THE CAMBRIAN-ORDOVICIAN BOUNDARY

AND THE POSSIBLE CHOICE OF THE STRATOTYPE IN NEWFOUNDLAND

by

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INTRODUCTION

In the summer of 1981, the authors participated in a field trip arranged by the International Union of Geological Sciences Working Group on the Cambrian-Ordovician Boundary. The excursion took place in the Gros Morne National Park, where sections of the Cow Head Group (Figure 1) were inspected. The group included Drs. B.F. Norford* (Canada Chairman), R. Ludvigsen (Canada), B.D. Erdtmann* (W. Germany), A.W.A. Rushton* (United Kingdom), J.F. Miller* (U.S.A.), C.H. Kindle (U.S.A.) and J. Shergold* (Australia). Dr. R.F. Fortey (United Kingdom) guided the trip and was assisted by R.K. Stevens. The I.U.G.S. Working Group will visit as many exposures as possible around the world, of the Cambrian-Ordovician transition, in order to make a formal decision with regard to boundary level and stratotype. On this trip, interest was centered on the graptolites, trilobites and conodonts of the Cow Head Group.

THE CAMBRIAN-ORDOVICIAN BOUNDARY STRATOTYPE

The boundary stratotype should be practical so that a world-wide correlation of different successions in other regions with the stratotype is feasible. Requirements for a boundary-stratotype section include the following:

(1) It should be a continuous and nondisturbed sequence; (2) it should be fossiliferous comprising both shelly and graptolitic facies; (3) the sequence should preferably consist of successively alternating facies rather than a sequence of uniform facies; and (4) the section should be easily accessible. Other qualities evaluated include political and tectonic stability of the area and the ownership of the land/coastline on which the section is located.

The Cambrian and Ordovician Systems were established in Wales by the pioneers A. Sedgwick, R.I. Murchisoni, C. Lapworth and H. Hicks. It has, therefore, been considered appropriate, mainly based on grounds of historical priority (Whittington & Williams, 1964) to define the Cambrian-Ordovician boundary in Britain. Traditionally, many British scientists placed the Cambrian-Ordovician boundary at the base of Arenigian. In Scandinavia, however, the boundary is placed at the base of Tremadocian or at the first appearance of *Dictyonema flabelliforme* (Moberg, 1900). A third possibility would be to place the boundary within the Tremadocian, at or near the base of Upper Tremadocian (Henningsmoen, 1972).

Of the three possible horizons, the most widely used is that at the base of Tremadoc Series.

The casual reader may ask "Why is the selection of the stratotype important? Does it really matter if a boundary is put here or a few metres over there?". There are two main reasons. In this Province, we understand the importance of agreement on geographic boundaries, both onshore and offshore. If there is no agreement, much energy and money is wasted on fruitless arguments. It is the same in stratigraphy. Secondly, there must be agreement on the correlation of zones

