foliations present in these zones which cut across and obliterate the regional trend present in the rocks. These zones are parallel to the east-west striking dolerite dykes which are emplaced in shear planes.

The next three trends which vary from N67°-73°W are also due to shear and are confined to narrow zones. Many of the east-west striking basic dykes in the area terminate with this trend towards their eastern end.

The fourth trend striking N-S, is also due to shear and is found in shear zones. N-S striking pink alaskite ridges and basic dykes are present in the area.

The next two foliation trends, N38°W and N30°E with steep dips are associated with migmatite zones. These trends are also present in the shear zones and apparently these shear zones have localised the emplacement of the quartz-feldspathic material to form migmatite zones. The N38°W trend also represents the regional trend of the foliations present in the coarse grained porphyritic granites.

One important trend, N30°W, associated with the major pink alaskite masses, has not developed well in the equal area projection.

A majority of the foliations whose trends are discussed above appear to be due to shear (wrench faults) and have vertical dips (Sitaramayya, 1969); but as most of the later intrusives have taken advantage of these weak planes, they also represent foliations due to shear as well as intrusive contact shear and igneous flow.

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STRUCTURAL ANALYSIS OF DHARWARIAN CONGLOMERATES FROM KANKAVALI DISTRICT, RATNAGIRI, MAHARASHTRA

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Introduction: In the Kankavali area of Ratnagiri district, Maharashtra (Kelkar, 1956; Kelkar and Ghodke, 1963) excellent exposures of three conglomerate bands are seen in the bed of the Gad river, a little to the south of the 3½ milestone on the Kankavali-Achra road. The conglomerates strike N15°W and are vertical or steeply dipping towards west. The eastern, central and western bands are respectively 80, 180
and 120 feet in width. They are separated by narrow zones of chlorite schist 120 to 150 feet wide. Within the conglomerate bands there are present some pebble-free zones up to three feet in width. When traced in either direction along the strike, the conglomerates disappear under soil cover and are not located in nearby areas.

Characteristics: The conglomerate bands are unicomponent being made up of quartzite pebbles and boulders of various sizes, embedded in a matrix of chlorite schist. The composition of matrix and of the boulders is largely uniform. The boulders are ellipsoidal or cigar shaped in appearance. The axis of maximum elongation \(X\) is parallel or nearly parallel to the dip. In vertical sections the conglomerate bands appear as wall-like masses with vertical columns of quartzite boulders. The intermediate elongation axis \(Y\) lies in the foliation plane of the matrix. The axis of minimum elongation \(Z\) is perpendicular to it. In transverse sections the boulders are roughly oval and without any sharp angularities. The smaller boulders and pebbles show the effect of plastic deformation and, at times, are crescent or even ‘S’-shaped. The foliation of the enclosing chlorite schist matrix invariably swirls around the pebbles and boulders. Many of the boulders show a prominent groove lineation parallel to the maximum elongation direction. Mesoscopic examination suggests that the quartz grains in the pebbles and boulders are likewise oriented. Transverse fracture cleavage is commonly observed in the boulders with the matrix material having often penetrated along these.

Statistical data: The size of the boulders is variable. \(X\) was found to be as large as 5 feet though it normally ranges between 2 and 3 feet. \(Y\) usually measures between 1 and 1.5 feet and \(Z\) less than 1 foot. Measurement of \(Y & Z\) in 200 boulders indicated that 50% of the boulders have \(Y : Z\) ratio between 1.5 and 2.5. All the three axes \(X\), \(Y\) and \(Z\) were measured in case of thirty boulders. It was not possible to separate and measure all the three axes in a larger number of boulders because of the extremely compact nature of the conglomerate and the large size of the individual ellipsoids. However, it has been shown that this number of measurements is sufficient for obtaining statistically reliable results (Flinn, 1956; Hossack, 1968). Correlating the data for all three axes with the data for transverse sections, the ratio between the three principal axes of boulders is found to be 4 : 2 : 1.

The analysis of shape provides a fairly valid method for the determination of strain within a body. Of the various methods known for the representation of shape the one formulated by Burns and Spry (1969) is used here in view of its many advantages. It involves a triangular plot of \(\log(x/r), \log(y/r), \text{ and } \log(z/r)\) for each boulder, where \(x, y, z\) are the semi-diameter lengths of \(X, Y, \text{ and } Z\) respectively and \(r\) is the radius of a sphere of equal volume. The triangular plot for the boulders of Kankavali conglomerate is given in Fig. 1. The uncontoured plot reveals a strong linear dispersion pattern along the direction 1 of Burns and Spry with a less apparent trend in the direction 3. These are in keeping with the observation regarding elongation along the \(X\) axis and flattening on \(Z\) axis. The various points indicate deformation to different extent under the same type of strain. In the contoured plot the elongation mode of 16.5% exhibits the most commonly occurring strain intensity.

