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Current Research

Earth Science Symposium on Offshore Eastern Canada, Ottawa, February 22-24, 1971, Abstracts.

Paper 1. Palaeomagnetism in Eastern Canada; A Key for Reconstructing the Atlantic; E.R. DEUTSCH (Department of Physics, Memorial University of Newfoundland, St. John's):

Palaeomagnetic results meeting minimum stability criteria are available from about 25 major rock units of known age (200 to 2000 m.y.) in the Canadian Appalachian region and Labrador. By their relative proximity to the continental margin such rocks can provide key evidence on plate movements pre-dating the evidence obtainable from present oceanic crust. Three types of palaeomagnetic comparison are examined: (1) between eastern Canada and other North American areas; (2) across the North Atlantic; (3) between parts of eastern Canada. The Triassic, Permian, Carboniferous and some Precambrian data are adequate for type (1) comparisons. Generally, even widely separated contemporaneous North American sites yield similar pole positions, suggesting (i) that the ambient Earth's field was mainly dipolar, and (ii) that North America has not been unduly deformed since the late Palaeozoic. This justifies using combined North American data for type (2) comparisons with Europe which, for post-Carboniferous times, are simultaneously compatible with (i) a Wegener-style separation between these continents and (ii) their joint northward movement representing either continental drift or polar wandering. Tests of "pre-Wegenerian" reconstructions, e.g. Wilson's "proto-Atlantic", involve all three types of comparison and require pre-Carboniferous evidence which is so far inadequate. Systematic palaeomagnetic sampling in the future should lead to conclusive tests, but not only more data but a critical choice of localities is required. For example, unambiguous evidence on rotation of Newfoundland is unobtainable from palaeomagnetic comparisons with New Brunswick, but should be sought by comparing contemporaneous sites in western Newfoundland and in North American outside the Appalachian belt.

Paper 2. The Late Paleozoic and Early Mesozoic Latitude Maps of the Land Masses Adjoining the Present North Atlantic Ocean; J.L. ROY (Geomagnetic Division, Earth Physics Branch, Department of Energy, Mines and Resources, Ottawa):

Paleomagnetic data from eastern North America and western Europe indicate that these regions and their adjacent continental shelves were in low latitudes (<25°) during the late Paleozoic and early Mesozoic. If the Atlantic is closed and the two regions are placed together, the late Paleozoic latitudes agree very well.

Paper 3. Continental Margins: A Review; M.J. KEEN (Department of Geology, Dalhousie University, Halifax), and C.E. KEEN (Atlantic Oceanographic Laboratory, Bedford Institute, Dartmouth):

The world's continental margins can be grouped into three types, the grouping reflecting their origin: (1) rifted, (2) trench, and (3) transform faulted. Each of these groups is associated with its own peculiar rock types, and its own structural and geophysical characteristics. These characteristics must be identified for two reasons. First, so that the nature of ancient continental margins now found on the continents can be properly identified. Second, so that the modifications caused by the very presence of a margin to the motions and deformation of the adjacent plates can be recognized. These modifications are well documented in the case of trench-type margins, but little attention has been paid to the effects arising where an active transform fault is associated with the margin.

Paper 4. The Canadian Atlantic Continental Margin: Paleogeography, Paleoclimatology and Seafloor Spreading; GRANT A. BARTLETT (Department of Geological Sciences, Queen's University, Kingston):

Microfaunas and sediments from thick sequences of Mesozoic and Cenozoic strata on the Atlantic Continental Margin indicate significant changes, and repetition, in ocean circulation, climate and depositional environments. Benthonic faunal communities as well as boreal and tethyan planktonic assemblages reflect these changes. Seafloor spreading is suggested as one of the principal mechanisms contributing to these differences. Present ocean circulation patterns were not apparent until late Miocene time. The most important marine environments were the shallow, warm estuaries, deltaic lagoons and open shelves of the Upper Jurassic, late Upper Cretaceous, Paleocene and lowest Eocene, mid-Eocene and portions of the Middle and Upper Miocene. Sand dunes, stream channels, flood plains and swamps typified the Lower and Middle Cretaceous and portions of the mid-Eocene. Tectonically, the area has undergone periodic, inter-regional oscillations and salt dome intrusions.

Paper 5. Regional Geology of Offshore Eastern Canada; G.H. AUSTIN (Consulting Geologist, Calgary) and R.D. HOWIE (Geological Survey of Canada, Ottawa):

The Continental Shelf of Eastern Canada extends from the Gulf of Maine off Nova Scotia, to the head of Baffin Bay in the Northwest Territories (Lat. 42°N to Lat. 77°N), a distance of approximately 3,500 miles. On the mainland, the Atlantic Provinces, exclusive of Labrador, occupy the northern part of the Appalachian System. This belt of folded and unfolded rocks, were involved in the Middle and Late Ordovician (Taconic) and Middle Devonian (Acadian) orogenies. Middle and Late Paleozoic faulting and folding along the narrow Fundy geosyncline resulted in the deposition of Carboniferous continental and marine sediments in intermontane troughs, followed by flat-lying Late Pennsylvanian and Permian sediments. Triassic sediments occupy an area of renewed faulting in the Bay of Fundy and Chedabucto Bay. The region has been positive since that time. On the Continental Shelf and Slope sediments overlying a granitic or metamorphic basement as calculated from seismic refraction, magnetics and estimates from the total depth of 17 wells are indicated to be greater than 5 km (16,000 feet), on the Scotian Shelf and greater than 6 km (20,000 feet) on the Grand Banks and Newfoundland Banks. Results of drilling show typical Coastal Plain sediment, Jurassic to Tertiary in age, covered by a layer of Quaternary sediments that includes glacial drift. Triassic and Late Paleozoic sediments may be represented in troughs on the inner Shelf. In the northern part of the Gulf of St. Lawrence and on Anticosti Island, nearly flat-lying Early Paleozoic platform rocks dip gently to the south and are at least 12,000 feet thick. In the central and southern part of the Gulf, sediments reach a maximum thickness of 7.6 km (25,000 feet); velocity data and extrapolation from onshore geology suggests the presence of mainly Permo-Carboniferous and possible Triassic sediments. No information has been released on three wells drilled in the Gulf to date. No published refraction data is available for the Bay of Fundy, but large thicknesses of Triassic and Carboniferous sediments are predicted from onshore geology and from seismic profiler results. Seismic refraction profiles display up to five velocity layers which can be roughly correlated throughout the area: Layer 1 (1.8-2.2 km/sec); Layer 2 (2.2-3.4 km/sec); Layer 3 (3.0-4.5 km/sec); Layer 4 (4.3-5.6 km/sec); Layer 5 (5.0-6.3 km/sec). An approximate correlation of the layers is made with Tertiary, Upper Cretaceous, Lower Cretaceous-Jurassic, Permo-Carboniferous and "Basement". The distribution of the deepest refraction layers suggests a fragmentation of the underlying "Basement" in post-Carboniferous time with initial deposition in marginal troughs, followed by the onlap of Coastal Plain sediments. North of the Appalachian System and at right angles to it are the narrow Labrador and Baffin Shelves, presumably underlain by Proterozoic basement rocks ranging in date from Kenoran to Grenville. The total thickness of sediments on the Labrador Shelf, based on magnetics, is in excess of 6 km (20,000 feet), with compressional velocities consistent with the Coastal Plain sediments to the south. On the Baffin Shelf a total thickness of sediments in excess of 9 km (30,000 feet) has been inferred from magnetics. Onshore geology suggests the Shelf may be underlain by Jurassic, Cretaceous and Tertiary sediments. Ordovician rocks are present in down-faulted structures along the coastline. Although oil shows and seepages have been reported in each of the Atlantic Provinces, the only commercial oil and gas production is from the Mississippian Horton Group at the Stony Creek field in New Brunswick. Many of the recent offshore wells contained shows of oil and gas, but no commercial production has been reported by the operators. Petroleum exploration on the Atlantic Continental shelves has stimulated research in the theory of continental drift, which could have a direct bearing on the nature and distribution of sediments and, hence, petroleum along the continental margin.

Paper 6. Offshore Exploration Drilling and Production; W.W. GREENTREE (Shell Canada Limited, Dartmouth):

Many companies have taken out exploration permits off the East Coast of Canada. Seismic surveys have been conducted on many permits and the second phase of activity, exploration drilling, has commenced. A variety of drilling vessels is available to drill offshore, however, few are suitable to conduct year-round drilling operations in this hostile environment. A significant discovery would promote the third phase, offshore production, and the subsequent development of resources. This speech will outline the equipment required to drill and produce offshore wells with emphasis on Shell Canada's current offshore program.

