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ASPECTS OF STRATIGRAPHY AND SHALE GEOCHEMISTRY IN SEDIMENTARY ROCKS OF THE HUMBER ARM GROUP

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INTRODUCTION

This report deals with aspects of a Ph.D. project presently underway at Memorial University. The project is concentrated on the Cook's Brook and Middle Arm Point formations, a suite of shales, limestone turbidites, carbonate conglomerates and cherts that occurs in the middle part of the Humber Arm Group, situated within the Bay of Islands, western Newfoundland. These late Middle Cambrian to Early Ordovician sedimentary rocks appear to be the deep-water equivalents of the Cow Head Group to the north.

The aims of the project are: 1) to define the stratigraphic framework of Middle Cambrian to Lower Ordovician deep-water sedimentary rocks in this area, 2) to describe and interpret the sedimentology of these sequences, and 3) to examine changes in shale geochemistry through the section as a potential aid in correlation, and a possible indicator of depositional environment.

Collaboration with Newfoundland Department of Mines and Energy personnel has been in three main areas: shale geochemistry with P. Dean and J. Meyer, analyses of shale samples for total organic carbon with the staff of the geochemical laboratory, and stratigraphy with D. Boyce.

Regional Geologic Setting

Rocks in the study area occur in a north-south-trending belt, best exposed in the Bay of Islands, which extends northward toward the Cow Head Group and southward toward the Port au Port Peninsula (Figure 1).

The Humber Arm Group is a slice of sedimentary rocks which structurally underlies the Bay of Islands Ophiolite Complex within the Humber Arm Allochthon. The lowest components of this group are the Early(?) to Middle Cambrian Summerside and Irishtown formations, clastic units thought to be derived from the west. The carbonate- and shale-dominated Cook's Brook and Middle Arm Point formations constitute the middle part of the group and appear to span the same stratigraphic interval (Late Middle Cambrian to Early Ordovician) as the Cow Head Group to the north. The Middle Arm Point Formation passes upward into quartzofeldspathic sandstones of Late Early to Middle Ordovician age which are interpreted to be easterly-derived and herald the destruction of the carbonate margin (Stevens, 1970).

STRATIGRAPHY

Previously, only reconnaissance mapping was conducted in this area, and only two or three fossil occurrences were located prior to this study. Approximately sixty new fossil localities have been discovered in the course of this project, many of which date key parts of the section. Whereas the majority of these are graptolite localities, several important trilobite discoveries have been made. Material from three localities found in 1984 were identified by Doug Boyce. In 1985, Boyce and the author visited three key areas where trilobite debris had been noted (in boulders within limestone conglomerates) in the course of earlier mapping. Thirty-three fossiliferous boulders were collected in two days. Approximately ten other boulders were subsequently collected by the author at different localities and this material is currently being identified by Boyce. Although these discoveries reveal important stratigraphic data, their greatest significance may be in demonstrating the great abundance of trilobite material in conglomerates of the Cook's Brook Formation. This opens up the possibility of biofacies comparisons with the well-studied Cow Head Group.

SHALE GEOCHEMISTRY

The Humber Arm Group in the Bay of Islands is one of the areas examined by Dean and Meyer (1983, 1984, 1985). They carried out a program of both shale and stream sediment sampling to assess the potential of these rocks as mineral hosts, and to establish shale geochemical properties for industrial uses.

In the present study, major and trace element analyses, and determination of clay mineralogy, total organic carbon and sulfur, have been performed on approximately 160 shale samples, which span the Cook's Brook and Middle Arm Point formations and adjacent units. Preliminary results suggest marked changes in the nature of these shales through time. Cambrian and earliest Ordovician shales are relatively rich in organic carbon (3 percent) and sulfur, and appear to have been deposited under moderately reducing conditions. A dramatic change occurs at the boundary between the Cook's Brook Formation and the overlying Middle Arm Point Formation; oxidizing oceanic conditions appear to have prevailed into the Middle Ordovician. The boundary marks the onset of 1) greatly increased bioturbation, 2) silicification, 3)

