

# ***British Silurian Stratigraphy***

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# References

In this reference list the arrangement is alphabetical by author surname for works by sole authors and dual authors. Where there are references that include the first-named author with others, the sole-author works are listed chronologically first, followed by the dual author references (alphabetically) followed by the references with three or more authors listed *chronologically*. Chronological order is used within each group of identical authors.

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# Glossary

This glossary provides brief explanations of the technical terms used in the introductions to the chapters and in the 'Conclusions' sections of the site reports. These explanations are not rigorous scientific definitions but are intended to help the general reader. Detailed stratigraphical terms are omitted as they are given context within the tables and figures. Systematic names for groups of organisms are given with the formal version followed by the informal plural suffix in brackets. This is followed by a vernacular translation of the Greek or Latin roots of the terms. Words in **bold** type indicate an internal reference to another glossary entry.

**Acadian (orogeny)**: the Early to Mid-Devonian phase of mountain building (late Caledonian) along a collision zone between **Avalonia** and **Laurentia**, after the **subduction** of the **Iapetus** ocean and the production of a range of mountains stretching south-westwards from Scandinavia, through northern Britain and Ireland, Greenland and the Maritime Provinces of North America.

**Acanthodii (-ians)**: 'spiny'; a member of the extinct class of **Palaeozoic** (Silurian–Permian) primitive jawed fish; these so-called 'spiny sharks', with spine-supported fins and a covering of small scales, occupied both marine and fresh waters.

**Accretionary prism**: a large composite wedge of sediment added to a continental margin during **subduction** by sediment being scraped off the downgoing (subducting) slab and stacked together as a series of **thrust** wedges.

**Acid**: referring to the composition of igneous rocks dominated by silica (SiO<sub>2</sub>) and characteristic of the **continental crust**.

**Acme**: 'prime'; the highpoint attained by an organism or group of organisms, as measured by some aspect of **phylogenetic** success, e.g. number of species; in palaeontol-

ogy this depends on the relative abundance of preserved fossils in a body of strata.

**Acritarch (-s)**: 'problematic box'; hollow organic walled microfossils of uncertain biological affinities, but most may be algal cysts; useful for **biostratigraphy** in marine mudrocks.

**Actualism**: a methodological approach to the interpretation of geological phenomena, based purely on an understanding of present processes on Earth.

**Aeolian**: 'of *Aeolus*, god of winds'; sediments carried and deposited by the wind.

**Aeronian**: the middle of three **stages** (chronostratigraphical divisions) of the **Llandovery Series**.

**Agnatha (-ns)**: 'without jaws'; primitive jawless vertebrates (Cambrian–Recent), including a large number of extinct marine and freshwater groups but now reduced to two – the hagfishes and the lampreys:

**Algal limestones**: carbonate sediments built up with a significant contribution from marine algae that secrete or promote the deposition of calcium carbonate.

**Ammonitina (-ites)**: 'horn of (Ammon) Jupiter'; an advanced group of **cephalopods**, usually characterized by coiled shells and the complexity of the sutures between septal



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chamber walls and the outer wall of the shell.

**Anaerobic:** literally 'without air' or oxygen.

**Anaspida (-ids):** 'without shield', a group of extinct small **agnathans** with fusiform bodies and heads and bodies covered by small bony scales.

**Anglian Basin:** a Lower Palaeozoic marine depositional basin on the north-east flank of the **Midland Platform**; only known from borehole evidence.

**Anoxic:** literally 'without oxygen'; synonymous with **anaerobic**.

**Anticline:** an upfold of rocks produced by **tectonic** activity (see also **syncline**).

**Arachnida (-ids):** 'spider form'; a large group of carnivorous chelicerate **arthropods** (Silurian–Recent), mainly terrestrial but with some aquatic forms; includes the spiders and scorpions.

**Arenite** (adj. arenaceous): 'sand', a **clastic** sediment made of sand-sized particles.

**Argillite** (adj. argillaceous): 'clay', a fine grained sediment made of silt- or clay- sized particles.

**Arthropoda (-ods):** 'jointed foot'; the most diverse phylum of animals, characterized by a toughened outer coat and paired jointed appendages; they have a long fossil record from early Cambrian times.

**Asteroids:** 'starry', a class of echinoderms, commonly known as starfish, and characterized by their star shape and five 'arms'.

**Autochthonous (benthos):** 'self land'; as applied to seabed-dwelling organisms in their life habitats.

**Avalonia:** 'Avalon Peninsula, Newfoundland'; a small early **Palaeozoic** crustal plate consisting of parts of the maritime states of North America, England, Wales, south-east Ireland and part of western Europe, which split from **Gondwana** early in **Ordovician** times and moved northwards, colliding with **Laurentia** during the Silurian.

**Azoic:** 'without life'; an old term for strata that were found to lie below Cambrian age rocks (synonymous with **Precambrian**) and were thought to be devoid of fossil remains; abandoned when Precambrian fossils were discovered.

**Back arc basin:** a sedimentary basin that is on the opposite side of a volcanic **island arc** to a submarine ocean **trench**.

**Baltica:** 'Baltic'; an early **Palaeozoic** crustal

plate consisting of much of present day north-western Europe, including Scandinavia, European Russia and parts of Central Europe; the plate formed the south-eastern continental margin of the **Iapetus** Ocean and amalgamated with **Avalonia** before moving northwards from Late **Ordovician** times and colliding with **Laurentia** to form the Caledonian mountain belt.

**Basaltic lava:** an **igneous** rock of **basic** composition formed by molten rock flowing from a volcano.

**Basic:** referring to the composition of igneous rocks, which have high concentrations of the elements of iron, magnesium and calcium and are typical of the **mantle** and **ocean crust**.

**Basin:** an area of subsidence in which sediments accumulate.

**Bed (-s):** in **lithostratigraphical** terms, a defined and uniform horizon within a **member** or **formation**, which is used in lithostratigraphical correlation.

**Benthos** (adj. benthic): 'depths', aquatic organisms living on or in a substrate.

**Bentonite:** a deposit of clay formed by the alteration of glassy volcanic ash.

**Beyrichiacea (-eans):** named after Beyrich, a German palaeontologist, an extinct group (late Ordovician?–early Carboniferous) of marine **ostracods**, which have **biostratigraphical** use.

**Bioclastic:** 'life fragment'; sediment grains made from fossil remains.

**Biocoenose:** 'life in common'; a living community of organisms occupying a particular **biotope**.

**Biofacies:** 'life surface'; a sedimentary **facies** defined by its characteristic fossil assemblage.

**Biogeography:** the distribution of organisms in space.

**Bioherm:** 'life reef'; a reef-type mound-shaped body of sediment made up from the skeletons and shells of living and dead organisms.

**Biom mineralization:** the biological process of toughening the integument ('skin') of an organism with non-living minerals, generally for protection and support of the body tissue.

**Biostratigraphy:** 'life layer writing'; the subdivision of sedimentary strata into **biozones**, and their correlation, based on their fossil content.

