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Petrographic and Microtectonic Studies of Rocks Exposed along Kaliguman Lineament, North-West of Udaipur District, Rajasthan

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Abstract: Metapelites, quartzites, and meta-ultramafics occur in and around village Maruwas situated north west of Udaipur district, Rajasthan. Kaliguman lineament passes through present studied area along which emplacement of meta-ultramafics took place which belongs to Jharol Formation of Upper Aravalli Supergroup. Analyses of structures carried out earlier (Chauhan, et. el., 2004a and b) from microscope to outcrop scale in the area reveal that the rocks were affected by three phases of deformations, i.e., AF_1, AF_2 and AF_3. The AF_1 folds are tight to isoclinal in nature and exhibit reclined fold geometry. The AF_2 folds are open, upright folds with vertical to sub-vertical axial planes striking NNE-SSW to NE-SW. While AF_3 folds are observed as broad warps on vertical axial plane. The area has been subjected to polymetamorphism that includes regional metamorphism followed by retrograde metamorphism. The grade of metamorphism is varying from low grade to medium grade that increases progressively from east to west, manifested by development of porphyroblastic almandine garnet with gneissic foliation in the metapelites and development of amphibolites towards the west of the area. The microstructures also reveal that the rocks of the area are deformed under low-grade to medium-grade metamorphic conditions.
Keywords Microtectonics, Aravalli Supergroup, Udaipur, Rajasthan.

I. INTRODUCTION

The lithounits exposed in northwest of Udaipur, along Kaliguman Lineament comprise low to medium grade, regionally metamorphosed metasediments. These rocks have distinct tectono-metamorphic history that, in the area under discussion, includes at least three phases of deformation and two phases of regional metamorphism. The rocks in the eastern part are of low grade, i.e., metapelites contain muscovite and biotite. Towards western margin the metamorphic grade increases slightly and the pelitic rocks exhibit increased percentage of biotite and development of porphyroblastic garnets with minor amount of muscovite. Other lithounits exposed are quartzite, dolomite, and meta-ultramafics (represented by talc chlorite schist), with minor intercalations of black phyllite (Fig.1). Almost all the lithologies exhibit a clearcut relationship between different structural episodes and metamorphic events. Microtectonic studies of different lithounits exposed in the region have been done for the first time in detail, in order to correlate the deformations with metamorphic events.

A. Geological setting

The various lithologies form a part of Middle Aravalli Supergroup of shelf sequence and Upper Aravalli Supergroup of deep-sea sequence (Roy, 1988, Roy *et.al.*, 1993 and 2002) and on the western margin; they are in contact with the quartzite of Delhi Supergroup (Kelwara Formation of Gogunda Group, GSI, 1981 & 1997). There is no decipherable unconformity observed between the rocks of both the Supergroups. However, Heron (1953) have reported a structural discordance between them. The rocks of self-facies sequence include quartzite, garnet-mica schist and dolomite with minor intercalations of black-phyllite and, are exposed in the north and northeast of village Maruwas and around village Kathar. They belong to Middle Aravalli Supergroup. The rocks of deep-sea facies, Jharol Formation of Upper Aravalli Supergroup are exposed around villages Maruwas and Chippala and comprise garnet-mica schist and meta-ultramafics with thin intercalatory bands of quartzite. The emplacement of meta-ultramafics in Jharol Formation took place along an important lineament known as 'Kaliguman Lineament" which runs parallel to Delhi-Aravalli contact. These ultramafic bodies are co-folded with the associated lithounits and exhibit all the features related to different deformational events which indicates that their emplacement occurs contemporaneous with sedimentation but prior to their deformation (Chauhan, et.al., 2004 a and b).

The regional stratigraphic succession of Maruwas is given in Table-1.

