

Geology and Landforms

Dartmoor Factsheet

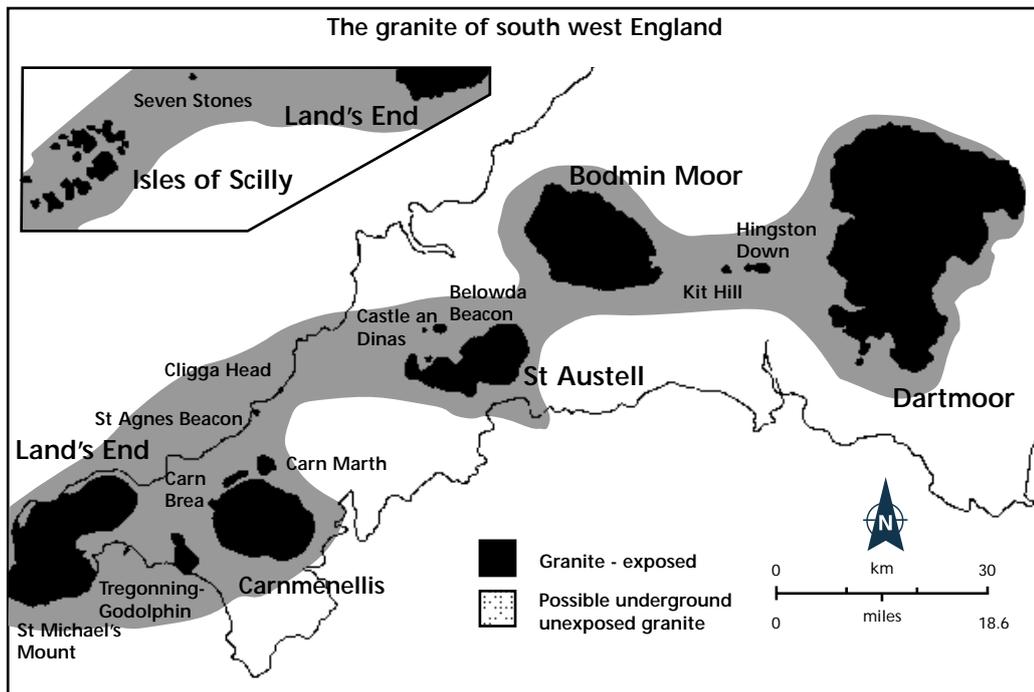
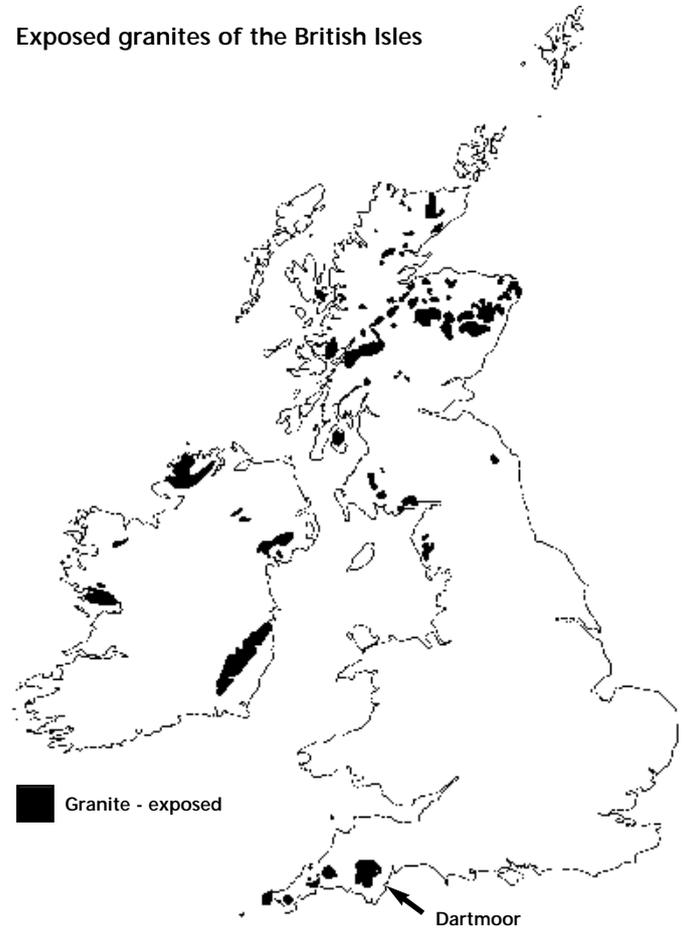


