

Information Sheet 1A: Introduction to the geology and geomorphology of the Meldon area (including access and conservation)

Introduction

The Meldon area is situated on the north-west corner of Dartmoor granite massif, south-west of the town of Okehampton and is one of the most important geological locations in the UK. It demonstrates, *par excellence*, the effects of contact metamorphism and mineralisation associated with the intrusion of a major granitic body, but is also famous for its structural geological features, including the well-known '*Meldon Anticline*' - a southwards inclined antiform dating from the late Carboniferous Variscan Orogeny. A range of other geological and geomorphological features are also well developed. In brief the Meldon area includes:

- The largest and most important exposures of the Lower Carboniferous, Lower Culm Group within the metamorphic aureole of the Dartmoor granite and the largest and most important exposures of the Variscan Greystone Nappe in Devon.
- The type locality of the Meldon Shale and Quartzite Formation, a valid stratigraphical name for equivalent rocks in western Devon currently included within the Greystone Formation.
- The most important area in Devon, and possibly south-west England, for demonstrating the effects of thermal metamorphism on a variety of rocks, including the development of skarn mineralisation
- The unique Meldon Aplite, with a remarkable range of rare igneous minerals, reflecting its highly unusual composition and enrichment in elements such as lithium. It was briefly worked to make glass, possibly the only such operation in the County.
- The highest area of England south of Yorkshire and the highest part of the Dartmoor granite massif at the Yes Tor-High Wilhays ridge (rising to 621 m).
- A geomorphologically important river system (the River Okement and its tributaries including the Red-aven Brook) with features related to the origin and evolution of a system on the high granite massif and stages in its evolution as it leaves the moor, including incision through the metamorphic aureole and then a rapid transformation into a more conventional lowland river towards Okehampton.
- The presence of potentially significant periglacial features on the granite massif, including well developed clitter slopes and apparently undescribed terrace-like features below Yes Tor.

Geological history and context

The solid geology of the area was classically and meticulously described by Dearman (1959) and Dearman and Butcher (1959), the former work containing remarkably detailed drawings of the faces observed in the

active Meldon Quarry as it expanded from the late 1940s. The structural interpretation in these works reflected a 'conventional' interpretation of the geological evolution of south-west England with a simple double-anticline in the Meldon Quarry area, which passed eastwards into a single anticline. A similar view was maintained by the Geological Survey memoir of 1968 (Sheet 324; Edmonds *et al.*), but supported by a wealth of additional site-specific descriptions.

In the 1980s, however, following remapping of the Tavistock-Launceston district (Sheet 337; British Geological Survey 1994) and part of the adjacent Dartmoor sheet (Sheet 338; British Geological Survey 1995) by the University of Exeter under contract to the Geological Survey, a major reinterpretation of the evolution of the Variscides of south-west England was possible. The realisation that nappe tectonics dominated central and southern Devon and much of Cornwall, as described by Issac, Turner and Stewart (1982), radically altered perceptions of previously described structural features and stratigraphical relationships.

This model was applied to the Meldon area by Selwood and Thomas (1984) who demonstrated that the so called 'Meldon Anticline' included parts of two of the nappe structures recognised to the south-west, the Greystone and Blackdown nappes (with respectively Lower and Upper Carboniferous sequences) which had been folded together by a later deformation event. In addition, they demonstrated that the Upper Carboniferous Culm Basin to the north had itself been thrust over the nappe sequence to the south. The latter, dominated by the Crackington Formation, forms the regional tectonically 'in-situ' *autochthon* – although this evidence of minor movement suggests a *paraautochthonous* character in part – with the Greystone and Blackdown nappes the moved *allochthon*.

The intrusion of the Dartmoor granite contact metamorphosed the Carboniferous sequences of the Greystone and Blackdown nappes, which lie entirely within a distinctive metamorphic aureole. In contrast, only the southernmost margin of the Carboniferous of the Culm Basin was similarly affected although this includes virtually all exposures within the Meldon area. The metamorphism included the release of fluids into the Lower Carboniferous country rock which reacted to form distinct garnet-rich skarn deposits in association with many rare and unusual minerals, some unique to the area in the UK. In addition, as part of the final stages of granite emplacement, several dykes of microgranite were also intruded, the most remarkable of which is the Meldon Aplite. The latter has anomalously high concentrations of elements such as lithium, caesium and beryllium and, consequently, also has a unique mineralogy, with pegmatitic lenses containing rare and unusual minerals.

