

The type Ludlow Series: Sunnyhill Quarry and adjacent section

Sunnyhill Quarry and the adjacent track section leading to Overton Quarry are situated in Mortimer Forest [SO 4948 7254 to SO 4974 7244], about 3 km SW of Ludlow. Strata from the Upper Bringewood Formation to the Lower Whitcliffe Formation are exposed. Numbers bearing the prefix 'C' refer to localities of White & Lawson (1978). Select '[Sunnyhill - vertical section](#)' to display the section, '[Sunnyhill - map](#)' for a plan of the section, and '[Ludlow Anticline](#)' for the location of the section.

Sunnyhill Quarry and the adjacent track section have yielded shelly faunas, graptolites, conodonts, chitinozoa and ostracodes, and so provide evidence to link these biostratigraphically important groups. Bentonites are also present, but their stratigraphical utility has not been tested.

Sunnyhill Quarry is the basal boundary stratotype for the Ludfordian Stage.

Sunnyhill Quarry and the adjacent track section are Sites of Special Scientific Interest. Permission to study them (researchers only) should be obtained from the Forestry Commission at Ludlow. Other visitors (school and undergraduate parties) are directed towards specially prepared exposures along the Wigmore Road. See Siveter *et al.* (1989) for details.

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.

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: [Boundary stratotype for the base of the Ludfordian Stage, Sunnyhill - bentonites, chitinozoa, conodonts, graptolites, lithostratigraphy, map, ostracodes, shelly faunas, vertical section, Ludlow Anticline.](#)

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Sunnyhill Quarry and adjacent section - lithostratigraphy

The **Upper Bringewood Formation** in Sunnyhill Quarry comprises light olive-grey, fairly massive, calcareous siltstones in the lowest 2.64 m of the quarry (beds C1-C5), argillaceous in the lower part, flaggy towards the top, and interbedded with bentonites. These are overlain by 2.07 m of medium grey, nodular limestones, massive towards the base, interbedded with light olive-grey, calcareous siltstones (beds C6-C8) (White & Lawson 1978; Lawson & White 1989).

Sunnyhill Quarry is the stratotype for the base of the **Lower Leintwardine Formation**, and the adjacent track section between Sunnyhill and Overton quarries constitutes a body stratotype. The lowest 2.36 m of the formation in Sunnyhill Quarry (beds C9-C13) consist of light olive-grey to medium grey, massive or nodular, occasionally silty limestones, interbedded with calcareous siltstones and bentonites. Lithologically, this lowest part of the formation resembles beds at the top of the Upper Bringewood Formation. They are overlain by light olive-grey, flaggy, calcareous siltstones with thin silty limestone beds (bed C14) (White & Lawson 1978; Lawson & White 1989).

The Lower Leintwardine Formation is less calcareous in the upper part of the section (localities C19-C25), and limestone beds are absent. Hard, massive, calcareous siltstones with scattered limestone nodules occur in the highest 3.2 m of the formation (localities C26-C28). The formation is estimated to be about 29 m thick in the Sunnyhill section (White & Lawson 1978).

The lowest metre of the **Upper Leintwardine Formation** (locality C29) comprises hard, light olive-grey, massive, calcareous siltstones with scattered limestone nodules, overlain by 2 m of light olive-grey, sandy, mainly flaggy siltstones (localities C30, C31). There is a 4 m gap between the highest beds of the formation exposed in the section, and beds of the Lower Whitcliffe Formation (White & Lawson 1978).

In detail, the section across the Gorstian-Ludfordian boundary and the Upper Bringewood Formation-Lower Leintwardine Formation boundary at Sunnyhill Quarry is as follows.

(continued...)

