within the iron-formation member of the "Mary River Group". Occurrences of sulphides and asbestos are also present.

The last recorded major Pleistocene ice movement in the map-area was south to north.

Jambor, J.L.

CONSTITUENTS OF CACOCLASITE; Can. Mineralogist, vol. 8, Part 4, pp. 527-529, 1966.

Cacoclasite from the type locality, Wakefield, Quebec, is a mixture consisting predominantly of grossular.

(J.L.J.)

Jambor, J.L.

NATURAL AND SYNTHETIC HYDROZINCITES; Can. Mineralogist, vol. 8, Part 5, pp. 652-653, 1966.

Recent contributions to the study of natural and synthetic hydrozincites are reviewed. Differences in the properties of various hydrozincites can be attributed to disorder rather than polymorphism.

(J.L.J.)

Kelley, D.G.

STRATIGRAPHY OF CAPE BRETON ISLAND; Geol. Assoc. Can. and Min. Assoc. Can., Technical Program, 1966 Ann. Meetings, Halifax, Nova Scotia, pp. 115-130, 1966.

Cape Breton Island is underlain by rocks ranging in age from Precambrian to Late Carboniferous. Precambrian rocks include metasedimentary sequences and a younger predominantly acidic volcanic sequence that is structurally conformable below Lower Cambrian sedimentary rocks.

Cambrian sedimentary rocks contain brachiopods and trilobites that range in age from late Early Cambrian to latest Cambrian. Intercalated with fossiliferous Middle Cambrian strata are intermediate to basic volcanic rocks. Volcanic rocks that do not contain intercalated fossiliferous strata have also been assigned to the Middle Cambrian. Graptolitic Lower Ordovician shales lie conformably upon Upper Cambrian shales.

Fossiliferous Silurian rocks occur in only one outcrop in the western part of the Island. An unfossiliferous, continental sequence in southeastern Cape Breton, tentatively assigned to the Silurian, may actually be younger.

Devonian sedimentary rocks, mainly arkose and conglomerate, include a few beds of shale that contain probable Middle Devonian megaplant and spore fossils. These continental rocks are present in a small area in central Cape Breton.

The plutonic rocks range in composition from granite to gabbro and are present in all upland areas of the Island. Some at least are older than the Devonian sedimentary rocks, and it is possible that more than one age of granitic rocks is present. Available isotopic ages do not aid in solving this problem.

Carboniferous rocks, which are almost wholly sedimentary, have a maximum thickness in any one section of about 15,000 feet. They consist mainly of clastic rocks ranging from coarse conglomerate to shale, lesser amounts of marine red beds, limestones and evaporites, and minor basic and acidic volcanic rocks that occur only in a few areas at the base of the Lower Carboniferous.

The Carboniferous in Cape Breton has been divided into eight rock-stratigraphic units. These units are briefly considered and a few of the problems of Carboniferous stratigraphy are mentioned.

L'île du Cap-Breton comprend des roches dont la chronologie va de Précambrien à Carbonifère supérieur. Le Précambrien comprend des séries métasédimentaires et une séquence plus récente de coulées volcaniques surtout acides qui est en concordance sous des sédiments du Cambrien inférieur.

Le Cambrien contient des brachiopodes et des trilobites dont l'âge s'échelonne entre Cambrien inférieur supérieur et Cambrien le plus supérieur. Dans des strates fossilifères du Cambrien moyen sont intercalées des roches volcaniques basiques et intermédiaires. D'autres roches volcaniques qui ne contiennent pas de strates fossilifères ont également été placées dans le Cambrien moyen. Des schistes argileux graptolitiques de l'Ordovicien inférieur reposent en concordance sur un schiste argileux du Cambrien supérieur.

Des roches fossilifères du Silurien n'apparaissent qu'en un seul affleurement à l'ouest de l'île. Une série de caractere continental, dénuée de fossiles, au sud-est de l'île, et considérée comme étant probablement silurienne, pourrait être plus récente.

Des roches sédimentaires dévoniennes qui sont principalement des arkoses et des conglomérats comprennent aussi quelques lits de schiste argileux. Ces derniers contiennent des mégaplantes et des spores fossilifères qui sont probablement du Dévonien moyen. Ces roches du milieu continental sont restreintes à une petite étendue au centre de l'ile.

Les roches plutoniennes allant du granite au gabbro se trouvent sur tous les hauts plateaux de l'île. Certaines au moins sont plus anciennes que les sédiments dévoniens et il se peut que les granites soient de plusieurs âges. Les datations isotopiques faites jusqu'à maintenant n'ont pu éclaircir ce problème.

Les formations carbonifères qui sont presque entièrement sédimentaires ont une puissance maximum dans toutes les coupes reconstituées d'environ 15, 000 pieds. Ce sont surtout des roches détritiques variant de conglomérat grossier à pélite. On trouve en quantités moindres des couches rouges marines, des calcaires et des évaporites et, à la base du Carbonifère inférieur dans quelques régions, quelques roches volcaniques basiques et acides.

Le Carbonifère au Cap-Breton a été divisé en huit étages que nous étudions brièvement en mettant en relief quelques-uns des problèmes d'ordre stratigraphique du Carbonifère.

Kerr, J.W.

NEW NOMENCLATURE FOR ORDOVICIAN ROCK UNITS OF THE EASTERN AND SOUTHERN QUEEN ELIZABETH ISLANDS, ARCTIC CANADA; Bull. Can. Petrol. Geol., vol. 15, No. 1, pp. 91-113, 1967.

Ordovician rock units in the eastern and southern Queen Elizabeth Islands have commonly been misidentified and the nomenclature has become confused, largely through a paucity of fossils and the failure of workers to

recognize that there are not one, but two major evaporite units. This paper reviews the earlier work, documents the misunderstandings, and sets forth an expanded nomenclature that is widely applicable.

The Copes Bay Formation is now more accurately dated as of early Canadian age by the dating of overlying and equivalent units. The Baumann Fiord is a new formation of Canadian age whose type section, 2,560 feet (790 m.) of mainly gypsum-anhydrite, occurs east of Trold Fiord on central Ellesmere Island. The formation is represented on Cornwallis Island by gypsum-anhydrite in the core of the Centre Dome. The Eleanor River Formation remains as first proposed (Thorsteinsson, 1958), with a type section of 2,000 feet (615 m.) of limestone on Cornwallis Island; however, it is now better dated as of Canadian, probably Whiterock to Marmor age.

The Cornwallis Formation is raised to group status, the type section remaining on Cornwallis Island, and the boundaries coinciding with those of the earlier formation as erected by Thorsteinsson (1958). Three new formations that comprise the Cornwallis Group have their type sections in a single, long, conformable section northeast of Irene Bay on Ellesmere Island. The oldest, the Bay Fiord, is 1,650 feet (510 m.) of recessive, argillaceous, anhydritic limestone, shaly limestone and shale, of Middle Ordovician (about Ashby to Wilderness) age. The Thumb Mountain Formation comprises about 1,500 feet (462 m.) of bluff-forming limestone of about Barneveld and Eden age. The Irene Bay Formation is about 270 feet (83 m.) of recessive, greenish weathering, argillaceous limestone. A prolific shelly fauna, which has been called the "Arctic Ordovician fauna," occurs in the Irene Bay Formation and is regarded as late Caradocian in age. Grapolites of Ashgillian age occur at the base of the overlying Cape Phillips Formation. The Cornwallis-Cape Phillips contact is arbitrarily regarded as the boundary of Caradocian (Middle) and Ashgillian (Upper) of the European standard section, and therefore occurs within the Upper Ordovician (about Maysvillian) of the American standard section.

Lachance, G.R., and Traill, R.J.

A PRACTICAL SOLUTION TO THE MATRIX PROBLEM IN X-RAY ANALYSIS, PART 1: METHOD; Can. Spectr., vol. 11, No. 2, pp. 43-48, 1966.

Commonly accepted concepts of interelement effects in X-ray spectrometry lead to extremely complex correction calculations and have prevented acceptance of a general computational method. A solution to the problem is found in the hypothesis: "the relative intensity of a constituent is directly proportional to its weight fraction and inversely proportional to 1 plus the sum of the products of the weight fractions of the remaining constituents times their respective alpha constants". This new approach to the intensity-concentration relation, found to be applicable to X-ray diffraction, X-ray fluorescence and electron probe microanalysis, provides a choice of three computational variants of a simple method for converting measured X-ray intensities to weight fractions in complex systems.

Lang, A.H.

