# CHAPTER 5

# S T R U C T U R A L  G E O L O G Y

The structural characters of the rocks above the North Almora thrust and the Kaushani thrust are quite identical, as they comprise the same structural unit, representing rocks above the two limbs of the antiformally folded Almora thrust. In the study area, a larger portion of the Almora nappe is included, and only a very small portion of the Baijnath nappe is encountered. The structural geology of the two nappes has been discussed below, taking into account the various minor structures contained within them and the structural history established by previous workers.

A critical study of the orientations of the various planar and linear structures present in the rocks, has revealed that the crystalline schists and gneisses have undergone deformation several times, and the various minor structures related to the successive fold episodes $F_1$, $F_2$ and $F_3$ are seen developed. The effect of the North Almora thrust is also quite conspicuous.

STRUCTURAL CHARACTERS

The portion of the Almora nappe lying within the study area, comprises a part of the south dipping limb of the great Almora nappe synform. The foliation is mainly of the gneissic type, and obviously derived from the original schistosity, the latter having been obliterated due to the migmatisation. Another S-plane is that related to the North Almora thrust, and is represented by phyllonitic cleavage in the thrust zone, and a shear cleavage in the mylonitised gneissic bands. The effects of $F_2$ though quite conspicuous and recorded all over, are rather sporadic and confined to a gentle crinkling and puckering only. Unlike the Majhkhali area near Ranikhet and its neighbourhood which lies near the synformal trough (Desai, 1968), the $F_2$ folding of the Almora thrust, has failed to develop a strain-slip cleavage in its northern limb. The effects of the open NNE-SSW flexuring $F_3$

are also not very conspicuous, and in the study area, this folding is faintly recognised on the map by the strike variation of the various rock formations.

From the structural point of view, the Almora nappe rocks seem to show evidences of $F_1$ folding and the shearing due to the Almora thrust. The $F_1$ structures in the form of minor folds in quartz veins, quartz rods, reveal ideally the axial plane relationship of the gneissic foliation (originally a schistosity). The effects of the North Almora thrust belong to two categories. One is the zone of phyllonites all along the North Almora thrust in its eastern part, and the other is a series of parallel shear zones farther away from the thrust along which the gneisses have been mylonitised.

A significant structural feature of these rocks is the presence of the Udyari-Chauthuli fault, which cuts the entire area and goes further south. Perhaps it is the same fault which Desai (1968) has mapped in the Majhkhali area. This dislocation appears to be of strike slip type, showing a dextral displacement of about 500 metres.

Only a very small and almost insignificant portion of the Baijnath nappe falls within the study area. Occupying a high ground in the extreme north, the crystalline rocks

rest over the younger quartzites, separated by the north dipping Kausani thrust. This thrust enters the area striking ENE-WSW and is truncated by the NS Bijoria fault in the west. Structurally, the rocks of this nappe are not of much interest, except that they show effects of the early $F_1$ folding only. The entire Baijnath nappe portion has been included in one single sub-area.

ANALYSIS OF STRUCTURAL DATA

The author subdivided the total area of the Almora nappe into 3 sub-areas, and the Baijnath nappe into a single sub-area for the purpose of structural analysis (Fig.5.1).

Sub-area 15

This sub-area includes almost one third of the rocks in the western part of the nappe. It is bounded by the Lod-Niral reverse fault in the N, and the Chunia fault in the ESE. Only a very small portion of the North Almora thrust falls within this sub-area in its north-eastern corner. The rocks encountered are mainly gneisses and quartzites, the latter forming the western extremity of a large quartzite band that underlies the gneisses. In this sub-area, phyllonites are absent, and the gneisses abut against the reverse fault. The gneissic foliation has in general a WNW-ESE trend and its dips are always due SSW to SW with moderate amounts. In