**Biota:** 'life'; the flora and fauna of a particular place.



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- Biotope:** 'life place'; habitats within which the environmental conditions are relatively uniform and similar assemblages of inhabitants recur.
- Bioturbation:** 'life disorder'; any physical disturbance of the substrate, such as burrows and feeding traces, by the organisms living on or in it. These traces are often preserved in ancient sediments.
- Biozone:** a **stratigraphically** restricted unit of sedimentary rocks defined by its fossil content, most usefully by species of narrowly defined temporal range but wide spatial range and named after abundant or characteristic species.
- Bivalvia (-ves):** 'two shells'; an ancient group (mid Cambrian–Recent) of aquatic **molluscs** that have their bodies enclosed by two shells and were common fossils in some Silurian shelf deposits.
- Bloom:** a seasonal and often dramatic increase in numbers of **phytoplankton** due to simultaneous reproduction.
- Bone-bed:** a stratigraphically restricted sedimentary accumulation and concentration of bones, or other vertebrate remains such as teeth or scales, often worn by transport and associated with fluvial deposition, especially channel **lag** deposits or marine near-shore sediments. Bone-beds represent an important source of palaeontological and geological information.
- Bouma (sequence):** a succession of sedimentary features found repeatedly within **turbidite** deposits, produced by decelerating turbidity currents and named after the Dutch sedimentologist Arnold Bouma.
- Brachiopoda (-ods):** 'arm footed'; a major group of bivalved and **lophophorate** shellfish (Cambrian–Recent), superficially similar to the **bivalved** molluscs but distinguished by a different anatomy. Particularly common in the **Palaeozoic** seas but replaced by the molluscs as the dominant shellfish since **Mesozoic** times.
- Braided stream:** a flow of water made up of numerous anastomosing channels.
- Breccia:** a coarse fragmental sediment, characterized by angular **clasts**.
- Bryozoa (-oans):** 'moss animal'; a major group of mainly marine colonial invertebrates that secrete tubular skeletons consisting of calcium carbonate or organic material. They are common as fossils in shallow shelf sediments.
- Calcite** (adj. calcitic): a calcium carbonate ( $\text{CaCO}_3$ ) rock-forming mineral.
- Calcrete:** a sedimentary deposit of fluvial environments in semi-arid regions, with nodular concretions of calcium carbonate; thought to represent ancient soils (synonymous with **concretions**).
- Caledonides:** 'of Caledonia'; the **Palaeozoic** mountain chain extending in a NE–SW direction in eastern Greenland, Scandinavia, Scotland, Ireland, the Lake District, Wales and continued in Newfoundland, which resulted from the closure of the **Iapetus** ocean.
- Caledonoid:** relating to the **Caledonides** and particularly their north-east to south-west structural trend.
- Cambrian:** the first geological period of the **Palaeozoic Era**, named by Adam Sedgwick in 1835 after *Cambria*, the Roman name for Wales, where he first studied rocks of this age. The base is taken where abundant fossil shells first appear and the period ranges from about 540 to 495 million years ago.
- Carbonate:** a mineral salt formed with carbon dioxide, usually referring to the common sedimentary form of calcium carbonate in limestones and invertebrate shells.
- Carboniferous:** a major stratigraphical division of the Upper **Palaeozoic**, below the Permian and above the Devonian and characterized in the British Isles by a lower marine carbonate sequence and upper marginal marine and terrestrial sequence containing the coal deposits.
- Cardiolidae (-ids):** 'heart'; an extinct group of Lower **Palaeozoic** marine **bivalves**, common in Silurian fine-grained, deeper shelf sediments.
- Centipede (-s):** 'hundred feet'; see **myriapods**.
- Cephalaspida (-ids):** 'head shield'; an extinct group of **osteostracan agnathans** characterized by a horseshoe-shaped and rigid, bony head-shield with broad horn-shaped processes.
- Cephalopoda (-ods):** 'head foot', a class of marine **molluscs**, usually with a chambered shell, including the surviving nautilus, the living squid, cuttlefish and octopus and their extinct fossil relatives.
- Channel-head:** the upper part of a submarine valley.
- Chelicerata (-ates):** 'clawed horns'; a large group of **arthropods** with the body divided



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- into two parts and generally having a pair of pincers (chelicerae) in front of the mouth; includes **arachnids**: **xiphosurans** and **eurypterids**.
- Chitinozoa (-oans)**: 'tunic animal'; an extinct group of organic-walled microfossils of unknown biological affinities but may be egg cases of marine animals.
- Chondrichthyes (-yans)**: 'cartilage fish'; a major group of fish, commonly called the **cartilaginous** fish, which have a cartilaginous endoskeleton, no lungs or air bladder and a spiral valve in the gut; typified at present by the sharks and rays.
- Chordata (-ates)**: 'string'; major group of coelomate animals, characterized by a **notochord** and perforated pharynx at some stage in their life history and a dorsal hollow nerve cord.
- Chronometric scale**: 'time measure'; a geological timescale based largely on **radiometric** dating of igneous rocks.
- Chronostratigraphy (-ical)**: 'time layer writing'; the correlation and subdivision of geological time into a hierarchy of sequential units to which the layers (strata) of sedimentary rocks are allocated, through the study and interpretation of their **stratigraphy**.
- Chronozone**: a fine division of geological time based on some recognizable feature preserved in contemporaneous sedimentary strata.
- Cladistic analysis**: 'branch analysis'; an attempt to characterize natural groupings of organisms by means of a search for shared derived characters.
- Cladogram**: 'branch picture'; a branched tree-like classification diagram produced by **cladistic analysis**.
- Clast**: 'fragment'; a rock or mineral fragment derived by erosion of older rocks.
- Clastic**: 'broken in pieces'; descriptive of fragmental sediment composed mainly of particles derived from pre-existing rocks or minerals, including organic remains (designated as **bioclastic**).
- Cleavage**: planes of parallel mineral orientation, well developed in fine-grained rocks, which have been subjected to tectonic compression.
- Coldhouse**: a climatic (**primo**) condition where there is global cooling with vigorous vertical circulation and oxygenation of the oceans.
- Conglomerate**: coarse-grained sediment made up of rounded pebble-sized **clasts**.
- Conodonts (-onts)**: 'cone teeth', an extinct group (Cambrian–Triassic) of small eel-like marine coelomates, characterized by feeding structures of paired teeth made of bone-like material; recently considered to be chordates and probably primitive **agnathan** vertebrates. The teeth have considerable use in **biostratigraphy**.
- Continental crust**: the uppermost 35 km thickness of the **lithospheric plates**, which make up the continents and are characterized by being less dense than **ocean crust** and **acidic** in composition.
- Contorted beds**: sedimentary layers that have been disturbed and deformed by submarine slumping or water escape (see also **disturbed beds**).
- Conulariida (-iids)**: 'cone'; a group of extinct **benthic** marine animals (Cambrian–mid-Triassic) that secreted and occupied conical chitinophosphatic shells and are thought to be related to the Scyphozoa (jellyfish).
- Coprolite (-ites)**: 'dung stone'; petrified or fossil faecal material, which may contain identifiable food remains and are occasionally abundant enough to be a source of **phosphate**.
- Coquina**: 'of shells'; a sedimentary deposit largely made of shells or their fragments.
- Corals**: a major group of marine coelenterates, both solitary and colonial, which secrete a supporting cup of calcium carbonate. Colonial forms can build **reef** structures in shallow shelf seas on such a large scale that they form extensive **limestone** deposits.
- Core**: the dense centre of the Earth, made up of iron and nickel minerals and thought to have a fluid outer layer.
- Cornstone**: a concretionary **limestone** deposit, characteristic of arid terrestrial environments (synonymous with **calcrete**).
- Cornwall–Rhenish Basin**: a marine depositional basin developed along the southern margin of the **Midland Platform** during Devonian and Carboniferous times.
- Correlation**: the matching of sequences of strata in different places, for instance by means of fossils, lithologies, magnetic or chemical signatures.
- Crinoidea (-oids)**: 'lily form'; a group of **pelmatozoan echinoderms** (Mid-Cambrian–Recent), characterized by 'roots', stems, cups