B. Deformational Events

The metamorphic rocks of the area under investigation contain structure of three recognizable generations i.e. AF_1, AF_2 and AF_3. The AF_1deformation are less conspicuous due to superimposition of second (AF_2) and third (AF_3) deformations. The AF_1 folds are isoclinal in nature and shows reclined geometry. Bedding plane (S_0) and first generation axial plane cleavages (S_1) are mostly observed parallel due to isoclinal nature of first folding. The S_1 schistosity on regional scale is marked by the parallel alignment of flaky minerals like muscovite, biotite etc. The second deformation (AF_2) is the most dominant deformation controlling the outcrop pattern of the area. These folds are open, upright, with vertical to sub-vertical axial planes (S_2) striking NNE-SSW to NE-SW. Crenulation cleavages (S_2 and S_3) are developed axial planar to AF_2 and AF_3 folds respectively. The third deformation (AF_3) is observed as steeply plunging folds with axial plane striking ESE-WSW. Early lineations (L_1), i.e., mineral and intersection lineations, which are parallel to the hinges of AF_1 folds are deformed by AF_2 folds. Deformation of AF_2 folds, L_2 lineations and S_2 cleavages by AF_3 folds are exhibited by varying amount of plunges and trends of L_2 lineations, folding of S_1 and S_2 cleavages by a broad warp on vertical axial plane (S_3) striking WNW-ESE and having steep plunges. Due to superposed deformation, intersection lineations are common features of the rocks. The intersection lineations related to all the three episodes of deformations are present in the area (i.e. L_1, L_2 and L_3). Lineations are also marked by crenulation / small-scale fold axes and boudins. The structural analyses of the present area (Chauhan *et.al*.,2004 a and b) exhibit that cleavages axial planar to AF_1 and AF_2, i.e., ($S_1$and S_2) are observed as , parallel, due to tight to isoclinal folding, except at the hinges. The early lineation (L_1) is steeply plunging either northeasterly or southwesterly, while later lineations (L_2) are sub-horizontal to shallow plunging either northerly or southerly. The younger generation lineations (L_3) have varied plunges and directions due to its development on earlier planes having varied attitudes.

II. METHODOLOGY

Besides the collected samples, about ninety fresh and unweathered rock samples were selected for petrographic and microtectonic studies under transmitted light (Olympus BX51).

A. Petrography

Textural relationships of different minerals in various rock types have indicated that the area has been subjected to polymetamorphism, i.e., regional metamorphism up to epidote-amphibolite facies (Winkler, 1976) followed by retrogression. The grade of metamorphism increases from east to west indicated by general coarsening of grain size of biotite, development of garnet porphyroblasts and decrease in the amount of muscovite. The different mineral assemblages as observed in various rock types are given below:

B. Pelitic Schists

1) muscovite-biotite-chlorite-epidote-quartz (albite) schist
2) biotite-almandine (Porphyroblastic)-quartz (□ muscovite □albite) schist

C. Meta-Ultramafic

1) actinolite-tremolite-chlorite-epidote (-quartz) schis
2) chlorite schis
3) talc-chlorite-antigorite schis
4) Serpentine (-talc-antigorite) schist

Petrographically quartzite of self-facies sequences is fine grained and comprises quartz, feldspars and incipiently developed mica. Quartz is the dominant mineral, varying between 95-98%, represented mostly by polycrystalline, undulatory and non-undulatory varieties. Quartz grains are usually inequidimensional; subhedral to anhedral in shape and the contact between them is interlocked and sutured. Feldspars consist mainly of rounded to sub-rounded plagioclase and microcline. Quartzite of deep-sea sequence is more micaceous than that of self-facies. Here, the micaceous minerals developed parallel to the cleavage plane and the quartz grain exhibit recrystallisation. Deformational features (deformational bands) are well preserved in this lithounits (Fig.2a). Quartzites of Delhi Supergroup are highly fractured and coarse grained and consist of quartz and mica, which are randomly oriented. The quartz grains show different types of grain contact. Dolomite exposed in the area is fine to medium grained in texture, ranging in size from 0.04to 0.02 mm (Chillinger, et.al, 1967). Dolomite as rock does not exhibit much mineralogical variations and comprises quartz and dolomite as major minerals. Among metapelites, which are exposed on the eastern margin of the area, is fine grained and phyllitic in nature, while towards west it becomes coarser and schistose with well-developed coarse-grained garnet (Fig.2b). Biotite and muscovite are of more than two generations and exhibit preferred orientations along schistosity. Garnets are generally euhedral of varying sizes reaching at times 10 mm across. Meta-ultramafics of the area show much mineralogical variations and are represented by actinolite-epidote schist, chlorite-schist and antigorite schist. Actinolite and tremolite occur as short, prismatic crystals to elongated needles that are aligned parallel to the schistosity (S1).