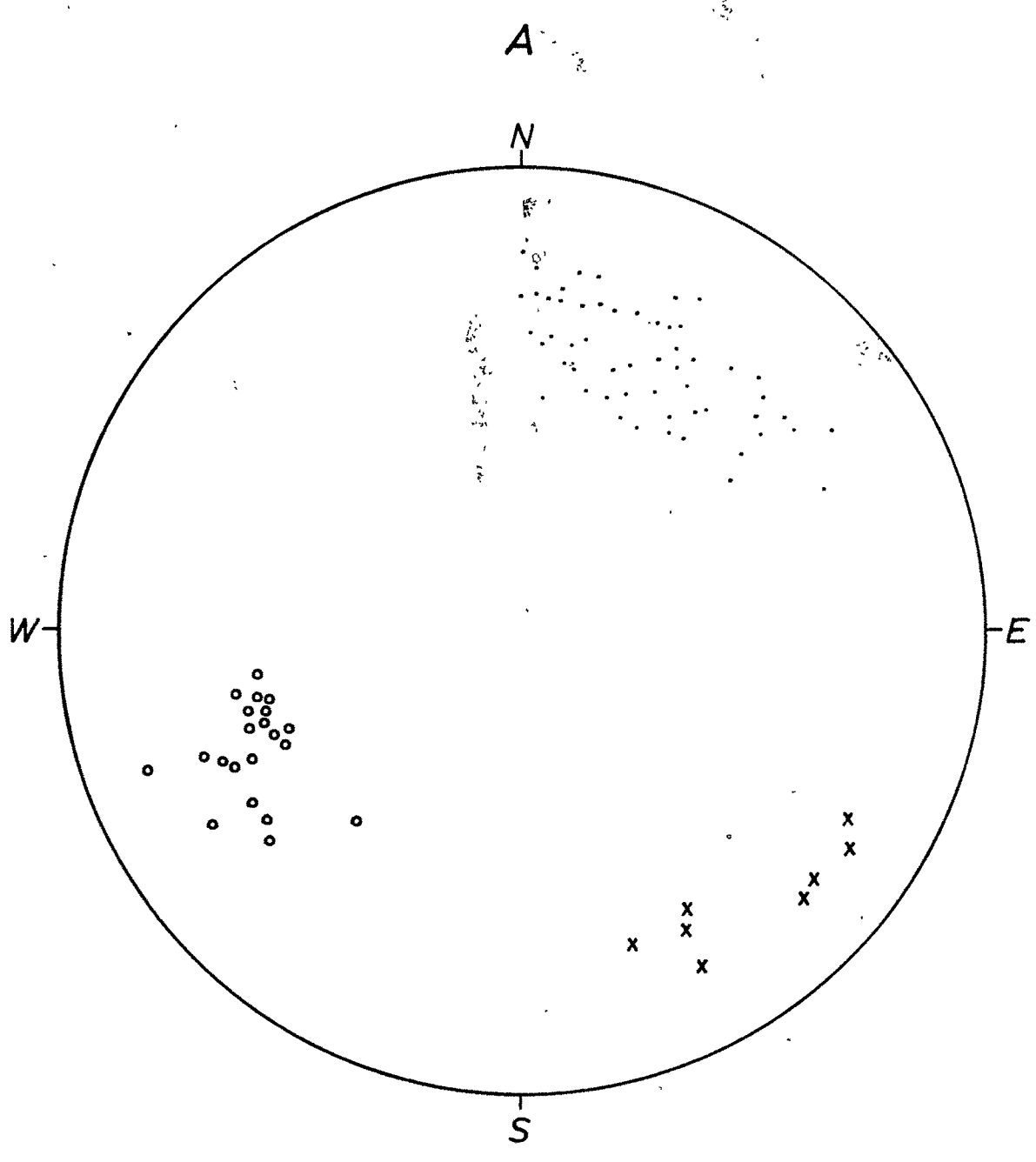
the neighbourhood of the Lod-Niral fault, the gneisses show considerable shearing and are almost pulverised. The dominant lineation is that relates to $F_1$, and is seen as axes of small folded quartz and quartz-felspar veins, quartz boudins and a distinct striation (? cleavage bedding intersection). All these lineation types plunge due SW at moderate angles (240°-265°/15°-45°). Occasional crinkling and puckering related to the $F_2$ folding, is recorded. No distinct strain slip or axial-plane cleavage has developed along these crinkles but their axes characterise the lineation related to $F_2$. This lineation shows a very gentle plunge due SE (120°-160°/18°-30°). The various planar and linear structures of the sub-area are shown on the stereogram (Fig. 5.2).

Sub-area 16

This sub-area comprises the central portion of the Almora nappe rocks of the study area and includes the terrain between sub-area 15 and the Udyari-Chauthuli fault. The rock types are gneisses, quartzites and phyllonites. The gneisses show numerous narrow zones of shearing that are easily identified by extensively mylonitised streaky rock. Structural elements related to the $F_1$ folding are as usual the gneissic (= axial-plane of the $F_1$) foliation and the various linear structures parallel to the $F_1$ fold axis. The most common types of this lineation, are the axes of folded

Fig. 5.2.