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- and arms made of jointed plates of calcium carbonate, hence the common name – ‘sea lily’; the carbonate skeleton is readily fossilized and they were particularly common from the Middle **Palaeozoic** to **Mesozoic** but less so in more recent times.
- Cross-bedding**: sloping layers of sediment deposited by current action on otherwise more or less horizontal surfaces by wind or water.
- Crust**: the thin surface layer to the Earth, either basic **oceanic crust** or acidic **continental crust**.
- Dasycladacean (alga)**: ‘hairy sprout’; a group of marine algae, some of which are encrusted with calcium carbonate, leading to their preservation as fossils.
- Debris flow**: an avalanche-like break up and displacement of sediments down a slope, resulting in a chaotic jumble of fragments of different sizes in a muddy matrix.
- Dendroidea (-oids)**: ‘tree form’; a group of predominantly **benthic graptolites** (upper Cambrian–Carboniferous) with a multi-branched bush-like form.
- Detritivore**: an organism that feeds on sediment enriched with organic material.
- Devonian**: a major division of geological time, the first period of the Upper **Palaeozoic**, ranging from about 417–354 million years ago.
- Diachronous**: ‘through time’, relating to sedimentary or **stratigraphical** units where the lithological boundaries cut across the time boundaries in the succession of deposition. Diachronism reflects the migration of a geological event through time (such as a marine **transgression**) so that the sediment produced by that event is not everywhere the same age.
- Diagenetic**: secondary, post-depositional changes (both physical and chemical) in sediments which occur at surface pressures and temperatures.
- Diastrophism**: ‘through twisting’, large scale movement and deformation of the Earth’s **crust**.
- Diorites**: coarse grained **igneous** rocks of intermediate composition, usually found as **intrusions**.
- Dip-slip (fault)**: a **tectonic** break in strata in which the sense of displacement is parallel to the direction of inclination (see also **strike-slip fault**).
- Disconformity**: ‘asunder with form’; a break in continuity of deposition, during which either no sediment is deposited or the sediment that is deposited is subsequently eroded before the succession of strata continues – but without angular discordance.
- Disturbed unit**: referring in Silurian sedimentary rocks to strata in which the bedding surfaces have been disturbed and often distorted or destroyed by submarine slumping down-slope or water escape.
- Downtonian**: an old term for post-Ludlow age Silurian strata.
- Durophagous**: ‘hard to eat’; consuming prey with hard parts, which need to be crushed, such as shellfish and crustaceans.
- Echinodermata**: ‘spiny skin’; phylum of marine invertebrates, characterized by a five-fold symmetry and calcareous skeleton, which includes the starfish, sea-urchins, crinoids and their fossil relatives.
- Ecostratigraphy**: ‘household layers, writing of’; the study of the changing relationships between organisms, their evolution and their environments through time.
- Elements (conodont)**: the fossil hard parts of the extinct marine **conodont** animals, now known to be tooth-like structures.
- Epeiric**: ‘mainland’; produced by large-scale uplift or subsidence of crustal rocks without the severe deformation associated with orogeny.
- Epicontinental**: ‘upon continent’; located on a continent or the surrounding continental shelf.
- Epoch**: ‘pause’; a subdivision of a geological **period** of time, corresponding to the **series chronostratigraphical** division.
- Era**: one of the five major divisions of geological time, namely the Archean, Proterozoic, Palaeozoic, Mesozoic and Cenozoic, each of which is comprised of several **periods**.
- Euramerica**: ‘Europe–America’; continental mass of North-western Europe and North America, formed when the **Iapetus** Ocean was subducted during the **Caledonian** orogeny; also used to denote a biogeographical province.
- Euryhaline**: organisms with a wide tolerance range for water salinity.
- Eurypterida (-ids)**: ‘of *Eurypterus*, a broad fern’; an extinct group (Ordovician–Permian)



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of large aquatic merostome **arthropods** (up to 2 m in length) which superficially resemble scorpions.

**Eustatic**: concerning global change of sea level (as distinct from local change) resulting from a geological event such as a major glaciation.

**Event stratigraphy**: the elucidation of the history of real geological events from the **stratigraphical** rock record, which provides the framework for regional history, as opposed to the more arbitrary time surfaces defined by **chronostratigraphy**.

**Exoskeleton**: a toughened outer integument ('skin'), strengthened with organic proteins and/or minerals to support and protect the body tissues.

**Extensional fault**: fractures in crustal rocks resulting from tension, which produce pull-apart structures such as sedimentary **basins**.

**External mould**: sediment surrounding a once solid object, like a fossil shell, which is shaped into the form of the outer surface of that object. In fine-grained sediments such moulds may preserve remarkably fine detail of the original object, which may have been dissolved away.

**Extrusive**: the process whereby an **igneous** rock flows out onto the surface of the Earth (see also **intrusive**).

**Facies (sedimentary)**: a sequence of strata with common features, deposited under similar environmental conditions and often containing fossil organisms that lived in that environment.

**Filter feeder**: an aquatic organism that feeds by sieving food particles from the surrounding water.

**Fining-up**: an upwards decrease in particle size of a deposit as a result of gravity settlement by a waning current; can be used to help determine the **way-up** of strata in highly folded strata.

**Fish (-ishes)**: the common and convenient name for a wide range of aquatic vertebrates, which used to be united under the old classificatory term *Pisces*.

**Flash flood**: an infrequent and ephemeral flood, characteristic of semi-arid regions and often associated with storms. The water may evaporate and dump its sediment load without discharging into the sea.

**Flute moulds**: elongate sediment infills of trough-shaped hollows excavated on the

seabed by **turbidity** currents.

**Fluviatile**: relating to rivers, their environments and deposits.

**Foraminifera (-ans)**: 'carrying an opening'; a member of a group of small unicellular aquatic organisms that construct a shell of various materials; often very abundant in marine waters with representatives that are **benthic** and **planktonic** (Cambrian–Recent).

**Foreland basin**: a sedimentary basin developed by depression of a continental margin, owing to the weight of sediment accumulating in front of an **orogenic** belt.

**Formation**: a 'package' of rock, which is distinctive enough in its **lithology** from the surrounding rocks to be mappable as a unit.

**Gastropoda (-ods)**: 'stomach foot'; an ancient class of univalved **molluscs**, mostly characterized by spirally shaped shells made of aragonitic calcium carbonate. They form common fossils in certain Silurian nearshore deposits.

**GCR**: Geological Conservation Review, in which nationally important geological and geomorphological sites were assessed and selected with a view to their long-term conservation as **SSSIs**.

**Geochronology**: 'Earth time study'; the calculation of geological time and its division into episodes measured in years before the present.

**Geochronometry (-etric)**: 'Earth time measure'; the method of measuring geological time in years before present, using the known decay rates of radioactive chemical elements that are mainly derived from **igneous** rocks.

**Glaciation (Ordovician)**: a period of alternating warm and cold climates during late Ordovician times when ice caps and sheets formed at the poles, locking up considerable volumes of seawater in ice and lowering sea levels. The weight of ice depressed the **crust**, which later (early Silurian) rebounded during warmer intervals when the ice melted and sea levels rose.

**Glacio-eustatic**: changes in sea level due to seawater being 'locked up' in ice sheets and vertical movements of the **crust** due to loading and unloading of the crust by the weight of the ice sheets.

