GENERALIZED STRATIGRAPHY AND STRUCTURAL GEOMETRY OF 'SUB-METAMORPHIC' ROCKS OF JABALPUR AREA

by BHAGWAN DAS, *Centre of Advanced Study in Geology, Sagar*

and

S. N. PANDEY, *Department of Applied Geology, University of Saugar, Sagar (M.P.)*

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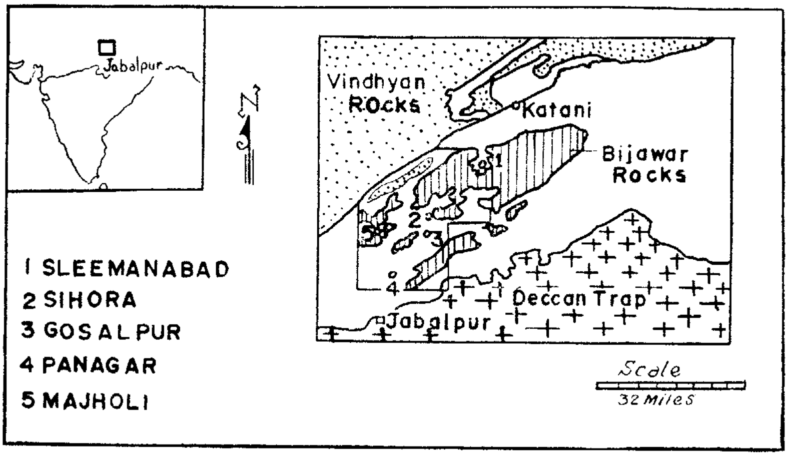
The 'sub-metamorphic' rocks of the central and north-eastern parts of the Jabalpur district form a part of the narrow, elongate and discontinuous belt of the 'sub-metamorphic' series occurring in the Narmada, Son and Ganges valleys. Intensive lithologic and structural studies of the rocks around several key sections (Majholi, Sihora, Gosalpur, Panagar and Sleemanabad) and determination of overall lithologic sequence, with the help of top and bottom criteria, clearly reveal a close resemblance with the 'Lowest Bijawar' sequence of the type area. The overall structure consists of close and asymmetric synclinorium plunging at moderate angle towards SW., which is made up of threefold generations. The first and second folds are more or less parallel or slightly inclined and the third fold intersects them at an acute angle. The average orientation of these superimposed folds has also been worked out.

INTRODUCTION

The central and north-eastern parts of the Jabalpur district (Map 1.) is occupied by a belt of 'sub-metamorphic' rocks, which is approximately 30 miles wide. There exists a great spread of the Vindhyan sandstones and the Deccan trap respectively towards the north and south of this belt. The 'sub-metamorphic' series includes a great variety of rocks and stretches eastwards into the Son valley.

Little has been published about the geology of this area in the past. The earliest account on the geology of these rocks is due to C. A. Hacket, who did extensive field work during a period between 1869 and 1871. Except for his manuscript report, much of his work has remained unpublished. These rocks were divided (Hacket 1872) into four groups, in ascending order as: (*a*) Majholi, (*b*) Bhitri, (*c*) Lora and (*d*) Chanderdip. He identified bedding plane, cleavage and numerous local contortions in the rocks and worked out the structure as 'shallow synclinal'. The geological studies carried out by Mallet (1883), Bose (1888, 1889) and Fermor (1909) were mostly directed towards the economic aspect of iron and manganese ores present in the rocks. In general, most of the workers seem to have adopted the lithologic sequence and structural form of the rocks as proposed by Hacket. Recently Choubey (1965) has published a preliminary note on the geology and structure of the area around Majholi, but he was unable to elucidate an overall structural form of the area. Das (1967) first mentioned about the presence of NW.–SE. superposed folds on the NE.–SW. cross-folded syncline in this area. The 'sub-metamorphic' rocks of Jabalpur constitute a series to which no definite stratigraphic position has yet been given. Hacket (1872), Mallet (1883) and Bose (1889) have correlated these rocks with the Gwalior or Bijawar of Bundelkhand and Fermor (1909) and Krishnan (1934) consider them equivalent to Dharwar and Gangpur of Orissa.



MAP 1. Location map of the area.

