Northumbrian rocks and landscape: a field guide

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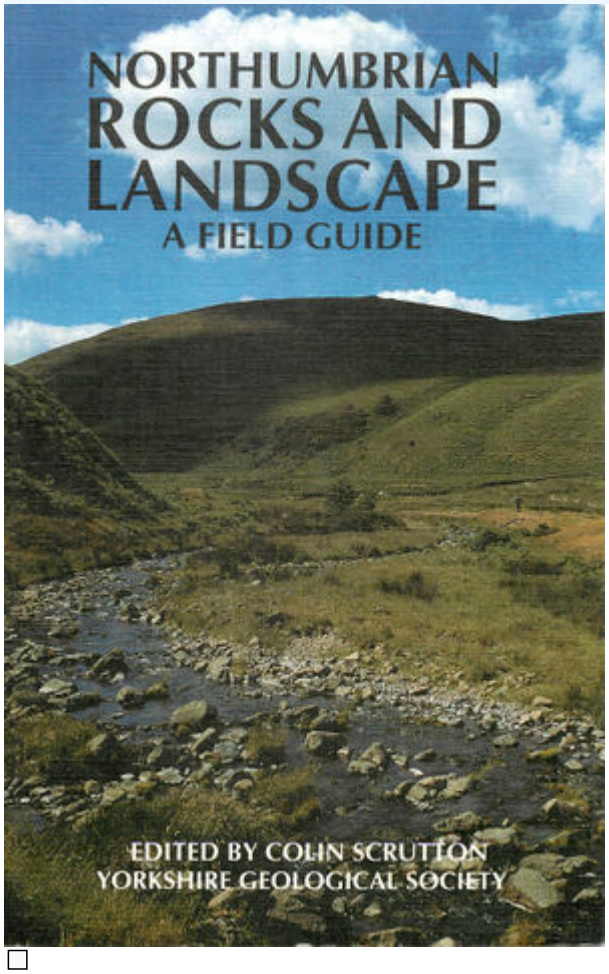

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Preface

This field guide, the second to be sponsored by the Yorkshire Geological Society, is mostly written and edited by its members. The Society has a long and distinguished history, having been founded in 1837. From small beginnings among amateurs with an interest in Yorkshire geology, it has grown to have influence well beyond the boundaries of the county and a membership of over 1 000 from all over the world. It brings together professional geologists of all descriptions, from universities, surveys and companies, together with amateur geologists who still form a significant proportion of our membership. The Society publishes a prestigious journal, the *Proceedings,* which has a major part of its original papers based on Yorkshire geology. The original aims of the Society are still observed in the lecture meetings held approximately monthly from October to March, and particularly in the programme of field excursions in the spring and summer months. The lectures are a mixture of original work, mainly on the geology of Yorkshire and Northern England, and general reviews often of much wider scope. Field excursions range all over the county and its near neighbours and offer an opportunity to demonstrate new observations and interpretations of the geology and geomorphology.

Many of you using this guide may already be members of the Yorkshire Geological Society. If you are not, and would like to know more about this fascinating subject, why don't you join us? We would be pleased to welcome you.

Colin Scrutton, President, Yorkshire Geological Society, 1995

Preface to the Second Edition

The success of the *Northumbrian Rocks and Landscape,* published in 1995, prompted the Yorkshire Geological Society, in 2004, to publish a Second Edition of the Guide with minor corrections. The Society wished to mark the occasion by dedicating the Guide to Professor Sir Kingsley Dunham FRS (1910–2001) and his son Professor Ansel Dunham (1938–1998), both past Presidents of the YGS, who contributed so much to the Society and to the geology of northern Britain.

Sir Kingsley, one of the most distinguished figures in British geology in the last century, was awarded a PhD from the University of Durham in 1932. Following a two-year period pursuing further research on mineralisation in the USA, he returned to Britain in 1934, joining the Geological Survey of Great Britain (now the British Geological Survey). In 1950, Sir Kingsley returned to Durham University to take up the Chair of Geology, and later he was appointed Director of the Survey in 1967; in both posts he oversaw great expansion, which he drove with enthusiasm, but always keeping in touch with his beloved science. His studies included the mineral resources of the northern Pennines, and scientific investigation that proved the presence of concealed granite beneath the Alston Block, an area covered, in part, by this Guide. Kingsley received a knighthood in 1972 and, following retirement in 1975, he pursued his academic career including co-authoring Volume 2 of *The Geology of the Northern Pennine Orefield.* Professor Ansel Dunham (MA, Cantab.; D.Phil Oxon.), another major figure in British geology, rose to become Professor of Industrial Mineralogy at the University of Hull, and later at Leicester where, as Head of Department, his research focused on mineralogy of brick clays and aggregates.

