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EVIDENCE OF MULTIPLE DEFORMATION IN THE ROCKS OF KARAKAR PASS AREA, SWAT, N.W. PAKISTAN

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ABSTRACT

Lithologically the Karakar Pass area is divided into Swat granitic rocks, Alpurai schists, and Nikanai Ghar Marbles. These rock units have undergone at least three different phases of deformation (D1, D2, D3).

D1 produced a pervasive regional foliation S1, mineral lineation L1, and tight to isoclinal, NW-SE oriented F1 folds. S1 is generally parallel to original layering (So) and axial-plane to F1 folds. D2 folded S1 into open, upright F2 folds, with north-south axes. It locally caused the development of an S2 crenulation cleavage. D3 resulted into small to large scale, east-west oriented, cross folds (F3).

In the Karakar Pass area the Swat granitic rocks and the Alpurai schists from the hinge and the southern limb of the east-west oriented large recumbent F3 fold. To the south, the Nikanai Ghar Marbles are interpreted to form a large fault-and-fold nappe, herein named as the Nikanai Ghar Nappe".

INTRODUCTION

The Karakar Pass area marks the south western corner of the topo sheet No. 43 B/6 of the Survey of Pakistan. To the north of the area lies the Main Mantle Thrust (MMT), which is the western extension of the Indus-Zangbo suture zone (IZS). The IZS is commonly agreed upon to mark an important boundary along which the Indo-Pakistan plate subducted under the Tibetan land-mass (Powell and Conaghan, 1973; Le Fort, 1975, Gansser, 1980).

Previous work carried out in the lower Swat-Buner region is mainly reconnaissance, regional tectonics, or establishing regional stratigraphy (Martin et al., 1962; King, 1961; Tahirkheli *et al.,* 1979; Kazmi *et al.,* 1984; Rosenberg, 1985; Ahmad, 1986; Lawrence *et al.,* in Prep; Ahmad *et* al., this volume). This paper presents a detailed structural analysis of the Karakar Pass area in the lower Swat-Buner region. The area is divided into five domains with internal homogeneity for D1, D2 and D3 structures (Fig. 1).

STRATIGRAPHY

The Karakar Pass area consist of the Swat granitic rocks, Alpurai schists, and the Nikanai Ghar Marbles. The Swat granitic rocks include Cambrian augen gneisses, and Tertiary(?) tourmaline granites. The Alpurai schists unconformably overlies the Swat augen gneisses, and includes (1) quartz-mica schist and amphibolite (2) calc-schist and schistose marbles and (3) graphitic schist (Kazmi *et al.,* 1984).

The tourmaline granites are present as a sill-like body showing intrusive relations with both the augen gneisses and the Alpurai schists. The Nikanai Ghar Marbles consist of massive to thick bedded, coarsly crystalline, and partly dolomitic marble, with lesser amount of quartzite, calc-schists and graphitic schist. This unit is separated from the Alpurai schists by the Nikanai Ghar fault.

STRUCTURE

Northwest of Jowar village the contacts and the regional foliation dip ENE, which changes to SW and S respectively, due east of the Jowar village. Toward the northwest and southwest, the regional foliation dips on the whole more shallowly with increasing distance from the Swat granitic rocks, except in the extreme southwest where the foliation steepens and forms a north dipping monocline (Fig. 2).

The study area is characterized by the presence of a large number of small to large scale folds. These folds are associated with major folding of the lower Swat-Buner region during Himalayan deformation. Three different sets of major folds with different styles and geometry are recognized (Rosenberg, 1985; Ahmad, 1986; Lawrence *et al.,* in Prep). In the Karakar Pass area the minor, tight to isoclinal, NW-SE oriented F1 folds are associated with the larger F1 folds reported from the lower Swat-Buner area. These large F1 folds have a fold width of more than a kilometer and fold heights of at least **5** kilometers (Lawrence *et al.,* in Prep; J. Dipetro, pers. Com. 1987). Axial planes dip gently to the east.