The chief object of writing this paper is to deduce a generalized stratigraphy and overall structural geometry of the cross-folded 'sub-metamorphic' rocks of the area. This has been done after making elaborate structural and lithologic examinations of the rocks around Majholi (Nos. 55 M/14 and 15) and Sihora, Gosalpur and Panagar (No. 64 A/3) and Sleemanabad (Nos. 64 A/2 and 6). The Majholi sector was selected for detailed sub-area analysis and only partial treatment of the Sihora and Sleemanabad areas proved very successful. The structural analysis of these areas gives a fairly accurate picture of the structural geometry of the 'sub-metamorphic' rocks, hence it was thought unnecessary to undertake this for Gosalpur and Panagar areas.

The overall stratigraphy of the region and the structural geometry of the areas around Majholi, Sihora and Gosalpur and Panagar have been worked out by B. Das. The structural geometry of Sleemanabad and Panagar areas was studied by Pandey. He has also checked and confirmed the results of structural mapping by photo-geologic techniques.

Overall Lithologic Sequence

The determination of exact lithologic sequence of the 'sub-metamorphic' rocks is obstructed by the presence of interbedded lithologies coupled with complex repetition of beds introduced by several directions of folding and discontinuous nature of the exposures. By the studies of drag folds and intersection of bedding and cleavage in these rocks, it has been possible to establish the following order of superposition:

Laterite

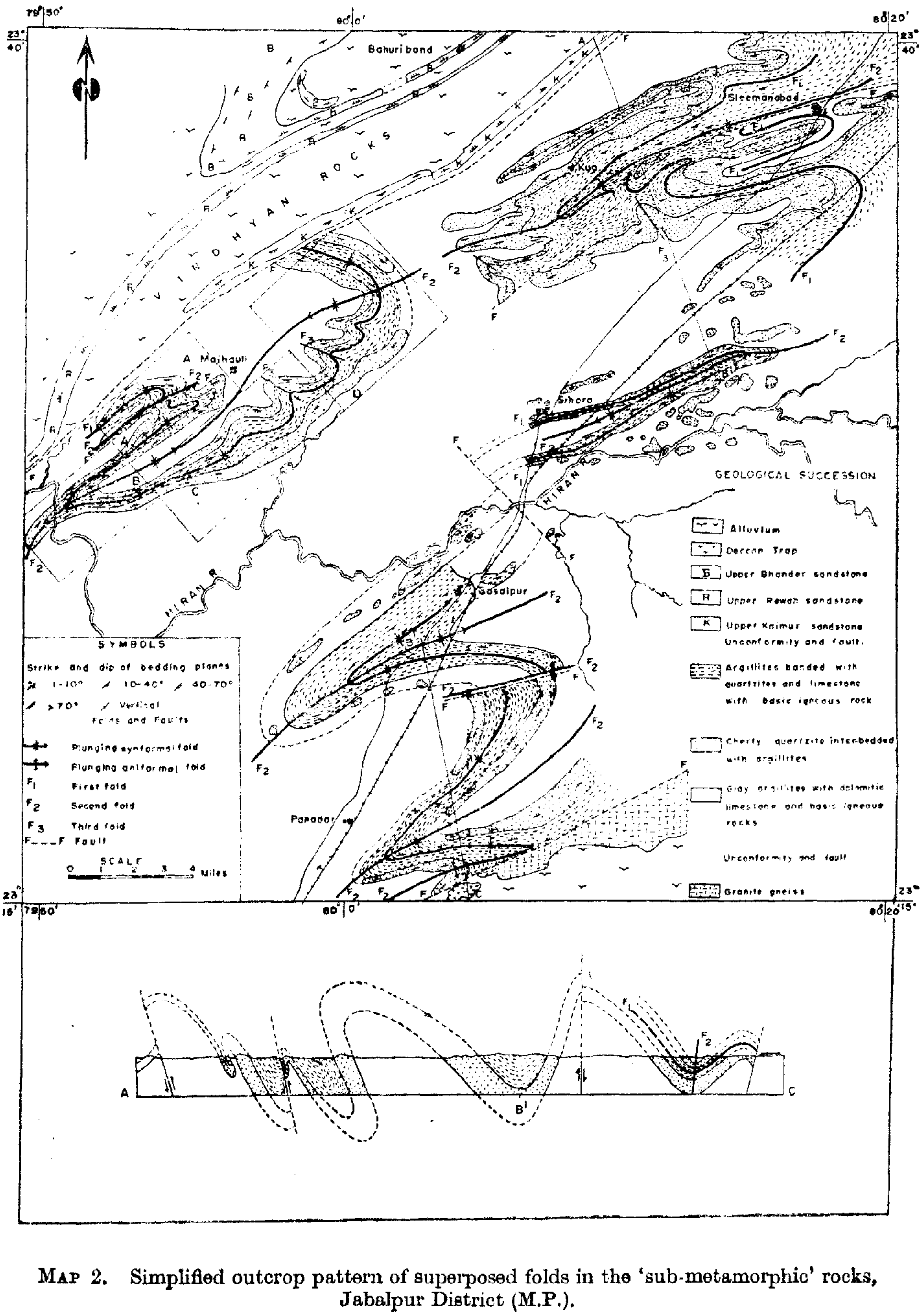
Black and fine-grained argillites (with manganese ores).
Quartzites and jasperite banded with haematite (with iron ores).
Ferruginous quartzites.
Ferruginous argillites with intraformational conglomerate and basic igneous rocks.
Metamorphosed basic igneous rocks.
Dolomitic limestone with argillite bands and basic igneous rock.
Cherty quartzites and jasperite interbedded with argillites.
Grey argillites with bands of dolomitic limestone and basic igneous rock.

