

STRUCTURAL CONTROL OF LEAD AND ZINC MINERALISATION IN A PART OF TONS RIVER VALLEY, UTTARAKHAND –HIMACHAL LESSER HIMALAYA

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Abstract

Occurrences of galena and sphalerite have been observed in Tons river valley regions of Uttarakhand and Himachal Lesser Himalaya. The structural analysis reveals multiple deformational phases that have rendered a complex geological setting in the study area. The lead and zinc ores have been localized because of tectonism. However the multiplicity of the deformation has distributed the ore localization along different structural planes. The present work aims to study the control of structures over the lead and zinc mineralization and distribution. Galena and sphalerite along with pyrite minerals have been mobilized and emplaced along pre-existing weak planes such as foliation and axial plane cleavages of the fold. Faulting has caused upliftment and exposures of the ore minerals in Amtiyar, Anyar and Chamri Blocks in the study area.

Key Words : Lesser Himalaya, Deformation, Mineralization, Lead, Zinc.

Introduction

In Lesser Garhwal Himalayan region base metal sulphide mineralization has been reported from Askot in Kumaon Himalaya and Tons valley region of the Garhwal Himalaya (Chattopadhyay 1974; Ganesan and Thussu, 1978; Kumar, 1984; Srivastava and Mathur 1990a,b; Kumar et al 1993). In the Tons valley region Ghildiyal et al (2000) carried out the study on the mineralogy and genesis of the sulphide ore of the Chamri area. On the basis of mineral chemistry they (2000) reported presence of sulphide minerals namely pyrite, galena, sphalerite and chalcocopyrite. The present work aims to study the control of structures in three localities namely Chamri, Amtiyargad and Anyar areas of Tons river valley of Uttarakhand and bordering regions of Himachal Pradesh.

Geology of the Area

The study area around Kwanu (Fig. 1) which lies partly in Dehradun District of Uttarakhand and partly in the Sirmaur district of Himachal Pradesh

in the Tons river valley regions, geologically forms a part of Lesser Garhwal Himalaya covering the Autochthonous zone and Krol Nappe tectonic divisions of Auden (1937). The regional geology of these tectonic zones has been significantly contributed by Gansser (1964), Valdiya (1964, 1969), Rupke (1974), Bhargava (1972, 1976, 1978), Kumar (1978), Srikantia and Bhargava (1974, 1976) Srikantia (1978), Srikantia et al. (1982), Saxena and Srivastava (1991), Srivastava and Lakhera (2007) etc. A brief account on the regional geology of these units is given below:

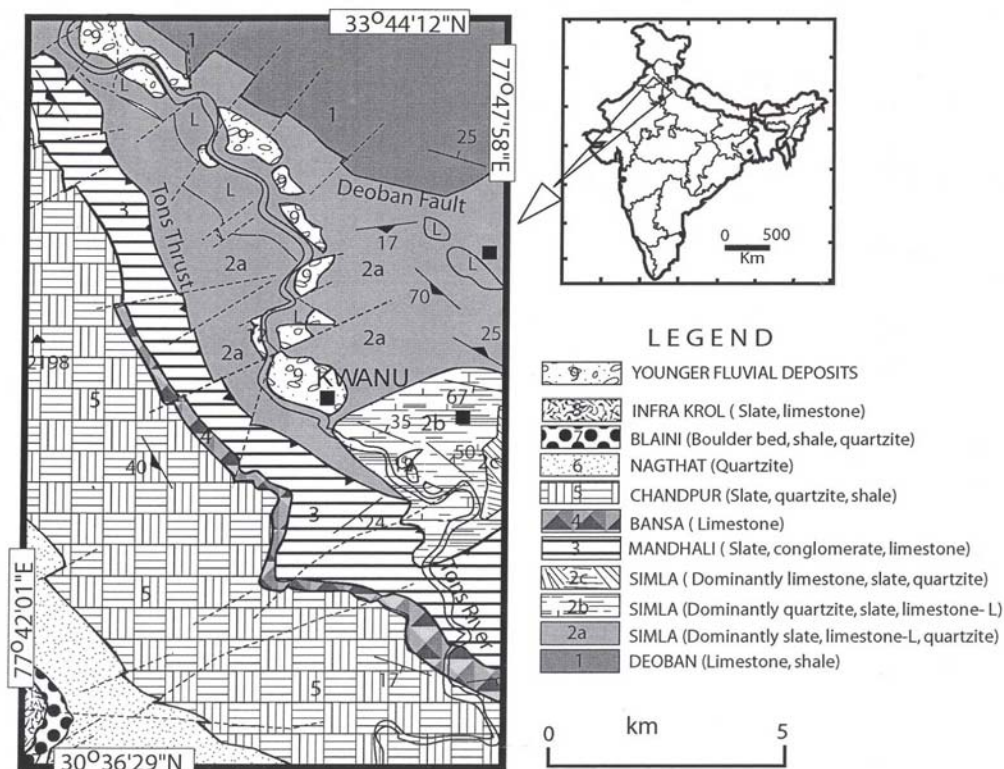


Fig.1 : Geological map of the study area around Kwanu in the Tons river valley

Autochthonous Zone

Auden (1934, 1937) called the low grade metamorphosed rocks above which the Krol allochthon moved as Morar-Chakrata Formation (referred as Simla Group in present work) in the Tons valley area and correlated them with Simla Slate of Simla area. According to him (1937) the Morar- Chakrata

Formation is younger than the Deoban. His observations were also supported by Valdiya (1969) and Srikantia et al (1982) who assign the age of Deoban between 1100 to 900 Ma. This suggests that the Precambrian rocks of Simla Group are younger than 1100-900 million years. Pilgrim and West (1928) recognized the tectonic contact between the rocks of Deoban Group and southerly lying rocks of Morar-Chakrata Formation.

Krol Allochthon

Auden (1934, 1937, 1970) considered the Krol belt to be allochthonous and Simla Slate as autochthonous and designated the Krol belt as Krol Nappe. Auden (1937) is of the opinion that the Krol, Nappe rocks - represented by Chandpur, Nagthat, Blaini, Infra Krol, Krol Tal and Subathu Formations, have been translated for about 8 kms southwards along the Krol Thrust over the Simla slates. Jain (1972) also recognized the allochthonous nature of the Krol thrust-sheet in Bidhalanala and Pharat windows.

Many workers have tried to explain the evolution of the Himalaya in different sectors but despite a large number of evolutionary models, facts remains that the stratigraphy and structural geology of the region is poorly understood and lack in factual ground data. Absence of structural maps showing trace of fold axial surfaces, trends of foliations and lineations, provide ample evidence for insufficient knowledge of the Himalayan geology (Dubey, 2004). One of the many reasons for this fact can simply be attributed to the poor accessibility and remoteness of the Himalayan terrain. Therefore, Srivastava and Lakhera (2007) used the techniques of remote sensing to decipher geology and structure of a part of Lower Himalaya in Tons valley region that have been used in present work (Fig.1). As stated earlier, the study area forms a part of Precambrian rocks of Deoban Group, Simla Group and Jaunsar Group of Lesser Himalaya terrain. Jaunsar Group rock are overlain over the Simla Group rocks along Tons thrust while the Deoban rocks in the study area are overlying the Simla Group rock along Deoban Fault. The ore mineralization has been found in the Simla Group which is considered as an autochthonous unit.

Deformation and Structural Analyses

The major structural features present in the area are folds, faults, joints and shear zones besides the primary foliation such as bedding plane (S_1), and secondary foliations such as slaty cleavages (S_2) and axial plane cleavages (S_3),

