The Ordovician-Silurian Boundary

by L.R.M. Cocks

The Ordovician-Silurian Boundary Working Group has formally defined the basal boundary stratotype for the Silurian System in a section at Dob's Linn near Moffat in the Southern Uplands of Scotland, U.K. The position of the stratotype point coincides with the base of the Parakidograptus acuminatus graptolite Biozone. This article outlines the background procedures leading to this definition.

Introduction

When Charles Lapworth created the Ordovician System in 1879, he unambiguously defined its top as coincident with the base of the Llandovery Series of the Silurian System, and, since that time, there has never been any serious disagreement with that general definition. However, it subsequently became obvious that the base of the Llandovery needed clarification for the purposes of correlation.

Since the 1870s, the standard method of correlation over wide areas for rocks of Ordovician and Silurian age has been by the analysis of graptolites and their zones. However, the base of the Llandovery Series in the type area of Llandovery, Wales, has not been easy to correlate directly because graptolites are uncommon there. Some authors took the base of the Silurian at the base of the Glyptograptus persculptus graptolite Biozone and others at the base of the succeeding Parakidograptus acuminatus Biozone. The situation was further complicated because the type development of the persculptus Biozone is in North Wales, whereas the type section of the acuminatus Biozone is at Dob's Linn, near Moffat, Scotland (Fig. 1).

Procedures Used

With the modern desire for more accurate international definitions of standard geological system boundaries, the Ordovician-Silurian Boundary Working Group of the IUGS Commission on Stratigraphy was set up in 1974 jointly by the Subcommissions on Ordovician Stratigraphy and on Silurian Stratigraphy. At its first meeting in Birmingham, England, during the Ordovician Symposium, R.B. Rickards (U.K.) was elected as Chairman, with L.R.M. Cocks (U.K.) as Secretary. Work was carried out mainly by correspondence, and numerous sections that spanned the Ordovician-Silurian boundary in many countries were documented and briefly described.

In 1979 a joint meeting of the Working Group and the Silurian Subcommission was held in Great Britain, and each of the various boundary sections was discussed in turn and graded according to its stratotype potential. Only two sections were classified as having primary stratotype potential: Dob's Linn, where the correlation would be effected by graptolites, and Anticosti Island in the Gulf of St. Lawrence, eastern Canada, where conodonts would be used for the dating. Accordingly, Dob's Linn was examined by the Group during the 1979 excursion, and in 1981 a field excursion was arranged to study the sections on Anticosti Island.

Between 1979 and 1983, a variety of written opinions on the boundary were circulated to all the members by post, and during the 1982 Ordovician Symposium in Oslo, an informal vote of those present preferred the Anticosti and conodont alternative. However, during the subsequent formal postal vote of the Voting Members of the Working Group, the decision was in favour of Dob's Linn by 12 votes to 5 (with two abstentions). A further vote was taken to determine the preference for defining a stratotype base in relation to either the persculptus or the acuminatus Biozone, and the result was 10 votes to 5 in favour of the acuminatus Biozone at Dob's Linn, with 4 abstentions. The Corresponding Members also voted informally in comparable proportions.

A factor in favour of the acuminatus Biozone was that this placed the Ordovician-Silurian boundary clearly above the widespread and distinctive Late Ordovician Hirnantia shelly fauna. Although most of this fauna is confined to pre-persculptus Biozone strata, in the last ten years it has become clear that some developments of the Hirnantia fauna, such as those occurring in Kazakhstan, Tasmania, and the English Lake District, extend upwards into rocks of persculptus Biozone age. Thus their clear-cut allocation to the Ordovician rather than to the Silurian, or spanning the boundary, has been welcomed by many scientists.

Figure 1: General view of the Dob's Linn area, near Moffat, Scotland.