DISCOVERY METHODS OF POST - 1955 NEW PRODUCERS; Can. Min. J., vol. 88, No. 1, pp. 47-50, 1967.

The manner of discovery of Canadian mines brought into production in the decade 1956-65 was studied to indicate the current relative importance of the four main categories of prospecting: conventional; geological; geophysical; and geochemical. Mines brought into production in 1966 and others almost ready were included, bringing the total to 175. Eighteen of these were reopened former producers. The method for some mines was uncertain because of incomplete data, lack of uniformity in terms used for initial discovery and subsequent testing, and multiple use of methods. This forced some tentative and arbitrary decisions but any errors so caused tend to balance out. When more than one category was involved an attempt was made to distinguish between dominant and supporting methods, the latter being listed separately. Specific methods within a main category were considered only in a general way.

Of the 175 mines, 87 (50%) were attributed to conventional prospecting, 49 (28%) to geological, and 28 (16%) to geophysical. Of the remaining 11 mines, 5 were found by combined methods none of which seemed dominant, and 6 were undetermined. Because some mines were developed from very old prospects the average time from discovery to production was about 30 years. To obtain a better concept of current methods the 55 mines that were discovered since 1945 were summarized separately, in other words, those of the 175 that were found between 1945 and 1965 and were brought into production after 1955. Their average time from discovery to production was 6 1/2 years. Of these 55 mines, 18 (33%) were attributed to conventional methods, 15 (27%) to geological, and 20 (36%) to geophysical; 1 was found by combined methods for which dominance could not be estimated, and 1 was undetermined. None was attributed mainly to geochemical methods but these provided support in 6 cases. To gain further information on methods recently in use 20 advanced prospects for which production plans had not been announced were studied. Five were indicated as being entirely or mainly conventional finds, 3 as geological, 2 as geophysical, and 1 as geochemical. No dominant method was indicated for the remaining 9. Many of the 20 were attributable to more than one method, comprising 4 conventional, 3 geological, 9 geophysical, and 6 geochemical approaches.

The 175 mines were analyzed as to size, main commodities produced, and geological province or sub-province of location.

(A.H.L.)

Larochelle, A.

PALAEOMAGNETISM OF THE ABITIBI DYKE SWARM; Can. J. Earth Sci., vol. 3, No. 5, pp. 671-683, 1966.

Previous data published on the palaeomagnetism of a group of Precambrian diabase dykes, referred to as the Abitibi swarm, were characterized by considerable angular dispersion attributed to a number of possible factors. The relative importance of these factors was investigated in the light of data obtained for an independent suite of samples from the same group of dykes. Most of the previous interpretation is probably no longer

valid because the magnetization of the swarm was found to be distributed tightly about three mean directions rather than dispersed widely about one mean direction, as originally thought. It is concluded that the dykes forming the swarm were injected intermittently during several widely distinct periods and that, accordingly, long-range correlation of diabase dyke swarms on the sole basis of their palaeomagnetism may be moré hazardous than was realized earlier.

La publication antérieure de données paléomagnétiques sur le groupe de dykes de diabase précambriens surnommé l'essaim de l'Abitibi y avait indiqué une dispersion angulaire considérable des directions d'aimantations. L'importance relative des différents facteurs auxquels cette dispersion avait été attribuée fait l'objet de la présente étude, laquelle est basée sur un nouvel échantillonnage des mêmes dykes. En grande partie, l'interprétation préliminaire est périmée par suite de cette étude puisque l'aimantation de l'essaim nous apparaît non plus comme dispersée autour d'une même direction moyenne, mais bien groupée autour de trois directions distinctes. On en tire la conclusion que les dykes formant l'essaim ont été injectés au cours de plusieurs étapes distinctes, ce qui suggère que la corrélation des dykes de diabase à l'échelle continentale et basée seulement sur des données paléomagnétiques comporte plus de dangers qu'on ne l'avait soupçonné au premier abord.

Larochelle, A., and Wanless, R.K.

THE PALEOMAGNETISM OF A TRIASSIC DIABASE DIKE IN NOVA SCOTIA; J. Geophys. Res., vol. 71, No. 20, p. 4949, 1966.

The paleomagnetism of a 110-km-long diabase dike in the southern part of Nova Scotia has been studied. A potassium-argon whole-rock age determination has confirmed the Triassic age assignment to the dike rocks. The magnetic stability and other magnetic properties of the rocks were examined, and the presence of a stable component was established. An analysis of the paleomagnetic data establishes their statistical significance and indicates that at the time of injection of the dike the North Pole was situated in the area presently occupied by northern Siberia (98°E, 69°N). This pole position is in good agreement with available paleomagnetic poles obtained for other North American Triassic formations.

Lewis, C.F.M., Anderson, T.W., and Berti, A.A.

GEOLOGICAL AND PALYNOLOGICAL STUDIES OF EARLY LAKE ERIE DEPOSITS; Great Lakes Research Division, University of Michigan, Pub. No. 15, pp. 176-191, 1966.

Coring and echo sounding of Lake Erie bottom sediments have indicated a thin lag concentrate of sand, in places with plant detritus, pelecypods, gastropods and other fossils, underlying Recent silty clay muds and overlying clay till or late-glacial lacustrine clays. Buried shallow pond organic sediments in the western basin and relict beach deposits, wave-cut terraces and intrabasinal discharge channels in the central basin, some of which are buried, all indicate former low water levels in central and western Lake Erie much below those at present. This evidence, combined with

radiocarbon dates of 10,200 and 11,300 years B.P. on the organic material and information from nearby regions, suggests that Early Lake Erie came into existence about 12,400 years ago, with water levels, 100 feet (30 m.) lower than at present, at approximately 470 feet above sea level. From this stage lake levels rose rapidly as the outlet area at Buffalo, N.Y., was uplifted isostatically following deglaciation, and probably reached their present elevation 9,000 to 10,000 years ago.

Examination of the cores indicated that pollen is sufficiently abundant and well preserved in the sediments for palynological studies. Pollen diagrams can be correlated with one another, and with those outside of the Lake Erie basin. The presence of a legible pollen record indicates that sedimentation has been probably continuous and undisturbed at the sites investigated since low-level Early Lake Erie. Palynological studies support the geological evidence of a low lake stage and provide a means for dating and correlating sediment sequences which do not contain enough organic matter for radiocarbon analysis.

McCartney, W.D., Poole, W.H., Wanless, R.K., Williams, H., and Loveridge, W.D.

Rb/Sr AGE AND GEOLOGICAL SETTING OF THE HOLYROOD GRANITE, SOUTHEAST NEWFOUNDLAND; Can. J. Earth Sci., vol. 3, No. 7, pp. 947-957, 1966.

The Precambrian Holyrood granite of southeastern Newfoundland is of particular geological interest, because of its tectonic position on the easternmost exposed flank of the Appalachian mobile belt. Although previously considered to have been emplaced during the Grenville orogeny, this granite yields a Rb/Sr isochron age of 574 $\pm$ 11 million years (m.y.). Tectonic and sedimentary events that followed the granite emplacement, and that preceded the deposition of nonconformably overlying fossiliferous Lower Cambrian strata, are believed to have required at least 15 m.y. Consequently, a tentative maximum age of 560 $\pm$ 11 m.y. is proposed for the base of the Cambrian in this region.

McDonald, B.C.

WISCONSIN STRATIGRAPHY AND ICE-MOVEMENT DIRECTIONS IN SOUTHEASTERN QUEBEC, CANADA; (abst.), Geol. Soc. Am., Program North Eastern Section, Meeting Mar. 16-18, 1967, Boston, Mass., 1967.

In the Appalachians of southeastern Quebec, evidence exists for three Wisconsin glacial phases, each antedated by a nonglacial interval. The stratigraphic succession with C^{14} dates follows:

Postglacial interval	– glacial-lake, marine, fluvial, and eolian sediments
Glacial phase III	– Till III
Nonglacial interval III	– glacial-like sediments

Glacial phase II – Till II

Nonglacial interval II – plant-bearing lake sediments: 54,000 B.P. (Y-1683); 41,500 B.P. (GSC-507)

Glacial phase I – Till I

Nonglacial interval I – oxidized gravel

On the basis of C^{14} dates and pollen content, nonglacial interval II is correlated tentatively with St. Pierre Interval.