Dartmoor's relief, soils, vegetation, farming, many of its buildings and much of its industry have been to some degree influenced by the nature of the area's geology. Most of Dartmoor consists of a single type of rock - granite.

This granite was intruded during the late Carboniferous/ early Permian Period (around 280 million years ago) into the area we now know as Devon and Cornwall. From the Isles of Scilly to Dartmoor, a number of granite domes are linked within the Earth's crust, where they form a *batholith*, one massive intrusion. Gradually, overlying rocks have been eroded thus exposing the granite.

Dartmoor granite covers an area of 241 square miles (625 square kilometres) and represents the largest area of exposed granite in southern Britain. It is this granite which underlies the contrast between Dartmoor and the surrounding countryside.

Exposed granites of the British Isles



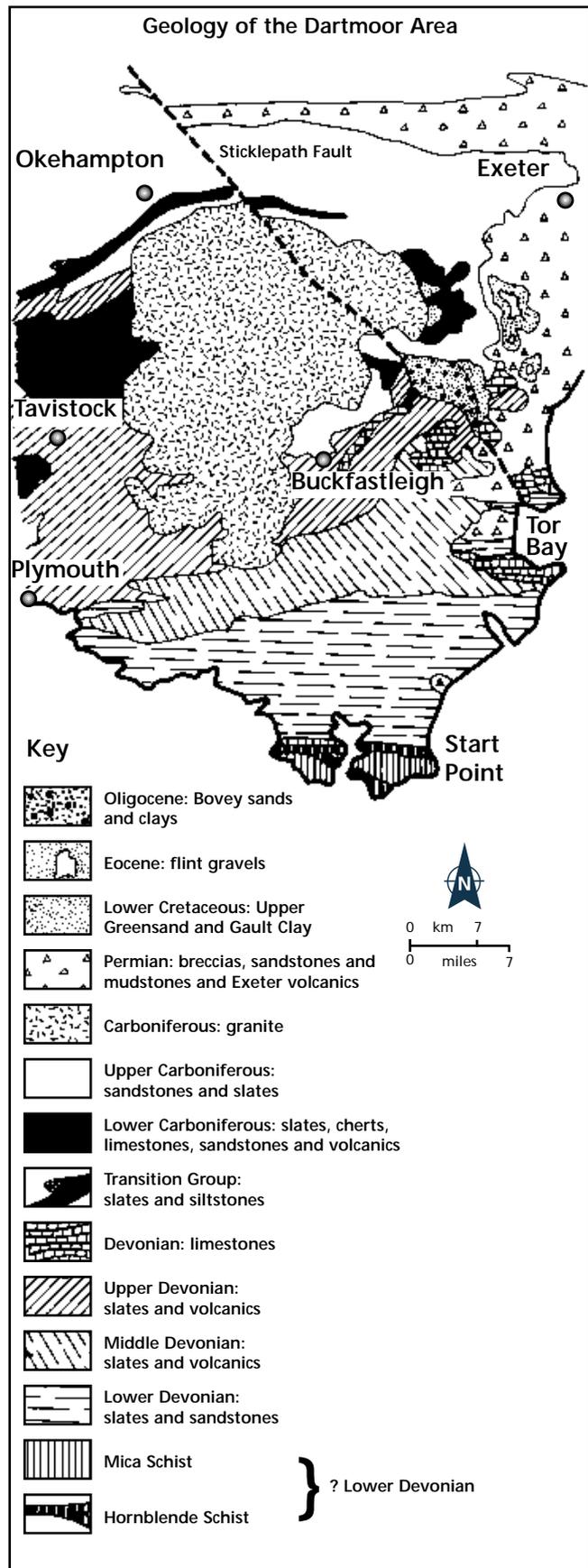
The Dartmoor granite, surrounding rocks and associated mines and quarries

The Dartmoor granite was intruded into Devonian and Carboniferous shales, sandstones, limestones and lavas. These surrounding *country rocks* were altered by the great heat and pressure that accompanied the granite intrusion, resulting in the development of many types of metamorphic rocks, which form an *aureole* around the granite.