Another factor that influenced the choice of Dob's Linn rather than Anticosti was the disappointingly sparse occurrence of graptolites near the boundary in Anticosti, coupled with the difficulty in finding the Anticosti conodonts in Ordovician-Silurian boundary strata elsewhere. This was a pity because the Anticosti sections have abundant shelly faunas, particularly brachiopods, trilobites and corals, as well as ostracodes, chitinozoans and the conodonts. None of these groups, however, can yet be used for such fine correlation as the graptolites. By contrast, the persculptus and acuminatus Biozones to which the boundary is now related are found in many parts of the world, even though there is often an

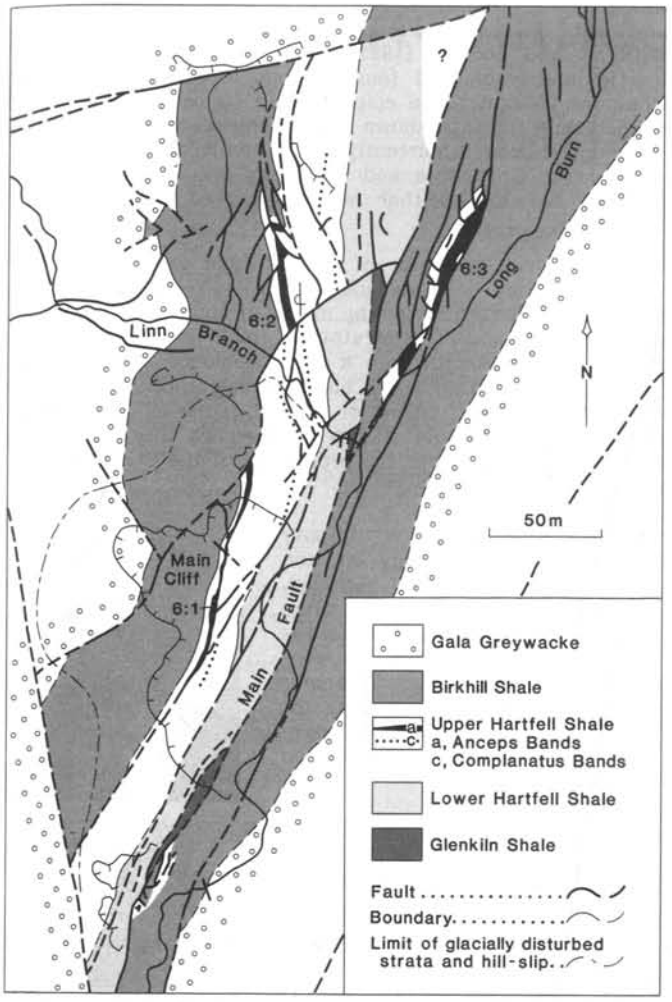

Figure 2: Geological map of the main part of the Dob's Linn Inlier (redrafted from Ingham, 1979). The stratotype boundary for the Ordovician-Silurian is at Locality 6:2. The base of the acuminatus Biozone is also exposed at Localities 6:1 and 6:3.

unconformity at the Ordovician-Silurian boundary due to the widespread latest Ordovician regressions and earliest Silurian transgressions, which were caused by the contemporary ice age.

The base of the acuminatus Biozone can be recognized in Scotland (at many other places in the Southern Uplands in addition to Dob's Linn), Wales, Ireland, England, Norway, Sweden, Denmark, West and East Germany, Poland, France, many parts of the U.S.S.R., China, Australia, North Africa, Canada and the U.S.A. (including Alaska). Of course, the stratotype Ordovician-Silurian boundary not only defines the base of the Silurian, but it is also by definition concomitant with the base of the lowest series of the Silurian, the Llandovery Series, and the base of the lowest stage within the series, the Rhuddanian Stage. Both these two latter names are now agreed formally by the Subcommission on Silurian Stratigraphy (see Holland, this issue).

The Stratotype

The Dob's Linn section was first described in 1878 in a now classic paper by Charles Lapworth, the founder of the Ordovician System. He recognized that bands of black shale containing different graptolite faunas were repeated tectonically, and by careful palaeontology he was able to establish a sequence of Ordovician-Silurian graptolite Biozones from near the base of the Caradoc Series to near the top of the Llandovery Series. These graptolites together with those from other areas were described in a substantial monograph by Elles and Wood (1901-18), inspired and edited by Lapworth. Subsequently these graptolite zones were recognized in virtually every part of the world.