The history of ice-movement directions as determined from striations and fluting, indicator fans, till fabrics, and stratigraphy suggests the possibility of a major change in center of glacial outflow during the Wisconsin Stage. Ice of glacial phase I probably advanced from northwest. During the early part of glacial phase II ice advanced from about N 85°E; this flow is documented by striations, till fabrics, and by an indicator fan over a distance of 30 miles. It is suggested that a center of glacial outflow lay to east-northeast in early post-St. Pierre time. By the end of glacial phase II ice was advancing from northwest. Finally, ice of glacial phase III advanced from northwest across the Quebec Appalachians. Several indicator fans adjacent to the International Boundary at Vermont, New Hampshire, and Maine indicate that the last ice flowed from northwest to southeast, thus discrediting the widespread belief that ice flowed into Quebec from late-glacial centers of outflow in northern New England.

McGregor, D.C.

DEVONIAN SPORES FROM EASTERN AND ARCTIC CANADA; Can. Bot. Assoc., Abstracts, 1966 Ann. Meeting, Vancouver, p. 14, 1966.

Work by the Geological Survey of Canada on Devonian spores from the Gaspé Peninsula, and the Arctic mainland and islands, serves to illustrate both the stratigraphical and botanical significance of Devonian spores.

In the Lower Devonian (Gedinnian to Emsian) of eastern Gaspé, a major change in spore assemblage composition occurred in the Emsian, reflecting a drastic change in the vegetation of the area in Devonian time. Spores above the change resemble those of the Eifelian of Scotland and the USSR, whereas those below it belong to an undescribed assemblage and are associated with the so-called Psilophyton flora.

In the Middle and Upper Devonian (Givetian to Famennian) of the Canadian Arctic there is a high degree of similarity of certain of the spore assemblages with those of Western Australia, the western part of the USSR, and North Africa. In addition certain species, for example Hymenozonotriletes lepidophytus (late Famennian) and Archaeoperisaccus spp. (Frasnian) appear to have very similar, if not identical, stratigraphic ranges in all of these areas.

MacKenzie, W.S.

UPPER DEVONIAN STRATIGRAPHY IN THE VICINITY OF MOUNTAIN PARK, ALBERTA; Edmonton Geological Society Guidebook, Eighth Annual Field Trip, Cadomin, Alberta, 1966, pp. 19-37.

Upper Devonian carbonates and associated argillaceous strata that outcrop along the Front Ranges of the Rocky Mountains in the region south of Mountain Park form part of a large complex that continues for many miles to the southeast. Two formations, which in the Alberta subsurface contain oil- and gas-producing reservoirs, constitute the carbonate sequence. They are the Cairn Formation of dark brown dolomite, and overlying lighter coloured carbonates, the Southesk Formation. Both formations are replaced by laterally equivalent argillaceous beds. In this area some aspects of the transition and of stratigraphic relationships involved can be seen on the northeasterly-facing cliffs. Dolomites of the Cairn Formation change abruptly to laterally contiguous shales whereas the Southesk Formation transition is gradual and accompanied by intertonguing. The carbonate sequence and associated strata are bounded above by a disconformity.

Milne, J.E.S.[1], and Howie, R.D.

DEVELOPMENTS IN EASTERN CANADA IN 1965; Bull. Am. Assoc. Petrol. Geologists, vol. 50, No. 6, pp. 1295-1310, 1966. (Also published in Can. Petrol. J., vol. 7, No. 4, pp. 45-57, 1966)

In southwestern Ontario, both exploration and development activity continued to decline. Exploration drilling decreased from 91 tests in 1964 to 80 in 1965 and development drilling from 125 wells in 1964 to 108 in 1965. Cambrian-Ordovician and Silurian objectives each accounted for 35 exploratory tests; however, Silurian development completions outnumbered Cambrian-Ordovician 91 to 12. Offshore drilling showed a 70% increase from 20 wells in 1964 to 34 in 1965. Ontario annual oil production set a new high of 1,279,079 bbls., and annual gas production declined to an estimated 12,760 MMcf.

Of the 80 exploratory tests, 3 were completed as oil discoveries and 9 as gas wells. The most important discovery appears to be I.O.E. Sombra 14-14, completed in a Guelph pinnacle reef for an AOF of 14 MMCFD. The remainder resulted in small increases to proved reserves.

In the Hudson Bay lowland, both industry and government geological and geophysical field activity showed a substantial increase from 1964. There was no exploratory drilling reported for 1965 and industry has not announced any drilling for 1966.

Industry activity in Quebec consisted of 6 crew-months of geophysics and 2 dry exploratory holes on Anticosti Island. In addition, there were 48 shallow-drift or bedrock tests and 8 storage tests completed. The Quebec government reported 5 party-months of geological surveying in the sedimentary area of the province.

[1] Imperial Oil Limited

In the Atlantic region, only 1 development oil well was reported from New Brunswick. Exploration drilling was limited to 2 holes in Newfoundland. Both gas and oil production from the Stony Creek field declined despite secondary-recovery operations.

Offshore activity in Eastern Canada overshadowed activity on land. Land holdings increased from 69,115,823 acres in 1964 to 113,969,453 acres in 1965. Geological and geophysical crew-months almost quadrupled from 7 in 1964 to 26 1/2 in 1965. Government and scientific institution surveys remained relatively constant with 36 crew-months reported for 1964 and 37 for 1965.

For 1966, it is anticipated that offshore geological and geophysical operations in the Hudson Bay lowland and particularly in Eastern Canada will continue to increase. No wildcat drilling has been announced for the Hudson Bay lowland, but drilling may be expected as the tempo and interest increase. On the Grand Banks off Newfoundland, 2 or 3 deep, 8,000-10,000 feet wildcat wells are expected to be drilled in 1966.

Morley, L.W., and Bhattacharyya, B.K.

QUANTITATIVE TREATMENT OF AEROMAGNETIC DATA IN MINERAL AREAS; Bull. Inst. Min. Metallurgy, vol. 59, No. 650, pp. 733-742, 1966.

The primary purpose of conducting aeromagnetic surveys in mineral areas, and interpreting the data thus obtained, is to aid in the extrapolation of the geology from known to unknown areas – both in a horizontal and vertical direction. This paper describes one of the steps in the process of interpretation which has, in the past, been neglected – that of mathematically or quantitatively treating the data in two-dimensional map form. For this, several techniques are available.

These techniques determine the downward and upward continuation fields, the second vertical derivatives and the fields reduced to the pole from the total magnetic field data. Second vertical derivatives and downward continuation fields increase the resolution and sharpness in the observed magnetic anomalies and tend to outline the surface traces of causative bodies with a reasonable amount of success in most cases. The 'reduction to the pole' is a mathematical process of calculating the field at the north pole from the observed field so that the undesirable effects of the dip and declination of the earth's field and of rock magnetization are eliminated.

New and accurate means of carrying out these calculations have been developed by the Geological Survey of Canada. In this paper are also presented the results of a method for obtaining the symbol and numerical map of the processed data with the help of the printer associated with the computer. The tedious work of digitizing magnetic field values in a map can be speeded up by the use of a semi-automatic coordinatograph, with the aid of which field values can be accurately transferred to punched cards.

Nassichuk, W.W.

A MORPHOLOGIC CHARACTER NEW TO AMMONOIDS PORTRAYED BY CLISTOCERAS GEN. NOV. FROM THE PENNSYLVANIAN OF ARCTIC CANADA; J. Paleontol., vol. 41, No. 1, pp. 237-242, 1967.

Clistoceras globosum n. gen., n. sp., an ammonoid from Pennsylvanian (Atokan) strata of northwestern Ellesmere Island in the Canadian Arctic is described and illustrated. This taxon bears unique primary deposits that formed on the venter of the penultimate volution, in front of the aperture and during adolescence tended to close the umbilicus. To describe these deposits the term helicolateral is coined. The position of a distinct runzelschicht layer suggests a homologous relationship between that layer and the conspicuous black film that is secreted in the vicinity of the aperture of living Nautilus.

Norford, B.S., Gabrielse, H., and Taylor, G.C.

STRATIGRAPHY OF SILURIAN CARBONATE ROCKS OF THE ROCKY MOUNTAINS, NORTHERN BRITISH COLUMBIA; Bull. Can. Petrol. Geol., vol. 14, No. 4, pp. 504-519, 1966.

The name Nonda Formation is introduced for a Silurian carbonate unit in the northern Rocky Mountains that is probably entirely Late Llandovery in age. The formation can be traced from the Peace River to the Yukon Border. Westward, the unit changes facies to graptolitic rocks; eastwards, it is apparently truncated beneath Devonian rocks. In the type area of the Sentinel Range the formation rests unconformably on Precambrian rocks and is overlain disconformably by the McConnell Formation of probable Early Devonian age.