Paper 7. Geodynamics Project; C.L. DRAKE (Dartmouth College, New Hampshire):

No abstract available.

Paper 8. Quaternary Sedimentation in the Bay of Fundy; D.J.P. SWIFT (Old Dominion College, Norfolk, Virginia), B.R. PELLETIER (Atlantic Oceanographic Laboratory, Bedford Institute, Dartmouth), A.K. LYALL (Smithsonian Institution, Washington, D.C.), and J.A. MILLER (Department of Geology, University of Texas, Austin, Texas):

The bulk of Fundy's sediment cover was emplaced under subaerial conditions during the Pleistocene low stands of the sea. Sub-bottom profiles reveal 0-30 m of outwash and till, and up to 100 m of finer sediment. The modern high-energy tidal regime is reworking the Pleistocene deposits and is generating additional sediment by means of coastal erosion. These materials are

being redistributed as the following textural provinces: 1) gravel provinces, thin lags which cover most of the central and southeastern bay; 2) sand provinces, tide-maintained, plano-convex lenses, mainly in the central and eastern portions of the bay; and 3) mud provinces along the northwestern side. This distribution reflects the pattern of tidal currents, with stronger currents on the southeastern side, and a counterclockwise residual circulation. The suspended sediment dispersal system has the following components: 1) an oscillating turbid water mass, with an average turbidity of 6.6 mg/l; 2) bay floor and margin provinces undergoing winnowing, which serve as fine sediment sources; 3) bay floor and margin provinces undergoing fine sediment accretion, which serve as fine sediment reservoirs; 4) minor fresh, turbid water input; and 5) minor salt, turbid water output into the Gulf of Maine. Three different rates of sediment transfer may be detected. Exchange between the mud provinces and the overlying water masses occurs during each semi-diurnal tidal cycle. Some sediment undergoes long-term storage of fine sediment in reservoir provinces, with residence times on the order of several millenia. Ultimately fine sediment either escapes at the mouth of the bay (on the order of magnitude of 1.6×10^6 metric tons per year) or undergoes permanent burial on the bay floor. It appears possible to resolve the system into two sub-systems, the main system of bay floor provinces and associated turbid water masses, and a marginal system of intertidal mud flats and associated water mass. The latter is volumetrically less important, but its rates of sediment transfer are much higher.

Paper 9. Geological Structure Beneath the Bay of Fundy and the Continental Margin from Ocean Tide Loading; C. BEAUMONT (Department of Physics, Dalhousie University, Halifax):

An on-going program of Earth Tide measurements is being conducted in Nova Scotia to determine the feasibility of obtaining crustal and upper mantle structure from ocean tide loading. Measurements have been completed, or are being made at the following sites: Rawdon (tilt) (by A. Lambert); Berwick (gravity) (by A. Lambert); Sambro (tilt); and New Annan (tilt).

A three dimensional axi-symmetric finite element model has been developed giving the local Green's Functions for tilt and surface displacement on a spherical earth. The Green's Functions are convolved with the spatial tidal distribution to determine the amplitudes and phases of the elastic tilt and displacement at the points of observation. Initial results, from Rawdon, indicate lower crustal and upper mantle structure to be in agreement with that expected from seismics for the Bay of Fundy; a Moho at a depth between 35 and 40 kilometres and Vp (upper mantle) $\sim$ 8.1 km/sec, Vs (upper mantle) $\sim$ 4.6 km/sec. Near surface and continental margin structures, however, do not agree with any laterally homogeneous layered model. Laterally inhomogeneous models are being constructed in order to predict the effects of Continental Margin and dipping structures on observations.

Paper 10. Spill-over of Sediment from the Continental Shelf to the Slope and Rise off Nova Scotia; DANIEL J. STANLEY (Division of Sedimentology, Smithsonian Institution, Washington, D.C.), DONALD J.P. SWIFT (Old Dominion College, Norfolk, Virginia), NORMAN SILVERBERG (Department of Oceanography, University of Washington, Seattle, Washington), NOEL P. JAMES (Department of Geological Sciences, McGill University, Montreal), and ROBERT G. SUTTON (Department of Geological Sciences, University of Rochester, Rochester, N.Y.):

The transfer of sediment from the outer continental shelf on the slope, rise and abyssal plain beyond is called spill-over. The movement of sediment off Sable Island Bank on the outer Scotian Shelf from late glacial to recent time has now been well defined as a result of detailed petrographic studies of numerous cores and grab samples collected in this region. Three distinct mappable facies are defined within the upper 1 to 3 m of surficial sediment section; these facies boundaries are too subtle to be detected by seismic studies. Facies changes are based largely on obvious colour and texture differences (but the three lithologic units contain similar light-, heavy- and clay-mineral suites). Colour and textural changes are attributed to the two events that most affected the continental margin during this period: glaciation and eustatic sea level oscillations. The lower terrigenous unit (below 200 cm in slope cores) accumulated at a time preceding, then coinciding, with the Wisconsin low stand of the sea. During this phase, glacial drift, including brown fluvio-glacial sediments, was deposited across the Nova Scotian Shelf as far as Sable Island Bank. Periglacial outwash spread across the Bank and flowed seaward around it (the coastline then occupied a position near the present 120 m isobath). Deposition of brown to brick-red irregularly stratified pebbly-sandy-clayey silt facies on the slope and rise is associated with this period; textural inhomogeneity suggests rapid large volume downslope transport by various mass processes (sedimentation rate to 15 cm/1000 years). Pebbly lenses also resulted from ice-rafting prevalent during this phase. The contact between this brown and an overlying olive gray facies (largely clayey silt with a low sand and pebble content) is often abrupt, at times occurring within several centimetres; this distinct change signals the rise of the late Quaternary sea above the margin of the outer banks. As the sea began to transgress across Sable Island Bank, fines winnowed from fluvio-glacial sediment were moved into the large east-west trending depression (Gully Trough) north of the Bank and seaward onto the slope. Coarse materials no longer reached the slope with former frequency, and fines also were deposited at a markedly lower rate (approximately 7 cm/1000 years on the slope; 4 cm/1000 years on the rise). The organic component of sediment accumulating on the slope increased, and suspended fines were reduced to a gray hue as they passed through the sediment-

water interface. On the lower rise, a pale yellowish-brown mud with a coarse fraction rich in foraminifera and shell debris may be the equivalent of the olive gray facies on the slope. The Pleistocene-Holocene boundary occurs within this olive gray facies. As sea level attained its near-present position and the present configuration of bottom currents was established, texturally modified relict (or palimpsest) sands began a pattern of movement that may now be observed on Sable Island and associated banks. This bottom current activity has resulted in the spill-over of lag sands off the banks and deposition of thin discontinuous layers (including some turbidities) on the slope and rise and in The Gully Canyon. These thin layers of relatively clean to muddy gray sand that locally cover brown and olive gray sediments constitute the third and youngest facies.

Paper 11. Geology of the Scotian Shelf and Adjacent Areas; LEWIS H. KING and BRIAN MacLEAN (Atlantic Oceanographic Laboratory, Bedford Institute, Dartmouth):

The geology of the Scotian Shelf and adjacent areas is interpreted on the basis of structural and stratigraphic relationships and acoustical reflectivity as revealed by a study of continuous seismic-reflection profiles, bedrock control from adjacent shore geology and a few dredged samples, and gravity, magnetic, and seismic refraction data. The geology of the offshore falls into four major divisions: (1) A Triassic Basin which occurs in the Bay of Fundy and northern Gulf of Maine. The Bay of Fundy section is essentially a half-graben with the Scots Bay Formation overlying the North Mountain Basalt and older Triassic formations, whereas the Gulf of Maine section is a synclinal basin with greater exposure of the interbedded basalt; (2) An area of acoustical basement and sedimentary outliers which underlie the eastern and central part of the Gulf of Maine. The Meguma Group and White Rock Formation extend southwest of Yarmouth and the acoustical basement farther west consists of undifferentiated pre-Pennsylvanian rocks; (3) A Coastal Plain Province of Tertiary and Cretaceous strata which underlies Georges Bank, the Scotian Shelf, and the outer part of the Laurentian Channel. South of Nova Scotia these rocks have a gentle dip seaward and lap on the Meguma Group and Devonian intrusives of the Appalachian Province approximately 50 km offshore. At the northeast end of the Scotian Shelf mildly-folded Cretaceous and undifferentiated Pennsylvanian-Triassic rocks occur north of the subsurface seaward extension of the Cobequid-Chedabucto fault system; (4) An area of pre-Pennsylvanian acoustical basement and Pennsylvanian strata which extends south and east of Cape Breton Island beneath the Laurentian Channel.