Sir Kingsley and Ansel Dunham's love of fieldwork and the companionship of fellow geologists, be they students, professionals or amateurs, is reflected in the aims of the Society. We hope that their enthusiasm for the subject, especially fieldwork, will be passed on to users of this Guide.

The Yorkshire Geological Society wishes to thank the following for their financial support for printing the Second Edition: Helen Dunham; English Nature; Northumberland County Council; and Professor John W. Neale. We should also like to thank Colin Scrutton, Editor of the Guide, for his help with minor corrections and John Powell for supervising the Second Edition.

Peter Rawson, President, Yorkshire Geological Society

Introduction

For the purposes of this book, Northumbria is defined as Northumberland, Durham, Tyne & Wear, and Cleveland north of the River Tees. The excursions described provide a broad coverage of this area and its borders, both geographically and geologically, although in a publication of this size a selection inevitably has to be made from among the wealth of excellent sites available. Wherever you live, or are staying in the area, we hope there will be something to interest you.

An introductory chapter outlines the geological history of Northumbria, providing a framework for the details of the local geology. Each excursion begins with notes on access, duration, useful Ordnance Survey (O.S.) and British Geological Survey (B.G.S.) maps, and background information on the geology and geomorphology. In many cases; observations on historical, archaeological and other related matters are included. A section towards the end of the book lists museums in Northumbria that have geological displays or collections.

All excursions have certain basic requirements for both safety and enjoyment. These include stout shoes or walking boots, sensible clothes including waterproofs in case of rain, and appropriate maps for location in the field. On higher ground, it may be much colder and more windy than in the valleys, and low cloud may not just spoil appreciation of geological and geomorphological views of the landscape, but may present a danger if you become lost. On foreshores, wellington boots may be a suitable alternative, but whatever your footwear, wet rocks can be very slippery, particularly those with veneers of green algae.

For more specific dangers, notes are given in the introductory material to appropriate excursions. However, it is worth repeating some general points. In locations near quarry or cliff faces, a safety helmet should be worn. Always look at the state of steep faces and if in doubt about their safety, do not approach them. When using a hammer, it is advisable to wear safety goggles and to make sure that fragments chipped off will not hit other people. In any coastal situation, the state of the tide may be crucial, not only to your view of the geology but to your safety as the tide comes in. Always check on the time of low tide and do not start an excursion on a rising tide where access to and from the foreshore is limited. Tide tables for the mouth of the Tyne are available from The Port of Tyne Authority, Bewick Street, Newcastle upon Tyne, NE1 5HS (tel. 455 2671), and tide times are published in local newspapers. Finally, if visiting remote locations alone, tell someone where you are going.

Some excursions include visits to Sites of Special Scientific Interest. These are designated not only to conserve our geological heritage but to protect other features, such as the flora. Please observe any particular requests not to hammer rocks or to collect fossils.

As far as possible, excursion routes follow public rights of way and keep to open land or the foreshore. However, where localities are on private land, permission for access should be sought

beforehand. We have given as much information as possible to facilitate this. In general, observe the Countryside Code and avoid damage to walls, gates or property. The Geologists Association have published a Code for Geological Field Work, which outlines good practice in the field and can be obtained from the Librarian, The Geologists Association, Department of Geological Sciences, University College, Gower Street, London WC1E 6BT.

Anyone with a general interest in geology and geomorphology should be able to follow the excursions in this guide. However, the complexity of the geology and level of technical description varies from place to place. As an aid, selected technical terms are highlighted in bold on first usage in each section and are briefly defined in a Glossary at the end of the book. For more information on any term, or for terms not covered, reference should be made to a geological dictionary (see Bibliography). Bibliographic entries are placed towards the end of the book and are mainly general works. A few more specific references are included where these have value for a particular excursion.

Finally, I would like to thank all those who have helped me in the compilation of this guide, particularly my colleague Brian Turner, and the authors for their contributions.

Colin Scrutton, University of Durham

Note

The details of routes given in this guide do not imply a right of way. Users of this guide are responsible for seeking permission where necessary to use footpaths and for access to any private land.

Every effort has been made to ensure that the contents of this book are accurate and up-to-date. However, information on any changes to footpaths or exposures, or threats to any S.S.S.I., would be welcomed by the Society.