Norris, D.K., and Price, R.A.

MIDDLE CAMBRIAN LITHOSTRATIGRAPHY OF SOUTHEASTERN CANADIAN CORDILLERA; Bull. Can. Petrol. Geol., vol. 14, No. 4, pp. 385-404, 1966.

The thin Cambrian sequence in the Flathead-Crowsnest Pass area of the Canadian Cordillera is distinctly different in character from the classical Cambrian succession of the Canadian Rockies to the north. It is unconformable on Purcell (Precambrian) rocks and consists of a basal diachronic sandstone from a few feet to 150 feet thick, a sequence of shales up to 290 feet thick, a lower carbonate unit up to 510 feet thick, and an upper carbonate unit that was initially more than 225 feet thick. These units comprise the Flathead, Gordon, Elko and Windsor Mountain (proposed) Formations respectively. This succession is most closely related to the Cambrian of the southern Alberta Plains and the northern Rocky Mountains of Montana, and is most probably entirely of Middle Cambrian age. It has been bevelled toward the northwest by pre-late Middle Devonian erosion which has locally cut deeply into the underlying Purcell rocks. Several channels in the upper part of the Windsor Mountain Formation filled with fossil plant-bearing siltstone provide a record of earlier Devonian fluvial erosion and deposition.

The contrast between the Cambrian succession in and south of Crowsnest Pass and that in adjacent areas can be ascribed to the influence of the tectonically positive area Montania, which, like a gigantic trapdoor structure, appears to have been bounded on its northwestern and western margins by faults or very steep flexures. Montania was apparently a feature of great antiquity. Coarse detritus accumulated along its northwestern and western flanks in both Windermere (Late Precambrian) and Early Cambrian time. The patterns of thickness and facies variations among the remnants of the Cambrian succession in the Flathead-Crowsnest Pass area that have escaped pre-Devonian and later erosion, indicate that this succession was initially much more widespread and thicker, and that all of Montania was inundated during the Middle Cambrian. The renewed uplift which left its distinctive imprint on the pattern of pre-late Middle Devonian erosion, appears to have assumed the same character as that which occurred in the Precambrian and Early Cambrian. The local absence of Cambrian rocks over the northwestern part of Montania is a result of this later erosion rather than of non-deposition.

Poole, W.H.

GEOLOGY OF THE APPALACHIAN REGION OF CANADA; Geol. Assoc. Can. and Min. Assoc. Can., Technical Program, 1966 Ann. Meetings, Halifax, Nova Scotia, pp. 40-42, 1966.

The Appalachian Geosyncline (senso lato) developed in Eastern Canada from late Proterozoic to Permian. Throughout its evolution, the Geosyncline was bounded on the northwest by Precambrian crystalline basement (Grenville) upon which was deposited platform-type sediments of Cambrian to Devonian age. A pre-Appalachian orogen was developed from upper Proterozoic sedimentary and volcanic rocks and intruded granites; it served as a platform within the southeast flank of the Appalachian Geosyncline throughout its Palaeozoic evolution. Relatively thin, marine, dominantly pelitic sediments of Cambrian to Early Ordovician age were deposited on the orogen.

Initial deposition within the Appalachian Geosyncline consisted of an uppermost Proterozoic (late Hadrynian) and Cambrian clastic assemblage with few volcanics, now present on the exposed flanks of the Geosyncline. In Early and Middle Ordovician, largely impure clastics with generally abundant volcanics were deposited mainly on the axial sides of the earlier clastic zones and within the axial parts of the Geosyncline. Ultramafic-mafic intrusions were first emplaced in Lower Ordovician volcanic belts along parts of the flanks of the Geosyncline; some were remobilized during subsequent deformations. The intrusions were accompanied, or followed immediately thereafter, by deformation. Probably at the same time, sedimentation ended on the pre-Appalachian orogen, and the platform of Ontario and western Quebec was uplifted and eroded. This was followed in Middle Ordovician by a major transgression. During Middle Ordovician, two now-separated klippen in western Newfoundland moved westward onto the platform.

In late Ordovician, some belts of the Appalachian Geosyncline were deformed and uplifted as geanticlines (Taconic orogeny) while sedimentation continued in other belts. Granites intruded some developing geanticlines. Deposition of thin-bedded argillaceous limestone in the Metapedia

belt continued from Middle Ordovician through to Early Silurian without recording the effects of orogeny taking place to its north and south.

The proportion of volcanics and the lithological characteristics of Silurian and Lower Devonian rocks varies from belt to belt across the Geosyncline, in large part controlled by the late Ordovician geanticlines.

During the Middle and Late Devonian orogeny (Acadian), almost the entire Geosyncline including the pre-Appalachian orogen and its cover were deformed and intruded by granites. Probably all of the geosynclinal belt and pre-Appalachian orogen became uplifted and subject to erosion. In response to the rising Acadian geanticline to the south, a trough developed in southern Quebec in which more than 10, 000 feet of late Lower and Middle Devonian sandstone and conglomerate were deposited. In Newfoundland, however, Silurian rocks are largely continental and probably reflect contemporaneous deformation within the geosynclinal belt, but these rocks were deformed, metamorphosed, and intruded probably in mid-Devonian.

Deposition upon the Acadian orogen began in Late Devonian nonmarine intermontane troughs. During mainly the Carboniferous, a broad tectonically active zone extending from Bay of Fundy to White Bay developed upon the Acadian orogen. Within the zone local linear belts of the disrupted orogen were intermittently raised in part on bounding faults, while intervening troughs received fluviatile and lacustrine clastics. Lower Mississippian clastics were restricted to and near the active zone. During Late Mississippian, tectonism ceased while seas spread throughout the zone and southward across the Meguma Platform, depositing limestone, evaporites, and clastics. Continental conditions returned in latest Mississippian and continued until early Permian. By early and middle Pennsylvanian, tectonic activity had all but ceased and clastics spread widely across the former active zone and bordering platforms, and offlapped to the present edges of the Gulf of St. Lawrence.

In late Triassic, a fault-trough developed along and across the older Carboniferous active zone; continental clastics and basalt were deposited, and subsequently warped and cut by steep faults. Cretaceous alkalic plugs of the Monteregian Hills intruded the stabilized geosynclinal belt and platform of the Eastern Townships and Montreal area.

Prest, V.K. and Grant, D.R.

LATE GLACIAL HISTORY OF NOVA SCOTIA AND PRINCE EDWARD ISLAND; (abst.) Geol. Soc. Am., Program North Eastern Section, Meeting Mar. 16-18, 1967, Boston, Mass., 1967.

Studies of ice-flow directions and the transport of erratics on Nova Scotia and Prince Edward Island reveal a very complex pattern of glacier retreat that is not in accord with the generally held and published concepts of deglaciation of the region. The ice-flow pattern suggests a very irregular ice front consequent in large part upon the incursion of the sea into the deeper channels and bays surrounding the region. The location and trend eskers and meltwater channels substantiate the ice-flow patterns.

The problem of late ice "centers" is discussed in terms of the ice-flow features and the distribution of erratics. Potassium-argon datings on granitic erratics from Prince Edward Island are of interest in regard to probable source areas.

The character of the tills in Nova Scotia suggests two major periods of emplacement. The tills generally reflect closely the character of the subjacent bedrock, but a red clay till is of widespread distribution in Nova Scotia. The implication of this till mantle and its manner of emplacement are discussed. Only one period of till emplacement is recognized on Prince Edward Island where it faithfully expresses the clayey or sandy nature of the island's mudstones and sandstones.

The absence of marine overlap in eastern Nova Scotia and Prince Edward Island is discussed in terms of glacial history, as is the amount of overlap elsewhere. Radiocarbon datings on marine shells from the Maritime provinces are few but they nevertheless provide a framework upon which to evaluate events of deglaciation in terms of marine overlap.

Price, R.A.

THE TECTONIC SIGNIFICANCE OF MESOSCOPIC SUBFABRICS IN THE SOUTHERN ROCKY MOUNTAINS OF ALBERTA AND BRITISH COLUMBIA; Can. J. Earth Sci., vol. 4, pp. 39-70, 1967.