Paper 12. Salt Structures East of Nova Scotia; G.W. WEBB (Department of Geology, University of Massachusetts, Amherst):

Several new continuous seismic reflection profiles across the Laurentian Channel and eastern parts of the Scotian Shelf further clarify the fold and fault structures in the area. A number of folds or domes, two of them diapiric, are recognized in the shelf north and east of Sable Island. Some of the bathymetric irregularities there appear to be fault controlled, and graben structures suggest the presence of deep uplifts not otherwise delineated, supporting the hypothesis of an extensive area of salt domes in the vicinity of Sable Island and Banquereau. Farther northeast, the Orpheus gravity anomaly folds, described by King and MacLean, seem divisible into at least two groups. Within the Laurentian Channel the most prominent folds occur to the northeast of the Chedabucto fault, with those closest to it apparently trending almost east-west, parallel to the fault, and those farther north apparently trending nearly north-south. The folds may be due primarily to salt flowage rather than to deep-seated compression. The north side of the Scatari Ridge appears to be defined by the Bateston-Mira Bay fault which extends eastward from Cape Breton Island and is tentatively traced across the Laurentian Channel into Saint Pierre Bank. Mild structures of uncertain trends occur east of Sydney and near Burgeo Bank. Several fold or dome structures were traversed in the slope and rise areas and in the southern Grand Bank, southeastward from the Laurentian Channel. In one, the Tors Cove structure, salt of probable Mesozoic age is known to be diapiric. Thus salt structures are believed to occur very widely in the offshore to the east of Nova Scotia.

Paper 13. Nova Scotia, Morocco, and Continental Drift; P.E. SCHENK (Department of Geology, Dalhousie University, Halifax):

Field work in the Atlantic Provinces and Morocco should test the hypothesis of a Late Precambrian through Early Paleozoic Ocean between North America and Africa. The argument is: (1) Late Precambrian redbeds and volcanics of both northwest Africa and southeast Atlantic Canada are graben-fills, recording a rift system along the sutured Africa-North America continent; (2) Eocambrian rupture led to an accreting plate margin (now southeast of the Maritimes and a coupled continental shelf (thick carbonate Adoudounien Series of the AntiAtlas) and rise (part Eocambrian of the Atlas Mountains, part Meguma Group of Nova Scotia); (3) Subaerial redbed deposition may have continued on the western land-mass until late Early Cambrian with shallow flooding of parts of the eastern margin in Early Cambrian time. In the Middle Cambrian the accreting margin relocated northwestward (to now central New Brunswick) and the intervening sialic blocks (southern New Brunswick, northern Nova Scotia and Cape Breton, and southeastern Newfoundland) accompanies Africa eastward. The sialic blocks were submerged away from the oceanic ridge, and buried beneath the prograding continental rise (Meguma-Charlotte-

Gander Lake groups); (4) Middle Ordovician plate consumption along the marginal trenches set North America and Africa on a collision course. The southeastern trench and volcanic arc lay immediately northwest of the sialic slivers. Perhaps the present Japan Trench - Sea of Japan with Yamato Bank is analogous; (5) Continental collision in the Late Silurian (Newfoundland) and late Early Devonian (elsewhere) folded, thrusted, and granitized the rise-volcanic silicic block complex and injected both ultra-basic and Middle Devonian granitic plutons in Morocco and Atlantic Canada. Middle Devonian through Permo-Triassic redbed-volcanic-restricted marine/salt flat deposition along the intercontinental weld herald initiation of the present North Atlantic, and mimics the Late Precambrian stage; (6) In the Atlantic Provinces, Late Permian or Triassic rupture along the old Eocambrian lineament established an accreting plate margin which shifted in the Cenozoic from between Greenland and Labrador to its present location in the Mid-Atlantic.

Paper 14. Marine Seismic Profiles; W.H. ELIAS (Catalina Exploration and Development Ltd., Calgary):

No abstract available.

Paper 15. Results of an Underwater Gravity Survey over the Nova Scotia Continental Shelf; A.K. GOODACRE, L.E. STEPHENS and R.V. COOPER (Gravity Division, Earth Physics, Branch, Department of Energy, Mines and Resources, Ottawa):

During the summer of 1970, 692 underwater gravity stations were established on the Atlantic continental shelf of Canada. The areas surveyed include the Laurentian Channel, Cabot Strait, and parts of St. Pierre Bank and the Scotian Shelf. Stations were located on a seven-mile grid and additional profiles were run across the Orpheus anomaly and across a diapiric structure northeast of Sable Island. During all three cruises of the CNAV SACKVILLE, Decca Lambda and radar were used as primary navigation aids but tests were also made to compare the accuracy of differential Omega and a Magnavox satellite navigator. The gravity data are presented as a Bouguer anomaly map which indicates significant structures and trends. The Bouguer anomaly values generally become higher towards the continental margin and strike in an easterly direction across the continental shelf. The linear Orpheus anomaly extends 250 km eastwards from Chedabucto Bay and is flanked to both north and south by positive anomalies. Both flanking anomalies appear to be related to Proterozoic metavolcanic rocks with interspersed Devonian basic intrusions. A broad negative anomaly is probably underlain by a Devonian granite batholith. Similar negative gravity anomalies occur over batholiths in the interior of Nova Scotia. Between the Miquelon Islands and Cape Breton Island, a broad arcuate positive anomaly coincides with a Carboniferous basin which was delineated by seismic surveys. This high is attributed to dense, shallow structures within the pre-Carboniferous basement. The Laurentian Trough is a major structural feature which displaces and distorts the dominant easterly trends of several linear anomalies including the Orpheus anomaly.

Paper 16. The Sable Island Deep Test of the Scotian Shelf; D.H. MAGNUSSON (Mobil Oil Canada Ltd., Calgary):

Mobil Oil Sable Island No. 1 was drilled to a total depth of 15,106 feet on the Scotian Shelf of the Canadian Atlantic offshore. As such it constituted the first deep test in the region. The well was drilled 190 miles (306 km) east of Halifax, Nova Scotia, on the outer shelf utilizing Sable Island as a drilling platform. The regional geological setting in which the well was drilled is considered in terms of Pre-Carboniferous Basement, Permo-Carboniferous, Early Mesozoic and, Cretaceous and Tertiary. The exploratory test bottomed in the Lower Cretaceous, hence further documenting the extension of the submerged Atlantic Coastal Plain south of Nova Scotia. The stratigraphy of the well section is described. It consists predominantly of marine, clastic strata composed of 4050 feet of Tertiary and Quaternary, and 11,056 feet of Cretaceous aged strata of which upwards of 6000 feet can tentatively be assigned to the Lower Cretaceous. These sequences can be subdivided into a total of 11 units based on gross sandstone abundance, paleontological data, as well as additional lithologic criteria. The succession of these units indicates the presence in this part of the Scotian Shelf of fluctuating mainly marine conditions of Cretaceous and Tertiary deposition in very shallow to bathyal water depths. Encouraging showings of gas were tested in several zones as well as a trace of oil on a test near the bottom of the hole. Source rock analyses as well as lithologic criteria suggest the former presence of environmental conditions conducive to the generation of oil and gas. Porous sandstones were encountered throughout much of the succession. Unpublished seismic and other data suggest the possibility of structural features in the region such as those related to salt tectonism and contemporaneous faulting. Stratigraphic entrapment conditions for oil and gas are likely present as well.