Notes on safety have been included but it is the responsibility of the user to take all necessary precautions for their own safety and that of third parties. The publishers and the Society take no responsibility for any accident or injury sustained on any of these excursions.

Glossary

Words in ***bold italic*** are defined elsewhere in the glossary.

accretionary prism Wedge of material built up by underthrusting of successive slices of sediment on the landward side of a ***subduction*** zone.

acritarch Marine, hollow, organic walled microfossil of uncertain affinities.

adit More or less horizontal tunnel to mine.

agglomerate ***Conglomerate*** or ***breccia*** of volcanic origin.

aggradation Accumulation of sediment resulting in raising of the substrate.

alga (pl. algae) Primitive plant-like organism. Some may secrete calcium carbonate and algal mats may play a role in sediment accumulation in some environments. *See* ***stromatolite.***

amygdale Cavity within a lava, ***dyke*** or ***sill,*** lined or filled with secondary minerals.

andesite Fine-grained volcanic rock of intermediate composition (with about 53-60% silica).

anhydrite $CaSO_4$ White to grey, rock-forming ***evaporite*** mineral.

ankerite $Ca(Fe,Mg,Mn)(CO_3)_2$ Mineral, may be crystalline of various colours but often yellowish-brown, massive or granular, commonly replacing the wallrock of Pennine veins.

anticline *See* ***fold.***

apatite Fluophosphate or chlorophosphate of calcium. Characteristically green or grey-green mineral in hexagonal prisms. Found in ***igneous*** and ***metamorphic*** rocks, and principal mineral of fossil bone.

aplite Pinkish, fine-grained ***quartz-alkali feldspar*** rock associated with granite and usually occurring in ***veins.***

arenite Sedimentary rock of sand-grade with <15% mud matrix (hence **arenaceous).**

argillaceous Silt to clay grade sediments (grains <0.0625 mm diameter).

arkose Sand-grade rock containing 25% or more ***feldspar.***

autobreccia Rock broken into angular fragments by internal processes. Usually applied to a lava crust brecciated by continuing movement within the flow hence **autobrecciation.**

back-arc basin Sedimentary basin formed behind a volcanic island arc, above a ***subduction*** zone.

baryte/barytes $BaSO_4$ **Baryte** is a colourless to white mineral, commonly in tabular crystals, noticeably heavy. A common ***gangue*** mineral. **Barytes** is the commercial product.

basalt Dark, often almost black, fine-grained basic volcanic rock, low in silica (no ***quartz)*** and relatively rich in iron, magnesium and calcium.

bioclast A shell or skeletal fragment.

biomicrite A ***micritic*** (mud-grade) limestone containing ***bioclasts .***

biostrome Sheet-like accumulation of fossil shells or skeletons.

biotite Common, dark brown to black, Mg, Fe-rich ***mica.***

bioturbation Reworking of unconsolidated sediment by burrowing organisms which may partly or completely destroy primary structures (i.e. bedding); hence **bioturbated.**

bismuthinite Bi2S3 Soft, greyish-white mineral, commonly in bladed crystals.

bivalve Marine to fresh-water ***mollusc*** in which the plane ofsymmetry of the bi-valved calcium carbonate shell is the plane of opening of the two valves (as in cockles or mussels).

Bouma sequence Idealized sequence of sedimentary structures found within a ***turbidite*** bed, from base: massive or graded sand; lower parallel lamination; ripple lamination; upper parallel lamination; pelagic shale.

B.P. Years before present (conventionally taken to be 1950).

brachiopod Solitary marine animal with bi-valved calcite shell. The plane of symmetry is perpendicular to the plane of opening of the valves.

breccia Coarse elastic rock in which the ***clasts*** are angular. *See also* ***fault.***

bryozoa Small colonial animals with a calcite skeleton consisting of large numbers of tiny tubular or box-like chambers. Colonial form very variable.

calcite $CaCO_3$ Colourless or white mineral which is the main constituent oflimestone. Crystals when formed (i.e. in ***veins)*** may be tabular or prismatic.

calcrete Nodular or massive, laminar carbonate bed formed in a soil in semi-arid regions.

