Quaternary of Northern England

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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. Words in **bold** type indicate an internal reference to another glossary entry.

Abbevillian: an archaeological term referring to a period of European culture during which crude hand axes first appeared. Part of the **Palaeolithic** division of the **Stone Age**, it precedes the **Acheulian** period.

Ablation: the disappearance of snow and ice by melting and evaporation from the surface of a glacier, controlled mainly by air temperature but also affected by sunshine, rainfall, humidity and wind speed.

Abrasion: the wearing away of rocks or sediments by an agent of transportation charged with a load of already eroded material, which acts as a tool for grinding, cutting, scratching and polishing. Abrasion by water and ice produces rounded forms and abrasion by ice produces **striations**.

Absolute age: the actual age, as opposed to the **relative age**, of a formation, rock or **fossil**, usually given in 'years before present' actually meaning years before AD 1950.

Absolute dating: a method of determining the **absolute age** of formation of a rock or mineral; includes techniques such as **radiometric dating**, **electron spin resonance**, **thermoluminescence** and palaeomagnetic techniques.

Accelerator mass spectrometry (AMS) ^{14}C dating: a method of dating whereby ^{14}C atoms are separated by their differences in mass rather than by their radioactivity. The technique uses much smaller samples than the conventional ^{14}C technique.

Acheulian: an archaeological term referring to a period of European culture noted for the manufacture of the hand axe and the cleaver. Part of the lower **Palaeolithic** division, it follows the **Abbevillian** period, and precedes the **Mousterian** period.

Aegelsee oscillation: a short-lived, low-amplitude climatic oscillation, leading to colder and drier conditions, which has been identified on the Swiss Plateau and in the UK, and dated to approximately 13 000 years BP, towards the end of the last glacial period (the **Devensian Stage**).

Aeolian: descriptive of sediments transported and deposited by the wind.

Age: a geological time unit (cf. **chronostratigraphy**), usually taken to be the smallest standard division of geological time, of shorter duration than an **epoch**.

Aggradation: the building upwards of a river valley or floodplain by accumulation of **fluvial** deposits; can also be applied to material deposited by other agencies, such as wind or sea.

Allerød Interstadial: a term used primarily in Europe to describe a short-lived climatic amelioration, or **interstadial** event, which

occurred approximately 11 000 years BP, towards the end of the last glacial period (the **Devensian Stage**), following the **Older Dryas** and prior to the **Younger Dryas**.

Allochthonous: descriptive of a rock which formed somewhere other than its current position and was subsequently transported.

Alluvial: a term applied to the environments, action, and products of rivers or streams. Alluvial deposits are composed of **clastic** material deposited in the river **floodplain**.

Alluvium: sediment deposited by rivers.

Alluvial fan: a cone-shaped deposit made up of water-laid deposits, and also some material transported by mud flows.

Alluviation: the process of the accumulation of material deposited by river water, usually located along the river valley and tending to be predominantly fine **silt** or **sand**.

Alpine orogeny: a period of mountain building resulting from the collision of the European and African plates that took place during the late **Tertiary Period**.

Amino acids: a group of organic compounds found within plant and animal tissues.

Amorphous: lacking a definite form or structure; non-crystalline.

Anastomosing: descriptive of a system which branches or contains a network; for example the channel pattern of a braided stream, or the veins on a leaf which form a netlike pattern.

Andesite: a fine-grained **volcanic** or shallow-level **intrusive** rock intermediate in composition between a **basalt** and **rhyolite**.

Anaerobic: literally 'without air' or oxygen.

Angiosperm: a major division of the plant kingdom; a flowering plant which has seeds that develop in an ovary.

Anglian Stage: a British chronostratigraphical division (**stage**; see **chronostratigraphy**); a cold (**glacial**) stage of the middle **Pleistocene Epoch**, equivalent to **oxygen isotope stage** 12, and occurring from about 300 000 to 250 000 years BP. It follows the **Cromerian Stage** and precedes the **Hoxnian Stage**.

Annelid: any worm-like invertebrate of the phylum Annelida, typically with a segmented body and a distinct head and appendages. Usually only preserved as a **trace fossil** due to the lack of a skeleton.

Aragonite: a form of calcium carbonate commonly found in the shells of invertebrates. It is less stable than **calcite** and more soluble in cold water than in warm. It is often replaced by other minerals, such as **calcite**, in **fossils**.

Arboreal: associated with, or living in, trees.

Arenaceous: descriptive of **clastic sediments** made up of **sand**-sized particles.

Arenig Epoch: a geological time division (**epoch**; cf. **chronostratigraphy**); the second epoch of the **Ordovician Period**.

Arête: a narrow mountain crest or sharp-edged rocky ridge, often present above the snowline in rugged mountains. It is formed by **glaciers** and is the result of the backward growth of the walls of adjoining **cirques**.

ARM (anhysteretic remanent magnetization): the remanence produced in a sample by subjecting it to an increasing and decreasing alternating magnetic field superimposed upon a steady direct-current magnetic field.

Atlantic period: a term primarily used in Europe to describe an interval of the **Holocene Epoch** that extends from about 7500 until 4500 years BP. It follows the **Boreal period** and precedes the **Sub-Boreal period**, and is characterized by a climate generally warmer and wetter than that of the present day.

Augite: a pyroxene (ferromagnesian) mineral.

Aurochs: a form of wild ox that is now extinct.

Authigenic: a mineral formed in place in a **sediment** or rock either by replacing or displacing an earlier mineral.

Autochthonous: descriptive of a rock formed in its current position.

Autogenic: descriptive of an ecological succession resulting from factors originating within the natural community and altering the habitat.

Basalt: a fine-grained, usually dark coloured, crystalline basic **igneous rock**, formed by a volcanic eruption, and therefore usually in the form of a lava or **dyke**. It has a silica content of less than 53 wt% and consists largely of plagioclase feldspar and ferromagnesian minerals.

Batholith: a large, irregular mass of intrusive **igneous rock** emplaced deep in the Earth's crust.

Baventian Stage: a British chronostratigraphical division (**stage**; see **chronostratigraphy**); a cold (**glacial**) stage of the early **Pleistocene Epoch**, which ended about 1.6 million years ago. It follows the Antian Stage and precedes the **Bramertonian Stage**.

Bedform: a small- or large-scale landform, formed by the deformation of the bed of a river, a sand dune, or the seabed, by current flow over a mobile sediment bed. Examples include ripples, large dunes, horizontal sheet-flow and antidunes.

Bedding plane: a planar feature in **sedimentary rocks** representing an original surface of deposition. Conspicuous bedding planes may indicate a short interruption in, or change in character of, **sediment** deposition.

Bedrock: the rock, usually solid, underlying soil and other unconsolidated surficial material.

Beestonian Stage: a British chronostratigraphical division (**stage**; cf. **chronostratigraphy**); a cold (**glacial**) stage of the early **Pleistocene Epoch**, which ended about 400 000 years BP. It follows the **Pastonian Stage** and precedes the **Cromerian Stage**.

Bioclastic: consisting of **clasts** of **biogenic** origin, e.g. broken shell or bone debris.

Biogenic: descriptive of sediments that have been produced by animals, for example coral reefs.

Biostratigraphy: the **stratigraphical** subdivision and correlation of **sedimentary rocks** based on their **fossil** content.

Biota: the **flora** and **fauna** of a particular place; the faunal and floral assemblage of a bed or other **stratigraphical** unit.

Bioturbation: the physical disturbance of unconsolidated **sediment**, such as by burrowing and feeding, caused by the organisms living on or in it. These disturbances are often preserved as **trace fossils** 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.

Blanket bog: an acid peat formed by high rainfall and the rapid leaching of bases, which blankets the topography in upland regions with a typically cool, wet, oceanic climate.

Blockfield: found on high mountain slopes above the treeline and in polar regions, composed of a thin accumulation of large and usually angular blocks over solid **bedrock**, formed by frost shattering.

Blockslope: Angular blocks on a slope formed by frost shattering, see also **blockfield**.

Bog: ground that is waterlogged and spongy. It consists mainly of mosses and contains acidic decaying vegetation that may develop into **peat**.

Bølling–Allerød Interstadial complex: a term used primarily in Europe to define the time during which the **Bølling** and **Allerød interstadial** events occurred. These two **interstadial** events were separated by the colder **Older Dryas**. The complex spans from approximately 13 000 until 11 000 years BP and is considered to be equivalent to the **Windermere Interstadial** in Britain.

Bølling Interstadial: a term used primarily in Europe to describe a short-lived climatic amelioration, or **interstadial** event, which occurred approximately 12 500 years BP, towards the end of the last glacial period (the **Devensian Stage**), prior to the **Older Dryas**.

Boreal period: a term used primarily in Europe to describe an interval of the **Holocene Epoch** that extends from about 9000 to 7500 years BP. It follows the **Pre-Boreal period** and precedes the **Atlantic period**, and was characterized by cold winters, warm summers and a growth of **boreal** forests.

Boreal: referring to the north or a cold climate.

Boulder: a sedimentary particle with a diameter of more than 256 mm.

BP: before present (see **Absolute dating**).

Brackish: waters with salinities intermediate between fresh and marine waters.

Braided channel: a stream or river channel that branches frequently and rejoins after separation by bars.

Braided river (braided stream): a stream or river that divides into an interlacing network of several small branching and rejoining shallow channels, separated by bars or islands.

Bramertonian Stage: a British chronostratigraphical division (**stage**; see **chronostratigraphy**); a short-lived temperate (**interglacial**) stage of the early **Pleistocene Epoch**, which began about 1.6 million years ago. It follows the **Baventian Stage**.

Breccia: a **sedimentary rock** consisting of angular pebbles (cf. **conglomerate**).

Bronze Age: an archaeological cultural division, designated in the **Three-Age System** as following the **Stone Age** and preceding the **Iron Age**, and characterized by a shift from the use of stone tools to the use of bronze. The timing of this division varies from region to region, but is considered to have occurred

in Europe about 5000 years BP.

Brown Earth Soil: a type of soil typically found in deciduous woodlands, where organic matter is rapidly formed by the abundant leaf litter and soil fauna.

Bryophyte: a group of plants that include mosses and liverworts.

Cainozoic Era: a geological time division (**era**; cf. **chronostratigraphy**); the youngest era, spanning from approximately 65 million years ago to the present, and consisting of the **Tertiary** and **Quaternary periods**.

Calcareous: containing large quantities of calcium carbonate ($CaCO_3$).

Calcification: the process of increasing the proportion of calcium carbonate in a rock or **fossil**.

Calcite: calcium carbonate ($CaCO_3$), the dominant component of **limestones**.

Calcrete: a 'fossil soil' (**palaeosol**) rich in calcium carbonate, indicative of arid or semi-arid environments.

Calving: the process by which a mass or block of ice breaks off of a **glacier** or **ice sheet**, usually in the sea.

Carboniferous Period: a geological time division (**period**; cf. **chronostratigraphy**); ranging from about 362 to 290 million years ago, it precedes the **Permian Period**.

Carbon isotope analysis: see **isotope analysis**.

