



GEOLOGICAL
SURVEY
OF
CANADA

DEPARTMENT OF ENERGY,
MINES AND RESOURCES

PAPER 70-4

ABSTRACTS OF PUBLICATIONS
IN SCIENTIFIC JOURNALS
BY OFFICERS OF
THE GEOLOGICAL SURVEY OF CANADA
APRIL 1969 to MARCH 1970

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ABSTRACTS OF PUBLICATIONS IN SCIENTIFIC
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SURVEY OF CANADA, APRIL 1969 TO MARCH 1970

This report contains abstracts of 76 papers by officers of the Geological Survey of Canada which were published in scientific journals and books during the period 1 April, 1969 to 31 March, 1970. Most of these papers included abstracts and these have been reproduced from the published text; for a few papers abstracts were not available and for these the authors have prepared abstracts for this publication. The abstracts are arranged alphabetically according to author.

The papers published in scientific journals together with the various Geological Survey memoirs, bulletins, papers, economic geology reports, miscellaneous reports and maps, which are listed in the Index of Publications (Geol. Surv. Can., Paper 70-3), represent most of the published output of the Geological Survey between 1 April, 1969 and 31 March, 1970.

Abbey, S.

U.S. GEOLOGICAL SURVEY STANDARDS - A CRITICAL STUDY OF PUBLISHED ANALYTICAL DATA; Can. Spectroscopy, vol. 15, pp. 10-16, 1970.

The recently published compilation of analytical data on the six new U.S.G.S. rocks is examined critically. Procedures are proposed for deriving the "best" values for use as standards. Comment is made on the analytical methods used and on other problems in the standardization of reference samples.

Anderson, F.D.

THE CATAMARAN FAULT OF NORTH CENTRAL NEW BRUNSWICK; Abstr., Geol. Soc. Am., vol. 2, No. 1, Jan. 1970.

The Catamaran Fault cuts across pre-Carboniferous rocks of the Miramichi Geanticline in north-central New Brunswick. It has been examined for about 60 miles across the Cambro-Ordovician core of the geanticline and into the Siluro-Devonian flank rocks. The fault strikes easterly in the core and northeasterly in the flanks. The general trend parallels that of other major faults in the Appalachian Geosyncline.

The eastern extension may be the fault thought to underlie Miramichi Bay and continuing under the Gulf of St. Lawrence. The western extension is probably a southwesterly trending fault in western New Brunswick. As such the fault may exceed 200 miles in length.

The fault, in places, is mainly strike-slip with a right-lateral displacement. The latest movement is pre-Pennsylvanian and probably post-Middle Devonian.

Becker, A.

SIMULATION OF TIME-DOMAIN, AIRBORNE, ELECTROMAGNETIC SYSTEM RESPONSE; Soc. Explor. Geophys., 1969.

The response of a time-domain electromagnetic system over a thin conducting sheet may be simulated by purely electronic means and without recourse to scale model experiments. The simulation is based on the similarity between the frequency domain response function for a thin sheet and the transfer function of certain RC active networks. Since this type of experiment employs actual field equipment, the proposed technique also constitutes a valid means of data quality control.

It is difficult to carry out an analog simulation for conductors which do not resemble a thin sheet. If, however, the frequency domain response function for the situation in question is known, the simulation may be carried out on a digital computer. The digital simulation process involves a numerical Fourier decomposition of the primary field waveform (as seen by the receiver), the calculation of the effect of the ground on each harmonic component, and the recombination of the secondary field harmonics to form the observed transient. The technique is illustrated with some calculations of theoretical responses for an EM system over a homogeneous ground and over a thin horizontal conducting sheet. The digital simulation technique is more useful than the analog.

Blake, W., Jr.

LES PONCES DES PLAGES SOULÉVÉES DU SPITZBERG ET DU CANADA ARCTIQUE; (abstr.) VIII^e Congress INQUA, Paris, Résumés des Communications, Sect. 6, p. 181, 1969.

Des ponces d'un brun sombre, de composition andésitique, sont fréquentes sur les plages soulevées du Spitzberg nord-oriental où 50 sites ont été nivelés de manière précise. En 1967, des ponces d'aspect similaire ont été découvertes sur les plages soulevées des îles d'Ellesmere et de Devon, ainsi qu'en des sites archéologiques de l'île de Baffin. L'origine des ponces demeure incertaine, l'Islande étant une possibilité.

Assumant que les ponces ont échoué sur les plages aux différents endroits approximativement au même moment, on peut déterminer:

1. Le soulèvement local du littoral,
2. la localisation des centres de glaciation.

Au Spitzberg, le niveau principal à ponces s'élève vers le sud-est indiquant qu'au dernier maximum glaciaire, la majeure partie de la mer de Barents était couverte d'un icecap qui était plus épais au sud-est de l'archipel actuel. Au Canada arctique, le niveau à ponces s'élève vers l'ouest le long du détroit de Jones, indiquant que la glace a été plus épaisse sur le nord-ouest de l'île Devon que sur la partie sud-est de l'île d'Ellesmere et la partie est de l'île de Devon.

Un grand nombre de datations au radiocarbone d'après les bois flottés et les os de baleine enfouis avec les ponces dans les plages du Spitzberg et du Canada arctique ont été réalisées. Celles de l'île d'Ellesmere

indiquent que les ponces ont approximativement 5,000 ans; au Spitzberg les dates sont plus incertaines. Dans les régions sises à la périphérie des anciens icecaps, les plages sur lesquelles les ponces apparaissent se situent juste sous un niveau d'abrasion marine. Ce niveau cartographiable sur de grandes distances, s'est formé lorsque l'intensité du mouvement eustatique positif de la mer égala ou excéda l'intensité du soulèvement isostatique; il correspond à ce qui s'est passé en Scandinavie durant une ou plusieurs transgressions à Tapes.

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

SULFUR ISOTOPE INVESTIGATIONS OF THE LEAD-ZINC-SILVER-CADMIUM DEPOSITS OF THE KENO HILL-GALENA HILL AREA, YUKON, CANADA; Econ. Geol., vol. 65, 1970.

Sulfur in the sulfides of the sedimentary rocks of the Keno Hill-Galena Hill area, Yukon, Canada are relatively enriched in S^{34} compared with sulfides in the lead-zinc-silver-cadmium lodes. This data supports the thesis that during diffusion of the sulfur from the country rocks the lighter S^{32} isotope was selectively concentrated in the sulfide deposits.

The sulfur isotope ratio of supergene sulfates in the oxidized zones of the deposits reflects the ratio in the hypogene sulfides. Similarly, the ratio in the sulfate of the waters leaching mineralized zones reflects the ratio in the ores, a fact that may be useful in hydrogeochemical prospecting.

Campbell, R.B.

STRUCTURAL AND METAMORPHIC TRANSITIONS FROM INFRA-STRUCTURES TO SUPRASTRUCTURES, CARIBOO MOUNTAINS, BRITISH COLUMBIA; Geol. Assoc. Can., Sp. Paper 6, 1970.

The structural and metamorphic transitions in northern Cariboo Mountains are believed to represent an example of a progressive change from infrastructure to suprastructure. In the Premier anticlinorium the infrastructure features the staurolite-kyanite grade of metamorphism and poly-phase folding whereby isoclinal folds are themselves arched across an anti-formal axis. The isoclines are interpreted to be flow folds in which compositional layering and schistosity are parallel. This zone passes upward through a transitional and simple anticline, in which metamorphic foliation parallels bedding, into a zone of large similar or composite folds with prominent axial-plane foliation. The axial surfaces of the similar folds are arranged in a broad fan so that they are about normal to the surface of the transition anticline and to the axial surfaces of the structurally lower isoclines. The uppermost feature of the structural progression, the suprastructure, is a zone of brittle fracture in which relatively competent and essentially unmetamorphosed rocks are broken into many fault blocks, tilted, and locally concentrically folded. Generally the same changes typify the transition from the Premier anticlinorium to the flanking Isaac Lake synclinorium. The relationship to the Mount Robson synclinorium is more complicated but broadly displays the same sort of change.

Collett, L.S.

REMOTE SENSING GEOPHYSICAL APPLICATIONS TO HYDROLOGY;
Proc. Hydrology Symp. No. 7, Natl. Research Council, Can.,
pp. 237-260, 1969.

Geophysical methods to date cannot detect groundwater aquifers directly. Fortunately, the presence of groundwater is ultimately related to the geology and geological structures. Earth materials can nearly always be characterized locally by the electrical parameters of conductivity and dielectric constant. The conductivity exhibits by far the largest variations of its magnitude for various rock materials. The host materials for groundwater aquifers usually, though not always, consist of sands, gravels, and fractured rocks. These structures which contain fresh water will always exhibit a fairly low conductivity. It is through the mapping of these properties by remote sensing that geophysical techniques can be applied to hydrology.

Where the host structures are shallow, airborne VLF (Very Low Frequency) systems look promising for detecting variations in ground conductivity. For the deeper case where faulting and shear zones contain water in the fractures, AFMAG, a synonym for audio frequency magnetics, is presently being applied. A conventional airborne EM system, INPUT, is used for resistivity mapping of geological structure and salt-water intrusions.

Cook, Donald G.

A CAMBRIAN FACIES CHANGE AND ITS EFFECTS ON STRUCTURE,
MOUNT STEPHEN-MOUNT DENNIS AREA, ALBERTA-BRITISH
COLUMBIA; Geol. Assoc. Can., Sp. Paper 6, 1970.

Rocks of the Main Ranges of the Canadian Rocky Mountains can be subdivided into an eastern, dominantly carbonate facies (eastern Main Ranges) and a western, dominantly shale (slate) facies (western Main Ranges). In the western facies, the Chancellor Formation, once believed to be an Upper Cambrian, homogeneous slate unit, can be subdivided into mappable stratigraphic units, and includes both Middle and Upper Cambrian rocks. The Chancellor Formation contains correlatives of the Cathedral, Stephen, Eldon, Pika, Arctomys, Waterfowl, and Sullivan Formations of the eastern facies.

All of the rocks studied occur in the Simpson Pass thrust plate. The eastern facies is characterized by broad open folds; one of these, the Cathedral Crags anticline, persists over the length of the map-area. The western facies has a ubiquitous, penetrative cleavage. This cleavage is parallel to the axial planes of folds, but occurs throughout the Chancellor Formation whether or not the strata are folded. Tight, nearly isoclinal folds occur in a narrow, complex belt of thrusts and folds near the facies boundary along the western flank of the Cathedral Crags anticline. Thrusts in this belt have developed in the western limb of the anticline. West of the complex belt, folds in general are broad and open.

The concept of the Stephen-Dennis fault, as a major fault separating the two facies, must be abandoned. Some thrusts do occur along the facies boundary, and a number of large transverse faults which cut the rocks

of the eastern facies trend obliquely into the zone of thrusts and folds, but no continuous fault separates the two facies. Strata can be traced unbroken from one facies into the other at four localities.

The large transverse faults do not emerge from the zone of thrusts and folds to offset rocks of the western facies. These transverse faults are confined to the block bounded by the Simpson Pass thrust on the east and by the zone of thrusts and folds on the west. Dip separations, invariably normal, suggest that these are extension faults, but slickensides measured on adjacent fractures indicate right-lateral displacements. Because such displacements require essentially horizontal compression, the faults must have formed prior to completion of compressive deformation in the Rocky Mountains.

Strata of the Chancellor Formation appear to be at least twice as thick as their correlatives in the eastern facies. Much of this thickening is probably a result of penetrative, plastic deformation resulting from horizontal compression. Compression of the slate sequence is commonly recorded in buckled, competent limestone beds, but in homogeneous slate sequences strain may have been uniform resulting in a plastically thickened, but essentially unfolded sequence.

Cumming, L. M.

ORDOVICIAN LITHOFACIES, NORTHERN MANITOBA; Abstr. Geol. Soc. Am., Pt. 7, p. 42, 1970.

Along the southwestern margin of the Hudson Bay Basin, Archean crystalline rocks form the basement and Ordovician strata are the oldest exposed Paleozoic rocks. An east-trending basement ridge, delimited by aeromagnetic anomalies, occurs six miles north of the Ordovician exposures on Gods River. The facies of these Ordovician strata reflects the occurrence of this ridge, which marks the southern boundary of the Churchill structural province.

A burrowed - carbonate - mud-facies occurs in the northern part of exposures of the Upper Ordovician Churchill River Group, on Gods River. This facies is similar to the burrowed carbonate strata of the lead-zinc district of Missouri.

This distinctive carbonate facies, examined during regional mapping of the Hudson Bay Lowlands (Operation Winisk) is a possible guide-lithology for base metal prospecting within the Lowlands.

Currie, K. L., and Larochelle, A.

A PALEOMAGNETIC STUDY OF VOLCANIC ROCKS FROM MISTASTIN LAKE, LABRADOR, CANADA; Earth and Planetary Sci. Letters, vol. 6, pp. 309-315, 1969.