Caledonian Mountains/Orogeny See ***orogeny.***

carbonate rocks Limestones or ***dolostones*** (dolomites).

cassiterite SnO_2 Hard, heavy, usually reddish-brown to black mineral, massive or with pyramidal or prismatic crystals. In Northumbria, known only as minute inclusions in other vein minerals.

cataclastic Formed by shearing and granulation as a result of ***tectonic*** movement.

cementstone General term for extremely hard carbonate-rich bed capable of being ground as cement.

chalcedony SiO_2 White or greyish-white, fibrous to cryptocrystalline, stalactitic or botryoidal ***quartz.***

chalcopyrite $CuFeS_2$ (copper pyrites) Brass-yellow mineral commonly with an iridescent tarnish. Most common copper mineral. Crystals usually tetrahedra.

chert Nodules, lenses or impersistent bands of cryptocrystalline ***quartz,*** usually black, grey or red in colour, usually of diagenetic origin in sedimentary sequences.

chlorite $(Mg,Fe)_5Al(AlSi_3)O_{10}$ Soft, green, platy mineral associated with low-grade ***metamorphism.*** Found also in ***amygdales*** and ***veins.***

chute A downslope, sub-glacial ***meltwater channel.***

clast Rock fragment; hence **clastic rock.** The principal elastic rocks are distinguished on grain size thus: ***conglomerate >*** 2 mm > sandstone > 0.0625 mm siltstones > 0.004. mm>mudstone/shale.

cleavage A close-spaced, regular fracture or fabric imposed on strongly ***folded*** beds and best developed in weaker, fine-grained rocks. Perfect cleavage is parallel to the axial plane of a fold.

cone-in-cone Fabric of adjacent sets ofvertically nested cones, each

about 3 cm or more in diameter, caused by precipitation of$CaCO_3$ under pressure in a mud-grade rock.

concretion Spherical or ellipsoidal, more resistant mass formed by local early cementation of the sediment. They often occur regularly or irregularly spaced in layers and weather out of the softer

surrounding sediment.

conformable Sequence of rocks in apparently continuous succession. **conglomerate** Coarse ***clastic rock*** in which the clasts are rounded. An **intraformational conglomerate** is one formed of locally derived clasts from a recently deposited source.

coral A polyp or polyps (anemone-like) with a basal skeleton of calcium carbonate. Corals may be solitary or colonial, the latter varying from flat, tabular masses to clusters of branching tubes.

crevasse Breach in a river bank or levee through which sediment-charged water may flow to form a **crevasse-splay** deposit.

crinoid (sea lily; feather star) Marine organism (echinoderm) with a plated cup, showing radio-pentameral symmetry and bearing feeding arms, supported in sea lilies by a stalk. The disc-shaped ossicles or columnals of the stalk are a major constituent of Palaeozoic limestones, hence crinoidal limestone.

cross-stratification, cross-bedding, cross-lamination Sedimentary structure in which the migration of the slip face of **ripples,** dunes or bars produces a series of inclined laminae **(foresets)** between sub-horizontal bedding surfaces. Different types are **planar,** when the laminae are flat, **trough,** when the laminae are scoop-shaped and **hummocky,** when individual **sets** of cross-beds cut across each other leaving hummocky bounding surfaces.

cyclothem A particular sequence of beds repeated again and again in vertical succession. Particularly notable in the Carboniferous (see ***Yoredale).***

dacite Light-coloured, fine grained, volcanic rock of acid– intermediate composition.

deflation Erosion of land surfaces through the agency of wind.

diagenesis The changes that take place in the conversion of a sediment to a rock.

diopside $CaMgSi_2O_6$ Pale, dirty green or grey silicate mineral of the ***pyroxene*** group, common in more basic igneous rocks. May form short prismatic crystals.

dip The maximum angle of inclination of a planar surface, usually bedding. Measured in the vertical plane at right angles to the ***strike.*** **dolerite** Dark coloured, medium-grained igneous rock of ***basaltic*** composition.

dolomite $CaMg(CO_3)_2$ White, colourless, yellowish or brown mineral; rhombic crystals with curved faces. Term also used for the characteristically browny-yellow rock composed mainly of the mineral, but more correctly termed **dolostone.**

downthrow *See* ***throw.***

draa A large sand ridge or dune chain, the largest desert landform. **drift** Any superficial, unconsolidated sediments of the Quaternary.

drumlin Smooth, streamlined, oval mound of ***till*** (boulder clay), usually in groups (drumlin field or swarm), formed beneath an advancing ice sheet. The long axis of the drumlin is parallel to the direction of advance.

dyke More or less vertical, cross-cutting intrusion. May exist **en echelon,** as discrete, overlapping

or more distant, offset elements **(echelons).**

echelon See ***dyke.***

echinoid (sea urchin) Marine invertebrate with body enclosed in a globular or discoidal test. Symmetry either pentameral radial (regular echinoids) or pentameral bilateral (irregular, burrowing, echinoids).