C. Microstructures

In order to reconstruct the structural and metamorphic history of the rocks, microtectonic studies of the area have been carried out which involves the identification of various deformational features in the rocks, resulting in response to different deformation mechanisms. The evidences for intracrystalline deformation are observed in quartz grains of different lithounits identified in the form of undulose extinction and deformational lamellae (Fig.2c). These features are caused due to permanent change in crystal lattice by the movement along interplanar spacing. The presence of these features indicates that the rocks of the area have deformed under retrograde metamorphic conditions. In the area, recrystallisation mainly occurs through grain boundary migration, due to differences in dislocation density between two grains. Bulging process, where grains with low dislocation density bulge into grains with high dislocation density, is observed in the quartz grains of quartzite, exposed on the western part of the area (Fig.2c). This process led to the reorganization of crystalline material; 'new grains' replace 'old grains' with high dislocation density. The grain boundary migration is also active under retrograde conditions and increases with increasing temperature, which is also observed in the rock types of the area, exposed mostly on the western margin indicating increase in the metamorphic grade on moving from east to west (Ghosh, 1978; Sharma, *et. al.*, 1988; Chauhan, et.al.,1996; Sinha-Roy, *et. al.*, 1998 p.105 and Roy & Jakhar, 2002). Deformation bands which are transition zones having approximately uniform extinction are mostly observed in quartz grains, exposed towards southwest of the village Chhipala (Fig.2a).

D. Time Relation Between Deformation And Metamorphism

There are three different phases of deformations related to metamorphic events and the interrelation of deformation with metamorphism can be demonstrated with the aid of the relationship between development of porphyroblasts of garnet, biotite and muscovite with the occurrence and geometry of the internal schistosity (Si) and the surrounding external schistosity (Se). The techniques used are similar to those applied elsewhere by Zwart (1963) and Spry (1963). The method involves a comparison of time relations of minerals to each other and inclusions of one mineral into another and comparison of the internal fabric defined by an array ofinclusions (Si) of a porphyroblast, with the external fabric (Se) of the host rock (Offler & Fleming, 1968).

Different metamorphic minerals including mica, tremolite-actinolite and garnet are observed as syn- as well as post-tectonic to all the three deformational phases in different lithounits of the area. Minerals, such as micas (muscovite & biotite) in garnet-mica schist and tremolite-actinolite in meta-ultramafics, which are syn-tectonic to AF_1 deformation, are identified by their parallel alignment to S_1 schistosity. The syn-AF_1 muscovite and biotite are refolded by AF_2 deformation. Syn-AF_2 mineral is mainly muscovite, which is coarser and is developed parallel to the axial plane of AF_2 folds (Fig.3a). Garnets of first generation are smaller in size, while garnets identified as syn-tectonic to AF_2 deformation by wrapping of external schistosity ($Se=S_2$) around these (Fig.2b). Muscovite, biotite, actinolite and tremolite that are post-tectonic to AF_1 and AF_2 deformations, have developed at an angle to S_1 and S_2 cleavages (Fig.3b). Post-tectonic porphyroblast of garnet are identified by its complete overgrowth of the main fabric of the rocks, i.e., the external schistosity (Se), does not envelope the porphyroblast but abuts against the crystal (Barker, 1990).

Such type of porphyroblastic growth is observed near village Maruwas where garnets are without trails of inclusions and external schistosity ($Se=S_1$) abuts against the crystal (Fig.3c). Garnets are considered as post-tectonic to AF_1 deformation as these do not show any trails of inclusions. The garnets that are post tectonic to AF_2 deformation are identified by their overgrowth over crenulated matrix (Fig.3d). In the present area chlorite psuedomorphs after garnet, have also been observed. It is a late-tectonic feature associated with retrogression (Fig.3e)

III. CONCLUSIONS

From the micro-structural studies it has been concluded that the area has been subjected to three deformational phases, i.e., AF_1, AF_2 and AF_3 out of which the second deformation is the most dominant structural event, which has controlled the map pattern of the region. The petrographical studies of various mineral assemblages of different lithounits indicate multiple deformations and polymetamorphism that include a regional metamorphism followed by diaphthoresis. The grade of regional metamorphism is varying from green schist facies to epidote-amphibolite facies and is time related to most conspicuous and dominant AF_2 deformation. The tectonic mineral criteria are indicative of progressive nature of metamorphism. The grade of metamorphism

