CHAPTER III

GEOLOGICAL SETTING

REGIONAL GEOLOGY:

The rocks of Majkhali area form a part of the overthrust sheet, which to its north and south, is bounded by North and South Almora Thrusts and Auden (1937) considered these rocks as belonging to the Chandpurs (? Mid - Palaeozoic) which in Kumaon, have been brought over the younger Nagthats (? Upper Palaeozoic). The rocks of this nappe constitute the crystalline zone of Almora of Heim and Gansser (1939). The underlying rocks of the Krol

Nappe (a part of Chandpur stage and the younger rocks) form a thick succession of quartzites with slates, phyllites, chloritic schists, metamorphosed basic rocks and dolomitic limestones. Though the quartzites immediately below the thrust are considered to be Nagthats, those rocks which underlie the quartzites are yet to be assigned proper stratigraphic positions. According to Heim and Gansser (1939,p. 28) the region between Bhowali and the South Almora Thrust forms a recumbent syncline overturned to the NE. Merh (1968), however, has ruled out the possibility of the existence of such an overturned structure. He has worked out the following structural succession of the various stratigraphic units for the Central Kumaon region.

Almora Nappe	Mica schists and migmatitic gneisses with quartzites	Chandpurs
	Chlorite schists	
	Sericite schists (phyllonites)	
	---------- Almora Thrust ----------	
Krol Nappe	Quartzites with slates	Nagthats
	Dolomitic limestones with slates	Deobans

	Chlorite and Talc chlorite schists (metamorphosed basic rocks) with quartzites	
Krol Nappe	'Porphyries' (mylonitised granite)	Chandpurs
	Talc chlorite schists (metamorphosed basic rocks)	

---------- Ramgarh Thrust ----------

Quartzites and associated basic rocks (Bhowali traps)	Nagthats

MEGASCOPIC CHARACTERS:

The rocks of the area under study consist of metamorphosed and granitized sediments predominantly of pelitic, semipelitic and psammitic composition. These major groups show variation within themselves, thus giving rise to a number of lithological types recognisable in the field. The psammite-pelite sequence obviously corresponds to the sedimentary sequence 'sandstone-clay', and the intermixing of the sand and clay components in all proportion has very often produced an imperceptible gradation from the most micaceous to the most quartzitic type. However, on the basis of field and laboratory studies, several fairly distinct rock-types have been recognised and demarcated in the field. Apart from the variations due to

the original nature of the sediments, the effects of varying metamorphism and deformation, have influenced the appearance of the psammites, pelites and semipelites in the field, producing distinctive varieties. The presence of calc-silicate bands indicates the occasional presence of $CaCO_3$ in the original sediments. Migmatisation of the pelites has given rise to a group of felspar-rich gneisses. The various rock types show difference in colour, grain size, structure and mineral content, and are easily recognisable in the field.

The main rock types recognised in the field can be classified as under:

Pelites - (1) Garnet mica schists

Semipelites- (2) Siliceous mica schists

(3) Phyllonites

(4) Graphite schists

Psammites - (5) Quartzites

Migmatites - (6) Gneisses

(7) Calc-silicate rocks

(8) Quartz-veins.

It may be pointed out that small lenses of one variety commonly occur in the other , viz. lenses of siliceous mica schists and quartzites are frequently present in the garnet mica schists, and the vice-versa is also true. Similarly, the migmatitic gneisses, in addition to forming a couple of big bands, also occur as a few discrete lenses in pelites.

Pelites:

This group consists of highly micaceous schists among which following types have been recognised:-

(i) "Normal" Pelitic Schists: Fairly coarse-grained and well foliated, these are highly micaceous rocks with varying garnet content. The minerals visible in hand-specimen are quartz, biotite, muscovite and pink garnets. These rocks have been referred to as 'normal' to distinguish them from a similar rock with a strongly crinkled schistosity.

(ii) "Crinkled" Pelitic Schists: These are bronze coloured micaceous and garnetiferous schists showing intense crinkling of the foliation. This microfolding has given rise to herringbones or chevron folds. With the increase in the intensity of the folding,the hinges of the chevron folds at many places have broken along the axial plane

giving rise to a strain-slip cleavage. These schists exhibit very well developed pucker lineation.

The author has intentionally considered the above two varieties of pelitic schists separately, as the investigations have revealed that the normal and crinkled varieties show textural and mineralogical characters distinctly related with the important deformational and metamorphic events.

Semipelitic Schists:

This group includes schists with less mica and more quartz. Best described as siliceous mica schist, in this type the quartz forms a considerable bulk of the rock. The micas and the garnet are proportionately less. These are hard and compact rocks and are seen to consist of quartz and micas with some garnets. In a way the siliceous mica schists represent the transitional rock types between pelites at one end and the psammites at the other.

Phyllonites:

These rocks are of light grey colour and confined to a few shear zones in the pelitic and semipelitic schists, and appear to have originated by intense mylonisation due

to differential slipping. They are seen to consist of finegrained aggregates of sericite, chlorite and fine granules of quartz (In most cases, the subsequent metamorphism has resulted into the formation of big biotite porphyroblasts grown across the foliation. The recrystallised and crinkled varieties have been described later in Chapter V).

Graphite Schists:

This variety is recognised in the field by its black colour and soapy touch. It soils the finger and easily marks the paper. It is a dark grey, finegrained, foliated and friable rock. It shows fine schistosity defined by parallel arrangement of mica and graphite. The essential minerals that constitute the rock are quartz, graphite, muscovite and sericite.

Psammites:

These are highly siliceous rocks, consisting mostly of quartz with small amounts of felspar and mica, and are of the nature of flaggy quartzites. These rocks are characterised by the presence of frequent films and thin layers of micaceous material, and these tend to impart a strong fissility to the rocks. The amount of mica in these

quartzites is variable and on the basis of the mica content and the flagginess, two varieties of these psammitic rocks have been recognised:-

(1) Grey sub-foliated quartzitic flag with more frequent micaceous layers.

(2) Unfoliated quartzitic flag with less frequent micaceous layers.

These flaggy quartzites occur as intercalated layers in pelitic and semipelitic varieties of schists.

Gneisses (Migmatites):

These are coarse to medium grained leucocratic rocks and show considerable textural and mineralogical variations. Based on the field study, the gneissic group can be classified as under:-

(a) Coarse grained porphyroblastic gneiss: Coarsely foliated rock with abundant porphyroblasts of felspar, the groundmass consisting of felspar, quartz and micas - both biotite and muscovite.

(b) Augen gneiss: Less felspathic than the former, lacking in porphyroblasts; instead the felspars occur as augens which are uniformly scattered and invariably wrapped

round by the selveges of mica. Augens appear to have grown as eye-shaped grains by pushing apart micaceous folia; foliation due to parallel orientation of micaflakes.

(c) Streaky permeation gneiss: Finer in grain size than the previous variety, containing felspar as small elongate grains which are seen wrapped round by micaflakes.