epidote $Ca_2(A1,Fe)_3(SiO_4)_2OH$ Characteristically green, radial,

fibrous or columnar mineral, sometimes forming prismatic crystals, associated with ***hydrothermal*** or contact ***metamorphic*** rocks.

erratic Glacially transported rock derived from outside the local area.

esker Long, sinuous, steep-sided ridge consisting ofsands and gravels, formed either in an englacial tunnel or at the edge of a retreating ice sheet.

eustatic World-wide change in sea level.

euxinic Environment with little or no oxygen, and sediments formed therein.

evaporite Rocks or minerals formed by precipitation ofsalts from natural brines by evaporation.

facies Features of a rock or rock sequence that reflect the environment of deposition.

facing Direction in which beds in a ***fold*** hinge become younger.

fault A more or less planar fracture in a rock mass along which relative displacement of adjacent blocks has occurred. The face of the block above an inclined fault plane is the **hanging wall,** that below is the **footwall.** In most faults, the direction of movement is known or assumed to be predominantly vertical. In a **strike-slip** or **wrench** fault, the direction of movement on a sub-vertical plane is predominantly horizontal. A **thrust** fault has a sub-horizontal plane of displacement. Fractured rock on the fault plane caused by movement between adjacent blocks is a fault ***breccia.***

feldspars Important group of rock-forming silicate minerals, common in **igneous** rocks, hence **feldspathic. Alkali feldspar** is K– Na series feldspar. **Plagioclase** is Na–Ca series feldspar, often forming white, lath-shaped ***phenocrysts*** in igneous rocks. Most feldspars break down quickly on weathering.

fireclay *See* ***seatearth.***

flat A lenticular zone of mineralization parallel to bedding.

flaser bedding Ripple bedding with silt or clay drapes between sets. **fluorite** CaF_2 Colourless to translucent, purple, green or yellow mineral commonly crystallising in cubes. **Fluorspar** is the commercial product.

flute cast (flute mark) *See* ***sole structure.***

fold A bend in bedded rocks or any planar rock mass. An ***anticline*** is arched upwards with older rocks in the core. A **pericline** is an anticline in the form of an elongated dome. A **syncline** is bent downwards with younger rocks in the core. A **monocline** is a step-shaped fold, with one steep limb

between two hinges. An **isoclinal fold** has subparallel fold limbs. The dip of the fold axis is the **plunge** of the fold.

foraminifera Microscopic single-celled organism with a chambered, usually calcium carbonate, test.

foresets *See* ***cross-stratification.***

galena PbS Lead grey mineral crystallizing in cubes and octahedra. The main ore oflead.

gangue Non-metallic mineral (i.e. ***quartz, fluorite, baryte)*** in ***veins*** with which ore minerals are associated. Formerly of no commercial value, fluorite and baryte are now important products.

ganister *See* ***seatearth.***

garnet Group of Ca, Fe, Mg, Mn silicate minerals ofvariable composition, often deep reddish-brown in colour, found in ***igneous*** and ***metamorphic*** rocks.

gastropod ***Mollusc*** with a usually helically coiled calcium carbonate shell (snail) or naked (slug).

glacioeustatic ***Eustatic*** changes in sea level resulting from growth or decay of an ice sheet.

glaciofluvial Sediments or landforms produced by meltwater from a glacier.

glaciogenic Of glacial origin.

gley Waterlogged, anaerobic soil.

gneiss Coarse-grained, banded rock formed under high-grade ***metamorphic*** conditions.

graben A linear tract of country, lowered between two bounding faults. A **half-graben** is fault-bounded on one side only.

graptolite Extinct group of marine, ***pelagic,*** colonial organisms with an organic skeleton. Individuals a few mm long, colonies t o's mm long. Usually preserved as a carbonaceous film.

granite A coarse-grained acid igneous rock containing ***quartz,*** alkali ***feldspar*** and ***mica.***

granodiorite A coarse-grained acid–intermediate ***igneous*** rock containing ***quartz*** and dominant plagioclase ***feldspar.***

granophyre A granite characterized by fine-scale intergrowths of **quartz** and **feldspar.**

greywacke A poorly sorted (immature) silt-sand grade *clastic* rock with >15% clay-grade material.