Paleomagnetic data are presented for an isolated occurrence of unaltered and undisturbed volcanic rocks, of apparent upper Triassic age, at Mistastin Lake, western Labrador. Pilot tests established that the magnetization of these rocks is remarkably stable and homogeneous, suggesting

that it was acquired by the rocks at the time of their original cooling. After a.f. cleaning in a peak field of 250 Oe, 73 cores (drilled at 10 sites distributed over an area of about 100 km²), yielded a mean direction of magnetization: declination 179.9°, inclination -68.2°. A statistical analysis of the data indicates that mean directions of magnetization of the 10 sites are significantly different. Their angular standard deviation is 4.4°, and the radius of the circle of confidence about their resultant ($\alpha'_{0.95}$) is 2.4°. The corresponding virtual pole position is 117.7°E, 85.5°N (computed from the resultant of the 'weighted' site means). The good agreement between this pole and the only other published, reliable Jurassic pole from North American rocks suggests (1) that the magnetic field was mainly dipolar during part of upper Triassic to Lower Jurassic time, and (2) the radiometric age of the Mistastin Lake volcanic rocks (202 m.y.) may be slightly too old. The low standard deviation of the site means is concordant with field observation that the eruptions of the various phases of the Mistastin Lake volcanics were almost simultaneous, and that the rocks have been almost undisturbed since original deposition.

Darnley, A.G.

AIRBORNE GAMMA-RAY SPECTROMETRY; Can. Inst. Mining Met., vol. 63, No. 694, pp. 145-154, 1969.

The Geological Survey of Canada is devoting considerable effort to finding ways to make airborne radiometric measurements both quantitative and reproducible. Equipment has been designed by Atomic Energy of Canada Ltd. to provide high count rates in order to minimize statistical uncertainty, this being essential to justify applying terrain clearance and Compton scattering corrections to the data. Correction factors have been determined experimentally and can be applied automatically. Considerable ground work has been undertaken in parallel with equipment development in order to determine field parameters.

Two airborne gamma-ray spectrometers are described. One is based on three 5 by 5 inch NaI (Tl) detector crystals and is used in a helicopter; the other employs twelve 9 x 9 inch detectors and is used from a Skyvan aircraft. The former is being used to investigate the range of radiometric response from specific rock types, and for the correlation of ground and air measurements; the latter has completed initial trials and will be commencing experimental surveys during 1969.

Results are given to show the comparative sensitivities of the various detector sizes, and operational requirements for a gamma-ray spectrometer survey are discussed briefly.

Douglas, J.A.V., Dence, M.R., Plant, A.G., and Trail, R.J.

MINERALOGY AND DEFORMATION IN SOME LUNAR SAMPLES; Science, vol. 167, pp. 595-597, 1970.

Observations on the mineralogy and deformation in samples of crystalline rocks, breccias, and fines from Tranquillity Base provide

evidence for magmatic and impact processes. Overall homogeneity, igneous textures, and absence of xenoliths in the crystalline rocks indicate derivation from a common titanium-rich magma by internal, anorogenic volcanism rather than by impact. Crystallization conditions allowed strong compositional variation in pyroxenes, olivine, and plagioclase and the growth of a new mineral, the iron analog of pyroxmangite. Subsequently, impact produced breccias containing shock-deformed crystals and glasses of varying compositions.

Dyck, Willy

URANIUM EXPLORATION USING RADON IN SOILS; Can. Mining J., vol. 90, No. 8, pp. 45-49, 1969.

This report gives the highlights of tests carried out during the 1968 field season to determine the applicability of the radon method for detailed prospecting for uranium. Radon tests in soils were carried out in two different geological environments: the Gatineau Hills, Quebec, and Elliot Lake, Ontario regions.

Where the overburden is one or two feet thick, on-site radon and thoron determinations in soil emanations in the Gatineau Hills outlined radioactive pegmatites more clearly than did gamma-ray tests. Although radon levels varied by a factor or two with season, correlations with source were reproducible.

On-site radon determinations in soil emanations across the uranium ore zone at the Rio Algom Quirke Mine, outlined the ore zone more distinctly than did gamma-ray determinations. Radon tests in soil across the projected contact of the Matinenda in the southern limb of the Quirke Syncline gave a negative anomaly.

In general the radon in soil investigations showed that the radon method outlined radioactive sources more clearly than did the Geiger counter. Under favorable conditions the method offers the possibility of looking for uranium through overburden.

Eisbacher, Gerhard H.

NEUE BEOBACHTUNGEN ZUR DEUTUNG DER KNOLLIGEN
MAGNESITE IM TONSCHIEFERKOMPLEX DES ALPINES
BUNDSANDSTEINS DER NORDLICHEN KALKALPEN; Mineral.
Deposita (Berl.) vol. 4, pp. 219-224, 1969.

Nodular magnesite has been found in most sections of Lower Triassic red beds ("Werfener Schiefer") of the Northern Calcareous Alps between Innsbruck and Saalfelden, Austria. Three genetic types of magnesite can be differentiated: 1. Cryptocrystalline concretions of early diagenetic origin; 2. Syntectonic recrystallisation fabrics of nodular habit which formed while the sand-shale matrix underwent deformation; 3. Post-tectonic spar-magnesite concretions which grew preferentially along tectonic cleavage surfaces.

Magnesitknollen in den roten Tonschiefern des alpinen Buntsandsteins ("Werfener Schiefer") wurden in fast allen der bearbeiteten Profile zwischen Innsbruck und Saalfelden angetroffen. Es handelt sich um drei Typen von Magnesitknollen, die in ihrer Genese voneinander abweichen: 1. Kryptokristalline Konkretionen fröhdiagenetischer Ausfällung; 2. Syntektonische Rekrystallisationsgefüge von knolligem Habitus, die in ihrer Entstehung zeitlich mit der Durchbewegung der sandig-tonigen Nebengesteine zusammenfallen; 3. Postdeformative Spatmagnesite, welche innerhalb des schiefrigen Starrgefüges als Konkretionen auskristallisierten und die Wegsamkeit der Schieferung als bevorzugte Wachstumsrichtung benützten.

Eisbacher, Gerhard H.

DISPLACEMENT AND STRESS FIELD ALONG PART OF THE COBEQUID FAULT, NOVA SCOTIA; Can. J. Earth Sci., vol. 6, No. 5, pp. 1095-1104, 1969.

The east-trending Cobequid Fault separates pre-Carboniferous rocks of the Cobequid Mountains to the north from Carboniferous clastic rocks along the southern flank of the mountains. A detailed study of the fault zone revealed the predominance of right-lateral displacements. The orientation of the stress field that existed during deformation along the fault trace was determined by the study of systematic fractures in pebbles within Carboniferous conglomerate. Maximum compressive stress was aligned in a NW-SE direction, being compatible with the orientation of the displacement vectors in the fault zone. Transcurrent movement along the Cobequid Fault occurred in late Pennsylvanian time and involved both Carboniferous and pre-Carboniferous rocks; total displacement is unknown.

Eisbacher, Gerhard H., and Bielenstein, H.U.

TECTONICS AND REMANENT ELASTIC ROCK SLIDES; Eos, Trans. Am. Geophys. Un., vol. 50, No. 11, 1969.

Bedding plane slip, contraction faults, slicken-sided fractures, matrix-clast displacements, quartz veins, joints and regional folds and faults were analyzed in detail near Elliot Lake, Ontario to test this approach for predicting the orientation of in situ stresses in rock masses. The major principal compressive stress during deformation of the region was oriented subhorizontally and south-southeasterly. Gradual stress release by slow regional arching during the last 1,000 million years is expressed in post-tectonic quartz veins and joints which have predominantly easterly trends. This arching reduced north-south stresses below the level of east-west stresses. Measurements of in situ state-of-stress by overcoring in vertical upholes indicate a boundary between stresses due to mining and field stresses unaffected by mining: about 3-6 meters above the mine roof maximum elastic-strain-recovery changes from a north-south to an east-west direction. Maximum in situ elastic-strain-recovery in the field stress environment is parallel to the trend of late quartz veins and joint sets. Field stresses are therefore interpreted as remanent components of former tectonic stresses.

During deformation elastic strains were probably stored preferentially in competent rock domains surrounded by less competent matrix.

Findlay, D.C.

ORIGIN OF THE TULAMEEN ULTRAMAFIC-GABBRO COMPLEX, SOUTHERN BRITISH COLUMBIA; Can. J. Earth Sci., vol. 6, No. 3, pp. 399-426, 1969.

The Tulameen Complex is a composite ultramafic-gabbroic intrusion that outcrops over 22 sq. mi. (57 km²) in the Southern Cordillera of British Columbia. The complex intruded Upper Triassic metavolcanic and metasedimentary rocks of the Nicola Group, and on the basis of geologic relations and a K-Ar age determination (186 m.y.) is tentatively dated as Late Triassic.

The principal ultramafic units - dunite, olivine clinopyroxenite, and hornblende clinopyroxenite - form an elongate, non-stratiform body whose irregular internal structure is best explained by deformation contemporaneous with crystallization of the rocks. The derivation of the ultramafic rocks is attributed to fractional crystallization of an ultrabasic magma. The gabbroic mass, which consists of syenogabbro and syenodiorite, partly borders and partly overlies the ultramafic body and was apparently intruded by it.

The ultramafic and gabbroic parts of the complex probably formed from separate intrusions of different magmas, but the two suites have sufficient mineralogical and chemical features in common to indicate an ultimate petrogenic affinity of the magmas. Comparison of the Tulameen rocks with nearby intrusions of the same general age, in particular the Copper Mountain stock, suggests that they are members of a regional suite of alkalic intrusions. The possibility is also raised that these intrusions may be comagmatic with the Nicola volcanic rocks.

Frebold, Hans, and Tipper, H.W.

STATUS OF THE JURASSIC IN THE CANADIAN CORDILLERA OF BRITISH COLUMBIA, ALBERTA, AND SOUTHERN YUKON; Can. J. Earth Sci., vol. 7, No. 1, pp. 1-21, 1970.

Jurassic index fossils of the Canadian Cordillera indicate the presence of some zones of most Jurassic stages. In this report the more important localities are listed, the source of information, published and unpublished, is indicated, and an up-dated correlation chart is presented. The importance of tectonic events and their effect on the completeness of the Jurassic fossil record and on the Jurassic paleogeography are stressed.

Froese, E.

CHEMICAL PETROLOGY OF SOME PELITIC GNEISSES AND
MIGMATITES FROM THE THOR-ODIN AREA, BRITISH COLUMBIA;
Can. J. Earth Sci., vol. 7, No. 1, pp. 164-175, 1970.

The Shuswap metamorphic terrain of British Columbia is marked by the occurrence of gneiss domes, one of these in the Thor-Odin area. In this case, a core of migmatites and granitoid gneisses is surrounded by a mantle of unmigmatized gneisses. Rocks of both structural zones belong to the sillimanite-almandine-orthoclase subfacies of the almandine-amphibolite facies. A common mineral assemblage in pelitic gneisses and migmatites is quartz + plagioclase + K feldspar + biotite + garnet + sillimanite. These minerals are related by the reaction



This reaction is used as a measure of P_{H_2O} -T conditions. Variations of biotite and garnet composition from rock to rock indicate differences in P_{H_2O} -T conditions of quenching. Furthermore, according to the ranges in composition, the migmatites from the core zone reflect either a higher P_{H_2O} at constant T or a lower T at constant P_{H_2O} than the mantling gneisses. Assuming that P_{H_2O} is approximately equal to P_{total} during metamorphism of pelitic rocks, the second case is more probable. The P_{H_2O} -T values, rather than representing peak metamorphic conditions, are attributed to quenching during cooling when no more water is available. A higher water content in the core rocks might account for migmatization as well as for a somewhat lower quench temperature.

Fulton, R.J., and Pullen, M.J.L.T.

SEDIMENTATION IN UPPER ARROW LAKE, BRITISH COLUMBIA;
Can. J. Earth Sci., vol. 6, No. 4, pp. 785-790, 1970.

Two rivers, the Columbia and the Incomappleux, empty into the north end of Upper Arrow Lake. The form and the general pattern of sedimentation of the two river deltas were determined by an echo sounder survey.

The three classical delta sedimentation zones were recognized and observations made on sedimentation in each. Sedimentation in the topset zone is largely channel and overbank deposition similar to that taking place on river floodplains. The bottomset zone receives fine silt and clay carried out to where it can settle under lacustrine conditions. The bulk of the sediment is deposited at the river mouths near the top of the foreset zone. Following initial deposition, the sand and silt dumped at the river mouths is carried into the lake basin by a slow sliding failure of the entire foreset zone.

Garrett, R.G.

THE DETERMINATION OF SAMPLING AND ANALYTICAL ERRORS IN EXPLORATION GEOCHEMISTRY; Econ. Geol., vol. 64, No. 5, 1969.

In order to assess the magnitude and significance of sampling and analytical errors in exploration geochemistry a duplicate sampling approach is proposed. It is felt that this technique is superior to the use of statistical series samples as sampling errors are included and the materials used are from the project under investigation. This is often important in exploration geochemistry where partial chemical attacks are used and unrealistic values can be obtained if material of the same grain size and mineralogy is not used in the estimation of the analytical precision. The error variance estimated by the proposed technique is then used in an analysis of variance to determine if the combined sampling and analytical errors are significantly smaller than the overall data variance. If the error variance is not significantly smaller only a general interpretation of the data should be attempted and under no circumstances should sophisticated statistical techniques be used.

Gavasci, A.T., and Helmstaedt, H.

