Mode of Eruption of the Deccan Trap Basalts

L. V. AGASHE * and R. B. GUPTE **

Abstract

The Deccan Trap basalts have long been considered to be products of fissure eruptions and the dykes intruding them have been supposed to represent the fissures of eruption. However, the question of the mode of eruption of Deccan Trap lavas seems to need more careful consideration in view of the features brought to light by detailed field work in Western Maharashtra.

Detailed studies of dykes suggest that majority of the dykes could not have acted as feeders as previously supposed.

When examined in detail the basalt flows have more often been found to have only a limited lateral extent and are not always quite horizontal. Thin irregular flows with ropy surfaces, dipping in different directions and piled up into a chaotic mass are frequently met with, indicating eruption from local vents of the central type. Volcanic vents are found at a number of widely separated localities. All this suggests that many lavas are products of central type of volcanicity.

However, central type of volcanoes would be inadequate to account for the vast amounts of lavas, and as the known dykes are not likely to have acted as feeders, and dykes still remain to be reported from large portions of the Deccan Trap area, the question of how the lavas came to the surface largely remains unanswered.

Extensive beds of volcanic breccia traceable over a few miles and upto 50 feet thick are met with. As such extensive beds are more likely to be associated with fissure eruptions the question arises whether these fissure eruptions were accompanied by considerable explosive activity.

Introduction

The Deccan Trap lavas building up the Deccan Plateau, cover thousands of square miles and when seen from a distance appear

* Board of Technical Examinations, Maharashtra State, Bombay.
** College of Engineering, Poona.

like extensive horizontal sheets with considerable lateral spread. Because of these characteristics they have been considered products of fissure eruptions and the basic dykes of Saurashtra, North Konkan, and Tapi and Narmada valleys, known from the earliest days were considered by the earlier workers to represent the fissures through

FIG. 1 - Volcanic vent, Koyna Quarry. The pipe is filled with volcanic breccia and the country rock has developed columnar jointing with joint columns radially disposed around the vent.

which the lavas were outpoured (KRISHNAN, 1949; WADIA, 1949). It was AUDEN (1949) who first raised doubts about the accepted origin of the dykes and pointed out that they may belong to a post — Trap hypabyssal phase. Subsequent detailed field work carried out by us in the Deccan Trap lavas of ten districts of Western Maharashtra

(AGASHE & GUPTE, 1968) and on the dykes in them (AGASHE, 1956; AGASHE & GUPTE, 1966; GUPTE, 1967, 1968) has necessitated a revision of the old ideas and has raised a number of problems which are presented here.

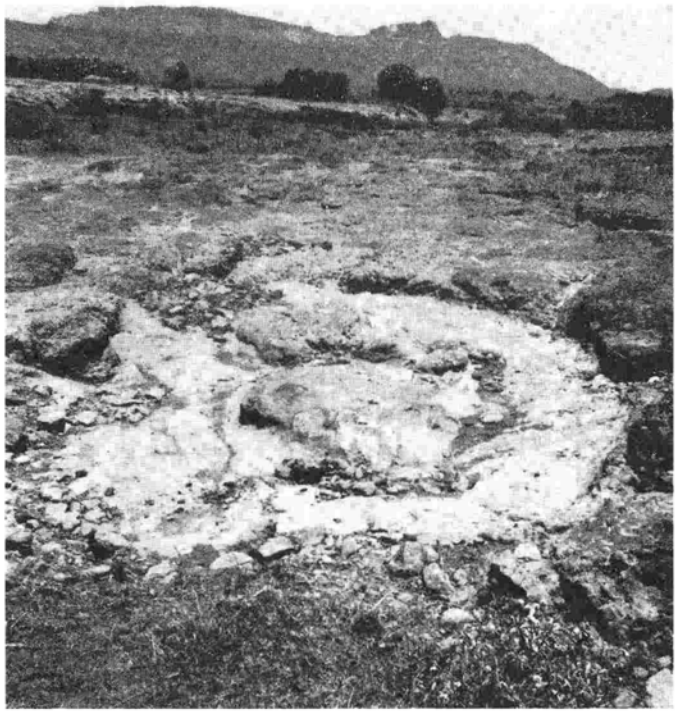

FIG. 2 - Volcanic vent in the bed of Ulhas near Badlapur (Dist. Thana). The country rock is a porphyritic basalt with very large phenocrysts of plagioclase and the vent rock is a highly zeolitized amygdaloidal basalt.