Carr: a water-logged ecosystem (mire) containing scrub vegetation, found on high productivity (mineral-rich nutrients) peat, dominated by alder and willow.

Catchment: a term often synonymous with drainage basin; the area that collects the water flowing to a particular river. See **watershed**.

Chalk: a poorly lithified, porous white **limestone**. Stratigraphically, *the Chalk* (a proper noun with a capital letter) is used synonymously with the Upper **Cretaceous Series**, which formed during the Late **Cretaceous Epoch**.

Charcoal: the carbonized remains of plant tissue burnt at very high temperatures, in which some internal structure of the plant may be still preserved.

Charophyte: a single-celled **planktonic** plant-like organism.

Chelford Interstadial: a term used in Britain to describe a short-lived climatic amelioration or **interstadial** event, which occurred from about 65 000 and 59 000 years BP, towards the beginning of the last glacial period, the **Devensian Stage**.

Chironomid: any member of the chironomidae family of the order Diptera. Includes over 200 species of midges, bloodworms and gnats.

Chert: cryptocrystalline silica (SiO_2) which may be of organic or inorganic origin, occurring as layers or **nodules** in **sedimentary rocks** (mainly **limestones**).

Chronostratigraphy: the **correlation** and subdivision of rock units on the basis of relative age – a hierarchy of sequential units to which the layers of sedimentary rocks are allocated, through the study and interpretation of their **stratigraphy**. The hierarchy of principal chronostratigraphical units is **erathem**, **system**, **series** and **stage**, which are related, respectively, to the geological time units of **era**, **period**, **epoch** and **age**. Rocks of the Jurassic System (a chronostratigraphical unit) were laid down in the Jurassic Period (a geological time unit).

Chronozone: a fine division of geological time based on some recognizable feature preserved in **contemporaneous** sedimentary **strata**.

Cirque: an overdeepened, steep-walled, hollow in a mountain caused by glacial and periglacial erosion; = **corrie** (Scotland); = cwm (Wales).

Clast (adj. **clastic**): a sedimentary particle, a fragment of a pre-existing rock or **fossil** (**bioclast**).

Clay: very fine-grained **sediment**, less than 0.004 mm in size.

Climax community: an assemblage of species representing the usual long-term or permanent inhabitants of an area.

Coal: a combustible rock containing primarily carbonaceous material formed from the compaction and hardening of plant remains.

Coal Measures: a stratigraphical term used for the sequence of rocks occurring in the upper part of the **Carboniferous System**, which were typically coal-bearing.

Cobble: a piece of rock with a diameter of between 64 and 256 mm. Generally rounded or subrounded in shape.

Col: the highest point on a divide between two valleys.

Coleopteron: an insect of the order Coleoptera, for example beetles or weevils.

Collapse breccia: a **breccia** formed by the collapse of rock that is overlying an opening.

Colluvium (adj: **colluvial**): any loose, mixed mass of soil or rock fragments deposited by runoff or slow downslope creep, usually found at the base of gentle slopes or hillsides.

Columnar joints: parallel columns which are hexagonal in cross-section, formed due to contraction during cooling, which are found mainly in basaltic flows, but also in other **igneous rocks**.

Congelifluction: see **gelifluction**.

Conglomerate: a **sedimentary rock** consisting of rounded pebbles (cf. **breccia**).

Consolidation: any process by which loose material becomes a solid and coherent rock.

Contemporaneous: formed or occurring at the same time.

Continentality: a condition of climate or **palaeoclimate** dominated by persistent, dry, descending air. It persistence can give rise to distinctive deposits and landforms, for example **loess**.

Convolute lamination (or **bedding**): a sedimentary structure characterized by marked crumpling or intricate folding of the laminations within a well-defined, undeformed sedimentation unit; thought to form mainly by density contrasts and load deformation in water-saturated sediment.

Coprolite: preserved and fossilized droppings.

Coral: an aquatic invertebrate animal that secretes a calcium carbonate external skeleton. It may live as an individual or in large colonies.

Corestone: a block of **granite**, oval in shape, formed by **weathering** in the same manner as a **tor**, but separated from **bedrock**.

Correlation: the tracing and identification of a **stratigraphical** unit away from its type area by comparing **lithologies** and/or **faunas**.

Corrie: a Scottish term for a **cirque**.

Coversand: an **aeolian** deposit of fine-grained **sand**, usually mainly **quartz**, deposited by strong winds during **glacial periods**.

Creep: the slow mass-movement of material down relatively steep slopes, mainly under the force of gravity, but also influenced by saturation with water and alternate freezing and thawing.

Cretaceous Period: a geological time division (**period**; see **chronostratigraphy**); ranging from 145.6 to 65 million years ago, it is the last period of the **Mesozoic Era**.

Cromerian Stage: a British chronostratigraphical division (**stage**; cf. **chronostratigraphy**); a warm (**interglacial**) stage of the lower–middle **Pleistocene Epoch**, equivalent to **oxygen isotope stages** 13 to 21, and ending about 300 000 years BP. It follows the **Beestonian Stage** and precedes the **Anglian Stage**.

Cromerian Complex: a north-west European chronostratigraphical division which forms part of the middle **Pleistocene Epoch** and appears to be equivalent to the **Cromerian**, **Beestonian** and **Pastonian** stages of Britain. It is believed to have consisted of 5 or 6 glacial–interglacial transitions.

Cross-bed, **cross-lamination**, **cross-stratification**: a series of inclined **bedding planes** deposited by currents (rivers, wind or coastal). Large-scale features are named '**cross-stratification**', smaller-scale features are known as '**cross-bedding**'; and '**cross-laminations**' are the finest-scale forms.

Cryoplanation: the alteration of a surface by processes associated with frost action, such as frost shattering and **solifluction**.

Cryoturbation: the disturbance and alteration of soil by frost action.

Cuesta: an asymmetric ridge, with a steep slope on one side, and a shallow slope on the other.

Debris flow: the rapid downslope flow of poorly-sorted debris mixed with water. Also refers to the landform produced by an individual flow.

Deforming layer (and/or **till**): a mobile, subglacial, soft deforming or deformable bed or till, composed of a slurry-like saturated debris, formed when the water pressure in the sediment pores increases enough to reduce the resistance between individual grains; in response to the shearing force from the overlying ice, the slurry forms a continuously deforming layer on which the glacier moves. Deformation tills may accumulate by the transport and accumulation of sediment within the deforming layer or by down-cutting and the assimilation of new sediment into the deforming layer. Recognized by characteristics such as tectonic laminations and folding, but when homogenized can be difficult to recognize from other till types.

Deglaciation: the processes whereby glaciers thin and withdraw from an area.

Delta (adj. **deltaic**): a fan-shaped or irregular

mass of **sediment** deposited where a river enters a lake or the sea.

Denudation: the combined processes of **weathering** and **erosion** that wear down landscapes. From the Latin *denudare*, to 'strip bare'.

Dessication crack: a crack formed when wet **sediment** dries out.

Devensian Stage: a British chronostratigraphical division (**stage**; see **chronostratigraphy**); the last cold (**glacial**) stage, during the late **Pleistocene Epoch**, equivalent to **oxygen isotope stage** 2, and occurring from about 120 000 to 10 000 years BP. It follows the **Ipswichian Stage** and precedes the **Flandrian Stage**.

Devonian Period: a geological time division (**period**; cf. **chronostratigraphy**); ranging from about 408 to 362 million years ago, it is part of the Palaeozoic Era.

Diachronous: describes an apparently continuous stratum that is a different age in different places.

Diagenesis (adj. **diagenetic**): the alteration of the mineralogy and texture of **sediments** and **fossils** when they are close to the Earth's surface by chemical and physical processes; the term excludes **metamorphic** alteration.

Diamictite: a poorly or non-sorted, non-calcareous, **terrigenous sedimentary rock**, that contains a wide range of particle sizes.

Diamicton: a non-lithified **diamictite**, for example a **till**.

Diatom: a single-celled, microscopic plant which grows in fresh and marine water. They secrete walls of silica, which may be preserved in **sediments**.

Differential weathering: **weathering** that occurs at different rates, due to differences in composition and resistance of a rock and/or differences in the intensity of weathering.

Dimictic: descriptive of a lake that has two yearly overturns or periods of circulation.

Dimlington stadial: a term used primarily in Britain to describe the final, short-lived climatic deterioration, or **stadial** event, which occurred between about 26 000 and 13 000 years BP, towards the end of the last glacial period (the **Devensian Stage**). Also referred to as the Dimlington Chronozone and the equivalent to the **Last Glacial Maximum**.

Dinantian Stage: a chronostratigraphical division (**stage**; see **chronostratigraphy**); equivalent to the Lower **Carboniferous Series** in Europe and preceding the **Namurian Stage**.

Dinoflagellate: a single-celled **planktonic** organism related to algae that has two flagella (tails) that are used in movement.

Dip: the angle between a surface and a horizontal plane.

Dissolution: the natural process of dissolving a solid; specifically in **karst** processes, the dissolving of carbonate rock to create a liquid solution of calcium and bicarbonate ions in water; also known as **solution**.

Dolerite: a medium-grained **igneous** rock that generally occurs in **dykes** and **sills**.

Drenthe ice advance: the second of three ice advances recognized in Scandinavia, which occurred during the northern European glacial **Saalian stage**.

Drift: a term used to characterize all unconsolidated rock debris transported from one place to another.

Drumlin: a low, rounded hill of glacial till, which was moulded into a streamlined shape by glacier ice passing over it. Its long-axis is parallel to the direction of flow of the ice sheet beneath which it formed.

Dry valley: a fluvial valley cut by a **subaerial** stream or river then abandoned and left dry owing to underground drainage; or caused by a glacial meltwater phase of erosion.

Dune: a ridge or mound of sand-size sediment that occurs in several forms, such as barchan, draa and seif, in deserts and coastal locations. On sandy-bedded rivers, dunes are a bedform that can take several forms and sizes, varying from about 10 cm to 40 m.

Dune Slack: a wet hollow in a sand dune system that is gradually filled in with sand and vegetation, formed when wind erosion reaches the water table and erosion is stopped

Dyke: a vertically orientated band of rock. The term is generally applied to **igneous rocks** which have 'intruded' or 'cut through' pre-existing rocks, although sedimentary (Neptunian) forms occur.

Edaphic: descriptive of ecological formations or effects due to the local conditions of the soil or substrate.

Eemian Stage: a north-west European (Dutch) chronostratigraphical division (**stage**; see **chronostratigraphy**); the penultimate warm (**interglacial**) stage, during the late **Pleistocene Epoch**, equivalent to **oxygen**

isotope stage 5 and the British **Ipswichian Stage** and occurring from about 130 000 to 120 000 years BP. It follows the **Saalian Stage** and precedes the **Weichselian Stage**.

Elbe: a term formerly applied in north-western Europe to an early glacial stage of the **Pleistocene Epoch**. This term has been superseded by the northern European (Dutch) **Menapian Stage**, which is assumed to be roughly equivalent to the British **Beestonian Stage**.

Electron spin resonance (ESR): a measure of the exposure of calcite speleothem to environmental radiation, which can be used to establish the speleothem's age.