Quartz orientation: The optic orientation of (0001) in 300 quartz grains, of both boulder and chlorite schist matrix, was determined on the Universal stage. In case of the boulder, a horizontal section was studied. Neglecting the lowermost concentrations, the diagram (Fig 2a) shows a near axial symmetry, tending to monoclinic, with a strong maxima of over 12% lying very close to \(X\). An ill defined girdle
approximately parallels the regional foliation. In case of the matrix a section perpendicular to the s-plane and the dip was studied. The contour diagram (Fig 2b) shows a strong maxima of over 10% lying close to the s-surface denoted by the dotted line. The diagram has a slightly distorted monoclinic symmetry with a girdle almost parallel to S.

Figure 1. Triangular shape diagram for boulders in Kankavali conglomerates. Contours at 3.3, 6.6, 9.9, 13.2 and 16.5%. For details see text.

Figure 2a. Contour diagram showing orientation of (0001) in quartz of quartzite pebble. Contours at 1, 4, 6, 8 and 12%. For details see text. 300 poles.
The two diagrams 2a and 2b show a high degree of correspondence in respect to the symmetry, girdles and maxima positions. The strong maxima positions could well be identified as the kinematic axis 'a'. The position of 'a' slightly away from the s-surface may be due to the fact that the latter is defined with respect to the parallel arrangement of chlorite while the diagrams are prepared with the data on quartz axes.

Discussion: It is often difficult to differentiate sedimentogenic conglomerates from tectonic ones, especially in the case of unicomponent conglomerates in Precambrian terrains where most of the evidence is obliterated by successive deformation phases. Kelkar and Ghodke (1956) consider the Kankavali conglomerates to be tectogenic but have not given any evidence in support of this conclusion. Such an origin which would involve either brecciation or boudinisation, seems unlikely because:

(i) The presence of three conglomerate zones of tectonic origin would necessitate the development of an equal number of shear zones with accompanying deformation of the associated rocks. In the present case the chlorite schists do not show any signs of mylonitisation or extensive deformation.

(ii) The boulders are, without exception, of quartzites and are enclosed in a matrix of chlorite schist. A tectonic origin would imply that the original lithologic unit was composed of alternate bands of arenaceous and argillaceous material. The complete pulverisation of the argillaceous component to the exclusion of any relict of schistose boulder is difficult to visualise.

(iii) The quartzite pebbles and boulders are subrounded to well rounded, Angular fragments, as produced by brecciation, are absent. The axes of the pebbles and boulders do not show alignment as would be expected in boudinisation.
The above mentioned characters are accounted for if the conglomerates are considered to be sedimentogenic. Further, it is seen that the maximum elongation of the boulders and pebbles is parallel or subparallel to the finite elongation of the geologic body as illustrated by the subfabric of the quartz grains, i.e., the longest axes of the boulders are parallel to the maximum strain axis. Varadarajan (1969) points out that this is the case in deformed sedimentary conglomerates only; in tectonic conglomerates the longest axes are parallel to the intermediate strain axis.

The available evidence, though largely of a negative character, indicates that the Kankavali conglomerates are deformed sedimentary conglomerates. On the basis of their characters they can be classified as unicomponent, oligomictic conglomerates of the platform type (Sreenivas and Srinivasan, 1968).

The conglomerates themselves were probably deformed under plastic conditions during one of the phases of Dharwarian orogeny. A reference to the shape orientation diagram suggests that the conglomerates may be interpreted in terms of two phases of deformation. The first phase, corresponding to a less apparent linear trend in direction 3, is of flattening in the XY plane during the initial period of compression. The second phase, corresponding to the linear trend 1, is of elongation along X during a later more intensive deformational phase. The phases are here separated on theoretical considerations but in fact must be parts of one continuous deformational episode. It is believed that under initial compression the boulders moved away radially from Z in the foliation plane. This led to a decrease in the number of boulders oriented parallel to Z and an increase in the boulders oriented parallel to X and Y, especially the former. The development of a near 'ab' girdle and the location of concentration of maxima near 'a' substantiates this conclusion. With the increase in stress and possible development of forward movement the pebbles were elongated in the 'a' direction. These phases of plastic deformation were followed by one of rupturing during which there was the development of the fracture cleavage observed in the boulders.

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