Stereograms showing the structu

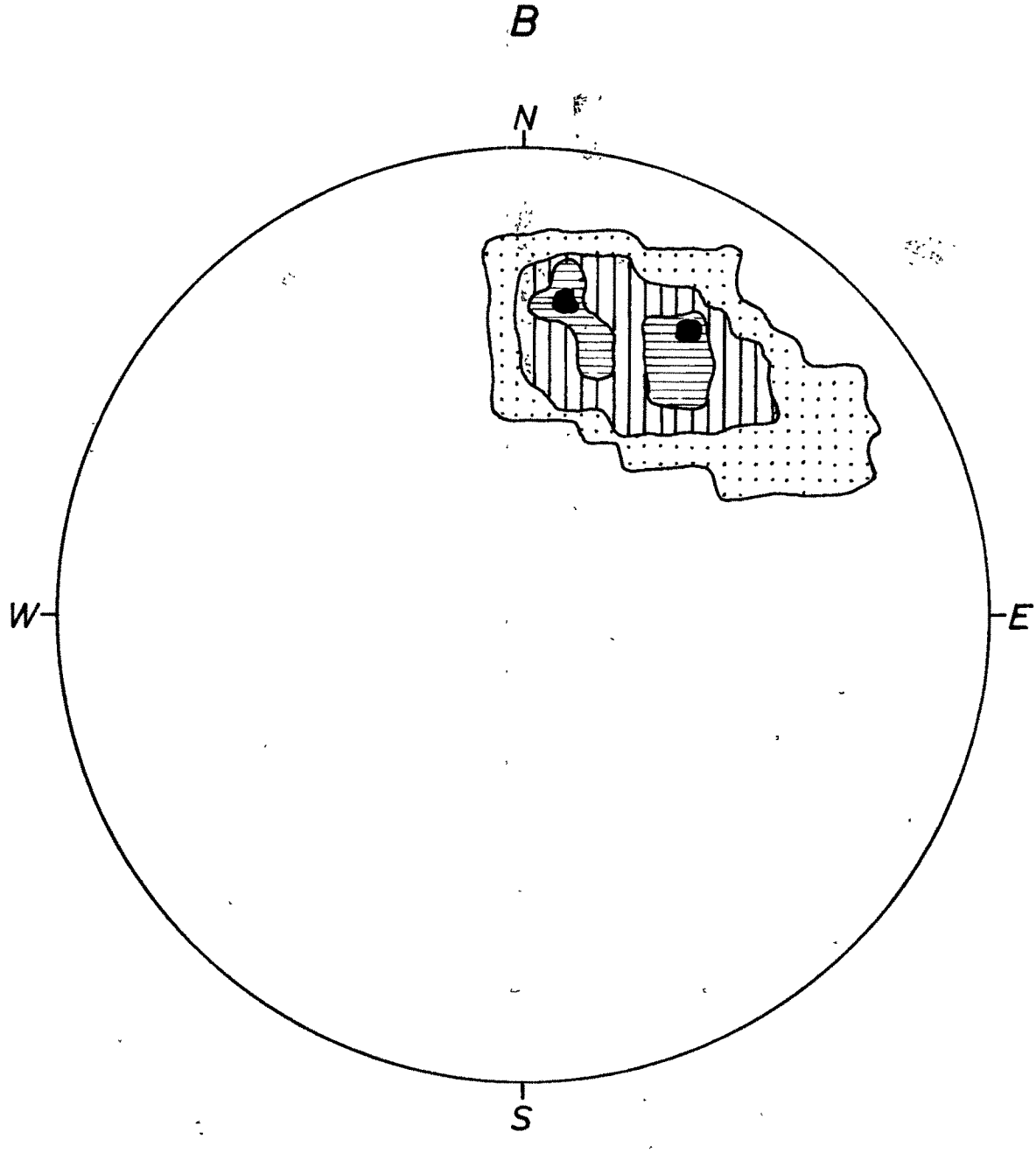



· Poles of foliation (55)

o Lineations related to $F_1$ (21)

x Lineations related to $F_2$ (8)

ral elements of the sub-area 15.



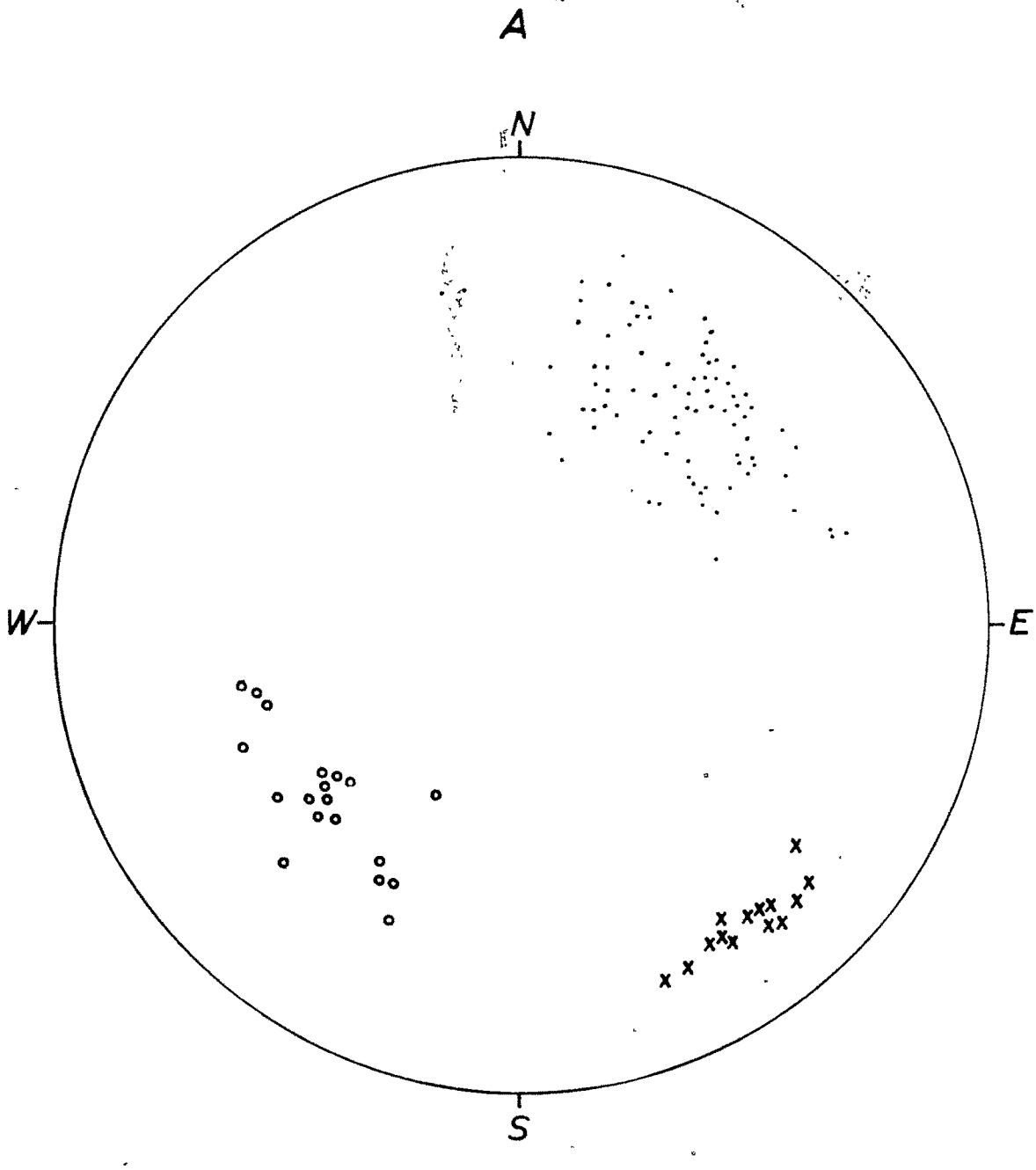
quartz veins and quartz-felspar veins. These plunge in the SW sector with moderate amounts (200°-260°/30°-50°). The pucker lineation due to $F_2$, are sporadic but conspicuous enough to be noted. These show the usual gentle plunge due SE to SSE (120°-152°/15°-25°). These structures, when plotted on the stereograms (Fig. 5.3), show much similarity in orientations to those of the sub-area 15.