(d) Tourmaline gneiss: Gneissic rocks containing the usual quartz, felspar, micas and large number of tourmaline needles either as clusters or in an oriented fashion giving rise to a marked lineation.

(e) Felspathic schists: More or less schistose and micaceous, transitional rocks containing small felspar grains. As compared to schists, these contain more felspars but while compared to the above mentioned varieties, the felspar content is much less.

Calc-silicate rocks:

These occur as thin layers in pelitic and semipelitic rocks. Generally 3 to 5 cm. thick, consisting of medium to finegrained aggregate of quartz, amphibole needles and cinnamon coloured garnets. One variety is a finegrained, rather greenish grey rock with amphibole and little garnet, while other a mediumgrained rock with considerable garnet

and less amphibole needles.

Quartz veins:

These occur in almost all parts of the area in varying abundance. They show rather sharp contacts with the country rocks and are quite often involved in folding.

DISTRIBUTION AND FIELD CHARACTERS:

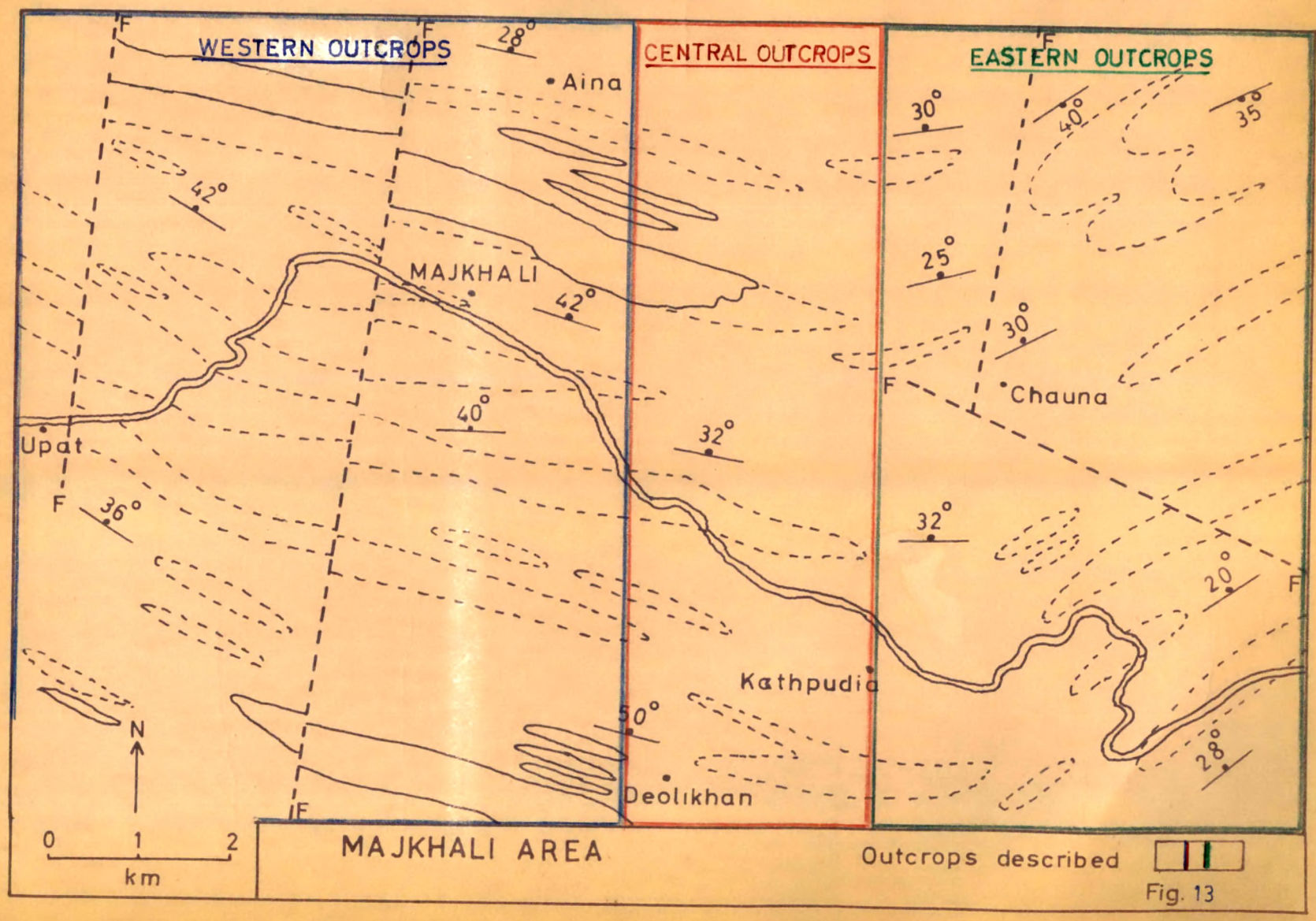
The various lithological types described above are seen in the field to form recognisable outcrops. But few of them can be traced for considerable distance along the strike. On account of the absence of sharp contacts between the pelitic and semipelitic types, and also as there is considerable lithological variation even along the strike, it is somewhat difficult to build up a precise succession of the various groups. However, considering the northerly dips of the foliation, a very broad and approximate sequence can be worked out. As the entire rock assemblage of pelites, semipelites and psammites is a result of early repeated isoclinal folding, the original sedimentary sequence cannot be established, and the succession putforth below is essentially a structural one.

	Thickness (in metres)
Garnet mica schists	0 to 1100
Flaggy quartzites	0 to 220
Siliceous mica schists	0 to 550
Migmatitic gneisses	0 to 880
Garnet mica schists with graphitic layers and phyllonitic rocks	0 to 1680
Flaggy quartzites	0 to 650
Siliceous mica schists	0 to 1100
Migmatitic gneisses	0 to 440
Garnet mica schists	0 to 1680
Flaggy quartzites	0 to 660
Garnet mica schists	0 to 1000

Neither a single locality nor any single traverse would show a complete succession. The author, therefore, proposes to describe the field characters of the various lithological units areawise, as this scheme will enable the reader to get a complete picture of the rock types as they occur in the field. It should be noted that the isoclinal folding on a regional scale, has perhaps caused the repetition of a single group more than once, when traced from one end of the area to the other.

In the following pages, a detailed and systematic description of rock types has been given. In addition to lithology, a critical account of the various structural elements has also been given. The present investigation has amply revealed a series of three successive folding episodes, each having left its imprint on the rocks. It is worthwhile to mention here, that the main foliation of the area - the schistosity (S_1) marks the axial plane of the earliest isoclinal folding (F_1), while the related lineation is parallel to the foldaxis. The folding of the schistosity due to a later deformation has resulted into widespread development of EW chevron type microfolds, a strain-slip cleavage and a late pucker lineation. The last folding episode that has left faint impression on the rock is that on open NS folding giving rise to gentle flexures. The structural aspects of the area have been discussed in a subsequent chapter.