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increases from east to west, which is indicated by the general coarsening of grain size from phyllite to mica-schist and its mineral constituents. Microtectonic studies reveal that the deformational structures observed in the lithounits are formed as a result of various deformation mechanisms viz. intracrystalline deformation, recovery and recrystallization. The optical properties of different minerals like undulose extinction, deformational bands, sub grains etc., indicate that the rocks exposed in the area have been deformed from green schist epidote-amphibolite facies metamorphic conditions. Based on the porphyroblast-matrix relationship, interrelations between deformation and metamorphism have been established. From these studies, it is evident that metamorphic events were synchronous not only during AF_1 and AF_2 phases of deformations (i.e. syn-tectonic) while they are post tectonic to AF_2 and AF_3.

REFERENCE

[1] Barker, A.J., 1990: Introduction to metamorphic texture and microstructures. Blackie, USA: Chapman and Hall, New York.

[2] Chauhan, N.K.,Sharma, B.L., and Mohemmad, Sabah,A.,1996: Structural geometry and strain history of the Early Proterozoic Aravalli Rocks of Gorimari, Udaipur District, Rajasthan, Journal of Geological Society of India, 47.

[3] Chauhan, N.K., Sharma, V., Sharma A., 2004a: A petrographic and micro-tectonic studies of rocks exposed around village Maruwas, District Udaipur, Rajasthan. In Rajasthan Mineral Bulletrin. DMG. Vol. 25. No.1 & 2.

[4] Chauhan, N.K., Sharma, A., Sharma V., 2004b: Geology and structure of rocks exposed north-east of Gogunda, District Udaipur, Rajasthan, In Rajasthan Mineral Bullein. DMG. Vol. No.3.

[5] Chilinger, G.V., Bissell, H.J., & Fairbrige, R.W., 1967: Carbonate rocks. Origin, occurrence and classification. Elsevier publishing company.

[6] Ghosh, K.P., 1978: Time relation between deformation and growth of metamorphic minerals in the pelitic schist, west of Rajnagarmarble band, Udaipur district, Rajasthan. Journal of GeologicalSociety of India,19 (7).

[7] GSI publication 1981: Explanatory brochure to the geological Map of the Aravalli region southern Rajasthan and northeastern Gujarat, Published under the direction of V.S. Krishnaswamy, Director General, Geological Survey of India.

[8] Heron, A. M., 1953: Geology of the central Rajasthan Memoir Geological Survey of India. Vol. 79. Memoirs of GSI 1997: The Precambrian Geology of the Aravalli Region, southern Rajasthan and northeastern Gujarat. v. 123.

[9] Offler, R., and Fleming, P.D., 1968: A synthesis of folding and metamorphism in the Mt. Lofty Ranges, South Austrlia., Jpour.Geological Society of Australia, v.15 (2).Roy, A.B., 1988. Precambrian of the Aravalli Mountain, Rajasthan India Memoir Geological Society of India, v.7.

[10] Roy, A.B., and Jhakar, S.R., 2002: Geology of Rajasthan (Northwest India), Precambrian to Recent. Scientific Publishers (India), Jodhpur.

[11] Sharma, B.L., Chauhan, N.K., and Bhu, H.,1988: Structural geometry and deformational history of the Early Proterozoic Aravalli Rocks from Bagdunda, District Udaipur, Rajasthan. In: A.B. Roy (ed), Precambrian of the Aravalli Mountain, Rajasthan, India. Memoir Geological Society of India.

[12] Sinha-Roy, S., Malhotra, G., and Mohanty, M., 1998: Geology of Rajasthan. Geological Society of India.

[13] Spry, A., 1963; The origin and significance of snowball structures in garnet. Journal of Petrology., v.4 (2).

[14] Winkler, H.G.F., 1976. Petrogenesis of Metamorphic rocks. 4th ed. Sprigerverlag. Berlin.

[15] Zwart, H.J., 1963. Some examples of the relation between deformation and metamorphism from the Central Pyreens. Geologie. En Mijnbouw-42e Javarganj.