Nature of the Dykes

The dykes of North Konkan, Saurashtra etc reported by the earliest workers have received little attention afterwards and little is known in detail about their field characters. However, the numerous dykes occurring in Western Maharashtra have been closely examined by us in the field and in the laboratory with the help of our colleagues in the Geology Department of the College of Engineering, Poona in an attempt to determine whether the dykes are feeders or are true hypabyssal intrusions that did not reach the surface. Though no direct

evidence either way was found the bulk of indirect evidence recorded strongly suggests the possibility that the dykes are true hypabyssal injections under cover. The more important points in this evidence are briefly stated below:

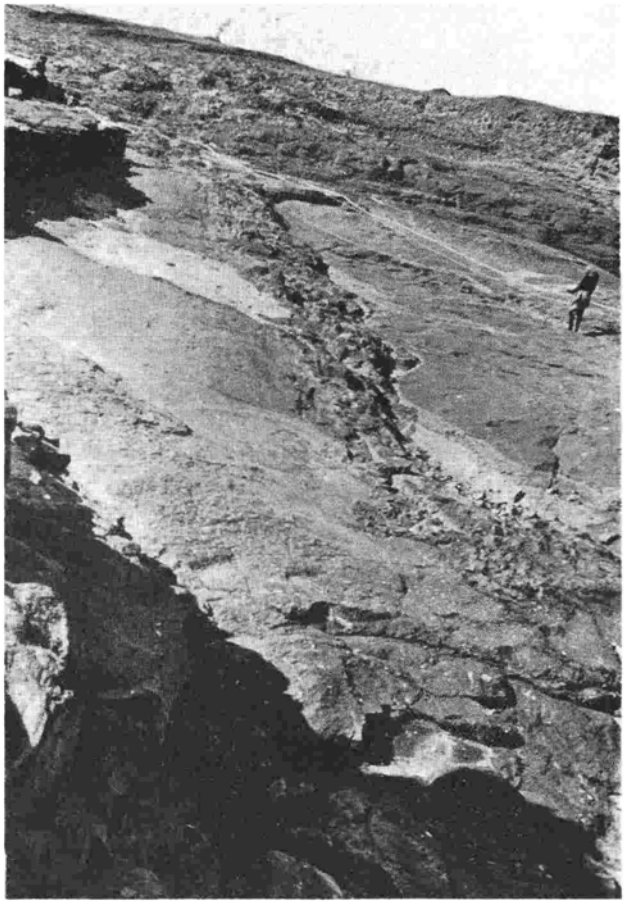

FIG. 3 - A dyke near Nasik with very irregular margins.

Most dykes contain fresh olivine which is not found in the Deccan Trap basalts.

The dykes contain cruciform twins of plagioclase which do not occur in the Deccan Trap basalts.

The dykes contain phenocrysts of plagioclase which are much larger than the phenocrysts found in the normal porphyritic basalts.

The dykes do not contain zeolites which are abundant in the Deccan Trap basalts.

Some dykes show incomplete unroofiing, disappearing completely even though there are excellent rock outcrops along the strike.

FIG. 4 - A dyke near Sangamner (Dist. Ahmednagar), occurring as the back bone of a low natural bund and having a zigzag outcrop.

Many dykes show irregular outline due to pinching and bulging, with sharp angular wedges of country rock protruding into the dyke. As hot magma flowing through a fissure of eruption for a long time would in all probability round up such protrusions of wall rock by

fusion and abrasion dykes with irregular outlines are not likely to be feeders.

Small offshoots perpendicular and oblique to the dyke are common. These are injections of magma into minor weaknesses in the country rock and their small size suggests that considerable pressure would be required for injection of magma into these small cracks. As such pressure is unlikely to develop in a feeder, dykes with small offshoots are more likely to be true hypabyssal intrusions under cover.

Some dykes show small inclusions of country rock which appear to be in their original positions. Such small included bodies would be brought to the surface by magma flowing continuously in a fissure of eruption and would have less chance of surviving in a feeder. Therefore dykes with these small inclusions of country rock are more likely to be true hypabyssal intrusions that did not reach the surface.

All this evidence considered collectively indicates very strongly that majority of the dykes are true hypabyssal injections and did not feed any lava flows, and the question then arises as to how the fissure lavas came to the surface.

Nature of the Lavas

The alternative that immediately suggests itself is central type of activity, and there are reasons to believe that all lavas are not fissure lavas. It is because of their supposed horizontality and extensive lateral spread that the lavas have been considered to be of fissure type. But a closer examination shows that the ideas of horizontality and extensive lateral spread are true only to a limited extent.

It is quite common to find two different sequences of lava flows on neighbouring hills or even on two flanks of the same hill with no possibility or evidence of faulting in between. This is because of limited lateral extent of flows. Undoubtedly there are flows, particularly of compact basalts, which have a considerable lateral extent, but there also are flows with very limited lateral extent. Such flows are mostly vesicular and amygdaloidal and are seen to pinch out when traced laterally. Such flows are often very irregular, pinching and bulging indeterminately, and also lie in all attitudes with varying dips. Zones up to 20 feet thick are commonly seen which are chaotic piles of shapeless masses of lava and thin irregular flows of very limited lateral extent dipping in different directions, often steeply.