A PYROXENE-RICH GARNET-PERIDOTITE INCLUSION IN AN ULTRAMAFIC BRECCIA DIKE AT MOSS ROCK, SOUTHEASTERN UTAH; J. Geophys. Res., vol. 74, No. 27, 1969.

A medium-grained rock composed of clinopyroxene, orthopyroxene, garnet, and olivine, apparently not previously found in the Colorado Plateau diatremes, was recently discovered at the Moses Rock dike, San Juan County, Utah. The occurrence of this mineral assemblage is of importance in the light of recent discussions proposing that dense xenoliths of these diatremes represent possible fragments of the upper mantle.

Helmstaedt, H.

EINE AMMONITEN-FAUNA DEN SPITI-SCHIEFERN VON MUKTINATH IN NEPAL; Zitteliana, vol. 1, pp. 63-88, 1969.

About 50% of the available specimens belong to the genus Blanfordiceras Coss-MANN 1970.

The genera Subplanites, Substeueroceras, Groebericeras and? Lemencia, with 5 species, are described for the first time from the Himalaya Mountains.

The following new species are created:

Blanfordiceras muktinathense n.sp., B. rotundidoma rotundum n.ssp., Subplanites nepalensis n.sp., Substeueroceras ubligi n.sp. and Virgatosphinctes kagbeniensis n.sp.

It was found that the majority of the fauna confirms the Upper Tithonian age (Upper Jurassic) of the Spiti shales. Genera like Berriasella, Groebericeras and Thurmanniceras indicate the presence of the Berriasian stage (Lower Cretaceous). Thurmanniceras suggests even the possible occurrence of a younger stage (Valanginian) of the Lower Cretaceous.

Hoffman, P.F., Logan, B.W., and Gegelein, C.D.

BIOLOGICAL VERSUS ENVIRONMENTAL FACTORS GOVERNING
THE MORPHOLOGY AND INTERNAL STRUCTURE OF RECENT
ALGAL STROMATOLITES IN SHARK BAY, WESTERN AUSTRALIA;
Abstr., Geol. Soc. Am.; Pt. 1, p. 29, 1969.

Stromatolites comparable in size and variability to those found in Precambrian and Paleozoic carbonate rocks are known in the Recent only from Hamelin Pool, a hypersaline lagoon in Shark Bay, western Australia. The stromatolites there are composed of ooids, formas and molluscan shell debris trapped and/or bound by mats of blue-green algae. The clastic grains in most of the stromatolites are cemented by, and in part converted to crypto-crystalline aragonite. There are six biologically and morphologically distinct types of algal mat, extending collectively from the shallow sub-tidal to the supratidal zone. Each mat type occurs within a well defined vertical range, and each type imparts a unique structure to the underlying sediment. The different structures, which range from smooth parallel laminations to massive fenestral or clotted fabric, are a consequence of differences in the growth habit and biological make-up of the algal mats.

Stromatolite morphology, as opposed to internal structure, is environmentally determined. Biologically identical mats form morphologically distinct stromatolites in each of the three main environmental settings in Hamelin Pool. Exposed headlands have discrete club-shaped stromatolites of high relief, large branching columnar stromatolites, and large mounds composed of many coalescent stromatolite heads. Semi-protected coastlines have linear to elliptical stromatolite domes of low relief and wavy laminated stromatolite beds. Protected embayments have flat laminated stromatolites with scattered small mounds composed of finger-sized branching stromatolites.

Elliptical and linear stromatolites are oriented parallel to the direction of wave surge, which is in most places perpendicular to the shore line. Asymmetrical and inclined stromatolites "lean" into the on-shore currents, which are responsible for most sediment transport.

The unique occurrence of Recent stromatolites in Hamelin Pool results from the absence of browsing of the algal mats by other organisms, the absence of burrowing of the sediment beneath the mats, and the extensive inorganic precipitation of aragonite which leads to penecontemporaneous lithification of the inter-tidal and sub-tidal sediments.

Hoffman, P.F.

PROTEROZOIC PALEOCURRENTS AND DEPOSITIONAL HISTORY
OF THE EAST ARM FOLD BELT, GREAT SLAVE LAKE, NORTH-
WEST TERRITORIES; Can. J. Earth Sci., vol. 6, No. 3, pp. 441-462,
1969.

Nearly 40,000 ft (~12,190 m) of unmetamorphosed Aphebian (and possibly lowermost Helikian) sedimentary and volcanic rocks are exposed in the East Arm of Great Slave Lake. This sequence is an erosional remnant of an Appalachian-type geosynclinal complex with a NNW depositional strike. Integrated paleocurrent, stratigraphic, and sedimentological analysis reveals

three stages in the depositional history of the complex: (1) a double transgressive, pre-orogenic miogeosyncline, which received sediment from a distant cratonic source to the ENE and which becomes thicker and more eugeosynclinal to the WSW; (2) a regressive, syn-orogenic exogeosyncline (clastic wedge), which received sediment from rapidly uplifted tectonic lands to the WSW; and (3) a continental, post-orogenic taphrogeosyncline (down-faulted intermontane trough), which received sediment locally from block-fault scarps within the East Arm area.

Facies predictions based on this model provide criteria for establishing stratigraphic correlation and contiguity between the East Arm and other Aphebian sequences in the northwestern Canadian Shield. The prevailing depositional strike is roughly perpendicular to the tectonic strike of the East Arm Fold Belt, and it should not therefore be assumed that depositional strike parallels tectonic strike in other belts. The Bear Province may have been the site of the orogenically active axial zone of the geosyncline, but that part of the Churchill Province near the East Arm remained passive until the final post-orogenic stage of sedimentation and may therefore be of epeirogenic origin.

Hofmann, H.J., and Jackson, G.D.

PRECAMBRIAN (APHEBIAN) MICROFOSSILS FROM BELCHER ISLANDS, HUDSON BAY; *Can. J. Earth Sci.*, vol. 6, No. 5, pp. 1137-1144, 1969.

A small assemblage of primitive microscopic fossils is here reported for the first time from the lower part of the Belcher Group in Hudson Bay. The microbiota includes chains and clumps of bacteria, and filamentous and spheroidal structures of probable algal or fungal affinities. In addition, a variety of isolated and clustered spheroids and other structures of probable biologic origin is present. The structures are more than 1,600 m.y. old, and occur in a black chert associated with thick dolomite beds considered to be of Aphebian (Early Proterozoic) age. Morphologically comparable Precambrian microfossils occur in the Gunflint Formation (Early Proterozoic, Ontario) and the Bitter Springs Formation (Late Proterozoic, central Australia).

Howie, R.D., and Hill, J.V.

DEVELOPMENTS IN EASTERN CANADA IN 1968; *Bull. Am. Assoc. Petrol. Geologists*, vol. 53, No. 6, pp. 1181-1193, 1969.

The production of petroleum and natural gas in eastern Canada during 1968 was 1,158,348 bbl and 12,455,044 Mcf, respectively. This represents a decline of 90,648 bbl of oil and 1,942,103 Mcf of gas from that of the previous year.

In southwestern Ontario, 73 exploratory tests and 79 development wells were completed during the year. This represents an increase of 5 exploratory and 12 development wells from the previous year. A general increase in drilling, combined with the trend toward Cambrian and deeper

Silurian drilling in the lower basinal areas, accounted for an increase of 28% in total footage drilled in 1968 over the previous year.

In the Hudson Bay region, private industry and various government agencies completed 14 crew-months of combined geologic and geophysical work. One deep stratigraphic test was completed to Precambrian basement rocks on the southern rim of the Hudson Bay basin.

In the sedimentary basins of Quebec, exploratory activity was confined to geologic and geophysical surveys; 9 crew-months were completed by industry and 12.5 crew-months by Quebec Provincial organizations.

In the Atlantic provinces, considerable interest was focused on the offshore continental margins. Offshore holdings increased by more than 50 million acres in 1968, to an all time high of 205,135,880 acres. Although industry accounted for 36 1/3 crew-months of geologic and geophysical work in the offshore areas, there was no exploratory drilling. Onshore, 1 exploratory well was completed in the Cape Breton Island area of Nova Scotia.

Howie, R.D.

RECENT OFFSHORE DEVELOPMENTS, ATLANTIC COAST OF CANADA; Bull. Am. Assoc. Petrol. Geologists, vol. 53, No. 3, p. 724, 1969.

Geophysical surveys indicate the following sedimentary features: a 20,000-ft sequence on the outer Labrador shelf, a 24,000-ft section in the Gulf of St. Lawrence, a 15,000 to 20,000-ft section on the Scotian shelf, and an 18,000-ft section on the Grand Banks of Newfoundland.

On the Scotian shelf shallow core drilling and grab samples indicate the presence of Quaternary, Tertiary, and Cretaceous sediments. On the Grand Banks, 10,084 ft of drilling in two holes penetrated Tertiary and Cretaceous sediments. One well was abandoned in salt at 4,839 ft.

Hood, P.

OBZOR GEOFIZICHESKOY APPARATURY, RAZBABOTANNOY v 1965 g (REVIEW OF GEOPHYSICAL APPARATUS DEVELOPED IN 1965); Geofizicheskaya Apparatura, No. 35, pp. 7-12, 1968.

This is the Russian version of the annual review article "Mineral Exploration: trends and developments in 1965" published in the February 1966 issue of the Canadian Mining Journal (see GSC Paper 67-4, p. 28), which was presumably published to keep exploration personnel in the USSR current in the latest methods and techniques developed in the western world.

Hood, P., and Ward, S.H.

AIRBORNE GEOPHYSICAL METHODS, IN ADVANCES IN GEOPHYSICS; Academic Press, New York, vol. 13, pp. 1-112, 1969.

This is a state-of-the-art review of airborne magnetic, electromagnetic, radiometric, gravity and remote-sensing methods used in mineral and petroleum exploration. Instrumentation, survey methods and compilation procedures are described, and a bibliography of 228 references on the various airborne geophysical methods is also contained in the article.

Hood, P., and Kellogg, W.C.

MINING GEOPHYSICAL ACTIVITY IN 1968; Geophysics, vol. 34, No. 6, pp. 848-858, 1969.

Data on worldwide geophysical activity in mining exploration programs is collected annually by the SEG Geophysical Activity Committee as part of a continuing service to the industry. The data are obtained by sending out questionnaires to all organizations which are known to be carrying out mining geophysical work; the organizations canvassed include mining companies, contractors, government departments, and universities. The questionnaire is divided into three sections, namely ground methods, airborne methods, and research. The data compiled from the questionnaires shows that worldwide utilization of mining geophysical methods reached a new high in 1968 with total expenditures of U.S. \$41,367,011. This was divided as follows: ground methods - \$20,398,288; airborne methods - \$14,937,733, and research - \$6,039,900. For the ground methods, most money was spent on induced-polarization techniques (\$6,735,315); geochemical methods were second in reported expenditure (\$3,437,712). The statistics for the past seven years show that induced-polarization methods have gradually outstripped the electromagnetic methods as the principal ground prospecting tools used in the search for sulfides. Since 1966, utilization of ground electromagnetic methods has definitely declined and in 1968 more than four times as much money was spent on induced polarization as on electromagnetic methods.

The expenditure for mining geophysics research reached a new high of \$6,039,000 in 1968 which is an increase of 48 percent from 1967. The leading research activity was the magnetic method, and in second place was electromagnetic method research. The amount of money spent on mining geophysics research increased by 54 percent in the United States, and significant increases also occurred in Canada and Europe.

In 1968, the total reported geophysical line-mileage flown was 1,575,835 line-miles, with aeromagnetic surveying again accounting for most line-mileage (837,068). Typical line-mileage costs in 1968 for the various airborne geophysical methods were: aeromagnetic U.S. \$6.75; airborne electromagnetic U.S. \$16; combined airborne electromagnetic/magnetic U.S. \$24; airborne radiometric U.S. \$7. Airborne radiometric line-mileage showed a nine-fold jump from 1967 to 1968, when the reported line-mileage was 400,559.

Hood, P.

MINING GEOPHYSICAL ACTIVITY IN CANADA AND THE WESTERN WORLD IN 1968; Can. Mining J., vol. 90, No. 11, pp. 53-58, 1969.

Canada reported by far the largest expenditure for mining geophysics in 1968 (\$14.2 million), followed in order by the United States (\$8.3 million), Africa, Europe, Australia, Asia and Latin America. Expenditures in mining geophysics in Canada have actually increased 2.8 times in the four-year period 1964 to 1968. Canada led the world in the total amount of money spent on ground geophysical methods, being \$5.8 million or 28% of the world expenditure in 1968. The induced polarization technique was by far the most popular ground method in Canada accounting for almost 47% of the total expenditure. The IP method was followed in order of utilization by the electromagnetic, geochemical, gravity, seismic, and magnetic methods. Over three times as much is now spent on IP as on the EM methods in Canada. Average line-mile costs for the various ground mining geophysical methods as reported by North American contractors are: EM \$98, gravity \$58, IP \$318, magnetic \$23, radioactivity \$54, resistivity \$181, seismic \$676 and SP \$133 per line-mile.

In Canada, the following line-mileages were flown in 1968 by the various airborne geophysical methods: electromagnetic, 44,465; magnetic, 410,336; combined EM/magnetic, 118,487; radiometric, 173,700; AFM-AG, 6,100; and VLF EM, 1,130 for a total of 754,218 line-miles which cost \$5.7 million and was a 39% increase from 1967.

