Shear Discontinuity along the Sone River Bed at the Bansagar Dam Site, South of Rewa, M.P.

by

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Introduction

THE Government of Madhya Pradesh has decided to construct about 80 m high dam across the Sone River near Rimar village (24° 11′ 45″ N : 81° 21′ E). It is designated as Bansagar Dam. Here the river has cut through the hard and resistant Basal quartzite (Lower Vindhyan) ridge forming a narrow gorge. The dam site is about 51 km south of Rewa on Rewa-Shahdol Road (Figure 1). It has been investigated by various geologists from Geological Survey of India and because there does not exist any apparent displacement or stratigraphic anomaly, they held the view that Basal quartzites at the dam site are unbroken and sound. In this paper a number of physiographic and geologic evidences have been given which point to the existence of a shear zone along the Sone River bed at the dam site. A shear zone is a zone of highly crushed and fractured rock along which slight movements have occurred. It is formed as a result of operation of over-powering stresses in rocks.

Geologic Setting of the Dam Site

The geologic succession of the rock formations that exist near the dam site are as follows :

Porcellanite stage	:	Shales, porcellanites, limestones and sand stones (These lie towards upstream side of the dam site).
Basal stage	:	Quartzites and conglomerates (These will form the foundation for the dam).
.....		Contact Faulted ?.....
Archaeans	:	Mostly granite-gneisses, and amphibolites (These lie towards downstream side).

The Basal quartzites form long and narrow ridges trending NE-SW (Figure 1). They are dipping with an angle of about 70° towards N50°W, and are overlain by rocks of porcellanite stage having dips of the order of 25° towards N50°W. The granite-gneisses and amphibolites are exposed

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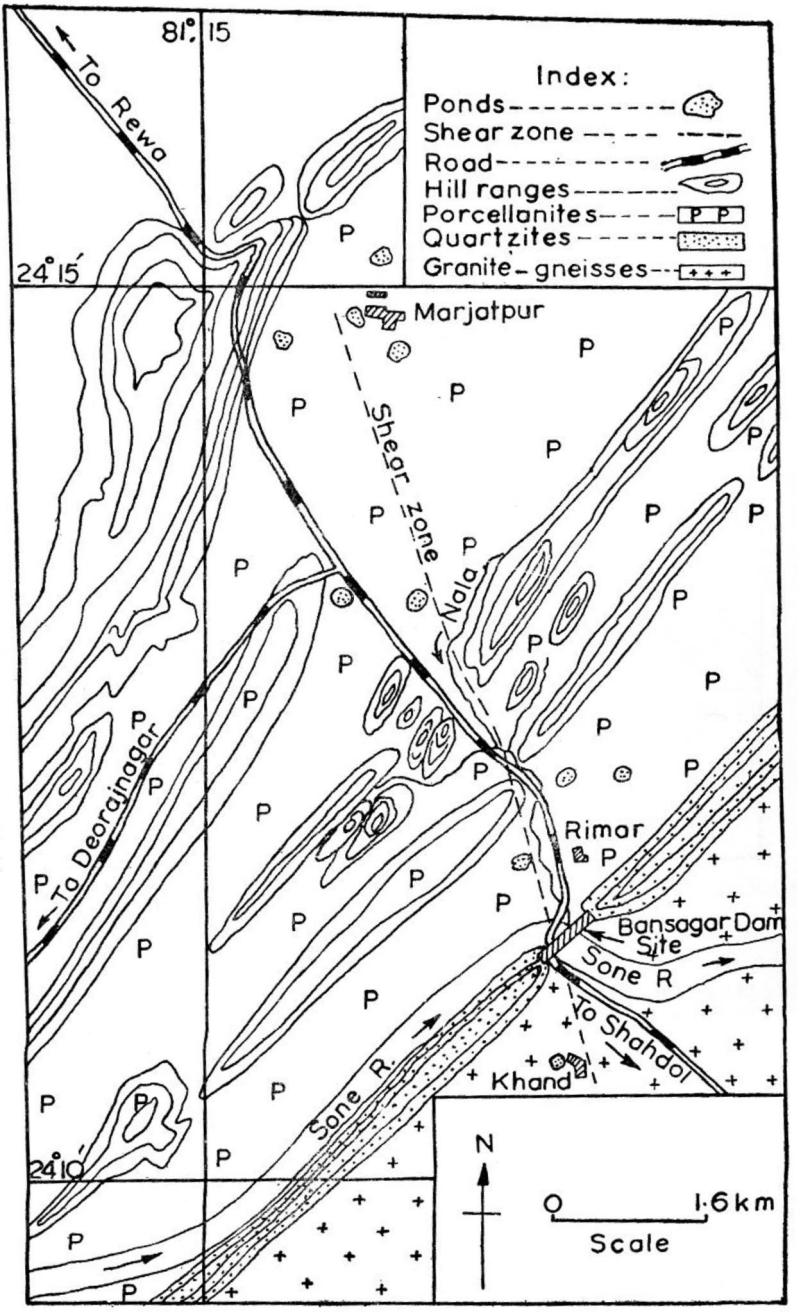