S₄...etc) of different generations of folds. The field observation suggests that where ever S₂ (Slaty cleavage) is developed they are parallel to S₁ except in the fold hinge zones. This indicates that the F₁ fold of isoclinal nature formed on the bedding plane during D₁ phase of deformation. Keeping this observation in view in order to analyze the second phase of folding (F₂), the dip and strike data on S₁ and S₂ measured in the field were plotted as poles on the lower hemisphere of the equal area net. The poles were contoured to obtain the best fit girdle for obtaining the direction of inferred fold axis (β_2). The data on S₁ and S₂ surfaces of the Simla Group rocks have been analyzed by dividing it into two subareas (subarea I and II, Fig.2)) on the basis of structural homogeneity found by plotting the poles as suggested by Turner and Weiss (1963). The trend of the inferred fold axis (β_2) indicative of second phase of deformation D₂, has been found to vary in different direction (Fig.2a, 2b) giving indications for post- D₂ folding. A synoptic (β_2) plots (Fig. 2c) shows the occurrence of all β_2 plots along a great circle girdle and thus suggests flexure slip mechanism of F₂ folding. To analyze the third phase of folding which occurred during D₃ deformational phase, the structural data of the axial planes (S₃) of mesoscopic folds were plotted on the equal area net and contoured (Fig. 2d). The inferred fold axis (β_3) thus obtained indicates a NW-SE trend of the F₃ fold. The fourth phase of deformation (D₄) appears to be more of brittle nature and has given rise to developments of numerous faults (Fig.1), joints and fracture planes. Some of these faults may represent deep seated fractures. The major faults recognized in the present area are Tons Thrust- separating Simla autochthonous zone from the Jaunsar Group rocks, and Deoban Fault- separating the Simla Group rocks from that of the Deoban Group. Besides these, there are a number of longitudinal and transverse faults. The river Tons itself appears to be controlled and criss-crossed by faults. Many faults have become a natural site for perpetual springs such as Amtiyar gad Fault (Fig. 3a). It appears that the faulting has caused uplifting of the mineralized body and exposed to the surface. Besides these faults evidences of brittle -ductile shearing have been noticed at many places in the area. Some of these shear zones are ore containing too.

Structural Control of Lead and Zinc Ore Mineralisation

The lead and zinc mineralization in study area have been observed in three localities namely Chamri, Amtiyar Gad and Anyar (Fig.2). The host rock of

mineralization is slate, siltstone and dolomitic limestone of Simla Group. The ore minerals occur as disseminations, stringers, veins and vug fillings and enechelon lenses in the host rocks mainly along fractures and cleavage planes of the host rocks in Chamri block over strike length of about 550m. The disseminations and stringers of pyrite grains are also present along the bedding laminae of slate. The mineralization in Amtiyar gad block is confined to bedding planes and also along two sets of shear planes due to remobilization. The one conforming to the bedding in NW-SE direction show moderate to steep northerly dips whereas the other trend in WNW-ESE direction with 70-80° northerly dips. The Pb-Zn mineralization in Anyar block is associated with slate and limestone sequence of Simla Group in close proximity of Deoban Group of