Sub-area 17

This sub-area includes the south-western portion of the study area, and contains the same rock types as the sub-area 16. The structural elements related to the $F_1$ and $F_2$ are identical to the previous two sub-areas (Fig. 5.4). The phyllonitic rocks need a special mention in this sub-area. The phyllonites contain numerous lensoid layers of quartzite, and these invariably show overfolding with axes plunging due SW. The phyllonitic cleavage shows an axial-plane relationship with the folds. Obviously these drag folds are related to the movement along the North Almora thrust. The fact that the fold axes and the shapes of these drags are identical to those of the minor folds of $F_1$ generation further south, clearly shows that the isoclinal folding and the Almora thrust were two events of the same deformational episode. The phyllonites also show crinkling related to $F_2$, and the puckers related to $F_2$ show a gentle plunge due SSE to SE (142°-170°/10°-20°

Fig. 5.3

Stereograms showing the structu



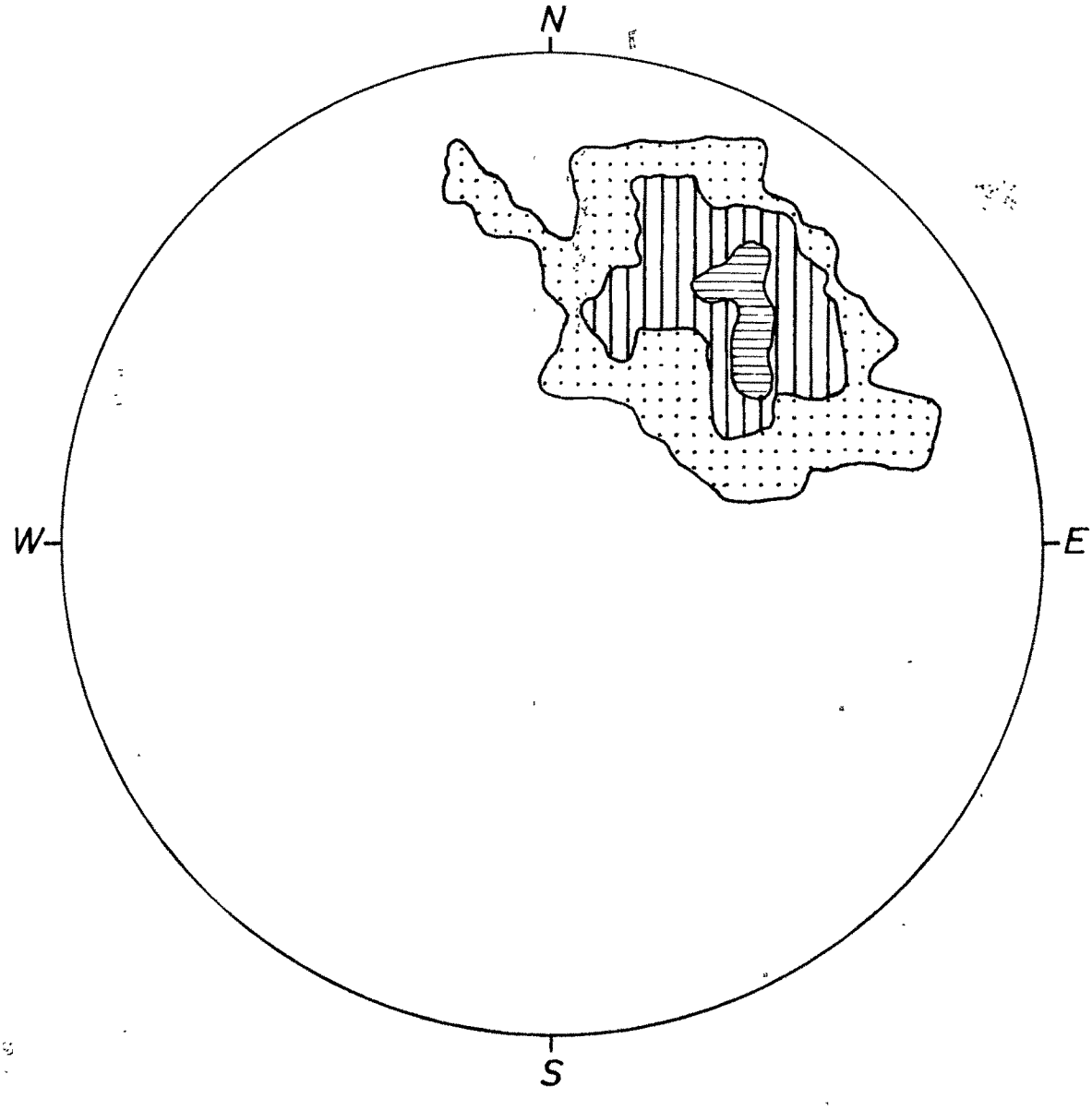

· Poles of foliation (83)

o Lineations related to $F_1$ (19)

x Lineations related to $F_2$ (14)

ral elements of the sub-area 16.

