CHAPTER VII

STRUCTURAL GEOLOGY

In this chapter, the author has attempted to critically discuss the various deformational structures of his study area. Though the various structural features encountered by him during his mapping, have already been alluded to in an earlier chapter, here, a detailed analytical account of their geometry, origin and age has been given.

The most salient structures, so characteristic of the area are (i) an E-W chain of domes and associated flexures to its south, (ii) a major E-W fault truncating the domes on their northern flanks and a few similar minor faults, and (iii) numerous transverse faults running almost N-S, NNE-SSW and NNW-SSE.

DOMES AND FLEXURES:-

In all, eight domelike structures big and small, have been mapped in the northern part of the area, all of them flanking the Katrol fault (Fig.2). The largest dome (Samatra-Bharsar) exists in the northwestern part. It is roughly elliptical, elongated in E-W direction, its longer axis being about 10 km. and the shorter axis about 5 km. It shows a sort of quaquaversal dips, the dip values being very low to the south, gradually increasing towards W and E, where the dome meets the Katrol fault. The entire dome comprises Chari rocks only. Scattered plug-like masses of dolerites are recorded at many places in the central part of the dome. At a few places (e.g. south-south-east of Samatra and south of Bharasar), a few thin sill-like bodies of dolerites are noted. In addition, 4 to 5 N-S doleritic dykes are seen cutting across the width of the dome. It is very obvious that these dykes have come up along the transverse (NS) faults. The basic rocks occurring in the central part of the domes, appear to be older than the N-S. dykes. This dome is truncated in the north by Katrol fault as a result of which the Dhosa oolite band which occurs round the dome almost disappears along the northern flank of the dome. A large number of transverse almost N-S faults are seen cutting the dome; four of such faults show major shifting of the Dhosa oolite band.

One big transverse fault practically cuts the dome into two halves; the western half having become much narrower. To the south of this western part of the dome lie two small domelike structures. It is obvious that the transverse fracturing and dome formation, are interrelated and this aspect has been discussed later.

To the east of the big dome, smaller domes flank the Katrol fault - all along its length. A semicircular dome is encountered just at the Bhuj-Mandvi road. On account of the truncation due to Katrol fault, only half portion of the dome has developed. About a Kilometer long and half a kilometer wide, this dome also is so characteristically flanked by Dhosa oolite band, all along except in the north where its outcrop becomes fragmentary. The dips of the west and southwest part of the dome are fairly high (about 35^{o} - 40^{o}), while those to the south and southeast are gentler, never exceeding 10^{o}. As usual, the dips are steeper in the north. At the eastern extremity of the dome, a transverse fault of moderate dimension is seen affecting the strata. Beyond this fault eastward, again the Dhosa Oolite is seen to characteristically form a narrow elongated, small domelike structure; the length of which running parallel to the Katrol fault, is about 200 metres, while the width is hardly 50 metres. Igneous intrusions on the whole, are sparse, and are confined to the central part of this western dome where these occur as sills.

About a kilometer further east, another narrow elongated dome about 700 metres long and 50 metres wide is met with. Unlike the previous structures, the Dhosa Oolite occupies its northern flank also, though the dips in this part are very high as much as 65° to the north.

To the southeast of this above mentioned dome, exists a rather complete elliptical dome, again easily identified by the Dhosa Oolite. No igneous intrusions are seen exposed in the dome. Further to the east, one encounters yet another dome of irregular shape. This is the last dome within the limits of the area and is about a kilometer long and 250 km. wide. This dome is rather incomplete, in the sense that to the north it is cut by Katrol fault and its eastern limb is truncated by a transverse fault. No igneous intrusions are recorded. This dome is seen cut by small transverse faults.

In addition to the various domal structures described above, the strata show associated flexures. Right inside the big Samatra-Bharasar dome its eastern half has synclinal and anticlinal flexure.