In the last twenty years, more modern studies have revised and enhanced Lapworth's results. Toghill (1968) revised the lower Silurian succession at Dob's Linn; Ingham (1974, 1979) has published more detailed geological maps (e.g. Fig. 2) than hitherto, and most importantly Williams (1980, 1982a, 1982b, 1983) has revised the latest Ordovician and earliest Silurian strata and their faunas. The present account is largely taken from Ingham and Williams' work.

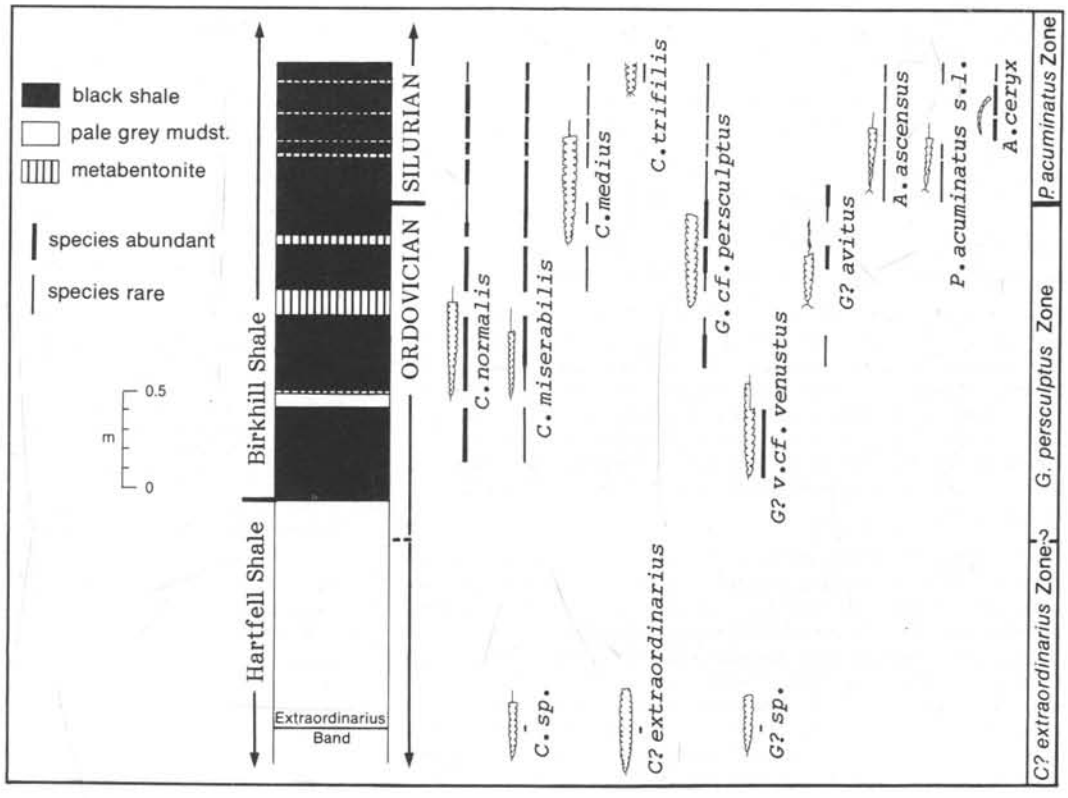

Figure 3: Lithological succession and species ranges of graptolites in the uppermost part of the Hartfell Shale and basal part of the Birkhill Shale in the stratotype boundary section at Dob's Linn, Scotland (after Williams, 1983, text-fig. 1).

Two lithological units (formations), originally recognized by Lapworth occur near the boundary. The lower is the Hartfell Shale (48 m thick), consisting chiefly of pale grey mudstones with subordinate black shales and several interbedded metabentonites. Above this is the 43 m-thick Birkhill Shale, which consists predominantly of black graptolitic shale with subordinate grey mudstones and metabentonites.