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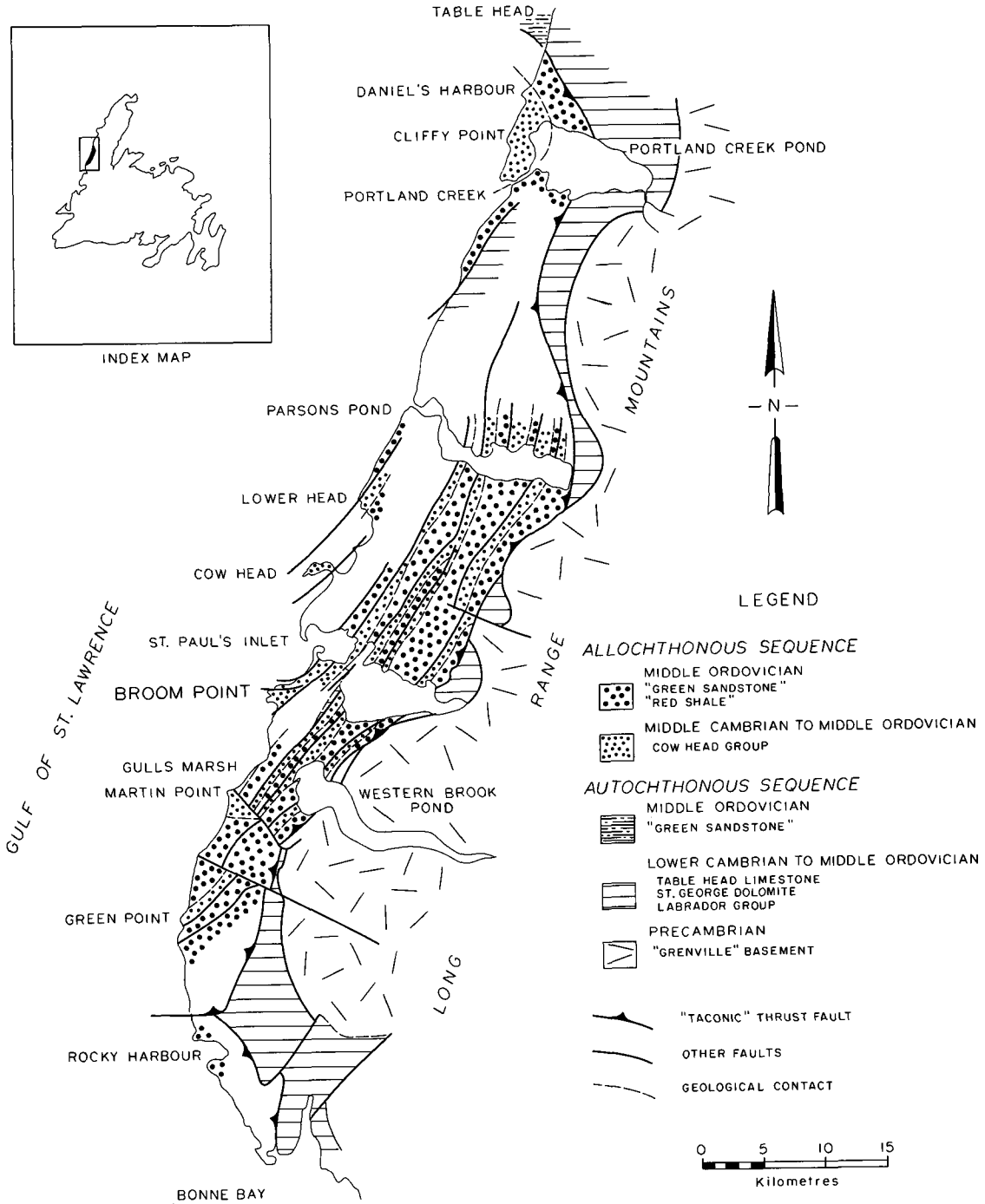

Figure 1 = Geologic map of the Cow Head Region. Geology modified from Oxley (Hubert et. al. 1977).

based on different taxa such as graptolites, trilobites and conodonts. Calibration points are needed if fine correlation between continents and fauna provinces within the continents is to be attained. The advantage of precise correlation should be obvious.

The major problem in fixing the Cambrian-Ordovician boundary with the subsequent choice of a suitable type section appears to be the position of the Tremadocian. The base of the Tremadoc Series has yet to be formally defined in a stratigraphic section. Stubblefield (1956) proposed a section in Wales where the Cambrian-Ordovician transition is preserved. Because the fossils are not abundantly represented or well preserved, strata in Wales have not generally been accepted as boundary stratotype. Furthermore, the sections in Wales are mainly of deep water facies.

In the United States, sequences spanning the Cambrian-Ordovician are developed in platform facies. Most studies there are concentrating on the Trempealeauan-Missisquoia Zones. The correlation over platform facies is good for shelly fauna elements, and conodonts provide good correlation to platform areas outside North America such as Siberia and Australia.