As the granite cooled, hydrothermal activity led to the local concentration of minerals in both the granite and the country rocks. This mineralization resulted in tin and copper ore veins, as well as arsenic and lead ores, all of which have in the past been worked commercially. Signs of past mining activity are frequent in the Dartmoor area (such as in the Teign valley). Even iron occurs, especially in the Haytor area, although its origin is the subject of much debate. Other metals to be found include zinc and tungsten, with much smaller amounts of cobalt, bismuth, antimony, uranium and gold. Many less well known minerals are found too, including some that are nationally or even internationally rare, such as those found in mine and quarry spoil in the Meldon area.

The same hydrothermal activity also led to the formation at depth of the china clay, through kaolinisation of the granite, which is now quarried at Lee Moor on south west Dartmoor. The ball clay deposits in the Bovey Basin area, and near Meeth in mid Devon, are sediments produced from the weathering of the Dartmoor granite and surrounding rocks after their exposure to the atmosphere some 200 million years later.

Igneous rocks other than granite occur in the Dartmoor area, notably dolerite dykes and sills and some lavas, among the surrounding rocks. Dolerite is, or has been, quarried commercially for road stone and railway ballast at Meldon Quarry, Crockam Quarry and Pitts Cleave, all of which are now designated as Sites of Special Scientific Interest. These sites, along with others such as Spara Bridge and Cholwell Brook, are also important for the study of the Carboniferous Period (about 350 million years ago), when the clays and sandstones of that time (later altered to slates and cherts) were laid down beneath a sea that covered present-day southern Britain.



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Granite The name granite comes from the Latin *granum*, a grain. Granites are composed of fairly large crystals and have an irregular granular or granitoid texture. Granite is a group name for a family of plutonic or deep-seated acidic igneous rocks. Dartmoor granite is made up mainly of quartz (glassy, grey/white crystals of silicon dioxide), felspar (particularly orthoclase - potassium aluminium silicate: but also plagioclase) and biotite, a type of mica - a complex hydrated silicate of aluminium and potassium with iron, magnesium and fluorine. Dartmoor granite is also characterised by a relatively high proportion of tourmaline, which is blacker than biotite and distinguishable by its finely grooved surface.

Some geologists have identified three major types of Dartmoor granite - the *contact granite* contaminated by minerals from the surrounding rocks; the *tor granite* which contains the large megacrysts typical of many of the tors, and the finer grained *blue granite*.