The second set of folds, F2, are upright, open folds with north-south axes. The larger F2 folds have a fold width of about 12 to 18 kilometers and fold height of 3 to 5 kilometers in the Mingora area (Lawrence *et al.,* in Prep). The last set of folds F3 have east-west axes. The Nikanai Ghar Marbles define

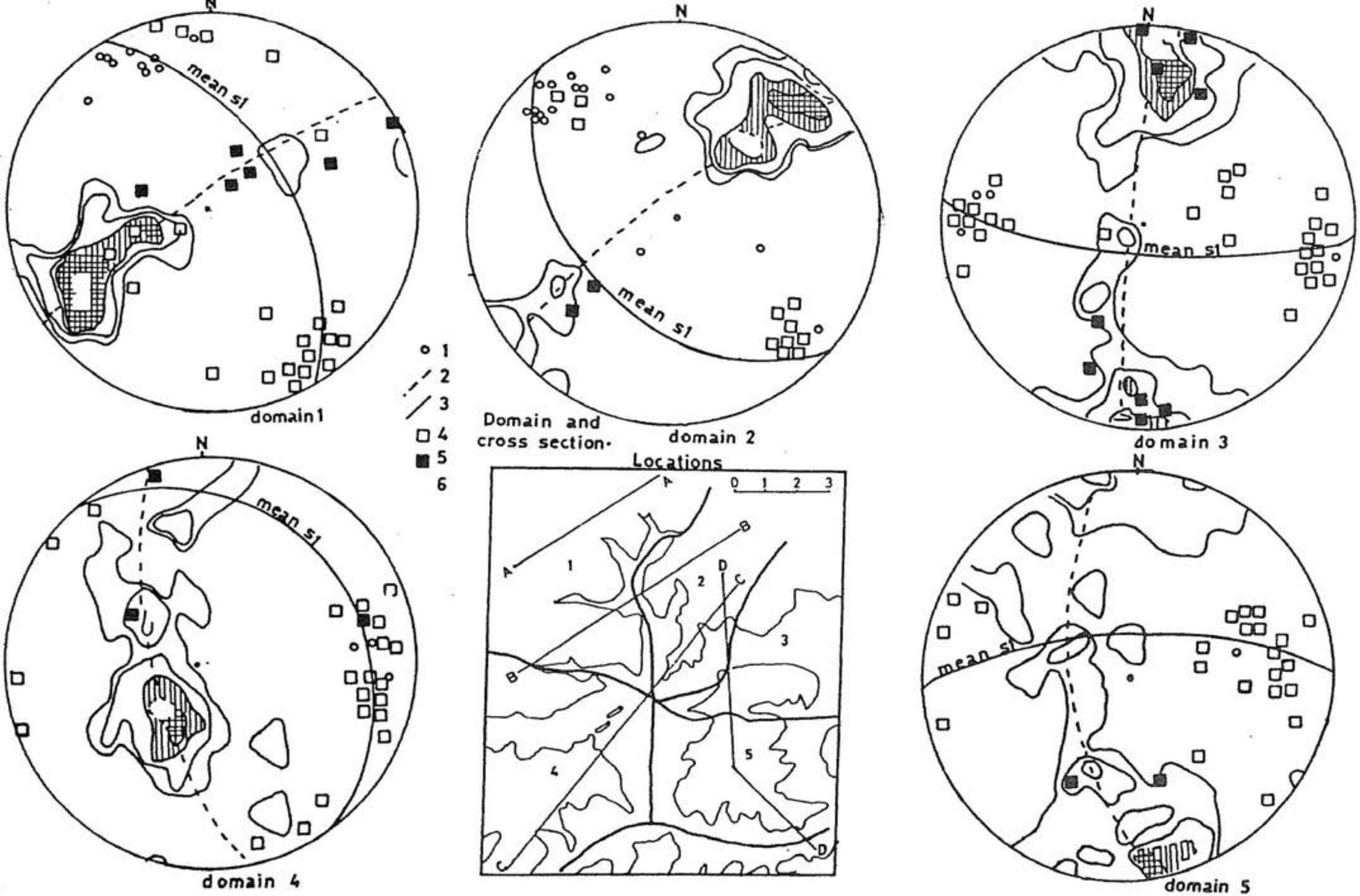

Fig. 1. Lower hemisphere equal area projections of D1 and D2 structures. Poles to S1 contoured as percentage of 1% area. Domain 1 = 63 poles, 3%, 5%, 8%, 10%, 19%. Domain 2 = 84 poles, 2%, 4%, 8%, 12%, 15%. Domain 3 = 52 poles, 2%, 4%, 8%, 13%, 17%. Domain 4 = 43 Poles, 2%, 5%, 12%, 19%, 21%. Domain 5 = 53 poles, 2%, 6%, 9%, 11%. Key to symbols: 1, L1: 2, great circle girdle to S1 : 3, mean S1 : 4, F1 axis: 5, F2 axial surface (S2); 6, satistical S_1 girdle axis.