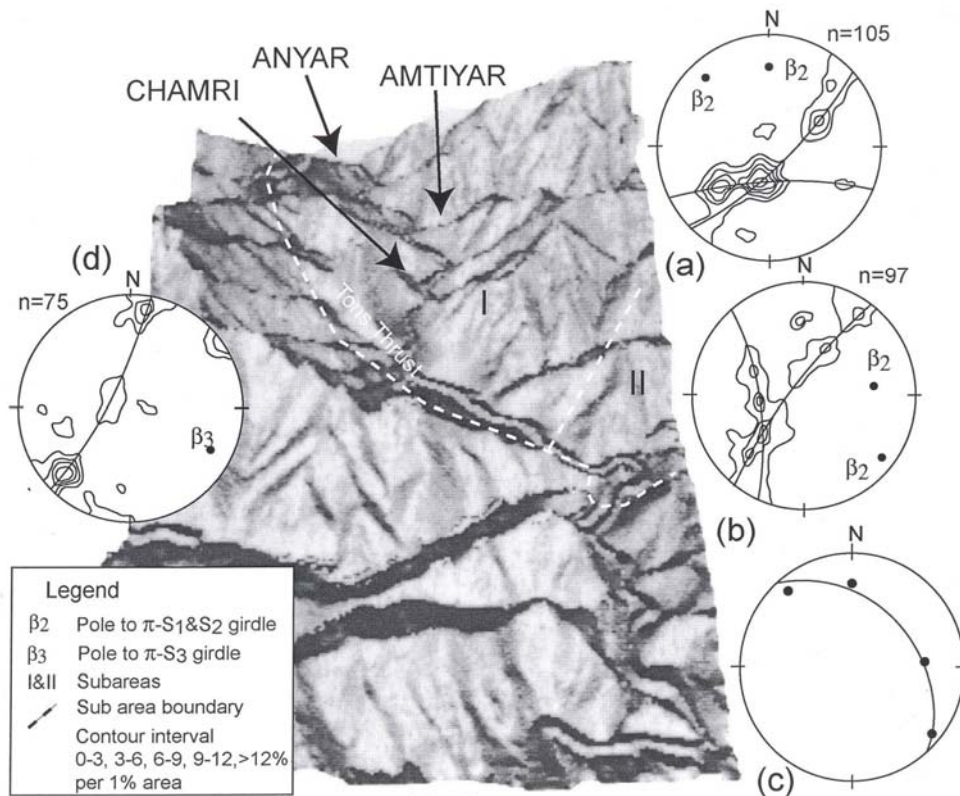


Fig. 2 : Digital Terrain Model of the study area around Kwanu, Tons River Valley. Subarea I and II belong to the Simla autochthonous rock unit lying north of the Tons Thrust. Location of Ore Mineralized Chamri, Anyar and Amtiyar blocks are also depicted. (a) and (b) represent trend of the inferred fold axes (β_2) obtained from S₁ and S₂ data from subarea I and II, respectively. (c) Synoptic β_2 plots from subareas I and II. (d) π -S₃ diagram depicting β_3 .

rocks. The rocks have NW-SE trending doubly plunging antiform and synforms. A number of NW-SE trending shears are also present in the area which appears to have controlled the mineralization to a limited extent.

The ore microscopic studies on the polished sections have indicated presence of galena and sphalerite in association with pyrite. Galena is more predominant mineral forming groundmass. It also occurs in patches in the gangue minerals. The cleavages of galena have shown deformation in the form of bending suggestive of tectonic influence on them (Fig. 3b). Sphalerite has been found in some patches in the ground mass of galena and pyrite (Fig.3d). The sphalerite patches have been found to have a preferred directional alignment suggestive of tectonic influence after their formation. The pyrite grains have fine to coarse grain sizes. The finer grains rounded in shape are associated in the ground mass while the larger crystals show fractures and cataclastic features suggestive of post crystallization deformation and faulting (Fig.3d). The field association, structural analysis and ore microscopic study of ore minerals and gangues suggests the following ore paragenesis.

The host rocks comprising originally of shale and limestone were subjected to deformation and low grade metamorphism due to tectonic activities of earliest (D_1) phase. The D_1 deformation phase was responsible the development of new cleavages or weak planes in the host rock. This deformation caused the original shale to convert into slates better known as Simla slate. The limestone however was slightly modified and became dolomitic at places and developed secondary cleavages. It was subjected to intrusion by the hydrothermal solution during later phase of deformation D_2 which caused folding of the host rock. From the solution the galena crystallized first among the ore minerals followed by crystallizations of sphalerite and pyrite subsequently. The host rock has been subjected to D_3 phase of deformation which is reflected in the form of bending of cleavage planes of the minerals (Fig.3b).The last and final phase of deformation D_4 was mainly of brittle character which caused the upliftment along fault planes and fracturing and shearing the rocks and minerals and development of cataclastic textures (Fig.3c) in the rocks.

