THE ICE ISLAND REFRACTION SURVEYS

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The 1985 and 1986 Ice Island based refraction surveys covered a transition zone along the Canadian Polar Margin north of Axel Heiberg Island. 840 km of reversed profile data with average recording density of 5 km was collected. Along the inner shelf, the upper 700 m with a velocity of 3.7 km/s are interpreted as Tertiary-Cretaceous strata overlying 5 km of deformed Lower Paleozoic strata with a velocity of 5 km/s capped by Upper Paleozoic-Triassic clastics and carbonates and/or Cretaceous volcanics. The lower unit with a velocity of 5.8 km/s most likely consists of Proterozoic-Lower Paleozoic rocks. Beneath the outer shelf, up to 4 km of strata with a velocity of 2.2 km/s probably represent Tertiary-Cretaceous clastics overlying material with a velocity of 4.5 km/s interpreted as a sedimentary succession of either Cretaceous-Tertiary clastics or Upper Paleozoic to Cretaceous strata. Beneath this section, a probable Proterozoic-Lower Paleozoic lower crustal layer with a velocity of 6.2 km/s extends to a Moho depth of about 25 km. Beneath the transitional onshore-offshore line, a Neogene sedimentary basin is floored by faulted blocks of probably deformed Proterozoic to Lower Paleozoic rocks on the landward side and possibly Cretaceous to Lower Tertiary rocks on the seaward side.

APPLICATION OF LEAD ISOTOPE STUDIES AS GENETIC TRACERS OF GRANITIC SOURCE REGIONS IN THE NEW ENGLAND APPALACHIANS

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Lead isotopic studies in the New England Appalachians are useful as genetic tracers and as chemical probes of the source regions of granitic plutons. Systematic variations of lead isotopic compositions in Devonian plutons have delineated at least three geographic groups arranged across the strike of the Appalachian Orogen; further work places constraints on source region compositions. The ratio of $^{207}Pb/^{204}Pb$ distinguishes the relatively unradiogenic plutons intruding the Connecticut Valley-Gaspe synclinorium (CVG) in Vermont and Maine (<15.55), from plutons intruding the Kearsarge-Central Maine synclinorium (KCM) (15.55-15.60) and the Coastal Lithotectonic Block (CLB) in southern Maine (>15.60). The relatively unradiogenic character of plutons in CVG suggests that the source includes a significant amount of mantle-derived rocks, in addition to a predominantly continental source perhaps best represented by Grenville basement. The relatively unradiogenic composition of these Devonian plutons is characteristic of plutons intruding the North American craton. Plutons having the most homogeneous isotopic compositions intrude the KCM synclinorium; these compositions suggest that their source consists of metasedimentary rocks (e.g., graywacke) and mantle-derived rocks. Plutons intruding the CLB have the most variable and radiogenic lead values; these values probably indicate a heterogeneous and isotopically evolved continental source. Such diversity in lead isotopic compositions precludes at present the recognition of subgroups that might indicate subterranes.

B

KEYSTONEITE, A NEW TELLURITE FROM THE KEYSTONE MINE, COLORADO, U.S.A.

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Keystoneite is a new mineral from the Keystone Mine, Magnolia District, Colorado U.S.A. Associated minerals are melonite, native tellurium, calaverite, pyrite, paratellurite and stibnite. Keystoneite forms radiating sprays and parallel growth aggregates of hexagonal, acicular crystals, the average size of the crystals being, 0.2 X 0.02 X 0.02 mm. The mineral is golden yellow with a light yellow-green streak and an adamantine lustre. It is brittle and no cleavage was observed. The hardness and density could not be determined because of the small grain size, but the calculated density is 4.40 gm/cm^3. Optically keystoneite is uniaxial positive, with ω=1.85(1) measured directly, and ε=1.99(1) calculated from the birefringence of 0.141(2), measured directly with a compensator. It is hexagonal with space group $P6_3/m$, a=9.344(2)Å, c=7.607(3)Å and Z=2. The five strongest XRD lines in the powder pattern are (d,I,hkl), 8.12(90)(010), 4.05(80)(020), 2.952(50)(112), 2.774(100)(022) and 1.720(60)(141). Electron microprobe analysis gave Na_2O 0.3, K_2O 0.1, MgO 4.3, MnO 1.0, FeO 4.6, NiO 12.7, TeO_2 65.5, H_2O (determined by TGA) 15.0±3.0 Total 103.5. Using the lower limit of H_2O 12.0, the total is 100.5. This yields the emperical formula (Z=14), $(Ni_{1.29}Fe_{0.49}Mn_{0.11})_{\Sigma 1.89}Te_{3.11}O_{9.33}Mg_{0.81}(H_{0.73}Na_{0.07}K_{0.02})_{\Sigma 0.82}\cdot 4.67H_2O$. The structure, refined to R=6.3%, is zeolite-like with a negatively charged framework having a total negative charge of 2. Divalent Mg, univalent Na and K are located within the channels with H_2O. Keystoneite is iso-structural with two related tellurites, zémannite and kinichilite. Keystoneite may be the incompletely described "ferrotellurite" named by Genth (1877).