Deformation throughout much of the southern Rocky Mountains was characterized by brittle failure in a strongly anisotropic layered sequence of non-metamorphic rocks. On a megascopic scale, the overall structure is dominated by an interlocking system of imbricate thrust plates that have moved relatively eastward or northeastward and upward. On a mesoscopic scale, the principal elements in the fabric of these rocks are fractures that are statistically parallel or perpendicular to the bedding, or else intersect it at preferred angles of approximately 25° or 70°. During deformation many of these fractures obviously were kinematically active, as discrete surfaces of slip that became slickensided, as zones of dilation that became filled with vein minerals, or as surfaces of pressure solution that are now marked by stylolites. Each of these fractures provides a partial record of the kinematics of some stage of the deformation, even when they are considered individually rather than as components in a fracture array whose symmetry is related to that of the movement picture during deformation. Each defines a unique line of slip and axis of rotation for slip, or a unique direction of relative extension or compression. Collectively, they provide a direct and succinct record of the kinematic history of an individual fabric domain, and a sound basis for dynamic analyses of deformation.

Some preliminary results of a reconnaissance study of these mesocopic subfabrics illustrate their tectonic significance.

A movement picture can be established for the deformation that occurs within an individual thrust plate during its development and translation. Kinematic relationships between and among the interlocking thrust plates can be studied.

Within a broad area centered along the prominent structural reentrant that crosses the Rocky Mountains near Crowsnest Pass, two different movement pictures occur in superposition. Movement about both northerly and northwesterly trending axes can be outlined on the basis of the mesoscopic subfabrics of rocks which, on a megascopic scale, have either a northwesterly or a northerly trending fabric axis. Movement patterns for the deformation associated with each of two regional structural salients converge in the vicinity of the reentrant.

The mesoscopic subfabrics associated with transverse faults in parts of the Front Ranges outline a pattern of movement which indicates that they did not originate as tear faults related to the translation of the thrust plates, but instead are probably older gravity faults, whose orientation may be controlled by the fabric of the Hudsonian basement extending beneath the mountains from the Canadian Shield.

Reinhardt, E.W.

PHASE RELATIONS OF CORDIERITE, GARNET, BIOTITE, AND HYPERSTHENE IN HIGH-GRADE PELITIC GNEISSES OF THE GANANOQUE AREA, ONTARIO; Trans. Am. Geophys. Union, Program, 47th Ann. Meeting, vol. 47, No. 1, p. 216, 1966.

Phase relations among sillimanite, cordierite, garnet, biotite, and hypersthene from regionally metamorphosed pelitic gneisses were determined from petrographic studies and the chemical compositions of 47 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 AFM 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 area of study. Partitioning of elements among coexisting minerals and geologic evidence indicate that equilibrium was reached at constant temperature; possible variations in load pressure were inadequate to cause the observed variations of 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 bulk rocks suggests that the mineralogical variations in F/M are a function of oxygen partial pressure. Increased oxygen pressures would produce magnetite at the expense of the ferromagnesian silicates, which would consequently become enriched in the magnesian end members.

Rimsaite, J.H.Y., and Lachance, G.R.

ILLUSTRATIONS OF HETEROGENEITY IN PHLOGOPITE FELDSPAR, EUXENITE AND ASSOCIATED MINERALS; Min. Soc. India, IMA Volume, Int. Min. Assoc., Papers, Fourth General Meeting, pp. 209-229, 1966.

Heterogeneity in natural minerals is a very common phenomenon as a result of changes in physical-chemical conditions during mineral growth and/or subsequent alteration.

Several examples of heterogeneity are described on the basis of microscopic, X-ray diffraction and electron microprobe analyses. These consist of:

(1) zoned phlogopite; and mica containing oriented inclusions and crusts;
(2) "antiperthitic" and lamellar plagioclases; and associated biotite and opaque minerals;
(3) fresh and altered euxenite; and inclusions in associated feldspar.

The purpose of this study is to determine the differences in chemical composition between various mineral varieties in zoned phlogopites, in "antiperthitic" and lamellar plagioclases, in ilmenite-hematite grains, and multicoloured euxenite.

The concentration of iron in zoned phlogopites may increase by a factor of four from the beginning (centre) to the end of crystallization (rim), and in some phlogopites potassium is absent in the outermost portion of the rim. "Antiperthitic" plagioclase is relatively homogeneous labradorite-andesine (An_{15-52}) with inclusions of potassium feldspar, while lamellar plagioclase consists of lamellae ranging in composition from An_5 to An_{70}, and of alkali feldspars.

The concentrations of uranium and lead show erratic variations in the altered euxenite.

Robinson, S.C.

STORAGE AND RETRIEVAL OF DATA; Can. Surveyor, vol. 20, No. 4, pp. 269-279, 1966.

The most common method of recording surveying data is still the field notebook which, after its contents have been made use of or transferred to maps, is stored away. However, more efficient methods of recording and storing data must be considered when the volume of data reaches the point where it becomes economical to use modern methods of storage such as edge-punched cards, punched paper tape, magnetic tape and magnetic disc packs.

The author deals with the various methods of recording data and discusses the factors affecting the choice of a given system.

La méthode d'enregistrement des données d'arpentage la plus répandue est encore le vieux carnet de notes, qui, après que son contenu a été traité ou

transcrit sur cartes, trouvé sa place sur une tablette de voûte. Cependant, l'on doit envisager des méthodes plus efficaces d'enregistrement, lorsque le volume de données dépasse le point où il devient économique d'utiliser les méthodes modernes de mise en réserve des données, telles que: cartes perforées, rubans perforés, rubans magnétiques et disques magnétiques.

L'auteur expose les différentes méthodes d'enregistrement, et fait la discussion des facteurs affectant le choix d'un système donné.

Roddick, J.A.

COAST CRYSTALLINE BELT OF BRITISH COLUMBIA; in Tectonic History and Mineral Deposits of the Western Cordillera, Can. Inst. Min. Metallurgy, Special vol. No. 8, pp. 73-82, 1966.

This paper is a summary of the available information concerning the part of the Coast Crystalline Belt lying in British Columbia. The Coast Crystalline Belt is herein defined as a plutonic and metamorphic terrain extending through British Columbia from northern Washington State to the vicinity of the north-trending part of the Alaska-Yukon Boundary. It includes only the eastern fringe of southeastern Alaska and excludes Queen Charlotte Islands and Vancouver Island except for the small segment that juts farthest northeast. The oldest known rocks in the Coast Crystalline Belt are the Ordovician-Silurian rocks of Prince of Wales and adjoining islands in the Alaskan Panhandle and Middle Devonian rocks in the San Juan Islands. These old rocks contain some granitic debris as does every major system associated with the Coast Crystalline Belt. The Coast Crystalline Belt contains numerous roof pendants, commonly metamorphosed to the amphibole facies. Both sharp and gradational pendant contacts have been observed. Most of the gradational contacts comprise broad zones of migmatite. In many places it is difficult to distinguish even the major units such as the plutonic rocks and the roof pendants. Diorite and quartz diorite are more common in the western part of the Coast Crystalline Belt and biotite-bearing granodiorite and quartz monzonite in the eastern part. Potassium-argon age determinations on biotite indicate older rocks on the west, and younger rocks on the east, the range being from about Lower Cretaceous to Eocene. It is probable that these dates reflect periods of general unloading rather than periods of intrusion. The most common rock by far is quartz diorite, followed by diorite and granodiorite. The region contains many synplutonic dykes. These dykes are partly granitized or otherwise altered by the plutonic rocks they cut. Most of the present relief of the Coast Crystalline Belt may be attributed to uplift since the Pliocene and very little uplift in the early Tertiary.

Roddick, J.A.

TINTINA TRENCH; J. Geol., vol. 75, No. 1, pp. 23-33, 1967.

Tintina Trench marks one of the great faults in western North America extending about 600 miles from southeastern Yukon Territory to Yukon Flats in Alaska. Most of the trench appears to have been excavated by the Pelly and Yukon Rivers before they were deflected from the trench by Pleistocene ice.

Offsets of geological units and regional trends indicate a right-hand movement along Tintina fault of from 220 to 260 miles. Two belts of late Proterozoic sediments and an intervening belt of older metamorphic rocks are best matched across the fault if a 260-mile displacement is assumed. A belt of Carboniferous (?) greenstone can be best matched across the fault if a 220-mile displacement is assumed. Regional trends flanking the southeastern part of Tintina fault are about parallel with the fault and offsets are difficult to establish, but adjacent to the northwestern part regional trends make angles as large as 70 degrees to the fault. The matching of these regional trends also requires restoration of a right-hand displacement of from 220 to 260 miles. Available evidence suggests that about 40 miles of transcurrent movement took place along the fault in lower Palaeozoic time and about 220 miles in Cretaceous time.

Roddick, J.A., Souther, J.G., Wheeler, J.O., and Gabrielse, H.