B




Contour intervals:-

0 - 1%

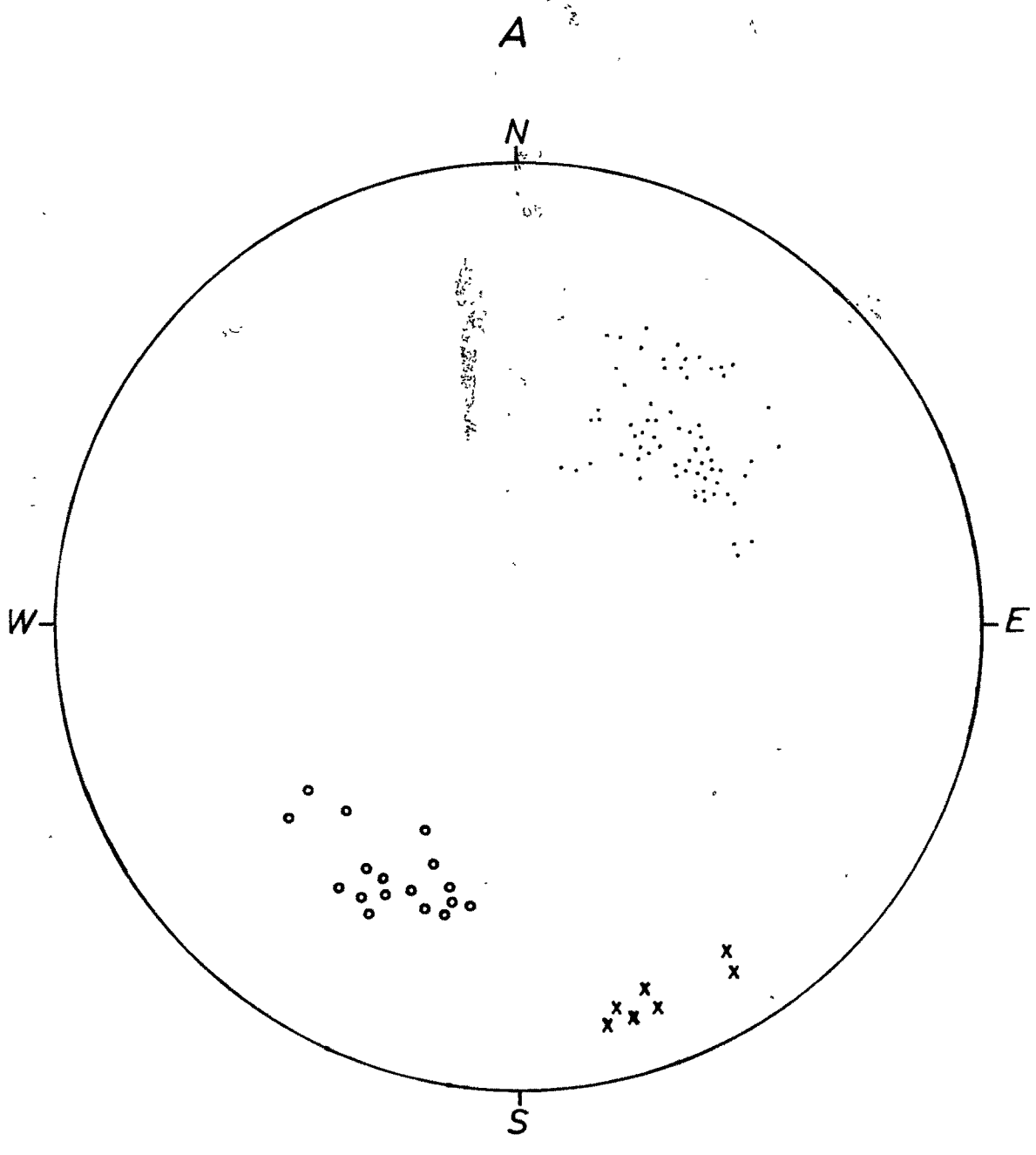
1 - 5%

5 - 10%

> 10%

Fig. 5. 4

Stereograms showing the structur

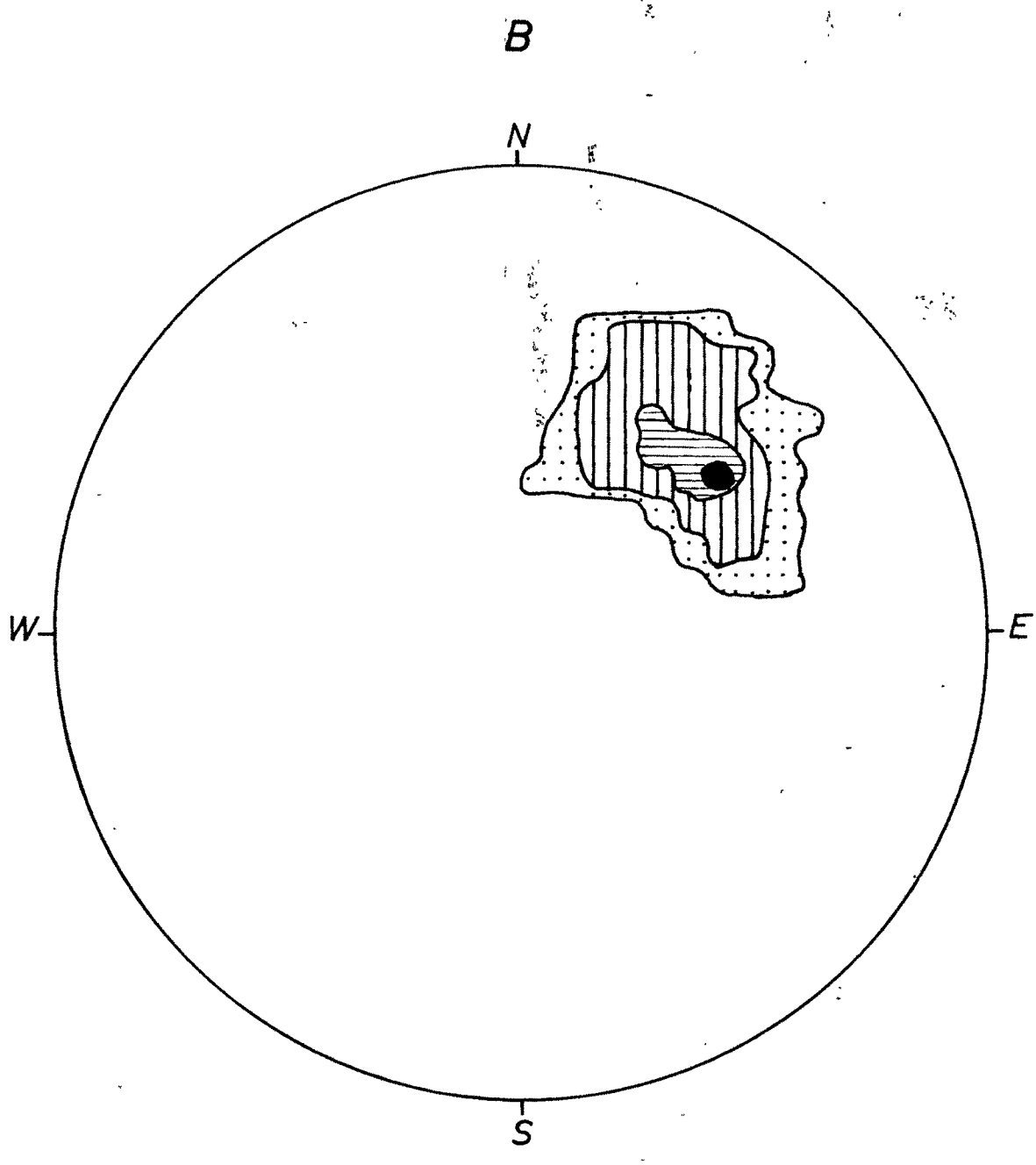



· Poles of foliation ( 67)

o Lineations related to $F_1$ ( 17 )

x Lineations related to $F_2$ ( 7)

*al elements of the sub-area 17.*



Sub-area 18

Sub-area 18 includes the Baijnath nappe rocks and contains mainly NNW dipping gneisses. The foliation shows moderate to gentle dips. The quartz veins and quartz-felspar veins are seen folded such that their axes plunging gently due NNE (20°-40°/20°-40°) characterise the main lineation related to $F_1$; and their axial-plane is marked by the gneissic foliation (Fig. 5.5). No other linear or planar structures are recorded. However, extensive shearing and mylonitisation of gneisses near the thrust is striking.