**Gnathostomata (-omes)**: 'jaw mouth'; a group



- of **vertebrates** with jaws and a considerable degree of development of the head.
- Gondwana (-land)**: a grouping of the major southern continental plates of Africa, Australasia, Antarctica, South America, India, several smaller plates and fragments of what are now parts of Mediterranean Europe, which together formed a massive southern supercontinent straddling the South Pole in Early **Palaeozoic** times and began to split up when **Avalonia** broke away early in the **Ordovician**.
- Gorstian Stage**: the older of two chronostratigraphical divisions of the **Ludlow Series**, the higher being the **Ludfordian Stage**.
- Graben**: 'trench'; a linear block of crust down-thrown between two parallel faults to form a rift or trough-shaped valley.
- Graded beds**: layers of sediment within which the grains decrease in size, generally from the base to top of the deposit.
- Granitoid**: an **igneous intrusive** rock with a composition close to that of granite, i.e. dominated by minerals such as quartz, feldspar and mica.
- Graptolithina (-lites)**: 'writing stone'; an extinct group (Cambrian–Carboniferous) of marine colonial hemichordates, which secreted a proteinaceous skeleton in the form of an interconnected series of cups to house and protect the zooids. Rapidly evolving and of great use in the **biozonation** and **correlation** of strata.
- Graptoloidea (-oids)**: a group of **graptolites** (Ordovician–early Devonian) with a reduced number of branches and **planktic** mode of life, often widely distributed and used for **biostratigraphical correlation**.
- Greenhouse**: a climate (**secundo**) condition whereby there is stagnation of the oceans with deep-water **anoxia** and global warming promoted by 'greenhouse' gases such as carbon dioxide, perhaps from large-scale volcanic eruptions (see also **ice/coldhouse - primo** condition).
- Greywacke**: a coarse-grained and poorly sorted sedimentary rock with a mixture of clay, sand and rock fragments, in which a proportion of the clay may be **diagenetic** in origin.
- Grits**: an old term for coarse-grained **greywacke** deposits.
- Group**: a **stratigraphical** unit consisting of one or more **formations**, important for local and regional **lithostratigraphical correlation**.
- Hardground**: a sediment surface preserved within a sequence of strata, which has hardened through early **diagenetic** processes and whose ecology has changed as it came to be occupied by various organisms.
- Hemipelagite (-s)**: marine deposits formed from fine mud, silt and the fossil remains of organisms that are mainly free-swimming (**nektonic**) or floating (**planktonic**).
- Hercynian**: an upper **Palaeozoic (Carboniferous)** phase of mountain building following **subduction** of a WSW–ENE oriented ocean, from south-west England through Scania, central and southern Europe and the Iberian Peninsula.
- Heterostraci (-acans)**: 'other shell'; an extinct group of **agnathans**, with extensive head armour of large plates and a pair of common gill openings on either side.
- Highland Boundary Fault**: a **tectonic** displacement that marks the southern boundary of the Scottish Highlands and northern edge of the **Midland Valley**.
- Hirnantia fauna**: an Upper Ordovician age shallow marine fossil assemblage dominated by **brachiopods** such as the genus *Hirnantia*; characteristic of cold water influenced by the late Ordovician ice age.
- Histology**: 'tissue discourse'; the detailed study of plant and animal tissues.
- Holotype**: 'whole pattern'; the single specimen selected to characterize a species.
- Homerian**: the younger of two (chronostratigraphical) stages within the **Wenlock Series**, the other being the **Sheinwoodian Stage**.
- Homoclinal**: a succession of strata dipping continuously in one direction.
- Horst**: 'eyrie'; an upfaulted block of crustal rocks, often on either side of a **graben**.
- Hyolithida (-ids)**: 'Y-shape stone'; an extinct group of Palaeozoic (Cambrian to Permian) **benthic** animals that secreted and inhabited conical calcareous shells (1–2 cm long) closed by a lid and are thought to be related to the **molluscs**.
- Iapetus**: a former 'proto-Atlantic' ocean, which separated the early **Palaeozoic** crustal plates of **Laurentia** and **Gondwana** (including **Avalonia**). The British Isles were split, with the north-west adjoining Laurentia and the south-east forming the eastern part of Avalonia, until the ocean floor was finally **subducted** in Ordovician–Silurian times.



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**Iapetus suture:** a north-east to south-west line, thought to extend along the Scottish border south-west through the Solway Firth and just north of the Isle of Man. The suture marks the line along which the Iapetus ocean floor was **subducted** and the junction of **Laurentia** and **Avalonia**.

**Ice/coldhouse state:** see **primo episode**.

**Ichnofossil (-s):** 'track fauna'; an assemblage of trace fossils, records of life in sediments disturbed by the activity of organisms, e.g. worm burrows or foot prints (see **bioturbation**).

**Ichnospecies:** a particular kind of trace fossil recognized as a taxonomic 'species' on the basis of its form.

**Ichthyolith (-s):** the fossil remains of fish, which often consist predominantly of dissociated scales and teeth scattered in sedimentary rocks.

**Igneous:** a rock formed by cooling and crystallization of a melt derived from within the Earth.

**Index fossil:** a particular fossil species that characterizes a named **biozone** within a **biostratigraphical** subdivision.

**Infauanal:** an organism living within a substrate such as the seabed.

**Inlier:** an area of old rocks exposed as a 'window' in the younger surrounding rocks (see also **outlier**).

**Intraclast (conglomerate):** 'within fragments'; a rock or sediment fragment derived by erosion from local contemporaneous strata within the same depositional basin.

**Intrusion:** an **igneous** rock that has been formed within other rocks below the Earth's surface (see also **extrusive**).

**Irish Sea Platform:** a small elongate area of Precambrian and early Palaeozoic rocks forming the north-west margin of the **Welsh Basin**; it probably was an upstanding block for much of Silurian time.

**Island arc (volcanic):** a chain of volcanic islands generated on an overriding **lithospheric plate** by **subduction** of an underlying oceanic plate.

**Isotope:** a variant of a chemical element; some isotopes are unstable and subject to radioactive decay, producing an isotope of a different element.

**Isostatic (movement):** vertical movement or re-adjustment of a relatively less dense body 'floating' on a more dense one, as a result of loading or unloading; with regard to crustal

rocks, the loading can be produced by sediment deposition or ice and the unloading by erosion or ice melting.

**Jawless fish:** see **Agnatha**.

**Jurassic:** the middle of three subdivisions of the **Mesozoic Era**, preceded by the **Triassic** and followed by the Cretaceous.

**Kaolinite:** a potassium-rich clay mineral (kaolin) from which china clay is made.

**Kerogen:** a naturally occurring organic material that yields petroleum-like hydrocarbons on heating and distillation.

**Lag (deposit):** a layer of larger or denser clasts, such as pebbles or bones, which have accumulated at the bottom of a bed during deposition from strong currents.

**Lagerstätten (fossil):** a rock containing exceptionally abundant or exceptionally well-preserved fossils that are of considerable intrinsic interest.

**Lake District Basin:** a late Ordovician to Silurian marine depositional basin built on a subsided volcanic **island arc**.

**Laminites:** thin layers of generally fine-grained sediment, reflecting rapidly fluctuating, often seasonal, changes in sediment supply or environmental conditions; characteristic of lakes and other shallow basins of deposition where there is a restricted bottom fauna.

**Lapworth: Charles:** author of the **Ordovician System**, which he established from the lower **Silurian** to resolve the historical impasse that had developed between the 'Murchisonians', who supported an extended **Silurian System** and the 'Sedgwickians', who defended Sedgwick's concept of the **Cambrian**.

**Laurasia:** 'St Lawrence-Asia' the northern supercontinental mass formed in the early **Mesozoic** by the rifting of **Pangaea** with the opening of the **Tethys** and Atlantic Oceans; comprised of the amalgamated fragments of North America, Greenland, Europe and Asia.

**Laurentia:** 'St Lawrence', the major North American continental crustal plate in Lower **Palaeozoic** times, which straddled the equator, prior to the **subduction** of the **Iapetus Ocean**; comprised mainly of the ancient **Precambrian** core of the Canadian Shield and Greenland plus Scotland and north-west Ireland.