As the highly fluid lavas of fissure eruptions characteristically spread over long distances as flat sheets, the flows of the type described above obviously can not be products of fissure type of volcanicity. The surfaces of these flows are very often ropy indicating central type of activity. Ropy lavas are extremely common in the Deccan Trap basalts and have been observed at innumerable places spread

FIG. 5 - A dyke exposed in a road cut in Dongargan Ghat near Ahmednagar. The dyke is seen to be a true hypabyssal injection with its roof in tact. Only the top of the dyke is seen in the photograph with its cover of basalts.

all over Western Maharashtra. All this indicates that volcanic activity of the central type must have taken place in the Deccan Trap period and all lavas are not fissure lavas.

More direct evidence of central type activity is available in the form of volcanic vents representing central pipes through which magma was fed to central type volcanoes the cones of which have been denuded away. The vents are usually small, but there are some having a diameter of 100 feet or more. The vent rock in most cases is a volcanic breccia or a highly zeolitised and hydrothermally altered basalt. The country rock is usually a compact well-jointed basalt often with belts of perfectly developed horizontal joint columns radially disposed around the vent.

The vents tend to occur in groups as at Koyna dam, Ghod dam, Alandi etc., and have been found in widely separated localities. The total number of known vents is however comparatively small and

inadequate to account for even the flows that appear to have issued from central type volcanoes. No vents are exposed near any of the zones of chaotically piled up lavas mentioned above, and the question how these and other central type lavas came to the surface is itself an unanswered question.

FIG. 6 - A dyke in the bed of Ulhas near Karjart (Dist. Kolaba) with an enclosed lens of country rock.

Moreover, though central type of vulcanicity seems to have been widespread, in view of the limited sphere of influence of central type volcanoes it is obvious that they would be inadequate to account for the eruption of the enormous amount of lavas that build up the Deccan Plateau. For the eruption of such vast amounts of lava the

mode of eruption must obvioulsy be capable of providing egress to vast amounts of magma, and it seems inevitable to conclude that a very large proportion of the lavas must have issued from extensive fissures. In that case the question as to how the Deccan Trap lavas came to the surface remains largely unanswered.

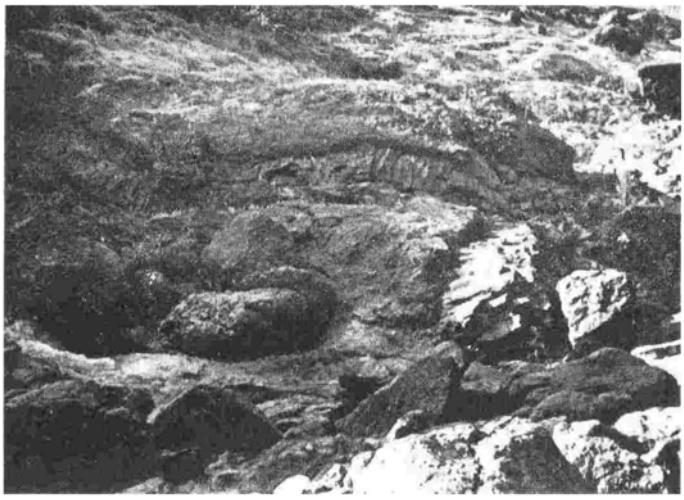

Fig. 7 - A dyke near Nasik sending out a horizontal offshoot.

The Nature of Fissure Eruptions

Fissure eruptions are visualised as essentially quiet eruptions unaccompanied by explosive activity which is characteristic of central type of eruptions. Pyroclastic material therefore is not expected in association with fissure lavas. However, we have found volcanic breccias very commonly associated with the Deccan Trap basalts. They are almost as characteristic of the Deccan Traps as the basalts and there is hardly any area in which we have not found some kind of volcanic breccia. Often breccia flows occur as extensive beds traceable for a few miles and upto 50 feet thick. Such extensive flows are obviously not likely to have resulted by central type of eruptions and must be associated with fissure eruptions as they occur as sheets typical of fissure eruptions. This raises the question whether the Deccan Trap fissure eruptions were not quiet as is usually supposed, but were accompanied by quite considerable explosive violence.