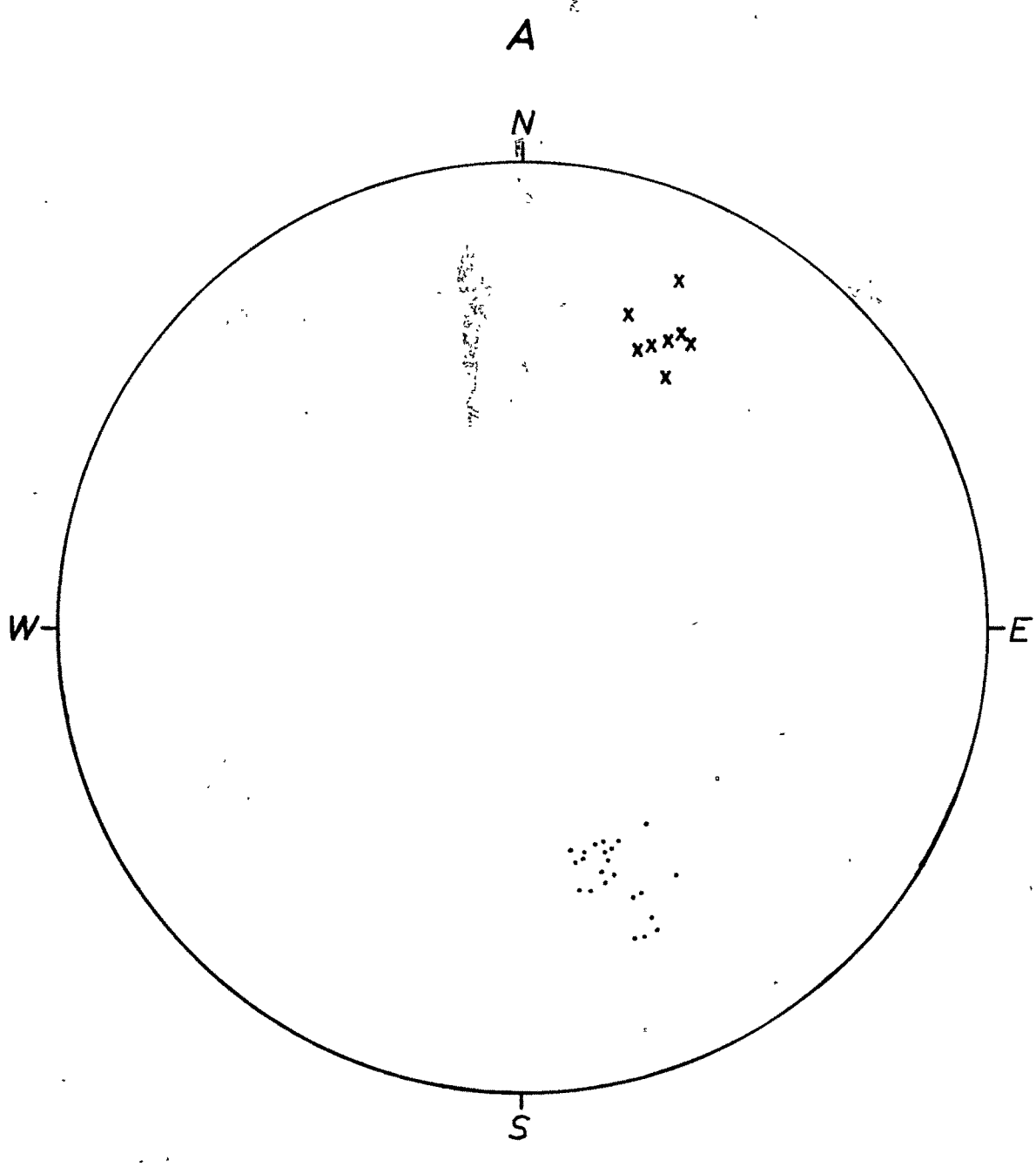
STRUCTURAL INTERPRETATION

The entire structural geology of the rocks of the two nappes can be summarised as under:-

(1) The main gneissic foliation of the rocks, derived from the original schists, characterises the axial plane cleavage of the early isoclinal folding $F_1$ that preceded the thrusting. This axial-plane relationship is very clearly seen in the small folds of quartz veins in gneisses. The axes of these folds plunge due SW, and obviously the $F_1$ folds to a certain extent were reclined such that the axial planes strike almost normal to the trend of the axis (Turner & Weiss, 1963, p.119).

