Department of Geology Seminar Series
Presents

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Terrane concept and Cape Breton Island

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Science 411

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Terrane concept and Cape Breton Island

by

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ABSTRACT
A terrane is primarily defined as having a distinct, **time-bounded**, fault-bounded tectonostratigraphy that cannot be explained by facies changes. The geology of Cape Breton Island has been interpreted either as exposing a cross-section of the Avalon Composite terrane based upon its unique **Cambrian-Ordovician** overstep sequence, or, the current concensus that it represents a complete cross-section of the Appalachian orogen from Laurentia across two intra-Iapetan terranes (the **Silurian** Aspy terrane and **Neoproterozoic** Bras d'Or terrane) to **Cambrian-Ordovician** Avalonia. Crucial to the latter view is the presence of ca. 1 Ga plutons, including anorthosites, which have been regarded as correlatives of Grenvillian basement, a correlation that overlooks the fact that Avalonia is also underlain by a ca. 1 Ga basement. U-Pb zircon analyses from the Red River anorthosite (Blair River Complex, northwestern Cape Breton Island) previously dated as ca. 1.1 Ga have yielded 421 ± 3 Ma intrusive ages with older ages between 865 ± 18 Ma and 1044 ± 20 Ma inferred to be either xenocrysts derived from the country rock or from the source. Implications of these data suggest that the accompanying low pressure granulite-amphibolite facies metamorphism of the Blair River Complex is either the root of a 440-410 Ma, magmatic belt produced during slab break-off or relict ca. 1 Ga basement. The Blair River Complex occurs in a NNE-SSW, sinistral positive flower structure that progresses upwards from a Neoproterozoic rifted arc through a low grade upper Ordovician-Silurian overstep sequence to amphibolite facies fault slices, capped by the low-pressure, granulite facies rocks (Blair River Complex). Furthermore, Pb isotopic data suggest the Blair River Complex has Amazonian (≈Avalonia) affinities. Thus, Cape Breton Island, rather than representing a complete cross-section of the Appalachian orogen, is part of pristine—deformed Avalonia with a positive flower structure exposing a cross-section of Avalonian crust.

CAREER SUMMARY

Since graduating with a Doctorate from Glasgow University (Scotland), I have been working in either a University or a Geological Survey:

(i) 3 years at Bryn Mawr College (USA),
(ii) 3 years with the Zambian Geological Survey,
(iii) 1 year at Acadia University (Canada),
(iv) 20 years with the Nova Scotia Department of Mines (Canada),
(v) 1 year at St. Francis Xavier University (Canada), and
(vi) 18 years at the Instituto de Geologia, Universidad Nacional Autonoma de Mexico.

During this time I rose from Geologist to Chief Geologist in the surveys, and Assistant Professor to Investigador Titular C, PRIDE D, and SNI level III. The practical field experience gained in surveys has benefited my academic work and teaching. In 2012, I awarded the Gesner Medal (Distinguished Scientist Award), and a Symposium was held at the Geological Society of America in Juriquilla to honour my career.

Over the 47 years my research has focussed on the following topics:

1. Paleogeographic reconstruction. The first paper on the Paleozoic global paleogeography published in 1977 and placing Mexico in the global context was followed by a number of subsequent papers

culminating in a synthesis of Mexican terranes in 2004 followed in 2008 by locating the Acatlan Complex (southern Mexico) in regional reconstuctions and in 2010 tracing the Oaxacan basement signature beneath eastern North America and into Europe (Southern England, France, Iberia, and Bohemia).

HIGHLIGHTS: (i) that Avalonia originated off Baltica (not Africa) in the Ediacaran arriving off NW Amazonia by the Ordovician, (ii) that Oaxaquia originated off NW Amazonia, not Laurentia, (iii) that the Acatlan Complex formed on the southern margin of the Rheic Ocean.

2. Terrane analysis. This started in 1981-2 with publication of the principles of tectonic mapping and the Tectonic Map of Nova Scotia. This was extended to the Appalachians in 1985, then to the Circum-Atlantic Phanerozoic Orogens in 1989, and finally to Mexico in 2004.

   HIGHLIGHTS: (i) Terranes map of the Appalachian Orogen, (ii) Tectonic Map of Pre-Mesozoic Terranes in Circum-Atlantic Phanerozoic Orogens, (iii) tectonic analysis of the terrane map of Mexico.

3. Recycling continental lithosphere through subduction erosion and extrusion. This was initiated in 2005 with the discovery that a large sliver of southern Mexico had been removed by subduction erosion. This led to the realization in 2008 that most high-pressure rocks in the Acatlan Complex of southern Mexico originated on the margin of the upper tectonic plate, were removed by subduction erosion only to be extruded back up into the upper plate. Such a discovery led to major reinterpretations of paleogeography because some high-pressure rocks, rather than representing ocean basin, were zones of extrusion into the upper plate and so did not represent a closed ocean. This mechanism was then applied to part of the Cordillera in British Columbia (2009) and to the high-pressure Iberian-Czech belt in the Variscan orogen (2010).

   HIGHLIGHTS: (i) that the Chortis block was not off southern Mexico in the Cenozoic; (ii) that a 250 km wide sliver had been removed from southern Mexico by subduction erosion; (iii) that the high-pressure rocks in the Acatlan Complex of southern Mexico, the Cache Creek terrane in British Columbia, and the Iberia-Czech belt represented extrusion into the upper plate.

4. U-Pb and $^{40}Ar/^{39}Ar$ geochronology to determine the age of tectonic events. This research was done with several geochronologists (R.D. Dallmeyer, T.E. Krogh, K. Cameron, J.W.K. Lee, A. Ortega-Rivera, and L. Solari) and initially was applied to Nova Scotia and subsequently to Mexico.

   HIGHLIGHTS: (i) unravelling the geological histories of Avalonia, Oaxacan and Acatlan complexes; (ii) documenting that the high-pressure rocks in the Acatlan Complex were exhumed during the Carboniferous, not during the Ordovician, Silurian and Devonian.

5. Tectonic Setting using Geochemistry of igneous (and sedimentary) rocks. This research was done mainly with two colleagues (J. Dostal and J.B. Murphy) and between 1979 and 2010 studies were in Nova Scotia supplemented in 2001 by research in Mexico.

   HIGHLIGHTS: (i) identifying arc and within-plate rocks in the Canadian and New England Appalachians; (ii) documenting the within-plate characteristics of most of the volcanic rocks in the Acatlan Complex; (iii) identifying the anorthosite-mangerite-charnockite-granite suite and a Grenvillian arc in the Oaxacan Complex.

6. Geometry and kinematics of folding. This interest began during my doctoral studies followed in 1976 with a paper on the gold-bearing folds in Nova Scotia.with techniques being passed on to one of my students in 2006.

   HIGHLIGHTS: (i) linking gold veins with high curvatures and conical folds; (ii) documenting the relationship between hydrocarbons and conical folds in the Cantarell area.

Publications

This research has resulted in publication of:

- (i) 151 papers published in pier-reviewed journals (103 at UNAM),
- (ii) 41 reviewed papers in books (25 at UNAM),
- (iii) 7 books (4 at UNAM),
- (iv) 10 maps,
- (v) 44 other publications,
- (vi) 14 unreviewed publications (including 3 field guides in Mexico),
- (vii) one educational video, and
- (viii) 248 published abstracts (119 at UNAM).