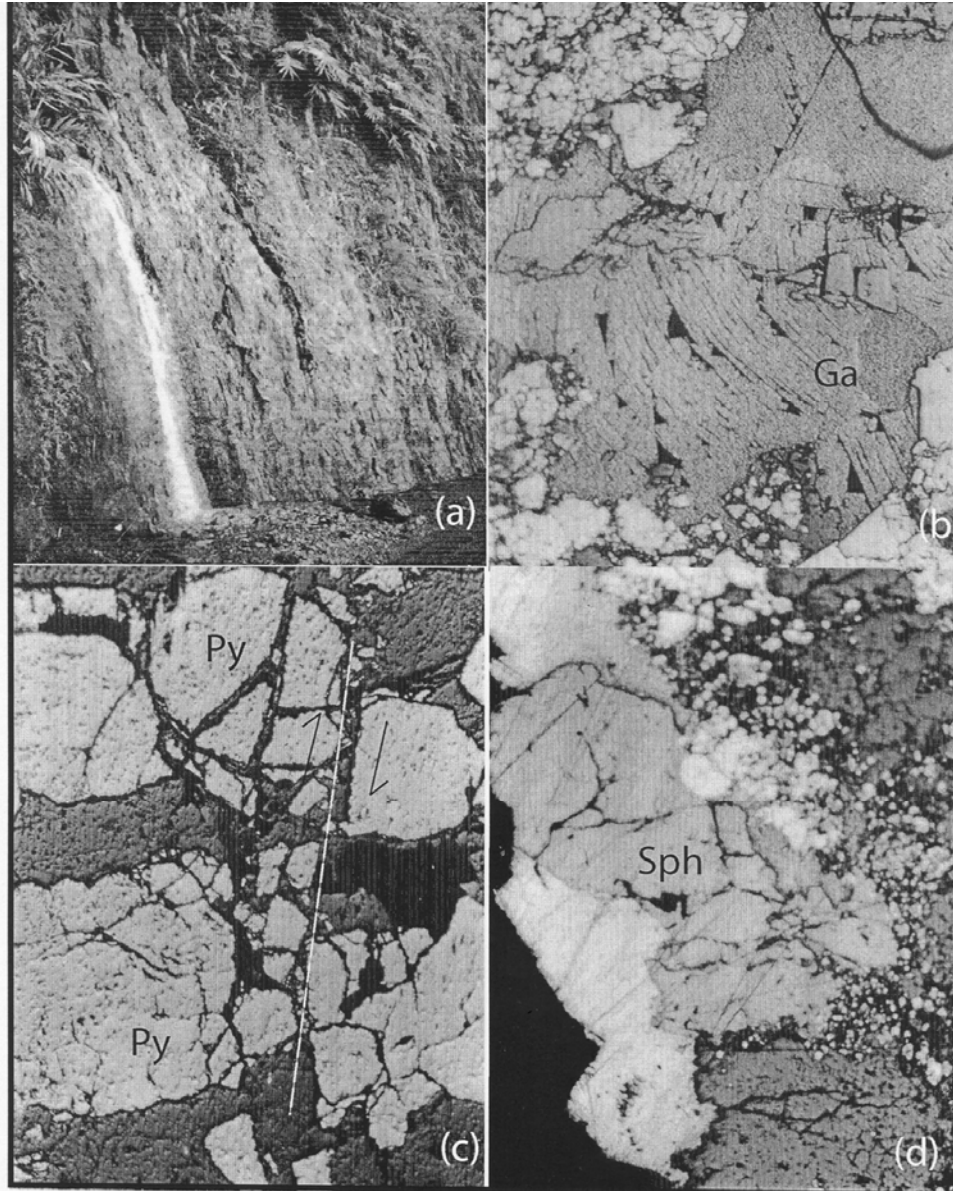


Fig. 3 : Field Photograph of Amtiyar gad stream running along Amtiyar gad fault. Because of mineralization and limonisation, the colours of the stream surroundings are very different from any other stream in the area. (b) Photomicrograph of polished ore section of galena (Ga). A curvature in the cleavages due to deformation is evident. (c) Photomicrograph of polished section of pyrite (Py). The grains show microfaulting and cataclastic texture due to crushing of the grains in vicinity of the fault. (d) Photomicrograph of sphalerite in association with small and bigger grains of pyrite.

Discussion and Conclusion

The above study explains the structural controls of the mineral deposits and mineral paragenesis of Chamri, Amtiyargad and Anyar blocks. Some of the analytical reports of the Geological Survey of India show that the lead content varies from 20 ppm to 1.57% in Amtiyargad block and 0.11 to 2.0% in Anyar block. The zinc content varies from 455 ppm to 0.37% in Amtiyargad block and 0.55% to 16.02% in Anyar block (Singh and Sharma, 1996; Kaura and Jain 1996). However, mining of above mineral deposits may have following constraints : (a) The mineral deposit is located in a hilly terrain of Himalaya where infra -structures are poorly developed. (b) The ore reserves are not observed sufficient in quantity to set full fledged mining operations. (c) The previous study carried out by GSI (Srivastava and Mathur 1990a, b) finds the mineral deposits to be uneconomical. (d) The ores occur in stringers and disseminations and thus lack continuity. (e) The deposits are structurally controlled. Since the area has suffered multiple tectonism, the ores have been spread over and distributed according to fold and fault related displacements.

These factors apparently seems to be undesired however, one should also keep in mind that these tectonic activities have given rise to ore concentration and localization. It is also to be kept in mind that rapid increase in consumption rate of metals and minerals over last few decades and consequent depletion of mineral resources have necessitated the effective utilization of low grade and finely disseminated ores. The effective utilization of such low grade ores may help to maintain an adequate supply of minerals to meet economic and strategic need of our nation (Raju, 2009). According to United Nation Framework Classification (UNFC), the estimated lead and zinc ore reserve will exhaust by the end of the current century. In order to maintain future supply it becomes necessary to recycle the metal waste and utilize the low grade ores with the use of technological developments. The low grade ore deposits such as those discussed in the present work need be given due consideration keeping the demands of the future and unavoidable crisis times.

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