The amount of money spent on research in Canada in 1968 was \$2.7 million which was an increase of 45% from 1967. The principal research activities in Canada were in order: magnetic, EM, radioactivity and geochemical method research. These four disciplines accounted for almost 90% of all research expenditures and 75% of the manpower utilization.

Hood, P.

SEA-FLOOR SPREADING AND CONTINENTAL DRIFT; Can. Geograph. J., vol. 80, No. 1, pp. 32-36, 1970.

This article was a review for the general public of our current understanding of sea-floor spreading which has caused the continents to move laterally with respect to one another during the last 175 million years or so. The continental drift hypothesis is an old one which received a greater impetus by the publications of Wegener in the second and third decades of this century. Palaeomagnetic studies in the 1950's revived the controversial subject and the sea-floor spreading hypothesis, later verified by geophysical studies in the deep-ocean, provided a mechanism which permitted most earth scientists to believe in its reality. Continental drift studies are of more than academic interest because the most productive oilfields are usually found in the younger marine sedimentary rocks. Thus knowledge of the time when adjacent continents separated puts an upper limit on the age of the sedimentary formations deposited on the continental shelves between them.

Hood, P.

MINERAL EXPLORATION: TRENDS AND DEVELOPMENTS IN 1969;
Can. Mining J., vol. 91, No. 2, pp. 185-209, 1970.

This article reviewed the following topics for the year 1969:

- (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.

Graphs showing mining geophysics expenditures in the non-communist world during the period 1962 to 1968, and airborne geophysical line mileage flown from 1961 to 1968 were presented. An index map showing aeromagnetic and shipborne magnetometer coverage in Canada to December 31, 1969 and an index map showing the gravity map coverage to October 1969 also appeared in the article.

Hood, P.

GEOPHYSICAL ACTIVITY SURGES IN THE WESTERN WORLD; Min. Engr., vol. 22, No. 3, pp. 63-64, 1970.

The total amount of money reported spent in the U.S. on mining geophysics during 1968 was \$8.3 million which is approximately 20% of the expenditure in the western world.

In the United States reported expenditures in ground mining geophysical exploration in 1968 were \$4.2 million which is an increase of 26% from 1967. Induced polarization was by far the most popular ground method in the U.S. accounting for almost 40% of the total ground expenditure. The IP method was followed in extent of utilization by the geochemical, seismic, gravity and magnetic methods. About eight times as much is now spent on the IP as on EM methods in the U.S.

Approximately \$2 million was reported spent in the U.S. on airborne geophysical methods for 284,981 line-miles of data which included 171,782 line miles of aeromagnetic and 84,899 line-miles of radiometric survey.

The principal research activities in the U.S. were EM, Magnetic, IP, and geochemistry in that order, and these four disciplines accounted for 96% of all research expenditure which totalled \$2.1 million.

Hood, P.J., Bower, M.E., and Godby, E.A.*

AEROMAGNETIC RECONNAISSANCE OF THE NORTH ATLANTIC OCEAN, LABRADOR SEA AND BAFFIN BAY; Abstr. Ann. Meeting, Geol. Assoc. Can. and Mineral. Assoc. Can., p. 63, 1969.

Fifty-five low level aeromagnetic profiles have been flown over the North Atlantic Ocean, the Labrador Sea and Baffin Bay using a North Star aircraft outfitted with digitally-recording magnetometers. Over the Reykjanes Ridge south of Iceland axial symmetry is detectable out to a distance of 500 km or so either side of the ridge (representing at least 60 million years of ocean floor spreading). The anomalies are lineated and can be traced from profile to profile for a distance of 750 km. South of the southern tip of Greenland the magnetic picture becomes somewhat confused due to the existence of fracture zones. A displacement of the ridge axis anomaly of 300 km was noted across the Charlie fracture zone at 53°N latitude. The axial anomaly has an amplitude of over 2,000 gammas over the Reykjanes Ridge but only 500 gammas south of the Charlie fracture zone. No axial anomaly is detectable on one profile which passes directly over the fracture zone. The profiles indicate that the band of anomalies running parallel to the east coast of Greenland bend around the tip of Greenland. A possible correlation of the profiles from the Labrador Sea with those observed over the Reykjanes Ridge has been noted, suggesting that at least part of the spreading in the Reykjanes Ridge and the Labrador Sea was contemporaneous.

Using the Lamont geomagnetic polarity time scale it has been deduced that continental drift between Europe, Greenland and Canada commenced in the late Cretaceous and terminated in the Eocene period some 38 million years ago. In the late Miocene (about 10 million years ago) ocean floor spreading recommenced in the North Atlantic Ocean but not in the Labrador Sea. Thus it is likely that the sedimentary rocks on the Labrador shelf are mostly Mesozoic and younger in age, which makes the continental shelves bordering the Labrador Sea (and Baffin Bay) attractive for prospecting by the petroleum industry.

Over the Labrador shelf, there is a marked change of character in the aeromagnetic profiles some tens of miles from shore. The anomalies are relatively sharp close in to shore and then quite abruptly the wavelength of the anomalies increases and the amplitude decreases. This change is due to a sudden increase in the depth to the crystalline basement. Depth determinations on the profiles indicate that the thickness of sedimentary rocks on the outer Labrador shelf exceeds 20,000 feet over a wide area.

Two zones of anomalies run up the Labrador Sea but are lost in the Davis Strait area. In central Baffin Bay the magnetic anomalies are quite flat but anomalies of 50 gammas amplitude having a wavelength of 20 km are discernible, indicating deeply buried sources. Because of the low amplitude of these anomalies it is however difficult to demonstrate conclusively that line to line correlation of the anomalies exists. Geological models for profiles in the North Atlantic Ocean, Labrador Sea and Baffin Bay have been computed in which the dimensions and magnetizations of the various causative bodies have been calculated.

* National Aeronautical Establishment, Ottawa.

Hopkins, W.S., Jr.

PALYNOLOGY OF THE EOCENE KITSILANO FORMATION, SOUTH-WEST BRITISH COLUMBIA; *Can. J. Botany*, vol. 47, pp. 1101-1131, 1969.

Approximately 55 genera and 75 species of plant microfossils are illustrated and described from the Kitsilano Formation of southwestern British Columbia. The general composition of the flora suggests a humid, warm temperate climate prevailed at time of deposition. Previous work on plant megafossils indicates a late Eocene to possibly early Oligocene age. Plant microfossils recovered in this study support a probable middle to late Eocene age for the Kitsilano Formation.

Jambor, J. L.

MUSKOXITE, A NEW HYDROUS MAGNESIUM-FERRIC IRON OXIDE FROM THE MUSKOX INTRUSION, NORTHWEST TERRITORIES, CANADA; *Am. Mineralogist*, vol. 54, May-June, 1969.

Muskoxite is a new hydrous Mg-Fe³⁺ oxide of uncertain formula which occurs with serpentine in small fractures in drill cores from the Muskox Intrusion, Northwest Territories. Chemical analysis gave Fe₂O₃ 41.1, FeO 0.0, MgO 35.4, H₂O 23.8 sum 100.3% wt. Thermogravimetric analysis showed no significant weight loss at <105°C; 2.45% was lost up to 200°, 16.2% between 200 and 400°, and a gradual additional loss of 2.9% up to 800° (cumulative total 21.55%). The product is a mixture of spinel, hematite, and periclase.

Muskoxite is dark reddish brown; streak light orange-brown; hardness about 3; luster vitreous; $\rho = 3.10$ to 3.20 ± 0.05 (by suspension); perfect basal cleavage; biaxial negative with 2V variable from 15 to 40°, $n = 1.80-1.81$. The mineral occurs typically as aggregates of intergrown minute crystals, less commonly as individual plates with hexagonal outline, paper-thin $\{001\}$. The X-ray powder pattern has strongest lines at 4.6 (s), 4.4 (m to w) 2.31 (vs), 1.74 (m), 1.46 Å (w). Single crystal films yield diffuse spots indicating that muskoxite is trigonal, with $a = 3.1$ Å, c uncertain.

Jambor, J. L., Fong, D. G., and Sabina, Ann P.

DRESSERITE, THE NEW BARIUM ANALOGUE OF DUNDASITE; *Can. Mineralogist*, vol. 10, Pt. 1, 1969.

Dresserite occurs with weloganite in cavities in an alkalic sill intruding limestone at St-Michel, Montreal Island, Quebec. Chemical analysis gave BaO 36.6, SrO 0.8, Al₂O₃ 25.6, CO₂ 22.2, H₂O 15.3, sum 100.5 wt. %, corresponding to Ba_{1.98} Al_{4.06} C_{4.06} O₂₃ H_{13.67}, ideally Ba₂Al₄(CO₃)₄(OH)₈.3H₂O. This is the barium analogue of the lead mineral, dundasite. Dresserite occurs as white spherical aggregates averaging about 2 mm in diameter, each made up of tapering fibres elongated parallel to c . The lustre is vitreous to silky, hardness is about 2 1/2, and it effervesces in

dilute HCl. It is biaxial negative, with $2V \approx 30$ to 40° , $n_\alpha(\parallel a) = 1.518$, $n_\gamma(\parallel c) = 1.601$, and extinction is parallel. The mineral is orthorhombic $a = 9.27$, $b = 16.83$, $c = 5.63 \text{ \AA}$ and the space group can be $Pbmm$, $Pb2_1m$, or $Pbm2$. The x-ray powder pattern superficially resembles that of dundasite. Strongest lines of the pattern are 8.09 (10)(110), 6.23 (6)(120), 3.66 (5)(131), 2.73 (4)(241), 3.17 (3)(150), and a complete listing of observed spectra are given with those of dundasite for comparison. Density and thermal stability data also are given and discussed.

Jambor, J. L.

COALINGITE FROM THE MUSKOX INTRUSION, NORTHWEST TERRITORIES; *Am. Mineralogist*, vol. 54, March-April, 1969.

Coalingite, a hydrous $Mg-Fe^{3+}$ oxide, discovered in 1965 in the New Idria serpentinite, California, occurs as fracture fillings in drill cores from the Muskox Intrusion, Northwest Territories. The Muskox coalingite contains more iron and significantly less carbon dioxide than the type material. The mineral is trigonal, with $a = 3.1 \text{ \AA}$, c uncertain.

Muskox coalingite is believed to have formed in situ at room temperature during storage of the drill cores.

Jambor, J. L.

SULPHOSALTS OF THE PLAGIONITE GROUP; *Mineralogical Mag.*, vol. 37, No. 288, 1969.

SUMMARY. Three of the members of the plagionite group, fülöppite $Pb_3Sb_8S_{15}$, plagionite $Pb_5Sb_8S_{17}$, and semseyite $Pb_9Sb_8S_{21}$, show linear correlations of cell volume and density versus $PbS:Sb_2S_3$ mol ratios. This relationship can be used better to define the nature of the fourth member of the group, heteromorphite, $Pb_7Sb_8S_{19}$. The cell dimensions derived for heteromorphite are $a 13.60$, $b 11.93$, $c 21.22 \text{ \AA}$, $890^\circ 50'$.

Jambor, J. L.

DADSONITE (MINERALS Q AND QM), A NEW LEAD SULPHAN-TIMONIDE; *Mineralogical Mag.*, vol. 37, No. 288, 1969.

SUMMARY. Dadsonite was previously described without a name: (mineral Q) from Yellowknife, N. W. T.; (mineral QM) from Madoc, Ontario, and Pershing County, Nevada. Material from a fourth locality (Wolfsberg, Germany) yields good powder patterns, identical with those of QM, and single crystal data identical with those for Q.

Microprobe analysis of the Nevada and Wolfsberg samples gave, respectively, Pb 49.3, 50.8; Sb 31.7, 31.8; S 20.7, 20.3; sum 101.7, 102.9 percent, giving $Pb_{11}Sb_{12.0}S_{29.8}$ and $Pb_{11}Sb_{11.7}S_{28.4}$, ideally $Pb_{11}Sb_{12}S_{29}$ or 11 $PbS.6Sb_2S_3$. Dadsonite is acicular [010], monoclinic,

space group P2, Pm, or P2/m, with a 19.05, b 4.11, c 17.33 Å, 896°20', Z=1, Sp.gr. 5.76. The strongest lines of the X-ray pattern are 3.78 (7), 3.62 (6), 3.38 (10), 2.84 (7), and 2.79 Å (6).

King, L.H., MacLean, B., Bartlett, G.A., Jeletzky, J.A., and Hopkins, W.S. Jr.

CRETACEOUS STRATA ON THE SCOTIAN SHELF; Can. J. Earth Sci., vol. 7, No. 3, pp. 145-155, 1969.

Samples of Cretaceous sediment have been dredged from the Scotian Shelf at a locality 100 km north-northwest of Sable Island.

Continuous seismic-reflection profiles across the sample area show the presence of well defined stratification within the bedrock. These beds are truncated by the slopes of submarine valleys which transect the area. Bedrock appears to outcrop along the upper portion of the valleywalls or be covered by a layer of unconsolidated material so thin as to be beyond the resolution of the seismic equipment. The dredged material appears to have come from rubble heaps near the base of the valley slopes and is believed to have originated locally.

Approximately 450 kg of sedimentary rock were recovered consisting principally of sideritic quartz sandstone and arenaceous sideritic carbonate, both with fossiliferous material. Glauconite is a significant constituent of many samples.