Paper 17. Tertiary and Late Mesozoic History of the Shelf Regions of the Eastern Canadian Continental Margin; L. SMITH (Department of Geological Sciences, Queen's University, Kingston):

The Amoco wells in the Grand Banks and the Mobil well below Sable Island in the eastern Scotian Shelf gave the first thick stratigraphic sections for the shelf region northeast of Long Island. Integrated analysis and stratigraphic synthesis of lithic and faunal data showed a minimum of seven unconformity - bounded sequences present. These are Pleistocene, Middle and Late Miocene, Intra-Eocene, Paleocene and earliest Eocene, Late Cretaceous, Middle Cretaceous and

Neocomian in age. Additional units of Middle (?) and Upper Jurassic age and probable Upper Triassic (Keuper) age are also present. The rocks include halite and anhydrite of probable Upper Triassic (Keuper) age, limestones in the Upper Jurassic, Middle Cretaceous, lower Upper Cretaceous, mid-Eocene and mid-Miocene, and sandstones which dominate the Neocomian, Upper Eocene and Middle Miocene successions. Variable proportions of siltstones, silty mudstones and claystones occur almost throughout. Depositional environments ranged from subaerial, for quartz arenites, through very low-land, for stream and swamp deposits, to lagoonal, bank and open-shelf warm-marine environments, in which fine sand to clay-size terrigenous sediments were deposited, or, in their absence, either skeletal carbonates or lime muds. Several salt domes occur in the shelf, one penetrated by the Tors Cove well, another very near Sable Island. Others have been reported. Periodic interregional tectonic oscillations produced the erosional and depositional episodes of the major baselevel transit cycles. Their result is the present sedimentary wedge, thickening by differential preservation toward the continent's edge, and representing one-half or less of upper Mesozoic and Cenozoic time.

Paper 18. Bedrock and Surficial Geology of the Northern Gulf of St. Lawrence as Interpreted from Continuous Seismic Reflection Profiles; J.M. SHEARER (Geological Survey of Canada, Ottawa):

In the fall of 1969, the author ran some airgun reflection profiles (≈ 1000 N.mi.) in the northern Gulf of St. Lawrence in conjunction with a refraction seismic program carried out by the Geophysics Division of the Geological Survey of Canada. Although penetration was very small in many of the rock types encountered, definite characteristics existed which enabled their tentative identification. In this respect, the northern Gulf seems to be underlain chiefly by bedded lower and middle (Cambrian to Silurian) Paleozoic rocks. Very gently east-dipping sediments occur over most of the area to a line about 5 miles off the west coast of Newfoundland, where a pronounced syncline exists. The east flank of this syncline is composed of quite steep west-dipping beds. The west Newfoundland "klippe" sequence extends barely beyond the present coastline (max. 5 miles) and is overlain by these steeply dipping beds. The Paleozoic section (autochthonous) just west of the Port au Port peninsula is probably close to 10,000 feet thick, with the Silurian making up 6000 feet of this. A gradual decrease in section thickness, as one moves northward, occurs. Acadian orogenic activity along the southern portion of the west Newfoundland coast is thought to be responsible for the synclinal folding of these platform sediments. The Esquiman Channel is apparently unrelated to any bedrock geological feature, with easterly-dipping beds of the lower Paleozoic sequence running right across it. The North Channel, just south of the Quebec-Labrador coast, is considered of glacial origin as is the Esquiman Channel, but, nevertheless seems to contain the contact between the Paleozoic (Cambrian) rocks and the shield rocks. Among a number of glacial and post-glacial features, of particular interest is an end moraine system located off the west coast of Newfoundland. A distinct contrast in the morphology of the glacial deposit exists at a depth around 350 feet. The best interpretation, so far, is to propose that the modified surface of this feature which is located at depths less than 350 feet is due to reworking by wave action associated with a lower sea level. This level being very close to that of the Wisconsin eustatic minimum implies a thin ice cover and an ice front very close to this zone. As well, because of the different nature of deglaciation along the west coast of Newfoundland, crustal warping in the order of 20 feet per mile is also implied.

Paper 19. Marine Geology of the Gulf of St. Lawrence 1. Bedrock Geology, 2. Glacial and Post-glacial Geology; D.H. LORING (Fisheries Research Board of Canada, Bedford Institute, Dartmouth):

The Gulf of St. Lawrence is an inland sea of triangular shape which occupies an area of approximately 96,000 square miles. It has an irregular submarine topography composed of long trough-shaped valleys and shallow platforms or shelves of varying widths and relief. Acoustical and sampling data (continuous seismic profiles, echograms, oblique sonargrams, underwater photographs, bottom and core samples) indicate that the major geomorphological features are not related to the present environmental conditions. Instead, the submarine troughs, and the adjacent shelves are pre-glacial erosional features developed in bedrock of differing structures (folded, unfolded, faulted) origins (sedimentary, metamorphic, and locally igneous) and ages (Pre-Cambrian-Permian). The valleys have been modified into their present form by glacial erosion (strongly controlled by the pre-glacial topography) and deposition during the Pleistocene Epoch, post-glacial rises in sea level, and recent marine sedimentation. The adjacent shelves are bedrock elevations on which the pre-glacial topography has a nearly continuous cover of glacial and post-glacial sediments. These sediments, like those in the troughs reflect the pattern of Pleistocene glaciations (continental as well as local), post-glacial rises in sea level (reworking of glacial deposits), and the present depositional conditions (resorting, redistribution, deposition) in the area.

Paper 20. Sedimentary Seismic Surveys, Gulf of St. Lawrence; GEORGE D. HOBSON and A. OVERTON (Geological Survey of Canada, Ottawa):

The Geological Survey of Canada has conducted seismic refraction surveys in the Gulf of St. Lawrence over a five-year period beginning in 1964. The two-ship method was used, one acting as the recording vessel moving along the profile, and the other as the shooting platform remaining

fixed for each profile. The objectives were to investigate the thickness, nature and attitude of the sedimentary rocks underlying the Gulf. The data are presented as a "basement" contoured map and in the form of several cross sections. Depths as great as 25,000 feet to the crystalline complex have been computed west of the Magdalen Islands.

Paper 21. Gravity Measurements in the Gulf of St. Lawrence; R.T. HAWORTH, A.B. WATTS (Atlantic Oceanographic Laboratory, Bedford Institute, Dartmouth) and A.K. GOODACRE (Gravity Division, Earth Physics Branch, Department of Energy, Mines and Resources, Ottawa):

Gravity, magnetic and bathymetry data have been collected in the Gulf of St. Lawrence by the Atlantic Oceanographic Laboratory of the Marine Sciences Branch, and the Gravity Division of the Earth Physics Branch of the Department of Energy, Mines and Resources. The Eastern Gulf of St. Lawrence has been covered with an average line spacing of approximately two miles. A quantitative interpretation has been made of the most prominent gravity anomalies. The validity of the interpretation is examined in light of the density and accuracy of the measurements used.

Paper 22. Magnetic Surveys of the Gulf of St. Lawrence and the Scotian Shelf; P.H. McGRATH and PETER HOOD (Geological Survey of Canada, Ottawa):

Aeromagnetic surveys have been flown in the southern half of the Gulf of St. Lawrence as far north as 48° N. There are several large wavelength anomalies in the central part of the Gulf which have been interpreted using a curve-matching computer technique. Depths to magnetic basement in excess of 14,000 feet were obtained west of the Magdalen Islands. These interpretations have been supported by measurements of the magnetic properties of rocks collected from the land masses surrounding the Gulf of St. Lawrence. Sea magnetometer and aeromagnetic surveys of the major portion of the continental shelf southeast of Nova Scotia were carried out during the last decade. Close to the shoreline the Meguma Group of slates and quartzites produces a characteristic pattern of sharp linear magnetic contours which parallel the coastline. Several circular granitic intrusions are apparent due to their low intensity of magnetization and the fact that they tend to have magnetic aureoles around their peripheries. Further to the southeast the amplitude of the magnetic anomalies decreases and their wavelength increases because of greater depth to the crystalline basement, i.e. thickness of sedimentary rock. Depth-to-crystalline basement have been carried out on most of the significant anomalies on the Scotian Shelf and it would appear that the greatest thickness of sediments occurs in the vicinity of Sable Island.

Paper 23. Magnetic and Telluric Measurements in Atlantic Canada; S.P. SRIVASTAVA (Atlantic Oceanographic Laboratory, Bedford Institute, Dartmouth), R.D. HYNDMAN and N. COCHRANE, (Department of Physics, Dalhousie University, Halifax):

The paper summarizes the magnetic and telluric measurements made in Atlantic Canada. These measurements were made to study the differences in the geological structures at various places on the Atlantic coast of Canada and to study the influence of the induced currents in the sea adjacent to these stations. The measurements across the coast show a pronounced coast effect except at Sable Island which unexpectedly shows strong attenuation of the vertical magnetic component. Measurements around the Gulf of St. Lawrence indicate strong electric currents induced in the water at high frequencies but little effect is observed at low frequencies (1 cpd). An effect apparently due to the geological contrast between Appalachian and Canadian Shield is observed on the north shore of lower St. Lawrence River. Telluric measurements on the continental shelf, Sable Island and on the coast show strong tidal induced electric currents.