Sunnyhill Quarry; section across the Gorstian-Ludfordian and Upper Bringewood Formation-Lower Leintwardine Formation boundaries

Bed		Lithology	Thickness		
C14	(I)	light olive grey, flaggy, calcareous siltstones; very fossiliferous	2.40 m		
C13	(H)	light olive-grey, silty, nodular limestones	1.37 m		
C12	(G)	bentonite	0.08 m		
C11	(F)	light olive-grey to medium grey, massive, nodular limestones; often crinoidal; with silty layers	0.38 m	Lower Leintwardine Formation	Ludfordian Stage
C10	(E)	shale (possibly bentonitic?)	0.05 m		
C9	(D)	nodular crinoidal limestones and calcareous siltstones; not very fossiliferous	0.48 m		
	(C)	shale parting	0.006 m		
C8	(B)	medium grey, nodular, crinoidal limestones; light olive-grey calcareous siltstones; shell debris	0.60 m		
C7	(A)	medium grey, nodular limestones; light olive-grey calcareous siltstones; shell debris; very fossiliferous	0.60 m		
C6		medium grey, hard nodular limestones, massive towards base; not very fossiliferous	0.85 m		
C5		light olive-grey, fairly massive to flaggy calcareous siltstones; very fossiliferous; including shell debris	1.40 m	Upper Bringewood Formation	Gorstian Stage
C4		bentonite	0.20 m		
C3		light olive-grey, irregularly flaggy, calcareous and finely micaceous siltstones; not very fossiliferous	0.58 m		
C2		bentonite	0.02 m		
C1		light olive-grey, calcareous and finely micaceous siltstones, with massive appearance but irregularly flaggy; small shells and debris common	0.44 m		

C1-C14 are combined bed and locality numbers used by White & Lawson (1978) and Lawson & White (1989). A-I are bed identification letters of Holland *et al.* (1963).

See also '[Sunnyhill Quarry - profile](#)' for a graphic display of the section across the stage and formation boundaries.

(continued...)

Sunnyhill Quarry and adjacent section - lithostratigraphy (continued)

- 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.
- 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: [Upper Bringewood Formation, Lower Leintwardine Formation, Upper Leintwardine Formation, Sunnyhill - map, vertical section, Sunnyhill Quarry - profile.](#)

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Sunnyhill Quarry and adjacent section - shelly faunas

Shelly faunas from Sunnyhill Quarry and the adjacent track section to Overton Quarry represent the *Mesopholidostrophia laevigata* Association, the upper phase of the *Sphaerirhynchia wilsoni* Association, and the *Shaleria ornatella* Association.

Mesopholidostrophia laevigata Association

Lawson & White (1989, fig. 52) assigned the shelly fauna from the Upper Bringewood Formation to the *Kirkidium knightii* Association, but White & Lawson (1978, p. 10) reported *K. knightii* (J. Sowerby) to have a scattered occurrence in the Upper Bringewood Formation at Sunnyhill Quarry, rather than forming the coquinas that characterize the association. Both Watkins (1979, fig. 16) and Watkins & Aithie (1980, fig. 14) assigned faunas from the Upper Bringewood Formation in the vicinity of Sunnyhill Quarry to the *Mesopholidostrophia laevigata* Association. The *M. laevigata* Association contains rare specimens of *Kirkidium knightii* (Watkins & Aithie 1980, table I), so the presence of the species is not necessarily diagnostic of the *K. knightii* Association.

Taxa recorded by Lawson & White (1989) are typical of the *Mesopholidostrophia laevigata* Association, and include large strophomenid brachiopods (*Mesopholidostrophia lepisma* (J. de C. Sowerby), *Strophonella euglypha* (Hisinger), *Leptaena depressa* (J. de C. Sowerby)), the trilobite *Dalmanites*, and tabulate and solitary corals. Of these, *S. euglypha* and the tabulate coral *Favosites*, along with *K. knightii*, have their last occurrences at locality C8, at the top of the Upper Bringewood Formation. Other characteristic forms (*Eospirifer radiatus* (J. de C. Sowerby), *M. lepisma*, *Pterinea* cf. *tenuistriata* M'Coy, *Poleumita globosa* (Schlotheim), *Dalmanites* and *Rhabdocyclus porpitoides* (Lang & Smith)) disappear at various levels in the Upper Bringewood Formation of Sunnyhill Quarry.