The rocks of the area, for the convenience of description, have been divided into three major groups (Fig. 13):-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Outcrops described

Fig. 13

(1) Western outcrops: From Upat in the west to east of Majkhali.

(2) Central outcrops: From Majkhali upto Kathpudia in the east.

(3) Eastern outcrops: From Kathpudia to further east marking the limits of the study area.

Western outcrops:

Good exposures have been recorded in the area around Upat and Majkhali, and they have been grouped as under:

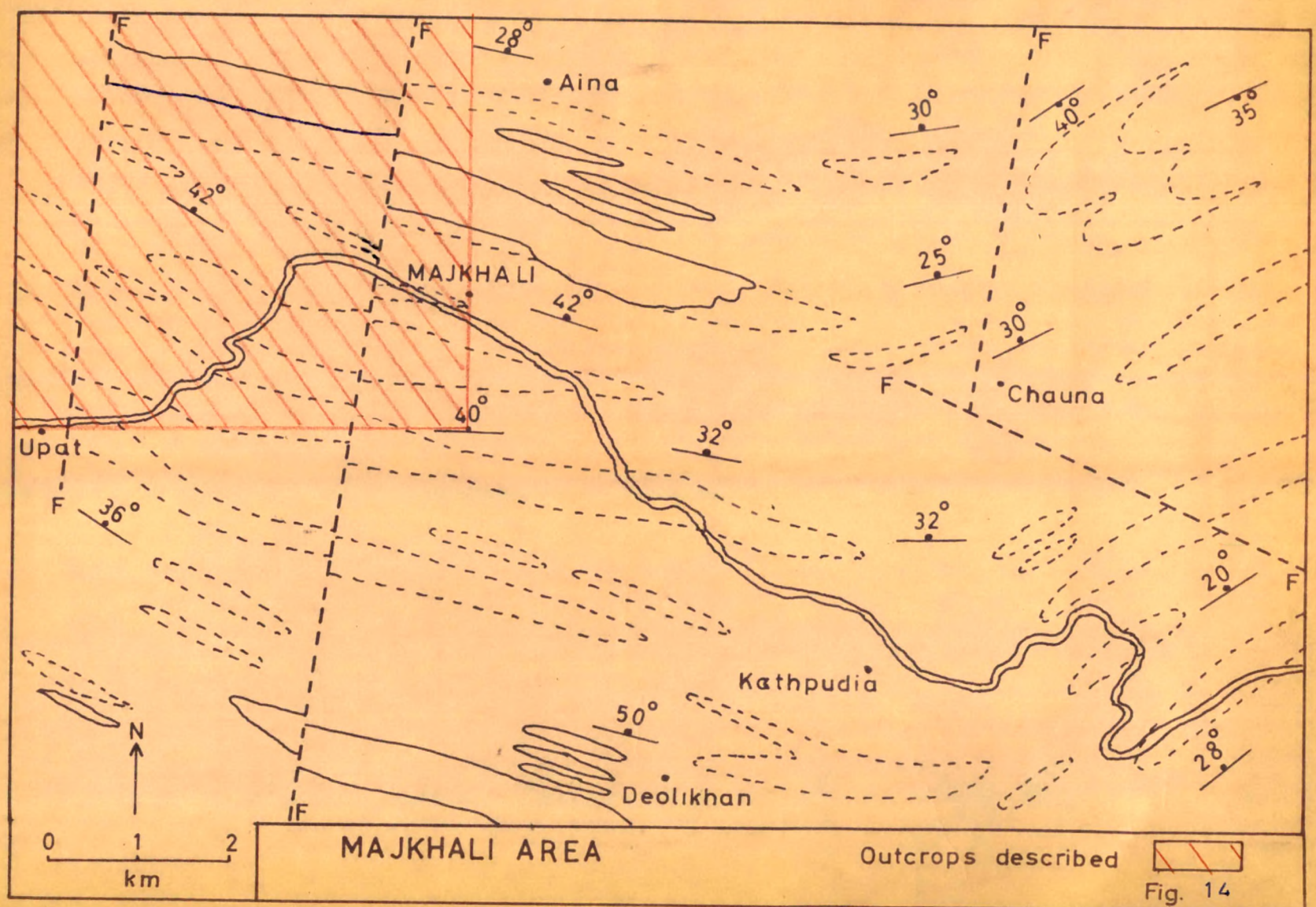
(i) Exposures to the N, NNW, NNE of Upat.

(ii) Exposures to the S, SW of Upat.

(iii) Exposures around Majkhali.

Exposures to the N, NNE and NNW of Upat consist of garnetiferous mica schists, migmatitic gneisses, siliceous mica schists and graphite schists (Fig. 14).

The garnetiferous mica schists are ideally exposed in the vicinity of Upat Golf Link. They are of typical bronze colour and have a regional WNW-ESE strike with dips of about 40° to N. These schists can be traced further to the N and NW of Upat. At least three lineations are recorded on the schistosity surface. The early lineation is mostly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Outcrops described

Fig. 14

a faint striation, plunging due NE. Superimposed on this lineation, is seen a puckering, plunging very gently due WNW. A third lineation marked by faint puckers plunges in NNW direction. The folding which has given rise to this late lineation has developed occasionally NNW-SSE to N-S crinkling.

These schists are seen gradually merging upwards into the migmatitic gneisses very well seen on the road to Kalka. The thickness of the gneissic outcrop on the road is approximately 440 metres. These migmatitic gneisses mostly belong to the augen bearing and streaky varieties. The gneisses contain considerable tourmaline needles which show a characteristic linear orientation. The augen variety contains eye-shaped felspars of variable sizes (2 mm to 5 mm) (Plate 2). The groundmass is equally felspathic. The foliation is marked by parallel mica flakes.

This augen bearing variety contains patches and bands of augen free variety, better described as streaky gneisses. This variety contains small elongate felspar grains, wrapped round by mica flakes and it is clear that they represent an early stage in the growth of augens. This gneissic band