Paper 24. Hudson Geotraverse; B.D. LONCAREVIC (Atlantic Oceanographic Laboratory, Bedford Institute, Dartmouth):

New emphasis in oceanographic research is towards a systematic study of selected areas. Several recent developments have made it possible to carry out detailed surveys in distant offshore areas: i) Improved means of ship positioning; ii) Use of larger, specially designed ships of greater endurance; iii) Development of automatic data acquisition techniques suitable for systematic surveys; iv) International co-operation and quick exchange of data. HUDSON GEOTRAVERSE is a co-operative project organized by a group from the Bedford Institute to study a one-degree wide strip of the Atlantic Ocean between the latitudes of 45° and 46° N and longitudes 18° to 60° W. The 380,000 sq. km area (one and a half times the area of Great Britain) stretches from Cape Breton, N.S. across the Grand Banks of Newfoundland to the eastern flank of the Mid-Atlantic Ridge. This Geotraverse crosses most of the major oceanic provinces recognized so far and spans the North American plate from the continent to its edge at the ridge crest.

Paper 25. Geological and Geophysical Results Bearing upon the Structural History of the Flemish Cap Region; A.C. GRANT (Atlantic Oceanographic Institute, Bedford Institute, Dartmouth):

Flemish Cap is a continental structure, physiographically isolated from the Grand Banks by Flemish Pass. Seismic profiler results show that the top of Flemish Cap is a smooth, erosional surface, cut on a central zone of seismically "hard" basement and an annular zone of outward-

dipping layered media. These layered media are also truncated on the flanks of Flemish Cap. Geological sample evidence suggests that the central basement zone of Flemish Cap may be an eroded complex of metamorphosed and intruded continental rocks, possibly equivalent in age to bedrock on the Avalon Peninsula of Newfoundland. Flemish Pass, to the west of Flemish Cap, is underlain by a thick accumulation of sediments, which is at least in part a continuation of prograding beds that underlie the slope off the eastern Grand Banks. The structural history of Flemish Cap has apparently been very different from that of the Grand Banks immediately to the west, where a thick accumulation of sediments reflects extensive subsidence of the basement.

Paper 26. Structural Implications of Gravity and Magnetic Anomalies over Eastern Notre Dame Bay, Newfoundland; H.G. MILLER[1] and E.R. DEUTSCH (Department of Physics, Memorial University of Newfoundland, St. John's):

A gravity survey covering 2500 km^2 at 2.5 km spacing was conducted on islands and the coast of Notre Dame Bay near the eastern boundary of the Paleozoic Mobile Belt of Newfoundland. The Bouguer anomaly field shows good correlation with dominant features of the surface geology: (1) a strong northeasterly structural trend; (2) the Luke's Arm fault; (3) several extensive granitic bodies; however, no significant anomalies were observed over sedimentary areas. Preliminary qualitative interpretation of the published total-intensity aeromagnetic maps indicates some overall correlation with gravity and surface geology. A satisfactory fit to the Bouguer field was obtained from three-dimensional model studies, dividing the area by geological criteria into 13 blocks, each with a mean density derived from rock samples. The model results lead us to propose two new features: (1) A structural discontinuity near Change Islands, suggested also on the aeromagnetic maps, separating the eastern (Fogo-Change Islands) and western parts of the survey area. (2) A basic to ultrabasic layer at 5-10 km depth to explain the overall positive character of the Bouguer anomalies. This layer appears to be a landward continuation of the intermediate layer of Sheridan and Drake (1968).

[1]Now at Geophysics Department, University of British Columbia.

Paper 27. Orphan Knoll: A "Chip" off the North American "Plate"; ALAN RUFFMAN (Atlantic Oceanographic Laboratory, Bedford Institute, Dartmouth) and JAN VAN HINTE (Imperial Oil Enterprises Ltd., Calgary):

Orphan Knoll (50°30'N, 46°30'W) is about 100 Km in diameter, its relatively flat upper surface lies at 1800 m depth and its base is surrounded by waters 2800 and 4200 m deep. The seamount was drilled in late June, 1970 by the drilling vessel GLOMAR CHALLENGER of the JOIDES Deep Sea Drilling Project (site 111, 50°25.27'N, 46°22.05'W). This paper presents the results of the drilling, the findings of the scientific team, and a geophysical interpretation of the Knoll. Orphan Knoll appears to be a continental remnant abandoned in the early stages of continental rifting and seafloor spreading. It has sunk vertically about 2100 m while the seafloor to the south and west may have sunk about 3500 m. The sedimentary succession sampled on the Knoll's upper section can be divided into four main divisions in contrast to the surrounding seafloor that is buried in a thick sequence of continentally derived turbidities. Down to 146 m below the seabed the sediments consist of glacial clays and deepsea foraminiferal oozes of Late Miocene to Pleistocene age. The onset of glaciation is tentatively put in the Mid Pliocene at 3 million years ago. The presence of rich sub-tropical microfauna and flora in the Lower Pliocene and Upper Miocene sediments below (3-9 million years ago) suggests that a branch of the Gulf Stream flowed over Orphan Knoll prior to the onset of glaciation. This was a period of extremely low sedimentation rates. The Miocene sediments rest disconformably on a thin glauconite-phosphorite(?) pavement at 147 m which overlies Eocene sediments that continue down to a subbottom depth of 180 m. The Eocene sequence is deep sea, has a very low sedimentation rate and may encompass two small disconformities. The Eocene disconformably overlies Maastrichtian chalks which were deposited in the outer neritic to upper bathyal zone (200-500 m depth). The Maastrichtian chalks rest disconformably on a manganese (?) pavement and an apparent limestone hardground at 190 m. The shallow water, glauconite rich, carbonate sands and shelly limestones, Cenomanian and Albian in age, continue down to 248 m. At this depth the drill crossed an angular unconformity, probably an erosion surface, and drilled two metres into a tectonically deformed coarse dark sandstone containing anthracite fragments. The lithic sandstone is non-marine and has been dated as Bajocian (early Middle Jurassic) with reworked Mississippian spores and Palaeozoic (?) Echinoid relicts. The dark sandstone is underlain by an unsampled jagged basement and the top surface of the Knoll is marked by a diapir-like dyke swarm or series of salt ridges. Considerable geophysical and bathymetric data has been assembled over the Knoll to compliment the drilling. The relationship of Orphan Knoll to a reconstruction of the pre-drift configuration of Europe and North America is discussed.

Paper 28. Surficial Geology of Labrador and Baffin Island Shelves; N.J. McMILLAN (Tenneco Oil and Minerals Ltd., Calgary):

The shelves of Labrador and Baffin Island are smooth plains in contrast to the rugged, glaciated and fiord-indented land to the west. These shelves are mainly underlain by sedimentary rocks that have also been glaciated. The abrupt boundary between Precambrian rocks and shelf

sediments occurs at tectonic hinge lines which are marked by "marginal channels" described by Holtedahl. Eastward moving continental glaciers, underloaded with debris, became loaded with available erodable sediments at the trace of the tectonic hinge line thus causing the channels. Hundreds of bottom samples from Baffin Bay and Labrador Sea have been described since 1900. The extent of the sedimentary component of these grab samples and gravity cores seems to coincide with the presence of sedimentary bedrock. The idea that icebergs dropped all of the material seems unlikely because sedimentary debris has not been found in previously flooded land areas and because the sedimentary component is absent in certain areas where icebergs are abundant. Furthermore, if all of the icebergs deposited all of their debris on the Labrador Shelf, only a few inches of sediment would be added to it in the last 10,000 years. It is tentatively concluded that the sedimentary component of bottom samples is part of the ground moraine which has moved only a few miles from its origin elsewhere on the shelf. Analysis of alleged ground moraine tends to show that in the south part of the Labrador Shelf at 53°N the bedrock is Tertiary. Progressively northward the rocks are older. At 58°N it seems only Lower Cretaceous rocks are present.