gypsum $CaSO_4.2H_2O$ ***Evaporite*** mineral, usually white, finely granular or massive. A transparent variety **(selenite)** may be precipitated within sediments under some conditions. The fibrous form (satin spar) may form ***veins.***

haematite Fe_2O_3 Steel-grey to black, sometimes red mineral, occurring as tabular crystals or massive, often botryoidal.

half-graben *See* ***graben.***

halite (rock salt) NaCl Common salt, an evaporite mineral, usually white, crystals usually cubes.

hanging wall *See* ***fault.***

hornblende Green or brown rock-forming silicate mineral of the amphibole group, characterised by two cleavages intersecting at 124°.

hornfels Massive hardened, splintery rock formed by alteration of the country rock by contact (thermal) ***metamorphism.***

hummocky cross-stratification *See* ***cross-stratification.***

hush Opencast workings or trials excavated in part by releasing torrents of water from reservoirs high on a hillside. Large examples may be difficult to distinguish from natural valleys.

hydrothermal Associated with the action of hot water.

imbrication More or less parallel orientation of platy/tabular clasts, generally sloping up-current and thus indicating the direction of water flow.

igneous Rocks crystallized or solidified from a molten state. May be divided into **basic** (45-53% silica), **intermediate** (53-60% silica), and **acid** (>60% silica, including free **quartz).**

inlier Area of older rocks surrounded by younger rocks.

intermontane basin Sedimentary basin being infilled from erosion of surrounding mountains.

intraclast Fragment derived from the erosion of a nearby sediment and redeposited within the same area.

isoclinal See ***fold.***

jarosite $KFe_3(SO_4)_2(OH)_6$ Yellowish-brown, usually earthy mineral of secondary origin.

joint Fracture in rock along which little or no movement can be detected. Usually they occur in more or less regularly spaced sets, and two or more sets may intersect at various angles. As well as ***tectonic*** joints, they may form through cooling ***(igneous*** rocks) or shrinkage in a sediment.

kame Steep sided mound of bedded ***glaciofluvial*** sand and gravel associated with stagnant ice. A **kame terrace** is a continuous linear feature formed between an ice mass and a valley wall. Subsequent ice melt may result in signs of marginal slumping.

kettle hole Depression in glacial ***drift****,* possibly containing a lake, left by the melting of an included mass ofice.

laccolith Concordant, lenticular, ***igneous*** intrusion, elliptical or circular in plan.

lacustrine Sediment or processes associated with lakes.

lag An accumulation of coarse ***clastic*** or ***bioclastic*** material, usually in the floor ofa channel.

limonite A general term for unspecified hydrous earthy iron oxides usually derived from the weathering ofiron minerals in rocks or ***veins.*** **linguoid** Tongue-shaped (of asymmetrical ripples).

lithology Physical features ofa rock. Hence **lithostratigraphy,** the statigraphic ordering ofdifferent rock types; **lithification,** process of turning unconsolidated sediment into rock.

Ma Abbreviation for 'million years'.

magma A hot, liquid or semi-liquid melt within the Earth's crust; the source for all ***igneous*** rocks and processes.

marcasite FeS_2 Pale brass-yellow or greyish metallic mineral, common as bladed or laminated crystalline masses in Pennine **veins**.

marl A calcareous clay with 35-65% soft calcium carbonate.

meltwater channel Channel cut by the action of meltwater from a glacier or from snow. Usually unrelated to the present drainage pattern.

metamorphic Rock formed by the alteration of a pre-existing rock by changes in temperature and/or pressure.

metasediment A ***metamorphosed*** sediment.

mica A group of complex silicate minerals characterised by a strongly platy habit.

micrite Microcrystalline calcite (lime mud).

microgranite A medium-grained (1-5 mm) rock ofgranitic composition.

mineral veins *See* ***veins.***

mollusc One of a very diverse invertebrate group including the ***bivalves, gastropods,*** and cephalopods ***(nautiloids,*** etc.)

monocline See ***fold.***

moraine An unsorted deposit of rock debris associated with the actions of a glacier.

nautiloid Cephalopod *mollusc* with a curved or straight, tapering, chambered shell; ***suture*** simple, siphuncular tube central in chambers.

olivine A group of olive green to brown or black rock-forming Mg, Fe silicate minerals, characteristic ofsilica-poor **igneous** rocks.

oncolite Spherical or sub-spherical particle up to 50 mm diameter formed by the action of ***algae*** in trapping sediment on the surface ofa mobile grain.

oolite Rock formed largely of ***ooliths.*** Characteristic ofhigh-energy, shallow-water environments.