The Unanswered Question

As has already been stated the dykes in the Deccan Traps of Western Maharashtra are unlikely to have acted as feeders of lava

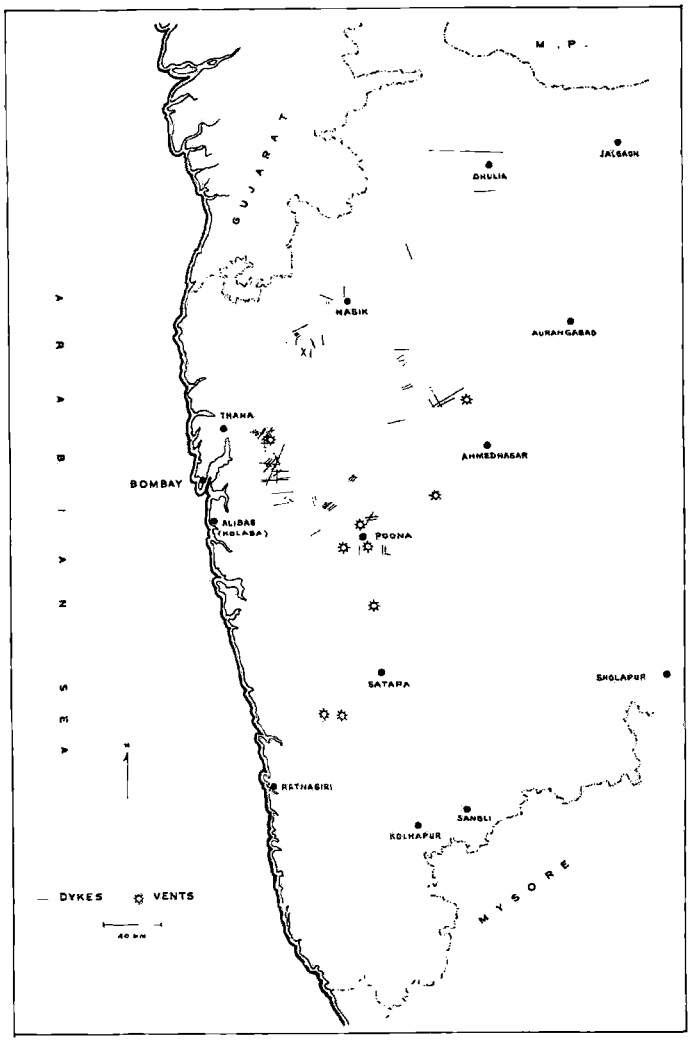

FIG. 8 - A sketch showing dykes and volcanic vents in Western Maharashtra. The sketch shows diagrammatically the approximate location of vents and approximate location and alignment of dykes mapped by us. Dykes known but not mapped by us are not shown. In areas where dykes have been shown more dykes have been mapped but could not be shown on the scale of the map. Groups of vents occur where vents have been shown.

flows, but even supposing that they represent feeders they do not provide a complete answer.

Firstly, there are large Trap areas from which dykes have not been reported. Not one dyke is known in the Southern districts of Satara, Sangli, Kolhapur, Ratnagiri and Sholapur. Of course these areas cannot finally be declared to be dyke free as no systematic search for them has been carried out, but the fact remains that we did not come across any dykes in these districts during fairly extensive field work carried out for other purposes as we did in Poona, Nagar, Nasik, Thana and Kulaba Districts.

Even in areas where they are found, except in portions of North Konkan, Saurashtra and Narmada and Tapi Valleys, they seem to be too few and far between to account for the enormous amounts of lava. Moreover, in view of the wide variety of types seen in the Deccan Trap basalts the known dykes seem to be too few to provide passage for so many different types of lava.

Thus in view of the apparent total absence of dykes in large Trap areas, the small number of known volcanic vents, the inadequate number of dykes in areas in which they are found and the unlikelihood of their having acted as feeders, and the wide spread occurrence of breccias as extensive sheets, the question as to how the Deccan Trap lavas came to the surface remains largely unanswered, and extensive field work by a number of teams of workers following a well coordinated plan will be required to get the answer and to understand properly the nature of these lavas.

References

AGASHE, L. V., 1956, *Dykes between Poona and Khandala.* Poona University Ph. D. Thesis, 1956, Unpublished.

——— and GUPTE, R. B., 1966, *Some Dykes of Poona, Nagar and Nasik Districts.* Prof. West Commemoration Volume (in Press).

——— and ———, 1968, *Some significant features of the Decan Trap.* Symposium on Cretaceous & Tertiary Formations of South India, Bangalore, 1968, p. 309-319

AUDEN, J. B., 1949, *Dykes in Western India.* Trans. Nat. Inst. of Sci. of India. Vol. III, 3, 1949, p. 123-157.

GUPTE, R. B., 1967, *Dykes in Deccan Trap around Karjat, Neral and Badlapur.* Poona University Ph. D. Thesis, 1967, Unpublished.

———, 1968, *Dykes in Deccan Trap in Western Maharashtra.* Nat. Inst. Sci. India, Symposium on « Deccan Trap Country », Poona, 1968 (in press).

KRISHNAN, M. S., 1949, *Geology of India and Burma,* p. 421.

WADIA, D. N., 1949, *Geology of India,* p. 211-221.