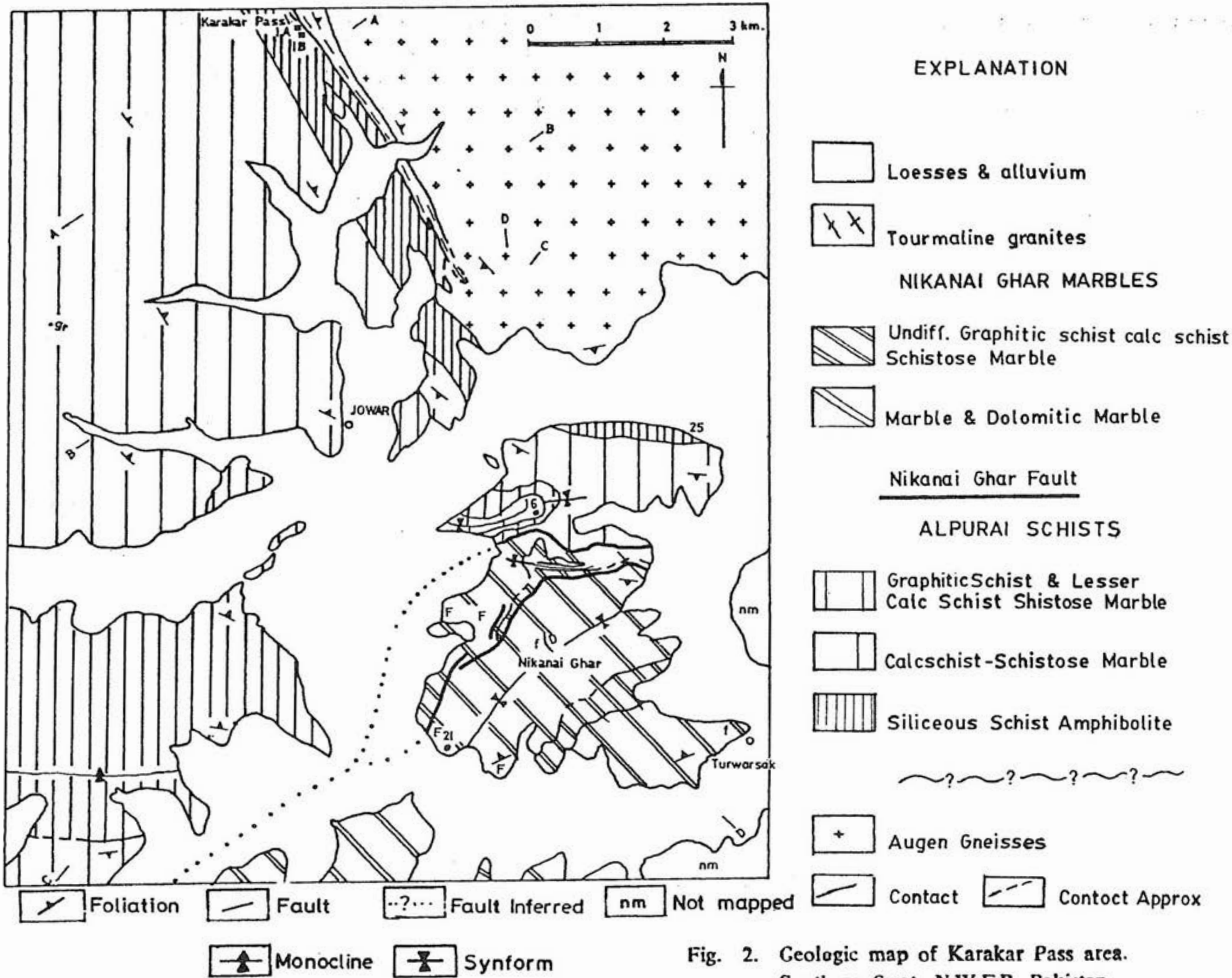

Fig. 2. Geologic map of Karakar Pass area. Southern Swat, N.W.F.P. Pakistan.