WHALE BASIN, OFFSHORE NEWFOUNDLAND: ROLE OF SALT IN EXTENSION

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Whale Basin is part of the southern Grand Banks Mesozoic extensional mosaic. The basin is composed of an articulated assemblage of four, narrow, northeast-trending, en echelon half-grabens, bounded by large, normal faults. The half-grabens are separated from each other, and from neighbouring southern Grand Banks Mesozoic basins by ridges of Precambrian and Paleozoic rocks. The basin segments are linked to each other and crossed by northwest- striking transfer faults. This structural array is superposed on the Appalachian Paleozoic compressional and transcurrent fault fabric.

Whale Basin segments underwent extension from Late Triassic to Middle Jurassic, contemporaneous with rifting of the Scotian Shelf. Whale Basin and other southern Grand Banks domains were linked to the Scotian Shelf extensional domain by the southeast-trending Newfoundland (transform) Fracture Zone. A second phase of whale Basin extension spanned the interval from mid Jurassic to mid Aptian, coeval with ocean crust generation in the region southwest of the Newfoundland Fracture Zone. After mid Aptian, the rift elements subsided thermally, and were covered by a drift-phase continental terrace prism of cratonic-derived, southward-prograding terrigenous clastics.

Vigorous salt migration took place during the Triassic to mid-Aptian rift interval, resulting in development of massive pillows and salt walls, commonly superposed on large, northeast-striking, basement extension faults. The locations and times of large-scale salt mobilization may have been determined by extensional fabrics and events; depositional loading may have been an accessory influence.

QUATERNARY PALEOMAGNETISM OF SITES IN WESTERN CANADA AND KENYA

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Dating of Quaternary sediments which are older than 40,000 yrs b.p. and are thus beyond the range of ^{14}C, as well as the dating of sediments which contain no datable carbon material, represents a major obstacle to the construction of a time stratigraphic history for these deposits. The perfected methods of absolute dating (amino acid racemization, thermoluminescence, electron spin resonance, uranium series, fission track, and potassium-argon) require materials which are often lacking in Quaternary sediments. Dating based upon the paleomagnetic characterization of sediments and rocks offers great promise for the partial alleviation of this problem.

Reversals are easiest to recognize and have attracted the most attention thus far. Because reversals have occurred repeatedly in the past their identification within incomplete sedimentary records is only possible through comparison with other stratigraphic or radiometric data collected for similar or related sequences. The Matuyama Polarity Chron (.73 my - 2.48 my) is the only major reversal during the Quaternary and has already proven extremely valuable in differentiating between early Pleistocene and late Pleistocene deposits. Shorter reversals (excursions) such as the Blake, Jaramillo, Olduvai, and Réunion, have also proven to be valuable markers where some other age controls are available.

Sediments collected from Banks Island; Mokowan Butte and Cypress Hills, Alberta; Wellsch Valley, Saskatchewan; and Mt. Kenya, showed reversed polarities of probable Matuyama age. At some of these sites, normal overprints on reversed magnetizations; reversed overprints on normal magnetizations; and normal overprints on normal magnetizations have provided additional magnetic histories of these sediments. Paleomagnetic measurements and stratigraphic data have allowed for the establishment of time-stratigraphic boundaries.

A COMPARISON OF THE SOUTHERN UPLANDS OF SCOTLAND WITH THE DUNNAGE ZONE OF NEWFOUNDLAND.