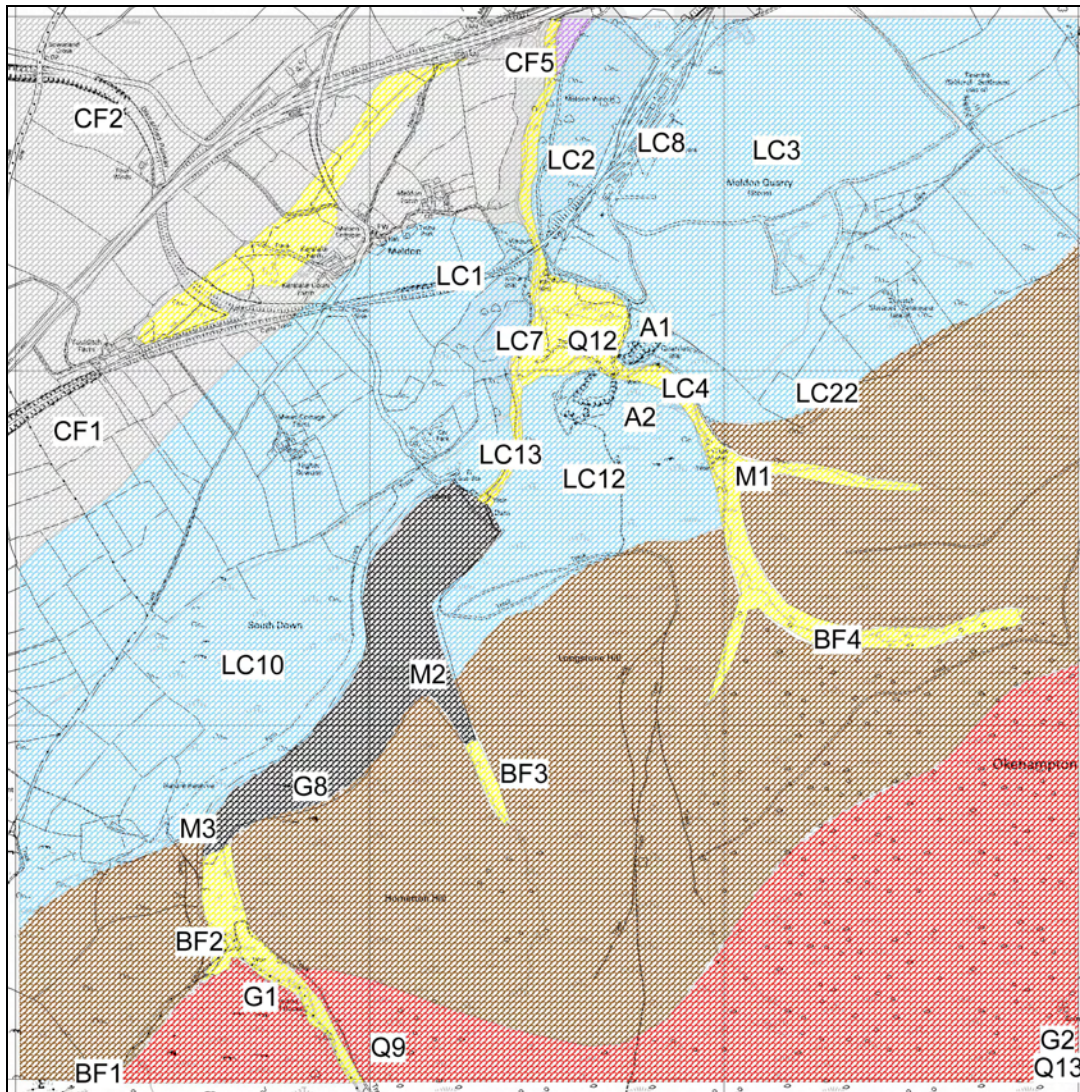
In addition to the soild, bedrock geology, the area includes a wide range of landscape features and deposits associated with the Quaternary evolution of the current landscape. Of particular importance are periglacial features, such as tors and clitter slopes, and fluvial systems, some of which have certainly been modified by the former processes. The general sequence of geological and geomorphological events and processes in the area is summarised by Table 1.