The macrofauna include sufficiently diagnostic forms to suggest correlation with the early Upper Cretaceous (Cenomanian) though the possible presence of older or younger forms cannot be wholly excluded. The microflora and microfauna appear to correlate mainly with the Albian-Aptian, and Albian-Cenomanian, respectively.

Cretaceous strata immediately underlie much of the central and eastern portions of the Scotian Shelf. Tertiary sediments reported by Marlowe and Bartlett overlie the Cretaceous toward the continental margin and appear to occur as a discontinuous veneer at other localities on the shelf.

Kornik, L.J.

AN AEROMAGNETIC STUDY OF THE MOAK LAKE-SETTING LAKE STRUCTURE IN NORTHERN MANITOBA; Can. J. Earth Sci., vol. 6, No. 3, pp. 373-381, 1969.

An integrated aeromagnetic-geologic interpretation of the Moak Lake-Setting Lake structure, a distinctive magnetic feature which contains the Manitoba nickel belt, is presented. This structure is separated, on the basis of aeromagnetic and geologic data, into eastern and western areas. A main fault zone, which is mapped in part and is also an aeromagnetic lineament, separates the two areas. It is deduced that the western area of the Moak Lake-Setting Lake structure was involved in the Hudsonian orogeny only. The eastern area is interpreted to have been initially involved in the Kenoran (?) orogeny, which produced the characteristic charnockite and

pyroxene granulite rocks, and was then reinvolved in the dynamic effects of the Hudsonian orogeny. A chronologic sequence of the major events in the area is presented.

Lang, A.H.

SIR WILLIAM LOGAN AND THE ECONOMIC DEVELOPMENT OF CANADA; Canadian Public Admin., vol. XII, No. 4, pp. 551-565, 1969.

This paper is the first of a series outlining some of the ways in which the Geological Survey of Canada has furthered this country's mineral industry and general economy, and thus implying how additional benefits can be expected to accrue from geological work already done or needing to be done. The papers also attempt to show the degrees to which such benefits can be quantified and analyzed.

The GSC was founded by Logan in 1842 because several prominent Canadians advocated a survey of the geology of, and the nature and extent of the mineral resources of, Upper and Lower Canada. Logan epitomized his view of his task as follows, when giving evidence before a select committee of the legislature a few years later: "The object of the Survey is to ascertain the mineral resources of the country, and this is kept steadily in view. Whatever new scientific facts have resulted from it, have come out in the course of what I conceive to be economic researches carried on in a scientific way . . . thus economics leads to science, and science to economics."

The economic benefits from the work of the GSC are direct or indirect, and short-term or long-term. Logan's greatest contributions were indirect, by laying a sound foundation for later research on the geology of eastern Canada and beginning an inventory of its mineral resources, and by soundly beginning an organization that has ever since been an important factor in the economic and cultural development of an expanded country. The full value of such benefits can be assessed only semi-quantitatively, by considering total values of production (or ore reserves) and asserting that some indeterminate share of credit must be accorded to the officer concerned or to the organization as a whole, or by comparing the value of production with the cost of the project concerned or the total cost of the organization. To consider general short-term benefits, it is pointed out that the Canadian mineral industry was virtually non-existent in 1842. When Logan retired 27 years later the value of production from Ontario and Quebec for the year was about \$1,300,000. Statistics for earlier years were not kept, but the foregoing figure for 1869 may be compared with the vote of \$30,000 for the GSC for that year, and the total votes of \$414,000 from 1842 to 1869. General long-term benefits can be judged by considering current production values (to say nothing of ore reserves) and pointing out that almost all mineral discoveries or developments were partly a result of use of GSC maps or reports, lectures, courses in prospecting, sale of mineral sets, or advice given orally or in answer to letters. The total value of mineral production in 1969 was about \$4.7 billion and the cumulative total from 1842 to 1969 inclusive, for metals and nonmetallics only, exclusive of fuels and structural materials, is estimated by the writer to be about \$36 billion. These figures can be compared with the total votes for the GSC for work in all Canada for the same

period, amounting to slightly more than \$100 million. This indicates a benefit/cost ratio of 360,000 to 1, in unconstant dollars and on the basis that work by the GSC was only one factor, but an important one. General comparisons of this kind are useful because, although many individual GSC projects did not yield economic results or have not done so yet, this point is taken care of in a general benefit/cost analysis.

More specifically, Logan was directly responsible for establishing copper mining in the Eastern Townships, as outlined below. His advice was partly responsible for important production at Bruce Mines, Ontario, the first large metal mine in Canada, and for the discovery of the Silver Islet deposit near Port Arthur; these two mines provided most of the mineral production of Ontario in 1869 and the next several years. Logan's recognition of the Huronian part of the Canadian Shield, and the inclusion in *Geology of Canada*, 1863 of the first report of a uranium occurrence in Canada, were factors in the establishment of uranium mining at Elliot Lake. Logan was the first to report asbestos in the Eastern Townships and his display and advice at an exhibition in London helped to provide investment in its mining; a minute share of the total value of asbestos production would compensate for the total expenditures on the GSC in all Canada. The display of economic minerals at GSC headquarters begun by Logan was an acknowledged factor, after his time, in causing a financier to organize the forerunner of Inco; again, a minute fraction of Inco's total production would offset total expenditures on the GSC. Logan is now acknowledged in standard textbooks to have been the first to recognize and describe the relationship of petroleum with anticlines, during observations of oil seepages in Gaspé; work by the GSC at the first oil field in North America, in southern Ontario, added further to knowledge of petroleum geology. Logan was also responsible for the beginning of quarrying for slate, soapstone and lime in Quebec. Of these contributions, further quantification seems possible only for copper mining in the Eastern Townships.

Logan was the first to observe copper minerals in the Eastern Townships and a few years later he studied the area, reported that he had found several other occurrences, and gave specific locations for three which he considered worthy of further investigation. As a result three large mines were established, which provided most of the value of production of Quebec in 1869, and which produced for years afterwards. Other mines, for which he did not provide specific advice but which resulted in a general way from his recognition of the district and the relationships of its copper deposits, were also productive, and two are currently in operation. Because of incompleteness of early statistics and company records the value of early production can only be estimated and that from the three mines for which Logan was particularly responsible cannot be separated. It is estimated, however, that the total production from 1855 to 1869 inclusive was worth between \$1 and \$2 million, and that the total production from the district to date has been worth about \$200 million (twice the total expenditures on the GSC in all Canada).

It is concluded in this and other papers that, although some benefits have occurred soon after publication of GSC data, most of its performance must be judged on a long-term basis. It is also concluded that gross values of production provide the best comparisons, because most of such values are represented by wages, supplies, services, and taxes. If, however, profits are considered, much of them resulted in federal or provincial

taxes or royalties. It is considered that adjustments for constant dollars are unnecessary because most benefits can be compared with costs occurring over about similar periods, and because adjustments would be small in comparison with the multiplying effect of new wealth provided by the mineral industry. It is also concluded that although shares of credit for GSC factors can be estimated for some cases, much useful evidence can be provided by stating merely that a factor was a major, considerable, or minor one.

The possibility of deposits being found eventually without help from the GSC is discussed, with conclusion that it is reasonable to judge by what actually happened, and that early discovery was especially important for a developing country. Mathematical treatment of this problem may be tried in a future paper.

Lang, A.H.

THE ROLES OF THE GEOLOGICAL SURVEY OF CANADA IN FORMER URANIUM PROGRAMS; Can. Inst. Mining Met., Bull., vol. 62, No. 691, pp. 1210-1218, 1969.

A review of events that led to the discovery and development of past and present sources of uranium in Canada is presented in the belief that knowledge of approaches that were successful and unsuccessful could benefit present and future searches for additional ores. The history of Canadian discoveries is traced from the time when uranium deposits were scientific curiosities, through the periods when they were in demand; first for their contained radium, then for military uses of uranium and later when demands for peaceful purposes caused a boom in prospecting and production.

Most mines evolved from a series of events commonly occurring over long periods and forming complex 'chains' or 'patterns' in mineral exploration. The most critical events involved prospectors and companies, but supporting incidents generally contributed to the successes. The Geological Survey of Canada was responsible for a wide variety of such 'assists'. An indication of the value of the work of the Geological Survey is suggested by comparing the total cost of the Survey's work with the estimated value of the ore in the most productive uranium district - Elliot Lake - where the Survey assisted in several ways. Appropriations for the Survey from 1842 to 1968, for all parts of Canada and for any purpose, totalled \$96 million. The gross value of production and reserves at Elliot Lake is estimated by the writer to be at least \$5.5 billion. On that basis, the total cost of the Survey is about 1.8 per cent of the value of this one district - and many other districts producing uranium or other commodities have benefited from Survey data.

Lang, A.H.

DISCOVERY OF THE PINCHI MERCURY DEPOSIT; Can. Mining. J., vol. 90, No. 11, pp. 45-46, 1969.

The Pinchi mercury mine in central British Columbia was of much strategic importance during World War II and has recently been re-opened after an expenditure of about \$10 million on new development and plant. The

deposit is an outstanding example of a discovery made directly by the GSC. It was found, 300 miles north of the nearest known mercury-bearing lodes, by a party doing standard geological mapping in 1937. Prospectors stated after the map and report were published that they had long been familiar with the cinnabar-bearing outcrop but thought the colour was caused by staining by berries. This is taken to indicate that the discovery required the eye of a geologist and that full credit for it should be accorded the GSC, although much credit is also due to Cominco for speedy and competent development and production after publication. Another officer of the GSC assisted by pointing out more detailed geological relationships while examining the deposit for the Wartime Metals Controller, and still another made a detailed study of the Pinchi fault zone which helped to cause additional discoveries up to 150 miles farther north, including one producer.

The total gross value of production from 1940 to 1944 was \$10,400,259. The production since reopening in 1968, and the value of ore reserves, are not available but must be substantial in view of the expenditures on development and plant. The cost of the survey, including the salary of the party-chief, was \$3,242. When the mine was opened in 1940 the Deputy Minister of Mines for B.C. stated that the ore reserves at that time were worth more than all expenditures on the GSC in the province since Confederation. The earlier production was, apparently, of greater gross value than expenditures on the GSC in all Canada from 1842 to 1937, estimated at \$9,650,000.

Lang, A.H.

HISTORICAL SIDELIGHTS ON BRENDA MINE AND REGION; Can. Mining J., vol. 91, No. 3, pp. 41-43, 1970.

The Brenda mine in south-central British Columbia is expected to be, at least for a time, the largest non-ferrous metal mine in Canada. The low-grade copper-molybdenum deposit, of the general porphyry-copper class, was re-discovered by a prospector in 1954. He soon learned that it had been described in a Memoir of the GSC published in 1947. The report stated that the veins on which earlier prospectors had done some work were probably too small to be valuable in themselves, but that their enclosing rock represented a large copper-molybdenum deposit that deserved further attention. This report was apparently overlooked when prospectors and companies became interested in such low-grade deposits, as had an earlier report of the GSC in 1931 which called attention to the favourability of the general area for prospecting. The prospector who re-discovered the prospect used the 1947 report to good advantage in interesting geologists of Noranda Mines Limited in examining and optioning the deposit, which appears to have a minimum gross value of about \$400 million. The surveys on which the Memoir was based were made during three field seasons, total costs including the salary of the geologist in charge being about \$15,000. The report was only one factor in the evolution of the mine, but it was an important one and serves to indicate the importance of government geological surveys and one of the kinds of useful information contained in the resulting publications, including old ones.

Larochelle, A.

PALEOMAGNETISM OF THE MONTEREGIAN HILLS: FURTHER NEW RESULTS; J. Geophys. Res., vol. 74, No. 10, May 15, 1969.

Magnetization measurements were made on a hundred-twelve independently oriented cores drilled at twenty-two sites distributed among six basic intrusive plugs forming part of the Monteregian Hills group in south-east Quebec. On the basis of adopted magnetization homogeneity criteria, less than 80% of the sampled cores were accepted as reliable carriers of paleomagnetic information, after a cleaning in a peak demagnetizing field of 250 oe. An analysis of the data obtained from these cores representative of sixteen sites yielded a mean direction of magnetization whose declination and inclination are, respectively, 157.4° and -59.9° . The circle of confidence about the resultant of the sixteen 'weighted' site means has a radius α'_{95} equal to 3.3° . No reliable evidence of mixed polarity in the paleomagnetic directions within any one of the six intrusives studied was found, although additional evidence was obtained to postulate at least one earth's field reversal during their formation. Combining the above mentioned data with seventy-five previously reported core mean directions representative of sixteen sites on four other members of the Monteregian Hills group yielded a paleomagnetic pole position at 170.5°W , 71.3°N . The low angular standard deviation of the thirty-two 'weighted' site means summarizing these data (7.8°) suggests that the non-dipole component of the earth's magnetic field was less important in Cretaceous time than it was over the last 10 m. y.

Lawrence, D.E.

A WIDE FIELD TECHNIQUE FOR VIEWING ROCK TEXTURES; Can. Mineralogist, vol. 9, Pt. 5, pp. 716-17, 1969.

By manipulation of its optical components the low power magnification range of the petrographic microscope may be extended. The technique described allows a five to ten times increase in the diameter of the field of view; an aid to the interpretation of small scale structures and coarse textures in petrographic thin sections.