Paper 29. Lateral and Vertical Variations in Sediment Characteristics within Baffin Bay; S.R. BAKER and G.M. FRIEDMAN (Department of Geology, Rensselaer Polytechnic Institute, Troy,N.Y.):

Analysis of cores and grab samples from Baffin Bay indicates that sediment texture reflects the local bottom topography and the random distribution of sediments by ice-rafting. The shelf sediments are composed primarily of sands and gravels intermixed with various amounts of mud. Large depressions on the shelf contain finer sediments similar to those found in the deeper bathyal basin. The sediment currently being deposited in many areas of the bay is not representative of the underlying sediments. Many cores exhibit alternating intervals of coarse and fine sediments of varying thickness. However, below the shelf break there is a general trend of decreased gravel and sand accompanied by increased clay content from depth to surface. Sediment colour indicates a marked shift in oxidizing conditions from the northern portions of the bay southward. In the shallower regions, the oxidation is probably related to decreased organic material and slow rates of sedimentation, while in the deeper areas it is probably related to the long column of water through which the sediment settles. Bottom currents are discounted as important oxidation agents because the presence of significant percentages of fine material at almost every sampling locality indicates very slow current velocities at best. Sandy layers which occur in the deeper areas of the bay probably were formed by localized downslope movements of sediment rather than by the winnowing action of bottom currents. Bottom topography on the west Greenland shelf suggests relict features, such as ancient stream valleys, established during times of decreased water depth associated with past glacial episodes. Further evidence for some of these features is provided by the sediment distribution obtained in this study.

Paper 30. Distribution Patterns of Benthonic and Planktonic Foraminifera in Baffin Bay; M.R. GREGORY and C. STEHMAN (Department of Geology, Dalhousie University, Halifax):

Globigerina pachyderma (Ehrenberg) dominates the planktonic foraminiferal fauna of the northern Labrador Sea, Davis Strait and Baffin Bay. Other species are rare. Abundance of planktonic foraminifera, in surface tows, varied greatly from station to station. To some extent, this variation can be related to physical oceanographic data. *G. pachyderma* displays geographic form variations that can be related to latitudinal change and oceanographic provinces. This form variation may be potentially useful in paleo-oceanographic studies. However, in a number of instances, it was difficult to recognize any direct correlation between data obtained from surface tow stations and data obtained from bottom samples below those stations. Over 100 species of benthonic foraminifera have been identified in grab samples and the topmost 2 cm of cores collected from northern Labrador Sea, Davis Strait and Baffin Bay. Apart from some shallow water stations near Disko Island and also some stations near Pond Inlet and Lancaster Sound, abundance of benthonic foraminifera was low. Even so, species diversity, especially in Baffin Bay is somewhat greater than earlier studies would suggest. The fauna is closely comparable to other faunas widely reported from arctic and subarctic regions. Distribution patterns of dominant and/or persistent species are irregular. Evidence available to date suggests transportation and mixing of faunas. Except that *Eggerella advena* seldom occurs in depths greater than 200 metres there is little conclusive evidence of depth zonation. Large arenaceous foraminifera (*Astrorhiza* cf *arenaria*, *Hyperammina subnodosa* and *Rhabdammina abyssorum*), conspicuous in abyssal depths of the northern Labrador Sea, are surprisingly poorly represented in the deeper stations of Baffin Bay.

Paper 31: Bathymetric Observations along the East Coast of Baffin Island; O.H. LØKEN (Inland Waters Branch, Department of Energy, Mines & Resources, Ottawa):

The paper presents results from surveys of the continental shelf and slope along the coast from Cape Adair to Broughton Island. The new topographic maps of the coastal area were used, thus providing accurate positioning. The results substantially modify bathymetry shown in recent publications and a large amount of details has been added. The main bathymetric features are described and their genesis is discussed. The bathymetry has important implications for the movement of icebergs in the area and this problem is discussed at the end of the paper.

Paper 32. The Geological Setting of the West Greenland Basin in the Baffin Bay Region; G. HENDERSON (Geological Survey of Greenland, Copenhagen):

The sediments and lavas of Cretaceous-Tertiary age exposed onshore in the peninsulas and islands of central West Greenland form only part of a more extensive sediment/lava pile that is largely concealed beneath the waters of Baffin Bay, the Davis Strait and the Labrador Sea. Non-marine sediments of probable Paleocene age overlain by Tertiary lavas in the Cape Dyer area are onshore remnants of this sequence on the opposite side of the Davis Strait. The thick sediments of probable Late Jurassic/Early Cretaceous to Tertiary age underlying the Labrador shelf can be regarded as an offshore continuation of the sedimentary area to the south. The Jurassic age determined for a prominent coast-parallel dike swarm in southern West Greenland shows that movements associated with the separation of Greenland and Canada were already taking place at this time. The well exposed and deeply dissected rocks preserved onshore in West Greenland between Svartenhuk peninsula in the north and Grønne Ejland in the south are considered to be of prime importance for the interpretation of the offshore area. Marine sediments whose base is not exposed are present in northern Nugssuaq; their exposed thickness is about 1500 m, but the true thickness is more and may reach 2000 m. Non-marine sediments in the southern part of the onshore area reach about 1500 m. Recent geophysical work in the outer part of Nugssuaq has proved the presence of some 2200 m of sediments below surface. The sediments are overlain by Tertiary basalts, which are up to 8 km thick in the western part of the onshore area. The basin is fault-bounded and evidence shows that there was more than one period of movement along the faults. One major fault system in the Nugssuaq peninsula is en echelon. Recently compiled maps of Nugssuaq and other parts of the onshore area are considered in the light of marine geophysical work undertaken by Canadian institutes. This work has shown the probable limit of the basalts in the offshore area and has proved the presence beyond the basalts of sediments that may be a continuation of those exposed onshore. The great thickness of basalts in the western part of the onshore area is clearly a local phenomenon whose origin may be attributable to concentration of eruptions along major faults.

Paper 33. Magnetic Properties of Rock Samples from the Baffin Bay Coast; L.G. KRISTJANSSON and E.R. DEUTSCH (Department of Physics, Memorial University of Newfoundland, St. John's):

Various magnetic properties of about 200 Tertiary basalt samples have been measured. The main collections are from (1) three traverses representing at least 30 lava flows on southern Disko Island, western Greenland, and (2) one traverse (six flows) near Cape Dyer, Baffin Island. In both areas, the natural remanence (NRM) of some of the samples is dominated by relatively unstable components having opposite polarity to that of the majority of samples, whose NRM was stable and was either reversed (Disko) or normal (Cape Dyer) relative to the present Earth's field. Various magnetic properties of about 40 other samples, mainly Precambrian gneiss, from western Greenland and Baffin Island have also been measured. In this initial paper, the results will be discussed with particular reference to the interpretation of local magnetic anomalies.

Paper 34. Magnetic Basement Mapping in the Sedimentary Basins of Nugssuaq, West Greenland; P. VALLABH SHARMA (Institute of Geology, University of Copenhagen, Denmark):

Magnetic and gravity ground surveys were made in the Cretaceous-Tertiary sedimentary basins of Nugssuaq in West Greenland in the summer of 1969 as part of the Geological Survey of Greenland (G.G.U.) field campaign to study the thickness of sediments and the configuration of the basement in that area and to assess its potentiality as to oil and gas prospects. Tedious operational and computational problems were involved in the reduction and correction of the observed field data owing mainly to the rugged and undulating topography, disturbing effects of basaltic masses and to the frequent occurrence of magnetic storms in the surveyed arctic area. This paper presents the maps of the observed magnetic and gravity anomalies in the area together with the magnetometrically determined boundaries of the basalt flanks underlying the Quaternary cover. Based on model calculations, possible interpretation of the maps in terms of depth and configuration of the basement features is presented. In the light of available geophysical and geological information, the overall potentiality of the area in terms of oil prospecting is discussed.

Paper 35. Low-level Aeromagnetic Surveys of the Continental Shelves Bordering Baffin Bay and the Labrador Sea; PETER HOOD and MARGARET E. BOWER (Geological Survey of Canada, Ottawa):

Since 1962, the Geological Survey of Canada and the National Aeronautical Establishment have co-operated in joint low-level aeromagnetic surveys of the continental shelves and deep-ocean basins adjacent to Canada. Reconnaissance aeromagnetic profiles at about 60 mile intervals have been obtained from the southern tip of Greenland to the Kane Basin between Ellesmere Island and northern Greenland. 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 and may mark the boundary between continental and oceanic crust. 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 Labrador Sea and Baffin Bay have been computed in which the dimensions and magnetizations of the various causative bodies have been calculated. Depth determinations carried out on the aeromagnetic profiles on the Canadian side of Baffin Bay show that a considerable sedimentary section exists on the Baffin Shelf. Moreover the presence of high-frequency anomalies on the outer part of the shelf would also strongly suggest that a basement ridge runs along the outer part of the shelf which is probably similar to that found along the eastern seaboard of North America. Depth determinations carried out on the profiles indicate that the thicknesses of sedimentary rock exceed 10,000 feet on the Baffin Shelf. However, sedimentary cover in the central deep-ocean part of Baffin Bay appears to exceed 5 km (16,000 feet) over large areas.