FIGURE 1 : Geologic and topographic map showing trend of shear zone.

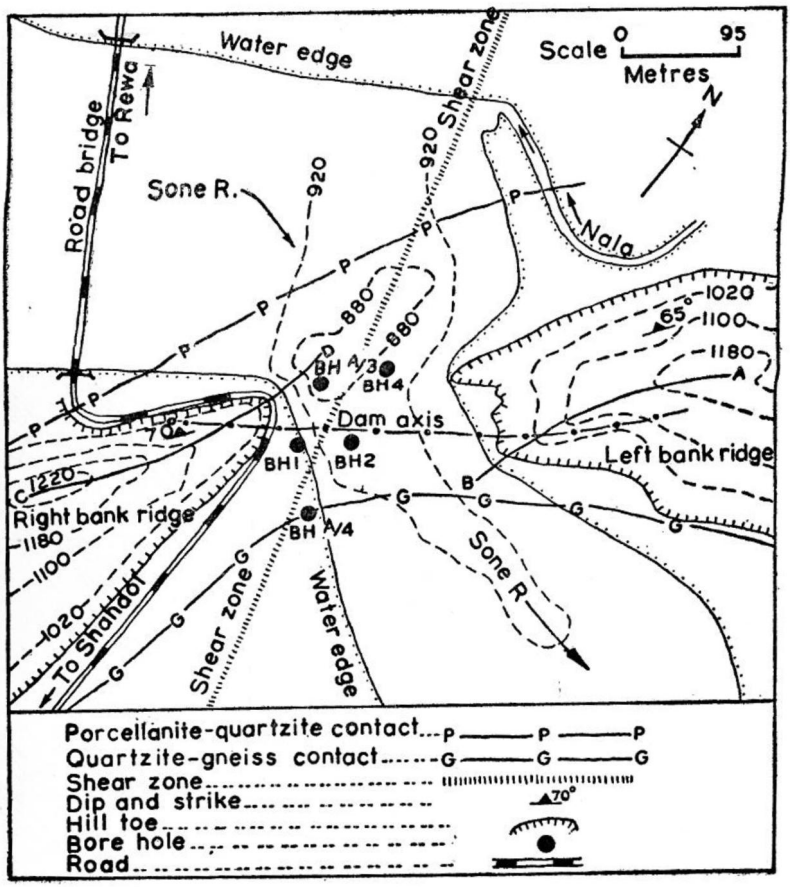

FIGURE 2 : Gorge at Bansagar Dam site showing pool and position of the shear zone (Plan reproduced from Report on Bansagar Project, Vol. II).

to the south in the Sone River bed just after the Basal quartzites. The Bansagar Dam is to be constructed on Basal quaitzite rock, the width of which in the river-gorge has been estimated to about 200 m.

Evidences for the Shear Zone

Elbow Bend in the Course of the Sone River at the Gorge

In general the course of the Sone River is parallel to the trend of the country rocks. It comes by flowing in the porcellanite-terrain, just to the north of Basal quartzite ridge and then near Rimar village it takes an elbow turn and cuts across the quartzite ridge nearly at right angles. Such sharp bends in the course of a river having rocky channel generally occur along a fault zone or a fracture zone.

Gorge or a Shear Zone Gap

At Bansagar Dam site, the Sone River has incised its course as a narrow gorge in the hard quartzite ridge across its trend. The ridge being

a hog-back, the short valley (gorge), which connects the low land on opposite sides of the ridge, can not be a consequent valley, but on the other hand it may be a shear zone gap.