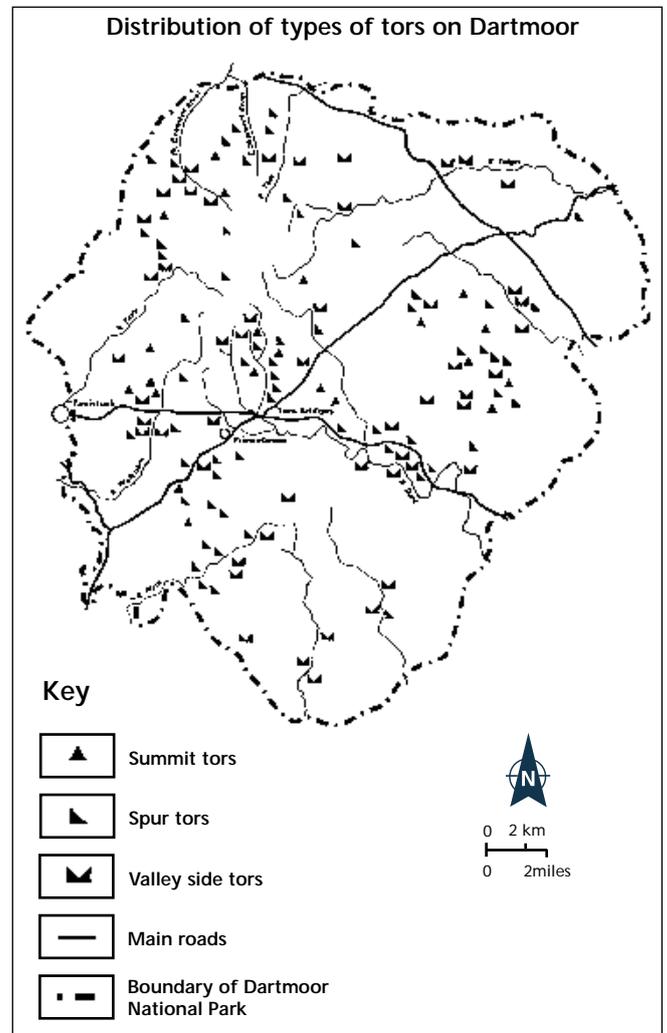
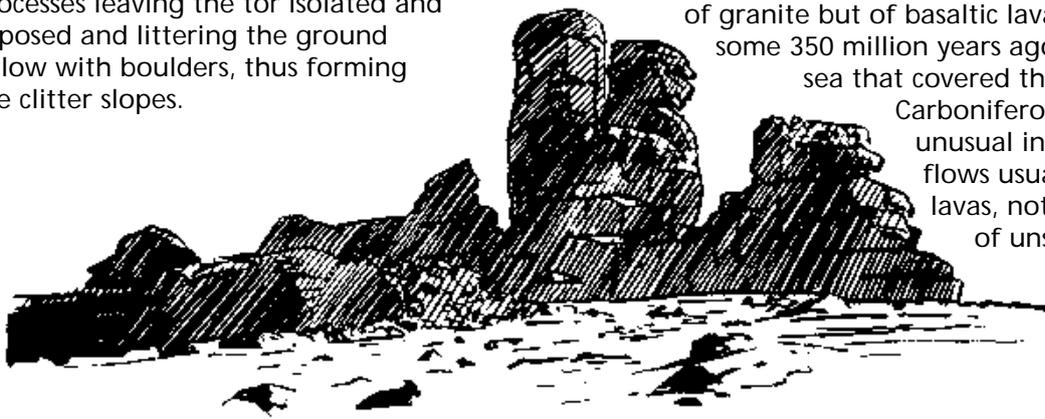
Land formation processes

The summits of the Dartmoor landscape slope steadily downwards from north to south and are interpreted as a Tertiary plain tilted south by Alpine earth movements. The main headstreams of the River Dart and the Rivers Tavy and Walkham drain the northern plateau in a generally southerly direction. The Rivers Plym, Yealm, Erme and Avon drain the southern plateau similarly. The River Dart collects its headwaters between the two plateaux and leaves the granite through the most spectacular of the fringe gorges. Only the River Taw and the East and West Okement Rivers leave towards the north after relatively short moorland courses. The River Teign drains the eastern edge of the northern plateau but turns south on leaving the granite. The River Lyd leaves Dartmoor through Lydford Gorge. This is a classic site for the study of gorge formation and river capture.

Dartmoor was south of the original glacial limit during the four Ice Ages of the Pleistocene Period, but during that time the sea-ice abutted the north coast of the south-west peninsula where periglacial conditions dominated. Features resulting from this include tors, clitter, head deposits, stone stripes, nets and other *patterned ground* features. These latter formations can be clearly seen above Merrivale Quarry and around Cox Tor, in the Meavy valley above Burrator Reservoir, and in the Leedon Tor area.