Paper 36. Cretaceous-Lower Tertiary Rift Basin of Baffin Bay - Continental Drift without Sea-floor Spreading; R. MARTIN (Consulting Geologist, Calgary):

The Cretaceous to Eocene sedimentary-volcanic sequence of the Disko Island area and on southern Baffin Island, indicates that the opening up of Baffin Bay by Greenland and North America drifting apart involved this sequence: (1) land-locked rift valley filled with terrestrial deposits, Barremian to Turonian; (2) widening of valley and intermittent marine connections, Upper Turonian to Danian; restricted bottom circulation with deposition of bituminous shales, Santonian through Danian; (3) deepening of rift, opening of magma chambers and effusion of basaltic lavas, Paleocene and Eocene (limited to Davis Strait area): (4) widening and deepening of rift valley to present Baffin Bay and Davis Strait; very thick young sedimentary sequence in deepest part of graben. There is no evidence of sea-floor spreading in Baffin Bay, nor is there a mid-Baffin Bay ridge. In this respect it recalls several other deep marine basins believed due to continental drift. Furthermore, the tectonic-depositional-volcanic history of the Rhine Valley and East African rift systems closely parallels stages 1 to 3 of Baffin Bay. Rifting and continental drift apparently can take place independent of sea-floor spreading, which would be the last phase of the sequence. If sea-floor spreading had created Baffin Bay, its sediments would not pre-date its volcanics by some 50 million years, nor would these be so limited in area. Sea-floor spreading in the Atlantic started only about 60 million years ago, long after the initial (Jurassic) phase of sedimentation. Practical implications to the petroleum industry of considering rifting the primary cause of continental drift are: (1) the same sedimentary sequence is common to many coasts broken by drift, e.g., the oil provinces of western Africa; (2) this sequence includes both source rocks and thick reservoir rocks; (3) the antithetically rotated fault blocks and cross-faults caused by rifting, created suitable structural traps; (4) since volcanism started only at the end of the sequence, there existed little danger of volatilization of hydrocarbons; (5) the central depression, last stage of rift widening, was filled with thick clastics without source rocks.

Paper 37. Geophysical and Geological Studies in Baffin Bay and the Labrador Sea; R.D. HYNDMAN, D.B. CLARKE, H. HUME, J. JOHNSON, M.J. KEEN, I. PARK, and G. PYE (Departments of Geology and Physics and Institute of Oceanography, Dalhousie University, Halifax):

The geophysical and geological data obtained from the 1970 Dalhousie University Arctic cruise of C.S.S. DAWSON will be described. Measurements included bathymetry, seismic profiling, magnetics, heat flow, dredging, coring and foraminifera plankton tows. Some results from the 1969 cruise of the JEAN CHARCOT will also be discussed. The major results are: (1) The Tertiary basalts known in western Greenland extend offshore many tens of miles and further north than previously known. They probably do not extend completely across Davis Strait to the similar basalts of eastern Baffin Island. (2) A thick sedimentary basin occupies the northern part of Baffin Bay on a crust which C.S.S. HUDSON showed subsequently, is oceanic. At its western and eastern margins these sediments rest upon deformed sediments which in turn rest on 'basement'. (3) The continental edge of Baffin Island is marked by a magnetic edge effect. (4) There may be magnetic lineations in northern Baffin Bay trending west north west agreeing with a Lancaster Sound "pole of opening". (5) Heat flow in Baffin Bay and over the buried Labrador Sea ridge is normal, confirming that there is no active spreading at present.

Paper 38. Geophysical Studies on the Structure of Baffin Bay; D.L. BARRETT, C.E. KEEN, K.S. MANCHESTER and D.I. ROSS (Atlantic Oceanographic Laboratory, Bedford Institute, Dartmouth):

Geophysical investigations in Baffin Bay carried out by Atlantic Oceanographic Laboratory have been designed to determine the nature of the crustal structure beneath Baffin Bay and to investigate the boundaries of the deep Bay with the adjacent land masses. A reversed seismic refraction line along the axis of the Bay has shown the crust to be oceanic in nature and gravity, magnetic and seismic reflection data provide information on the nature of the boundaries.

Paper 39. Icebergs: A New Problem for Offshore Oil Operations; JEAN DUVAL (Eastcan Exploration Ltd., Calgary):

In offshore eastern Canada and western Greenland the sea ice limits the drilling season for floating platforms and during the drilling season a major danger is the threat of icebergs. When an iceberg is coming towards the drilling ship, and if a decision is made to move offsite, drilling operations must be stopped at a certain time before the drilling platform can be moved. This time multiplied by the speed of the icebergs provides the concept of warning distance. It is necessary to detect all the icebergs trespassing the warning area. The path of an iceberg is very erratic and it is difficult to predict its short-term route and to make the subsequent decision to move or not. It is feasible to tow the icebergs before they enter the warning area but provisions must also be made to move should there be a failure in the towing operations. During the winter, there are the cumulative problems of ice plus icebergs. For development of a field, the fixed platforms are eliminated. A suggested solution is to drill in the summer and to use submarine completion, separation and pipes. This submarine equipment must be protected from the scouring of icebergs.

Some Current Research being undertaken at the Wood's Hole Oceanographic Institution, Wood's Hole, Massachusetts, compiled by D.A. ROSS.

Seismic Studies in the Western Gulf of Maine, by ELAZAR UCHUPI, R.N. OLDALE and K.E. PRADA:

A survey of the western Gulf of Maine, Nantucket Sound, Vineyard Sound, and Buzzards Bay was carried out during the latter part of 1969 and early 1970. Compilation of structure maps and isopach maps of the basement and the sediment blanket has yielded information on the nature of the sedimentary framework of this segment of the continental margin. A well developed drainage system can be recognized throughout most of the area. In Nantucket Sound in water depth of about 20 m some of the buried fluvial valleys have depths along their axes of over 300 m below present sea level. Glaciation of the shelf has only resulted in the burial of these fluvial features. The drainage system delineated by these valleys is believe to have carved the Gulf of Maine and the other lowlands in northeastern United States with Northeast and Great South Channels representing the water gaps of this system. The buried erosional unconformity present on the continental slope in the vicinity of Corsair Canyon was probably cut at the same time. Erosion of the Gulf and the other lowlands probably occurred in Late Tertiary in response to uplift of the region. This uplift appears to have affected most of northeastern North America as evidences of this erosional cycle in the form of lowlands and cuestas carved out of the shelf strata can be recognized as far north as the Labrador Shelf.

Seismic Studies in the Central and Southern Gulf of Maine by ELAZAR UCHUPI and R.D. BALLARD:

An east-west trending fracture zone appears to be located along the southern margin of the Gulf of Maine just north of Georges Bank. The fracture zone consists of several narrow troughs separated by ridges. Strata within the basins are steeply dipping and cut by high angle normal faults. Acoustic similarities to known Triassic deposits in the Gulf of Maine and Bay of Fundy suggest that these deposits may be Triassic in age.

Sediments of the Continental Margin off the Eastern United States, Maine to Florida by JOHN D. MILLIMAN, ORRIN H. PILKEY and DAVID A. ROSS:

Surficial sediments from the continental shelf and slope between northern Maine and southern Florida have been investigated on the basis of over 6000 bottom samples. Sediments north of about 41°N were derived from Pleistocene glaciers that covered much of the shelf. Sediments over much of the rest of the shelf north of Cape Hatteras are arkosic to subarkosic to subarkosic fluvial sands. Quartz-rich fluvial sands, presumably derived from Piedmont rivers, cover much of the inner shelf off the southeastern United States. Carbonate sedimentation is also important over much of the southern shelf. Locally, in such areas as Georges Bank-Nantucket Shoals, Onslow Bay, the southern Florida Shelf, the Florida-Hatteras Slope, and the Blake Plateau, much of the detrital sediment has been derived from underlying mid-Tertiary formations.

At present sediment is accumulating only in estuaries, in certain nearshore areas and on the continental slope; most of the shelf sediments are relict sands. A significant portion of the "modern" nearshore sediment may have been derived by landward transport of material from the central and outer shelf. Although evidence of bottom current activity abounds, regional laterial transportation or extensive sediment mixing is not evident. Because of the lack of present-day terrigenous sedimentation, the principal sediment source over much of the shelf is calcareous skeletal material. If the present-day shelf surface were preserved in the geologic record, it would be a carbonate-rich layer with altered and reworked skeletal material, representing a variety of environments.