Elsterian Stage (Elster): a north-west European chronostratigraphical division (**stage**; see **chronostratigraphy**); a cold (**glacial**) stage during the middle **Pleistocene Epoch**, approximately equivalent to the British **Anglian Stage**. It follows the European **Cromerian Complex** and precedes the **Saalian Stage**.

Englacial: contained or carried within a glacier or ice sheet.

Ephemeral: short-lived, intermittent.

Epiphyte (adj. **epiphytic**): a plant which does not grow in soil, but lives attached to another plant or inanimate object.

Epoch: a geological time unit (cf. **chronostratigraphy**), of shorter duration than a **period** and itself divisible into **ages** (e.g. the Late **Triassic Epoch**; the **Pleistocene Epoch**).

Era: a major geological time unit (cf. **chronostratigraphy**); the geological record is divided into five such units; the Archean, Proterozoic, Palaeozoic, **Mesozoic** and **Cainozoic eras**. Each is composed of several **Periods**.

Erathem: a major chronostratigraphical division (cf. **chronostratigraphy**) which comprises all the rocks formed during an **era**.

Erosion: the wearing away of the land's surface by mechanical processes such as the flow of water, ice or wind, or chemical processes such as solution.

Erosion surface: a surface shaped by the processes of **erosion**.

Erratic: a large clast left behind by melting ice and composed of rock not found locally.

Esker: a sinuous ridge of sand and gravel deposited by a **meltwater** stream flowing within a tunnel under a **glacier** or **ice sheet**.

Estuarine: relating to estuaries, where a river opens into the sea or lake.

Etchplain: an extensive **erosion surface**, developed by the rapid lowering, during uplift, of a **peneplain** surface kept at or near base level by the removal of a deep, overlying cover of weathered debris.

Eurythermal: descriptive of a marine organism that can tolerate a wide range of temperatures.

Eustatic: concerning world-wide changes in sea level (as distinct from changes when land locally sinks into or rises from the sea). **Eustatic** changes of sea level may be caused by ice-ages or may reflect periods of major tectonic activity.

Eutrophic: a body of water with high levels in plant nutrients, with correspondingly high productivity.

Eutrophication: the process by which water bodies become **eutrophic**; the artificial or natural enrichment of a lake by an influx of nutrients.

Exogenic (also **exogenetic**): descriptive of a process starting at or near the surface of the Earth, for example **weathering** or **erosion**, and of rocks and landforms that owe their origin to these processes.

Extraglacial: descriptive of **glacial deposits** formed by **meltwater** outside the limits of the ice, or of areas never covered by ice.

Facies: the total characteristics of a rock or sediment, including the rock or sediment type, sedimentary structures (for example **bedding**), and **fossils**. Together these features indicate a characteristic environment of deposition.

Fan: a low-lying accumulation of **sediment** with a roughly triangular outline. See **alluvial fan**.

Fault: a fracture within a rock along that there has been displacement due to tectonic deformation (e.g. earthquakes).

Fauna: animals – often referring to the characteristic animal assemblage of a region of time period.

Fen: a high productivity (mineral-rich nutrients) waterlogged ecosystem (mire), with a winter water table at ground level or above, usually dominated by sedge and an accumulation of peat.

Fissure: a fracture surface or crack within a rock along which a clear separation can be seen. Often filled with material, frequently mineral-bearing.

Fjell: a Norwegian term for field; also an English term for a rocky, elevated, barren plateau above the treeline, covered with snow during the winter.

Flame structure: a structure with an irregular flame-like shape, formed when an unconsolidated layer of **sediment** is covered by a layer of denser sediment. The dense material pushes down into the underlying **sediment**, which is squeezed upwards in 'flames'.

Flandrian Stage: a European chronostratigraphical division (**stage**; see **chronostratigraphy**); the most recent warm (**interglacial**) stage of the **Quaternary Period**. It is roughly equivalent to the **Holocene Epoch** and commenced approximately 10 000 years BP.

Flaser bedding: **cross-laminated sandstones** that contain **mudstone** streaks.

Flocculation: the effect on water of the bunching of clay particles into aggregates called 'floccules'. It takes place when the repulsive charge that normally exists between clay particles is reduced by the electrolytic action of saltwater, allowing particles to stick together if they collide.

Floodplain: the level surface next to a river that is water covered during times of flood.

Flora: plants – often referring to the characteristic plant assemblage of a region of time period.

Flowstone: a calcium carbonate rock deposited in caves.

Flow till: a **superglacial till**, modified and transported by mass flow from a glacier into a proglacial area.

Fluvial: relating to a river or river system

Fluvio-aeolian: relating to the combined action of rivers and wind.

Fold: a flexure in rocks.

Foliation: the planar arrangement of minerals, or other textural or structural features in rocks.

Foraminifer: a single-celled marine animal that has a protective external shell, often with an elaborate form. These micro-organisms are usually less than one millimetre in diameter (a few are larger).

Foreset: a steeply dipping surface of **cross-bedded strata**; also applied to the large-scale cross strata deposited by rivers in glacial lakes as deltas.

Foreshore: the outer, or lower, seaward-sloping zone of a shore or beach. Also applied to the area of land in between a body of water and land that is occupied or cultivated.

Fossil: the preserved remains of animals and plants.

Fossiliferous: containing abundant **fossils**.

Frost creep: the downslope movement of soil or sediment in permafrost areas due to freeze-thaw processes.

Fuhne ice advance: the first of three ice advances recognized in Scandinavia, which occurred during the northern European glacial **Saalian stage**.

Gabbro: a coarse-grained, often dark-coloured, basic **plutonic igneous** rock that generally forms large intrusions (**batholiths/plutons**).

Gastropod: a **mollusc** with a spiral shell; for example a snail.

Gelifluction: the lateral flow of material under **periglacial** conditions, i.e. **solifluction** in an area underlain by frozen ground.

Gelivation (gelifraction): frost shattering; the mechanical breakup of rocks and soils due to pressures exerted by the freezing of water in cracks, pores or **bedding planes**.

Geomorphology: the study of the landforms and the processes that formed them.

Gerzensee oscillation: a short-lived, low amplitude climatic oscillation, leading to colder and drier conditions, which has been identified on the Swiss Plateau and in the UK, and dated to approximately 12 000 years BP, towards the end of the last glacial period (the **Devensian Stage**).

Gibbsite: a white monoclinic mineral formed by the **weathering** of **igneous rocks**, and the principal component of bauxite.

Glacial: relating to the activity and presence of glaciers or ice.

Glacial advance: a time interval marked by an advance or expansion of a **glacier**.

Glacial age: a subdivision of a glacial epoch.

Glacial deposit: a deposit or **drift** transported by **glaciers** or ice bergs, and deposited directly on land or in the sea.

Glacial cycle: a major climatic oscillation of the order of 100 000 years, during which the ice sheets advanced and subsequently retreated and recurrent at fairly regular times.

Glacial drainage: the system of **meltwater** streams flowing from a **glacier** or **ice sheet**.

Glacial drift: see **glacial deposit**.

Glacial epoch: any period of geological time during which the climate was cold in both the northern and southern hemispheres and **ice sheets** and **glaciers** covered a larger total area than those of the present day.

Glacial erosion: the **erosion**, by, for example grinding, gouging and scratching, by the movement of a **glacier** with rock fragments within it, and also by **meltwater** streams.

Glacial lake: a lake fed primarily by the **meltwater** of a **glacier**, and found beyond the margins of the **glacier**.

Glacial maximum: the time or position of the greatest advance of a **glacier** or **ice sheet**.

Glacial period: a synonym for **glacial epoch**.

Glacial plucking: a common mechanical weathering process in glaciated areas where glacial ice frozen into cracks in the bedrock plucks rock material from the valley floor.

Glacial recession: a time marked by a decrease in the size and volume of a **glacier**.

Glacial refuge (or **refugia**): a restricted, ice-free area in which plants and animals can or could persist during a time of **glacial advance** or a **glacial epoch**.

Glacial scour: the eroding action of a **glacier**. This includes both the removal of material, and the processes of **abrasion**, scratching, and polishing of a rock surface, caused by rock fragments within the **glacier**.

Glacial stage: a major subdivision of a **glacial epoch**, for example one of the major cycles of growth and disappearance of the **Pleistocene ice sheets**.

Glacial trough: a deep, steep sided U-shaped valley leading from a **cirque**, carved by a **glacier** that has widened and deepened a pre-existing river valley.

Glacial valley: a U-shaped, steep-sided valley influenced by the presence of glaciers and showing signs of glacial erosion.

Glaciation: a term to describe the formation, movement and recession of **glaciers** and **ice sheets**.

Glacier: a large body of ice formed in part on land by the compaction of snow, which moves slowly by **creep** downslope, or outwards in all directions under the influence of gravity.

Glacier advance: see **glacial advance**.

Glacier flow: the slow outward or downward movement of the ice in a glacier under the force of gravity.

Glacier ice: descriptive of any ice that was once part of a **glacier**.

Glacier lobe: a large rounded projection from the margin of a **glacier** or **ice sheet**.

Glacier outburst flood: a sudden release of **meltwater** from a **glacier** or a glacier-dammed lake, which may result in flooding; see also **jökulhlaup**.

Glacier recession: see **glacial recession**.

Glacier surge: a period of very rapid flow of a glacier, usually lasting no longer than a few years.

Glacio-aqueous: resulting from the combined action of water and ice.

Glacio-eustatic: relating to 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**.

Glacio-fluvial: relating to the **meltwater** streams that flow from melting **glacier** ice, and to the deposits and landforms created by such streams, for example **outwash plains**.

Glaciokarst: a limestone landscape which has been glaciated.

Glaciogenic: of or relating to **glaciers** and **glaciations**.

Glacio-isostasy: crustal movements associated with the addition and removal of **glaciers**.

Glacio-lacustrine: relating to **glacial lakes**.

Glaciology: the study of all aspects of **glaciers**, snow and ice.

Glaciomarine sediments: glacially eroded, terrestrially derived **sediments** (**clay**, **silt**, **sand**, and **gravel**) deposited in the marine environment. The sediments may accumulate by ice rafting, as an ice-contact deposit or by **aeolian** transport.

Glaciotectonic: the deformation of rocks or **sediments** caused by **glacial** movement.

Gley: the product of waterlogged soil conditions, often represented by colour mottling.

Gneiss: a coarse-grained, inhomogeneous **metamorphic rock**, formed at high temperatures and pressures, characterized by a coarse **foliation** or layering of light and dark bands, more widely spaced, irregular, or discontinuous than in a **schist**.

Goethite: a hydrated iron oxide mineral.

Graben: a linear block of crust downthrown between two parallel **faults** to produce a rift or trough.

Graded bedding: beds that show a change in grain size through the bed. Normal graded bedding is a fining upwards sequence. In

reverse graded bedding, the grain size coarsens upwards.

Granite: a pale-coloured, coarse-grained **plutonic igneous rock**, commonly occurring as large intrusions but also found in veins.

Gravel: sedimentary particles with a diameter of between 2 and 4 mm.

Gravity anomaly: the difference between the observed value of gravity at a location and a theoretically calculated value.