In general the grey mudstones of the 28 m-thick Upper Hartfell Shale contain very few fossils, but the interbedded black shales are rich in graptolites. The lowest of these graptolite bands carries Diplograptus complanatus Biozone species. Above these come several groups of bands that are referable to the Dicellograptus anceps Biozone, including, near the top, bands that can be referred to the complexus and pacificus Subzones. Following these comes a single graptolitic band referable to the Climacograptus extraordinarius Biozone and overlain by 1.17 m of unfossiliferous grey mudstone before the top of the Hartfell Shales is reached (Fig. 3).

The succeeding Birkhill Shale is composed chiefly of black graptolitic shale and is thus virtually continuously fossiliferous. G. persculptus Biozone graptolites at its base change 1.6 m higher to P. acuminatus Biozone forms, succeeded 5.1 m later by Cystograptus vesiculosus Biozone species and so on in a sequence representing every Llandovery graptolite zone up to the late Llandovery Rastrites maximus Biozone at the top of the Birkhill Shale. Above this are much less fossiliferous turbidites.

Comment

As stated above, the Ordovician-Silurian stratotype boundary has been drawn in the sequence at a point coincident with the base of the acuminatus graptolite Biozone. This horizon is exposed in several different sections in the Dob's Linn area, but the best, and hence the one selected for the boundary stratotype itself is in an artificial excavation (Locality 6.2 in Fig. 2) created just north of the Linn Branch stream (U.K. National Grid Reference NT 1962 1584). Although the rocks here are steeply dipping, there is no sign of structural disturbance or minor faulting across the boundary interval and a complete sequence is exposed continuously through the anceps, extraordinarius, persculptus, acuminatus and the lower part of the vesiculosus Biozones.

The lithological base of the Birkhill Shale Formation is clearly visible here, and the base of the acuminatus Biozone, although not marked by any lithological changes, is verified at 1.6 m above the base of the Birkhill Shale Formation by the incoming of Parakidograptus acuminatus (Nicholson, 1867) and Akidograptus ascensus (Davies, 1929). The stratotype base of the Silurian System is thus defined at this point, 1.6 m above the base of the Birkhill Shale Formation.

The environment of the Birkhill Shale succession is considered to represent steady deposition of mudstone interrupted by occasional ash deposits on the floor of the Iapetus Ocean, in very deep water, hundreds and perhaps more than a thousand kilometres away from the nearest land. After the closure of Iapetus in latest Silurian or early Devonian times, the Moffat area was fortuitously preserved in the accretionary prism of the whole Southern Uplands area of Scotland.

Over eighty different species of graptolites are known and monographed from the Birkhill Shale Formation, and an accurate chart of the 13 species in the few metres surrounding the Ordovician-Silurian boundary is shown in Figure 3. Although the preservation of some of the Dob's Linn graptolite material is poor, graptolites are extremely abundant at numerous horizons here. Many specimens, however, are very well preserved, including some in full relief, such as the specimen of Akidograptus ascensus figured by Williams (1983, Fig. 9f) from the acuminatus Biozone.

Apart from graptolites, fossils of other groups are not abundant in the Dob's Linn boundary beds. However, Williams and Lockley (1983) have described some of the inarticulate brachiopod fauna found, consisting largely of what are thought to be epiplanktonic forms. A large blind dalmanitinid trilobite known from many specimens from the persculptus Zone is currently being studied by J.K. Ingham and others. Chitinozoa and conodonts are known from the section, but are neither well preserved nor very age diagnostic.

In conclusion, the choice of a stratotype section at Dob's Linn will ensure accurate and widespread correlation of the base of the Silurian System by means of abundant and diverse graptolite faunas. The stratotype itself is in an uncomplicated succession through a thick sequence of sediments. The section is within a few hundred metres of a main road with no problems of access or for collecting of comparative faunas, and the whole site is a scheduled Site of Special Scientific Interest under the protection of the British Nature Conservancy Council.

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