Tors and clitter slopes

Tors and clitter slopes, which are characteristic of Dartmoor, have been formed through the weathering of the granite over at least the last ten million years. They are concentrated where the effects of weathering and erosion have been greatest, ie on summits, valley lips, spur ends and steep valley sides, particularly on the edges of the two great plateaux of Dartmoor and close to the main river gorges. Tors are the remnants of former landscape surfaces. Weaknesses and joints in these surfaces have been subsequently exploited by acidic waters over a long period and by freeze-thaw action during the four Ice Ages. Blocks of granite are levered away by these processes leaving the tor isolated and exposed and littering the ground below with boulders, thus forming the clitter slopes.



© Dartmoor National Park Authority 2005.

Weathering eventually causes the disintegration of the granite down to individual crystal level. The resultant gravel is called *growan*. During periglacial times it became very mobile - moving down slopes and accumulating on flat ground as *head deposits*. It is the parent material for a number of Dartmoor soil types.

Weathering can also give rise to smooth, bowl-like depressions known as *rock basins* and found on some tors. These are formed by the repeated freezing of water in surface irregularities where the expanding ice gradually prises out individual mineral grains.

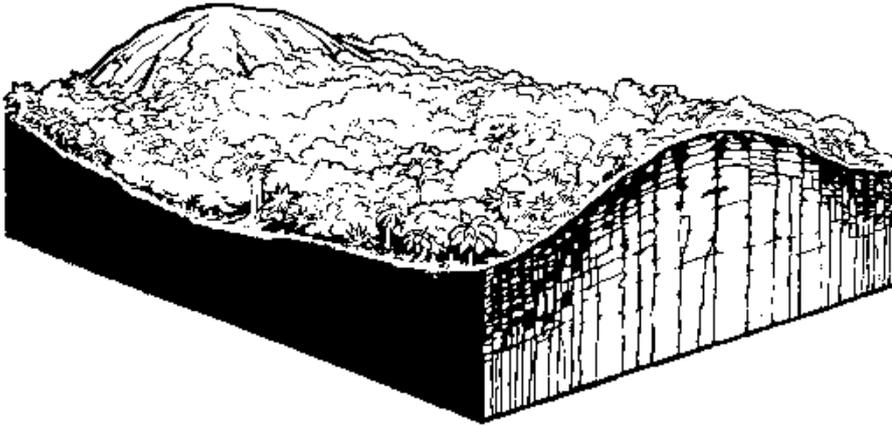
The famous land mark of Brent Tor on west Dartmoor, with its hill-top church, is not formed of granite but of basaltic lava which flowed out some 350 million years ago into the shallow sea that covered the area during the Carboniferous Period. It is unusual in that underwater lava flows usually result in pillow lavas, not in the accumulations of unsorted glassy, rocky fragments found at Brent Tor.

Tor formation

Dramatic rocky outcrops, known as tors, are distinctive features in the Dartmoor landscape. They have been sculpted by weathering into strange shapes. The formation of tors has been the subject of considerable debate. Some observers have noted their resemblance to the granite *kopjes* found in the tropical African savanna.

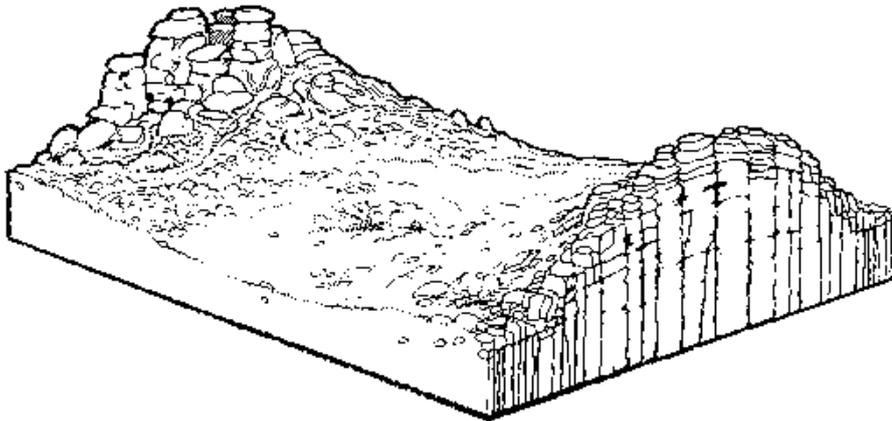
Debate centres around which type of weathering predominated - the sub-surface chemical weathering leaving the corestone to be exposed later, or the mechanical freeze/thaw action that can shatter rocks and prise one stack away from another.