The correlation between the shelly faunas of the shallow and warm water platforms of U.S.A., Siberia and Australia with the graptolitiferous deep and colder water facies such as those from Wales is virtually impossible and correlation is at best tenuous (Table 1). This is due to faunal provincialism that persisted during this time interval. Thus, the platform sequences of North America have not yielded *Dictyonema flabelliforme* and the recognition of the Cambrian-Ordovician boundary based on graptolites is not possible on direct evidence there.

In Canada, the Cambrian-Ordovician boundary transition is best known from marginal areas to the Canadian Shield. The critical outcrops are preserved in the Cordilleran (west), the Franklinian (north) and the Appalachian (east) orogens (Norford, 1981). The shield formed a stable craton during the Late Cambrian-Early Ordovician time. The craton was fringed by wide carbonate platforms; offshore ocean basins were sites of shale deposition.

The intermediate zones, the deep water slopes of the carbonate platforms and adjacent basin floors were sites of mixed deposition. Coarse and fine carbonate debris were swept from the platform and deposited in deep water. A pelagic rain of fine carbonate was episodically put into suspension on the platform and transported out to sea to settle on the slope with ferrigenous silts and clays. The resulting strata are interbedded coarse breccia and conglomerate beds, lime sand turbidites and conglomerate beds, limes and turbidites, pelagic slope mudstones and shales. Just as the sediments are mixed, containing shallow-water platform components and deep water deposits, so the fossils are mixed and elements of both the North American craton succession and the traditional British deep water forms occur interbedded.

In Newfoundland, two localities have been proposed for a stratotype, both of which fulfill many of the requirements outlined above. The first is at Broom Point, western Newfoundland (Fortey & Skevington, 1980) (Figure 1), and the second is on Random Island, eastern Newfoundland (Poulsen, 1976) (Figure 2).

WESTERN NEWFOUNDLAND - BROOM POINT (FIGURE 1)

At Broom Point, limestones, shales and breccias of the Cow Head Group are exposed. The paleontological significance of the Cow Head Group was realized as soon as it was discovered by Richardson (in Logan, 1863) but useful faunal lists were not available until 1958 for graptolites and trilobites

NORTH AMERICA					EUROPE (SCANDINAVIA)				
SYSTEM	SERIES	STAGE	TRILOBITE ZONES	CONODONT ZONES	CONODONT ZONES	TRILOBITE ZONES	GRAPTOLITE ZONES	SERIES	SYSTEM
ORDOVICIAN	CANADIAN		*Symphusurina*	MIDCONTINENT FAUNA B	*Cordylodus angulatus*	*Peltocare*	*(Clonograptus)*	LOWER / TREMADOCIAN	ORDOVICIAN
					?	*Boeckaspis*	*Dictyonema flabelliforme*		
			Missisquoia	*Cordylodus proavus*		*Jujuyaspis Boeckaspis*			
CAMBRIAN	CROIXIAN	TREMPEAL-EAUAN	*Saukia*	*Proconodontus*	NOT ZONED	*Acerocare*	*(Radiograptus)*	UPPER / OLENID SERIES	CAMBRIAN

TABLE 1: Nomenclature of North American and European divisions. Correlation of Cambrian-Ordovician boundary between North America and Europe is not possible. The location of the Cambrian-Ordovician boundary in Europe follows that of Fortey & Skevington (1980) and in North America that of Erdtmann & Miller (1981). Data from Landing, et al., (1978), Henningsmoen (1972) and Erdtmann & Miller (1981).

(Kindle & Whittington, 1958) and 1978 for conodonts (Fahraeus & Nowlan, 1978). Since then additional data has been provided by Erdtmann (1971), Whittington (1963) and Fortey and Skevington (1980). The Working Group also had access to considerable unpublished data collected by N. James, R. Stevens, R. Fortey and E. Landing. These included detailed stratigraphic sections at a scale of 1:100.

Lithologically, the Cow Head Group consists of interbedded calcareous rocks of all grain sizes (micrometres to hundreds of metres) and shales with various carbonate content. Deposition mechanisms of the rocks represent a wide spectrum from debris flows, through turbidity currents and contour currents to pelagic rains. Considerable erosion often took place at the base of some of the coarser beds.