Greywacke: a poorly sorted, **clastic sedimentary rock** composed of fragments of rocks and crystals and sand set in a clay-rich **matrix**.

Grike: a fissure in a **limestone pavement**, formed by dissolutional enlargement of a joint.

Gritstone: a hard, coarse-grained **sedimentary rock**.

Groundwater recharge: the recharging of groundwater by water collected above an impermeable material which creates a saturation zone (the upper level of which is the water table).

Grus: the fragmental by-products formed by the granular disintegration of granitic or sandstone rocks.

Gypsum: a white or colourless calcium sulphate mineral ($CaSO_4.2H_2O$) often associated with evaporite deposits.

Gyttja: a dark mud, pulpy in texture and rich in organic matter. Found in marshes or lakes whose waters are rich in nutrients and oxygen.

Haematite: an iron oxide (Fe_2O_3) often used as a source of iron ore.

Halleflinta: a no-longer used term for a fine-grained **quartz-** and **feldspar-**rich metavolcanic rock, often **rhyolitic**.

Hanging valley: a tributary valley whose floor is higher than the floor of the main valley. Usually the result of **glaciation**.

Holocene Epoch: a geological time division (**epoch**; cf. **chronostratigraphy**); the most recent global epoch, which began approximately 10 000 years BP. It is roughly equivalent to the European **Flandrian Stage**.

Honeycomb weathering: a form of chemical **weathering** in which numerous pits occur on a rock exposure, causing the surface to look similar to a large honeycomb. It typically occurs in arid or coastal regions, affecting granular rocks such as **sandstones** and **tuffs**.

Hoxnian Stage: a British chronostratigraphical division (**stage**; cf. **chronostratigraphy**); a warm (**interglacial**) stage during the middle Pleistocene Epoch, equivalent to oxygen isotope stage 9 and occurring between about 250 000 and 200 000 years BP. It follows the **Anglian Stage**.

Humic: derived from or referring to **humus**.

Hummocky moraine: an undulating landscape, formed along an active ice front, or where masses of stagnant ice have melted out in a moraine landscape.

Humus: the dark organic content of a soil, generally so well decomposed that its origin cannot be determined.

Hydrosere: a **sere** developed in an aquatic environment.

Ice Age: a name often applied to the **Pleistocene Epoch** during which large areas were repeatedly covered by **ice sheets** and **glaciers**.

Iceberg: a piece of ice that has been detached from the main body of a glacier or ice sheet into a body of water.

Ice cap: an area of ice, smaller than an **ice sheet**, occurring in the polar regions and high mountain areas.

Ice-contact slope: an irregular **scarp** against which glacier ice once rested.

Ice floe: an extensive sheet or large fragment of ice, floating freely in water.

Ice-rafted: descriptive of material deposited by the melting of a **glacier** or **ice sheet** which contained it.

Ice-rafting: the transportation of rock fragments of all shapes and sizes on **icebergs** and **ice floes**, and the subsequent deposition in the sea from the melting of the ice.

Ice sheet: a very large area of ice, such as those covering much of Greenland and Antarctica in the present day. During the **Pleistocene Epoch**, ice sheets covered much of the Northern Hemisphere.

Ice-wedge: a massive wedge-shaped body of banded ice formed in a **permafrost**, which occurs as a vertical structure and tapers downwards. Formed by seasonal freezing and thawing of ice and **sediment** and the pressures exerted by its resultant expansions and contractions.

Ice-wedge cast: a sedimentary structure formed by the filling of the space previously occupied by an **ice wedge** that has melted.

Ice-wedge polygon: a large polygon formed by the borders of intersecting **ice-wedges**.

Igneous rock: a rock that has formed from molten rock (magma), either by volcanic activity or intrusive processes. It consists of interlocking crystals, the size of which depends on the rate of cooling of the magma.

Ignimbrite: a rock, typically silica-rich and pumiceous, formed by deposition from a **pyroclastic** flow; may partly or wholly comprise welded tuff.

Ilfordian Stage: a British chronostratigraphical division (**stage**; see **chronostratigraphy**); a warm (**interglacial**) during the middle **Pleistocene Epoch**, equivalent to **oxygen isotope stage** 7 and occurring after about 200 000 years BP. It follows the **Hoxnian Stage**.

Imbrication: a sedimentary fabric displaying typically elongate fragments that are aligned in a preferred angle to the bedding, usually indicative of the direction of transport.

Interfluve: the area between rivers.

Interglacial: a period of relatively warm climate between two episodes of **glaciation** where ice is in retreat.

Interstadial: a relatively short period within a major phase of **glaciation** when ice was not advancing and conditions were comparatively warm, although trees did not migrate back into the country.

Intertidal: littoral; the zone between high- and low-water marks on a shoreline.

Involution: an irregular, contorted, complex sedimentary structure, caused by the formation, growth and melting of ground ice.

Ipswichian Stage: a British chronostratigraphical division (**stage**; see **chronostratigraphy**); a warm (**interglacial**) stage during the middle **Pleistocene Epoch**, approximately equivalent to the north-west European **Eemian Stage**, and occurring between about 135 000 and 115 000 years BP. It follows the **Wolstonian Stage** and precedes the **Devensian Stage**.

IRM (isothermal remanent magnetization): the remanence produced in a sample by the application and subsequent removal of a known magnetic field.

Iron Age: an archaeological cultural division, designated in the **Three-Age System** as following the **Stone Age** and the **Bronze Age**, and characterized by a general shift to the use of iron as the main material for tools. The timing of this division varies from region to region, but is considered to have occurred in Europe around 3000 years BP.

Iron pan: a thin layer of concentrated iron that forms in soils (podsols) and may be preserved in **palaeosols** and other sedimentary sequences.

Isochrones: lines of equal age.

Isostasy: the condition of equilibrium, comparable to buoyancy, of the Earth's crust 'floating' in the aesthenosphere. Crustal loading, for example by ice, water or volcanic flows, leads to isostatic depression, and the crust sinks deeper into the aesthenosphere. The removal of weight leads to isostatic uplift or rebound, and the crust rises.

Isotope analysis: a study of the relative abundances of usually two forms of an element having the same atomic number but different atomic weights, such as ^{18}O and ^{16}O. The relative abundances of certain of these isotopes may be related to the climatic conditions, in which they were produced, and therefore they can be used to investigate past environments.

Joint: a fracture in a rock that exhibits no displacement across it (unlike a **fault**). May be caused by shrinkage of **igneous rocks** as they cool in the solid state, or, in **sediments**, by regional extension or compression of **sediment** caused by Earth movements.

Jökulhlaup: an Icelandic phrase for a **glacier outburst flood**.

Jurassic Period: a geological time division (**period**; cf. **chronostratigraphy**); ranging from about 208 to 145.6 million years ago, it precedes the **Cretaceous Period**.

Kame: a mound of stratified **sand** and **gravel** originally deposited on top of, or at the margin of, a **glacier** or **ice sheet** by **meltwaters**, and remaining as a topographic feature after the ice has melted.

Karren: small dissolution features formed on **limestone** outcrops and on **limestone** surfaces beneath a soil cover; dominated by channels or runnels, mostly 10–500 mm deep, which are entrenched to leave sharp or rounded intervening ridges; originally a German term but now used throughout international literature.

Karst: a distinctive terrain created by **erosion** of a soluble rock, where the topography and

landforms are a consequence of efficient underground drainage; characterized by caves, **sinkholes** and dry valleys and mainly developed on **limestone**.

Kettlehole: a depression in glacial or **glaciofluvial sediments**, resulting from the melting of a mass of **glacier** ice that was buried in sediment.

Lacustrine: relating to, formed within in, or produced by, lakes.

Lamina (pl. **laminae**): the finest layer within a **sedimentary rock**, typically less than 1 cm thick.

Larvickite: an alkali-rich **syenite**

Last Glacial Maximum: the time of the last great glacier advance, when **ice sheets** and **glaciers** reached their maximum thickness and extent. Dated to between 22 000 and 18 000 years BP, and often assumed to be equivalent to the **Dimlington Stadial**.

Late-glacial: relating to the time of the end of the last glaciation of the **Pleistocene Epoch**, part of the **Devensian Stage**.

Lateral moraine: a ridge-like **moraine**, built along on the side margin of a **glacier**, formed mainly from valley-side rockfall sediment.

Leach: to dissolve or remove material from a soil or rock.

Lead-210 dating (^{210}**Pb dating**): a method of calculating an age by determining the lead content.

Levee: a broad ridge alongside a river or stream, deposited by floodwaters when they overtop the channel banks.

Lignite: a brown coal formed from peat under moderate pressure having a low calorific value, typically of **Tertiary** age

Limestone: a **sedimentary rock** composed of calcium carbonate (calcite), often derived from the shells of organisms.

Limestone pavement: a bare **limestone** surface produced by solution processes that enlarge **joints** to produce horizontal flat areas ('clints') and clefts ('grikes'); usually fretted by **karren** landforms.

Limnic: referring to or relating to a body of fresh water, such as a lake.

Limnology: the study of the characteristics of all inland waters, such as lakes, **wetlands**, rivers and bogs.

Lipid: a class of molecules consisting of fats, oils and waxes that contain fatty acid chains. A major component of the cells of plants and animals.

Lithofacies: a **facies** defined by **sedimentary rock** type (using, for example, colour, texture and mineral composition).

Lithology: descriptive of the constitution of a **sediment** or a rock, including texture, composition and colour.

Lithostratigraphy: the determination of the **stratigraphical** relationships between rocks based on their **lithology**. Units are named according to their perceived rank in a formal hierarchy, namely Supergroup, Group, Formation, Member and Bed.

Little Ice Age: a brief cool interval in the Middle Ages (1400 to 1900 AD), during which temperatures were between 1°C and 2°C lower than the present day.

Little Climatic Optimum: a brief warm and dry interval in the Middle Ages (1100 to 1300 AD), which occurred prior to the **Little Ice Age**.

Littoral: 'seashore'; the zone between high- and low-water marks on a shoreline.

Load structure: a protuberance of sand or coarse clastic material that extends downwards into a finer-grained, softer underlying material such as wet **mud** or **clay**. Produced by downsinking and unequal settling and compaction of the overlying material.

Loch Lomond Stadial: a term used primarily in Britain to describe a short-lived climatic deterioration, or **stadial** event, which occurred about 10 500 years BP, towards the end of the last glacial period (the **Devensian Stage**). It is equivalent to the European **Younger Dryas**.

Loess: a fine-grained sediment of windblown silt and clay, largely derived from cold **periglacial** deserts, or from reworking by wind of the fine components of glacial sediments.

Lodgment till: a glacial deposit laid down underneath an **ice sheet** or valley **glacier**. It is usually clay-rich and contains boulders.

Loss on ignition: a method for estimating the **organic** and **carbonate** content in **sediments**, by burning the material at high temperatures.

Macrofossil: a **fossil** that is easily seen by the naked eye.

Macrophyte: a plant that can be seen by the naked eye, typical of aquatic regions.

Magnetic mineral analyses: the measurement of the magnetic properties of a material.