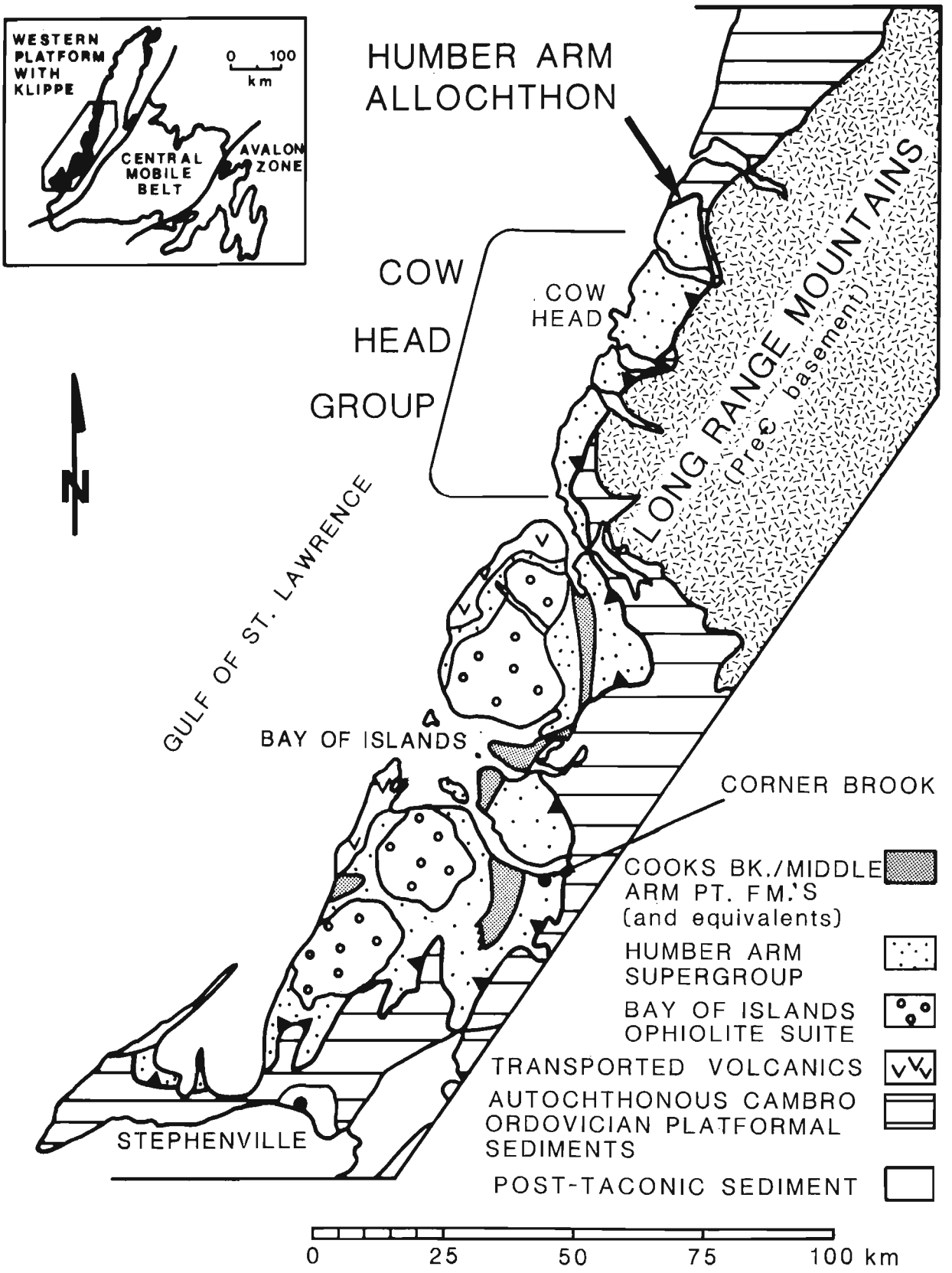

Figure 1: *Regional geology of the Humber Arm Allochthon showing the distribution of the Cook's Brook and Middle Arm Point formations.*

dolomitization, 4) anomalous trace metal occurrences within shales, and 5) manganese and barite precipitation.

Shales of the Middle Arm Point Formation locally demonstrate anomalously high concentrations of manganese, which is probably related to the ambient oxidizing conditions. Manganese carbonates and oxides have precipitated within shale along discrete zones up to several centimetres thick. Several of these zones demonstrate anomalously high concentrations of lead and zinc (about 300 ppm), which may have been scavenged from seawater by the manganese crusts. Shales from several sections spanning the uppermost Middle Arm Point Formation also demonstrate anomalously high barium concentrations (up to 0.5 percent). One such sample displays authigenic barite crystals visible in hand specimen. This precipitation is also interpreted to be related to the ambient oxidizing conditions.

Base metals may be concentrated in shales of the Middle Arm Point Formation to varying degrees, and this may be responsible for some of the base metal anomalies noted in this area by Dean and Meyer (1983, 1984, 1985). Metamorphosed equivalents of these rocks have been noted in the basal aureole of the Bay of Islands Ophiolite, and may also conceivably display anomalous metal concentrations.

A preliminary examination of the shale geochemical data suggests that they may also be useful for correlation and mapping purposes; a statistical approach will be used to test this idea. When combined with the large body of data assembled by Dean and Meyer (1983, 1984, 1985), this may prove to be a useful tool in mapping structurally complex areas within the Humber Arm Allochthon. It may be possible, for example, to identify geochemical signatures in the red and green shales on Wood's Island (possibly Summerside Formation) and thus provide a great aid in sorting out the structure.

Carbon and Sulfur Analysis

Analyses for total organic carbon and sulfur can be a time-consuming and tedious process when dealing with large numbers of samples. The Infrared Carbon/Sulfur/Water Analyser used in the Newfoundland Department of Mines and Energy geochemical lab is particularly well suited to projects of this kind, since it provides simultaneous analyses for all three components (Bouvier and Abbey, 1980). Discrimination between organic carbon and 'carbonate carbon' is critical in dealing with shales; this was done in this case by analyzing acidified and non-acidified pairs of samples. A more direct approach will be investigated this winter in cooperation with Mines and Energy staff, which should provide a faster and more precise method of determining organic carbon content in sedimentary rocks.

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