As each tectonic unit in the area has a different stratigraphical sequence, they are described separately below. Separate sections also review the Dartmoor granite and associated igneous rocks, the structural evolution of the area and Quaternary deposits and features. Metalliferous mineralisation is also treated separately, although descriptions of the metamorphic facies and associated skarn mineralisation are included within the accounts of the stratigraphical sequences of the Greystone and Blackdown nappes. Localities where the various formations and other described geological features have been recorded are also listed and briefly described. The numbering of these localities follows Page (2006).

Geological Period / System	Epoch / Subsystem	Regional Series or Stages	Main deposits or processes affecting the Meldon area
Quaternary	Holocene Epoch	(from 10Ka)	Climates improve at the end of the last ice age, and peat begins to form in waterlogged upland basins and gentle slopes. The Okement rivers and their tributaries adjust their base again and cut down through earlier terrace deposits, but only very locally develop a typically very narrow floodplain
	Pleistocene Epoch	Devensian Stage (110K-10Ka)	Glacial phase – Intense permafrost activity including frost shattering and the development of head and clitter (periglacial slope deposits), including as weathered granite moves downhill revealing rocky outcrops to form tors.
		Ipswichian Stage (150-110Ka)	Interglacial phase – Warmer, wetter conditions promote the weathering of the Dartmoor granite to produce growan. Possibly includes the development of the 1 st Terrace of Okement rivers.
		Waltonian-Wolstonian stages (2.5Ma-150Ka)	(Not recorded in the area)
Permian – Neogene		(290-2.5Ma)	High sea levels during the late Cretaceous, around 100-80 million years ago, or Ipeneplanation, during the Palaeogene or Neogene, may have created distinctive plateaux in the landscape, such as that developed on the outcrop of the Culm Basin, Crackington Formation. Distinctive NNW-SSE faulting in the region, of possible Neogene age, includes the Pewsey Fault along which the West Okement river flows upstream from Meldon Reservoir.
Carboniferous	Upper Carboniferous Subsystem	Stephanian Series (303-290Ma)	Climax of the Variscan Mountain-building phase (orogeny) with faulting and folding of the Devonian and Carboniferous rocks and intrusion of the Dartmoor granites (with associated metamorphism and mineralisation). Possible time of arrival of the Blackdown Nappe (or possibly Westphalian).
		Westphalian Series (318-303Ma)	(Not recorded in the area, but present in northern central Devon)
		Namurian Series (part-Chokierian-Yeadonian stages; 328-318Ma)	'Autochthon'/'Parautochthon' (bedrock geology in its original location): Crackington Formation (part) (turbidite deposits, formed as sand and mud flowed down the margins of a deep but unstable marine basin). Chokierian-?Langsettian recorded in the district.
	Lower Carboniferous Subsystem	Namurian Series (part-Pendleian-Arnsbergian stages; 333-328Ma)	'Allochthon' (bedrock geology moved into place from somewhere else): Blackdown Nappe - Sandstone-dominated turbidite deposits, formed closer to the source of the flows than the Crackington Formation. Presumed to be of a similar age.
		Viséan Series (350-333Ma)	'Allochthon' (bedrock geology moved into place from somewhere else) - Greystone Nappe: Deposition of shales, volcanic rocks and cherts of the Lower Culm Group, followed by the development of the Greystone Nappe, as a consequence of the beginning of tectonic activity in the region. Emplacement of the Nappe believed to be during the late Lower Carboniferous.
		Tournaisian Series (363-350Ma)	

