The type Ludlow Series: Chronostratigraphy

The Ludlow Series comprises two stages, the Gorstian Stage below and the Ludfordian Stage above. Boundary stratotypes of all three chronostratigraphical divisions are located in the Ludlow area. The base of the overlying Prídolí Series approximates to the base of the Downton Castle Sandstone Formation in the Ludlow area.

See: Boundary stratotype for the base of the Ludlow Series and Gorstian Stage.
Boundary stratotype for the base of the Ludfordian Stage.
Local base of the Prídolí Series.

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[Author: SGM]

Boundary stratotype for the base of the Ludlow Series and Gorstian Stage

The boundary stratotype for the base of the Ludlow Series and the Gorstian Stage is at Pitch Coppice Quarry. The base of the Ludlow Series (and the Gorstian Stage) is at the base of bed F1 (0.25 m thick, comprising shales with nodular limestones, numerous shells and corals, immediately overlying bed E, a hard, crystalline, poorly fossiliferous limestone). See: Pitch Coppice Quarry - vertical section.

The lithological transition from the Wenlock Series to the Ludlow in the latter's type area is accompanied by a change in the environmentally controlled shelly fauna. The coral and large brachiopod-dominated assemblage of the Wenlock is replaced by the small brachiopod-dominated assemblage of the lowest Ludlow, although the change is not abrupt and is not fully achieved within the Ludlow strata exposed in Pitch Coppice Quarry. The shelly fauna, being facies controlled, is of no value in defining the series boundary. Nevertheless, a distinction can be made between Wenlock and Ludlow faunas where the appropriate facies are developed, and the base of the *Glassia obovata* Association is placed at the base of the Ludlow Series. See: Pitch Coppice Quarry - shelly fauna.

Definition of the series boundary is based on the graptolite faunas. In the stratotype section, ?*Saetograptus* (*Colonograptus*) *varians* (Wood) and ?*Neodiversograptus nilssoni* (Barrande) occur respectively 0.03 m and within 0.23 m above the base of the Ludlow Series, i.e. both are from bed F1. Although firm identification is precluded by poor preservation, these graptolites are considered to provide a strong indication of the *nilssoni* Biozone (Lawson & White 1989, pp. 81-82). The highest graptolites from the Wenlock Series, collected approximately 25 m above the base of the Much Wenlock Limestone Formation, indicate the *ludensis* Biozone (Holland *et al*. 1969; see also Lawson & White 1989, p. 84, and Siveter *et al*. 1989, p. 61, loc. 3.7e). Although no graptolites have been collected from the upper two thirds (40 m) of the Much Wenlock Limestone Formation (Lawson & White 1989, p. 84), the base of the Ludlow Series is correlated in practice with the base of the *nilssoni* Biozone on this evidence.

Other fossil groups provide no basis for precise correlation of the series boundary. Conodonts from the highest Wenlock and lowest Ludlow Series at Pitch Coppice are sparse, and faunas from both comprise the long-ranging species *Ozarkodina excavata* (Branson & Mehl) and *Panderodus equicostatus* (Rhodes). The series boundary lies within Chitinozoan Biozone 1 (Sutherland 1994) at Pitch Coppice Quarry, and within the *Scylaspora downiei-Concentricosiporites saggitarius* Spore Biozone in south Wales, although spores indicative of that zone have yet to be recorded from the Ludlow area. Furthermore, many ostracode taxa cross the series boundary from the Wenlock. Accordingly, the base of the Ludlow Series cannot yet be recognized using any of these groups.

The base of the *Leptobrachion longhopense* Acritarch Biozone has been correlated with the base of the Ludlow Series, but no details have been published.

As yet, only biostratigraphical criteria have been used to correlate the base of the series.

(continued...)