The term 'argillites' is adopted to cover slaty shale and phyllitic slate lithotypes. The fore-mentioned lithologic sequence of the 'sub-metamorphic' rocks of the area is certainly more representative than those proposed by Hacket (1872) and Bose (1889) and closely agrees with the 'Lowest Bijawar' sequence of the type area (Das and Khan 1967), which is characterized by the presence of pure siliceous-ferrugineous facies of rocks (meta-sedimentary). This mark (bedded chert-ferrugineous argillites-ferrugineous quartzite association) has been very successfully employed by Das for the identification and correlation of such rocks present elsewhere, e.g. Dhar forest, Gwalior, Rajgir, etc.

Structural Geometry

The widely prevalent lithographic feature of these 'sub-metamorphic' rocks is interbedding and banding of the competent and incompetent units, which signify the presence of well-developed bedding planes (S_1). The other structural planes present in them are the conspicuously developed first cleavage (S_2) and obscure second cleavage (S_3) in the incompetent bed or band. S_1 and S_2 run parallel except near the fold closures and S_2 and S_3 seem to be axial-plane cleavage. Fold axes and crenulations (L_1), intersection of S-surfaces (L_2) and striations (L_3) are linear elements. L_1 and L_2 are 'b' lineations and L_3 may be a or b. On a mesoscopic scale S_1 and L_1 are the most prominent planar and linear structures which define the style of deformation. A statistical study of mesoscopic geometry of S_1 and L_1 should clearly reveal the geometry and orientation of megascopic structures in the area. Therefore, for rapid determination of generalized structural geometry, S_1 and L_1 have been exclusively employed.

Majholi—The outcrop pattern of the 'sub-metamorphic' rocks of the Majholi area (Map 2, 79° 50′–80° 00′/23° 25′–23° 34′) is inverted *S* in type, the



Map 2. Simplified outcrop pattern of superposed folds in the 'sub-metamorphic' rocks, Jabalpur District (M.P.).

southern part of which has been superimposed by asymmetrical U with an easterly pointing apex. This figure clearly shows the presence of an interference structure. The outcrop pattern has resulted due to the appearance of an original synformal structure (F_1), the axial trace of which has been folded (F_2) into an antiform (sub-area A) and synform (sub-area B) along NE.–SW. axes and latter (F_3) into an WNW.–ESE. antiform (sub-area D).

In general, the axial traces of F_1 and F_2 folds of the area have formed a very small angle; therefore, individual maxima, submaxima and girdles cannot be possibly correlated with them. Another difficulty in correlation arises due to the presence of less regularly preserved pattern of distorted earliest folds (F_1) which give unexpected maxima and submaxima. In sub-area A, the 63 βS_1 diagram 1 exhibits a pronounced maximum and several submaxima arranged along an inclined girdle. The 8 per cent well-developed submaximum indicates ENE. gently to moderately plunging $F_1 \parallel F_2$ folds with moderately inclined axial plane towards SE. as is indicated by the girdle. The 16 per cent maximum and 8 per cent submaximum give the limiting position of F_3 fold moderately plunging S. to SE. The diagram 2, representing 235 βS_1 of sub-area B, shows more or less similarly situated maxima, submaximum and girdle. An additional 9 (10) per cent peripheral maximum in this diagram indicates a change in the plunge of $F_1 \parallel F_2$ fold axes to sub-horizontality. The other folds attitude remains constant.