AGE AND NATURE OF THE CANADIAN PART OF THE CIRCUM-PACIFIC OROGENIC BELT; Symposium on Age and Nature of the Circum-pacific Orogenesis, abstracts of papers, Eleventh Pacific Science Congress, Tokyo, 1966.

The Canadian Cordilleran orogen evolved from a miogeosyncline, which existed from Proterozoic to mid-Jurassic time in Rocky Mountains and northern and eastern Yukon, and a slightly younger complex eugeosyncline on the west. Evidence exists locally for mild orogeny in the late Proterozoic in the western part of the miogeosynclinal belt. Pre-Devonian plutonism in southeastern Alaska and near Vancouver indicates that sialic crust prevailed in early Palaeozoic time near the present continental margin.

The history of the eugeosynclinal belt since the mid-Palaeozoic was influenced by the more or less persistent Coast and Cassiar-Columbia crystalline geanticlines and at times by the non-metamorphic Pinchi geanticline between them. Since mid-Triassic time the geanticlines, particularly the crystalline ones, have been the principal sites of frequent uplift, recurrent granitic intrusion, metamorphism, and deformation. In addition to clastic and carbonate rocks the eugeosynclinal belt received thick accumulations of basalt and basic andesite flows in the Permo-Carboniferous andesitic and spilitic lavas from Late Triassic to mid-Jurassic time.

Orogeny was rarely widespread at any one time. The crystalline geanticlines were repeatedly deformed but not always synchronously whereas adjoining troughs were rarely deformed more than once. Orogenic pulses took place at the following times: mid-Palaeozoic, Middle and locally Early Triassic, Middle Jurassic, latest Jurassic and earliest Cretaceous, late Lower and early Upper Cretaceous, early and late Tertiary.

By late Jurassic time uplift along northeast-trending arches segmented the trough between the crystalline geanticlines into three syntectonic basins whereas uplift of the Cassiar-Columbia geanticline shed debris eastward to an exogeosyncline. After the extrusion of rhyolitic and andesitic, mainly pyroclastic deposits in Late Cretaceous to Middle Eocene time and post-tectonic,thin basalt flows in the Miocene and Pliocene the orogen was stabilized.

Structures in the Coast geanticline are complex and generally steep; those in the Cassiar-Columbia geanticline complex and commonly recumbent. The latter geanticline was thrust eastward onto Rocky Mountain structures characterized by shallow folds and piles of thrust sheets in the south and by large folds in the north. Troughs within the eugeosynclinal belt which contain abundant Mesozoic volcanics are faulted and broadly folded. Syntectonic basins and troughs with few Mesozoic volcanics are tightly folded and faulted, locally in response to gravity sliding from adjacent uplifts. Transcurrent faults are important along the Pacific Coast and probably along Denali and Tintina lineaments.

Rose, E.R.

THE COPPER-NICKEL DEPOSITS OF TIMAGAMI ISLAND, ONTARIO; Econ. Geol., vol. 61, pp. 27-43, 1966.

The complex copper-nickel sulfide deposits of Timagami Island, Ontario, occur in altered, folded, and faulted volcanic rocks of Archaean age near younger mafic intrusions. The sulfide deposits are of two main types, namely pyritic and chalcopyrite ore, the former being low-grade in copper, nickel and cobalt, the latter high-grade in copper and low-grade in nickel, but commercial ore has not yet been produced from the pyritic deposits. In both types copper is carried largely in chalcopyrite; nickel, on the other hand is carried mainly in millerite and gersdorffite in the chalcopyrite deposits, and in pyrite, millerite, gersdorffite, linneaite (siegenite?) and possibly also bravoite and violarite in the pyritic deposits. Nodules of cellular pyrite occur within the chalcopyrite ore. From the textural relationships of these and the ore minerals it is concluded that the ores are of medium to high-temperature-pressure origin, formed by injection of magmatic fluids rich in sulphur, away from their source rock.

Close spatial relationships between the pyrite and chalcopyrite deposits, and the occurrence of mutually common minerals in them, as well as similarities in the distribution of metallic trace elements in the ores suggest not only that the pyritic and chalcopyrite ores are closely related to one another, but that they are probably also both genetically related to mafic rocks, presumably deep-seated mafic intrusions. These conclusions suggest that the ancient belt of rocks between Sudbury and Cobalt in particular should be carefully prospected for other copper-nickel sulfide deposits.

Rutter, N.W.

PRELIMINARY REPORT ON THE GLACIATION OF THE BANFF AREA, ALBERTA, CANADA; (abst.), Geol. Soc. Am., Program, Ann. Meeting Nov. 14-16, 1966, San Francisco, Calif., p. 186, 1966.[1]

Four major glacial advances are recorded by Pleistocene deposits in the Bow River Valley within the Canadian Rocky Mountains. The earliest, the pre-Bow Valley advance, is inferred from outwash underlying till deposited by the succeeding Bow Valley advance, in which ice extended east of the Front Ranges. The Bow Valley advance is evidenced by breaks in slope on valley walls up to 8200 feet, glacial erratics found below 8000 feet, and the wide distribution of till on the Bow River Valley floor. Ice-contact fluvial

deposits record at least two periods of glacier equilibrium during the deglaciation of the Bow Valley advance. In the succeeding Bow Valley re-advance, recorded by discontinuous patches of till over outwash of the Bow Valley advance and by breaks in slope at elevations up to 5300 feet in the walls of the Bow River Valley, the ice margin re-advanced from about Banff townsite, downstream to the Foothills. In the last major advance, the Eisenhower Junction, ice extended down the Bow River Valley to about Eisenhower Junction. Evidence for this advance includes well-preserved ground and lateral moraines, breaks in slope up to 7500 feet, fresh cirques, and a terminal moraine. Evidence is present for a minor re-advance following the Eisenhower Junction advance.

Comparison of the glacial succession in the Bow River Valley with that of the U.S. Rocky Mountains suggests correlation of the Bow Valley advance, Bow Valley re-advance, and the Eisenhower Junction advance with the early, middle, and late Pinedale stades respectively.

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1 Full text published in Bull. Can. Petrol. Geol., vol. 14, No. 4, pp. 613-626, and a modified version appears in The Canadian Alpine Journal, pp. 157-173, 1966.

St-Onge, D.A.

GEOMORPHOLOGY OF THE LANCER AREA, SASKATCHEWAN; Revue Géographie Montréal, vol. 20, Nos. 1 and 2, 1966.

Geomorphological mapping techniques developed by the author for an Arctic area have been modified and improved to fit a small area in the semi-arid zone of southwest Saskatchewan. The purpose of this experimental study is to illustrate the type and nature of scientific and practical information that can be portrayed on this type of thematic map. The paper describes and explains the geomorphology of the map-area and points out some of the fields in which the map can be used.

L'étude de la région de Lancer dans la zone semi-aride du sud-ouest de la Saskatchewan a été effectuée en vue d'améliorer les méthodes de cartographie géomorphologique utilisées par l'auteur dans son étude de l'île Ellef Ringnes, T.N.-O. Le présent travail a pour but d'illustrer le type et la nature de données géomorphologiques pouvant être consignées sur une carte. Le rapport étudie la géomorphologie de la région et souligne quelques-unes des applications pratiques possibles des cartes géomorphologiques.

St-Onge, D.A.

LA VALLÉE DE L'ATHABASCA, ENTRE WINDFALL ET CHISOLM, ALBERTA, Bull. de l'Assoc. des Géographes de l'Amérique française, No. 10, p. 80, 1966.

Depuis sa confluence avec la rivière Berland à l'WSW de Whitecourt jusqu'au lieu-dit Vega, la rivière Athabasca s'écoule par de multiples chenaux entre des îles de gravier grossier. Dans ce segment, la vallée est très large (3 à 8 km) et parfois bordée de terrasses recouvertes de till. Au nord de

Vega, la rivière à chenal unique coule dans le fond d'une vallée étroite et peu profonde. Dans le premier secteur, la rivière est surimposée à une vallée préglaciaire et elle remanie des graviers quartzitiques préglaciaires (Saskatchewan gravels), dont la taille atteint 40 cm de diamètre; dans le second secteur, la rivière s'est taillée une nouvelle vallée dans le till Wisconsin et les roches tendres du Mésozoique.

St-Onge, D.A.

LES <<HUMPHIES>> DE LA RÉGION DE WHITECOURT, ALBERTA; Bull. de l'Assoc. des Géographes de l'Amérique française, No. 10, p. 76, 1966.