All along the northern fringe of the domes, immediately to the south of the Katrol fault, the rocks show typical flexures, evidently caused by the drag effect of the fault. In the area to the south of the chain of domes, gentle synclinal and anticlinal E-W flexures are commonly recorded. Some of the prominent flexures are shown on the map (Fig. 2). These flexures are very gentle, the dips hardly exceeding 10^{o}. A major E-W flexure is worth mentioning in the area around Shedata village, where it is seen flanked by several faults in the East, West and South and it appears that the folding and faulting are interrelated.

A small E-W flexure of about 500 metres length is recorded south of Mankuwa village immediately to the north of the Katrol fault. Obviously, this folding is connected with the Katrol faulting.

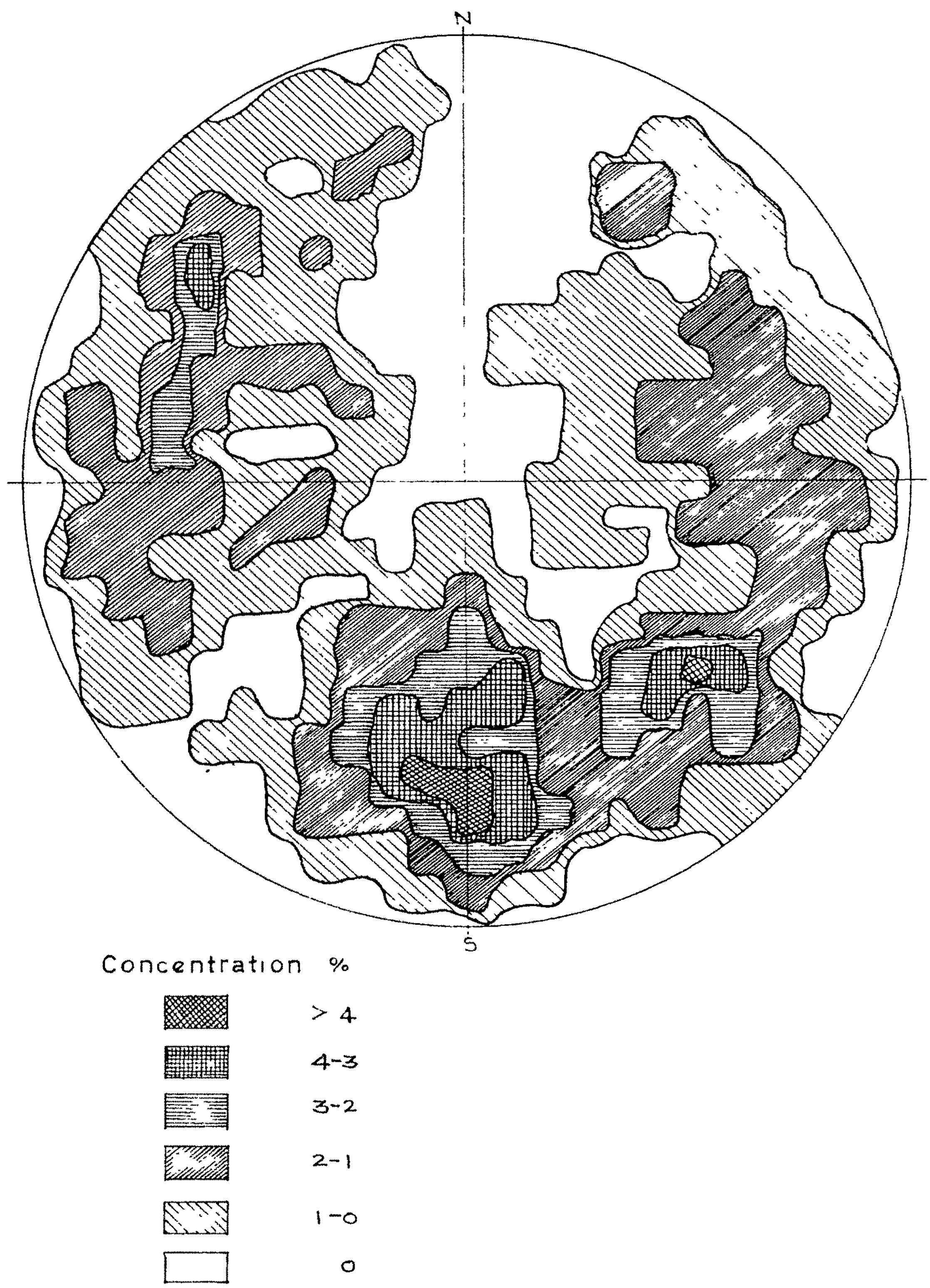
FAULTS:

Katrol Fault:-

The most important of all the faults is the major E-W dislocation which separates the Bhuj Series from the Chari rocks and borders the chain of domes

Fig 24

STEREOGRAM ILLUSTRATING
FAULT PATTERN



to its south. This fault runs uninterrupted from East to West though its strike fluctuates between WNW-ESE, to ENE-WSW. At several places the fault plane is ideally exposed, and is seen to be dipping due south with angles of about 60^{o} to 65^{o} (Fig. 2).

From its nature, the fault appears to be of reverse type, such that the Chari rocks have been pushed over the Bhuj sandstones. The reverse faulting and the movement from south to north is clearly supported by the following structural features.

1. The fault plane dips due south i.e. towards older rocks (Fig. 24).
2. The drag folding in the rocks of Katrol series overlying the Charis in the vicinity of the dislocation clearly indicates their northward movement. Almost all along, these rocks are seen dipping very steeply to the north and at some places they show even inverted dips due south (e.g. Walakhawas, Wandh, south of Bharasar).
3. The way in which the various domes lie flanked to the fault and show steeper dips toward north and gentler dips to the south suggest a close link between the dome formation and northward pushing of strata over the Katrol fault plane.

<u>Transverse Faults</u>:

The area particularly to the south of Katrol fault is riddled with dislocations - big and small, transverse to the regional strike of the strata. In most cases the faults run NS, NNE-SSW and NNW-SSE (Fig.2). Some of the faults are of local significance only extending for a kilometer or so, while quite a few extend for more than 2 km. The most striking faults are the larger ones, extending for more than 10 km., almost right across the area. These faults show either vertical planes or are steeply inclined to either side (60^{o} to 70^{o}). In a general way, the fault planes dip towards the domes. The sense of movement is always dominantly lateral and both - sinistral as well as dextral slips are noted (Fig.24). A look at the map (Fig. 2) clearly shows the relation between the direction of slip and the width of the various parts of the domes cut by faultes.Curiously enough all such regional fractures abut against the Katrol fault beyond which they do not extend. To the south these go below the trap-flows. Many of such faults are occupied by doleritic dykes and it is so obvious that these fractures served as the channels for the intrusion of basic dykes of Deccan Trap age.

The way in which these faults cut the domes, is indicative of a close relationship between the uplift of the domes and this transverse fracturing. The fact that these fractures do not transgress the Katrol fault has also to be considered as an indication that these transverse dislocations developed during the Katrol fault movement.

Reference may also be made to a few E-W and NE-SW faults recorded mostly in the area south of the domes (Fig.2). These generally extend for a few kilometers, and get truncated by the transverse faults at either or both ends. Generally these faults are of normal type and they dip due south with angles 60° to 65°. It is seen that such faults are generally associated with E-W flexures (e.g. Bharapur-Godpur fault and Shedata flexures), and appear to have developed during the flexuring.

Lastly, the reference may be made to the transverse faults seen to the north of the Katrol fault in Bhuj rocks. Their trend is almost the same as those described above and obviously these fractures can be related to the bigger domes further north e.g. Jhura, Lodai, etc.

Looking at the tectonic map of the area (Fig.2), it is seen that these transverse faults flanking the domes to the E-W dip towards the domes and converge and meet due south and thus exhibit a sort of conjugate relationship. Perhaps these faults developed on account of unequal drag along the Katrol fault plane, as conjugate shear planes, doming up the rocks in between.

DISCUSSION:

The author is inclined to suggest that the main structural features of the area, viz. Domes, Katrol (reverse) faults and transverse strike-slip faults, are all products of a connected tectonic event.