The sub-areas C and D are dominated by predominantly F_1 and F_3 folds. The β-diagrams (3 and 4) of these areas are characterized by the presence of cleft girdles indicating folding of the axial plane of folds. The 360 βS_1 (diagram 3) for the sub-area C shows a peripheral maximum and several submaxima and they are arranged along cross-girdles. The axial plane of subhorizontal F_1 fold is moderately inclined towards SE. The axis of F_3 fold is gently plunging towards SE. with dip of the axial plane moderately to steeply inclined towards NE. The three characteristics 9 (11) per cent maxima, observed in the 200 βS_1 diagram 4 representing sub-area D, indicate gently to moderately and steeply plunging folds respectively towards westerly and southerly directions. The plunges in other directions are not uncommon as is indicated by the appearance of submaxima. There is definite tendency to form several girdles indicating variable rotation of axial planes. In general, successive rotation of the earlier axes and axial planes by the latter folds is quite evident by the studies of these diagrams.

The overall structural geometry of the folded rocks of the whole area has been deduced by plotting the maxima and submaxima from the four selective diagrams (1–4) of sub-areas (A–D) in the synoptic 108 πS_1 diagram 5. The S_1 diagram shows a pronounced 20 (21) per cent maximum and several submaxima. The poles of π-girdles suggest that the average $\beta F_1 \parallel \beta F_2$ while βF_3 axes are respectively sub-horizontal and moderately plunging towards NE.

and SE. as is indicated by definite concentration of the β-maxima and submaxima around the poles of the girdles axes. A considerable amount of inhomogeneity is indicated by the departure of the maxima and submaxima from these fields.