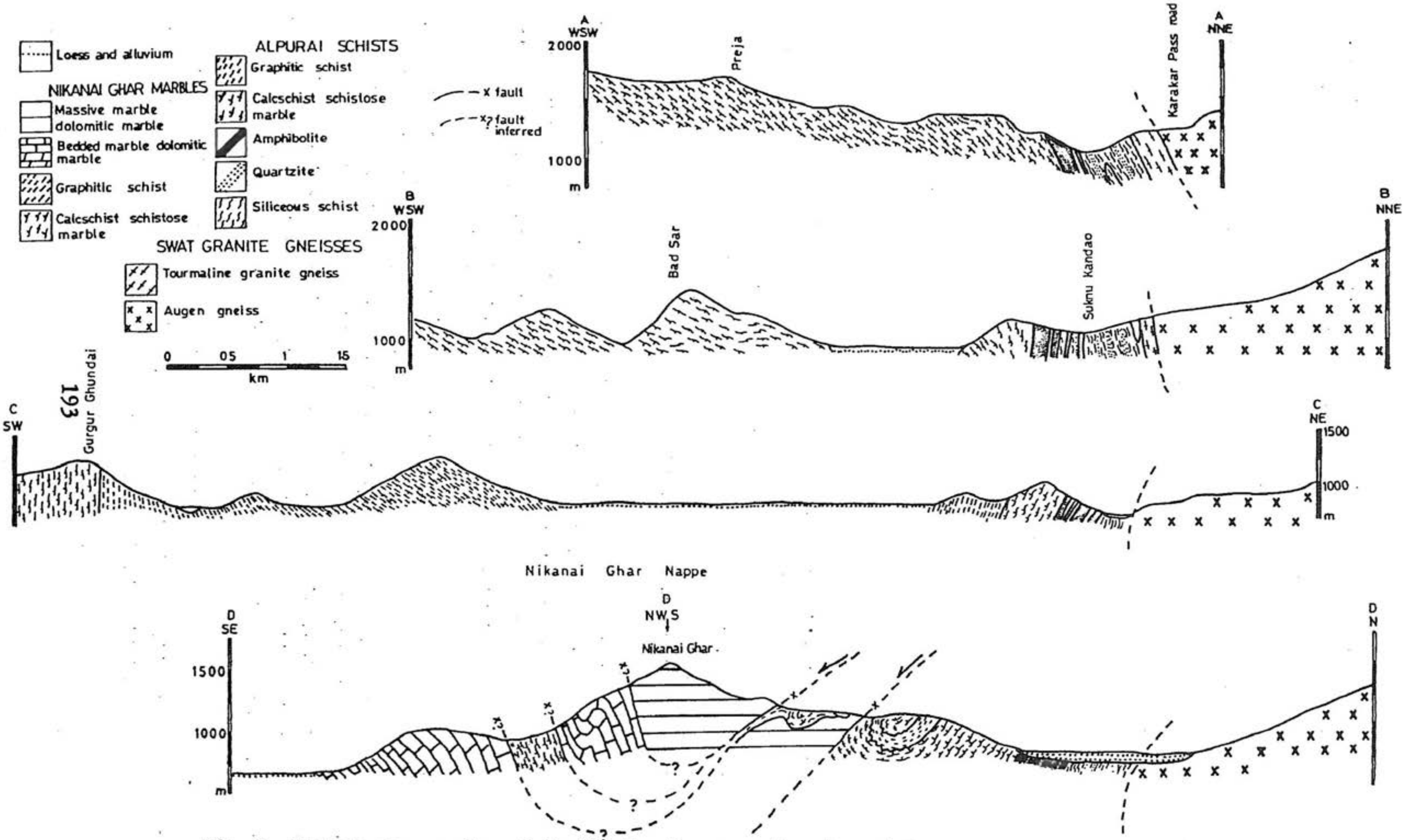

Fig. 3. Geologic cross section of the Karakar Pass area. Locations of the cross sections are shown in Fig. 2.

an F3 fold (synform) with E-W to NE-SW axis (Fig. 3). To the north of Nikanai Ghar Marbles, the Alpurai schists also defines E-W oriented synform whose southern limb is attenuated by the Nikanai Ghar fault.