**Laurussia:** 'St Lawrence-Russia'; the amalga-



- mated plates of North America and Russia, following the **subduction** of the **Iapetus** Ocean.
- Lectotype**: 'chosen pattern'; a specimen chosen from available **syntypes** to be the designated type of the species.
- Leptostrophiids**: a group of extinct **brachiopods**.
- Lineament**: a large-scale, tectonically produced line of disruption and distortion of rocks.
- Lingulate**: a group of **brachiopods**, which includes the **lingulids**.
- Lingulida (-ids)**: 'tongue'; a group of extant **brachiopod** shellfish, which were much more abundant in the **Palaeozoic** than at present.
- Lithofacies**: a volume of sediment with similar characteristics, deposited within a single environment under the same conditions.
- Lithology**: the composition and form of sedimentary rock.
- Lithosphere**: those surface layers of **crustal** rocks and the upper part of the **mantle**, which are strong and form the **crustal plates** of the Earth.
- Lithostratigraphy**: 'rock layer writing'; the organization and division of strata into mappable rock units and their correlation based entirely upon their lithological (rock compositional) characteristics.
- Littoral**: 'seashore'; the zone between high- and low-water marks on a shoreline.
- Llandovery Series**: coined by **Murchison** in 1859, now a 'series' name for the oldest division of the **Silurian System**; includes, in ascending order, the Rhuddanian, Aeronian and Telychian stages.
- Loganellida (-ids)**: 'Logan (Water)'; a group of **thelodont agnathans** with a characteristic form of scale.
- Log (section)**: a diagrammatical representation of a vertical succession of strata.
- Lophophore**: an organ with a high surface area (usually bearing numerous hair-like tentacles) for **filter-feeding** and respiration.
- Ludfordian Stage**: the younger of two divisions of the **Ludlow Series**, the older being the **Gorstian Stage**.
- Ludlow Series**: a major chronostratigraphical division of the **Silurian** which is younger than the **Wenlock Series** and older than the **Přídolí Series**: Within the Ludlow Series there are two stages, the older **Gorstian** and younger **Ludfordian**.
- Maceration**: 'softening'; the process of softening or isolating tissue and separating cells.
- Machaeridia(-ians)**: 'dagger shape'; an extinct and enigmatic group (class) of Palaeozoic (**Ordovician–Carboniferous**) marine **benthic** animals with flattened bilaterally symmetrical bodies covered with calcareous plates; thought to be related to either the **molluscs** or **annelids**.
- Magnetostratigraphy**: the relative dating of **strata** based on the succession of reversals of the Earth's magnetic field as measured by **palaeomagnetism**.
- Mantle**: the 2300 km thick zone within the Earth, lying between the thin surface **crust** and the **core**.
- Member**: a rock unit within a **formation**, which is impersistent or can only be mapped locally.
- Mesoderm**: 'middle skin'; the embryonic cell layer between the **ectoderm** and **endoderm**.
- Mesozoic**: 'middle life'; the middle division of geological time with abundant life, younger than the **Palaeozoic**, older than the **Cenozoic** and containing the Triassic, Jurassic and Cretaceous periods.
- Metabentonite**: a **bentonite** altered from its original condition by increased pressures and temperatures during **metamorphism**.
- Metamorphism**: the processes of alteration of rocks in the solid state by changes in pressure and temperature within the Earth's **crust**.
- Micrite**: the fine-grained microcrystalline carbonate matrix of limestones, much of which is chemically precipitated as a lime mud but also may include a significant proportion of mud derived from organisms.
- Microcraton**: a **crustal plate** fragment such as the **Midland Platform**.
- Microstructures**: small scale features found within rocks that have been tectonically deformed, such as **cleavage** and **slickenslides**.
- Microvertebrates**: often referred to as 'ichthyoliths'; literally the small fossil remains of **vertebrates**, such as scales, teeth and bones, which may be barely visible with the unaided eye when disarticulated. They can be separated from many kinds of rock matrix by careful acid preparation and are then available for microscopic study. Although known for over 150 years, their potential for revealing so much about the palaeontology of vertebrates and their use in **biostratigraphy**, has only



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- been realized in the last 30 years.
- Midland Platform:** a buried structural unit of **Precambrian** rocks in central England that has acted as an upstanding block throughout much of the **Palaeozoic**.
- Midland Valley (Scotland):** a NE–SW trending tectonic depression with a complex history and within which a variety of **Palaeozoic** rocks are exposed. The valley is bounded by the **Highland Boundary Fault** to the north and the **Southern Uplands Fault** to the south.
- Milankovitch cycles:** periodic shifts in the Earth's orbital parameters, thought to be one of the driving mechanisms behind glacial events.
- Miospore (-ores):** 'less seed'; a fossil plant spore less than about 0.22 mm in diameter, for which the parent plant is often unknown.
- Molasse:** a terrestrial **clastic** deposit, generally of poorly sorted, immature sediment associated with the uplift and rapid erosion of newly formed mountain belts; often accumulating to considerable thickness, in marginal or intermontane basins.
- Mollusca:** 'soft'; a major group of invertebrates including some of the most important fossil forming groups such as the **bivalves**, **cephalopods** and **gastropods**.
- Monograptids:** an extinct group of **graptolites** whose organic skeletons are characterized by a single branch with individuals of the colony on one side only.
- Monophyletic:** a natural taxonomic group that includes all descendants of a single common ancestor; e.g. the **Amniota** which includes the reptiles, birds and mammals.
- Murchison: Sir Roderick Impey:** author of the **Silurian** (1835) and **Permian** (1841) systems and co-author of the **Devonian** System with **Sedgwick** (1839).
- Myodocopida (-ids):** 'closed'; a group of marine **ostracods** characterized by relatively large size, thin shell and, in many species, the ability to swim within the water column.
- Myriapoda (-ods):** 'numberless feet'; a living class (Silurian–Recent) of terrestrial **uniramous arthropods**, which includes the centipedes and millipedes, some of which were amongst the first land-living animals.
- Nautiloidea (-oids):** 'nautilus form'; group of **cephalopods** with straight or coiled conical shells, which were more abundant in the **Palaeozoic** but survive today in only one genus, *Nautilus*.
- Nekton** (adj. **nektonic**): 'swimming'; those organisms that actively swim in water.
- Neotype:** 'new pattern'; a new or replacement type specimen taken from the original type locality and horizon.
- Neptunian dyke:** a transgressive and unconformable rock made of sediment, usually the infill of a fissure.
- Niche:** a defined space in an environment occupied by organisms with a particular set of habits, e.g. feeding habit.
- Nodule:** 'knob'; a spherical or elliptical mineral concretion, generally grown post-depositionally within a sediment, as the result of the concentration of a particular mineral around a nucleus.
- Nomen nudum:** 'name naked'; in nomenclature, an invalid name because the organism to which it refers was inadequately described or illustrated.
- Non-vascular plant:** a large group of primitive plants that do not have conducting tissues, many of which are aquatic.
- Notochord:** 'back cord'; a stiff flexible rod of large vacuolated cells that acts as an anterior–posterior axis between the gut and dorsal nerve cord in **chordates**.
- Oceanic crust:** the rocks of the ocean floor, which are relatively denser than those of the continents as a result of their **basic** composition, which include relatively higher proportions of elements such as iron, magnesium and calcium.
- Ocean trench:** see **trench**.
- Old Red Sandstone:** a classic term still applied to the terrestrial, largely **clastic** facies of the late **Silurian** to earliest **Carboniferous** in Britain; characterized by red sandstones and conglomerates.
- Ordovician:** the second period of the **Palaeozoic Era**, ranging from about 495–440 million years ago and named after a Romano-British hill tribe, the *Ordovices*, by Charles **Lapworth**.
- Organic:** fossil remains made up of materials such as cellulose, chitin or keratin but often oxidized to carbon.
- Orogenesis** (adj. **orogenic**): 'mountain genesis'; a process of crustal thickening during which the rocks and sediments of a particular area of a continent(s) are deformed and