Major breccia horizons can be traced throughout the area (Hubert *et al.*, 1977; James *et al.*, 1979). The coarseness and thickness of the breccia beds or megabreccias decrease from the northwest (*i.e.* Stearing Islands and Lower Head) to the south and east (Green Point and Western Brook Pond). The megabreccias are considered to have been deposited during eustatic lows or regressions (James *et al.*, 1979; Stouge, 1980) that periodically occurred during Cambrian-Ordovician time.

The age of the Group is from Late Cambrian to latest Arenig or earliest Llanvirn. The Group is only 300 m thick at Cow Head, and hence, it is a condensed sequence. Therefore, collecting must be done at closely spaced intervals or whole zones may be missed.

The Cow Head Fauna has four major elements:

(1) Transported fossils contained in clasts of shallow water limestone of several different facies, representing a plexus of bank faunas.

(2) Transported slope faunas.
(3) Indigenous slope faunas.
(4) Pelagic faunas.

It is clear then that a single section of the Cow Head Group allows correlation between several faunal provinces using a variety of taxa. Strangely enough, correlation between Australia and Newfoundland can be established with all post-early Tremadoc pelagic faunas. In contrast, these faunas differ from the classic areas of Europe. Fortunately, the opposite is true during the Lower Tremadoc so that the Cambrian-Tremadoc boundary, as defined in Europe, can be recognized in several sections in the Cow Head Group using graptolites.

Not all sections are equally useful, however. The best shallow water faunas occur in the coarse northwestern facies. Indeed, it is these that have made Cow Head famous because they contain bank edge genera (*e.g.* Whittington, 1963) which are not commonly preserved in the presently exposed banks of the North American craton. As a rule, the coarsest breccias cut deep into the underlying stratigraphy and, in extreme cases may cut into the underlying breccia beds so that the resultant faunas are of mixed ages. The age of the underlying beds is of little use in determining the age of breccia formation and the pelagic sequence is incomplete. The problem is compounded because sea level change seems to have been particularly pronounced during late Cambrian and Tremadoc times so that breccia generation peaked about then.

In the more distal sections, pelagic sequences are more or less complete judging from the graptolite faunas. The breccias are so thin that there is very little if any erosion beneath them. It is very difficult, however, to extract or find trilobites from both the finer breccias and the interbeds. Only three or four trilobites have been collected, for example, from the Green Point section.

Fortunately, intermediate outcrops at Broom Point combine the best of both the distal and proximal sections. The pelagic sequence is well preserved, the breccias are fossiliferous as are the interbedded limestones.

BROOM POINT SECTION

The following description of the Broom Point Section is based on Fortey and Skevington (1980) and personal communication from Fortey (1981).

Sections through the Cambrian-Ordovician boundary are exposed at two places around Broom Point (see Fortey & Skevington, 1980, Figure 1 for location). Here they are referred to informally as Broom Point north and Broom Point south. Both have yielded excellent faunas through the critical interval.

Graptolites are abundant in the shales; conodonts and "autochthonous" trilobites are recorded from the interbedded limestones and trilobites and conodonts were obtained from clasts in the breccias.

The graptolite record is particularly clear. Rooted dendroids of Cambrian aspect occur with Cambrian trilobites and conodonts. A peculiar radiating form, *Radiograptus*, is the first siculate species and is followed by early Tremadoc members of the *Dictyonema flabelliforme plexus* accompanied by typical early Tremadoc conodonts and trilobites.

The Broom Point south section is complicated by slight erosion at the end of the *Proconodontus* conodont zone and the end of the *Saukia* trilobite zone. This coincides with the Cambrian-Ordovician boundary of most North American workers (Erdtmann & Miller, 1981) but is below the *Dictyonema flabelliforme* fauna and, therefore, according to Europe useage, within the Cambrian. All points considered, the group felt that the Broom Point north section is the better of the two.