oolith Spherical or sub-spherical particle less than 2 mm diameter formed by the concentric deposition ofrings of (usually) calcium carbonate around a mobile grain.

orogeny Process of mountain building by the lateral compression of thick rock sequences. The **Caledonian Orogenic Cycle** refers to a series of orogenic events in the Lower Palaeozoic culminating in the late Silurian/early Devonian. The **Variscan Orogeny,** whose main effects are seen in southwest England and Central Europe, spanned the late Devonian to late Carboniferous.

ostracode Small to microscopic, marine to fresh-water crustacean with calcitic bivalved shell.

outlier Area ofyounger rocks surrounded by older rocks.

overflow channel, spillway Channel carved by the overflow from an ice-dammed lake. Usually unrelated to the present drainage pattern.

overstep Relationship where a bed deposited by a ***transgression*** rests on the eroded ends of several beds below the plane of ***unconformity***.

palaeosol Fossil soil.

pedogenic Associated with soil formation.

pegmatite Exceptionally coarse-grained variety of an ***igneous*** rock. **pelagic** Organisms living in the body of the water, either floating (planktonic) or swimming (nektonic).

pericline See **fold.**

phenocryst Larger, usually well-formed crystal in a finer groundmass. **phonolite** Fine grained, porphyritic, Na-rich volcanic rock. **phytoplankton** See ***plankton.***

plankton Mainly small to microscopic organisms that float in near-surface oceanic waters; divided into **phytoplankton** (photosynthetic) and **zooplankton** (animals).

plate A part of the Earth's rigid outer shell (lithosphere), internally relatively free of earthquakes and volcanic activity but bounded by more or less continuous zones of earthquakes and volcanoes where the plates move against each other. **Plate tectonics** describes the processes and effects of plate motions and interactions.

plunge *See fold.*

pluton A large ***igneous*** intrusion (excluding ***dykes*** and *sills).*

porphyrite Medium grained, intrusive ***igneous*** rock with many

conspicuous ***feldspar phenocrysts;*** hence **porphyritic =** containing phenocrysts.

post A bed of rock, often applied to limestones.

progradation The outward extension of a sedimentary deposit, such as a delta building out from a shoreline.

pseudomorph Retention of the original crystal form after a mineral has been replaced.

pyrite FeS_2 (fools gold) Common pale brass-yellow mineral, often crystallising in cubes.

pyroclastic A *clastic* rock of volcanic origin.

pyroxene Important group of dark green, brown or black, rock-forming silicate minerals, characterised by two cleavages at right-angles; crystals prismatic.

pyrrhotite (magnetic pyrites) FeS Bronze-yellow, reddish-brown weathering, usually massive or granular mineral; magnetic.

quartz SiO_2 Very common mineral, usually transparent or white but may be variously coloured. Occurs in many *igneous* and *metamorphic* rocks, is the main constituent of sandstones and siltstones and a common *gangue* mineral in *veins* when prismatic crystals with a six-faced pyramidal termination may be found.

regression Withdrawal of the sea from the land area due to a relative fall in sea level.

rhyolite Fine-grained acid *igneous* extrusive rock; volcanic equivalent ofgranite.

rock-salt *See halite.*

schist A metamorphic rock with a strong, platy fabric, caused by the parallel alignment of *micas.*

seafloor spreading Process whereby volcanic activity at mid-ocean ridges causes igneous rock material to be accreted to **plate** margins resulting in the growth of oceanic crust.

seatearth A fossil soil with root traces found immediately below a coal seam. A **fireclay** is a pure clay seatearth, whilst a **ganister** is a pure quartz sand seatearth.

septarian Nodules or *concretions* with a series of internal mineral-filled (usually *calcite)* cracks. Results from the formation of a hardened exterior shell before desiccation and shrinkage of the material inside the nodule.

serpulid A group of polychaete worms with calcareous tubes. **sheath fold** A highly deformed fold form with a strongly curved fold axis, produced in shear zones.

siderite $FeCO_3$ Grey to grey-brown mineral widespread in certain sedimentary rocks, particularly sedimentary ironstone deposits and Coal Measures sequences. Also common in many Pennine *veins.*

siliciclastic *Clastic* rocks formed predominantly of *quartz,* other silicate mineral and rock fragments.

sill A tabular *igneous* intrusion, mainly concordant with bedding, although it may cut across beds from one level to another. slickensides A lineation on a *fault* or bedding plane caused by the relative movement of rock masses on either side. The surface is often coated by fibrous crystals, usually of ***quartz*** or ***calcite,*** aligned in the direction of movement.