Boundary stratotype for the base of the Ludlow Series and Gorstian Stage (continued)

From a study of benthic communities, which he considered to be depth related, Hurst (1975) concluded that a rapid transgressive event had been initiated close to the Wenlock-Ludlow boundary, and was synchronous throughout the Welsh Borderland. He proposed that the base of the Ludlow should be redefined at the level of the initiation of this transgression, which he identified as being some 3 m above the top of the Much Wenlock Limestone Formation in the type area (see Lawson & White 1989, p. 81). However, Bassett (1976) argued that the recognition of such an event was no basis for chronostratigraphical redefinition of the boundary. Furthermore, Bassett (1976) maintained that there was no evidence for such a synchronous rapid eustatic or epeirogenic transgression, and concluded that the undoubted deepening across the Wenlock-Ludlow series boundary could be explained by downwarping of the Welsh Borderland shelf.

Bassett, M.G. 1976. A critique of diachronism, community distribution and correlation at the Wenlock-Ludlow boundary. *Lethaia*, **9**, 207-218.

Holland, C.H., Rickards, R.B. & Warren, P.T. 1969. The Wenlock graptolites of the Ludlow district, Shropshire, and their stratigraphical significance. *Palaeontology*, **12**, 663-683.

Hurst, J.M. 1975. The diachronism of the Wenlock Limestone. *Lethaia*, **8**, 301-314.

Lawson, J.D. & White, D.E. 1989. The Ludlow Series in the Ludlow area. *In* Holland, C.H. & Bassett, M.G. (eds) *A global standard for the Silurian System*. National Museum of Wales, Geological Series No. **9**, Cardiff. 73-90.

Siveter, D.J., Owens, R.M. & Thomas, A.T. 1989. *Silurian field excursions: a geotraverse across Wales and the Welsh Borderland*. National Museum of Wales, Geological Series No. **10**, Cardiff. 133pp.

Sutherland, S.J.E. 1994. Ludlow chitinozoans from the type area and adjacent regions. *Palaeontographical Society Monograph*, London, 1-104, pls 1-18 (publ. No. 594, part of vol. 148 for 1994).

See: Chitinozoan Biozone 1, *Glassia obovata* Association, Gorstian conodont faunas, Gorstian ostracode faunas, carbon isotopes, *Leptobrachion longhopense* Biozone, *Neodiversograptus nilssoni* Biozone, Pitch Coppice Quarry, *Scylaspora downiei-Concentricosiporites saggitarius* Biozone.

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Boundary stratotype for the base of the Ludfordian Stage

The boundary stratotype for the base of the Ludfordian Stage is at Sunnyhill Quarry, where the boundary coincides with the stratigraphical contact between the Upper Bringewood and Lower Leintwardine formations. The basal 2.3 m of the Lower Leintwardine Formation at Sunnyhill Quarry are lithologically similar to the Upper Bringewood Formation, but are faunally distinct, the base of the Lower Leintwardine Formation coinciding approximately with the boundary between the *Mesopholidostrophia laevigata* and *Sphaerirhynchia wilsoni* shelly faunal associations. At or near the formational boundary, the following fossils either disappear or become very rare: the brachiopods *Kirkidium knightii* (J. Sowerby), *Strophonella euglypha* (Hisinger), *Gypidula lata* Alexander (not recorded at Sunnyhill Quarry) and *Eospirifer radiatus* (J. de C. Sowerby), colonial tabulate corals and solitary corals, the trilobite *Dalmanites myops* (König) and the gastropod *Poleumita globosa* (Schlotheim). Other brachiopod species, although present in pre-Ludfordian rocks, come to dominate faunas above the boundary, notably *Atrypa reticularis* (Linnaeus), *Dayia navicula* (J. de C. Sowerby), *Isorthis orbicularis* (J. de C. Sowerby), *Microsphaeridiorhynchus nucula* (J. de C. Sowerby), *Shagamella minor* (Salter) (= *Shagamella ludloviensis* Boucot & Harper) and *Sphaerirhynchia wilsoni* (J. Sowerby).

A record of *Saetograptus leintwardinensis incipiens* (Wood) from the Upper Bringewood Formation at Ludlow (Holland *et al*. 1963, p. 113) indicates that this part of the succession is still within the *Pristiograptus tumescens/Saetograptus incipiens* Biozone (Lawson & White 1989, p. 79). *Saetograptus leintwardinensis leintwardinensis* (Lapworth), indicating the *Saetograptus leintwardinensis* Biozone and common in the upper part of the Lower Leintwardine Formation, is present near the base of the formation at some localities, particularly Aymestrey and Leintwardine, and occurs about 0.25 m above the base of the formation at the boundary stratotype (Cherns 1988). The base of the Ludfordian is considered to approximate to the base of the *leintwardinensis* Biozone.