Table 1: Regional stratigraphic succession of the area around village Maruwas

DELHI SUPER GROUP	Quartzite			
------------------------------Structural Discordance--				
	Shelf Sequence		Deep-Sea Sequence	
S Upper			Jharol	Meta-ultramafic,
A U Aravalli			Formation	Mica schist
R P Group				with
A E				thin bands of
V R				quartzite
A G -------------------------Unconformity (not observed)-------------------------------				
L R Middle	Bowa Formation	Quartzite		

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L O U P	Aravalli Group	Mochia Formation	Dolomite, quartzite with thin bands of black phyllite
		Udaipur Formation	Phyllite/Garnet-mica schist
	Lower Aravalli Group	Not Exposed in the area	
----------------------------- ---Unconformity (not observed)-----------------------------			
MEWAR GNEISS		Not exposed	Exposed further south near Bagdunda (Chauhan, 1983)

Nomenclature as per Roy, 1988; Roy, *et. al.*, 1993 and 2002).

Figure: 1.Geological Map of the region around Udaipur

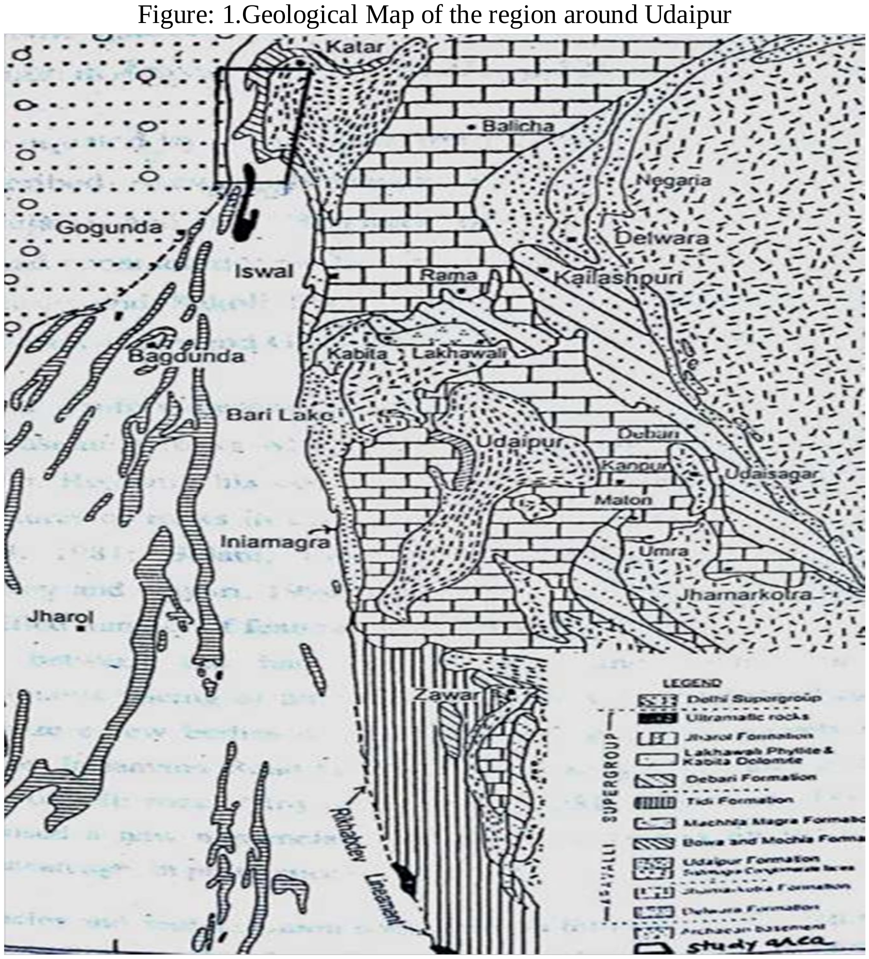

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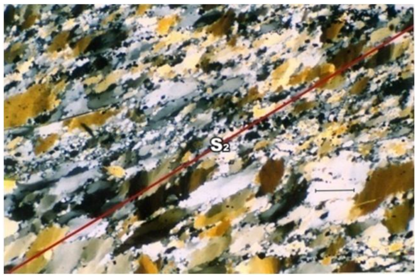
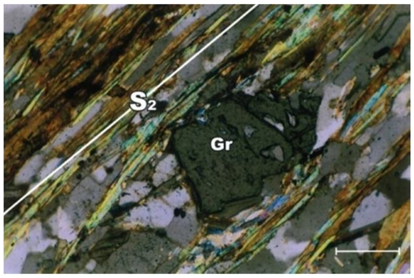
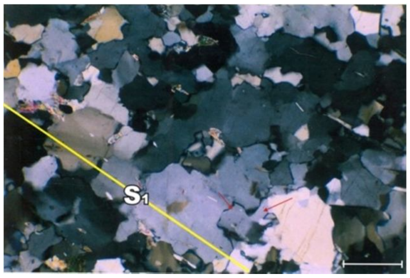
Figure 2