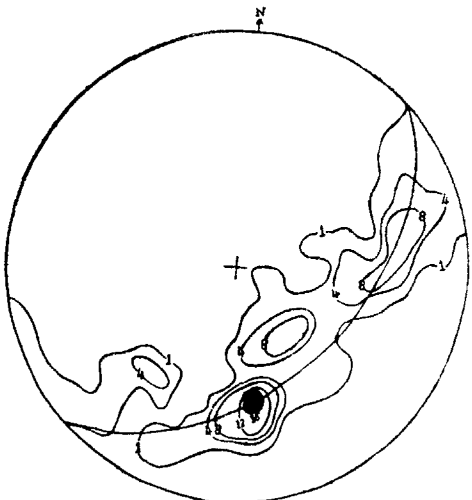


DIAGRAM No. 1 PLOTS OF 63 βS_1

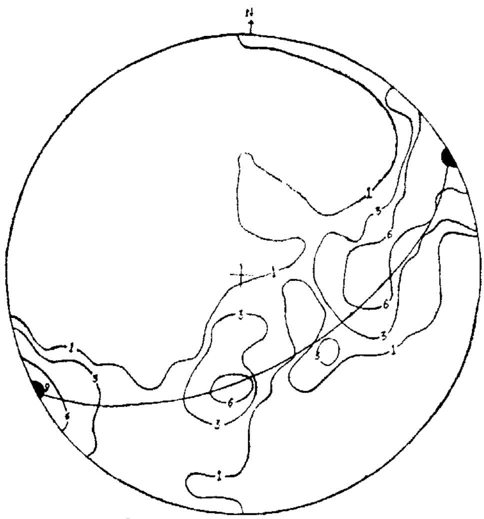


DIAGRAM No. 2 PLOTS OF 235 βS_1

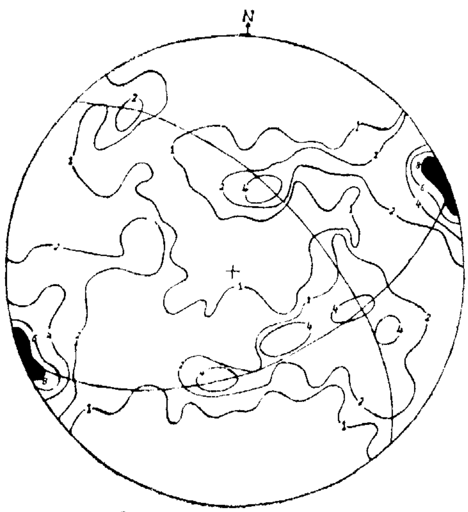


DIAGRAM No 3 PLOTS OF 360 βS_1

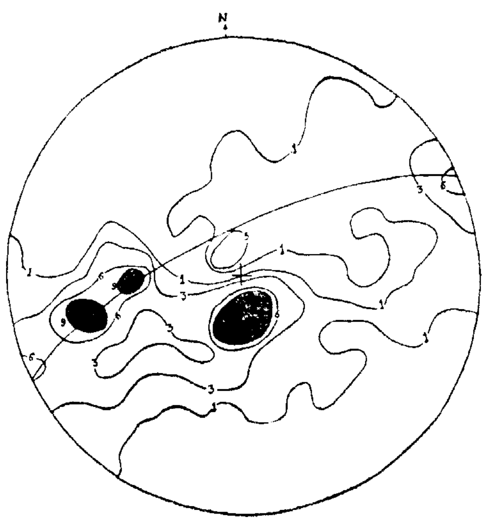


DIAGRAM No 4 PLOTS OF 200 βS_1

Sihora, Gosalpur and Panagar—The *S*-shaped outcrop pattern of the 'sub-metamorphic' rocks of the area around Sihora (80° 00′–80° 15′/23° 25′–23° 32′)

lying east of Majholi is the result of refolding (F_2) of the axial trace of original synform (F_1). The 100 πS_1 synoptic diagram 6 for the area is characterized by the presence of a 11 per cent peripheral maximum and several submaxima. The β-pole derived from the S_1-girdle indicates a gently plunging $F_1 \parallel F_2$ folds towards SW. direction. The contour diagram 7 prepared from 82 minor folds of the area shows a prominent 6 (7) per cent maximum suggesting folds