PLATE 2

Augen gneiss showing augens of felspar

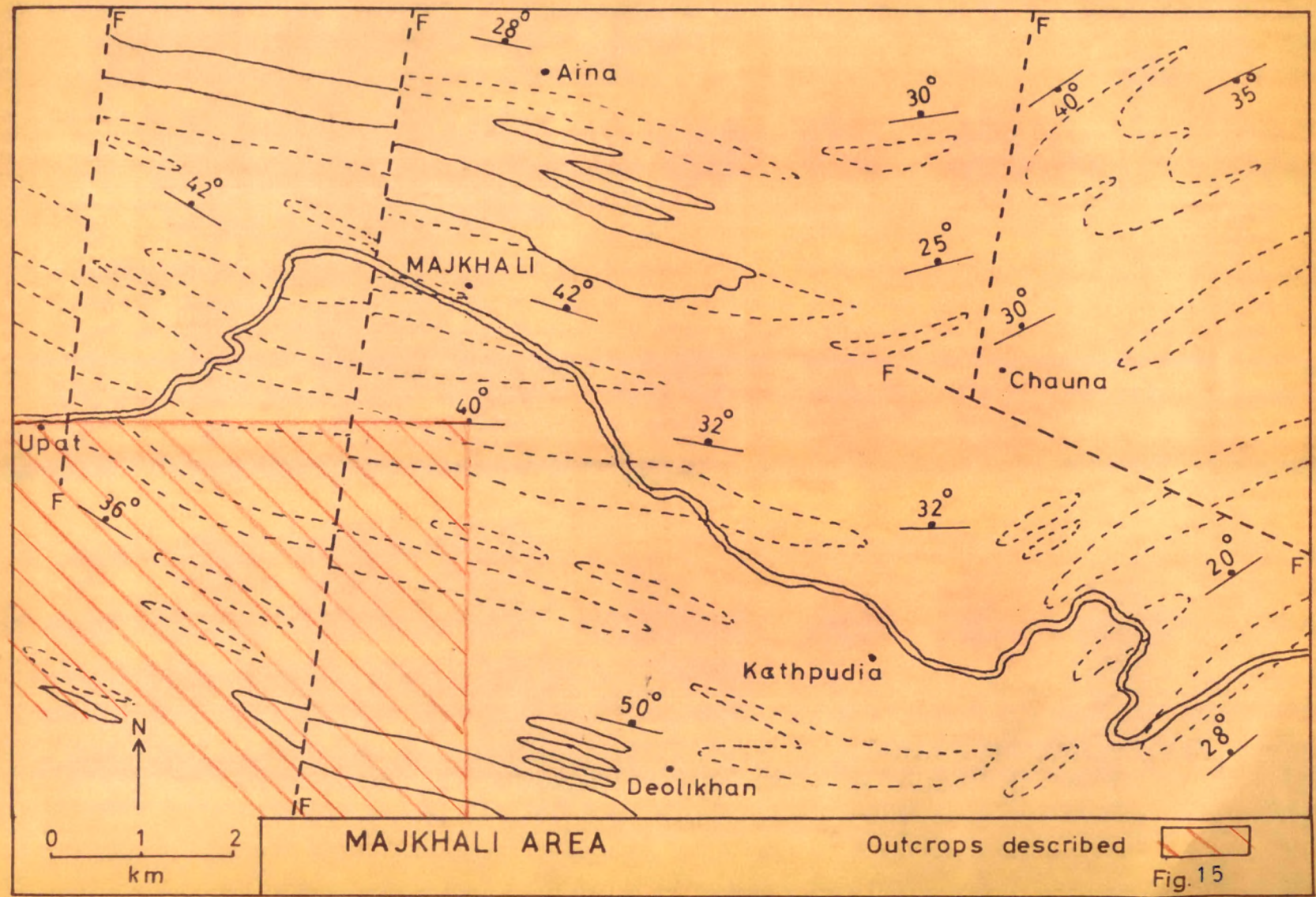
extends in the northwest to as far as Chaukhuni along the Dwarahat-Chaukhutia road. Near Chaukhuni (NW of Kalka) the migmatites are rather coarse gneissic with big idioblastic porphyroblasts of felspar (10 mm to 20 mm). A number of felspar porphyroblasts are seen to grow,cutting across the foliation. This porphyroblastic variety occupies the main median portion of the gneissic band. The groundmass consists of felspars, quartz and micas - both biotite and muscovite. The foliation is characterised by the parallel orientation of mica flakes which are uniformly distributed as streaks and tufts throughout the mass. The general trend of the foliation of gneisses is WNW-ESE with a dip to ENE though considerable local variation from place to place are noted. This migmatitic band is cut by a Nagoti-Mauna NS fault along the nala, such that its eastern side has been laterally displaced 1000 metres due south.

Above the migmatites, lie a fairly wide outcrop of garnetiferous mica schists gradually diminishing in thickness towards the west, while to the east this outcrop shows broadening and has been cut by a major NS fault following the Jaurasi nala. In the NW, these schists are seen intercalated with a small lensoid band (200 metres thick) of

graphite schist, which is ideally seen near the village Chamna. This graphite schist shows two sets of lineations - one plunging due NNE and the other as puckers plunging gently due westward.

Coming over the garnetiferous mica schists, are siliceous mica schists which are seen forming good exposures near the villages Jana, Nagoti, Malla Riuni, Dadgalia, Bano and Kotli Biant. These are rather transitional rocks, more siliceous than the mica schists. On account of the larger proportion of quartz as compared to the micas, these rocks are more compact and less schistose. These semipelites occur as lenses in the garnetiferous mica schists. Micro-folding of the schistosity is occasionally seen and on account of the siliceous nature of the rocks, the crinkling is less pronounced. The related lineation trending EW is almost subhorizontal or has a westerly plunge of a few degrees.

Exposures to the south and southeast of Upat (Fig.15) consist of garnetiferous mica schists interbanded with siliceous mica schists, flaggy quartzites and migmatitic gneisses. The garnetiferous mica schists are highly micaceous with varying garnet content. The minerals visible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Outcrops described

Fig. 15

in handspecimen are quartz, biotite and muscovite. The garnets are pink almandine type. The general trend of the foliation is WNW-ESE, with moderate dips due NE. Good exposures are observed on Dalmoti road and near Ranger's quarters south of Upat. The mica schists in this region contain a few lensoid bands of streaky permeation gneisses. Faint striations on the schistosity mark the early lineation which plunges moderately in the NE quadrant. This lineation perhaps represents obliterated cleavage-bedding intersection and is due to a slightly oblique orientation of mica flakes. A late lineation due to gentle puckering is faintly developed. It is seen plunging due N and NW. Wherever this late lineation is observed, the schistosity shows crinkling in a NNW-SSE direction. Exposures of these rocks continue in the nala SE of Upat, but here they are seen intercalated with quartzites. The quartzite layers show recumbent folding giving rise to conspicuous fold mullions ideally seen in the nala (Plate 3). These mullions plunge to NE. Here the schists show an axial plane relationship with these folded quartzites (Plate 4). A late lineation in the form of puckers in schists plunges WNW. The schists in this region contain thin streaks and pockets of graphitic material.

PLATE 3

Quartzites from Upat nala showing mullion structure.