- uplifted to form mountain belts. Although taking a long time these processes can be distinguished as recognizable and discrete phases in Earth history and are named accordingly, e.g. **Acadian** orogeny.
- Orthocones:** 'straight cone'; straight and elongate conical shells of squid-like **cephalopod molluscs**.
- Osteostraci (-ans):** 'bone shell', an extinct group of **agnathans** with both exoskeleton and endoskeleton of bone, characterized by a 'horseshoe' shape and a pair of pectoral flap-shaped fins.
- Ostracoda (-ods):** 'shell like'; a group of small crustaceans having a bivalved shell around the body. Throughout their long geological history (Cambrian?–Recent) they have diversified into a wide range of aquatic ecological niches both on land and at sea.
- Ostracoderms:** 'shell skin'; all those jawless **craniates** with an exoskeleton of **dermal bone**, i.e. the fossil **agnathans**.
- Outcrop:** an area of rock strata that appears at the surface and is unencumbered with soil and vegetation.
- Outlier:** an area of young rocks surrounded by older rocks (see also **inlier**).
- Overflow channel:** an erosive trough cut by water spilling over from another flow or a standing water body like a lake.
- Overlap:** where successive layers of sedimentary strata progressively cover one another but extend farther geographically than their predecessor, generally indicative of a **transgression**.
- Overstep:** where successive layers of sedimentary strata extend **unconformably** onto different older strata with a time gap between those rocks above and below the plane of unconformity.
- Oxic:** suffused with oxygen; as opposed to **anoxic**.
- Palaeocurrent:** a flow direction, as deduced from sedimentary structures or aligned fossils associated with an ancient depositional or erosive event.
- Palaeoecology:** 'ancient household discourse'; the study of the relationship between organisms and their environments in the past.
- Palaeoenvironment:** an ancient environment; mainly reconstructed from its sediments and fossils.
- Palaeogeography:** 'ancient earth study'; the study and reconstruction of the ancient environments of the Earth's surface, especially through the mapping of contemporaneous and contiguous deposits, and how they have changed through time in response to a range of factors including changing sea level, climate, tectonism, sediment supply and the interaction with living organisms.
- Palaeomagnetism:** the previous states of the Earth's magnetic dipole field, which can be determined by measuring the orientation of magnetic minerals within the rocks of the Earth's crust (see also **magnetostratigraphy**).
- Palaeoslope:** 'ancient slope'; the orientation and inclination of an original surface as determined from an ancient depositional or erosive event.
- Palaeosol:** 'ancient soil'; a 'fossil' soil deposit characterizing a terrestrial environment.
- Palaeozoic:** 'ancient life'; the first major division of geological time, coined by **Sedgwick** in 1838, characterized by abundant life and preceded by the **Proterozoic** and succeeded by the **Mesozoic**; divided into six periods (Cambrian to the Permian).
- Palinspastic:** 'again draw'; restored to an original condition or in the case of a map to represent original conditions, features or relative positions.
- Palynology:** 'pollen discourse'; the study of microscopic plant fossils, such as spores, pollen, algal cysts and acritarchs and their distribution, which has proved to be of considerable **biostratigraphical** use.
- Palynomorph:** 'pollen form'; a microscopic, resistant-walled organic body found in palynological preparations, including both plant derived bodies such as **spores** and **pollen** and also other acid resistant remains such as **acritarchs** and **chitinozoans**.
- Palynozone:** 'pollen zone'; a **biostratigraphical** subdivision characterized by an assemblage of organic-walled microfossils such as pollen and spores.
- Pangaea:** 'the whole Gaea', a supercontinent formed by ocean floor **subduction**, plate collision and assembly of all continents in the late Permian.
- Paratypes:** 'beside pattern'; a specimen or specimens in the same series or collection from which the **holotype** has been selected.
- Pelagic:** referring to the open sea and particularly the organisms that swim and float with-



- in the water column and are largely independent of the sea bed.
- Pelmatozoa (-oans):** 'sole of foot animal'; a group of **echinoderms** (Middle Cambrian–Recent) including **crinoids**, most of which have a stem carrying a small plated body and arms for food gathering and are common fossils in Silurian shelf carbonate sediments.
- Peneplain:** 'almost plain'; a landscape surface with greatly reduced features as a result of prolonged weathering and erosion.
- Pericline:** a structural fold with a hinge that has opposing plunges along its length, producing ellipsoid outcrop patterns.
- Period:** a major division of geological time, of shorter duration than an **era** and itself divisible into **epochs**.
- Permian:** the youngest major subdivision (**system**) of the **Palaeozoic**, following the **Carboniferous** and whose upper boundary marks the end of the **Palaeozoic Era**.
- Petrography:** the detailed study of rocks, their composition and form.
- Phosphate:** a phosphorous salt often found in mineralized bone.
- Phyllocarida (-ids):** 'leaf crab'; an ancient but surviving group of marine crustacean **arthropods** (Cambrian–Recent) with a bivalved carapace enclosing the body; many were swimming predators and some grew to 75 cm in length.
- Phylogeny:** 'race descent'; the evolutionary relationships and history of a species or group of organisms.
- Phylum (-la):** a major natural grouping within the kingdoms of life (e.g. Phylum **Mollusca**), comprising one or more subgroups (e.g. Classes **Bivalvia**, **Cephalopoda**, **Gastropoda**).
- Phytoplankton:** 'plant wandering'; free-living plants within an aquatic environment, often microscopic and with limited powers of locomotion, therefore mainly dispersed by currents, wind and tide.
- Pisocrinidae (-ids):** 'pea lily'; a group of extinct **crinoids** (Ordovician–Permian) characterized by their small size.
- Plankton (adj. planktonic):** 'wandering', belonging to the plankton; those generally small organisms, which drift in water bodies and have limited powers of locomotion.
- Plate (-s):** segments of **lithosphere**, which comprise the stiff upper part of the ultrabasic mantle and the **basic** rocks of the **oceanic crust** or the **acidic continental crust**.
- Platform:** a stable area of **continental crust**, generally a fragment of **Precambrian** basement rocks, e.g. the **Midland Platform** of central England during Silurian times, upon which **epicontinental** deposits are laid and which does not readily deform by folding but may fracture into fault blocks.
- Playa:** the flat dry bottom of a desert basin, often the bed of an ephemeral lake and underlain by **evaporites**.
- Point-bar:** a low bank of sediment on the inside bend of a river channel, consisting in part of material derived from the eroded outside bank.
- Polychaete:** 'many bristles', a group of annelid worms, some bearing bristles, tentacles and hard organic tooth structures (**scolecodonts**).
- Precambrian:** 'before Cambrian'; the first major division of geological time which includes the first four billion or so years of Earth history before abundant metazoan life capable of secreting skeletons had appeared in the fossil record; the top of the **Precambrian** is defined by the base of the Cambrian Period of the **Palaeozoic Era**.
- Pretannia:** a putative landmass in the area of the Bristol Channel during Silurian times.
- Přídolí:** the fourth and youngest series of the Silurian, for which no formal stages have yet been established. Although the base of the Přídolí is established in the Czech Republic it is thought to correlate closely with the base of the Downton Group of the central part of the Welsh Borderland.
- Primo (P) episode:** an episode of cold global climate and sea-level lowstand when ocean depths were oxygenated by dense water from high latitude seas, producing upwellings of nutrient-rich deep water, which promoted high productivity, drawdown of CO<sub>2</sub> from the atmosphere and enhancement of the cold global climate (see also **secundo episode**); may be accompanied by glaciation, for which the term **icehouse state** has been used.
- Proglacial lake:** a body of water formed in front of a melting glacier.
- Prokaryote (-otes):** 'before nucleus'; organisms such as blue-green algae and bacteria whose chromosomes are not surrounded by a nuclear membrane.
- Prolapsed bedding:** flat lying folds, probably of slump origin, within beds of an otherwise