DIAGRAM NO 5 PLOT OF 108 π S_1 WITH β MAXIMA β SUB.MAXIMA

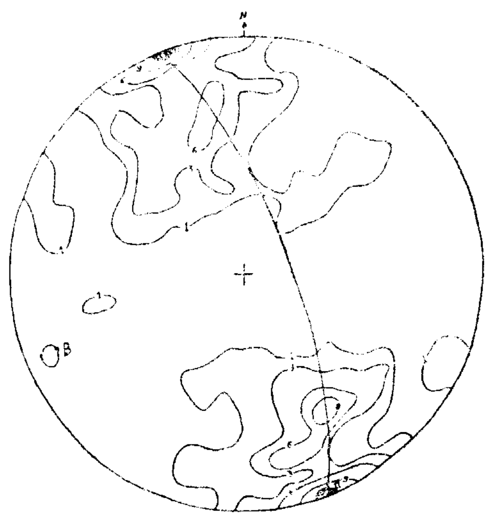


DIAGRAM NO.6 PLOTS OF 100 π S_1

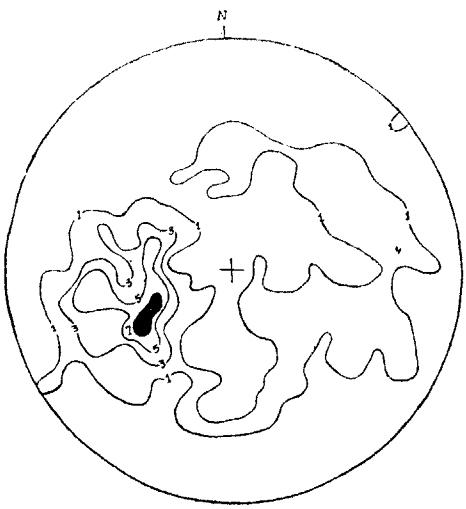


DIAGRAM NO 7 PLOTS OF 82 MINOR FOLDS

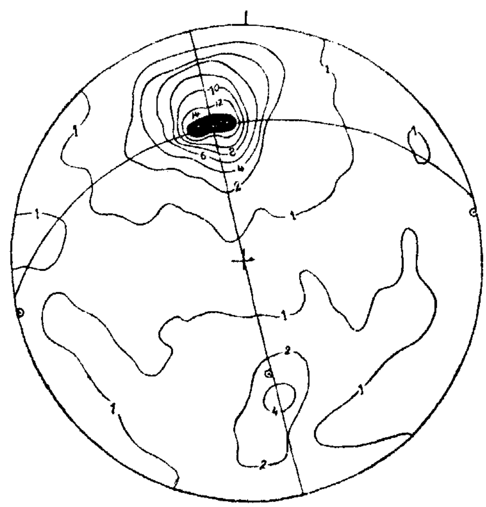


DIAGRAM No.8 PLOTS OF 590 π S_1

moderately plunging towards SW. direction. The presence of cleft girdle indicates axial plane folding.

The refolded axial trace of original synform present in the 'sub-metamorphic' rocks of the Sihora area passes towards south through Gosalpur and Panagar (Map 2, 80° 00′–80° 05′/23° 15′–23° 25′) and it has formed characteristic *W*-, *U*- and *V*-shaped outcrop patterns. The structural geometry of the 'sub-metamorphic' rocks of the areas around Sihora, Gosalpur and Panagar closely resembles with that of Majholi area, except for a minor noticeable difference in the inconspicuous development of F_3 folds.

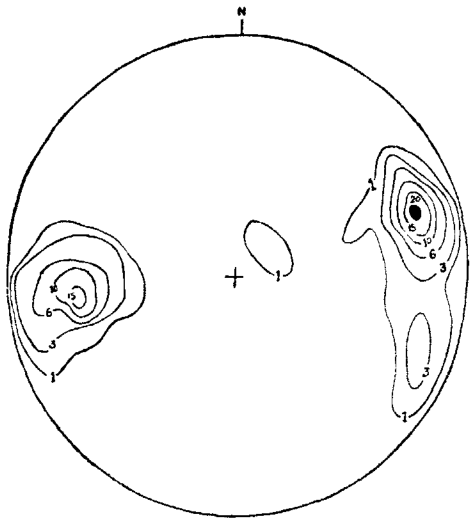


DIAGRAM No 9 PLOTS OF 100 MINOR FOLDS

Sleemanabad—The characteristic outcrop pattern of the 'sub-metamorphic' rocks of Sleemanabad (Map 2, 80° 03′–80° 17′/23° 33′–23° 41′) is elongate and narrow *V*-shaped in form and consists of several fold closures transected by a thrust fault. The refolded (F_2) axial trace of original synform (F_1) traceable across the area represents the northern extension of the refolded original synform of Sihora. The 590 πS_1 synoptic diagram 8 of the area shows a prominent 14 per cent maximum and a 4 per cent submaximum and the poles are arranged along cross-girdles. The β-pole derived from the NNW.–SSE. girdle indicates the presence of ENE.–WSW. trending sub-horizontal $F_1 \| F_2$ folds broadly confirmed by the maxima described in the diagram 9 representing plots of 100 minor folds.

Summary of the Structural Geometry

The overall structure of the 'sub-metamorphic' rocks of the Jabalpur area is not so simple as to be termed as 'shallow synclinal' but consists of complex syncline, rather close and asymmetric synclinorium plunging at moderate angle towards SW. This synclinorium is bounded on the north and south respectively by high angle reverse and normal faults, giving a general rifted appearance. The information obtained from the above analysis clearly indicates the presence of three generations (F_1, F_2 and F_3) of folding in the rocks. The F_1 and F_2 folds are overturned or isoclinal and the axial trace of F_2 is more or less parallel or slightly inclined to the F_1. The broad and gentle asymmetrical or symmetrical superposed F_3 folds intersect them at an acute angle. The average attitudes of the three generations of folds are given below:

F_1—The distorted earliest fold is irregularly preserved.

F_2—The bowing downward and upward axes are sub-horizontal and gently to moderately plunging towards ENE. or NE. in the western parts of Majholi and Gosalpur and Panagar and SW. in Sihora and Sleemanabad with axial planes moderately inclined towards SE.

F_3—Fold axes are gently plunging towards SE. and axial planes are moderately to steeply inclined towards NE.

Acknowledgement

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