PLATE 4

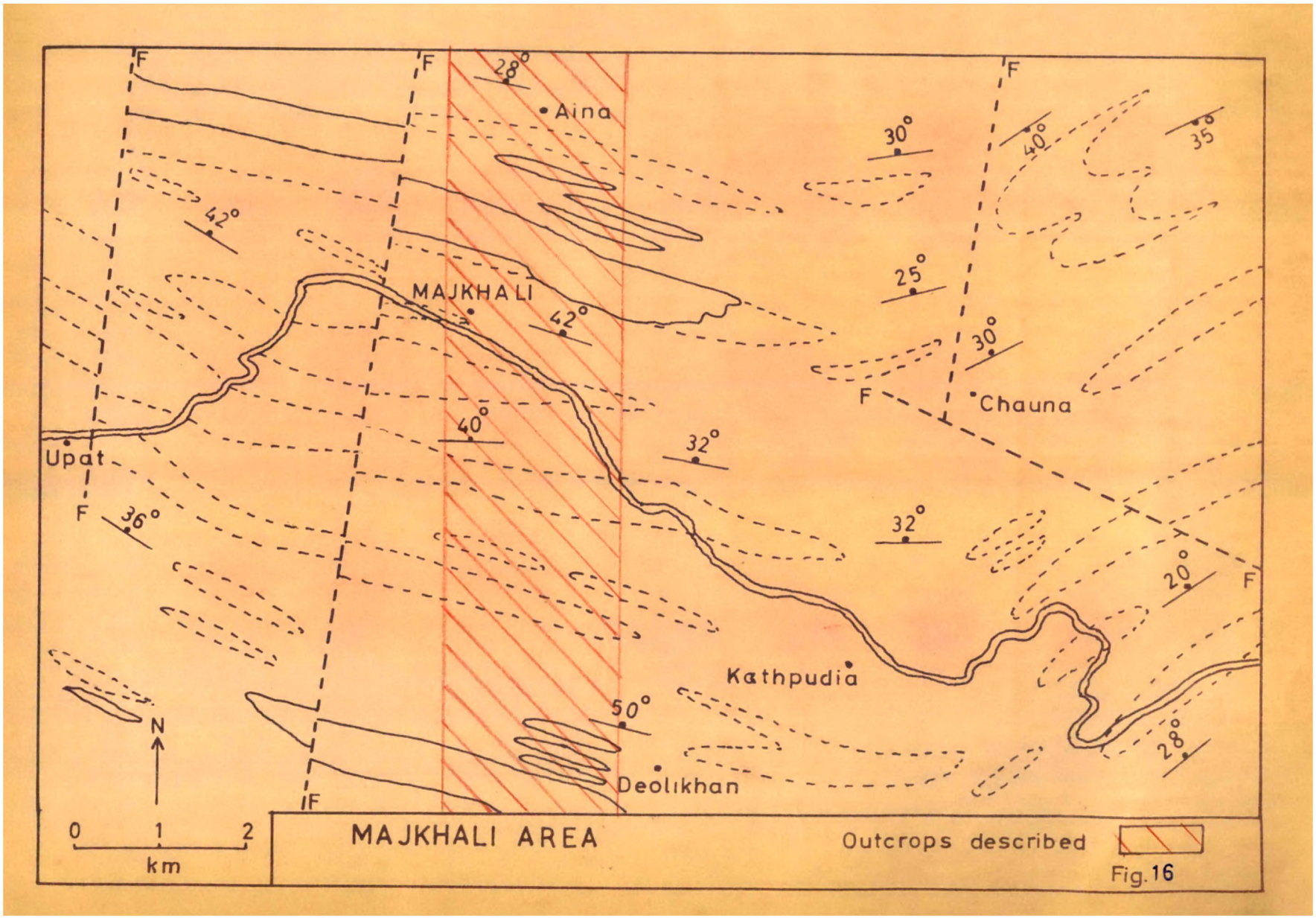
Quartzites showing recumbent fold.

Exposures around Majkhali: Ideal exposures are again seen around the village Majkhali. To the N, NW, NNE, S and SE are exposed various rocks, obviously a continuation of the different lithological types detailed above. In the tract between Upat and Majkhali, the rocks outcrop at a number of places in the villages Majkhali, Majethi, Talla Riuni, Uroli and Sugarikhal (Fig. 16).

The rocks as usual consist of garnet mica schists, siliceous mica schists, migmatitic gneisses and quartzites. On account of the intimate lithological interbanding, the variation in the rock types from place to place is well marked.

The regional trend of the foliation is WNW-ESE with a dip due ENE but occasionally it swings to EW as well. Moreover considerable variation in dips is also seen. About 8 to 10 calc-silicate bands of about 10 to 20 mm. thickness are observed in these schists.

North of the village Majkhali, the garnet mica schists form conspicuous exposures across the cultivated fields. These northern outcrops of schists show marked crinkling and the development of herringbones. On the whole the proportion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MAJKHALI AREA
Outcrops described

Fig. 16

of garnet is somewhat decreased. At times the weathering has imparted a characteristic red coloration to the schists. These schists show only pucker lineation plunging WNW. Significantly, in this region this lineation occasionally plunges due east,of course with a small angle of a few degrees only. A few folded quartz veins are present in these schists whose fold axis also plunge gently to WNW. Calc-silicate bands are scarce and only occasionally recorded. When present, they contain large actinolite needles and big garnets (10 to 20 mm.). One such band is noted on the road leading to Tikhunkot near the bifurcation towards Koirala. Quite a few places in these outcrops, schists show considerable bluish grey colour on account of the presence of graphite.

The pelitic rocks very often tend to be siliceous and are seen interbanded with compact siliceous mica schists. The colour of this siliceous variety is rather dark greyish. Both the north-easterly and westerly lineations are observed. The above mentioned group of pelitic and semipelitic schists with graphitic layers, extends SE of the villages of Aina and Dhankoli.

These micaceous rocks are overlain by psammitic rocks. North of Majkhali, these rocks occupy most of the tract between Tikhunkot and Koruchhina. Mostly the rocks are greyish flaggy quartzites, consisting of siliceous layers separated by thin micaceous layers and partings. On account of well developed joints, these quartzites yield big slabs (Plate 5). The surfaces of the quartzites show well developed lineation due to the oblique orientation of mica flakes. The lineation plunges due NE.

Further north, towards the limit of the area, the quartzites are seen passing upward rather abruptly into pelitic rocks. Again, the garnet mica schists with more frequent graphite layers and phyllonitic rocks are encountered. Several small lenticular patches of quartzites are also noticed in these schists.

The phyllonites though extending for considerable distance are restricted to narrow zones only. These rocks have obviously developed along a major shear zone. These rocks show a WNW-ESE to E-W foliation with a dip of 30° to 50° towards N and are ideally recorded across the villages of Aina, Bhainskhet. These highly sheared finegrained rocks of grey colour, show a characteristic faint crinkling

PLATE 5

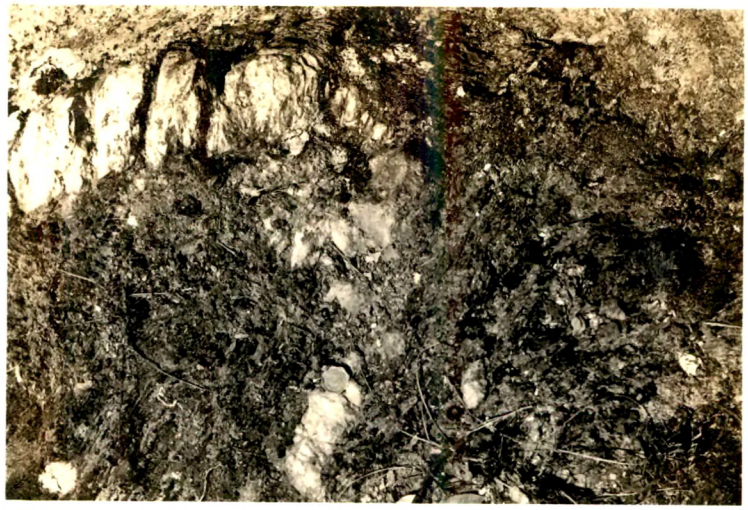
Joints in quartzites

and widespread development of biotite porphyroblasts almost at right angles to the foliation.