Approximately 30 million years ago



For many millions of years Dartmoor was covered in tropical and sub-tropical forests. Tropical rainwater ran down into the underlying granite and along the joints (natural cracks) and ate away the rock. This created a landscape in waiting. Some geologists believe that the granite was also weathered by chemical rotting just after its emplacement.

Present



Later, the granite was exposed and during the cold glacial phases, water froze in the joints and prised bits off the rock, forming clitter on the ground. Seasonal freezing still continues to attack the tors.

Jointing Tors are a product of differential erosion determined by the spacing of the joints within the granite. The exposed granite generally displays both vertical and horizontal jointing. The vertical joints are thought to have been caused by the contraction of the granite as it cooled. The more horizontal joints often appear to closely follow the shape of the surrounding land; these probably formed as the pressure was released from overlying rocks when these were removed by the agents of erosion.

How Dartmoor came into being

Overview	Years Ago	Geological Period	Land and seascape	Fauna/Flora
400 million years ago there was no Dartmoor, just the sea which was perfect for a nice warm dip... except when volcanoes were erupting!	400 - 290 million	Early Devonian to Late Carboniferous - deposition period. Some volcanic activity.	Huge warm sea, 100s of miles wide - river sediment from mountains to north gradually building up on sea floor - slates shales, mudstones, sandstones, limestones, cherts, conglomerates. Islands of lava and ash erupt into the sea.	Corals in subtropical sea. Earliest bony fishes. Earliest forest on land to north and south of sea. Palm and fern-like trees, arthropods including insects and, later, amphibians.
But nothing lasts forever and after 100 million years or so, the ocean floor became a mountain range! What was to become Dartmoor, pushed up through the earth's crust.	290 - 270 million	Cornubian mountain building period. Intrusion of magma. This cooled to become granite - the birth of Dartmoor.	Sedimentary rocks on sea floor are squeezed and formed into new mountains. Beneath them, a mass of molten granite rises up distorting and baking the surrounding rocks (now metamorphic rocks) - eg limestones and marbles. As the granite cooled, a wealth of minerals were formed including tin and china clay.	
The climate blew hot and cold... and sometimes brought heavy rain...	270 - 200 million	Permian and Triassic - fast erosion and deposition.	Semi-arid mountains - wind, temperature change, intermittent torrential rain - severe weathering and erosion - deposition of New Red Sandstone.	Reptiles, including the first dinosaurs. Few trees - some giant conifers.
and became milder.	200 - 145 million	Jurassic Period	Milder climate.	Larger dinosaurs. Forests of ginkgos, conifers and cycads (fern like trees).
With another change in climate... the area was flooded again... and sea creatures lived and died there and afterwards turned into chalk.	145 - 65 million	Cretaceous Period. Chalk platform lifted and tilted.	Shallow sea, minute calcareous algae fall to bottom and die, producing thin layer of chalk.	
After about 65 million years, the sea retreated... and eventually the wind, sun and rain wore away the soft chalk to reveal the hard granite, which had been underneath a long time - about 200 million years. But time does not stand still and nor does the land which developed faults... and then tilted to one side.	65 million	Tertiary Period - more crustal movements - tear faults, tilting and subsidence.	Tropical climate, moist and humid. Sea retreated, sedimentary rocks eroded and granite revealed. Rivers began to cut out courses, first eastward then southward - ancestors of Rivers Teign and Dart. Subsidence produces lake near Bovey Tracey - eroded granite is deposited as gravels and clays.	Mammals and flowering plants, similar to some tropical ecosystems of today. Evergreen and semi-evergreen forest. Insects and monkeys.
With all this restless movement Dartmoor was an island for a while.	2 million	Early Pleistocene	Dartmoor is now an island; evidence of ancient shoreline at about 212m at edge of moor.	
About half a million years ago, the climate changed again. Glaciers spread from the north but stopped at the Bristol Channel... Dartmoor was covered in snow and frozen solid. Ice crystals swelled in rock crevices and when they couldn't stand the strain, rock fragments broke off, littering the slopes with debris... There were four Ice Ages; in between the climate was quite warm. The last one ended quite recently, only 11 thousand years ago.	600 - 10 thousand	Pleistocene Ice Age - at least 4 cold spells with interglacial spells.	Glaciers and ice-sheets reached only to Bristol Channel, but land alternately froze and then thawed -interglacial periods. In cold spells Dartmoor is similar to Northern Europe or Canada in winter. During interglacial periods, warmer than today's climate. Soil and decomposed granite moved downhill, exposed solid granite broken up - domes become craggy slopes littered with debris -'clitter'.	Interglacials - mixed conifers (juniper, pine) and deciduous woodland (dwarf birch, dwarf willow, then hazel, oak, elm). Bones show presence of lion, elephant, hyena and rhinoceros but also wolf and beaver. Also first men - tropical in origin. At beginning and end of each period, oceanic heathland with scattered shrubs.
Trees grew when the climate improved. If it wasn't for the forest fires and the prehistoric farmers and the increased rainfall, most of Dartmoor would be wooded still.	10 thousand	? Interglacial	At first warmer than today. Around 6000 BC rainfall increased, climate less mild - blanket bog began to develop. Natural fires and later settlers began to clear forest. More leaching of soil, less humus, build up of iron pan, waterlogged soil gradually turns to pale grey podsol infertile.	As climate improves, trees of European temperate forest spread. Fullest extent of forest on present Dartmoor surface 7000-6600 BC - dominated by oak, plus hazel and elm. Deer, foxes and horses, salmon and trout still persist. Too wet now for moorland moles and earthworms found in earlier part of period.