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- conformable succession of sedimentary strata.
- Proterozoic:** 'former life'; the younger subdivision of **Precambrian** time, from 2.5 billion years ago until the beginning of the **Cambrian** at the base of the **Palaeozoic**; a time when primitive life had evolved and has been preserved as rare fossils of **prokaryotes**: and soft bodied metazoans, in the youngest rocks of the division.
- Protobranch (-anchs):** 'first gills'; a member of a 'primitive' group of marine **bivalve** molluscs with a very long fossil record (lower Cambrian–Recent) that commonly occupy mud substrates and feed by extracting organic material from the mud, e.g. the *nuculids*.
- Protochordata (-ates):** 'first string'; a group of primitive **chordates**, with perforated pharynx, **notochord** and hollow dorsal nerve cord at some stage of their life cycle but no skull structure or biomineralized skeleton.
- Protoscorpiones (-ions):** 'first scorpion'; an extinct (Silurian–Devonian) group of primitive aquatic **scorpions**.
- Province (faunal):** the geographical region occupied by a particular assemblage of organisms in response to certain environmental factors such as climate, water temperature etc..
- Pterineid:** 'wing'; a group of marine **bivalve** molluscs characterized by an elongate 'wing-like' extension of the hinge; often attached to a substrate by a byssus thread.
- Pyrite:** 'fire stone'; an iron sulphide mineral common within sediments; results from the biochemical action of bacteria within **anaerobic** environments.
- Pyroclastic:** 'fire fragments'; the fragmentation of **igneous** rock materials during volcanic eruption; deposits range from large rock bombs to pulverized rock dust and ash.
- Radio-isotope:** 'ray - equal place'; the radioactive **isotopes** of chemical elements, which have the same atomic number as other isotopes of the same element but different atomic weights.
- Radiolarian (-ians):** 'feeble sunbeam'; a group of marine, single-celled, **planktonic** micro-organisms that secrete siliceous skeletons that are often preserved as fossils in deep-sea sediments.
- Radiometric dating:** the establishment of a numerical age scale for rocks, based on measurement of the amounts of daughter **isotopes** produced by the decay of radioactive elements at known decay rates.
- Raptorial (predators):** a carnivorous hunter equipped for snatching prey, e.g. many **chelicerate arthropods**.
- Red beds:** sedimentary deposits reddened in colour by iron oxides and deposited in oxidizing situations, (e.g. in an arid terrestrial environment) and may be associated with **evaporites**. Reworking of the sediments may carry red beds into marine environments and in some deep sea environments red muds may also accumulate from meteoric dust particles of volcanic origin.
- Reef:** a marine sedimentary structure built up predominantly by the shells and skeletons of invertebrates such as corals, bryozoans and algae that lived in shallow, warm shelf sea waters.
- Regression:** referring to the retreat of the sea from land areas as a result of a fall in sea level or elevation of the landmass.
- Rheic (ocean):** an approximately east–west oriented ocean that opened up at the same time as the closure of the **Iapetus** ocean and separated part of **Gondwana** (in part, what is now Brittany and central Germany) from southern Britain, northern France and northern Germany during the Silurian; its closure resulted in the **Variscan** orogeny.
- Rhuddanian:** the oldest stage of the **Llandovery Series**, the base of which is coincident with the base of the **Silurian System** and is defined at the Dob's Linn GCR site.
- Rhyniophytoids:** 'Rhynie plants'; a group of primitive **vascular** plants with simple branched stems, terminal reproductive capsules and water-conducting tissues that allowed them to colonize the land.
- Rhythmic sequence:** a regularly banded vertical sequence of sediments, reflecting rhythmic changes in the supply of sediment often related to seasonal changes, e.g. the **varved** couplets of silt and clay in glacial lakes.
- Rift (-s):** a depressed area of continental **crust** produced by tensile stretching of the crust and down-faulting along parallel faults.
- Rudite:** a coarse-grained body of sediment.
- Sabkha:** a salt-encrusted surface of salt flats, which are often developed just inland parallel to dry hot tropical coastlines, where periodic flooding by the sea is evaporated with



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- precipitation of various **evaporite** minerals and laminae of dried algae.
- Scale**: 'husk'; a flat, plate-like protective structure for the skin, generally small and in rows to allow for flexibility; may be either dermal or epidermal in origin.
- Scaphopoda (-ods)**: 'boat foot'; a group of living marine benthic **molluscs** (Ordovician–Recent) that burrow into sediment and secrete and occupy hollow calcareous tubes open at both ends.
- Sclerite**: 'hard'; an exoskeletal element in the form of plates or spines, often mineralized.
- Sclerotized**: where the integument ('skin') of an organism is toughened by organic material.
- Scolecodont (-onts)**: 'worm tooth'; organic 'teeth', the feeding structures of **polychaete** worms.
- Scorpionida (-ids)**: 'scorpion'; a group of chelicerate arachnids (Silurian–Recent), which includes the living scorpions and their fossil ancestors.
- Sea-squirt**: common name for the **hemichordate** ascidians, marine organisms with a free-swimming larval stage and a sessile benthic adult stage.
- Secundo (S) episode**: an episode of warm global climate resulting from salinity stratified oceans with anoxic deeps, little upwelling of nutrient-rich water, low productivity and the release of CO<sub>2</sub> to the atmosphere, consequently enhancing warm global climate (synonymous with **greenhouse state**, see also **primo episode**).
- Sediment**: grains of rock material that is deposited on or near the Earth's surface by natural (e.g. marine, lacustrine, fluvial, terrestrial) processes at surface pressures and temperatures.
- Sedimentology**: the study of **sediments** including their deposition, structure and composition.
- Sequence**: a **stratigraphical** succession of strata.
- Series**: a major **stratigraphical** division of a geological **system**, comprising all the rocks formed during a particular length of geological time.
- Serpulid (-ids)**: 'small snake'; a small tubular fossil, mineralized with calcium carbonate and generally regarded as related to the living polychaete worms, which have similar form and encrusting habits.
- Shear zone**: a region of concentrated tectonic deformation of rocks between two less deformed blocks.
- Sheinwoodian**: the older of two stages within the **Wenlock Series**, the other being the **Homerian Stage**.
- Shelf**: referring to the gently sloping continental shelf platform which is marginal to the continents and extends with varying width into ocean basins. At the present time the outer edge of the shelf is generally about 200 m deep.
- Shell lag**: a sediment deposit made up predominantly of the shells or skeletons of organisms that have usually been accumulated by the selective action of currents.
- Shelly**: referring in general to the hard and biomineralized fossil remains of invertebrates such as **bivalves** and **trilobites**, as opposed to **organic** soft tissue fossil remains.
- Siliciclastic**: 'hard stone fragments'; a fragmental deposit, consisting mainly of grains of silica minerals, especially quartz.
- Silurian**: 'of the *Silures*' (an ancient Welsh tribe); a Lower **Palaeozoic** period of geological time, approximately between 417 and 440 million years ago, preceded by the **Ordovician** and succeeded by the **Devonian periods**; first recognized as a **chronostratigraphical** unit (system) by Sir Roderick **Murchison** in 1835 for a succession of marine sediments in the Welsh Borderland, characterized by particular fossils and subsequently recognized globally.
- Slate**: a mudrock that has been altered and **cleaved** by **tectonic** pressure.
- Slickenslides**: scratch marks made on a rock surface by the relative movement of rocks along fault planes.
- Slide scar**: a rock surface, often arcuate, left after the collapse and downslope movement of a mass of rock.
- Slope (shelf)**: the gently inclined outer surface of the continental shelf where it descends to the ocean floor.
- Slumps**: sediments that have been contorted (generally into folds) by submarine movement downslope.
- Southern Uplands**: an upland region in southern Scotland dominated by NE–SW trending Ordovician and Silurian sediments that are folded and faulted as part of an **accretionary prism**.
- Southern Uplands Fault**: the southern bound-