The areas immediately to the south of Majkhali are poor in exposures on account of cultivated fields, but here and there, scattered outcrops of garnet mica schists are observed. In general, the proportion of garnets in these schists has decreased and the colour is somewhat yellowish and shining due to a larger proportion of muscovite. Lineations in the form of faint striation, though on the whole scarce, are occasionally recorded and are seen to plunge due NE. Thin quartz veins folded recumbently form quartz rods which also plunge in the same direction. Quartz veins in these schists also show open EW folding. One such quartz vein is seen forming a typical fold mullion(Plate 6) near the Air Force water reservior well exposed on the southern foot tract. This mullion plunges due west. On proceeding further south the schists show intense crinkling and chevron folding (Plate 7), with occasional development of a strong strain-slip cleavage and puckers related to this folding. This pucker lineation plunges due WNW.

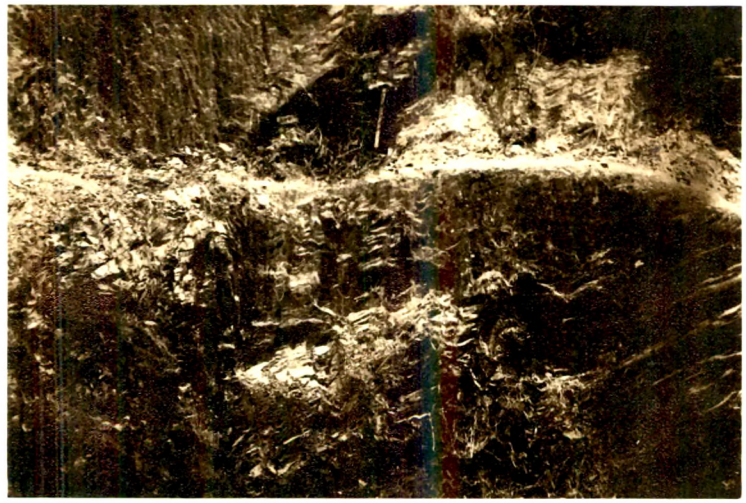
These garnet mica schists when traced southward gradually pass below into siliceous mica schists. These

PLATE 6



Quartz vein folded on F_2

PLATE 7



Schists showing chevron folding

schists are farily compact and contain a few small pockets of graphite schists.

In two conspicuous hills, immediately to the WSW of Majkhali village, these siliceous mica schists are seen capped by a quartz-tourmaline rock. These rocks occupy the upper portions of the hill and are seen dipping 50° due north. These peculiar siliceous rocks are highly crushed and sheared and their true nature difficult to make out.

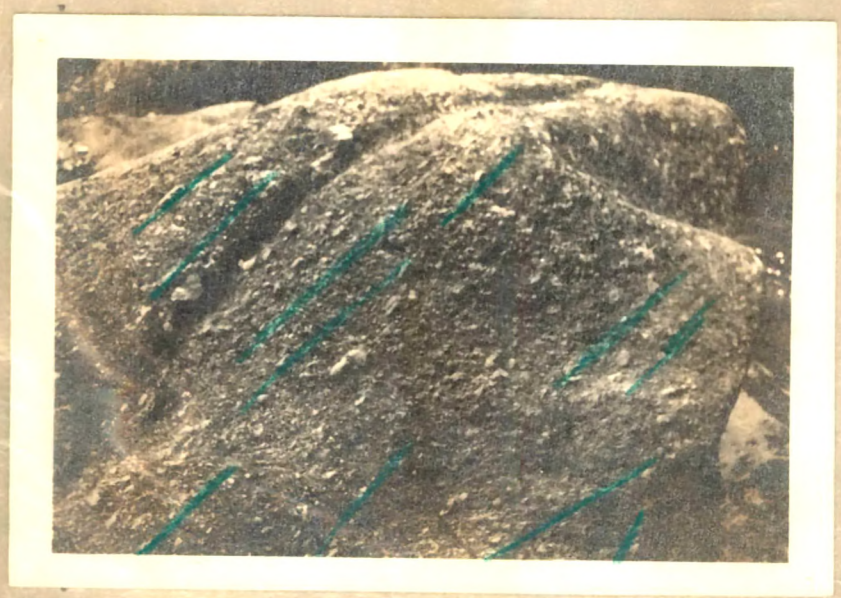
The siliceous mica schists also contain occasional calc-silicate band parallel to the schistosity. Strong puckers have developed on pelitic partings, and these mark the dominant lineation, plunging generally with a small angle to the west. Although the frequency and number of EW crinkles and chevron folds are not much, but wherever they occur, they are very clearly developed. In general, it was observed that the chevron folds are such that their axial planes steeply dip due north.

The siliceous mica schists southward merge into garnet mica schists, which in turn merge into migmatitic gneisses. These highly felspathic rocks form a distinct

440 metres wide band (obviously a continuation of Kalka band described earlier) extending roughly ESE and passing through the vicinity of the villages of Uroli, Manbajaun, and Sugarikhal etc. The rocks show a coarse foliation due to micas, which conforms with the schistosity of the overlying and underlying schists. These gneisses are well exposed in the nala south of Sugarikhal. Grey coloured coarsegrained both porphyroblastic as well as augen bearing varieties are seen. The rocks have very frequently developed tourmaline rich patches. Conspicuous outcrops of tourmaline bearing gneisses, somewhat finer grained, are recorded in the area near Uroli, SE of the nala exposures. The tourmaline needles occur either as radiating clusters or as small needles oriented in a regular fashion. These gneisses also show orientation of felspar porphyroblasts (Plate 8). The trend of the tourmaline needles as well as the felspar porphyroblasts roughly conforms with that of the early striations so commonly seen in the adjoining schists.

The gneissic band is seen underlain by garnet mica schists again. To the south, the gneisses are seen passing into felspar free schists, the contact of course

PLATE 8



Felspar porphyroblasts showing orientation

is not very gradual, but is still considerably diffused. The trend of the foliation as usual is WNW-ESE with local variations. Occasionally, the early NNE plunging lineation is seen on the foliation, but the dominant lineation is the late one, characterised by the axes of well developed chevron microfolds. Its plunge here is due west. The villages of Bhatulya and Jhasani lie on these schists.