The rocks of lower Swat-Buner area, from north to south, define a large overturned fold (F3) having granitic rocks in the core (Fig. 4). The Alpurai schists and the Swat granitic rocks occupy the hinge and the southern limb of the same F3 fold in the Karakar Pass area.

DEFORMATION

First Deformation (D1). The first deformation is characterized by a pervasive regional foliation, S1. In metasedimentary rocks the degrees to which S1 is developed is mostly proportional to the amount of platey or elongate minerals in the rocks. It is almost always parallel to original lithologic layering. So, and defines a bedding-plane cleavage. In the Swat granitic rocks, S1 forms the gneissic foliation. The orientation of S1 in each of the five domains is shown in Fig. 1.

Associated with D1 are several types of lineations, L1. In many places, S1 contains mineral lineation defined by the alignment of hornblende, mica, tourmaline, or feldspar augen. Other L1 include the long dimension of boudins formed by quartz veins or sills of tourmaline granites, and the rare intersection of S1 and So where these are not parallel. Tight to isoclinal F1 folds are also formed during D1. S1 is mostly axial-planer to these folds.

In general, D1 structures appear to be more strongly developed in the northern part of the area, and near the Swat granitic rocks. At these locations, grain size of syn-D1 minerals increases as do the abundance of mineral lineations and F1 folds. These differences are probably the result of change in metamorphic grade, rock type, and inhomogeneties in strain associated with D1.

Second Deformation (D2). The second deformation is characterized by abundant folding of S1. Most mesoscopic folds are F2 folds. These differ in size and vary widely in style. Competent lithologies such as quartzite and amphibolites are less strongly folded by F2, and contain open, upright folds. F2 folds in less competent rocks, such as calcareous schists, are more abundant and approach the form of similar folds. These folds are commonly represented by widespread and locally pervasive crenulation cleavage, S2, or by abundant crenulations of S1.

Third Deformation (D3). The third deformation results into the formation of large scale F3 folds (For detail see structure). Minor structures related to D3 are not well established in the study area.