Of other stratigraphically important faunal groups, conodonts and chitinozoa have been recorded from Sunnyhill Quarry. The Upper Bringewood Formation has yielded reasonable numbers of conodonts, although there is no precise indication of where they occur in the succession. Collections are dominated by *Ozarkodina confluens* (Branson & Mehl), *O. excavata* (Branson & Mehl) and species of *Panderodus* (Aldridge & Smith 1985; see also Siveter *et al*. 1989, loc. 3.6a). The lowest metre of the Lower Leintwardine Formation at Sunnyhill Quarry has yielded abundant conodonts in a fauna dominated by *Ozarkodina confluens*, *O. excavata* and *Panderodus*. Bed F of Holland *et al*. (1963; C11 of White & Lawson 1978), approximately 0.5 to 0.9 m above the base of the Lower Leintwardine Formation, also yielded *Kockelella variabilis* Walliser and *Coryssognathus dubius* (Rhodes) (Aldridge & Smith 1985, p. 31, Siveter *et al*. 1989, p. 56, Lawson & White 1989, p. 86). This represents the highest recorded occurrence of *Kockelella variabilis* in the type Ludlow succession.

The base of Chitinozoan Biozone 9 is located at the top of the Upper Bringewood Formation in Sunnyhill Quarry, immediately below the thin shale at the base of the Lower Leintwardine Formation (Sutherland 1994, text-fig. 47).

(continued...)

Boundary stratotype for the base of the Ludfordian Stage (continued)

Aldridge, R.J. & Smith, M.P. 1985. Lower Palaeozoic succession of the Welsh Borderland. Fourth European Conodont Symposium (ECOS IV) Field Excursion B Guidebook, 39 pp.

Cherns, L. 1988. Faunal and facies dynamics in the upper Silurian of the Anglo-Welsh basin. *Palaeontology*, **31**, 451-502.

Holland, C.H., Lawson, J.D & Walmsley, V.G. 1963. The Silurian rocks of the Ludlow district, Shropshire. *Bulletin of the British Museum* (*Natural History*), Geology, **8**, 95-171, pls 1-7.

Lawson, J.D. & White, D.E. 1989. The Ludlow Series in the Ludlow area. *In* Holland, C.H. & Bassett, M.G. (eds) *A global standard for the Silurian System*. National Museum of Wales, Geological Series No. **9**, Cardiff. 73-90.

Siveter, D.J., Owens, R.M. & Thomas, A.T. 1989. *Silurian field excursions: a geotraverse across Wales and the Welsh Borderland*. National Museum of Wales, Geological Series No. **10**, Cardiff. 133pp.

Sutherland, S.J.E. 1994. Ludlow chitinozoans from the type area and adjacent regions. *Palaeontographical Society Monograph*, London, 1-104, pls 1-18 (publ. No. 594, part of vol. 148 for 1994).

White, D.E. & Lawson, J.D. 1978. The stratigraphy of new sections in the Ludlow Series of the type area, Ludlow, Salop, England. *Report of the Institute of Geological Sciences*, No. **78/30**, 1-10.

See: Chitinozoan Biozone 9, Ludfordian conodont faunas, *Mesopholidostrophia laevigata* Association, *Pristiograptus tumescens/Saetograptus incipiens* Biozone, *Saetograptus leintwardinensis* Biozone, *Sphaerirhynchia wilsoni* Association, Sunnyhill Quarry.

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Local base of the Prídolí Series

The Ludlow Series is succeeded by the Prídolí Series. In the Ludlow area, the Upper Whitcliffe Formation is overlain by the Downton Castle Sandstone Formation. Immediately above the base of the Downton Castle Sandstone Formation, residual upper Ludlow faunal elements, including the brachiopods *Microsphaeridiorhynchus nucula* (J. de C. Sowerby), *Protochonetes ludloviensis* Muir-Wood and *Salopina lunata* (J. de C. Sowerby), and the ostracode *Calcaribeyrichia torosa* (Jones), overlap with an ostracode fauna that comprises *Frostiella groenvalliana* Martinsson, *Londinia arisaigensis* Copeland, *Londinia fissurata* Shaw and *Nodibeyrichia verrucosa* Shaw (White & Lawson 1989, fig. 103).