Includes **magnetic susceptibility**, declination, inclination, isothermal remanent magnetization (**IRM**) and 'hard' IRM (HIRM).

Magnetic susceptibility: a measure of the inherent magnetism of a rock, sediment or soil. It is measured by comparing the ratio of induced magnetization to the strength of the magnetic field causing the magnetization. It can be used to investigate the textural, mineralogical and chemical properties of the medium being measured.

Marine regression: the withdrawal of the sea from large areas of land due to a fall in sea level relative to the land.

Marine transgression: the encroachment of the sea across large areas of land, due to either a rise in sea level, or subsidence of the land.

Marker horizon: a distinctive layer or rock in a body of rock that may help to distinguish between **lithostratigraphical** units.

Marl: a very fine-grained calcium carbonate-rich **mud** or **clay**.

Mass wasting: the dislodging and transport of soil and sediment due to gravity. Processes include **solifluction** and rock falls.

Matrix: the **sediment**, usually very fine grained, which infills the spaces between larger grains.

Meltwater: water produced by the melting of snow and ice.

Meltwater plume: a two- or three-dimensional plume-shaped body of water caused by the mixing of the flow entering a lake or the sea from a glaciated basin, with turbulent eddies along the inflow margins. The shape and velocity patterns within the plume are governed by the discharge and velocity of the incoming water, channel shape, suspended sediment concentration and the density differences between the inflow and surrounding waters and the density stratification in the water.

Mere: a shallow lake, notably formed by flooding of a subsidence depression in the salt **karst** of Cheshire, or by ice melting to form **kettleholes**.

Mesolithic: an archaeological term to define the middle division of the **Stone Age**, following the **Palaeolithic** division and preceding the **Neolithic** division. It is characterized by a broad use of food resources and localized populations, and is broadly dated from about 12 000 to 10 000 years BP.

Mesozoic Era: a geological time division (**era**; cf. **chronostratigraphy**); ranging from about 250 to 65 million years ago, it comprises the **Triassic**, **Jurassic** and **Cretaceous periods**.

Metamorphic rock: a rock that has been altered by the action of heat and/or pressure, without melting.

Metamorphism: the process of alteration of **igneous rocks** and **sedimentary rocks** by increases in pressure and/or temperature within the Earth's crust.

Meteoric water: groundwater of atmospheric origin, which reaches the Earth's surface as precipitation.

Microfauna: a microscopic animal assemblage.

Microfossil: a microscopic **fossil**.

Microgranite: a type of **granite** with characteristically small crystals.

Miocene Epoch: a geological time division (**epoch**; cf. **chronostratigraphy**); ranging from about 23 to 5.3 million years ago, it is the fourth of the epochs of the **Tertiary Period**. It follows the **Oligocene Epoch** and precedes the **Pliocene Epoch**.

Misfit river: a river, small in size in comparison to the size of the valley in which it is found.

Mire: a small area of marshy or boggy ground.

Mollusc: a group of invertebrate animals with shells that includes gastropods, bivalves, ammonites and belemnites.

Monocline: a localized steepening of beds in an otherwise gentle dip sequence.

Monolith: a fragment of unfractured **bedrock** generally greater than a few metres in size.

Moraine: a ridge of unsorted, unstratified glacial till deposited on top of or at the margins of a **glacier** or **ice sheet**.

Mottled: descriptive of a **sediment** that has irregular patches of colour.

Moulin (glacier mill): a vertical shaft in a glacier, formed by the erosion by surface debris and water, when surface streams reach a crevasse and plunge down.

Mousterian: an archaeological term referring to a period of European culture during which a wide variety of specialized tools, such as spear points, were developed. Part of the Palaeolithic division of the **Stone Age**, it follows the **Acheulian** period. Approximate dates suggest it occurred from 70 000 to 30 000 years BP.

Mud: a mixture of **silt** and **clay**-sized particles.

Mudstone: a very fine-grained rock.

Mutual Climatic Range (MCR) method: a

method of investigating past climatic and environmental change using the climatic ranges for beetle (coleoptera) species found both in the present day and in fossil assemblages. By establishing the climatic ranges of these beetles, climatic conditions are inferred for the past by considering the overlap of the climatic ranges of the species found in a fossil assemblage.

Namurian Stage: a chronostratigraphical division (**stage**; cf. **chronostratigraphy**); equivalent to the early part of the Upper **Carboniferous** Series in Europe. It follows the **Dinantian Stage**, and precedes the Westphalian Stage.

Neogene Period: a geological time division (**period**; cf. **chronostratigraphy**); incorporating the **Miocene** and **Pliocene epochs**, it is equivalent to the upper **Tertiary Period**.

Neolithic: an archaeological term to define the last division of the **Stone Age**, following the **Palaeolithic** and **Mesolithic** divisions. It is characterized by the use of ground and polished tools, the manufacture of pottery and the practice of farming, and is broadly dated to after approximately 10 000 years BP.

Nivation (snow patch erosion): the work of **periglacial** processes associated with a snow patch, including frost shattering and **gelifluction**, which can form characteristic landforms such as nivation hollows, terraces, benches and ledges.

Nordmarkite: a red, quartz-bearing alkali **syenite**.

Nunatak: a mountain peak that projects above surrounding **ice sheets** and is subjected to intense frost action but is not scoured by glacial **erosion**.

Older Dryas: a term used primarily in Europe to describe a short-lived climatic deterioration, characterized by **tundra** and the expansion, or restricted retreat, of **glaciers**. It occurred approximately 11 500 years BP, towards the end of the last glacial period (the **Devensian Stage**), following the **Bølling Interstadial** and prior to the **Allerød Interstadial**.

Oligotrophic: lacking in the nutrients required by plants.

Ombrogenous: usually descriptive of a peat that receives all its moisture from precipitation and rain water. It is often highly acidic and low in plant nutrients, mineral matter and nitrogen.

Ombrotrophic: term meaning 'nourished by rain', which refers to areas exclusively dependent on nutrients derived from precipitation. Usually descriptive of a peat whose nutrient supply is exclusively from rain water, making it very **oligotrophic**. See also **ombrogenous**.

Optical Luminescence dating: a dating technique whereby instead of the luminescence signal being stimulated by the application of heat (thermal luminescence), an optically stimulated luminescence signal is measured while the mineral is exposed to photons of visible or infra-red electromagnetic radiation. Useful for dating sediments which have received a relatively short light exposure at deposition.

Organic: descriptive of **fossil** remains made up of materials such as cellulose, chitin or keratin but often oxidized to carbon.

Orogeny: a process of mountain building during which the rocks and **sediments** of a particular area of a continent are deformed and uplifted to form mountain belts. Although these processes take a long time they can be distinguished as recognizable and discrete phases in Earth history and are named accordingly, for example the **Alpine Orogeny**.

Ostracod: a class of crustaceans with two calcareous valves. Most are less than 1 mm in size.

Outwash: load-debris and **sediment**, often stratified, which is removed from a **glacier** by **meltwater** streams and deposited in front of the **glacier**.

Outwash fan: a fan-shaped accumulation of **outwash**.

Outwash plain: a gently sloping, broad sheet of **outwash**.

Overflow channel: a channel cut by the overflow waters from a lake, particularly a channel draining **meltwater** from a glacially dammed lake.

Oxygen-isotope analysis: see **isotope analysis**.

Oxygen isotope stages (OIS): the subdivision of the **Pleistocene Epoch** into a series of glacial-interglacial oscillations numbered from the top (the present day, or stage 1) downwards based on **oxygen isotope analysis**, which has enabled the identification of these glacial/interglacial stages.

Palaeobotany: the study of ancient plants.

Palaeochannel: an ancient (occurring in geological time) channel.

Palaeoclimatology: the study of ancient climates.

Palaeocurrent: a current-direction from an ancient fluvial flow.

Palaeoecology: the study of the relationships between ancient organisms and their environments.

Palaeoenvironment: an environment older than the recent.

Palaeokarst: a fossil **karst** landform assemblage.

Palaeolithic: an archaeological term to define the first division of the **Stone Age**, prior to the **Mesolithic** and **Neolithic** divisions. It is characterized by the first use of stone tools and is broadly dated from about 2.5 million years ago to 12 000 years BP.

Palaeomagnetism: the study of magnetism, used to consider the intensity and direction (polarity) of the Earth's magnetic field.

Palaeontology: the study of **fossil** animals and plants.

Palaeosol: an ancient or 'fossilized' soil.

Palaeotemperature: the average temperature at a given place or time in the geological past.

Palaeozoic Era: a geological time division (**era**; cf. **chronostratigraphy**); ranging from about 540 to 245 million years ago, it precedes the **Mesozoic Era**.

Paludal: referring to or relating to marsh.

Paludification: the formation of peat due to a change in environmental conditions.

Palynology: the study of **fossil** or preserved pollen enabling reconstructions of **palaeoenvironments**.

Palynomorph: a small, walled organic body, such as pollen or spores.

Palynozone: '**pollen zone**'; a biostratigraphical subdivision characterized by an assemblage of organic-walled **microfossils** such as pollen and spores.

Paraglacial: usually descriptive of a particular phase between **glacial** and **interglacial** conditions, immediately after deglaciation.

Pastonian Stage: a British chronostratigraphical division (**stage**; cf. **chronostratigraphy**); a temperate (**interglacial**) stage of the early **Pleistocene Epoch** and occurring about 600 000 years BP. It follows the **Baventian Stage** and precedes the **Beestonian Stage**.

Pea-shingle: a clean **gravel**, the individual particles of which are similar in size to peas.

Peat: an unconsolidated deposit of semicarbonized plant remains in a water saturated environment, such as a **bog** or **fen**.

Pebble: a fragment of rock with a diameter of between 4 and 64 mm.

Pedestal: a thin neck or column of rock topped by a wider mass, produced by undercutting due to **wind abrasion** or differential **weathering**.

Pediment: a plain of eroded bedrock, occasionally covered by a thin layer of **sediment**, characteristic of **sedimentary basins** in arid and semi-arid areas.

Pediplain: an extensive, thinly covered erosion surface in a desert region, formed by the coalescence of two or more **pediments**.

Pedogenesis: the origin and formation of soils.

Peneplain: a virtually flat and featureless landscape of considerable size, caused by prolonged weathering and erosion, especially **mass-wasting** and **sheetwash**.

Periglacial: a zone or environment peripheral to **glaciers**, so that it is very cold but is not covered by ice sheets; it is characterized by the frozen ground known as **permafrost**.

Periglacial activity: in a region adjacent to a **glacier**, processes that occur as a result of either intense frost action, or the presence of permanently frozen ground, or both; now generally applied to frost processes.

Perimarine: descriptive of the sedimentary facies of a lowland area protected by barrier islands, which may consist of fluvial, lagoonal and peat deposits.

Period: a geological time unit (cf. **chronostratigraphy**); of shorter duration than an **era** and itself divisible into **epochs**.

Permafrost: permanently frozen ground within a **periglacial** environment; may extend to more than 100 m deep, but the active layer of the top few metres thaws each summer and then refreezes in winter.