sole mark/structure Sedimentary structure cut into an underlying mud by a turbidity current and infilled by the overlying ***turbidite*** bed. Preserved as a cast on the base of the turbidite. **Flute cast (mark):** ovoid scoop-shaped structure caused by turbulent water flow, preserved as a tapered lobe on the base of the turbidite. Sole marks may also occur less typically in fluvial sediments, etc.

solifluction Downhill movement of surface layer ofunconsolidated weathered material when saturated by water.

sphalerite (blende) ZnS Commonly a brown or black mineral with a resinous lustre and variable form. Most common ore of zinc.

spillway 1. General term for glacial ***meltwater*** or ***overflow channels.*** 2. Overflow channel constructed on a dam.

sponge Primitive invertebrates with an asymmetrical body supported by spongin and/or siliceous or calcareous spicules. Some may have a massive calcareous basal skeleton.

S.S.S.I. Site of Special Scientific Interest.

stadial A period of increased cold or advancing ice.

stope Underground excavation in a ***vein.***

strike Intersection ofa bedding plane, or other planar surface, with the horizontal.

strike-slip ***See fault.***

stromatolite A carbonate rock with a fine horizontal, domal or columnar banding, reflecting the control ofdeposition by an ***algal*** mat or microbial community living on the surface of the sediment.

stylolite An irregular, suture like contact, most common in limestones, produced by solution of the rock under high pressure.

subduction The process whereby oceanic crust descends into the interior of the Earth beneath oceanic or continental crust at a convergent *plate* margin.

suture 1. A linear zone ofcontinental collision, marking the site ofa former ocean. 2. Line ofjunction of septum with conch wall in cephalopods.

syncline ***See fold.***

tachylite Black, glassy rock formed by chilling of a ***basaltic*** lava or shallow ***igneous*** intrusion.

tectonic Relating to deformation of rock masses, as in mountain-building episodes.

tholeiitic basalt/dolerite A type of ***basalt/ dolerite*** oversaturated in silica, so that small amounts of ***quartz*** are present.

throw Description of vertical component of movement on *afault* plane. **Downthrow** emphasises the relative downward displacement ofa block on one side of the fault, **upthrow** (less commonly used) emphasises the relative upward displacement of a block.

thrust ***See fault.***

till (boulder clay) Collective term for the group of unsorted sediments laid down by direct action ofice.

tourmaline A group of complex boro-silicate minerals, normally black or bluish-black; prismatic crystals with a typical triangular cross-section.

trace fossil A structure resulting from the activity of an animal, such as a burrow or a grazing trail.

transgression 1. An advance of the sea over the land, caused by a relative rise in sea level. 2. Change of stratigraphic level by a ***sill.***

tremolite $Ca_2(Mg,Fe)SiO_8O_{22}(OH)_2$ White or greyish-white mineral with needle-like crystals.

trilobite Extinct group of arthropods, with a dorsal skeleton divided into head (cephalon), thorax and tailplate (pygidium).

tufa Rock formed by the depositon of calcium carbonate (more rarely silica) as a sometime porous

and/or banded mass around saline springs, or associated with stalactites and stalagmites.

tuff Lithified volcanic ash-fall.

turbidite Rock deposited from a **turbidity current/flow,** a fast flowing turbulent current charged with a high sediment load, commonly initiated by the disturbance ofsoft sediment on a slope. A turbidite is poorly sorted but may show grading and ***sole structures*** on its base.

unconformity Surface of contact between two groups of rocks resulting from the tilting or folding and erosion of the lower group (often in an ***orogenic*** event) before the deposition of the upper group.

Variscan Orogeny *See* ***orogeny.***

vein/veinlet A fracture, usually sub-vertical, which is mineralized, often with ***quartz*** or ***calcite.*** Crystals may grow from the walls towards the centre. A **mineral vein** normally implies the presence of ore minerals.

volcaniclastic A ***clastic*** rock of volcanic origin.

witherite $BaCO_3$ A white, pale creamish white or grey mineral, crystals six-sided prisms and pyramids. Notably heavy.

xenolith An inclusion of country rock within an ***igneous*** body.

Yoredale Name applied to repeat cycles oflimestone-shale-sandstone (-seatearth-coal) ***(cyclothems)*** in the Carboniferous (Dinantian, early Namurian), derived from the old name for Wensleydale, where they are typically developed.

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