The Kutch area is characterised by at least three major E-W faults; one (Island fault) forming the northern flank of these islands of Patcham, Khadir, Bela and Chorar in the Rann. All these islands form a chain of large domes. The next one -

the Mainland fault, marks the northern limit of the rocky mainland and is characterised by a chain of domes of slightly smaller dimensions than those marking the islands. The southernmost fault is the Katrol fault, lying within the present area. This fault is also flanked to its south by a chain of small domes.

The manner in which the strata show doming and drag effect in the vicinity of the Katrol fault is a convincing evidence to suggest that movement along the fault, was in someway responsible for the folding of the strata. The reasons why the strata, instead of forming linear fold ridges, have given rise to chain of elliptical domes, is somewhat obscure. But the most likely cause of the dome formation might be in the fact that the movement along the fault plane being unequal, differential movements gave rise to several sets of somewhat conjugate folds and these conjugate folds in conjunction with the drag experienced in the immediate vicinity of the fault plane tended to lift the strata into dome shaped structures. The strata appears to have ruptured along the axial planes of these conjugate folds, giving rise to transverse strike slip faults. Thus,it is seen that the Katrol fault and the related conjugate transverse faults, bounding the various domes, are genetically part and parcel of the doming process.

This mechanism of dome formation may be valid, even for the other still bigger structures flanking the Mainland fault and the Island fault.

It is obvious that the gentle flexures so common in the areas south of domes, are also connected with these processes. At several places, these flexures are seen bounded by transverse faults and the folding having taken place in the block with faults on two sides.

From a restricted study of the rocks of the present area, it is not possible to make any conclusive and definite statement about the causes of the development of these structural features. However, this is certain that faulting and doming have taken place simultaneously. Doming is related to the movement along the Katrol fault, and so are the transverse faults. It is difficult to say when and how the Katrol dislocation developed. But the activity along its plane did take place simultaneously with the Deccan trap activity. The manner in which trap (dolerite) dykes have arisen along the transverse strike-slip faults, rules out any later date for these movements. The occurrence of bodies of basaltic rocks inside the domes, may have assisted in the doming of the strata, but it is unlikely that they are the main cause of uplift. If these basic intrusions were the causes as suggested by a number of workers (Tewari; 1948, Shukla; 1953), the shape of the domes, the dips of the strata away and near the Katrol fault and the close relationship between doming and faulting seen not only in the present area but throughout the Kutch, cannot be properly explained. However, it is not unlikely that some of the unexposed masses of basaltic rocks, right in the vicinity of the fault, acted as impediment and thus causing unequal movements along the fault plane, so very essential for doming and transverse faulting.

Lastly, the author would like to point out the difficulty of suggesting the principle cause for this structural phenomenon. There is little doubt that the Katrol fault is of reverse type. The problem is how did it develop and what forces caused it. A look at the three E-W regional faults of the Kutch and the associated chain of domes clearly shows a gradual decrease in the sizes of the domes and the associated E-W faults from North to South. This could be due to the decreasing intensity of the doming up along the three dislocations. Perhaps the Katrol fault is a miniature of the Island fault. It is not quite clear as to how this fault movement was brought about. The author is not in a position to make any definite suggestion. Perhaps these movements were associated with the immense Deccan Trap activity in the south (Saurashtra, Gujarat, Maharashtra) and the volcanic eruption was in someway responsible for pushing the strata northward. Or, could it be that these tectonic movements constituted the fore-runners of the orogenic upheaval in the north resulting into some sort of underthrusting from the north?

In the end, the author is tempted to put forth the concept of oscillatory movements of Beloussov (1962) to explain these structural phenomena. According to this eminent Russian geologist, orogenic movements in the horizontal sense do not exist. He has invoked vertical movements only to explain folding and faulting of rocks. As he puts it,"the fold mountains are also a product of oscillatory movements"......"Rise and subsidence of crustal blocks bound between parallel fracture could develop folding in the strata involved." How far this explanation is valid for the Kutch area, only the future work will decide.