Fig. 5.5

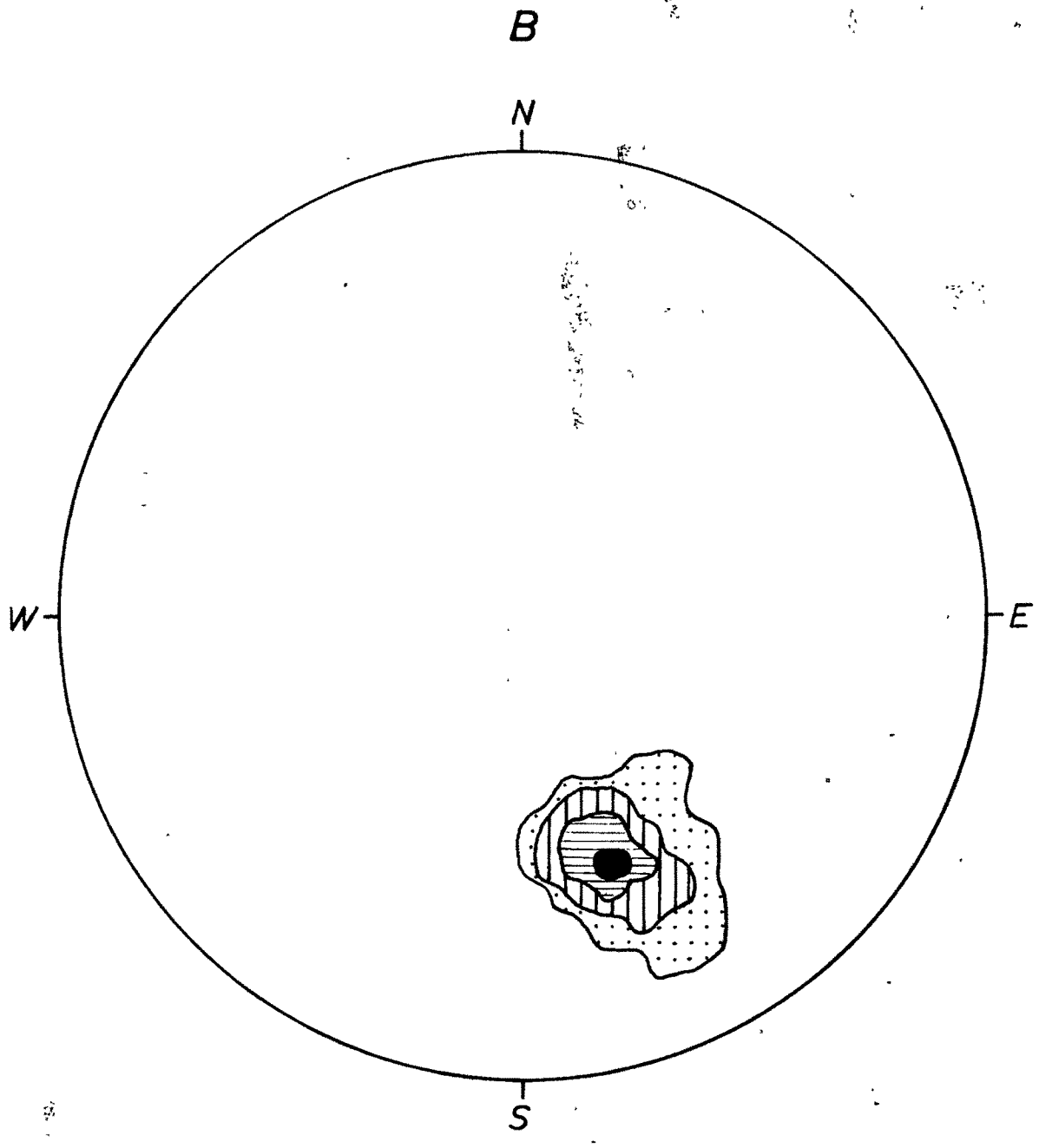
Stereograms showing the structu




· Poles of foliation ( 23 )

x Lineations related to $F_1$ ( 8 )

ral elements of the sub-area 18.



(2) The $F_1$ folding culminated into the North Almora thrust, with extensive shearing and mylonitisation of the gneisses. The shearing took place along the earlier S planes, and thus the shear cleavage in the mylonitised gneiss shows parallelism with the gneissic foliation. The close relationship between the $F_1$ and the Almora thrust is ideally seen in the phyllonites, which contain numerous quartzitic lenses intimately drag-folded during the thrust movement. The overfolded quartzite lenses show axial-plane relationship with the phyllonitic cleavage and the axial planes and axes of these drag folds show the same orientation as those of the folded quartz veins in the gneisses. It is very evident that the isoclinal folding $F_1$ and the Almora thrust represent two stages of a single deformational event that started with folding and ended with thrusting.

(3) The effects of the intense shearing during the Almora thrust is, in the study area, not confined to the immediate vicinity of the main thrust (North Almora thrust), but is spread over a zone of about 2 km. The numerous shear zones parallel to the thrust, along which the gneissic rocks have been mylonitised indicate

that at least in this part of the Almora nappe, the displacement was not confined to a single plane but comprised an imbricate structure of small parallel dislocations generally related to the North Almora thrust.

(4) The $F_2$ folded the Almora thrust sheet into an antiform, the northern limb of which is the Kausani thrust and the southern limb is designated as the North Almora thrust. During this fold episode, the rocks did not develop any significant structures except microfolds, crinkles and puckers in the sheared gneisses and phyllonites.

(5) Effects of $F_3$, i.e. the NNE-SSW folding are faint but quite evident. The gentle fluctuations in the strike directions of the gneissic foliation, shear cleavage and the phyllonitic cleavage, in both the nappes is very clearly an effect of $F_3$. But for a few puckers and open mesoscopic folds sporadically recorded, no other planar or linear structures related to this folding appear to have developed.

(6) The last tectonic event that has left its impress on these nappes, is that of widespread fracturing, seen in the form of several faults.