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It has long been recognised that the Dunnage terrane of Newfoundland and the Southern Uplands of Scotland were formed at the same time on the same continental margin. In spite of this, few attempts have been made at more than rudimentary correlation. With the recent reinterpretation of the northern portion of the Southern Uplands as a back-arc basin it is both timely and fruitful to re-examine posible correlations. Detailed litho-stratigraphical correlation is not yet possible but comparisons can be made between stratigraphical events, for example: 1. Ordovician flysch in the Southern Uplands contains abundant lithic and crystalline detritus requiring a contemperaneous volcanic arc provenance. Volcanic suites of similar age are exposed in Newfoundland. 2. Marine (flysch) sedimentation continued for longer in Scotland but the late Llandovery greywackes deposited there include red coated mica detritus and are interbedded with red mudstone. These features may be related to contemporaneous continental red sandstones present in Newfoundland. 3. Post-tectonic, late Silurian to early Devonian, I-type granitic plutons present in both areas show a similar zonation from relatively basic margins to granite cores in multiple intrusions.

THE TECTONIC SETTING OF THE RÅNA LAYERED INTRUSION

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The Råna Layered Intrusion presently lies in the Koli Nappe, 15 km SW of the town of Narvik in northern Norway. It was intruded into the graywackes of the Narvik Group at 437 Ma ± 2 m.y. On the basis of the lack of coronas between plagioclase and olivine in some portions of the intrusion the pressure during intrusion was 5kb, further the Al content of pyroxenes suggests pressures of 2 to 4 kb. The magma was mildly enriched in incompatible elements Cs, Rb, LREE, Zr and Hf relative to the HREE, Y and Sc, $(La/Lu_N=2.5$ and contained 12-15% MgO. The overall composition of the magma was similar to an E-type MORB. The estimated MgO content of the magma would be in equilibrium with the fosterite content of the olivine (87-89) and the enstatite content of the orthopyroxene (88-91) from the ultramafic zone. The Cr plus Ti content of the clinopyroxenes implies that the magma formed at a divergent plate margin. A suggested tectonic setting that is consistent with whole-rock geochemistry, geological setting, and mineral geochemistry is either a back-arc basin or a passive-continental margin.

Subsequent to intrusion, possibily during emplacement of the Koli nappe on the Baltic Shield, Råna was metamorphosed to 8-10 kb and 600-700 C°. The high-pressure metamorphism in the Koli Nappe has been attributed the "Finnmarkian Event", at 500 Ma. Since the age of Råna is 437 Ma and Råna has experienced the high-pressure metamorphism this metamorphism cannot be of Finnmarkian age.

NEW U-Pb AGES FROM THE CAPE BRETON HIGHLANDS AND CORRELATIONS WITH SOUTHERN NEWFOUNDLAND: A LITHOPROBE EAST CONTRIBUTION

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Geological correlations between the Cape Breton Highlands and southwestern Newfoundland have been suggested recently on the basis of similarities in igneous and metamorphic rock units and geophysical data. Preliminary radiometric ages from several key units in the Cape Breton Highlands support this correlation. The Sarach Brook rhyolite, part of the characteristic volcanic-sedimentary sequence of the Aspy Zone of the Highlands, has yielded a U-Pb (zircon) age of about 430 Ma. This indicates a Silurian age for the volcanic-sedimentary sequence, similar to volcanic rocks of the La Poile Group of southern Newfoundland. Orthogneisses in the Aspy Zone have also yielded Silurian ages, and Siluro-Devonian and Devonian Rb-Sr and $^{40}Ar/^{39}Ar$ cooling ages have been obtained from most intrusions in this zone. The Aspy Zone is separated by a major mylonite and chlorite schist shear zone from the Gisborne Flowage and Kathy Road diorites and Ingonish River Tonalite in the Bras d'Or Zone to the southeast which have given U-Pb (zircon) ages of 564, 560 and 555 Ma respectively, and slightly younger titanite ages. The age of titanite from the Indian Brook granodiorite farther east in the Bras d'Or Zone is 564 Ma. These Late Precambrian ages are similar to those from tonalitic intrusions in southern Newfoundland, which are probably separated from the La Poile Group by a major structural break. In contrast to these Late Precambrian ages, the Cameron Brook Pluton in the northern Bras d'Or Zone of the Cape Breton Highlands has given zircon and titanite ages of about 400 Ma, perhaps indicating proximity to the Aspy Zone by that time.

