ORDOVICIAN BLACK RIVER GROUP AND TRENTON GROUP LIMESTONES, INGHAM MILLS, NEW YORK STATE

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INTRODUCTION

The New York state Ordovician carbonate rocks research project was conducted during June, 1991. The research group consisted of eight juniors and one sophomore representing five Keck Geology Consortium institutions. Project faculty comprised Brian White and Al Curran for the month, Mark Wilson for the first two weeks, and Connie Soja (Radcliffe-Harvard) for the first week. We were aided in our work by shorter faculty visits from Bill Fox (Williams) and Carol de Wet (Franklin and Marshall).

GEOLOGIC BACKGROUND

Excellent exposures of Ordovician carbonate rocks of Caradocian age occur immediately downstream from the Niagara-Mohawk dam on East Canada Creek, 33 kilometers east-southeast of Utica, New York (Figure 1). A simplified stratigraphy for this locality is given in Figure 2. The oldest Ordovician limestones at the Ingham Mills locality belong to the Lowville Formation of the Black River Group. Lowville Formation rocks disconformably overlie Upper Cambrian dolostones of the Little Falls Dolomite. The top of the Lowville Formation is marked by a discontinuous paleosol indicating at least a hiatus and possibly a disconformable relationship with the overlying Trenton Group rocks. Trenton rocks at this locality belong, in ascending stratigraphic order, to the Napanee, Kings Falls, and Sugar River limestones.

The Ordovician System was established by Lapworth in 1879 to settle the Murchison-Sedgwick controversy concerning their overlapping Cambrian and Silurian systems, thus defining the three oldest Paleozoic periods. Subsequent usage in Britain did not adhere strictly to Lapworth's definition, and the Ordovician expanded by the addition of the Tremadoc Group at the base. Meanwhile, a separate terminology was developed in North America for rocks of Ordovician age, not without its own set of confusions and ambiguities. Keith (1989) attempted to assign strata of the Black River and Trenton groups to an international stratigraphic system based largely on the American Association of Petroleum Geologists' COSUNA charts. According to Keith, the rocks exposed at the Ingham Mills site would be assigned to the Champlainian Series of the North American scheme and would all be part of the Caradocian Stage of the Upper Ordovician Series. Traditionally, North American geologists have thought of the Champlainian Series as belonging to the Middle Ordovician, but this reassignment places all but the oldest part of the series within the Upper Ordovician. In a recent article, Harland *et al.*, (1990) proposed a tripartite division of the Ordovician Period into Sub-periods, from oldest to youngest, Canadian, Dyfed, and Bala. Harland *et al.* assign the Black River and Trenton rocks to the Caradoc Epoch of the Bala Sub-period.

In Ordovician time, what is now central New York state was located at the southern edge of the continent of Laurentia. During the Late Precambrian, a supercontinent rifted into several continental fragments, and this formed new oceans separating the once connected continental landmasses. Through the Cambrian the continents of Laurentia, Siberia, and Baltica continued to separate, the intervening Iapetus Ocean widened, and the southern edge of Laurentia formed a passive margin (Scotese and McKerrow, 1990). Throughout Ordovician time, Laurentia was astride the Equator, which ran southwest to northeast across the middle of the present continent of North America. This placed southern Laurentia in the carbonate belt of the southern tropics (Witzke, 1990). The enormous carbonate platform that had developed along the passive margin of southern Laurentia in Cambrian time persisted into the Ordovician. Laurentia was completely surrounded by oceans and it was located perhaps as much as 1000 km from other land masses (Scotese and McKerrow, 1990). This isolation resulted in the development of endemic shallow marine shelly faunas (Cocks and Fortey, 1990) and an American faunal realm. Such a location also favored a non-monsoonal, zonal climate with carbonates and evaporites being formed along the tropical zones and terrigenous clastics confined to the more humid equatorial zone sandwiched between (Witzke, 1990).