Extensive peat deposits

Just over a third of all the unenclosed moorland on Dartmoor is covered by peat that is more than 50 cm thick: in places it is over seven metres thick. Peat forms the blanket bogs at the heart of the two plateaux as well as the valley mires of the area. The peat of the blanket bogs is no longer accumulating and is thought to have been formed under wetter conditions than those of today. In geological terms, peat is especially important for what it can tell us about the environment and vegetation of Dartmoor since the last Ice Age through studies of preserved pollen. It also provides an important water-holding resource for the whole of Devon.

The Sticklepath Fault

This zone of faulting runs across the whole of the south west peninsula from Bideford to Torbay. It is also of Alpine date, probably contemporary with the southern tilt referred to earlier. It cuts across the north-eastern part of the Dartmoor area where it can be traced by a series of valleys parallel to the NW/SE fault line. It has been exploited by various rivers over time including the Bovey and tributaries of the Teign and Taw.

Caves and vertebrate fossils

In the south east part of Dartmoor there is a limestone outcrop in which a cave system developed during the Pleistocene Period, about 150,000 years ago. This system is important not only for the study of cave formation, but also for mammal fossils that accumulated there when debris was washed into the caves. Indeed, Joint Mitnor Cave has yielded the richest fossils of the Ipswichian interglacial age in Britain. Hippopotamus, straight-tusked elephant, wild boar, fallow deer, spotted hyena and lion fossils have all been found. The caves also contain spectacular mineral deposits and well-developed stalactite formations.

The caves today are also of significant biological conservation importance because of the large population of greater horseshoe bats that roost there.

Conservation

The geology and landforms of Dartmoor have been much studied and reflecting this there are a number of sites that have been recognised as being of national importance.