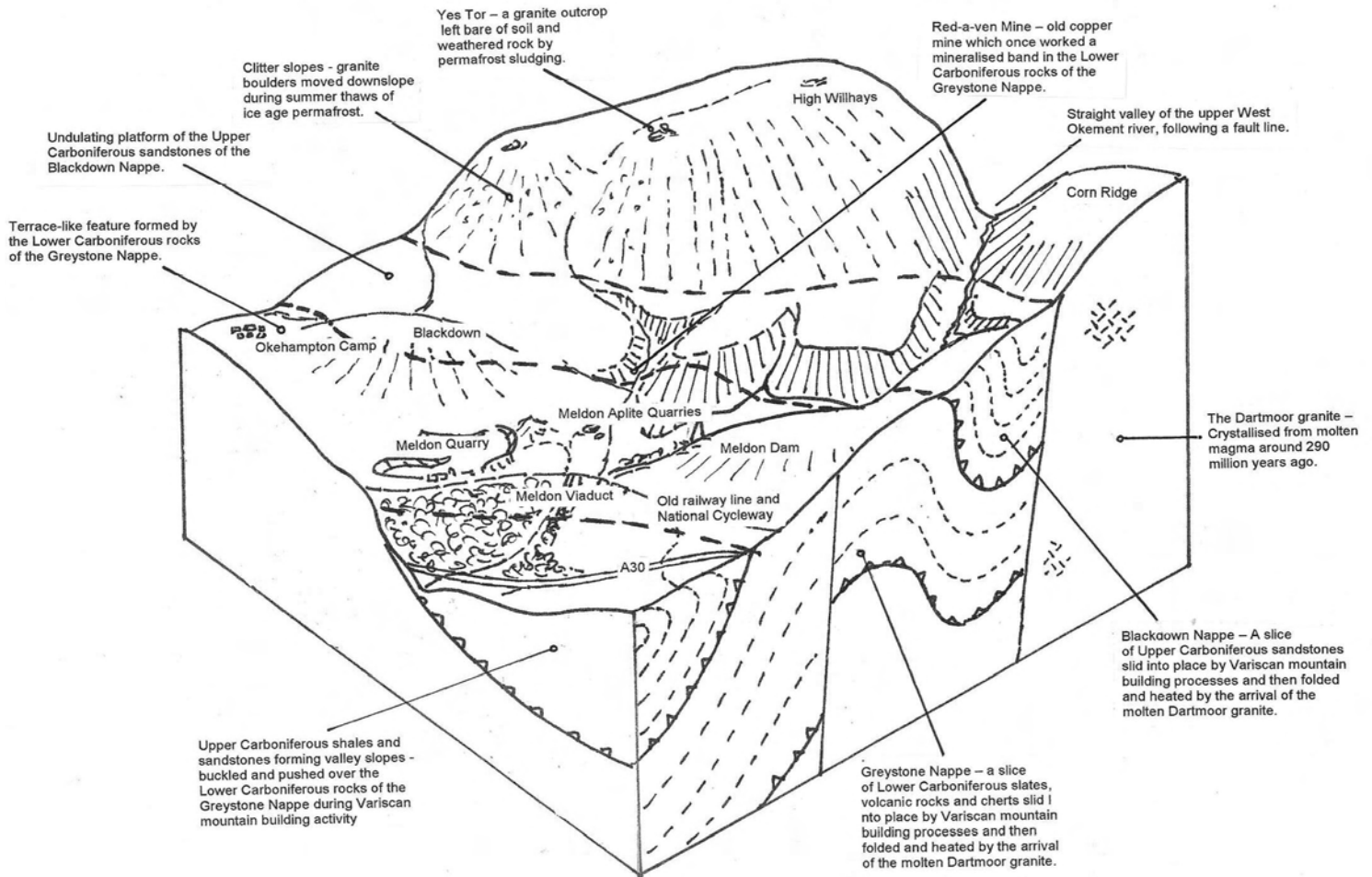
Geological timescale for the Meldon area (Ka = thousands of years ago, Ma = millions of years ago)

Geology and landscape map showing general geology and localities referred to in text



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'Geological landscapes' map of the Meldon area, showing the expression of the bedrock geology in the modern landscape (see Information Sheet 11 for a full explanation). Key: Crackington Formation (Upper Carboniferous autochthon) = grey, Lower Culm Group (Greystone Nappe) = pale blue, Bealsmill Formation (Blackdown Nappe) = brown, granite = red, Quaternary (alluvium, valley head, etc) = yellow. Localities indicated are described further on Information Sheet 1B to 1H (CF = Crackington Formation, LC = Lower Culm Group, BF = Bealsmill Formation, G = granite, A = Meldon Aplitite (Locality A1 is equivalent to LC21 and A2 to LC5), Q = Quaternary, M = mines (Locality M1 is also LC20 and M3 is LC11).



Block diagram of the Meldon area showing key geological and geomorphological features.