The tectonic setting changed in the Ordovician, however, as the Iapetus Ocean began to narrow (Figure 3) and a subduction zone developed along the southern margin of Laurentia. A collision between Laurentia and the Ammonoosuc Arc produced the Taconic Orogeny and the associated mountain building (Cisne *et al.*, 1982). These large-scale tectonic events had major impacts on sedimentation with the development of a foreland basin, in which deepwater sediments accumulated, and, with the burial of the carbonate platform by terrigenous sediments derived from the newly formed orogenic highlands. Pre-collisional tectonism associated with the narrowing of the Iapetus Ocean may have caused epeirogenic lowering and raising of relative sea level and thus affected sedimentation patterns within the carbonate platform. Such events may explain some of the facies changes and disconformities found in the sequence of platform carbonate rocks exposed in New York state (Titus, 1989). In a recent paper, Bradley and Kidd (1991) propose that syn-depositional normal faulting produced by flexural extension associated with a subduction zone influenced sedimentation patterns in Caradocian limestones now exposed along the Mohawk Valley, New York.

Other Ordovician events of a more global nature may have influenced the deposition and subsequent diagenesis of the Black River and Trenton limestones. The drift of West Gondwana to a south polar position led to widespread glaciation before the end of the Ordovician (Scotese and McKerrow; 1990, Van der Voo, 1988). Ice volume fluctuations resulting from Milankovitch solar radiation cycles may have resulted in eustatic sea-level rises and falls that may have caused depositional cycles in carbonate sequences, especially in peritidal environments. It may be difficult to separate such effects from possible autocyclic mechanisms that may have contributed to the vertical facies changes evident in the Ingham Mills section.

It has been postulated that terrestrial plants may have evolved by the Caradocian (Gray *et al.*, 1982). Whenever this event occurred, it would have had a profound impact on the biogeochemistry of the subaerial diagenesis of carbonate material. Extraction of carbon dioxide during photosynthesis would have enhanced the precipitation of calcite, whereas the excretion of humic acids from plant roots would have favored dissolution. The net result of this interplay would be more complex soils than those formed prior to the evolution of terrestrial plants. Shallowing-upward cycles in peritidal carbonate environments commonly shoal to supratidal or terrestrial zones. Limestones formed in such environments likely would contain paleosols that formed during periods of subaerial emergence.

RESEARCH PROJECTS

Keck participants gathered in Dolgeville, New York, and spent the first two days on a reconnaissance of the well-exposed sequence of limestones exposed on East Canada Creek at Ingham Mills. A preliminary stratigraphic column was developed and students zeroed in on their particular research topics. After a week of section measurement, photography, and sample collection, the group moved to the Geology Department at Smith College and spent the next week on sample preparation and data processing. The third week of the project was spent at the Ingham Mills field site for more data and sample collection, guided by preliminary laboratory results and library research accomplished the previous week. The final week was spent back at Smith College for further laboratory and library studies.

Peter Johannsen (Williams), Ian King (Amherst), and Patti Schroth (Smith) chose to work on the Lowville Formation of the Black River Group. With supervision from Al Curran and Brian White, they made detailed descriptions of the vertical sequence and collected numerous samples. In addition, Peter studied and made measurements of channel-like features, Ian concentrated on paleoenvironmental analysis, and Patti focused on the diagenesis and cements history of the formation. Jennifer Tegan (Smith), with supervision by Al Curran, examined trace fossils in both the Lowville Formation and overlying Trenton limestones and collected numerous rock samples for her laboratory studies. Durelle Smith (Smith), supervised by Brian White and in the initial stages by Bill Fox, made detailed measurements of mega-ripples and interference ripples in the lower Kings Falls Formation. Mike Rahnis (Franklin and Marshall), initially supervised by Connie Soja and later benefiting from a visit by Carol de Wet, made detailed field observations and collections for his study of the diagenetic history of the Trenton limestones.

