Recent Investigations of the Stratigraphy and Paleontology of Devono-Carboniferous Successions in Mainland Nova Scotia

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Introduction

During the field season of 2010, targeted stratigraphic and paleontological studies were conducted in the Cumberland Basin and Cobequid Highlands of northern Nova Scotia and in the Minas Basin of central Nova Scotia. The goals of this work were: (a) to ascertain stratigraphic relationships and correlations in Devono-Carboniferous rocks potentially coeval with Horton Group strata; (b) to investigate organic-rich strata co-occurring with basalts in the Cobequid Highlands, identified by T. MacHattie in the course of investigations of Rare Earth Element-bearing volcanics; (c) to continue paleontological research and reconnaissance of the Cumberland Group at the Joggins Fossil Cliffs World Heritage Site; and (d) to document the trackway record of early tetrapods in Horton Group strata at Blue Beach.

Devono-Carboniferous Stratigraphic Investigations

Nutby Formation

The stratigraphic assignment of basin-margin rocks adjacent to the Cobequid Highlands is problematic due to their coarse-grained character and poorly constrained age, which makes correlation difficult with laterally equivalent, finer-grained basinal rocks. This has long been a challenge in Devono-Carboniferous basins of Nova Scotia (Bell, 1944 and others).

One such unit that has been of questionable affinty is the Nutby Formation (Donohoe and Wallace, 1982). Roadside and stream sections mapped as Nutby Formation were examined on West Branch North River, and on roadside exposures east of the river. A marked change in style and degree of deformation was observed in the sequence exposed on West Branch North River. Our preliminary interpretation is that two different stratigraphic units with different structural histories are superimposed in the stream section, and that the section warrants further investigation and possible stratigraphic revision.

Where exposed on the roadside east of the stream section the Nutby Formation is characterized by bright reddish-brown, finely laminated siltstone with abundant calcareous liths, in places leaving vugs; immature arkosic sandstone lenses; greenish-grey siltstone; and rare dark grey laminated mudstone. Samples were taken for palynology analysis at its northern contact with unnamed Ordovician-Silurian diabase and quartzite.

Organic-rich Shale Associated with Basalt of the Diamond Brook Formation

In the course of investigating the Rare Earth Element (REE) potential of the Fountain Lake Group volcanics in the Coequid Highlands, T. MacHattie identified organic-rich shale apparently interstratified with basalt of the Diamond Brook Formation (Fig. 1). The co-occurrence of these fine, organic-rich strata with bimodal volcanics reflects Devono-Carboniferous crustal extension and provides additional insight into the development and initial infilling of late Paleozoic basins in northern Nova Scotia. The organic-rich shale may be coeval with similar rocks assigned to the Murphy Brook Formation. The Murphy Brook

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Figure 1. Organic-rich shale apparently interstratified with basalt of the Diamond Brook Formation.

Formation strata, equivocally assigned a Frasnian-Famennian age on the basis of macrofloral remains, are of significantly higher thermal maturity, however. Organic-rich units that constitute early basin fill may be more widespread than previously understood, although it remains unknown whether such units floor the Cumberland Basin to the north.

Paleontological Investigations

Joggins World Heritage Site

Research at the Joggins World Heritage Site focused on identification and retrieval of tetrapod-bearing trees. In more than a century since the pioneering discoveries of Dawson, there had been few additional discoveries. Examination of specimens in the collections of the Redpath Museum, Montreal, and the Natural History Museum, London, by the author and A. C. Scott of the Royal Holloway University of London, led to the development of a search strategy that now yields ongoing discoveries. Subsequent to the first of these in 1994, an additional five productive trees have been identified. Furthermore, the number of productive stratigraphic horizons has been expanded from three to seven.

A potentially productive charcoal-infilled lycopsid tree newly exposed in the Springhill Mines Formation south of MacCarrens River was identified in late 2010. The tree had been exposed at the cliff base by recent storm events, and rendered vulnerable to destruction by waves. Two enigmatic coalified tree casts (Fig. 2), both rooted in a layer above the lycopsid tree, were also threatened by imminent destruction by waves. In light of the vulnerable state of the trees due to their exposed condition at the cliff base, the potentially productive lycopsid tree (Nova Scotia Museum Specimen 011.GF025.002) and the taller of the two enigmatic trees (Nova Scotia Museum Specimen 011.GF025.001) were retrieved under a Heritage Research Permit and are being re-assembled at Saint Mary’s University.