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

GEOLOGICAL SURVEY OF CANADA RADIOCARBON DATES IX; Radiocarbon, vol. 12, No. 1, pp. 46-86, 1970.

One hundred and forty-five radiocarbon age determinations on geologic samples made by the Geological Survey of Canada Radiocarbon Dating Laboratory are reported. They are on samples from various parts of Canada as follows: Newfoundland (2), Nova Scotia (18), New Brunswick (15), Quebec (10), Ontario (18), Manitoba (9), Saskatchewan (3), Alberta (11), British Columbia (18), Yukon (33), Northwest Territories - mainland (2), Northwest Territories - Arctic Islands (6). Many of the ages reported have been corrected for isotopic fractionation.

Further testing was carried out in regard to several problems: 1) varying the length of time that bone samples (from an Arctic environment, and utilizing the collagen fraction only) were given base treatment did not produce significant differences in the resulting ages; 2) comparisons between the ages of marl samples (inorganic fraction), the organic residues in marls, and closely associated gyttja samples showed that dates on marl in particular must be treated with great caution, as "old" carbon in varying amounts is often incorporated into the marl; 3) an additional pair of dates on peat from a permafrost area showed, as usual, good agreement between the ages of the less base-soluble and more base-soluble fractions.

Macqueen, R.W., and Sandberg, C.A.¹

STRATIGRAPHY, AGE, AND INTERREGIONAL CORRELATION OF THE EXSHAW FORMATION, ALBERTA ROCKY MOUNTAINS; Bull. Can. Petrol. Geol., vol. 18, No. 1, pp. 32-66, 1970.

The Exshaw Formation of the Alberta Rocky Mountains and foothills consists of a lower, black shale unit and an upper, siltstone unit, which are separated by a gradational contact. At the type section on Jura Creek, near Exshaw, Alberta, the upper contact of the Exshaw is redefined so that the formation includes all, rather than merely the lower part, of an unbroken sequence of dark-yellowish orange-weathering calcareous siltstone. At the type section, the black shale unit is 33 ft. thick and the siltstone unit 127 ft. X-ray diffraction data from the type section indicate that the shale is composed mostly of quartz and contains only minor amounts of illite, feldspar, and carbonates. The siltstone has considerably more calcite and dolomite than most of the shale. Throughout its area of outcrop, the Exshaw unconformably overlies limestones of the Devonian Palliser Formation, and is sharply (disconformably?) overlain by shales at the base of the Mississippian Banff Formation.

The silts and clays, and some of the carbonaceous material in the black shale unit, were probably derived from soils and deposited in shallow-marine, euxinic lagoons. The siltstone unit was deposited in a regressive, marginal-marine environment of widespread, well-oxygenated tidal flats.

Physical continuity is demonstrated between the Exshaw Formation and a) the lower two members of the Bakken Formation in the subsurface of southeastern Alberta and Saskatchewan, b) the Sappington Member of the Three Forks Formation in Montana.

Conodont evidence from the Exshaw Formation and circumstantial conodont and spore evidence from the Sappington Member and Bakken Formation show the age of the Exshaw to be Devonian and Mississippian. The systemic boundary is probably positioned near the middle of the black shale unit. Evidence previously cited for the age of the Exshaw at Crowsnest Pass is shown to be more pertinent to the age of the overlying Banff Formation.

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Macqueen, R. W.

UPPER DEVONIAN AND LOWER MISSISSIPPIAN SEDIMENTARY RECORD, WESTERN CANADA SHELF; (abstr.) Bull., Am. Assoc. Petrol. Geologists, vol. 53, No. 3, p. 730, 1969.

Western Canadian Upper Devonian and Lower Mississippian shelf rocks, several thousand feet thick, are characterized by three sedimentary domains: a carbonate-evaporite area on the southeast (Saskatchewan), a central area dominated by carbonates (Alberta), and a terrigenous clastic and argillaceous carbonate area on the north (northeastern British Columbia). The carbonate-evaporite and carbonate domains include sabkha-type microdolomite-evaporite cycles, as well as barriers and blankets of skeletal and nonskeletal limestones. Although many of these rocks compare closely with sediments of certain Holocene carbonate settings, the makeup of these fossil sediments tends to be distinctive at various stratigraphic levels.

To illustrate: within the carbonate domain (Alberta), the Frasnian Stage contains wave-resistant organic reefs in which stromatoporoids and colonial corals are abundant. In contrast, reefs, stromatoporoids, and colonial corals are almost unknown in Fammenian strata, most of which form an extensive blanket of nonskeletal limestone with evaporites and redbeds on the east. A widespread black shale unit caps the Fammenian. Kinderhookian rocks are argillaceous carbonates in which echinoderm detritus increases upward. Although colonial corals reappear in the Kinderhookian, the Mississippian lacks organic reefs. The Osagian is distinguished by an explosive and geologically unique development of echinoderms - the main source of the enormous volumes of skeletal sands of this age which cover much of the area - and also contains well-developed cyclic lagoon-sabkha sediments.

Two dominant factors that influenced Late Devonian-Early Mississippian sedimentary patterns on this continuous shelf are oscillatory variations in water depth (probably tectonically controlled) and change in composition of the dominant fauna and flora from frame-builders to sediment-contributors.

Maxwell, J. A.

GEOLOGICAL SURVEY OF CANADA PARTICIPATION IN APOLLO LUNAR PROGRAM; Chemistry in Canada, vol. 22, No. 3, pp. 13-17, 1970.

The five areas of investigation undertaken by scientific teams in the Geological Survey include mineralogy-petrology, magnetic properties, electrical conductivity, chemical composition, and elemental concentrations, isotopic abundance ratios and geological ages. A brief history and explanation of the program are given, and the results obtained by each team on Apollo XI samples are discussed.

Maxwell, J.A., Abbey, S., and Champ, W.H.

CHEMICAL COMPOSITION OF LUNAR MATERIAL; Science, vol. 167, No. 3918, Jan. 30, 1970, pp. 530-531.

Abstract. Chemical and emission spectrographic analyses of three Apollo XI samples, 10017-29, 10020-30, and 10084-132, are given. Major and minor constituents were determined both by conventional rock analysis methods and by a new composite scheme utilizing a lithium fluoborate method for dissolution of the samples and atomic absorption spectroscopy and colorimetry. Trace constituents were determined by optical emission spectroscopy involving a d-c arc, air-jet controlled.

Norris, D.K.

INCLINED FLEXURAL-SLIP FOLDS IN THE EASTERN CANADIAN CORDILLERA; Abstr. Geol. Soc. Am., vol. 2, No. 4, p. 296, 1970.

Eastward-inclined, flexural-slip folds are intimately associated with the family of west-dipping thrust faults in the southeastern Canadian Cordillera. In the northeastern Cordillera flexural-slip folds are commonly associated with thrust or high-angle reverse faults and like them are inclined either toward or away from the craton. In both regions the folds are bounded above and below by faults transecting the layering or décollements in shale, coal or salt.

The model proposed for the nucleation and growth of these inclined, flexural-slip folds is that of a laminated plate in which axial surfaces perpendicular and subperpendicular to detachment surfaces are generated before significant external rotation of the beds. The hinges are assumed fixed in position on each bedding slip surface. The asymmetry of simple folds, therefore, is established by the spacing of the axial surfaces at fold nucleation because there is no transfer of material across the hinges during folding. With regular spacing the limbs will be of equal length and the folds will remain symmetrical as they grow. With irregular spacing the limbs will be of unequal length and folds asymmetric. As appression increases, the hinges move toward one another; axial surfaces rotate, decrease in dip, and extend themselves perpendicular to the hinges. The folds will automatically be inclined if their limbs are of unequal length.

In the growth of a fold train the long limbs are externally rotated so that flexural slip is congruent to motion on associated detachment surfaces and the incongruity due to slip in the short limbs is minimized. Thus the model explains eastward inclination of asymmetric folds in the southeastern Canadian Cordillera and no preferred inclination in the northeastern Cordillera.

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

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

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

Petryk, A.A.¹, Mamet, B.L.², and Macqueen, R.W.

PRELIMINARY FORAMINIFERAL ZONATION, RUNDLE GROUP AND UPPERMOST BANFF FORMATION (LOWER CARBONIFEROUS), SOUTHWESTERN ALBERTA; *Bull. Can. Petrol. Geol.*, vol. 18, No. 1, pp. 84-103, 1970.

Lower Carboniferous rocks of the uppermost Banff Formation and the Rundle Group of southwestern Alberta contain an abundant foraminiferal microfauna and algal microflora, from which the distribution and relative abundance of 95 taxa have been determined. Foraminifera, which are most common in mixed skeletal and oolitic calcarenites, less common in micritic limestones, and least common in echinoderm-bryozoan limestones, permit recognition of Zones 7 to 16 of a widely applied zonal scheme derived initially from Carboniferous rocks of Europe. Vertical variations in foraminiferal families include an upward decrease in the abundance of endothyrids, tournayellids, and earlandiids, corresponding with an upward appearance and increase in the abundance of cornuspirids, forschids, tetrataxids, palaeotextulariids, archaediscids, and others, and are similar to familial variations in Lower Carboniferous platform rocks in other parts of the world. The more precise correlations derived from the 95 microfaunal and microfloral taxa are in agreement with correlation of the Rundle Group, Pekisko, Shunda and Turner Valley formations with the Rundle Group, Livingstone Formation, as recently indicated by lithostratigraphic and macrofaunal studies.

Preliminary foraminiferal zonation suggests the following ages: The uppermost Banff Formation is middle Tournaisian, whereas the overlying

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Pekisko Formation and the lower part of the Livingstone Formation are late middle Tournaisian. Foraminiferal data are as yet too meagre to delineate the precise Kinderhook-Osage boundary, in terms of the American Midcontinent stages. The Shunda Formation, and the middle part of the Livingstone Formation, are of late Tournaisian age. The Shunda-Turner Valley contact closely corresponds to the Tournaisian-Viséan boundary, which is approximately equivalent to the Osage-Meramec boundary of the American Midcontinent Lower Carboniferous. The upper Livingstone Formation (type area only) and the Turner Valley Formation are of early Viséan age. Overlying rocks of the Mount Head Formation (type area) are late early Viséan to middle late Viséan (Meramec). The Mount Head-Etherington contact corresponds to the base of the Aux Vases Sandstone (type Chester) of the Midcontinent. The transitional nature of the Mount Head-Etherington foraminiferal microfauna does not support the presence of a Meramec-Chester hiatus as previously postulated. The Lower Etherington Formation is latest Viséan in age.

Poole, W.H.

SOLID-EARTH SCIENCE IN THE APPALACHIAN REGION OF CANADA; Bull. Can. Inst. Mining Met., vol. 63, No. 694, pp. 204-213, 1970.

Geological investigation in the Appalachian region of Canada began more than 150 years ago. The distribution of rock formations, and their ages and regional structure are today reasonably well known in most parts of the region to 1- or 2-mile scale. Most Newfoundland geology is known only to 4-mile scale. About 200 earth scientists carry out research in the region, of whom about 25 per cent are government employees, 50 per cent university staff and graduate students, and 25 per cent industry employees.

Increased activity is needed toward both regional analyses and problem studies through the efforts of multi-disciplinary teams. The ultimate objectives of earth science must be the discovery and development of mineral resources and the use and conservation of natural material in the environment, all for the benefit of the local inhabitants. To accomplish this, the scientific community must carry out an array of research projects ranging from the technical products of geological, geophysical and geochemical surveys through to the research products designed to renew theories and hypotheses bearing on natural processes. Some scientific sub-objectives are listed.

Recommended is the increase and broadening of communication among Appalachian scientists, specifically those resident in the Atlantic Provinces. It is proposed that an Appalachian Division of the Geological Association of Canada be formed to provide a forum for discussion of Appalachian topics. In addition, a committee or council of university, industry and government earth scientists should be formed to examine the state of the science in the region, to identify programs of investigation and individual projects of research, and to recommend methods of approach. If the committee succeeds and the scientific community acts upon the recommendations, the quantity, quality and pertinence of research will increase, and earth science will better serve Appalachian society.

Rimsaite, J.

STRUCTURAL FORMULAE OF OXIDIZED AND HYDROXYL-DEFICIENT MICAS AND DECOMPOSITION OF THE HYDROXYL GROUP; Contrib. Mineral. Petrol. , vol. 25, No. 3, pp. 225-240.

Studies of the structural formulae of Canadian micas indicate that the anionic framework of most natural micas differs from that of ideal mica in the quantity and/or charge of the anions per unit cell. Seven chemically analysed micas having variable chemical properties were chosen for heating experiments under controlled laboratory conditions. Ferric and ferrous iron, water and fluorine were determined after heating. The structural formulae of the oxidized and altered micas were calculated on the basis of " $44 + z$ " valencies where " z " is a charge difference between the original and altered mica, and depends mainly on the degree of oxidation of iron.