CRUSTAL EXPRESSION OF TECTONOSTRATIGRAPHIC ZONES IN CAPE BRETON ISLAND, NOVA SCOTIA, USING OFFSHORE DEEP REFLECTION SEISMIC AND AEROMAGNETIC DATA

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Results of geological mapping, petrological studies, and radiometric dating indicate that Cape Breton Island consists of four pre-Carboniferous tectonostratigraphic zones, termed from north to south the Northwestern Highlands, Aspy, Bras d'Or and Southeastern Zones. The limited onland across-strike extent of these zones and the isolated geographic position of Cape Breton Island has inhibited interpretations of their offshore extension and their correlation to other areas of Atlantic Canada. A marine reflection seismic profile of 20 seconds of two-way travel time running across the Sydney Basin, northeast of Cape Breton Island, was collected as part of the 1986 deep seismic survey in the Gulf of St. Lawrence area. The profile is characterized by abrupt changes of reflector patterns in the lower crust and along the crust-mantle discontinuity (Moho), that are interpreted as near-vertical boundaries between crustal blocks. Aeromagnetic data, recently acquired in the Laurentian Channel between Newfoundland and Cape Breton Island, delineate the offshore extension of the tectonostratigraphic zones identified in Cape Breton Island, and their link with some of the deep crustal features observed in the reflection seismic profile. These data confirm the absence of Dunnage Zone in Cape Breton Island and in the Laurentian Channel, and the presence of the Bras d'Or Zone which widens to the northeast under the Sydney Basin.

DROWNED BARRIER ISLAND-SAND RIDGE FACIES ON THE GRAND BANKS OF NEWFOUNDLAND AND THE NORTHERN BRITISH COLUMBIA CONTINENTAL SHELF

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During the late Pleistocene a transgressive barrier island was in place at the present 75 to 80 m water depth on the northeastern Grand Banks of Newfoundland. The low sea level stand (85 - 100 m) ended sometime after 18,000 years B.P., with subsequent transgression resulting in erosion and finally submergence of the barrier island around 8,500 years B.P. A lack of topography on the Island of Grand Bank would not allow the formation of further stairstep barriers, though oblique shoreface-connected sand ridges formed in the shallow early Holocene sea covering Grand Bank.

Similarly, a shore-parallel sand ridge, considered to be a drowned barrier, formed the shoreface of northeastern Hecate Strait and southern Dixon Entrance (northern British Columbia continental shelf) at 20 m water depth during the early Holocene with shore-parallel connected ridges seaward of the barrier. Unlike the barrier of the Atlantic shelf, the Pacific barrier retreated in a stepwise fashion. A second barrier formed behind the lagoon of the initial barrier. The Holocene transgression along the Pacific margin appears to have occured not only as a result of isostatic adjustments but was complicated by the collapse of a subcrustal forebulge during ice retreat and by tectonic uplift.

PREGRENVILLIAN(?) ELEMENTS OF THE SOUTHERN APPALACHIAN BASEMENT: DISTRIBUTION AND POSSIBLE SIGNIFICANCE

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About a dozen age determinations for basement rocks in the southern Appalachians have yielded ages of 1150 Ma or greater. Initial 87 Sr/86 Sr ratios for some of these rocks are low suggesting they probably are not derived from older cratonic sources. Sample locations plotted on a Late Proterozoic palinspastic base for Grenvillian basement massifs of the Ancestral North American Craton (ANAC) allow preliminary evaluation of 1150+ Ma rocks. On the palinspastic base, a Grenvillian (1000-1130 Ma) volcanic belt (Blue Ridge Terrane) lies southeast of the belt of Grenvillian platform rocks (Central Gneiss Belt of Canada, Adirondack Highlands, New England massifs, and Reading Prong). The Grenvillian platform sequence is associated with older crust along the middle Proterozoic ANAC margin. Thus, preGrenvillian age determinations, paleogeographic position and stratigraphic relationships from the Watauga massif and Pine Mountain window suggest that these southern Appalachian massifs were originally a contiguous part of the middle Proterozoic basement associated with the Grenvillian platform sequence. Available data from within the Grenvillian volcanic belt suggest its development was along or near older basement which served as source rocks for charnockites. East of the volcanic belt lies a middle Proterozoic metasedimentary belt (Mars Hill Terrane) in which age determinations are 1200-1800(?) Ma. This terrane could be the source area for 1800 Ma detrital zircons found in the Lovingston Massif of the Blue Ridge Terrane. Middle Proterozoic elements from the Appalachian Piedmont, as well as the Mars Hill Terrane, may ultimately be affiliated with the African Craton.