Permian Period: a geological time division (**period**; cf. **chronostratigraphy**); ranging from about 290 until 250 million years ago, it follows the **Carboniferous Period** and precedes the **Triassic Period**.

Phreatic: relating to the **water table**; groundwater.

Phreatic tube: a tubular cave passage formed by almost equal dissolution of the walls, ceiling and floor, while full of water within the

phreatic zone; abandoned tubes are common and may be filled with **sediment**.

Phreatic zone: the saturated zone of the ground, below the **water table**, where all pore spaces, fissures and caves are filled with groundwater.

Phytophagous: descriptive of an organism that feeds on plants.

Phytoplankton: plant forms of **plankton**, for example **diatoms**. They are often microscopic and with limited powers of locomotion, so mainly dispersed by wind and tide.

Piedmont: an area at the base of a mountain or mountain range linking to the lowlands.

Piedmont glacier: a glacier formed where a valley glacier flows onto lowland and expands after travelling through a bedrock trough. Radial crevasses will generally be evident, relating to the spreading of the ice.

Pingo: a large frost mound, caused by extensive ground ice cover.

Pioneer: in ecology, a species or community that establishes itself in a previously barren area and therefore begins a new ecological cycle.

Planation: the process of **erosion** by which the surface undergoing erosion becomes flat or level.

Planation surface: a term used in Britain to describe a fairly flat plain resulting from prolonged **erosion** by rivers, slope processes, marine erosion, or other types of erosional activity.

Plankton: minute aquatic organisms that drift with water movement.

Planktonic: belonging to the plankton, those generally small organisms that drift in water bodies and have limited powers of locomotion.

Pleistocene Epoch: a geological time division (**epoch**; cf. **chronostratigraphy**); the first epoch of the **Quaternary Period**. It is composed of alternations of great cold with stages of relative warmth and sometimes referred to as the '**Ice Age**'.

Pleniglacial: the full glacial phase of a palaeoclimatic cycle.

Plinthite: a material consisting of **clay** and **quartz** found in a soil that is poor in **humus** and highly weathered. It often occurs as red **mottles** in a polygonal pattern.

Pliocene Epoch: a geological time division (**epoch**; cf. **chronostratigraphy**); ranging from about 5.3 until 1.6 million years ago, it is the last division of the **Neogene Period**, and precedes the **Pleistocene Epoch** of the **Quaternary Period**.

Ploughing block (or **boulder**): a boulder located at the downstream end of vegetation-covered furrows, indicating downslope boulder movement at a rate exceeding that of the surrounding soil.

Ploughmark: a curved, flat-bottomed trough of furrow formed as grounded icebergs are dragged over a lake or sea floor by currents.

Pluton: an intrusion of **igneous rock** emplaced at depth in the Earth's crust. Shape, size and composition are variable.

Plutonic: descriptive term for **igneous** bodies that have crystallized at depth and commonly have coarse grain sizes.

Pocket valley: a **valley** with a head enclosed by steep sides at the base of which water emerges from underground from a spring.

Podsol (Podzol): a soil where the minerals have been leached from its surface layers into the lower layers.

Podsolization: the process by which a soil becomes more acidic and develops surface layers that are leached of **clay**.

Polje: a large **karstic** depression with a flat floor and sharp breaks of slope to its rock walls.

Pollen zone: see **palynozone**.

Porphyry: a field term for an **igneous rock** that contains large phenocrysts within a fine-grained groundmass of indeterminate composition; usually preceded by a mineral qualifier indicating the type of phenocryst present; e.g. feldspar porphyry.

Postglacial: referring to the time interval since the total disappearance of **glaciers** at middle latitudes.

Pre-Boreal period: a term primarily used in Europe to describe an interval of the **Holocene Epoch** that extends from about 10 000 to 9000 years BP. It follows the **Younger Dryas** and precedes the **Boreal period**, and is characterized by a climate generally colder and wetter than during the boreal period, and birch and pine vegetation.

Preglacial: referring to the time prior to a **glacial** period. Also said of material underlying glacial deposits.

Proglacial: in front of, or just beyond the margin of an advancing or retreating **glacier**. Also

said of features and deposits produced by or derived from glacier ice.

Projected profiles: a cartographic technique involving the drawing of cross-sections to provide a panoramic and pictorial view of the landscape and landforms, enabling the identification of consistent flatter areas. Consists of a complete first cross-section, with parallel sections behind the first only being drawn in so far as they project above the earlier sections.

Protalus rampart: a curved ridge of angular, large blocks of rock derived by single rock falls from a cliff or steep, rocky slope above, which marks the edge of a snowbank.

Protozoan (pl. **protozoa**): any unicellular and microscopic organism of the phylum Protozoa. Includes flagellates, which have plant and animal affinities, and organisms that secrete calcareous or siliceous skeletons (**foraminifera**, radiolaria).

Proxy record: a climatic record inferred from the types of flora and fauna – or their features – present in a sequence, such as pollen, tree-rings, diatoms or beetles.

Pteridophyte: a generalized term used for those vascular plants, including ferns, horse-tails and club mosses, that reproduce by spores.

Pyrite: a widespread, naturally occurring iron sulphide mineral, FeS_2, which often results from the biochemical action of bacteria within **anaerobic** environments, and may be oxidized to form corrosive sulphuric acid.

Pyritize: to alter to the mineral **pyrite** (FeS_2).

Pyroclastic: a term denoting the volcanic origin of fragments such as glass shards, euhedral or fragmented crystals, 'accidental' or 'cognate' lithic blocks, generated as a direct result of explosive volcanic action.

Quartz: a mineral composed entirely of **silica**. (SiO_2), the most common mineral in the Earth's crust.

Quartzite: descriptive of both an **arenaceous** rock composed primarily of **quartz** and a **metamorphic rock** formed from more or less pure **quartz sandstones**.

Quaternary Period: a geological time division (**period**; cf. **chronostratigraphy**); ranging from about 1.6 million years ago to the present day, it is the latest **period** of geological time, and the second period of the **Cainozoic Era**. It is divided into two **epochs**, the **Pleistocene** and the **Holocene**.

Racemization age method: a method of dating rocks or minerals using **amino acids**.

Radiocarbon dating: a method of radiometric dating by measuring amounts of carbon-14 within organic material. The method is based on the assumption that upon removal from the Earth's carbon cycle (for example when an organism dies), carbon-14 production stops, and therefore a closed system is formed and relative abundances of stable and radioactive carbon can be measured.

Radiometric age: the age in years calculated from the decay of radioactive elements.

Radiometric dating: methods of dating certain rocks or minerals using the relative abundances of radioactive and stable isotopes of certain elements, together with known rates of decay of radioactive elements. **Radiocarbon dating** can extend back to only 50 000 years, but other elements (potassium, lead, uranium) can be used to obtain dates of the order of tens to thousands of millions of years.

Radiometric: a general term used for those techniques that measure isotopic abundances in whole rocks or component minerals.

Rainwash: the movement of loose material along the ground by rainwater.

Raised beach: a former beach now situated above the level of the present shoreline as a result of Earth movement (uplift), or changes in global sea level or land. See **isostasy** and **eustatic**.

Recurrence horizon (Grenzhorizont): a horizon in a peat bog succession where the differences in peat type and colour may reflect a periodic drying out of the bog surface and recurring growth; i.e. representing a climatic change from drier to wetter conditions.

Regolith: descriptive of the unconsolidated fragmented material covering **bedrock**. It can include both **allochthonous** and **autochthonous** material.

Relative age: the age of a formation, rock, **fossil** or event defined relative to other formations, rocks, **fossils** or events, rather than in years before present.

Relict: descriptive of a geological feature surviving in its earlier form.

Remanent magnetization: the component of a

rock's magnetization that has a fixed direction relative to the rock.

Rhyolite: a fine-grained extrusive **igneous rock** (lava) with the same chemical and mineralogical composition as **granite**.

Riparian Wetland; a wetland close to the bank of a stream or river.

Ripple: a small-scale undulation in **sediment** produced by the movement of air or water over the **sediment** surface.

River valley: a valley or elongate depression formed by a river during its development.

Rock flour: very fine-grained, angular, **silt** and **clay** sized material formed by crushing. Often applied to the fine-grained material formed when stones in a **glacier** erode the underlying rocks.

Roddon: an East Anglian term for a natural **levee** built of **sediment** carried upstream by the tide rather than downstream by a current.

Ruderal: descriptive of a plant growing on or in rubbish or rubble.

Saalian Stage (Saale): a north-west European chronostratigraphical division (**stage**; cf. **chronostratigraphy**); a cold (**glacial**) stage during the middle **Pleistocene Epoch**, equivalent to **oxygen isotope stage** 10 and the British **Wolstonian Stage**. It follows the **Holsteinian Stage** and precedes the **Eemian Stage**.

Sand: typically material that is smaller than a **granule** and larger than **silt**. It has a grain size of between 0.625 mm and 2 mm.

Sandbank: a large, often submerged, deposit of **sand**, especially found near the shore.

Sand-blasting: a **weathering** process in which an exposed rock is eroded by a stream of windblown **sand**. It often leads to **ventifacts**.

Sandstone: a **sedimentary rock** composed of lithified **sand** grains.

Sandur (pl. **sandar**): a widely used Icelandic term generally synonymous with **outwash plain**.

Saprolite: a soft, often red or brown, earthy **clay** rich decomposed rock, formed in place by chemical **weathering**, and often forming a layer of cover, up to 100 m thick, in humid environments. It is characterized by its retention of some of the structures that were present in the rock from which it was derived.

Scar: a steep, rocky eminence or cliff where bare rock is prominently exposed.

Scarp: a line of cliffs or a steep clifflike slope rising above the surrounding land that has been produced by faulting or erosion.

Schist: a coarse-grained **metamorphic rock** that displays a strong **foliation** (schistosity) that is often defined by mica alignment.

Scour mark: a mark produced by the scouring and cutting action of water flowing over the underlying sediment surface.

Scree: see **talus**.

Secular variation: slow changes in the orientation of the Earth's magnetic field, measured in years, decades and centuries, which appear to be long term and internal in origin.

Sediment: loose material derived from the **weathering** and **erosion** of pre-existing rocks, biological activity (e.g. shells and organic matter) or chemical precipitation (e.g. evaporites).

Sedimentary basin: a large-scale depression that acts as a focus for **sediment** accumulation.

Sedimentary rock: a rock composed of **sediments**, deposited by wind, water or ice.

Sedimentary structure: any structure of a **sediment** that was formed at the time of deposition; includes bedding, **cross bedding**, **graded bedding**, **ripples**, **scour marks** and **dessication cracks**.

Sedimentology: the study of sediments and sedimentary rocks, including their deposition, structure and composition.

Seismic stratigraphy: the study of **stratigraphy** and depositional **facies** through the interpretation of seismic data.

Sequence: in **stratigraphy** is used both in a general way to mean a succession of strata, and in a particular technical way to refer to a body of strata bounded below and above by unconformities (a 'sedimentary sequence').

Sere: a sequence of ecological communities that develop and succeed one another from the **pioneer** to the **climax community**.

Series: a chronostratigraphical division (see **chronostratigraphy**); it comprises all the rocks formed during an **epoch** and can be divided into **stages**.