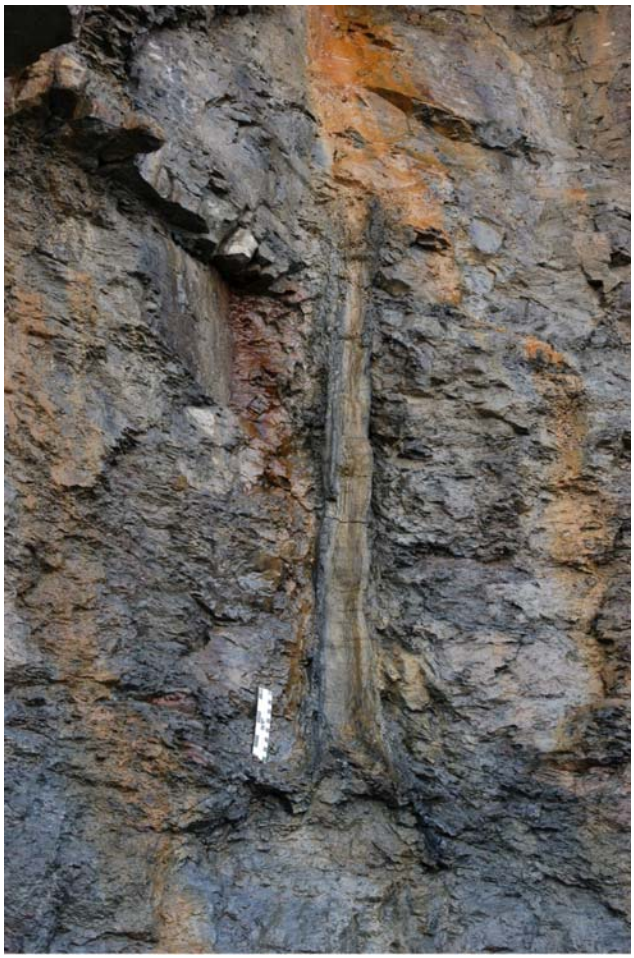

Figure 2. Enigmatic coalified tree cast *in situ.* (NSM011.GF025.001)

The coalified tree, which is cruciform in transverse section, is unlike any taxon known to the authors, and will be investigated for cellular preservation. Investigation into the application of CT scanning to identify the disposition and taphonomy of skeletal material within the lycopsid trees is being undertaken by Andrew MacRae at Saint Mary's University.

Blue Beach

The tetrapod trackway record of the Horton Group at Blue Beach, Kings County, represents the oldest example in the fossil record of a diverse tetrapod community. In 2004, a research team led by Spencer Lucas and Adrian Hunt, New Mexico Museum of Natural History, examined the tetrapod trackway record of Nova Scotia at various localities, including Blue Beach. Consequently, Chris Mansky of the Blue Beach Fossil Museum has amassed a collection of more than 1000 specimens bearing footprints, which represents the richest fossil record of early tetrapods, either in the skeletal or footprint records.

In 2011, a research team led by Lucas and including Chris Mansky and the author re-examined the Blue Beach record and revised the provisional taxonomy developed in 2004. The diversity of specimens in the Mansky collection provides new insight into extramorphological variation of individual taxa due to either gait or substrate variation. The result is a list of tetrapod ichnotaxa that more closely approximates tetrapod diversity from this pivotal time in terrestrial vertebrate evolution.

Preliminary research results have yielded five distinctive tetrapod ichnotaxa. Three of these (*Paleosauropus*, *Pseudobradypus*, *Hylopus*) almost certainly represent different tetrapod trackmakers. A fourth (*Attenosaurus*) most probably represents a fourth tetrapod taxon, but the trackway contains extramorphological features, requiring some caution in this assessment (Fig. 3). A fifth ichnotaxon (*Bactrachichnus*) may represent either a juvenile or small temnospondyl amphibian. This list represents a minimum number of taxa due to the conservative nature of early tetrapod foot morphology, and confirms the significance of Blue Beach as a site of global significance in vertebrate paleontology.

References

Bell, W. A. 1944: Carboniferous rocks and fossil floras of northern Nova Scotia; Geological Survey of Canada, Memoir 238, 277 p.

Donohoe, H. V., Jr. and Wallace, P. 1982: Geological map of the Cobequid Highlands; Cumberland, Colchester and Pictou Counties; Nova Scotia Department of Mines and Energy, Map 1982-009 (4 sheets), scale 1:50 000.

Figure 3. Attenosaurus, exhibiting the forward-directed toe drags that in part define the ichnogenus.