

# TERTIARY DEPOSITS

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Ball clay workings at Petrockstowe - pale grey clay with beds of dark lignitic clay

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## 1. BRIEF DESCRIPTION

Rocks which date from the Tertiary geological time period in Devon include ball clays, gravels and clay-with-flints.

Ball clays are used to make a wide range of quality ceramic products in everyday use for domestic and industrial purposes, such as tableware and sanitary-ware. It is a scarce and valuable raw material of national and international importance.

The ball clay deposits in Devon occur locally in thick accumulations of sedimentary sands, silts and clays in ancient lake and swamp basins along an important geological structure, the Sticklepath Fault zone, which cuts across the county southeast-northwest from Torquay to near Lundy Island. The two areas actively worked are the Bovey Basin near Newton Abbot and the smaller Petrockstowe Basin about 10 miles north of Okehampton. The sediments contain beds of nearly black clay formed from accumulations of vegetation within the clay. Fossil plant remains of tropical to sub-tropical species show that the deposits were formed in the early Tertiary period, about 50 million years ago when the climate was much hotter and wetter than now.

The Haldon Gravel is considered to be a residual deposit remaining from the chalk which was completely dissolved away in the aggressive tropical climatic conditions of the early Tertiary. It is an unusual and distinctive accumulation of about 18m of flint gravel that caps the Haldon ridge west of Exeter. The flints can be seen abundantly in soils along the footpaths in the Forest Park on the crest of the ridge.

The Aller Gravel is similar flint gravel believed to be of the same age found as a layer beneath the ball clay deposits on the eastern edge of the Bovey Basin near Newton Abbot.

In east Devon (and elsewhere in southern England) a widespread surface layer of rock of a similar age and origin is known by the descriptive term 'Clay-with-Flints'. This is the scourge of farmers and gardeners alike because of the abundant flint cobbles in the soil.

## **2. GEOLOGICAL DETAIL**

The ball clay sediments, both in scale and commercial value, are the most important feature described in this section. However, some other rocks of closely similar geological age are grouped with them because they are important for understanding the hot, humid climate of the early Tertiary period.

The two main ball clay basins have been much explored both geologically and commercially by drilling, sampling, geophysics and quality testing. The total thickness of sediment in the Bovey Basin is more than 1000m, but only the upper 300m is known in any detail. The Petrockstowe Basin is about 700 metres deep, again only the upper part is well known. The clay properties are different in detail in both areas and find uses in different applications.

The commercially valuable clays occur only in parts of the sequence and even within those parts the clay varies in quality requiring careful selective working and blending to suit customer needs. Further information can be found at the following link: [www.clayheritage.org/pages/whatisballclay.htm](http://www.clayheritage.org/pages/whatisballclay.htm)

The sediments formed in hot and humid swamps and temporary lakes in a river flood plain draining a tropically weathered landscape on the southern borders of Dartmoor. The Sticklepath Fault was active at the time. A fault is a geological structure along which movement of the earth's crust takes place - as in an earthquake. In this case most of the displacement appears to have been horizontal, about a mile sideways where the Dartmoor granite is displaced on its northern edge. Gradual subsidence occurred in basins along this weakness allowing accumulation of hundreds of metres of sediment all of shallow water origin.

The Haldon Gravels are made up almost entirely of flint. Flint is nearly pure silica occurring exclusively in the Chalk and in younger gravels derived from the Chalk. A small outcrop of Chalk occurs at Beer in East Devon, but most Chalk occurs to the east of this. There is no Chalk at or near Haldon. So how is there this large deposit of flint gravel up to 18m thick on top of Haldon?

A clue is that flints in the lower part of the Haldon Gravels are mostly unworn and have clearly not been transported any distance. The most likely explanation is that Chalk is believed to have covered the whole of Devon when it was formed and some time in the past, probably about 55-65 million years ago, the entire thickness of several hundreds of metres was dissolved away completely leaving a residue of the insoluble flint.

The upper part of the gravel contains flints that are moderately abraded, indicating some erosion and disturbance. Minor clay content is largely kaolinite (like ball clay

and suggesting a connection) indicating a freshwater rather than marine environment. Transport by streams is therefore most likely.

How could there have been a stream on top of Haldon, you may ask? The Haldon ridge was not there at that time, it is a product of more recent erosion. The Haldon Gravels appear to have formed part of a large flood plain east and south of Dartmoor connecting with the Aller Gravel of about the same age near Newton Abbot.