Channel Depth Anomaly

Where a river makes a pronounced bend in its course, the thread of maximum current and location of greatest turbulence occur along the concave bank. As a result the concave bank becomes the site of concentrated erosion and the channel is dug obliquely towards it instead of being dug vertically. At the sharp bend in the Sone River, which exists near the gorge at Bansagar Dam site, the deepest spot, having depth of about 24.38 m has been located near the Right Bank Ridge, which is the convex-bank side (Figure 2). This anomaly suggests that the position of the fracture zone may be close to the Right Bank Ridge.

Resistance of Rocks and Stream Channel Profile

The rivers that have not yet reached grade are apt to have rock ledges across their channels where they flow through hard rocks. Such ledges form a temporary base level for the river above, until it is cut through by waterfalls and rapids. At Bansagar Dam site, the Sone River flows over the hard quartzite rocks and therefore, there should be a rock ledge in the river channel, retarding erosion upstream. But in place of quartzite ledge, there exists a cauldron size pool which indicates the presence of a fracture zone.

Deep Pool near the Gorge

A pool of 24 m depth is present in the Sone River bed, in the Basal quartzites near the gorge. It has been considered as a plane erosional feature. Had this pool been originated due to simple river erosion, then according to law of head word erosion, there would have been intensification of retrogressive erosion, and the river bed would have a tendency to assume a smoother curve approaching a horizontal line in the lower stream. But this is not the case here. The configuration of the pool (Figure 2) shows that there has been very limited down cutting at its outlet by the out flowing water.

Shape of the Pool

As shown in Figure 2, the pool is elongated in the direction N10°W—S10°E. This direction of elongation does not coincide with the direction of river flow. It means that the excavation of the pool in the above said direction is not done exclusively by river erosion but the possibility is that the pool has been opened out in that part of the river channel which coincided with the shear zone. Thus the shape of the pool gives a clue to the direction in which the shear zone may be running.

Relation of River Velocity and Channel Depth

The down cutting by a river in rocky channel is done mainly by abrasion. The abrasive effect of a particle carried by river water on bed rock is in proportion to the product of its mass and velocity. The rate of particle movement varies from zero to the velocity of water current. The abrasive resistance of particles and bed rocks is also variable. Therefore,

the abrasive ability of a river can not be expressed as a simple exponential value of velocity. Nevertheless, the flow rate of a river is a very important factor in determining its erosive power. The mean flow rate of a river can be given by Manning Formula (in F. P. S. units)

$$V=\frac{1.486}{n} R^{2/3} S^{1/2}$$

where, n is the coefficient of roughness and for a channel with large stones, its value can be taken as 0·006. R is the hydraulic radius, and S is fall of river per unit length.

By taking depth of the Sone River channel, near the gorge as 24 m (pool depth during summer), the value of mean flow rate by above formula comes to about 2.8 m/sec., while the maximum value observed on 17.9.68 is of the order of 1 m/sec. It implies that at the observed velocity, the river is incompetent to erode its bed of hard and resistant quartzite up to such a great depth. Therefore, there is every possibility that the pool exists in the shear zone.

Geometrical Pattern of the Ridges

From the Figure 2, it is clear that the lines AB and CD, drawn by joining the nose of contours of the two ridges lying on either side of the gorge show curvature in opposite directions, thereby indicating some disturbance.

Change in the Attitude of Rock Beds

The precise measurements show that there is a change in the strike direction of the Basal quartzites from N35°E—S35°W on the Left Bank Ridge to N40°E—S40°W on the Right Bank Ridge, while the dip values on the two ridges are 65° and 70° towards N55°W and N50°W respectively.

Shear Zone and Bending of Rock Beds

The mechanism of formation of a shear zone involves the bending of rock beds and bending in beds of Basal quartzites and porcellanites does occur at the dam site which is reflected structurally in the change of their attitudes.

Transverse Valley in the Direction of Shear Zone

A linear depression running from the gorge towards N10°W in the direction of the shear zone can be traced right up to Marjatpur village for a distance of about 7.5 km The valley intersects the porcellanite-ridges across their trend, and contains a nala. The valley may have formed due to the presence of crushed rocks along the shear zone which have yielded easily to erosion. Further, the discontinuous porcellanite-ridges and knobs lying adjacent to the valley, appear as if they were off-setted (Figure 1), suggesting that some movements have occurred along the shear zone.