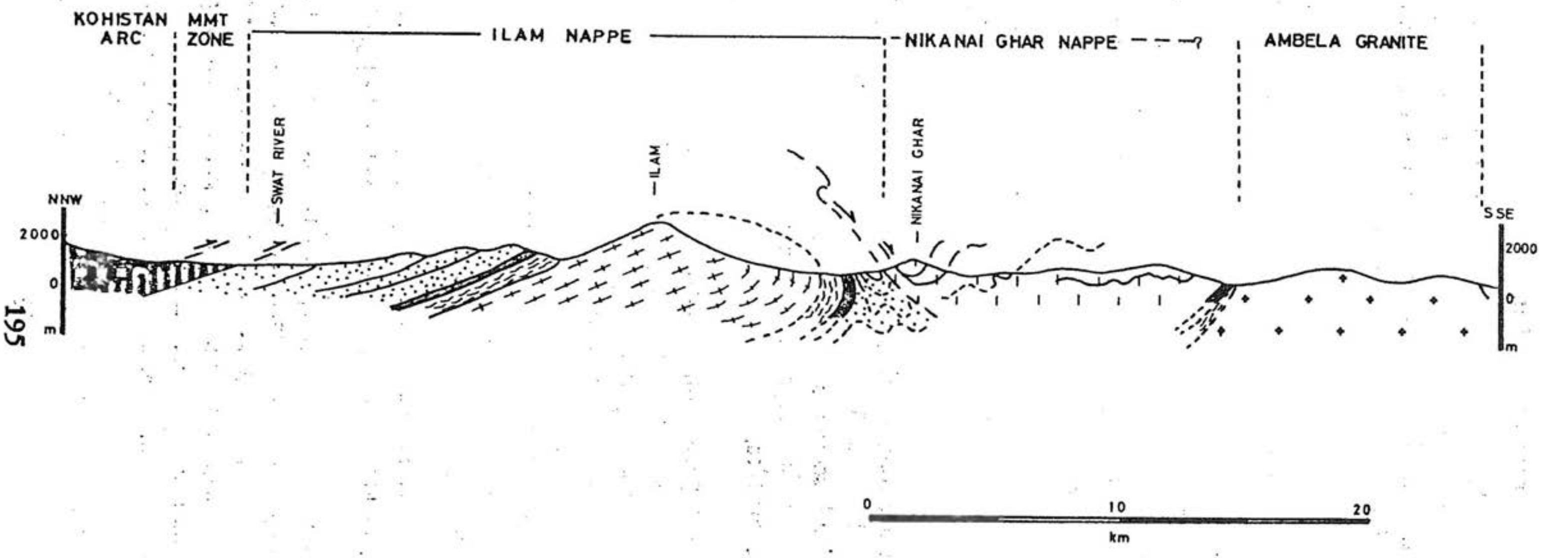

Fig. 4. Hypothetical cross section through Karakar Pass area from slightly north of the Swat river to Ambela Granite.

Evidence for faulting and nappe formation.

The presence of thin braccia horizons or shearing along the contacts between rocks of different competency suggest that faults might be abundant in the area. Several lines of evidence indicate that a complex of important faults exists on the north and west sides of Nikanai Ghar. We suggest that major displacement has taken place along these faults, named here the Nikanai Ghar fault complex, and that they have juxtaposed the Nikanai Ghar Marbles against the Alpurai schists. The following observations are considered important.

i) The entire western portion of the area is covered by the calc-schists, schistose marbles, and graphitic schist units of the Alpurai schists for about 9 km, having a mean strike ranging from NNW-SSE to NW-SE. But in the east, the Alpurai schists has an areal extent of less then 2.5 km, and the rest of the area is occupied by the Alpurai schists (Fig. 2).

ii) To the north of Nikanai Ghar Marbles the Alpurai schists is folded into a synform. The southern limb of this synform is attenuated by the Nikanai Ghar Marbles, which suggests the presence of a fault.

iii) There is a strong lithologic contrast between the Alpurai schists and the Nikanai Ghar Marbles. The attenuated Alpurai schists consists predominantly of thin layered calc-schists, schistose marbles, and graphitic schist, whereas the Nikanai Ghar Marbles is composed primarily of massive to thick bedded marbles and dolomitic marbles.

iv) The Nikanai Ghar fault complex is also indicated by the structural contrast between the Alpurai schists in the west and the Nikanai Ghar Marbles in the east. In the Alpurai schists, the mean orientation of S1 is NW-SE and dip 17° NE, whereas in the east the Nikanai Ghar Marbles, has a mean orientation of S1 striking E-W with a steep dip of 70° toward north (Fig. 1). The structure is complicated, but on the whole, it defines an E-W to NE-SW oriented complex synform. These two structural patterns between metamorphic lithologies are incompatable, unless there is a fault between them.

v) Reconnaissance in the adjacent areas shows that the structure of the mountain due east of Nikanai Ghar is a complicated faulted synform.

The amount and even the sense of displacement along these faults is difficult to determine directly. The moderate dip probably indicates that they are not strike-slip faults. A sense of displacement in which the Nikanai Ghar Marbles moved northward with respect to the Alpurai schists and Swat granitic rocks seems unlikely give the overall south-southeast vergence of the Himalaya of northern Pakistan. Therefore, we propose that the Nikanai Ghar Marbles may represent a large south-vergent block which has slid south off the rising F3 anticline to the north (Fig. 4).

CONCLUSIONS

The rock units of the karakar Pass area are penetratively deformed during DI. Associated with DI are several types of lineations L1, and tight to isoclinal F1 folds. These folds have an NW-SE axes. D2 results into N-S oriented F2 folds, L2 lineations, and S2 crenulation cleavage. During D3, the Nikanai Ghar synfrom, the E-W oriented synform defined by the Alpurai schists, and the Nikanai Ghar nappe are formed. Besides, the large recumbent fold (Fig. 4) in the lower Swat-Buner region is a also formed during D3.

The unconformity between the Precambrian to Cambrian augen gneisses and the Paleozoic Alpurai schists could neither be confirmed nor denied in the study area. All direct evidence relating to this question have been obscured by the intense Himalayan deformation, metamorphism and later intrusion of tourmaline granites. However, this unconformity has been confirmed by extensive mapping in the north and east of the study area (J. Dipetro, pers. com. 1987). The Alpurai schists and the Nikanai Ghar Marbles are separated by the Nikanai Ghar Fault which formed during D3.

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