(a) Photomicrograph of quartzite showing elongate subgrains of quartz which passes laterally into domains of small dynamically recrystallised grains.Deformation bands are also visible . (XN, Bar scale- 0.5 mm).

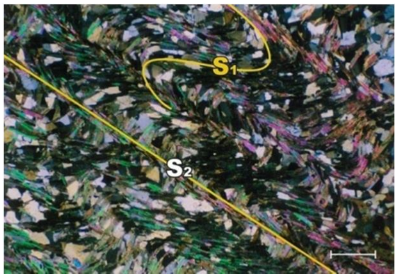


(b) Photomicrograph of garnet-mica schist showing syn-AF_2 garnet (Gr) porphyroblast with poor trails of inclusions. Muscovite and biotite are arranged parallel to S_2 schistosity. (XN, Bar scale-0.5 mm).

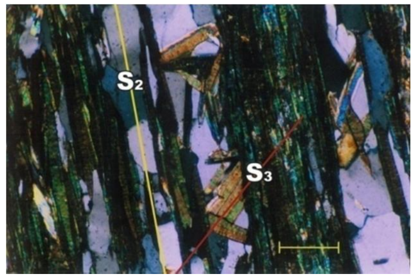


(c) Photomicrograph of quartzite, where quartz grains exhibit undulose extinction and bulging of grains into one another (as shown by arrow marking). (XN, Bar scale-0.5 mm).

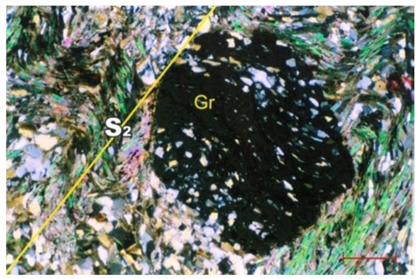
Figure 3



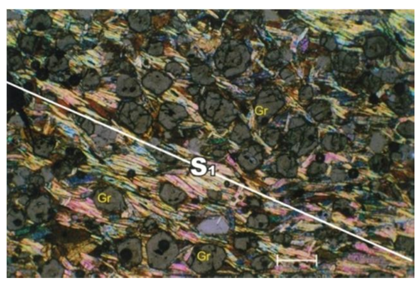
(a) Photomicrograph of mica-schist showing S_1 schistosity refolded by second deformation (AF_2) and syn-AF_2 mica developed parallel to its axial trace (S_2). Mica exhibits controlled pleochroism. (XN, Bar scale-0.5 mm).



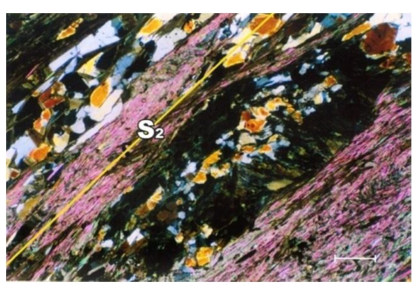
(b)Photomicrograph of garnet-mica schist, showing post AF_2 biotite and muscovite with its cleavage at an angle to S_2 cleavages. (XN, Bar scale-0.5mm).



(c)Photomicrograph of garnet-mica schist exhibiting and development of post-AF_1 garnet (Gr) where S_1 schistosity abuts against the crystal. (XN, Bar scale-0.5 mm).



(d) Photomicrograph of garnet-mica schist exhibiting post-AF_2 garnet porphyroblasts overgrowing crenulated micaceous matrix. Note that external fabric does not deflect around the matrix. (XN, Bar scale-0.5 mm).



(e) Photomicrograph mica schist showing chlorite (penninite). Note the inclusion of quartz in penninite crystal. (XN, Bar scale-0.5 mm).