Watkins (1979, fig. 16, section 2D) placed the top of the *Mesopholidostrophia laevigata* Association slightly more than 1 m below the top of the Upper Bringewood Formation in Sunnyhill Quarry, above the highest common occurrences of *Gypidula lata* Alexander, *Mesopholidostrophia laevigata* (J. de C. Sowerby), *Dalejina hybrida* (J. de C. Sowerby), *Leptostrophia filosa* (J. de C. Sowerby), *Leptaena*, stropheodontid brachiopods and solitary corals, and below the level at which he recorded a sharp increase in the abundance of *Isorthis*, *Dayia navicula* (J. de C. Sowerby) and *Microsphaeridiorhynchus nucula* (J. de C. Sowerby). This differs slightly from the level determined for the faunal change by Lawson & White (1989), at the top of the Upper Bringewood Formation.

See [‘Faunal distribution across the Gorstian-Ludfordian boundary’](#) for a table showing the occurrence of shelly fossils in beds C1 to C14 at Sunnyhill Quarry, and [‘Sunnyhill Quarry - profile’](#) for the ranges of taxa through the same interval.

(continued...)

***Mesopholidostrophia laevigata* Association (continued)**

- 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.
- Watkins, R. 1979. Benthic community organization in the Ludlow Series of the Welsh Borderland. *Bulletin of the British Museum (Natural History)*, Geology, **31**, 175-280.
- Watkins, R. & Aithie, C.J. 1980. Carbonate shelf environments and faunal communities in the Upper Bringewood Beds of the British Silurian. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **29**, 341-368.
- 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: [Faunal distribution across the Gorstian-Ludfordian boundary, *Mesopholidostrophia laevigata* Association, Sunnyhill - map, vertical section, Sunnyhill Quarry - profile.](#)

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***Sphaerirhynchia wilsoni* Association**

Species that typify the upper phase of the *Sphaerirhynchia wilsoni* Association, including *Dayia navicula* (J. de C. Sowerby), *Howellella elegans* (Muir-Wood), *Isorthis orbicularis* (J. de C. Sowerby) and *Microsphaeridiorhynchus nucula* (J. de C. Sowerby), appear in the Upper Bringewood Formation at Sunnyhill Quarry (Lawson & White 1989, fig. 61). In addition, Cherns (1988, text-fig. 5) has shown that solitary corals, considered to characterize the *M. laevigata* Association rather than the upper phase of the *S. wilsoni* Association (Watkins 1979, pp. 228, 230), persist into the lowest part of the Lower Leintwardine Formation, and therefore into the *Sphaerirhynchia wilsoni* Association as defined by Lawson & White (1989). The change from the *Mesopholidostrophia laevigata* Association to the *Sphaerirhynchia wilsoni* Association at Sunnyhill Quarry is therefore transitional across the Upper Bringewood to Lower Leintwardine Formation boundary.

See [‘Faunal distribution across the Gorstian-Ludfordian boundary’](#) for a table showing the occurrence of shelly fossils in beds C1 to C14 at Sunnyhill Quarry, and [‘Sunnyhill Quarry - profile’](#) for the ranges of taxa through the same interval.

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

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.

Watkins, R. 1979. Benthic community organization in the Ludlow Series of the Welsh Borderland. *Bulletin of the British Museum (Natural History)*, Geology, **31**, 175-280.

See: [Faunal distribution across the Gorstian-Ludfordian boundary](#), [Sunnyhill - map](#), [vertical section](#), [Sunnyhill Quarry - profile](#), [Sphaerirhynchia wilsoni Association \(upper phase\)](#).

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***Shaleria ornatella* Association**

The *Shaleria ornatella* Association is the fauna that characterizes the Upper Leintwardine Formation, but it is difficult to distinguish the Upper Leintwardine Formation fauna from the highest fauna of the Lower Leintwardine Formation on the range chart for the Sunnyhill section published by Cherns (1988, text-fig. 5). Many of the characteristic *Shaleria ornatella* Association forms seemingly appear below the base of the Upper Leintwardine Formation on that figure. For example, *Aegiria grayi* (Davidson), *Calymene*, *Encrinurus* and *Neobeyrichia* all occur in the highest metre of the Lower Leintwardine Formation, as well as in the Upper Leintwardine Formation. (It should be noted, however, that the species of *Calymene*, *Encrinurus* and *Neobeyrichia* were not recorded by Cherns).