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- ing fault to the Scottish **Midland Valley**, marking the northern edge of the **Southern Uplands**.
- Sphaeromorph**: 'ball shape'; a microscopic and organic fossil, shaped like a ball.
- Sponge**: primitive multicelled animals which were entirely marine in Lower **Palaeozoic** times and secreted skeletons made either of silica, calcium carbonate or an organic material. Siliceous sponges and spicules are known as fossils in Silurian deposits.
- Sporomorph**: 'seed form'; a fossil pollen grain or plant spore.
- SSSI**: Site of Special Scientific Interest; the designation of an area of land for statutory protection under the provisions of the *Wildlife and Countryside Act 1981*.
- Stage**: a **chronostratigraphical** subdivision of a series.
- Stem group**: in **cladistics**, an extinct group defined on the absence of advanced features of its living relatives.
- Stenohaline**: refers to organisms with a narrow tolerance range for water salinity (see also **euryhaline**).
- Stratified (basin)**: the layering of a water body within a lake or marine basin, produced by a change of temperature or salinity from upper to lower waters.
- Stratigraphy**: 'layer writing'; the study of rock successions preserved from the geological past, in order to reveal the history of the succession of events and life of the past.
- Stratotype**: 'layer pattern'; a sequence of strata at a particular location, which has been internationally recognized as the definitive section for a **lithostratigraphical** unit for a particular **chronostratigraphical** subdivision of geological time and the recognition of key points on that time-scale.
- Strike**: the trend of a geological surface (such as a bedding plane) measured at right angles to the direction of maximum slope, or 'dip'.
- Strike-slip (fault)**: a tectonic break in strata in which the sense of displacement is at right angles to the direction of inclination (see also **dip fault**).
- Strike-slip**: horizontal movement along a fault.
- Stromatolite (-ites)**: 'bedded stone'; layered structures built up by mats of blue-green 'algae' (cyanobacteria), which trap fine sediment as they grow; typically found in shallow tropical seas, they extend back as fossils for more than three billion years.
- Stromatoporoids**: 'bedding hole'; primitive multicelled marine animals probably related to the sponges, which secrete calcareous skeletons and were important members of reef communities.
- Subduction**: 'lead under'; the process of one crustal plate descending beneath another during plate convergence and collision, with the release of energy in the form of earthquakes and often accompanied by volcanicity. The line of subduction is usually marked by an oceanic **trench** and a volcanic **arc**.
- Submarine canyon**: a valley below sea level, which has been cut into the edge of the continental shelf by sediment charged density currents.
- Succession**: in **stratigraphy**, a sequence of sedimentary rock units.
- Sulphate (-ates)**: a chemical compound containing sulphur and oxygen, which forms common sedimentary minerals with a variety of other elements, especially in **evaporite** deposits.
- Supergroup**: a major **stratigraphical** unit that unites **groups** and is important for regional **correlation**.
- Suture**: 'seam'; the line of collision between two crustal plates following the **subduction** of any intervening crust, e.g. **Iapetus** suture.
- Synapomorphy**: 'joined together shape'; a shared derived character(s), which unites a group in **cladistic** analysis.
- Syncline**: a structural down-fold produced by **tectonic** deformation.
- Synclinatorium**: a large-scale tectonic down-fold that has minor folds within its limbs.
- Synsedimentary**: at the same time as the deposition of the sediment.
- Syntype**: 'with pattern'; any one of a series of specimens that characterize a species when there is no designated **holotype**.
- System**: a **chronostratigraphical** unit comprising all the rocks formed during a geological **period**, e.g. the Silurian System comprises all the rocks of Silurian age.
- Taphonomy**: 'burial cutting'; the study of the processes of death, decay and burial by which organisms become recruited to the fossil record.
- Taxonomic group**: a category of organisms at any level in their classification, e.g. Phylum, Class, Order, Family, Genus, species.
- Tectonism** (adj. **tectonic**): 'builder'; the



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- processes of crustal deformation, often associated with plate tectonics and mountain building.
- Telychian:** the younger of three stages in the **Llandovery Series**.
- Tentaculitoidea (-oids):** 'feeler'; an extinct group of **Palaeozoic** (Ordovician–early Triassic) marine fossils that secreted narrow and elongate conical shells (1–3 cm long), ornamented with annular rings; their affinities are unknown but they may have been related to the **molluscs**.
- Terrane:** 'earth'; a small crustal plate or fault bounded fragment of a larger plate, with distinctive characteristics, which can be displaced considerable distances from its original site and added to another plate during plate tectonic movement.
- Tethys:** '*Tethys*, a mythical titaness and wife of *Oceanus*'; an east–west extending major ocean, which separated the southern supercontinent of **Gondwanaland** from **Laurasia** in **Mesozoic** times; **subducted** to form the Alpine–Himalaya mountain belt.
- Thanatocoenose:** 'death common'; an assemblage of fossil organisms that have been brought together by the processes of sedimentation, following their death, so that the assemblage may contain organisms that did not originally live near one another.
- Thelodonta (-onts):** 'teat teeth'; an extinct group of **agnathans**, characterized by their shark-like dermal **denticles**, which are commonly fossilized as separate elements within the sediment.
- Thrust (fault):** a relatively low-angle fault displacement of crustal rocks, produced by compressive forces.
- Trace fossils:** marks produced on or in sediments by the activities of living organisms or their post-mortem transport.
- Transgression:** 'across walk'; referring to the encroachment of the sea across a landscape as a result of either a (**eustatic**) rise in sea level or subsidence of the land.
- Trench:** a narrow elongate depression in the ocean floor, generally parallel and near to the coastline or string of volcanic islands, produced by **subduction** of the ocean floor.
- Triassic:** the first major subdivision (**system**) of the **Mesozoic Era** following the end of the **Palaeozoic** and before the **Jurassic Period**.
- Trigonotarbidia (-ids):** 'triangle frightful'; an extinct Order (Silurian–Carboniferous) of primitive **chelicerate arthropods**, which include some of the earliest land living animals.
- Trilobita (-ites):** 'three lobe'; an extinct group of marine **Palaeozoic arthropods** (Cambrian–Permian), characterized by tri-lobed head, body and tail comprising an articulated and mineralized dorsal carapace.
- Trophic pyramid:** 'food pyramid'; a layered subdivision of the food chain with a broad base of numerous primary producers rising to the relatively few top carnivores at the apex of the 'pyramid'.
- Tuff:** consolidated volcanic ash, comprising rock and possibly crystal fragments, from an explosive eruption.
- Turbidite:** the sedimentary deposit of a gravity-driven turbidity current flow.
- Turbidity flow:** a gravity-driven density current, generally laden with sediment in turbulent suspension and capable of travelling great distances before losing momentum and depositing its sediment load.
- Type locality:** the location where the type section (or **stratotype**) for a **stratigraphical** unit is located, or where the original type section was first described, or from where a fossil species was originally described.
- Unconformity:** a break in the relationship between successive rocks in a sequence, as a result of a variety of causes from a lack of deposition to an intervening phase of **tectonism** and erosion; consequently the missing time interval may also vary enormously.
- Uniramous:** relating to those **arthropods** with appendages consisting of a single branch, as opposed to a double (**biramous**) branch.
- Urochordata (-ates):** 'tail cord'; a group of **protochordates** in which the chordate features are often only expressed in the larval stages; see **sea-squirts**.
- Variscan:** 'land of the Varisci or Vogtland', synonymous with **Hercynian**.
- Varved:** a **laminite** deposit in which the layers of sediment are graded and generally result from a seasonal influx of sediment-laden water into a low-energy water body such as a lake or lagoon.
- Vascular (plant):** 'small vessel'; the major group of tracheophyte plants, in which there are special cells for the transmission of fluids; includes the earliest land-living higher plants.



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**Vertebrata (-ates):** 'back bone'; those metamerically segmented **chordates**, with a high degree of cephalization in which the **notochord** is commonly replaced by a backbone as part of an endoskeleton of **cartilage** or bone.

**Volcanic (arc):** see **island arc**.

**Welsh Basin:** a marine basin between the **Irish Sea Platform** and **Midland Platform** within which a considerable thickness of Lower Palaeozoic sediments accumulated before the closure of the **Iapetus Ocean**.

**Wenlock Series:** a major **chronostratigraphical** division; the second series of the Silurian, younger than the **Llandovery** and older than the **Ludlow**; includes, in ascending order the Sheinwoodian and Homerian stages.

**Wrench faults:** tectonic fractures through rocks, in which the sense of displacement is horizontal (see also **strike-slip**).

**Xiphosura (-ans):** 'sword tail'; a group of aquatic merostome **arthropods** (Silurian–Recent) which includes the living king-crabs.

**Younging:** referring to the direction in which strata decrease in age, following the law of superposition of strata, whereby younger layers are deposited upon older layers.

**Zircon:** a mineral oxide of zirconium that includes minute traces of **radio-active isotopes** that are particularly useful for dating rocks **radiometrically**.

**Zone:** a **stratigraphical** division defined by fossil content; see **biozone**.



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