By comparing the structural formulae and anionic compositions of dehydrated and altered micas with those of ideal mica, it is possible to study the process of decomposition of the hydroxyl group during oxidation and dehydration. The decomposition of the hydroxyl group takes place either as a result of the oxidation of iron or by loss of water (and/or fluorine). The process of decomposition thus depends on the quantity of ferrous iron in the mica, on the composition of the hydroxyl group, and on the available atmospheric oxygen, or environmental conditions. The iron-poor micas, phlogopite, muscovite and lepidolite, lose hydroxyl mainly as water, without changing the charge of the layers, whereas biotite may also oxidize, resulting in a change of charge balance. Where the hydroxyl group is composed predominantly of fluorine the biotite either remains in a semi-oxidized state, or oxidizes at the expense of atmospheric oxygen or water. Micas containing partly deficient anionic frameworks are susceptible to adsorption of water and argon from the atmosphere. The stability of mica during physical-chemical changes of the environmental conditions depends not only on its cationic content but also on the composition of its anionic network and layer charges.

Rimsaite, J.

EVOLUTION OF ZONED MICAS AND ASSOCIATED SILICATES IN THE OKA CARBONATITE; Contrib. Mineral. Petrol., vol. 23, pp. 340-360, 1969.

Thin section study of the Oka carbonatite revealed the presence of zoned pyroxene, amphibole, mica and carbonate which were studied by means of electron probe line scans to establish the relationship between optical zoning and chemical composition. The zoned micas were studied in more detail by means of optical, X-ray, classical chemical, spectrographic and electron probe point counting analyses. The results indicated two- to ten-fold variations in ionic proportions of titanium, iron and aluminium, and lesser variations in concentrations of magnesium, silicon and potassium in six different mica zones.

Distribution coefficients of Si, Al, Fe^{III}, Fe^{II}, Ti and Mg in adjacent mica zones indicate that, with the exception of ferrous and ferric iron

which show a straight line relation, the relationship between the major constituents is more complex. Iron and magnesium exhibit opposite trends, modified by prominent variations in aluminium and titanium. Gradual variations within the zones are accounted for by gradual differentiation of the magma. The abrupt changes in chemical composition between the zones, coinciding with optical boundaries, indicate sudden changes in the environmental conditions, resulting from crystallization of associated minerals and periodic emplacement of certain elements into magma.

High Fe and high Ti-Al zones are used as markers for correlating cogenetic zones in pyroxene, amphibole and mica, and for establishing periods of crystallization of Fe-Ti ore minerals (also published in abstract form in 1) Can. Mineralogist, vol. 10, Pt. 1, p. 145, 1969, and 2) Abstr. Ann. Meeting, Geol. Assoc. Can. Mineral. Assoc. Can., p. 43, 1969.

Rutter, N.W.

SUMMARY OF PRELIMINARY WORK ON THE QUATERNARY GEOLOGY OF THE LAKE WILLISTON AREA, B.C.; Edmonton Geol. Soc., Guidebook, P.A. Zeigler, ed., Edmonton, Alta., 1969.

The Lake Williston area includes that part of the Rocky Mountain Trench which extends from about Deserters Canyon southeastward to near the John Hart Highway. This area encompasses parts of the former Parsnip and Finlay Rivers drainage basins. At Finlay Bay (formerly Finlay Forks) the area extends eastward crossing the Rocky Mountains along the former Peace River valley to Portage Mountain (W.A.C. Bennett Dam).

Pleistocene deposits are widespread in the Rocky Mountain Trench. Fortunately, Quaternary deposits are relatively well preserved because of the broad nature of the trench that has minimized mass wasting and erosion. Prior to flooding, a good cross-section of these deposits was provided by the widely meandering Parsnip and Finlay Rivers.

Along the Parsnip River, bluffs up to 200 feet high exposed a variety of glacial deposits. The deposits forming the surface today display for the most part typical deglaciation features such as kames, eskers, sand dunes, and lake and outwash plains. In the northern part of the area glaciolacustrine deposits are the most common. In the southern part, in the vicinity of the John Hart Highway, widespread drumlin fields are present. These units are generally unconformable with underlying glacial deposits. Some of the more important sections consist in part of two distinct till units separated by gravel. The lower contact of the underlying deposits is generally obscured but in a few places the deposits were seen to truncate Tertiary gravel or older bedrock. Prior to flooding, one of the most complete sections was located near the mouth of the Manson River on the Parsnip River. The section included:

Top	23.5 feet	Lacustrine silt and sand
	9.0	Fluvial sand
	10.0	Lacustrine clay
	46.0	Till and gravels
	15.0	Fluvial sand and gravel
Bottom	49.0+	Fluvial sand

Thick sections of surficial deposits crop out in many localities along the lake shore in the area of the former Finlay River. These consist for the most part of lacustrine silt and clay (some units over 150 feet thick) from Finlay Bay north to about Davis Creek. Locally, the lacustrine deposits are overlain and underlain by till and glaciofluvial deposits. North of the Davis Creek area to Deserters Canyon thick glacio-fluvial deposits including outwash, kames and eskers, are the dominant deposits with some till and lacustrine sediments present.

North of Deserters Canyon (out of the Lake Williston area) to Ft. Ware the best stratigraphic sections occur. One section, about 1 1/2 miles southeast of Del Creek displays the following sequence:

Top	9.0	feet	Till 1
	45.5		Till 2
	18.0		Lacustrine silt
	1.5		Fluvial gravel
	3.5		Till 3
	67.0		Fluvial sand and gravel
	<u>+50.0</u>		Till 4
	<u>+35.0</u>		Fluvial gravel
Bottom	<u>+50.0</u>		Oxidized fluvial sand and gravel

In the narrow valley formally occupied by the Peace River, the surficial deposits are almost entirely of fluvial and glacio-fluvial origin. Prior to flooding, four major sets of terraces up to more than 500 feet above the uncontrolled river level could be traced, although not continuously, from Finlay Forks to Portage Mountain. Generally, the terraces are underlain by silty to gravelly material with some of the higher terraces pocketed by kettles. From about Carbon Creek down to Portage Mountain, the higher terraces are capped by lacustrine silt. The deposits beneath the terraces are partly aggradational, related to the terraces themselves, and are partly erosional, remnants of pre-existing deposits. Beneath at least the three lower major terraces a distinct unconformity separates overlying, fairly flat-lying, moderately well sorted gravel and sand from underlying, highly contorted steeply dipping beds of poorly sorted gravel interbedded with sand and silt. Within this lower unit, restricted unconformities are common. The implication of these two distinct units found beneath terraces is that subsequent to down-cutting of each terrace, there was a period of aggradation. Till of restricted extent was found interbedded with the contorted sediments in some localities. Till also occurs beneath the contorted sediments and overlies oxidized gravels. Little is known about the unconsolidated material below the former river level although over 1,700 feet of such material has been reported from borings near Portage Mountain.

An arcuate end moraine extends from Bullhead Mountain southward to Portage Mountain across the former route of the Peace River composed principally of fluvial gravel and sand, formed during final deglaciation of the area. The moraine at least in part, dammed water upvalley that formed a lake and deposited the sediments seen in the high terraces in the area. During the drainage of the lake, water flowed over a saddle to the south of Portage Mountain and eroded bedrock forming the present Peace River Canyon, the site of the W.A.C. Bennett Dam. Material from the moraine was used extensively during the dam construction.

Until further office and laboratory studies are made only a general glacial history can be presented for the Lake Williston area. Evidence is present for four glacial advances that flowed in the Finlay River valley. The two thick till units represented by Tills 2 and 4 in the second lithologic section cited, may correlate with the two units observed in the Parsnip River valley. If this is so, the till units represent widespread advances and may have passed through the Peace River valley being evidenced in this area by till observed within and below the contorted sediments. Till 3 may represent a minor readvance of the glacier that deposited Till 4. Till 1, which is relatively thin, appears to mantle pre-existing surficial topography down-valley to about the area of Deserters Canyon. A third advance is indicated in the Parsnip River valley by certain till outcrops found in the uplands that may be higher stratigraphically than the two tills commonly found in succession along the former Parsnip River banks.

The four well preserved major terraces observed in the Peace River valley formed after ice withdrew from the valley. They may relate to three periods of glacier fluctuation outside the Peace River valley, or water level control from damming, perhaps when the Peace River changed course and cut the canyon adjacent to Portage Mountain.

Preliminary information suggests that at least the latest advances followed the natural drainage of the area (pebble orientation studies in till are not as yet analysed). The paucity of glacial erratics from sources west of the Rocky Mountain Trench and the poor preservation of striated and fluted surfaces on or near mountain summits in the Rocky Mountains, suggest that only early and extensive glaciations have crossed drainage routes and penetrated deeply into the Rocky Mountains.

Radiocarbon dating has given some insight into the age of the surficial deposits. A mammoth tusk found in the end moraine near Portage Mountain was dated at about 11,600 years B.P., suggesting that the last mountain ice was present in this area at about that time. Wood dated from surface deposits on the west bank of the Ospika River well up the Finlay River valley indicates that that part of the Rocky Mountain Trench was ice-free at least about 7,470 years B.P. (GSC-1069).

The oxidized sands and gravels found under Till 4 as indicated in the second lithologic section presented, may be the only interglacial deposits preserved in the area. Radiocarbon dates derived from several samples taken from these deposits indicate that they were deposited prior to 44,000 years ago (GSC-837, 841, 1057).

It is interesting to note that since flooding of the narrow Peace River valley large scale landsliding has taken place. The largest slides have resulted from failure of glacial gravel and sand (forming the major terraces) and overlying Post-glacial talus. Waves on the order of 40 feet in amplitude have been generated by the slides according to loggers working in the area.

Rutter, N. W.

PLEISTOCENE PALEOSOL INVESTIGATIONS IN PARTS OF WESTERN CANADA; Pedology and Quaternary Res., Natl. Res. Council, Can., Univ. Alberta, 1969.

Very few Pleistocene paleosols have been described in Western Canada and these are confined mostly to buried soils. Three areas are

discussed that offer promise for relict paleosol study at the present time - the Interior Plains, the Rocky Mountains and environs, and parts of the Yukon. Reconstruction of past geomorphology, climate and vegetation, and time relationships may be aided by comparing soils on different surfaces and by individual study.

In the Interior Plains, stillstands and readvances of the last glaciation may be detected by recording differences in weathering intensity and profile thicknesses of soil in till on either side of a former ice front position. In the southern Rocky Mountains and environs three surfaces of widely varying age are present - at lower elevations, Wisconsin; at intermediate elevations, pre-Wisconsin (?); and at higher elevations, unglaciated surfaces. By relict soil study it may be possible to confirm that the pre-Wisconsin (?) surface actually represents an interglacial interval. In parts of the Yukon, at least four distinct surfaces are present. These include a non-glacial surface, at least Miocene age: a high terrace, whose surface dates from pre-Illinoian time; and lower terraces, dating from early Wisconsin or Illinoian and late Wisconsin times. The presence of ancient surfaces at varying elevations permits detailed study of the complexities and inter-relationships of soil development and geomorphic evolution.

Rutter, N. W.

COMPARISON OF MORAINES FORMED BY SURGING AND NORMAL GLACIERS; Can. J. Earth Sci., vol. 6, No. 4, pp. 991-999, 1969.

A Neoglacial moraine of Bighorn Glacier, St. Elias Mountains, Yukon, probably formed by a surging glacier, and a Neoglacial normal moraine of nearby Grizzly Glacier were studied. Surficial deposits and erosional features were mapped. Fabric analyses were done in till at five sites in each moraine. Samples were subjected to laboratory lithologic and texture analyses.

The Bighorn (surge) moraine is a thin, discontinuous, irregular mantle, mostly till, but including ice-contact stratified material. Lateral moraines show subdued ridges marking the upper limit of glaciation. Ground moraine of the Grizzly (normal) glacier is an irregular, continuous, thick mantle, mostly till and ice-contact stratified material. Upper ice limits are marked by prominent ridges. Rocks of similar lithologies within the till are concentrated in bands parallel to glacier flow.

Stones in till of the Grizzly moraine have strong preferred orientation roughly in the direction of glacier flow. In the Bighorn moraine, rocks in till are weakly oriented. Where orientation is apparent, it is not necessarily in the flow direction. For the size fraction finer than 2 mm, Bighorn till is coarser than Grizzly till although the bedrock terrain is similar.

These differences are useful in distinguishing moraines of normal and surging glaciers.

Rutter, N. W.

A LATE PLEISTOCENE GLACIAL ADVANCE, BOW RIVER VALLEY, ALBERTA, CANADA; Quaternary Geol. and Climate, Publ. 1701, Natl. Acad. Sci., Washington, 1969.

In the Bow River valley, Banff National Park, Alberta, Canada, evidence indicates a relatively recent glacial advance, probably the last significant glacial event in the area. The glacier originated at the head of the Bow River valley (elevation $\pm 6,600$ ft or $\pm 2,000$ m) and flowed as far as Eisenhower Junction (approximately 40 miles or 64 km), receiving ice from numerous tributary valleys along its way.

Evidence for the advance is not based on a distinctive till or stratigraphic sequence, but rather on geomorphic criteria and related glacial deposits, such as relatively fresh lateral moraines and cirques, and breaks in slope caused by glacial scouring and side-glacial stream action. The extent of the advance was determined by an end moraine consisting of ice-contact outwash, by the relative development of the postglacial Bow River and flood plain plus alluvial fans from tributary creeks upstream and downstream from the end moraine, and by the geographic distribution of relatively fresh cirques and glacial troughs.