A l'est de Whitecourt, un alignement orienté NW-SE de collines de limon lacustre fossilifère marque la limite entre la zone des dépôts lacustres au SW et la plaine de till au NE. Ces collines atteignant parfois 15 m de haut ont des versants de 28° et un sommet plat ou en légère dépression (en forme de beigne). Ce type de dépôt et de forme est caractéristique d'un front glaciaire en voie de désintégration.

St-Onge, D.A., and Aitkens, D.S.W.

MORPHOLOGIE GLACIAIRE DANS LE CANADA SEPTENTRIONAL; Revue Photo-Interprétation, No. 1 – 1966, fasc. 1.

Interprétation d'un triple stéréoscopique de la région de Hanbury
75 p. (D.A. St-O.)

Sangster, D.F., Hood, P.J., and Gross, G.A.

RELATIONSHIP BETWEEN GEOLOGY AND GEOPHYSICAL PARAMETERS OF A MAGNETITE IRON-FORMATION; Bull. Can. Inst. Min. Metallurgy, vol. 59, No. 646, pp. 154-158, 1966.

Some results are presented of an integrated geological and geophysical study of Precambrian magnetite-quartz iron-formation in the Kapiko Iron Range north of Nakina, Ontario. Detailed geological and topographical mapping was carried out in conjunction with detailed geophysical investigations such as vertical magnetic field, vertical magnetic gradient, hammer seismic, horizontal-loop electromagnetic and magnetic susceptibility surveys. In addition, oriented drill cores were obtained for magnetic polarization studies.

Vertical-force magnetic anomalies within individual rock units showed a strong positive correlation with topographic relief. Moreover, magnetic intensity was found not to be quantitatively proportional to the magnetite content in the rocks, due to the presence of high remanent magnetization of the magnetite. Also, the remanent polarization direction was subparallel to the plunge of the fold structure and mineral lineation in associated rocks.

Vertical magnetic gradient measurements were found to be more accurate in locating buried contacts between magnetite-quartz iron-formation and country rock than the vertical magnetic force data.

An in-situ magnetic susceptibility meter was used to measure the magnetite content of iron-formation, and the measurements were subsequently compared with vertical-force magnetic results.

The results of the EM survey were inconclusive; some magnetite-rich zones produced anomalies in the out-of-phase component, whereas others did not. The reasons for such inconsistencies are not yet apparent.

Longitudinal seismic wave velocities measured parallel to the bedding in magnetite-quartz iron-formation ranged from 10,600 ft./sec. to 14,500 ft./sec. The seismic velocity appears to increase with an increase in deformation of the rocks.

Sen Gupta, J.G.

ARSENAZO III AS A SENSITIVE AND SELECTIVE REAGENT FOR THE SPECTROPHOTOMETRIC DETERMINATION OF PALLADIUM IN IRON AND STONY METEORITES; Analytical Chemistry, vol. 39, p. 18, 1967.

Arsenazo III is a very sensitive and selective reagent for the spectrophotometric determination of palladium in mixtures of palladium, platinum, rhodium, and iridium isolated from iron and stony meteorites and copper-nickel matte by perchloric acid decomposition and ion exchange separation. Palladium forms a 1:1 complex with Arsenazo III, with a dissociation constant of 5.04×10^{-6} at 24°C. The optimum concentration range for the determination of palladium is from 1.16 to 3.00 ppm. Also, a combination of ion-exchange separation and the sensitive thorium-arsenazo III reaction has been used in the determination of microgram amounts of thorium in some stony and iron meteorites. Palladium concentrations were found to be in the range of 2.4-13.4 ppm in three iron meteorites, 0.4-0.8 ppm in five stony meteorites; the thorium concentrations were in the range of 0.10-0.15 ppm in the iron meteorites and 0.05-0.09 ppm in the stony meteorites.

Skinner, B.J.[1], Jambor, J.L., and Ross, M.[2]

MCKINSTRYITE, A NEW COPPER-SILVER SULFIDE; Econ. Geol., vol. 61, pp. 1383-1389, 1966.

Mckinstryite, $Cu_{0.8+x}Ag_{1.2-x}S$, where $0 \leq x \leq 0.02$, was found on a specimen collected in 1907 at the Foster Mine, Cobalt, Ontario. Mckinstryite is orthorhombic, space group Pnam or $Pna2_1$, $a = 14.043 \pm 0.005$ Å, $b = 15.677 \pm 0.006$ Å and $c = 7.803 \pm 0.003$ Å, $Z = 32$, specific gravity 6.61 ± 0.03. Strongest X-ray powder diffraction lines are 2.606 Å (10), 2.070 Å (7), 3.062 Å, 3.508 Å, 2.862 Å, 1.948 Å (5), 2.407 Å (4), and 2.567 Å(4).

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[1] Kline Geology Laboratories, Yale University, New Haven, Conn.
[2] U.S. Geological Survey, Washington, D.C.

Mckinstryite is named in honour of Hugh Exton McKinstry, 1896-1961, late Professor of Economic Geology, Harvard University.

Souther, J.G., and Armstrong, J.E.

NORTH CENTRAL BELT OF THE CORDILLERA OF BRITISH COLUMBIA; in Tectonic History and Mineral Deposits of the Western Cordillera, Can. Inst. Min. Metallurgy, Special vol. No. 8, pp. 341-348, 1966.

A brief account of the tectonic history of north central British Columbia is outlined. It is not possible to fully document the geological data on which many of the interpretations are based. Only a broad outline of the main tectonic events is considered, omitting many of the details of this complex region. In searching for some general principles, this very complexity is perhaps one of the most significant characteristics of the Northwestern Cordillera. It is not a region where tectonic events can be separated into the conventional orogenic and non-orogenic periods. There has been a continuity of events; folding has been contemporaneous with sedimentation, and sedimentation contemporaneous with intrusion in different parts of the mobile belt. Another generalization that may be made concerns the type of folding - there is little evidence that this part of the Cordillera has been periodically compressed and the strata deformed into parallel folds that reflect the northwesterly Cordilleran trend. When the fold systems are analyzed they are found to conform much more closely to large, individual fault-bounded blocks. Thus the folds in the Atlin Horst conform to the margins of the horst and folds in the Bowser Basin conform to the margins of the basin itself. The region is broken into many discrete crustal blocks, bounded by deep faults and these have had a profound influence not only on the pattern of deformation but also on the pattern of land and sea areas that are shown on the paleogeographic maps.

Also discussed is the practical problem of relating the sequence of geological events to the genesis and distribution of ore deposits. For many years the eastern contact of the "Coast Range Batholith" was regarded as the most favourable target zone for prospecting. When the "Batholith" was shown to be a composite of many different phases emplaced over a long period of geological time it became apparent that some phases were more favourable than others. Deposits of copper and molybdenum, for example, are most frequently associated with relatively young syenitic or monzonitic phases. In addition, copper deposits appear to be closely associated with Upper Triassic volcanic rocks. Anyox, Granduc, Stikine Copper, Schaft Creek and many of the smaller copper deposits in Tulsequah area are within or very near the arcuate belt of Upper Triassic lavas described in the paper. The relationship of mineral deposits, such as Pinchi Lake mercury, to major faults has also been recognized for many years. In parts of north central British Columbia the position of ancient faults is reflected in facies changes in younger rocks and can be determined only through careful stratigraphic study. Moreover, there appears to be a relationship between certain types of mineralization and the environment of sedimentation. Thus, the near shore facies of the Bowser Group is more commonly mineralized than the offshore sedimentary rocks in the central part of the basin. Although these are only empirical relationships they suggest that the study of stratigraphy,

paleogeography and tectonic history may eventually become as important in the search for mineral deposits as they have already become in the search for petroleum.

Stott, D.F.

CRETACEOUS ALBERTA GROUP IN THE REGION OF McLEOD RIVER, ALBERTA; Edmonton Geological Society Guidebook, Eighth Annual Field Trip, Cadomin, Alberta, 1966, pp. 81-97.

The Upper Cretaceous Alberta Group consists of a sequence of shales and sandstones, predominantly of marine origin. Lithology, age relationships, and depositional environments of the Blackstone, Cardium, and Wapiabi Formations in the McLeod region are reviewed briefly. Two diagrams depict the relationships of non-marine and marine strata within the Cardium Formation in the region between Athabasca and North Saskatchewan Rivers.

Taylor, F.C., and Schiller, E.A.

METAMORPHISM OF THE MEGUMA GROUP OF NOVA SCOTIA; Can. J. Earth Sci., vol. 3, pp. 959-974, 1966.