There are also approximately 35 Regionally Important Geological Sites (RIGS) on Dartmoor. For further details about a range of typical Dartmoor sites refer to the Register for Geological Sites www.devon.gov.uk/geology/

Geological Sites of Special Scientific Interest (SSSIs)

Brent Tor
Buckfastleigh Caves
Burrator Quarries
Cholwell Brook
Crockam Quarry, Trusham
Devon United Mine
East Dartmoor (Birch Tor)
Haytor Rocks and Quarries
Haytor and Smallacombe Iron Mines
Laughter Quarry (Believer Quarry)
Leusdon Common
Lydford Gorge
Meldon Aplite Quarries
Meldon Quarry
Merrivale
North Dartmoor (Black Ridge Brook)
Pitts Cleave
South Brentor Quarry
South Dartmoor (Blacklane Brook)
Spara Bridge
Two Bridges Quarry



Key Conservation Objectives for Geology and Landforms

(as identified in *Action for Wildlife: the Dartmoor Biodiversity Action Plan*; Dartmoor National Park Authority, 2001)

- *Identify, maintain and enhance all existing rock exposures and natural landforms that are important for understanding the origin and geological development of Dartmoor and its landscape.*
- *Encourage appreciation of the Dartmoor landscape and its geology, and an understanding of its links with scenery, tourism and mining, through education and interpretation targeted at the public, educational establishments, the minerals industry and other bodies.*
- *Protect the processes of natural evolution of the Dartmoor landscape, including drainage patterns, slope development and peat formation.*
- *Encourage surveys of old mine workings and spoil tips, promote appropriate protection measures and responsible use and, where necessary, their positive conservation management.*
- *Ensure that there is a Cave Conservation Plan for caves in the Buckfastleigh area.*
- *Maintain the biodiversity of tors and clitter slopes, quarries, caves, mines and buildings.*

Please note: for conservation reasons, particularly to safeguard salmon spawning grounds, education groups are requested not to carry out river studies in the riverbed at

Lower Cherrybrook Bridge
(Grid reference SX 631 747)

Bellever Bridge
(Grid reference SX 659 773)

Runnage
(Grid reference SX 669 788)

Pizwell
(Grid reference SX 670 777)

Geological Fieldwork Code

The Geologists' Association has published a *Geological Fieldwork Code*, copies of which are available from The Geologists' Association, Burlington House, Piccadilly, London W1V 9AG (☎ 0171 434 9298).

The adherence to this Code for any geological fieldwork is crucial to safeguard our geological heritage and its scientific interest and value. In particular, when on Dartmoor please:

- *always seek permission before entering on to private land;*
- *avoid undue disturbance to wildlife. Plants and animals may inadvertently be displaced or destroyed by careless actions;*
- *when working in remote areas, follow the advice given in the booklet Safety on Mountains issued by the British Mountaineering Council, and in particular inform someone of your intended route;*
- *when exploring underground, be sure you have the proper equipment and the necessary experience and appropriate permissions sought. Never go alone. Report to someone your departure, location, estimated time below ground and then your actual return;*
- *remember that rock outcrops are important to science and should not be hammered or damaged in any way - please observe and read and do not hammer indiscriminately;*
- *keep collecting to a minimum. Avoid removing in situ fossils, rocks or minerals;*
- *never collect from walls, bridges, buildings or other structures;*
- *take care not to undermine fences, walls, bridges or other structures;*
- *remember that rock faces, quarry faces and old mine workings may be highly dangerous - always consider your personal safety and the safety of others.*

Some of the information in this Fact Sheet is taken from:

The Nature of Dartmoor - a Biodiversity Profile, Second Edition, published jointly by English Nature and the Dartmoor National Park Authority, 2001.

Useful web links for further information:

- Other factsheets:**
 - Tor Formation
<http://www.dartmoor-npa.gov.uk/dnp/factfile/tors.pdf>
- Other publications:**
 - The Nature of Dartmoor: A Biodiversity Profile
<http://www.dartmoor-npa.gov.uk/dnp/pubs/natureod.html>
 - Action for Wildlife: The Dartmoor Biodiversity Action Plan
<http://www.dartmoor-npa.gov.uk/dnp/pubs/bap.html>
 - Evolution of a Dartmoor Landscape
<http://www.dartmoor-npa.gov.uk/dnp/factfile/burrator.pdf>
- Other information:**
 - Dartmoor Rock
<http://www.dartmoor-npa.gov.uk/dnp/factfile/rigs.pdf>

For further information, and a list of other Fact Sheets available, contact the:

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