White & Lawson (1978) and Siveter *et al.* (1989, p. 57) have indicated that the characteristic arthropod species of the *Shaleria ornatella* association, namely *Calymene puellaris* Reed, *Encrinurus stubblefieldi* Tripp and *Neobeyrichia lauensis* (Kiesow), occur in the Upper Leintwardine Formation of the Sunnyhill track section.

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

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.

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: [Shaleria ornatella Association, Sunnyhill - map, vertical section, ostracodes](#).

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Sunnyhill Quarry and adjacent section - graptolites

Cherns (1988, fig. 5) recorded *Saetograptus leintwardinensis leintwardinensis* (Lapworth), indicative of the ***Saetograptus leintwardinensis* Biozone**, about 0.25 m above the base of the Lower Leintwardine Formation at Sunnyhill Quarry (locality C9), and therefore an equivalent distance above the base of the Ludfordian Stage. The base of the *leintwardinensis* Biozone is considered to approximate to the base of the Ludfordian Stage (Lawson & White 1989, p. 86).

Cherns (1988, fig. 5) also recorded *S. l. leintwardinensis* 10-12 m above the base of the Lower Leintwardine Formation (equivalent to localities C17 and C18), 22-27 m above the base of the Lower Leintwardine Formation (C23-C26), from the highest metre of the Lower Leintwardine Formation, and from the Upper Leintwardine Formation. Siveter *et al.* (1989) reported the subspecies from their localities 3.6b (= locality C24, Lower Leintwardine Formation) and 3.6c (= locality C29, Upper Leintwardine Formation), noting that it did not occur above the Upper Leintwardine Formation.

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

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.

See: [Saetograptus leintwardinensis Biozone, Sunnyhill - map, vertical section, Sunnyhill Quarry - profile](#).

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Sunnyhill Quarry and adjacent section - conodonts

The Upper Bringewood Formation at Sunnyhill Quarry has yielded reasonable numbers of conodonts, with collections 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). There is no precise indication of where the conodonts occur in the succession.

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). The specimens of *Kockelella variabilis* from C11 are the highest representatives of that species recorded in the Ludlow area.

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.

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.

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: [Conodonts from the Upper Bringewood Formation](#), [Conodonts from the Lower Leintwardine Formation](#), [Coryssognathus dubius](#) and [Pelekyognathus dubius](#), [Kockelella variabilis](#), Sunnyhill - map, vertical section, Sunnyhill Quarry - profile.

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Sunnyhill Quarry and adjacent section - ostracodes

The stratigraphically important ostracode species *Neobeyrichia lauensis* (Kiesow) occurs in the Upper Leintwardine Formation along the track between Sunnyhill and Overton quarries (Siveter *et al.*, 1989, p. 57, loc. 3.6c; White & Lawson 1978).

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.

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: [Ludfordian ostracode faunas, *Neobeyrichia lauensis*, Sunnyhill - map, vertical section](#).

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Sunnyhill Quarry and adjacent section - chitinozoa

The bases of chitinozoan biozones 9 and 10 are located in Sunnyhill Quarry and the adjacent track section.

The base of **Chitinozoan Biozone 9** is defined by the appearance of *Gotlandochitina?* sp. A of Sutherland (1994) in sample SH15, collected from 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).

The base of **Chitinozoan Biozone 10** is located at the appearance of *Angochitina milleri* Sutherland in the section above Sunnyhill Quarry, in sample SH25 from the Lower Leintwardine Formation. Sutherland (1994) stated the base of the biozone to be 8 m above the base of the formation, but his text-fig. 47 suggests that this distance is slightly less, at about 7.3 m. Both of these distances above the base of the formation lie within the 1.5 m of strata at locality C16.

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 9](#), [Chitinozoan Biozone 10](#), [Sunnyhill - map](#), [vertical section](#), [Sunnyhill Quarry - profile](#).

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Sunnyhill Quarry and adjacent section - bentonites

Bentonites occur in the Upper Bringewood Formation (localities C2 and C4) and Lower Leintwardine Formation (localities C10 and C12) at Sunnyhill Quarry.

See: [Bentonites, Sunnyhill - lithostratigraphy, map, vertical section, Sunnyhill Quarry - profile](#).

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