The *Frostiella groenvalliana* association forms part of a sequence of ostracode associations of widespread occurrence, although the sequence cannot be fully demonstrated in the British succession. The same association is present in Arisaig (Nova Scotia), Maine, the Baltic states and Poland. In the Baltic states, it is accompanied by graptolites that enable correlation with the type Prídolí Series. In particular, *F. groenvalliana* appears 68 m above *Monograptus parultimus* Jaeger, indicative of the basal Prídolí *parultimus* Graptolite Biozone, in the Dubovskoe Borehole of the Kaliningrad area, Estonia, and consistently appears above levels correlated with the base of the *parultimus* Biozone in Estonia, Lithuania and Poland (Miller 1995). As *F. groenvalliana* appears at the base of the Ludlow Bone Bed Member of the Downton Castle Sandstone Formation at Ludlow (Miller 1995, p. 351, text-fig. 6), it provides strong evidence for placing the base of the Prídolí Series at or below the base of that formation.

Records of the conodont *Ozarkodina* cf. *crispa* (Walliser), 0.15 to 0.3 m below the base of the Downton Group in the Ludlow type area, support correlation of the base of the Downton Group with the base of the Prídolí Series. In Bohemia, the base of the Prídolí Series is 0.5 m above the highest occurrence of *O. crispa*, which has a limited stratigraphical range in the highest Ludlow rocks there (2.75 to 0.5 m below the base of the Prídolí Series in the stratotype section at Pozáry; see Miller 1995, p. 372; see also White & Lawson, 1989, p. 138; Aldridge & Schönlaub, 1989, p. 278).

Similarly, a record of *Eisenackitina barrandei* Paris & Kríz from the top of the Upper Whitcliffe Formation, between 0.23 and 0.26 m below the top of the Ludlow Series near Downton, west of Ludlow (Richardson & Rasul 1990, fig. 10b), suggests correlation with a level immediately below the base of the Prídolí Series. *Eisenackitina barrandei* is restricted to the *barrandei* Biozone, the base of which lies 6.5 m below the Ludlow-Prídolí boundary in the stratotype section at Pozáry (Verniers *et al*. 1995). The *barrandei* Biozone extends just into the base of the Prídolí Series in Bohemia, the base of the overlying *Fungochitina kosovensis* Biozone lying 0.1 m above the base of the Prídolí at Pozáry.

(continued...)

Local base of the Prídolí Series (continued)

Aldridge, R.J. & Schönlaub, H.P. 1989. Conodonts. *In* Holland, C.H. & Bassett, M.G. (eds) *A global standard for the Silurian System*. National Museum of Wales, Geological Series No. **9**, Cardiff. 274-279.

Miller, C.G. 1995. Ostracode and conodont distribution across the Ludlow/Prídolí boundary of Wales and the Welsh Borderland. *Palaeontology*, **38**, 341-384.

Richardson, J.B. & Rasul, S.M. 1990. Palynofacies in a Late Silurian regressive sequence in the Welsh Borderland and Wales. *Journal of the Geological Society, London*, **147**, 675-686.

Verniers, J., Nestor, V., Paris, F., Dufka, P., Sutherland, S. & Van Grootel, G. 1995. A global Chitinozoa biozonation for the Silurian. *Geological Magazine*, **132**, 651-666.

White, D.E. & Lawson, J.D. 1989. The Prídolí Series in the Welsh Borderland. *In* Holland, C.H. & Bassett, M.G. (eds) *A global standard for the Silurian System*. National Museum of Wales, Geological Series No. **9**, Cardiff. 131-141.

See: Conodonts from the Upper Whitcliffe Formation, *Eisenackitina barrandei* Biozone, *Frostiella groenvalliana*, Ostracodes and correlation of the base of the Prídolí Series, *Ozarkodina crispa*, *Protochonetes ludloviensis* Association, Whitcliffe Road.

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