The Wooster group of Drew Barton, Anne Lewellen, and Jamie White, supervised by Mark Wilson, focused their attention on the Kings Falls and Sugar River formations of the Trenton Group and constructed a very detailed stratigraphic section of the sequence. Drew worked on a paleoenvironmental analysis of the units and explored the nature and origin of some conglomerate layers in the lower Kings Falls, Anne studied the systematics and paleoecology of the bryozoan *Prasopora*, and Jamie began a petrographic analysis of the Trenton limestones.

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REFERENCES

Bradley, D. C. and Kidd, W. S. F., 1991, Flexural extension of the upper continental crust in collisional foredeeps, Geological Society of America Bulletin, 103, 1416 - 1438.

Cisne, J. L., Karig, D. E., Rabe, B. D., and Hay, B. J., 1982, Topography and tectonics of the Taconic outer trench slope as revealed through gradient analysis of fossl assemblages, Lethaia, 15, 219 - 246.

Cocks, L. R. M. and Fortey, R. A., 1990, Biogeography of Ordovician and Silurian faunas, *in* McKerrow, W.S. and Scotese, C. R., (editors), Paleozoic Paleogeography and Biogeography, The Geological Society, Memoir # 12, 97 - 104.

Gray, J., Massa, D., and Boucot, A. J., 1982, Caradocian land plant microfossils from Libya, Geology, 10, 197 - 201.

Harland, W. B., Armstrong, R. L., Cox, A. V., Craig, L. E., Smith, A. G., and Smith, D. G., 1990, A geologic time scale 1989, Cambridge University Press, Cambridge, 263 p.

Keith, B. D., 1989, Regional facies of Upper Ordovician Series of eastern North America, *in* Keith, B. D., (editor), The Trenton Group (Upper Ordovician Series) of eastern North America, American Association of Petroleum Geologists, Studies in Geology # 29, 1 - 16.

Scotese, C. R., and McKerrow, W. S., Revised World maps and introduction, *in* McKerrow, W.S. and Scotese, C. R., (editors), Paleozoic Paleogeography and Biogeography, The Geological Society, Memoir # 12, 1 - 21.

Titus, R., 1989, Facies of the Trenton Group of New York, *in* Keith, B. D., (editor), The Trenton Group (Upper Ordovician Series) of eastern North America, American Association of Petroleum Geologists, Studies in Geology # 29, 77 - 86.

Van der Voo, R., 1988, Paleozoic paleogeography of North America, Gondwana, and intervening displaced terranes: Comparisons of paleomagnetism with paleoclimatology and biogeographical patterns, Geological Society of America Bulletin, 100, 311 - 324.

Witzke, B. J., 1990, Paleoclimatic constraints for Paleozoic paleolatitudes of Laurentia and Euramerica, *in* McKerrow, W.S. and Scotese, C. R., (editors), Paleozoic Paleogeography and Biogeography, The Geological Society, Memoir # 12, 57 - 73.