Evidence is also present for a minor readvance. Airphotograph interpretation and ground reconnaissance indicate that the Eisenhower Junction advance probably was not local but extended throughout much of the Main Ranges subprovince of the Canadian Rocky Mountains.

The minimum age for the advance may be about $9,330 \pm 170$ years B.P., as dated from charcoal samples collected in a nearby area.

Schaeffer, R.M., and Schwarz, E.J.

THE MID-ATLANTIC RIDGE NEAR 45°N . IX. THERMOMAGNETICS OF DREDGED SAMPLES OF IGNEOUS ROCKS; Can. J. Earth Sci., vol. 7, No. 2, 1970.

The thermomagnetic properties of 15 basalts dredged from the Mid-Atlantic Ridge near 45°N were studied in air at low pressure. One of the samples was used for detailed optical, X-ray diffraction, and electron microprobe studies. The Curie point and the cell edge of the original ferromagnetic constituents indicate the presence of titanomagnetite with Fe to Ti ratios of about 4.6. This was corroborated by electron microprobe results. During heating up to 550°C , the Curie point and the saturation magnetization increased gradually while the cell edge decreased. This suggests that the titanomagnetite was oxidized to titanomaghemite. After heating above 600°C , a Curie point at -20°C was observed while the saturation magnetization decreased. This may be considered as the result of an exsolution of a titanium-rich phase and a transition of maghemite to hermatite. The thermomagnetic properties do not seem to be related with the pattern of alternating magnetic anomalies. However, the increase in Curie point with distance from the ridge suggests natural oxidation. Consequently, a part of the original TRM appears to have been replaced by CRM components, which cancelled out one another as they were acquired in periods of different geomagnetic

polarity. This decay of the TRM offers an explanation for the decreasing intensity of the magnetic anomalies with distance from the axis.

Slankis, J.A., and Becker, A.

TELLURIC AND MAGNETO-TELLURIC MEASUREMENTS AT 8 Hz;
Trans. Soc. Mining Engr., vol. 244, pp. 237-244, 1969.

Equipment has been developed to utilize natural 8 Hz electromagnetic fields to measure rock resistivities. Telluric and magnetotelluric surveys have detected resistivity variations associated with geological contacts and metallic sulfide deposits. The fundamental premises of these methods are illustrated by the results of surveys across a Pleistocene-Precambrian contact in the Ottawa Valley and a near-surface sulfide deposit in Northern Quebec. Such interfaces are characterized not only by variations in apparent resistivity, but also, unexpectedly by the spatial anisotropy of the electric fields and the presence of a strong vertical magnetic field component in their vicinity.

Sen Gupta, J.G.

RAPID COMBUSTION METHODS FOR DETERMINING SULFUR IN
ROCKS, ORES AND STONY METEORITES

A COMPARATIVE STUDY OF THE USEFULNESS OF RESISTANCE-
TYPE AND INDUCTION FURNACES; Anal. Chim. Acta, vol. 49,
pp. 519-525, 1970.

A satisfactory procedure for determining total sulfur in rocks, ores and stony meteorites with a Leco induction furnace is described. Suitable fluxes, time for complete evolution of sulfur dioxide, and suitable absorption solutions for sulfur dioxide are discussed. A comparative study of three different combustion methods for determining sulfur in a variety of geological material has also been made. The results indicate that induction heating is superior to resistance heating for most samples containing up to 20% total sulfur.

Sen Gupta, J.G.

ABUNDANCES OF THE SIX PLATINUM METALS IN SOME IRON
AND STONY METEORITES: RELATIONSHIPS TO THE THEORIES OF
EVOLUTION OF PARENT BODIES OF METEORITES AND THE
ORIGIN OF THESE ELEMENTS; Chem. Geol., vol. 3, pp. 293-305,
1968.

The abundances of the six platinum metals (Pt, Pd, etc.) in five stony and three iron meteorites have been determined by improved spectrophotometric methods, following perchloric acid decomposition and ion-exchange separation. The average atomic abundances of the six platinum

metals (relative to 10^6 silicon atoms) in one enstatite and four ordinary chondrites are found to lie in the range 0.45-1.47, values which are close to those calculated from some theories of nucleosynthesis and to some neutron activation and spectrographic analytical data. The platinum metals are 5-100 times more abundant in the iron than in the stony meteorites. Fractionation of the platinum metals in parent bodies of meteorites, earth and sun, and reasons for the depletion of osmium and ruthenium in these bodies relative to platinum and palladium, are discussed. An approximate positive correlation has been found between platinum metals content and nickel content. This paper also offers an analytical verification of the theory of Burbidge et al. (1957) regarding the origin of the various nuclides of the platinum metals.

Smith, A. Y., and Dyck, Willy

THE APPLICATION OF RADON METHODS TO GEOCHEMICAL EXPLORATION FOR URANIUM; Bull. Can. Inst. Mining Met., vol. 62, No. 683, p. 215, 1969.

Regional reconnaissance tests of radon and uranium in surface waters were carried out in the Bancroft and Elliot Lake districts during the summer of 1968. At Bancroft, an area of 1,650 square miles was sampled at a density of one sample per two square miles. Both lake and stream waters were sampled. At Elliot Lake an area of 560 square miles was sampled at a density of 1.5 samples per square mile. Only lake waters were collected.

At Bancroft, considering both lake and streamwaters, backgrounds were 1.9 pc/l (picocuries/litre) of Rn-222 and 0.15 ppb (parts per billion) of U. For stream waters only, backgrounds were 4.4 pc/l Rn-222 and 0.16 ppb U, while for lake waters only, backgrounds were 0.96 pc/l Rn-222 and 0.14 ppb U.

At Elliot Lake, where only lake waters were sampled, contamination from mine wastes was an important factor. For all waters, backgrounds were 2.1 pc/l Rn-222 and 0.96 ppb U. If contaminated water samples are excluded, backgrounds become 0.8 pc/l Rn-222 and 0.17 ppb U.

Results are shown in the form of contoured maps which depict regional variations in both radon and uranium. At Bancroft the radon distribution clearly outlines uraniumiferous areas, but at Elliot Lake the results are not as clear. In both areas tests to assess the effects of air and water temperature, barometric pressure, and water pH showed no correlation between these factors and either radon or uranium.

Detailed tests of radon in surface waters were carried out in the Gatineau Hills area north of Ottawa, and at Elliot Lake. In the Gatineau Hills area, seasonal variation, variation with depth of water, distance from shore and distance along the shore from known uranium occurrences, was studied in three lakes. These studies suggest that surface runoff as well as groundwater outflow is responsible for the presence of radon and radium in the lake systems.

Stalker, A. MacS.

A PROBABLE LATE PINEDALE TERMINAL MORaine IN CASTLE RIVER VALLEY, ALBERTA; Bull. Geol. Soc. Am., vol. 80, pp. 2115-2122, 1969.

Radiocarbon dates from the Castle River Valley of southwestern Alberta indicate that the last major glacier advance down that valley reached its maximum extent 6,200 radiocarbon years ago. This advance is considered to be late Pinedale in age. The Pinedale then ended with onset of the "Climatic Optimum" or "Altithermal," which lasted in that region from about 6,000 to 4,500 years B.P.

The dates were obtained on bison bones found in outwash near the base of a 250-ft-high cliff. This cliff, here called Mountain Mill Bluff, lies on the south side of Castle River, 7 miles east of the Rocky Mountains and 6 miles due west of the town of Pincher Creek. The lower part of the outwash extends downvalley from a terminal moraine (Mountain Mill Moraine) of the former Castle Valley Glacier. The bison wandered into a meltwater stream draining from that glacier about 6,200 years ago, drowned, and were buried by outwash accumulating below the moraine. As moraine and outwash were laid down contemporaneously, dates on the bison bones indicate the time of construction of the moraine.

Stalker, A. MacS.

GEOLOGY AND AGE OF THE EARLY MAN SITE AT TABER, ALBERTA; Am. Antiquity, vol. 34, No. 4, 1969.

Human bones, found by the writer's geological field party in 1961, came from a cliff (Woodpecker Island Bluff) on the east side of Oldman River about 3 mi. north of Taber, Alberta. This paper discusses stratigraphy of the bluff and age of the bones, which have been described by Langston and Oschinsky (1963). The bones cannot be dated directly; however, they were found about 60 ft below prairie level, in a sand unit lying beneath a till sheet. As the till was deposited by a Classical Wisconsin ice sheet that spread over the area more than 22,000 years ago, the bones are at least that old. Correlation with other bluffs along Oldman River indicates they are more than 32,000 years, and probably more than 37,000 years old.

Wanless, R.K., Loveridge, W.D., and Stevens, R.D.

AGE DETERMINATIONS AND ISOTOPIC ABUNDANCE MEASUREMENTS, ON LUNAR SAMPLES (APOLLO XI); Geochimica Cosmochimica Acta, 1970, Supp. 1.

Abstract. Three samples of crystalline rock yield K-Ar whole-rock ages of 2,270, 2,875 and 3,370 m.y., while Rb-Sr results are compatible with a 4,600 m.y. reference isochron having an initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratio of 0.6989. The $^{207}\text{Pb}/^{206}\text{Pb}$ age determined for a sample of type D fines is 4,670 m.y. The K/Rb ratios do not differ greatly from those found in

chondritic meteorites and certain types of terrestrial basic rocks. The primordial ^{36}Ar content of two samples of type A crystalline rock are similar to the concentrations found for carbonaceous chondrites.

Isotopic compositions of Li, K, Rb, Sr, U and Th agree with terrestrial and meteoritic values.

Wanless, R.K., Loveridge, W.D., and Stevens, R.D.

AGE DETERMINATIONS AND ISOTOPIC ABUNDANCE MEASUREMENTS ON LUNAR SAMPLES; Science, vol. 167, pp. 479-480, 1970.

Abstract. A K-Ar age of $2,300 \times 10^6$ years has been determined for a sample of type A crystalline rock (57, 34). The presence of an anomalously large quantity of ^{40}Ar , in a sample of type C breccia (65, 35) precluded the calculation of its K-Ar age. Both of the rock types are characterized by low Rb/Sr ratios and consequently low $^{87}\text{Sr}/^{86}\text{Sr}$ values. The U-Th-Pb results for a sample of type D fines (84, 33) yield a $^{207}\text{Pb}/^{206}\text{Pb}$ age of $4,760 \times 10^6$ years, but ages based on U-Pb and Th-Pb ratios are anomalously high. Isotopic compositions of Li, K, Rb, Sr, U, and Th are very close to the accepted values for terrestrial materials.

Wanless, R.K., Stevens, R.D., Loveridge, W.D.

ANOMALOUS PARENT-DAUGHTER ISOTOPIC RELATIONSHIPS IN ROCKS ADJACENT TO THE GRENVILLE FRONT NEAR CHIBOUGAMAU, QUEBEC; Eclogae Geol. Helvetiae, vol. 63/1, 1970.

Anomalously high K-Ar 'ages' have been obtained for biotites from granitic rocks adjacent to the boundary between geologic provinces of the Canadian Shield. This phenomenon is particularly marked in one such area southwest of Chibougamau, Quebec, where the Dauversière Stock outcrops in the Superior Province immediately north of its boundary with the Grenville Province. The stock is roughly circular in configuration having a diameter of approximately 8 miles. Rock samples selected from several localities have yielded concentrates of both biotite and muscovite, thereby providing two mineral indicators within the same rock. In some instances the muscovite K-Ar 'ages' are much lower than those of the associated biotites.

When the results obtained, using both the K-Ar and Rb-Sr methods, are plotted with respect to the distance of the sample sites from the Grenville Front, it is apparent that the anomalies are a function of the proximity to the front. A sample of biotite, containing the greatest quantity of excess radiogenic argon, was selected for special study. The argon was extracted at a series of gradually increasing temperatures in order to ascertain if a portion of the argon could be readily removed thereby leaving a fraction that would provide an indication of the 'true' age of crystallization of the mineral. No evidence of such a component was found; the gas being released regularly as the temperature was increased to the fusion point of the biotite.

The Rb-Sr whole-rock isochron technique has been applied to samples selected from the stock and from the Grenville Province immediately south of the front. The results appear to define a single isochron indicating

an age of $2,610 \pm 170$ m.y. with an initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratio of 0.7011 ± 0.0015 . This evidence is believed to indicate that the rocks on either side of the boundary were formed during the same geological period. Mineral isotopic evidence for those samples now located in the Grenville Province indicates that they were reconstituted during the Grenville orogeny. While the latter event was sufficiently intense to have modified both the $^{40}\text{K}/^{40}\text{Ar}$ and $^{87}\text{Rb}/^{87}\text{Sr}$ isotopic ratios of the constituent minerals, the whole-rock samples appear to have remained as closed systems for Rb and Sr.

In the Superior Province, north of the front, the effects of the Grenville orogeny are strikingly illustrated where the two isotopic systems have responded differentially and anomalously to the thermal gradient, although the lithologic and petrographic character of the rocks has remained unchanged.

Wanless, R.K., Stevens, R.D., and Loveridge, W.D.

EXCESS RADIOGENIC ARGON IN BIOTITES; Earth and Planetary Sci. Letters, vol. 7, pp. 167-168, 1969.

The response of the K-Ar and Rb-Sr isotopic systems to thermal events has been studied for both biotite and muscovite samples. Anomalously high radiogenic argon concentrations have been found in some biotites.