Set: an individual bed of **cross-bedded sediment**.

Shale: a fine-grained **sedimentary rock** composed predominantly of **clay**, that splits easily into thin layers.

Shear structure: a rock structure caused by shearing.

Sheet flood: a short-duration flood that spreads over a large area as a broad, thin, continuous film rather than being concentrated in a channel.

Sheetwash: the material transported and deposited by a **sheet flood**.

Shingle: rounded pebbles of various sizes but generally fairly coarse in size.

Sill: a tabular body of **igneous rock**, originally intruded as a sub-horizontal sheet and generally concordant with the bedding or foliation in the country rocks.

Silt: a fine-grained **sediment** size range.

Siltstone: a rock made of **silt**.

Sinkhole: a funnel or saucer-shaped surface depression produced by the solution of surface **limestone** or the collapse of underground caverns.

SIRM (saturation isothermal remanent magnetization): the highest amount of magnetic remanence that can be produced in, and retained by, a sample as a result of its emplacement in a strong magnetic field at a given temperature (usually room temperature).

Slickenslides: parallel scratch marks made on a rock surface by the relative movement of rocks along **fault** planes.

Solifluction: the slow downslope movement of saturated sediment or soil debris, occurring most commonly in **periglacial** environments (synonymous with **gelifluction**).

Sorting: the distribution of grain sizes. A well-sorted rock will have a narrow range of grain sizes.

Speleothem: a general term for all cave mineral deposits, mostly formed of calcite by precipitation from lime-saturated groundwater.

Spillway: see **overflow channel**.

Spring: the point where underground water emerges onto the ground surface from any aquifer; the largest springs are mostly the outlets from **limestone** caves.

Spur: a subordinate ridge or rise that projects sharply from the crest or side of a larger elevation feature such as a hill or mountain.

Stade (stadial): a substage of a **glacial stage** marked by a glacial readvance.

Stage: a chronostratigraphical division (see **chronostratigraphy**); it comprises all the rocks formed during an **age**, and is usually taken to be the smallest standard division.

Star dune: a sand dune with a complex star-shaped morphology.

Steppe: a flat, extensive, treeless grassy plain, typically found in the semi-arid mid-latitudes of south-eastern Europe and Asia.

Stone Age: an archaeological cultural division, designated in the **Three-Age System** as preceding the **Bronze Age** and the **Iron Age**, and characterized by the use of basic stone tools. The timing of this period varies from region to region, but it ended approximately 5000 years BP.

Stone polygon: a form of patterned ground characterized by a polygonal mesh, which has a sorted appearance resulting from a border of stone surrounding finer-grained material.

Stone stripes: a form of patterned ground characterized by downslope trending parallel bands of coarse rock debris alternating with wider bands of finer-grained material.

Stratum (pl. **strata**): a bed, or single layer, of a **sediment**.

Stratigraphical unit: a body of rock defined by its **lithological** features (lithostratigraphical unit) or fossil content (biostratigraphical unit).

Stratigraphy: the study of the temporal and spatial relationships between **strata**.

Stratotype: a sequence of **sedimentary rocks** at a particular locality chosen as the standard against which other sequences can be compared. Stratotypes are established for lithostratigraphical and biostratigraphical units, both regionally and internationally. See **stratigraphical unit**.

Stream valley: a **valley**, or elongate depression, carved by a stream.

Stria (pl. **striae**): one of a series of fine furrows or grooves in a pattern of striation caused by ice movement.

Strike: the trend of a geological surface (such as a **bedding plane**) measured at right angles to the direction of maximum slope, or **dip**.

Subaerial: descriptive of processes and conditions, or features and deposits, that exist, operate or were formed, in the open air on or adjacent to the land surface.

Subaqueous: descriptive of processes and conditions, or features and deposits, that exist, operate, or were formed in or under water.

Sub-Atlantic period: a term primarily used in Europe to describe an interval of the **Holocene Epoch** covering the last 2500 years. It follows the **Sub-Boreal period**, and is characterized by a climate that was

generally milder and wetter than that of the present day.

Sub-Boreal period: a term primarily used in Europe to describe an interval of the **Holocene Epoch** from about 4500 to 2500 years BP. It follows the **Atlantic period** and precedes the **Sub-Atlantic period**, and is characterized by a climate that was generally cooler and drier than that of the present day.

Subglacial: formed in or by the basal parts of an **ice sheet** or **glacier**.

Subglacially-engorged esker: a ridge of sand and gravel covered by **ablation moraine** formed by deposition in a tunnel in a lateral ice margin as meltwater makes its way down beneath ice, running at almost right-angles to the slope topography.

Subsidence: a sinking of a local or regional portion of the Earth's surface with respect to its surroundings accompanied by little or no horizontal displacement.

Subterranean: formed, or occurring, under the ground.

Succession: in stratigraphy, a continuous sequence of **sedimentary rock** or **sediment** units.

Superglacial (also **supraglacial**): over, or upon the ice; descriptive of the upper surface of an ice sheet or glacier.

Superglacial deposits: deposits that have accumulated on the ice surface. When the ice disappears they are left on the land surface, frequently forming hummocks of **sand**, **gravel** and **clay**.

Supraglacial: see **superglacial**.

Syenite: a coarse-grained intermediate **igneous rock** consisting largely of alkali feldspar and various ferromagnesian minerals.

System: a chronostratigraphical division (see **chronostratigraphy**); it comprises all the rocks formed during a **period**, and can be divided into **series**.

Talus: an accumulation of rock litter at the foot of a slope, generally with a wide size-range (up to several metres) and ungraded; commonly used to denote debris shed from the high part of a reef slope and transported basinward by gravity ('reef talus', 'talus apron'). Also called **scree**.

Tarn: a small and deep mountain lake, often occupying an ice-gouged basin. The term is often, however, applied to any small land-locked pool or lake.

Telmatic peat: a general term for peat developed on wet ground.

Temperate: a temperature that is moderate and mild.

Tephra: descriptive of all **pyroclastic** material, irrespective of size, shape or composition, from a volcanic eruption.

Tephra-based chronology (**tephrochronology**): chronological and correlation studies involving the dating of volcanic ash layers.

Terminal moraine: the end **moraine** of a **glacier** or **ice sheet**, which marks the maximum extent of the ice advance.

Terrace: a landform composed of water-deposited materials now located at an elevation different from the contemporary **floodplain** or lake level.

Terrestrial: of or relating to the Earth or the Earth's dry land.

Tertiary Period: a geological time division (**period**; cf. **chronostratigraphy**); ranging from 65 to 1.6 million years ago, it is the penultimate geological **period** and is followed by the **Quaternary Period**.

Thallus (pl. **thalli**): a plant-body that has no vascular tissue, and cannot be divided into root, stem and leaf.

Thermokarst: a **karst**-like topographical feature formed in a **permafrost** region due to the melting of ground ice and the resultant settling of the ground.

Thermoluminescence dating: a method of dating applicable to objects that have once been heated or have been exposed to ultra-violet light from the sun, by measuring the release of light energy from the object.

Thermophile (adj. **thermophilic**): an organism that prefers high temperatures.

Three-Age System: an archaeological term that divides human prehistory into three successive stages (the **Stone Age**, **Bronze Age** and **Iron Age**), based on the main type of material used to make the tools of the period.

Thufa (pl. **thufur**): an Icelandic term, meaning 'earth hummock', formed by ground ice segregation.

Thurnian Stage: a British chronostratigraphical division (**stage**; see **chronostratigraphy**); a cold (**glacial**) stage of the early **Pleistocene Epoch**. It follows the Ludhamian Stage and precedes the Antian Stage.

Till: unsorted, non-stratified sediment deposited directly from glacial ice; commonly

known as 'boulder clay' or 'glacial till'.

Till fabric analysis: the analysis of the three-dimensional spatial position of particles in a till by measuring the dip and orientation of clasts within the till. This information can be used to determined any preferred particle orientation and the strength of this orientation.

Tor: a mass of rock rising above the surrounding landscape with free-faces on all sides, commonly shaped by frost shattering or exfoliation in past **periglacial** conditions.

Trace fossil: a **sedimentary structure** produced by biological activity, for example burrows and footprints.

Travertine: see **tufa**.

Triassic Period: a geological time division (**period**; cf. **chronostratigraphy**); ranging from 245 to 208 million years ago, it is the first period of the **Mesozoic Era**, and is preceded by the **Permian Period**.

Tributary: a stream that joins, or flows into, a larger river or lake.

Trimline: a sharp line determining the limit of the maximum upper level of the margins of a glacier that has receded from the area. Often it coincides with a break in slope.

Tripartite: consisting of three parts, or divided into three sections.

Trough (cross) bedding: **cross-bedding** in which the lower bounding surfaces are curved surfaces of erosion, due to local scour and subsequent deposition.

Truncation: the cutting or breaking off of the top of a geological structure or landform.

Tufa: a soft, porous chemical **sedimentary rock** of calcium carbonate, formed by evaporation or precipitated by algae and bacteria. The hard, dense equivalent is **travertine**.

Tuff: cemented and lithified volcanic ash, comprising rock and crystal fragments from an explosive eruption.

Tundra: a treeless plain typical of arctic and subarctic areas. Often it has a marshy surface, supporting lichens, mosses and low shrubs, and is underlain by dark soils and **permafrost**.

Tunnel valley: a shallow trench cut by a subglacial stream not loaded with coarse material.

Turbidite: a sedimentary **clastic** deposit that was formed by the settling out of detrital matter from a mass of **sediment** in water, which, being denser than normal water, had flowed (as a turbidity current) down a submarine slope under the influence of gravity. Often of **greywacke** composition.

Type locality: the location where the type section (or **stratotype**) for a **stratigraphical unit** is located, or where the original type section or **fossil** was first described.

Unconformity: the surface that separates two sedimentary sequences of different ages; it represents a gap in the geological record when there was **erosion**, and/or tectonism and/or no deposition. There is often an angular discordance between the two sequences.

Undermelting: melting from below floating ice; or in the Carruthers (1948) sense, bottom melting of interbedded ice/sediment layers.

'Up and down' channel: a **subglacial** channel that has a long profile where part of the floor is both up and down in terms of the general meltwater flow direction and is thought to have been eroded by meltwater flowing under hydrostatic pressure.

Upton Warren Interstadial: a term used in Britain to describe a short-lived climatic amelioration or **interstadial** event, which occurred sometime between 50 000 and 26 000 years BP during the last glacial period, the **Devensian Stage**.

Uranium series dating: a method of **absolute dating** used most widely on cave deposits from the **Quaternary Period**, which measures the decay of uranium isotopes.

Vadose zone: the zone of rock above the **water table** where groundwater freely flows downwards and cavities are only partially filled with water; also referred to as the unsaturated zone. cf. **phreatic**.

Valley: a generally broad, flat area lying between two mountains or stretches of high ground, often containing a river or stream.

Valley axis: a **thalweg**; the surface profile along the centre line of the **valley**.

Valley Bottom: see **Valley floor**.

Valley floor: the broad, flat bottom of a **valley**.