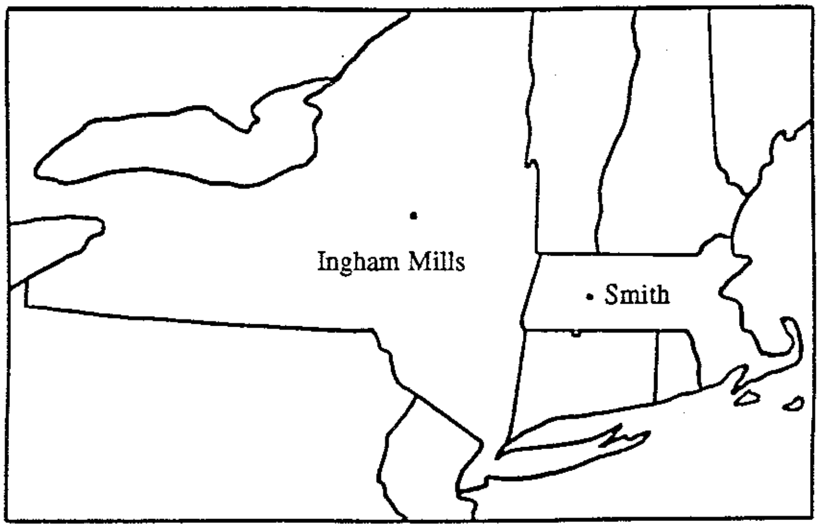

Figure 1. Location of Ingham Mills

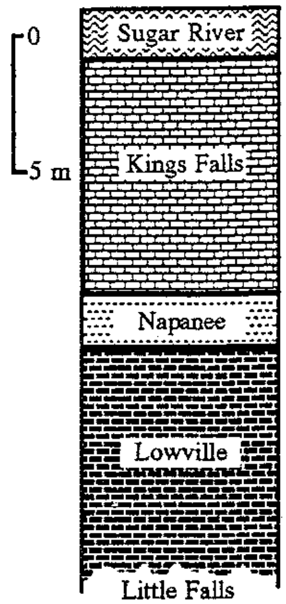

Figure 2. Ingham Mills stratigraphy

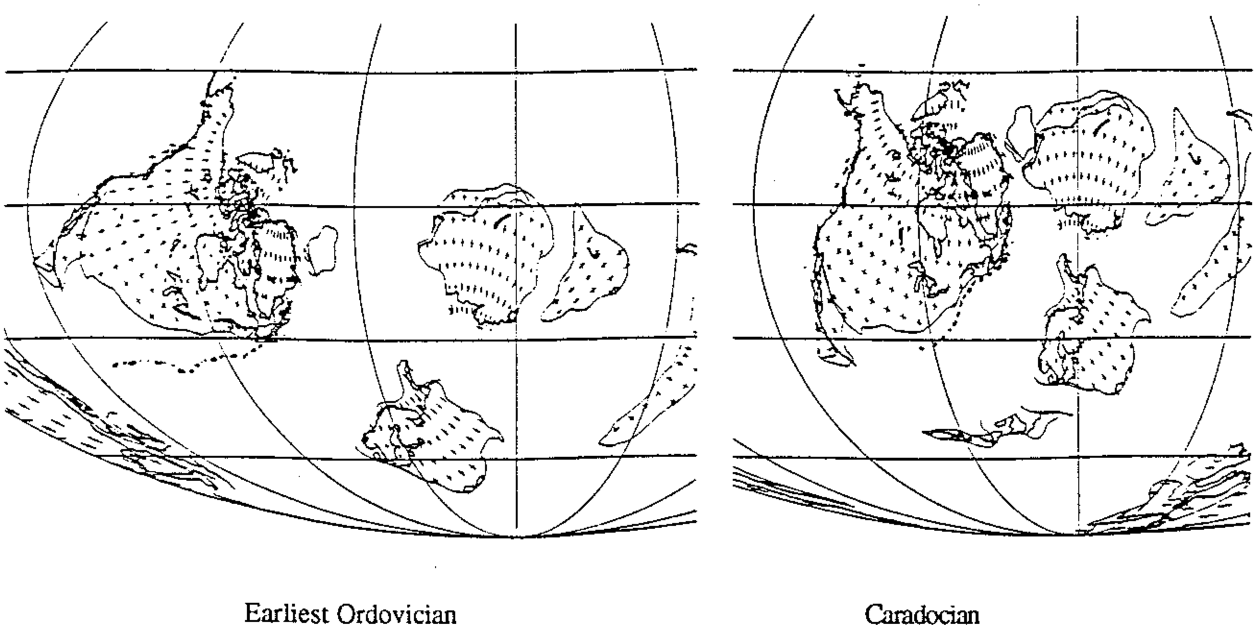

Figure 3. Continental configurations