Line of Ponds

Eight small ponds have been spotted in the 7.5 km long shear zone trench lying in-between Marjatpur and Rimar villages (Figure 1). They probably contain ground water, which have ascended through the shear

zone. In addition to these, mention should also be made of the 24 m deep pool, which exists in the Sone River bed itself, just in the line of the shear zone.

Joints Pattern in the Rock Beds

The study of the joints of the rock beds lying in the vicinity of the shear zone has been done and the strike directions of nearly 150 joints have been measured and analysed statistically with the help of "rose diagram" (Figure 3). In the diagram the longest rays are in the directions N10°W, N50°E and N50°W, which indicate the trends of predominant fissures present in the area. This analysis supports the inference already made, that the shear zone strikes in the direction N10°W.

Evidences from Drilling

During the preliminary sub-surface exploration programme 14 bore-holes were drilled and inspite of the abnormalities recorded in some of the bore-holes, the Basal quartzite at the dam site was described as sound and unbroken. In this connection the results of the five bore-holes, namely A/4, A/3, 1, 2 and 4 (Figures 2 and 4) are noteworthy. The bore-hole Nos. A/3 and 2 are located in the deeper portion of the pool and the over-burden of sand met with was 6.3 m and 9.3 m respectively. In bore-hole No. A/4 highly broken and weathered rock have been met with below 21 m of overburden throughout its length. In bore-hole No. 4 at depths of about 49 m, the core was recovered in the form of powder and frag-ments, while in bore-hole No. 1, there was complete loss of drill water at depths of about 57 m. Such bore-hole features are characteristic of a shear zone or a fault zone.

Conclusion

In view of the evidences given above, it may be concluded that a shear discontinuity exists in the Basal quartzite formation along the Sone River at the Bansagar Dam site. It is running in the direction N10°W—S10°E and lies close to the Right Bank Ridge. The shear zone appears to have originated quite recently because the physiographic evidences which have betrayed its presence are still fresh.

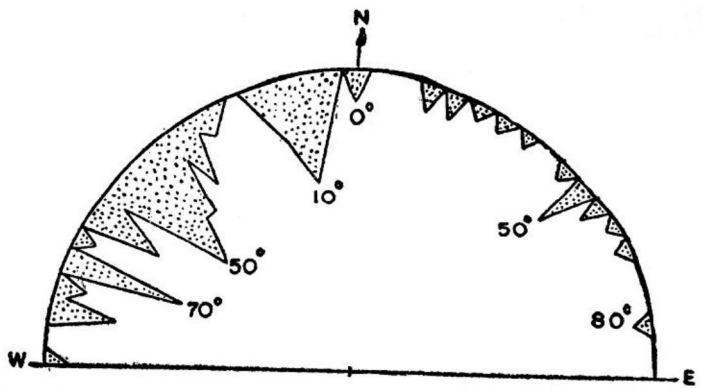

FIGURE 3 : Rose diagram indicating positions of predominant fissures in the area near Bansagar Dam site.

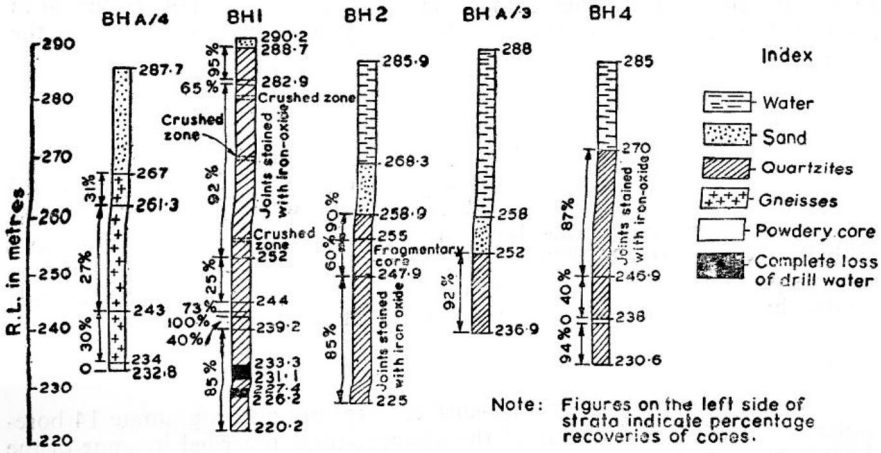

FIGURE 4 : Bore-hole logs showing crushed zones at Bansagar Dam site.

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