The Meguma group of lithic greywacke, feldspathic quartzite, slate siltstone, and argillite is Early Ordovician or older in age and has undergone both regional and contact metamorphism. Both types of metamorphism have resulted in recrystallization and locally in orientation of newly formed minerals. Metasomatism and retrogressive metamorphism are subordinate and only locally important. Regionally metamorphosed rocks are divided into greenschist and almandine-amphibolite facies, although some assemblages cannot be assigned with certainty. Locally, biotite and garnet isograds are mappable within the greenschist zone.

Relationships between regional metamorphism and structural elements (folding) show that deformation preceded regional metamorphism. Intrusion of granitic rocks has produced a zone of contact metamorphism (hornblende-hornfels facies) that is superimposed upon regional greenschist facies rocks, which shows that granite emplacement occurred after the regional grade was reached. Gold-quartz veins are confined to areas lying in the greenschist zone of regional metamorphism, which suggests that the almandine-amphibolite zone is not favourable.

Terasmae, J., and Hughes, O.L.

LATE-WISCONSINAN CHRONOLOGY AND HISTORY OF VEGETATION IN THE OGILVIE MOUNTAINS, YUKON TERRITORY, CANADA; Palaeobotanist, vol. 15, pp. 235-272, 1966.

Studies of Pleistocene geology and history in the western Ogilvie Mountains, bordering on the east of the unglaciated region in Yukon, were made by Hughes who has recognized three major glacial episodes characterized by successive advances and retreats of valley glaciers originating in

cirques along the axis of the southern Ogilvie Ranges. Palynological studies and radiocarbon dating have been used to support and confirm the chronology of complex moraine sequence. The youngest of these glacial episodes is believed to have culminated prior to 10,000-12,900 years ago.

The history of late Wisconsinan vegetation in this area, as inferred from palynological and paleobotanical studies, holds special interest because of the postulated survival of plants in the adjacent unglaciated area which provided a potential late-glacial dispersal centre in addition to migrations reaching the area later from the southeast and south. It seems that birch, alder, willow, and spruce were among the early pioneers from the western source. A mixing of the western and eastern floral elements after deglaciation is an interesting problem. The magnitude of the postglacial climatic changes appears to have been smaller than in the more southerly regions. At several sites studied, the onset of the permafrost regime has been an important factor in the development of vegetation, because of its influence on both the groundwater conditions and soil development.

Terasmae, J., Webber, P.J.[1], and Andrews, J.T.[2]

A STUDY OF LATE-QUATERNARY PLANT-BEARING BEDS IN NORTH-CENTRAL BAFFIN ISLAND, CANADA; Arctic, vol. 19, No. 4, pp. 296-318, 1966.

Buried plant-bearing beds along Isortoq River at the northern end of Barnes Ice Cap on Baffin Island have been dated at more than 38,830 and 40,000 years B.P. A palynological and palaeobotanical study has indicated the presence of species (e.g. dwarf birch) which now occur several hundred kilometres south of this locality. Because of the inferred climatic conditions, more favourable than the present, an interglacial age (Sangamon) is assigned to the Isortoq plant-bearing beds. Folding of the Isortoq beds by overriding ice and the orientation of the overturned folds indicate accumulation of the initial ice cap east of this locality.

On a daté à plus de 38,830 et 40,000 ans av. p. respectivement des horizons végétaux enfouis le long de la rivière Isortoq, a l'extrémité nord de la calotte de Barnes, sur l'île Baffin. Des études palynologique et paléobotanique indiquent la présence d'espèces (comme le bouleau nain) qui se retrouvent aujourd'hui a plusieurs centaines de kilomètres au sud de cette localité. En déduisant des conditions climatiques plus favorables qu'à présent, on assigne à ces horizons un âge interglaciaire (Sangamon). Le plissement des horizons par de la glace de recouvrement et l'orientation de ces plis indiquent que l'accumulation d'une calotte initiale s'est produite à l'est de la localité.

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[1] Biology Department, Queen's University, Kingston, Ontario.

[2] Geographical Branch, Department of Energy, Mines and Resources, Ottawa.

Traill, R.J., and Lachance, G.R.

A PRACTICAL SOLUTION TO THE MATRIX PROBLEM IN X-RAY ANALYSIS, PART 2: APPLICATION TO A MULTICOMPONENT ALLOY SYSTEM; Can. Spectr., vol. 11, No. 3, pp. 63-71, 1966.

A new and practical approach to the solution of matrix problems in X-ray analysis is demonstrated by applying a simple linear relationship between relative intensities, weight fractions and α constants, to the X-ray fluorescence analysis of a nine-element alloy system. The results of 85 analyses provide good experimental evidence of the validity of the relationship and disprove widely-accepted viewpoints that: (a) coefficients representing the effect of one element on the radiation of another can not be constants and are useful only over narrow ranges in matrix composition; and (b) enhancement effects are much more difficult to evaluate than absorption effects.

Wheeler, J.O.

EASTERN TECTONIC BELT OF WESTERN CORDILLERA IN BRITISH COLUMBIA; in Tectonic History and Mineral Deposits of the Western Cordillera, Can. Inst. Min. Metallurgy, Special vol. No. 8, pp. 27-45, 1966.

The eastern belt, lying west of Rocky Mountain Trench, is composed mainly of Proterozoic and Palaeozoic marine clastics with subordinate carbonates and volcanics and sparingly of Mesozoic marine volcanics and sediments and Tertiary continental clastics and volcanics. Its western border lies along Cassiar crystalline belt and along the western boundaries of Wolverine and Shuswap metamorphic complexes and Cariboo Mountains.

The southern half is essentially anticlinorial. Near the Trench structures are overturned eastward and are locally connected with and thrust over Rocky Mountain structures. The west side of the anticlinorium is overturned westward merging with and thrust against Shuswap gneiss dome complex along Kootenay Arc and meeting northeastward overturned structures in western Cariboo Mountains. Granitic plutons are mainly discordant and range in age from Proterozoic to Tertiary. Near the north end of the belt structures near the Trench meet it at a small angle and are overturned eastward. Those near Cassiar batholith are locally overturned southwestward. In Wolverine area structures are not clear but are mainly overturned away from the Trench. Plutons are regionally concordant but discordant in detail.

Differential uplift and subsidence, locally controlled by faults, was important in determining the character and distribution of sediments.

Folding, regional metamorphism, and uplift – all of varying intensity together with local granitic intrusion took place in ancestral Purcell Mountains in the late Proterozoic and throughout the belt in Mississippian and mid-Triassic times. Since late Jurassic time the belt has been emergent with local intermontane basins. Intense deformation and plutonism occurred throughout between the late Jurassic and the early Upper Cretaceous and some deformation, intrusion, and uplift in latest Cretaceous and early Tertiary. Normal faulting, uplift, and volcanism followed in the mid- and late Tertiary.

Gross, G.A.

IRON DEPOSITS OF THE SOVIET UNION; Bull. Can. Inst. Min. Metallurgy, vol. 60, No. 658, p. 143, 1967.

The Soviet Union has enormous reserves of iron ore in many different kinds of deposits that are widely distributed in this vast land area. The present iron ore industry is based mainly on deposits in Precambrian cherty iron-formation at Krivoy Rog, Kursk and Murmansk. Extensive reserves of both naturally enriched hematite ore and magnetite iron-formation in these areas alone could supply all the domestic ore required for several hundred years.

Many contact metasomatic magnetite deposits discovered in recent years in the eastern Ural Mountain belt and east of the Kusnetsov basin in Siberia are being developed; ore reserves are measured in billions of tons. Oolitic limonite-chamosite-siderite ores of Cretaceous and younger age at Kerch on the Black Sea and around the east and southern perimeter of the West Siberian basin constitute some of the largest concentrations of iron in the world. These sedimentary ores are low grade, of poor quality and difficult to beneficiate. Banded jasper magnetite and hematite iron-formation in volcanic rocks of Devonian age in Kazakhstan and along the Mongolian border are of special geological significance.

Iron deposits in the Krivoy Rog and Kursk areas were examined, and a large number of geologists discussed their work on deposits in many other parts of the Soviet Union during the writer's seven-week study tour of mines and Research Institutes in Moscow, Leningrad and Novosibirsk in Siberia and Kiev in the Ukraine. The descriptive geology of iron deposits of usable ore and of marginal material has been well documented in the course of systematic work and a large number of scientists are studying fundamental problems on the origin and treatment of iron ore.

AUTHOR INDEX