A band of flaggy quartzites about 660 metres wide occurs in these schists. This psammitic rock forms very conspicuous outcrops. It is a typically white coloured rock with well developed parting planes. The bedding is clearly marked by the thin micaceous layers, so frequently present. On a careful scrutiny of these micaceous laminae, it is seen that they lie somewhat oblique to the main bedding. This oblique orientation obviously marks the schistosity (which is only slightly different from the bedding orientation) and the cleavage-bedding intersection has given rise to a very marked lineation on the bedding surfaces.

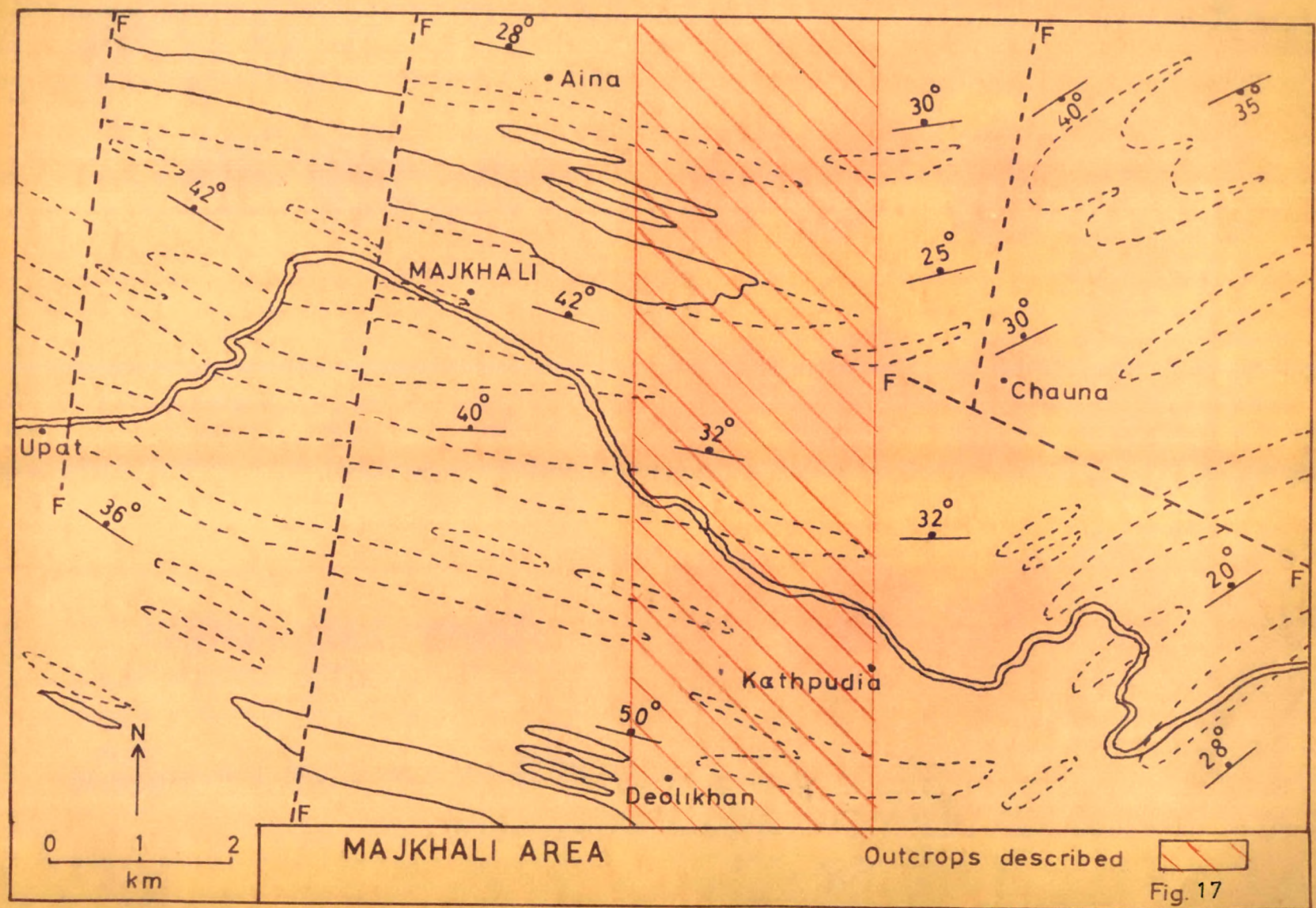
The strike of these quartzites fluctuates between 90° to 150°, the dips are as usual to the N or NE with

angles of 35° to 55°. Occasional minor folds - fairly open, related to the late NNW-SSE fold are recorded whose axes are seen plunging due N 10° W.

Central outcrops:

To this group belong the outcrops to the NE, E and SE of Majkhali, almost comprising the central part of the area lying between North Latitudes 29°39'30" to 29°42'15" and East Longitudes 79°32'30" to 79°34'45" from Majkhali to Kathpudia in the SE. Outcrops to the east and north-east of Majkhali lie to the north of the road going to Almora, while the south-eastern exposures fall to the south of the road (Fig. 17).

Exposures to the north of the road: The garnet mica schists recorded at Majkhali are seen extending north and eastward and form very good exposures around the villages Aina, Dhankoli, Bhainskhet, Gallichhina, Machhaliya, Koirala and Khauri. The constituent rocks are for the most part, garnetiferous mica schists. In the extreme northeast, these schists contain graphite. These pelitic rocks are comparatively free from siliceous layers and show strong development of chevron folds. Though the trend of the schistosity is E-W, it is intensely microfolded as a result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MAJKHALI AREA
Outcrops described

Fig. 17

of which a strong strain-slip cleavage and the related lineation has frequently developed. This lineation plunges rather gently due W, WNW, E or ESE. In fact, it is the only well marked lineation recognised in this area and is most widespread. As the quartzite layers are scarce, the early recumbent folding and the related lineation are not so well developed in this part. Wherever the early lineation (a sort of cleavage-bedding intersection) is developed, its plunge is seen to be as usual to the NE.

The garnet mica schists to the north become rather graphitic and this graphite content is responsible for the dark grey colour of the schists, SE of Bhainskhet. In the graphite schists, the NNW plunging lineation (puckers) is frequently recorded. Obviously this lineation is connected with the third folding.