Valley glacier: a **glacier** that flows between the sides of a mountain valley along all or part of its length.

Valley head: the upper part of a **valley**.

Valley system: descriptive of a **valley** and all of its tributaries.

Varve: a sedimentary layer, or sequence of

layers, which consists of coarser- and finer-grained materials deposited within a body of still water within one year. A glacial varve, deposited by **meltwaters** in a **glacial lake** often has a lower coarse-grained summer layer formed by rapid melting of ice in the summer months, and an upper, fine-grained winter layer, formed when glacial **meltwaters** and their deposits are unavailable.

Varved clay: a clearly laminated sediment consisting of clay-rich **varves**, deposited in a lake or other still water body. Also the upper, fine-grained, winter layer of a glacial **varve**.

Ventifact: any rock or pebble shaped or worn by the **sandblasting** action of windblown sand, usually under desert conditions.

Villafranchian Stage: a European chronostratigraphical stage (**stage**; see **chronostratigraphy**); a warm (**interglacial**) stage of late Pliocene–Early Pleistocene times, characterized by mammalian fossils.

Volcanic rock: an **igneous rock** formed when a volcano erupts.

Warthe ice advance: the third of three ice advances recognized in Scandinavia, which occurred during the northern European glacial **Saalian Stage**.

Watershed: the boundary delimiting a river drainage basin as the basic hydrological unit.

Water table: the level within a rock mass below which all voids are filled with groundwater; above it the **vadose zone** is freely draining, and below it the **phreatic zone** is totally and permanently saturated.

Weathering: the breaking down of rocks through the effects of exposure to the weather; the term does not infer any transportation of the weathered rock material.

Weichselian Stage: a north-west European chronostratigraphical division (**stage**; see **chronostratigraphy**); the classical fourth and last glacial stage of the **Pleistocene Epoch**, equivalent to the British Devensian Stage. It follows the **Eemian Stage**.

Wetland: an area of low-lying land where saturation with water is the dominant factor in determining the nature of soil development and the types of fauna and flora living in the soil and on its surface. Examples include **bogs**, **fens**, marshes and swamps.

Windermere Interstadial: a term used primarily in Britain to describe a short-lived climatic amelioration, or **interstadial** event, which occurred between 13 000 and 11 000 years BP, towards the end of the last glacial period (the **Devensian Stage**). It is often considered to be equivalent to the **Bølling–Allerød Interstadial complex** of north-west Europe.

Wolstonian Stage: a British chronostratigraphical division (**stage**; see **chronostratigraphy**); a cold (**glacial**) stage at the end of the middle **Pleistocene Epoch**, equivalent to **oxygen isotope stages** 6–8, and occurring from about 200 000 to 130 000 years BP. It follows the **Hoxnian Stage** and precedes the **Ipswichian Stage**.

χ **magnetic susceptibility**: a measure of the degree to which a substance can be magnetized. Its value is roughly proportional to the concentration of ferrimagnetic and paramagnetic minerals within the sample.

X-ray diffraction analysis: a technique involving the firing of X-rays at a crystalline structure (e.g. a rock) placed in an X-ray camera, some of which are diffracted to create a pattern on the camera film. This pattern is dependent on the make-up of the structure and can therefore by used to 'fingerprint' the sample.

Younger Dryas: a term used primarily in Europe to describe a short-lived climatic deterioration, characterized by the expansion, or restricted retreat, of glaciers. It occurred approximately 10 500 years BP, towards the end of the last glacial period (the **Devensian Stage**), following the **Allerød Interstadial** but preceding the **Pre-Boreal period**. It is considered to be the equivalent of the British **Loch Lomond Stadial**.

Glossary of botanical names

This glossary of botanical names provides the Latin and common names for the botanical species used in the text and in the pollen diagrams.

Acer Sycamore or Common maple
Agropyron Couch-grass
Alchemilla Lady's mantle
Alisma Water plantain
Alnus Alder
Anagallis Pimpernel, chaffweed
Andromeda polifolia Bog Rosemary
Anemone Anemone
Anthemis Chamomile
Apiaceae Carrot family
Armeria Thrift
Artemisia Mugwort
Artemisia norvegica Norwegian mugwort
Aster includes Aster
Althaea Marsh mallow

Baldellia ranuculoides Lesser water plantain
Bellis Daisy
Betula Birch
Betula nana Dwarf birch
Bidens Bur-marigolds
Botrychium Moonwort

Callitriche Water-starworts
Calluna vulgaris Heather or ling
Calystegia Bindweed
Campanula Bellflower
Caltha Marsh marigold
Cannabis Hemp
Carduus cirsium Thistle
Carex Sedges
Carex echinata Star sedge
Carex ericetorum Rare spring sedge
Carpinus Hornbeam
Caryophyllaceae Pink family
Castanea Chestnut
Centaurea cyanus Cornflower
Centaurea nigra Lesser knapweed
Chenopodiaceae Goosefoot family
Chrysoplenium Golden-saxifrage
Circaea Enchanter's nightshade
Cirsium Thistle
Cladium mariscus Great fen sedge
Coryloid Hazel, or Bog myrtle
Crataegus Hawthorn
Cruciferae Brassica family
Cynoglossum Houndstongue
Cyperaceae Sedge family
Cystopteris Bladder-ferns

Drosera Sundew
Dryas octopetala Mountain avens
Dryopteris Buckler-ferns

Eleocharis Spike-rushes
Elymus Lyme-grass
Empetrum Crowberry
Epilobium Willow herbs
Equisetum Horsetails
Endymion-type Bluebell
Erica tetralix Cross-leaved heath
Erica-type Heaths or Heathers
Ericaceae Heather family
Eriophorum Cotton-grasses
Eriophorum angustifolium Common cotton-grass

Glossary

Eriophorum vaginatum Hare's tail cotton grass
Euonymus Spindle tree

Fabaceae Pea family
Fagus Beech
Filicales Ferns
Filipendula Meadowsweet
Frangula Alder buckthorn
Fraxinus Ash

Galium-type Bedstraws
Genista-type Greenweed or Needle furze
Gentiana Gentians
Gentiana verna Spring gentian
Gentianella Gentians
Geranium Cranesbill
Geum Avens
Glaux maritima Sea milkwort
Glyceria Flote-grass or Reed-grass
Gramineae Grasses

Hedera Ivy
Helianthemum Rockrose
Hippophäe Sea buckthorn
Hippuris Mare's tail
Hordeum Barley
Hornungia Hutchinsia
Humulus Hop
Hydrocotyle Pennyworts
Hypericum St John's-worts

Ilex Holly
Iris Yellow flag
Isoetes Quill-wort

Juncus Rushes
Juniperus Juniper

Knautia Field scabious
Kobresia simpliciuscula False sedge

Labiatae (Lamiaceae) Deadnettle family
Lamium Deadnettles
Lastrea Rigid buckler fern
Larix Larch
Leguminosae or Papilionaceae Pea family
Lemna Duckweed
Linum catharticum Purging flax
Linum usitatissimum Flax
Littorella Shoreweed
Lobelia Lobelia
Lonicera Honeysuckle
Lotus Birdsfoot trefoil
Lychnis flos-cuculi Silene flos-cuculi
Lycopodium selago Fir clubmoss
Lycopus europeus Gypsywort
Lysimachia Loosestrifes
Lythrum Purple loosestrife

Malva Mallow
Matricaria Mayweeds
Melampyrum Cow-wheats
Mentha Mints
Menyanthes trifoliata Bogbean
Mercurialis-type includes Dog's mercury
Minuartia stricta Teesdale sandwort
Molinia caerulea Purple moor-grass
Myosotis-type Forget-me-nots
Myriophyllum alterniflorum Alternate-flowered Water-milfoil
Myriophyllum spicatum Spiked water-milfoil

Narthecium ossifragum Bog asphodel
Nuphar Yellow water-lily
Nymphaea White water-lily

Oenanthe-type Dropwort
Onobrychis-type Sainfoin
Ononis-type Restharrow
Osmunda Royal fern
Oxycoccus (Vaccinium) Bilberries
Oxyria-type Mountain sorrel

Peplis Water purslane
Phragmites Common reed
Picea Spruce
Pinus Pine
Plantago coronopus Buck's-horn plantain
Plantago lanceolata Ribwort plantain
Plantago major Great plantain
Plantago media Hoary plantain
Plantago maritima Sea plantain
Polemonium caeruleum Jacob's ladder
Polygala amara Dwarf milkwort
Polygonum Knotweed and Bistorts
Polygonum aviculare Knotgrass
Polygonum convolvulus-type Black bindweed
Polypodium Polypody
Populus Poplar
Potamogeton Pondweed
Potentilla Cinquefoils
Potentilla erecta Tormentil
Poterium Salad burnet
Prunus Cherry and Blackthorn
Pteridium Bracken

Quercus Oak

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Ranunculaceae Buttercup family
Ranunculus Buttercups
Rhamnus Buckthorn
Rhinanthus-type Yellow rattle
Rhododendron Rhododendron
Rosaceae Rose family
Rubus includes Brambles and Raspberry
Rubus chamaemorus-type Cloudberry
Rumex Sorrels and Docks
Rumex acetosa-type Sorrel

Sagittaria Arrowhead
Salix Willow
Sambucus Elder
Sangu isorba Burnets
Saussurea alpina Alpine saw-wort
Saxifraga aizoides Yellow saxifrage
Saxifraga oppositifolia Purple saxifrage
Saxifraga stellaris Starry saxifrage
Scleranthus-type includes Knawels
Scrophulariaceae Figwort family
Secale cereale Rye
Selaginella selaginoides Lesser clubmoss
Senecio Ragworts
Serratula Saw-wort
Silene-type Campions
Sinapsis Mustards
Solanum Nightshade
Sorbus Mountain ash (Rowan) and White beam
Spergula Spurreys
Spergula arvensis Com spurrey
Sphagnum Spaghnum moss
Stellaria Stitchworts
Stellaria-type includes Chickweeds and Stitch worts
Succisa Devil's bit scabious

Taxus Yew
Taraxacum Dandelions
Teucrium Germanders
Thalictrum Meadow rue
Thelypteris Marsh fern
Thymus Thymes
Tilia Lime
Trapa natans Water chestnut
Trichophorum caespitosum Deergrass
Triticum sp. Wheat
Typha angustifolia Lesser bulrush
Typha latifolia Bulrush

Ulex-type Furze or Gorse
Ulmus Elm
Umbelliferae Carrot family
Urtica Nettle

Vaccinium-type Bilberries
Vaccinium vitis-idaea Cowberry
Valeriana Valerian
Viburnum Viburnums
Vicia Vetches (Tares)
Vicia sativa-type Common vetch
Vicia sylvatica Wood vetch
Viola rupestris Teesdale violet

Fossil index

Note: Page numbers in **bold** and *italic* type refer to **tables** and *figures* respectively. Most mammals and some orders of plants can also be found in the General Index, e.g. bilberry; deer; hyaena. For named pollen zones, see the General Index. See also 'pollen assemablages and zones' in the General Index.

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General index

Note: Page numbers in **bold** and *italic* type refer to **tables** and *figures* respectively.