The Aller Gravel is about 25m of grey to brown, moderately abraded flint gravel and silty sand at the base of (and therefore older than) the Lower Tertiary clay and sand sediments in the Bovey Basin. The deposit has the characteristics of sediment transported by a river and, as well as flint, the gravel contains cobbles and pebbles of other minerals and rocks derived from the west, an important clue to the direction from which the river was flowing.

Research on these ancient climates is ongoing but evidence is accumulating that the climate was unusually warm, largely tropical, between about 65 and 45 million years ago when the lower Tertiary sediments were formed.

The 'Clay-with-Flints' forms a cap on the flat topped plateau of East Devon. It can be seen from a distance as a brownish-yellow layer up to about 5m thick on the highest points of the sea cliffs between Sidmouth and Lyme Regis. This deposit is a clay containing abundant unworn flints and, like the Haldon Gravel, it is believed to result largely from Chalk having been dissolved away leaving behind the unworn flints.

### **3. USES**

The ball clays of Devon have been in general use in Britain for making pottery since the 17th century and since the mid 19th century they have been exported to countries throughout Europe and to the United States.

High quality ball clays are scarce globally and Devon is fortunate to have this 'world class' mineral resource which supports several hundred jobs locally and many jobs elsewhere in the manufacture of products that we all use everyday without much thought to it. The clays are marketed from Devon throughout the world and they owe their continuing demand to their high quality, unique and consistent combination of physical properties.

The main mineral in ball clay is kaolinite, the same mineral as in china clay but in this case with a different crystal structure. This gives it its value as a ceramic raw material because it is highly plastic and can be formed into intricate shapes like tea services and toilet pans that can be handled before firing in a kiln without undue risk of damage. Moreover, after firing it has a light colour, unusual in most other clays.

Exacting standards of quality requirements for different ceramic uses means that clays from different quarries or seams have to be selectively worked and blended.

Ball clay is also used in refractories and electrical insulators, in pharmaceuticals and fertilisers and on a relatively small scale it has uses as a filler for rubber and plastic products such as windscreen wipers and garden hoses.

The Haldon Gravel has been worked intermittently on a small scale, mainly for local use on forestry and farm roads. Wider use for construction purposes was not favoured by the content of mainly coarse flint cobbles of limited use and difficult to crush. Better sand and gravel deposits were available elsewhere. Similarly, the Aller Gravel also suffered from the predominance of coarse flint cobbles of little direct use without expensive processing, but gained from the underlying Greensand being suitable for building sand permitting a wider commercial range of products.

The Haldon flints used to be worked on a small scale as a source of silica in the mix for making ceramic tiles at Bovey. The flints were calcined by burning them slowly for several days in small heaps with sawdust or other fuels readily available locally. The silica product was then in a state to be crushed fine for thorough mixing in the ceramic feed. The Haldon flints would not seem to have any special properties for this purpose, just the location being the source closest to the manufacturing site.

Flint was favoured by Stone Age man for making stone tools. This was because it is nearly pure silica, hard and highly durable. It is very fine grained and capable of being 'knapped' to a fine and very sharp edge. It is also widely distributed.

There is no known evidence for the Haldon Gravel having been a source of flints for tool-making. Flint can be almost any colour from black to white or shades of brown but the Haldon flints are generally pale grey in colour and may be recognisable if found elsewhere (see Photo TD4). Quality of the Haldon flint may have been adversely affected by the harsh tropical weathering in the Tertiary and later the cold periglacial conditions of the Quaternary.

#### **4. PLACES TO VISIT**

Please refer to the safety guidance about visiting geological sites on our website before visiting the places listed below.

There are relatively few places to visit to see the Tertiary deposits of Devon. In particular, the ball clay pits are mostly well concealed, and as working clay pits they are not accessible to the public.

Haldon Forest Park, Bullers Hill Quarry – is accessible and provides exposures of the Haldon Gravel.

East Devon Coast (part of World Heritage Coast), in particular the sea cliffs east of Sidmouth – provides long distance views of the surface layer of Clay-with-Flints along the tops of cliffs, but generally there is no safe access to allow close inspection of these deposits.

## 5. PHOTOGRAPHS



Ball Clay working, Southacre Pit, Bovey Basin  
Photo TD1 © Sibelco UK



Merton Ball Clay Pit, Petrockstowe Basin  
Photo TD2 © Sibelco UK



Aller Gravel, with moderately abraded flints.  
Photo TD3 © Clive Nicholas



Haldon Gravel unconformably overlying the Upper Greensand (in badger sett) – at Bullers Hill, Haldon Forest Park. Photo TD4. © Clive Nicholas



Distant view of 'Clay-with-Fints' forming surface layer above the vertical cliff of Greensand Chert, at Dunscombe Cliff, east Devon. Photo TD5 © C Nicholas