Department of Geology, Duke University

Geophysical Studies in the Southeastern Bahamas by ELAZAR UCHUPI, J.D. MILLIMAN, B.P. LUYENDYK, C.O. BOWIN and K.O. EMERY:

The structural framework of the southeastern Bahamas was reconstructed from seismic profiler, magnetic and gravity data. These data indicate that the Bahama Escarpment may be located along an ancient fracture zone. The banks landward of this escarpment appeared to be located atop a subordinate topographic high. Crustal thickness in the area is about 20 km, a value intermediate between the crusts of continents and oceans. The southeastern segment of the Bahamas appears to be located along a fracture zone that was formed during the opening of the Atlantic Ocean. As the Atlantic widened, this fracture zone subsided with carbonate accretion keeping pace with subsidence. The northwestern Bahama segments may be located atop a trough that was formed during the opening of the Atlantic or existed before rifting was initiated. This trough was first filled with terrigenous deposits to nearly sea level and carbonate sedimentation was initiated. As the Atlantic opened, this sediment-filled trough subsided with carbonate deposition keeping pace with subsidence.

Seismic Survey of Corsair Canyon by ELAZAR UCHUPI and R.D. BALLARD:

A detailed seismic profiler survey was made of Corsair Canyon and the continental slope in the immediate vicinity of the canyon. The recordings indicate that the slope in this area has undergone considerable erosion in the past, that the resulting unconformity was buried under a blanket of sediment, and that this blanket in turn underwent erosion during the Pleistocene.

Black Sea Seismic Studies by DAVID A. ROSS and ELAZAR UCHUPI:

Continuous seismic profiler recordings obtained during the Black Sea cruise in 1969 have yielded considerable information as to the nature of the Black Sea basin. The shelf has its greatest development on the western side of the basin. The basin's side slope in this region appears to be depositional in nature, having been formed by sediment outbuilding. In contrast the shelf on the south and east is very narrow with the side slopes being characterized by faulting, diapiric structures, and large slump blocks and gravitational slides. The central part of the Black Sea basin has a subsurface north-south trending structural high that can be traced from the Yalta peninsula across the width of the basin to the Turkish coast. Strata above the structural high appear to be warped.

Detailed Grain-Size Analysis and Post-Glacial History of Port-Au-Port Bay, West Newfoundland by JAMES M. SHEARER - Abstract of Thesis, Memorial University of Newfoundland.

Grain-size analysis of about 130 bottom grab samples taken from the recent marine sediments of Port-au-Port Bay have led to the distinction of three sediment types with different, although characteristic, cumulative grain size distribution curves. The three types encountered are: 1) unimodal sands found in areas of high wave and tidal current energies, 2) bimodal silts and clays deposited in the low energy basin areas, and 3) bimodal gravels in areas of medium to high energies. The coarse component of Type No. 3 is often a residual deposit from a time of even high energy associated with the lower post-glacial sea level.

Based on this analysis, it is proposed that the characteristic "break" to the finer grades in many fine sand and silty sediments is due to the inherent scarcity in the natural environment of material with diameters between 10 and 40 microns. This size range represents the gap between a fine sand and a clay population, each of which is representative of a different mode of formation. This is in opposition to many workers who believe that this "break" is due to a different mode of transport.

A correlation between particle diameter and mode of transport is nevertheless attempted. It is based on the assumption that tidal currents do not affect the areas of the bay below the deepest sill which, in turn, is deduced from studies of the faunal distribution and the physical oceanographic properties. Deposition in the basin areas, then, is thought to be from suspension only with the maximum particle diameter in these sediments, after removal of the ice-rafted fraction, being around 0.125 mm.

The sea level at the time of the last ice retreat from Port-au-Port Bay (around 13,500 yrs. B.P.) was at the "marine limit", more than 100 feet above the present datum. Isostatic recovery of the land area, as a result of glacial unloading, was apparently occurring faster than the accompanying eustatic rise of the sea, a consequence of the returning glacial meltwaters. Following the ice withdrawal sea level fell rapidly until the isostatic component had diminished to a rate equal to that of the eustatic rise, when the lowest post-glacial sea level was registered. This lowest level calculated from the grain size variations within one of the basin cores was around -35 and -45 feet from the present datum. This is in close agreement with the lowest level calculated from the difference between the theoretical rebound curve and the world-wide eustatic curve. Subsequently, with a further decrease in the isostatic rebound rate, the eustatic component was greater and slow submergence of the land area took place.

MEETINGS

FORTHCOMING MEETINGS

24th Annual Canadian Geotechnical Conference, Nova Scotia Technical College, Halifax, N.S., September 2-3, 1971.

The 24th Annual Canadian Geotechnical Conference will have as its theme DEEP FOUNDATIONS. Papers will be given on topics associated with deep foundations, which will be defined for purposes of the conference as; (1) foundations acting as structural elements carrying loads to competent strata at depth, such as piles and caissons, and (2) foundations made in conjunction with deep excavations which involve special considerations with respect to sheeting, bracing, earth pressures, dewatering, bottom heave, etc.

Papers are invited not only from geotechnical engineers, but also from geologists, geophysicists, and others associated with deep foundation problems.

The organizing committee and the Nova Scotia Technical College will arrange to have the papers reproduced to a standard form and collected as part of the proceedings of the 24th Canadian Geotechnical Conference. Inquiries should be addressed to: Dr. J.D. Brown, Department of Civil Engineering, Nova Scotia Technical College, P. O. Box 1000, Halifax, N.S.

Canadian Exploration Frontiers, 1971 Symposium, Banff, Alberta, September 22-26, 1971.

This symposium will be held under the auspices of the Alberta Society of Petroleum Geologists, and will be housed entirely in the Banff Springs Hotel, Banff, Alberta.

Technical Sessions: These will be held each morning from 8:30-12:00. Papers will be delivered on the following topics: Arctic Islands, Northwest Territories, Labrador Shelf, East Coast Offshore, West Coast Offshore, Hudson Bay, Yukon Territory, and Disturbed Belt of the Canadian Rockies. Running concurrently with the above sessions a series of papers will be given dealing with the Practical Framework of Exploration. This will cover such areas as Federal Regulations, Demand Forecast, Environmental Control, Native Populations and Market Accessibility, etc. Seminars will be held each afternoon between 2 and 4:30 p.m.

Field Trips: Will take place on Thursday and Friday afternoon and all day Saturday. Thursday - Structure and Stratigraphy of the Canmore Coal Basin. Friday - The Rocky Mountains Pt. 1 - Foothills and Front Ranges. Saturday - The Rocky Mountains Pt. 2 - The Main Ranges to west of the Rocky Mountain Trench.

For further information contact the Registration Chairman, ASPG Symposium, Box 6660, Calgary 2, Alberta, Canada.

24th International Geological Congress, Montreal, Quebec, Canada, August - September, 1972.

The following comments are from GEOCONG NEWS No. 3, January 1971 by C.G. Winder, University of Western Ontario, London, Canada. By the middle of November, 1970, more than 7200 responses had been received from 114 countries, of which 85% indicated the chances of attendance are good. With accompanying members, the total number of persons could be more than 10,000 persons, which will make the Congress the largest scientific event ever held in Canada, and possibly the largest geological meeting yet held in the world.

The SECOND CIRCULAR has now gone to press. The computer will remember addresses only of those who replied to the FIRST CIRCULAR.

The official I.G.C. pin has been struck. The design is the traditional circular emblem approximately 1 cm. in diameter set on a stylized maple leaf in red lacquer. The Congress motto is "Mente et Malleo".

The Congress has published reports by the International Subcommission on Stratigraphic Classification edited by Hollis Hedberg as follows - No. 3 - Preliminary report on Lithostratigraphic units, 30 pages, and No. 4 - Preliminary report on Stratotypes, 39 pages, English only. Copies are one dollar each, postpaid from the Secretary General. (One of the principal objectives of the first Congress held in Paris 1878 was to propose rules on geological nomenclature - see Thurston, Geotimes Feb. 1968).

Potential authors of Congress papers should be prepared to submit their manuscripts at least two months ahead of a previously set date -- the deadline will be August 1, 1971.

Citation refers to Issue Number and Page Number.