# C2 Birch Tor

[SX 686 814]

## Highlights

This site has an important display of varied xenoliths illustrating material thought to have influenced the final composition of the main Dartmoor Granite magma.

## Introduction

The site is situated 8 km south-west of Moretonhampstead. It encloses Birch Tor itself, which contains xenoliths and rafts of precursors of the Dartmoor Granite and is adjacent to the remains of the open-cast workings of the Birch Tor and Vitifer tin mine.

One of the cornerstones of Brammall and Harwood's hypothesis (discussed earlier), regarding the composition of the main Dartmoor Granite was that it had been modified from its original 'sodipotassic' nature by assimilation of country rocks and older granites which it had intruded. They noted several areas, for example Haytor Rocks and Believer Tor, in which evidence for this can be found, but one of the most important is Birch Tor which shows a particularly good range of xenoliths contained within their 'giant' or 'tor' variety of granite. Particular reference is made to the dark rock at the base of the tor, in Brammall's paper of 1926 (in which there is a field photograph) and in joint papers of 1923 and 1932 (in which there are chemical analyses, with a photomicrograph in the latter). There has been no serious dispute about Brammall and Harwood's evaluation of the origin and composition of these xenoliths at high levels in the granites, and a similar range is described from a few miles to the north by Hawkes (*in* Edmonds *et al.,* 1968). Reynolds (1946) has, however, questioned the identification of some as originally basic as a result of her calculations of the changes resulting from granitization. Stone (1979) and Stone and Exley (1986) have noted that some of the biotite in the granite is of 'restite', not xenolithic, origin and Bromley and Holl (1986) have shown that on geophysical, as well as geochemical grounds, assimilation at depth was probably very limited.

## Description

Birch Tor is a low, extended tor with two main outcrops and conspicuous subhorizontal jointing. It is composed of coarse, megacrystic, biotite granite and contains a variety of xenoliths of different shapes, sizes and compositions. Some inclusions are rounded and others flat and subangular, but the most conspicuous is a sheet-or raft-like mass, some 7 m long and at least 3.5 m thick at the base of the south face of the western summit. This was illustrated by Brammall (1926) who described it as 'dark, blue-grey microgranite', and has been figured and analysed by Brammall and Harwood (1923; 1932) who also gave an analysis of a smaller xenolith. Many of these xenoliths look similar and are microgranodioritic or microdioritic; evidently they have undergone recrystal-lization as a consequence of entrapment in the granite magma.

## Interpretation

The Dartmoor Granite was the subject of intensive investigation, especially by Brammall and Harwood between 1923 and 1932. For the most part, it consists of coarse-grained, megacrystic biotite granite, but the size and concentration of megacrysts is rather variable and, partly on this basis, Brammall and Harwood separated it into two intrusions: an earlier, coarser 'giant' or 'tor' variety and a later, finer 'blue' or 'quarry' variety. It has been proved subsequently that these textural features are gradational and both varieties are now included in the coarse-grained megacrystic or poorly megacrystic categories (of Dangerfield and Hawkes, 1981) and Type B (of Exley and Stone, 1982 and Exley *et al.,* 1983). Other intrusive varieties also occur and can be found around Birch Tor, but these are present in comparatively small amounts, all are younger and are not relevant in the present context.

The granite here is believed to have originated by lower crustal anatexis, much of its biotite being 'restite' material carried over from the source rocks which were probably more grano-dioritic than those in the contemporary upper crust (Stone and Exley, 1986). It is therefore an 'S-type' granite essentially (Chappell and White, 1974), and, as noted in Chapter 2 and the 'Petrogenesis' section above, shows appropriate chemical and mineral features. In Brammall and Harwood's view (1932), the initial magma was both acid and 'sodipotassic' or even sodic, and it became more basic and potassic by assimilating country rocks of overall argillaceous composition but which also contained dolerite, dioritic and granodioritic units. They based this argument on examination of this section and on chemical analyses from xenoliths found in the main granite and from a series of analyses across the granite/ country rocks contact at Burrator.

Although, as has been said, Brammall and Harwood believed that some xenoliths were of originally basic composition, Reynolds (1946) pointed out that their present compositions are inappropriate to such a derivation when desilication and other changes are calculated, and that the xenoliths were more probably metasedimentary in origin.

Brammall and Harwood's concept has also been modified in three respects by more recent work (Hawkes, *in* Edmonds *et al.,* 1968; Exley and Stone, 1983; Exley *et al.,* 1983; Stone and Exley, 1986; Bromley and Holl, 1986). First there is the recognition that biotite is a derived or 'restite' mineral (Stone, 1979), and this has important implications with respect to the water content of the magma. Secondly, is the recognition that the feldspar megacrysts are a secondary phase and have developed as a result of potash metasomatism, sometimes on nuclei provided by plagioclase crystals. Brammall and Harwood saw the 'potassification' of the magma by xenoliths taking place in such a way that feldspars grew from the liquid as primary crystals, whereas the later workers, following the lead of Stone and Austin (1961), attribute them to the action of a later and separate K-rich aqueous phase. Thirdly, assimilation of much country rock is precluded by the composition of the magma, now known to be close to the 'granite' system's ternary minimum melt composition, and by the rapid rate of settling of xenoliths. Moreover, the observed density increase with depth in the batholith is consistent with a concentration of sunken xenoliths.

Brammall and Harwood were strongly influenced by the work of N. L. Bowen, whose important research, culminating in the publication of *The Evolution of the Igneous Rocks* in 1928, was coincident with much of their own. Hence, among other things, they emphasized the importance of assimilation and differentiation in modifying magma, and concluded that the latter was responsible for their second magma fraction (giving 'blue' granite) and subsequent fractions. At the time, however, many physicochemical controls of crystallization were still unrecognized, including the nature of the partitioning of elements between solid, liquid and gas phases, and it is this later knowledge that has led to revisions of Brammall and Harwood's interpretations.

## Conclusions

This site contains an outcrop of coarse, megacrystic biotite granite containing xenoliths of various rock types. These have been taken to illustrate the kinds of material whose incorporation into the magma substantially modified the chemistry and mineralogy of the Dartmoor Granite. It exemplifies a significant part of a concept of petrogenesis which was sustained for many years and was a foundation of modern thinking.

**References**