Access

The Meldon area has three main access routes:

1. *Meldon Reservoir car-park* [SX 562918]: Dartmoor National Park Authority car-park adjacent to Meldon Dam, with toilet block and information point including display boards introducing aspects of the geology and geomorphology of the area.
2. *Okehampton Hamlets Parish car-park* [SX 567921]: Small public car-park adjacent to Meldon Aplite quarries; accessible from minor road leading to Meldon Quarry. Includes information board and picnic tables.
3. *Meldon Quarry Station* [SX 566924]: Access is by foot or bicycle along national cycle-way, or seasonally via train from Okehampton (independent touristic line, regular services only during summer season). Facilities seasonal, although open some winter weekends, including toilets, café, interpretation centres and information boards (the latter interpreting the general landscape and Meldon Quarry itself).

Health and safety

As in much of Dartmoor, the area contains a range of features presenting a range of potential risks, including quarry faces, disused mines, boulders, torrent rivers, water bodies (reservoir and flooded limestone quarry), road traffic, a military training area, upland weather conditions, vegetation and animals. Access is permanently open to most of the area with the exception of privately owned farmland and woodland above Meldon Pool [SX 564922] and Meldon Quarry [SX 570925] - an active aggregate-producing site. In addition, as the granite massif which includes Yes Tor lies within the Okehampton military training area, public access may, on occasions, be restricted (for further information see range notice boards, e.g. at Meldon Dam car-park, or [www. Dartmoor-ranges.co.uk](http://www.Dartmoor-ranges.co.uk)).

As with any field study, appropriate hygiene measures are also important, partly as there is always a risk of biological contamination of water bodies and surfaces, but also as several minerals present contain potentially toxic elements – although, generally, the actual risk is negligible as these elements are usually not readily bioavailable in the natural mineral form. An appropriate assessment of potential risk is, however, always advisable before any visit, especially a group visit.

Geological fieldwork and conservation

The Meldon area and its unique geology is a classic part of Britain's rich geological heritage – it is therefore essential that all visitors treat the area with respect. Excellent guidance on responsible site use is available from the Geologist's Association Code of Conduct for Geological Fieldwork (www.geologist.demon.uk) although the special circumstances of the unique mineralogical resource in the area means that certain legal restrictions also apply.

Specifically, as Meldon Aplite quarries and Red-a-ven Mine lie within the Meldon Aplite Quarries Site of Special Scientific Interest (SSSI), a formal, legal consent from the governmental conservation body, English

Nature (soon to become Natural England), is required before *any* collection of geological materials can take place. Such consents will only normally be granted for *bone-fide* geological study and applications should be made in writing, stating the objectives for any such sampling, to English Nature's local office (devon@english-nature.org.uk). After October 2006, Natural England will take over this function and new contact details will then be available. Nevertheless, as most of the key features of the area including igneous intrusions, metamorphic mineralisation and geological structures can be seen without any need to hammer, such restrictions will not affect most visitors and help ensure that the geological features present are safeguarded for not just our own, but for future generations to enjoy and learn from.



Meldon Aplite Quarries (south) – Removal of apatite-bearing vein by illegal mineral collectors in 1999; the size of the blocks of debris created suggests that power tools or explosives were used (Photo: © K.N.Page)

As a working quarry with high active faces and heavy machinery, access to Meldon Quarry, however, is not generally possible. For bone-fide research purposes however, prospective visitors should contact Aggregates Industries directly (www.aggregates.com). Proof of appropriate insurance may be required. The quarry is also an SSSI for structural geological features, but includes additional features of at least regional mineralogical and stratigraphical significance.