The graphite schists contain occasional bands of calc-silicate rocks, 20 to 30 cm. thick. These calc-silicate bands are boudinaged and show typical sausage-shaped lenses. A number of quartz veins are present which show pinch and swell structures (Plate 9). The graphite schists occasionally show rather big E-W folds of several

PLATE 9

Quartz veins showing pinch and swell structure

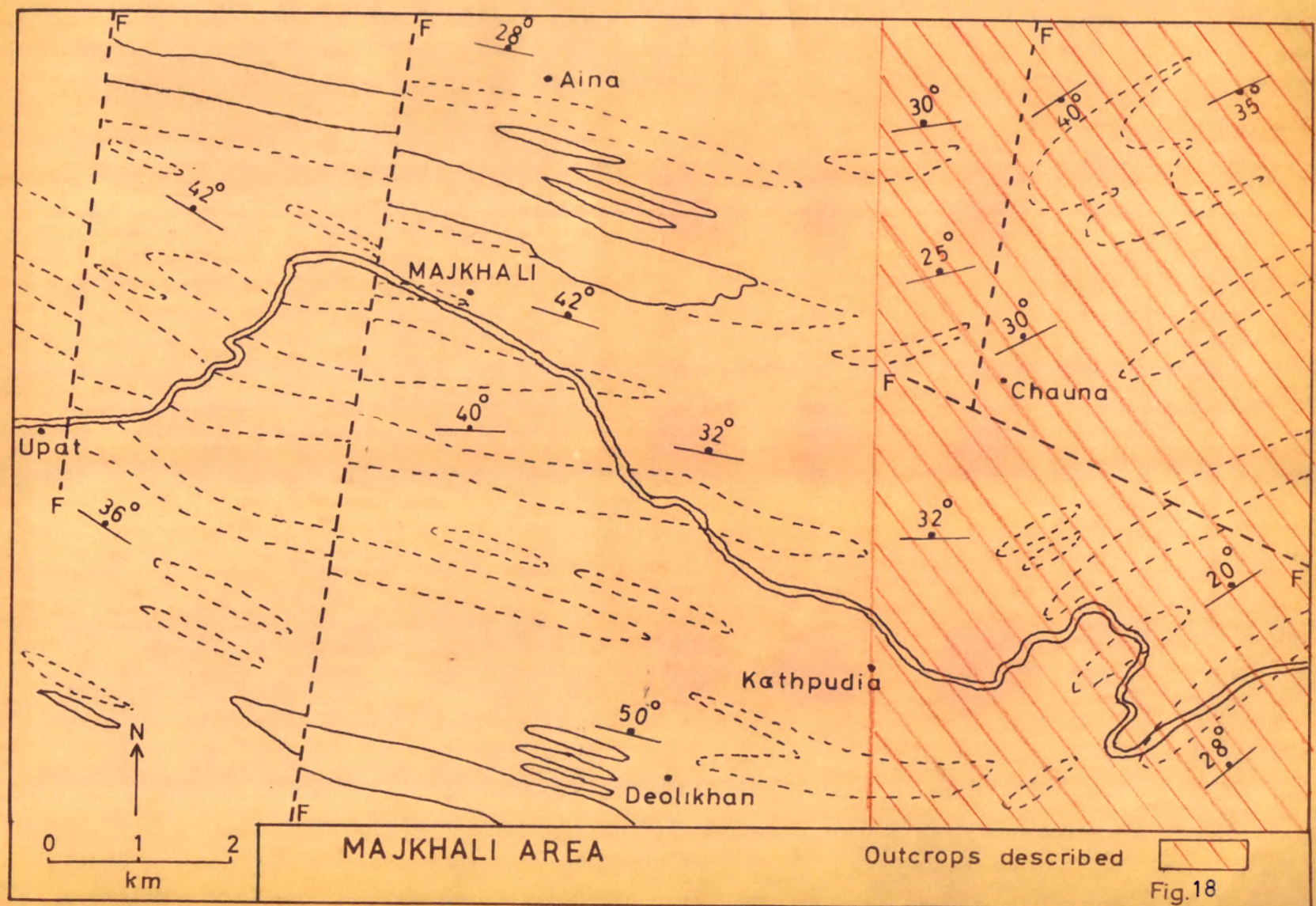
metres size. One such fold is recorded to the NE of Koruchhina, on the foot-tract to Gallichhina. This fold has an axis which plunges due WNW.

Exposures to the south of the road: Outcrops to the south of the road and west of the village Kathpudia consist mainly of garnet mica schists with frequent layers and lenses of siliceous mica schists. The foliation trend is seen in these outcrops to take a swing from WNW-ESE to E-W and then ENE-WSW, of course the dips continue to be due N, with variable angles. The schists of this area show very strong chevron type microfolding. The fold axis and the pucker lineation is very prominent and shows a plunge due ENE. The early lineation shows a plunge due WNW.

Eastern outcrops:

These include the exposures in the eastern part of the area, generally to the N, NE, E and S of Kathpudia. Ideal exposures are located in the villages Takauli, Bangsar, Papoli, Chhanar, Ramra, Pankot, Bhagoti, Gurna etc. (Fig. 18).

The various lithological types recognised in the western and central part of the area, obviously continue in this region, but characteristically enough, the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MAJKHALI AREA
Outcrops described

Fig.18

foliation trend is seen swinging to NE-SW. The area thus forms large open synformal structure plunging due NNW.

The rocks in the extreme northeastern corner of the area, typically show a big synformal structure - its axial trace being WNW-ESE. This fold is brought into this position by a major Daulagad nala fault trending NNE-SSW and it is likely that to the west of this fault, this fold exists perhaps further outside the area. It is interesting to record that this synformal structure is truncated to its south by NW-SE trending Nana Kosi river fault.

The rock types in the portion bound by these two faults, show very interesting lithology and structure. In the southern part of this segment, the dips of mica schists are due NW but when traced northward, they show dips to the SE and these are seen to pass into gneisses that form an 'E' shaped band. This migmatite almost wholly forms the south dipping northern limb of the E-W synform (referred to above), and its shape very clearly reveals that these felspathic rocks form a folded band,

perhaps of a very early generation. The schists are seen passing into the gneisses, the contact being quite diffused. It is significant to record that the main schistosity which is NE-SW cuts across the gneiss-schist contact. A lineation due to orientation of the porphyroblasts of felspars shows a plunge in the SSW direction (Plate 10).

The gneisses are mostly of augen bearing and porphyroblastic type. Good exposures are seen in the hills at Selani, Kestra and Rikhal. To the immediate east of these gneisses, are recorded siliceous mica schists. In general it can be said that to the west and south of this gneissic band, occur garnet mica schists, while to the east, the dominant rocks are siliceous mica schists.

The rocks around Kathpudia, and to its immediate E and NE are mostly the usual mica schists of typically bronze colour. The strike of the foliation is NE-SW with the dips of 30° to 40° due NW. These schists show fair amount of crinkling. The related lineation is seen quite frequently plunging due NE. The early lineation, however, plunges due WNW.

PLATE 10

Gneiss showing orientation of felspars

Interbanded with these, are graphite schists exposed at Kayala village on the Kathpudia-Almora road. Two small lenses of graphite schists have also been observed between Koirali and Sundra villages.

Further east, outside the limits of the area, these garnet mica schists gradually tend to become rather siliceous, and the foliation trend also is seen to swing back to as much as EW.

In the area to the south of Kathpudia, there is a widespread interbanding of garnet mica schists, siliceous mica schists, graphite schists and flaggy quartzites. No single rock type forms distinct outcrops traceable for some distances. On the whole, siliceous rocks tend to dominate.

The intensity of crinkling is more in garnetiferous mica schists and less in siliceous schists. These schists show two lineations - one plunges due WNW and the early one due NNW. The pucker lineation shows a plunge due NE.