EASTERN NEWFOUNDLAND - RANDOM ISLAND (FIGURE 2)

On Random Island a 1500 m thick Cambrian-Ordovician section was only mildly disturbed during the Acadian Orogeny. The sediments consist of uniformly bedded black shale with siltstones, without any lithological breaks, and represent deep-water deposition. The fossils are predominantly trilobites (Poulsen, 1976; Poulsen & Anderson, 1975), and acritarchs (Martin & Dean, 1981), which indicate a complete transition from

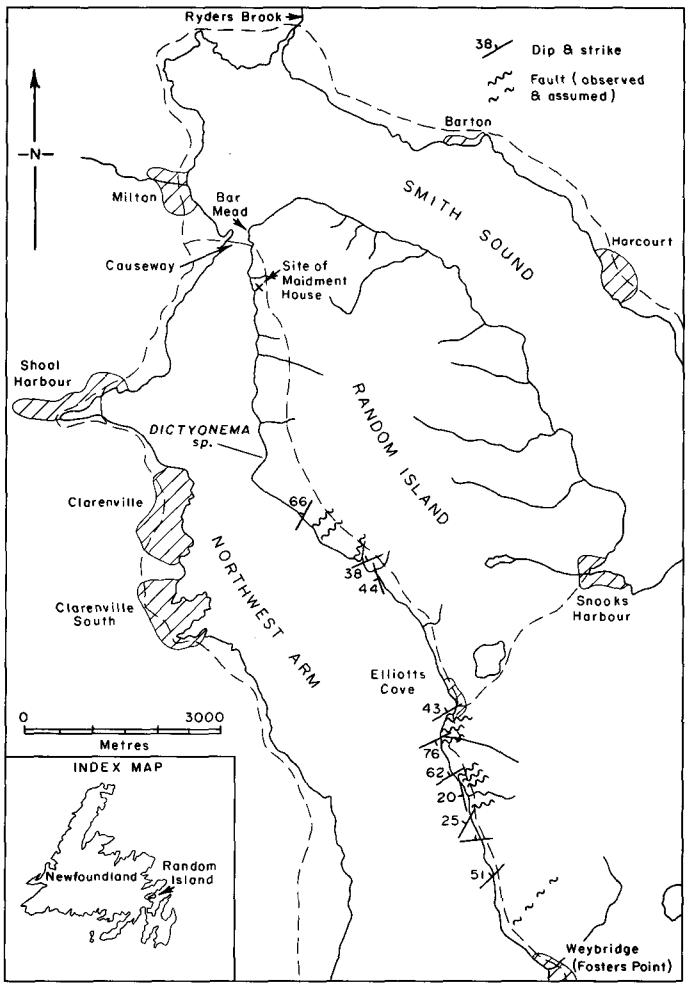

Figure 2 - Location map of northwestern of Random Island and adjacent mainland (modified from Martin & Dean, 1980).

Upper Cambrian into the Tremadocian. The presence of a *Dictyonema* of the *D. flabelliforme* type hints at the occurrence of Lower Tremadoc. Work on the Random Island section is still in a preliminary state and the Upper Tremadocian and basal Arenigian are poorly known.

SUMMARY

The decision of the location of the Cambrian-Ordovician boundary stratotype is still undecided. In Newfoundland, the Cambrian-Ordovician transition has been recognized and described from Broom Point in the Cow Head region, western Newfoundland and from Random Island, eastern Newfoundland. Both localities are excellently exposed and fossiliferous, and hence provide the basis for a choice of a stratotype for the Cambrian-Ordovician boundary in Newfoundland. Presently, little detailed work has been carried out on the Random Island Section. Trilobites, acritarchs and graptolites are known, but graptolites are rare. In contrast, the intensive study over the years on the Cow Head Group culminated in 1981 with the visit of the International Union of Geological Sciences Working Group on the Cambrian-Ordovician Boundary. The Broom Point Section allows for the intergration of zonal schemes based on graptolites, trilobites and conodonts - even across faunal provinces, and all agreed that the Broom Point north section of the Cow Head Group, western Newfoundland was an excellent contender for the honor of being the world stratotype of the Cambrian-Ordovician boundary.

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