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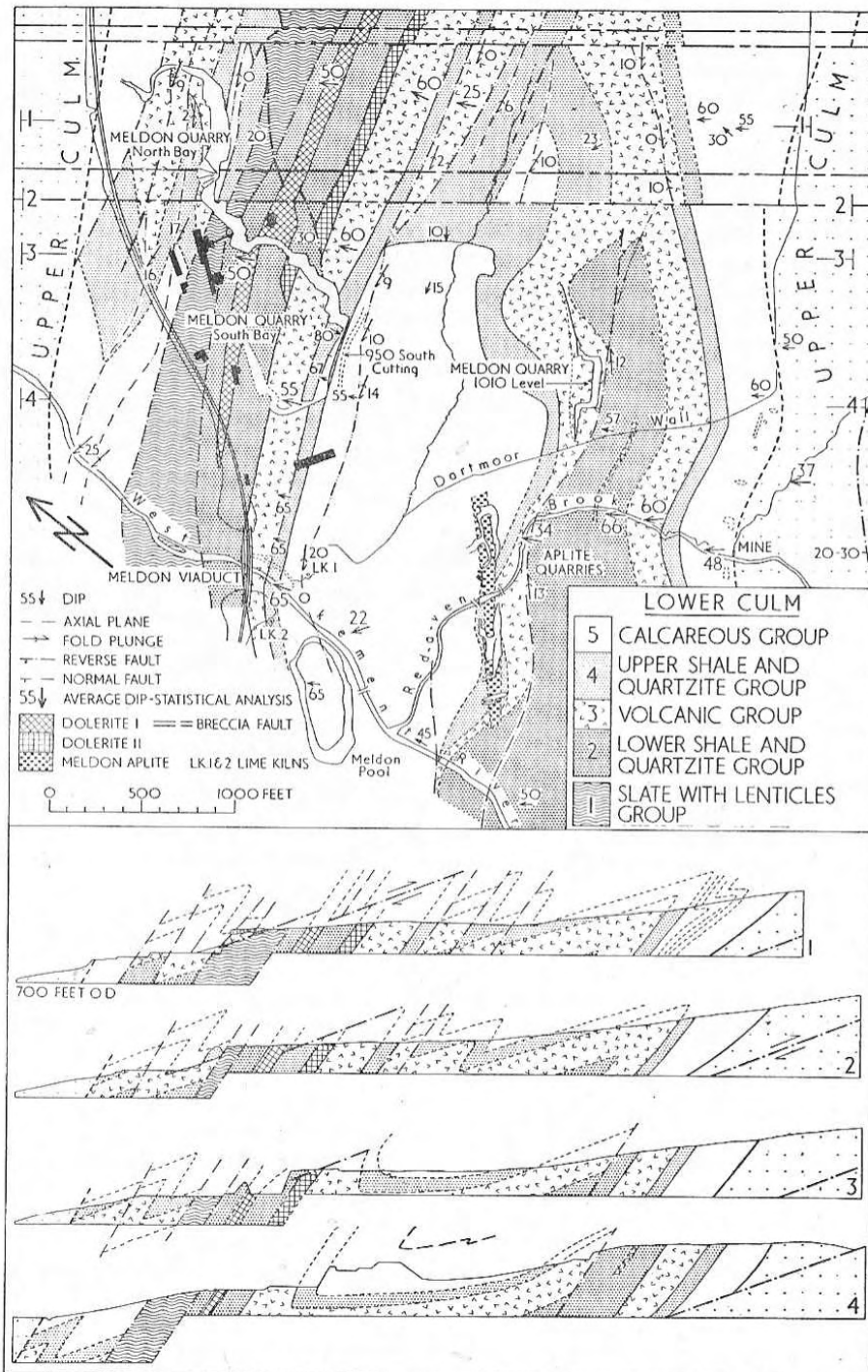
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Useful Website addresses

British Geological Survey: www.bgs.ac.uk
Devon County Council, Educational Register of Geological sites in Devon: www.devon.gov.uk/geologysite
Devon County Council, Geodiversity Audit of Active Aggregates Quarries: www.devon.gov.uk/geology/geodiversity
Devon RIGS Group: www.devonrigs.co.uk
Earth Science Teachers Association (ESTA): www.soton.ac.uk/~ukgec/ESTA
English Nature: www.english-nature.org.uk
Geologist's Association: www.geologist.demon.uk
Joint Nature Conservation Committee: www.jncc.gov.uk (see also: www.geoconservation.com/conference)
ProGEO – The European Association for the Conservation of Geological Heritage: www.sgn.se/hotell/progeo
UK RIGS: www.ukrigs.org.uk

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Geological map and cross-sections of the Meldon Quarry - Red-a-ven Brook area (after Dearman 1959) ('Slate with Lenticles Group' = tectonic mylonite; 'Lower Shale and Quartzite Group', 'Volcanic Group' and 'Upper Shale and Quartzite Group' = Meldon Shale and Quartzite Formation; 'Calcareous Group' = Firebeacon [Meldon] Chert Formation (all Greystone Nappe). 'Upper Culm' (in north) = Crackington Formation (autuchthon/parautochthon); 'Upper Culm' (in south) = Bealsmill Formation (Blackdown Nappe))
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