₹ 200 ISSN - 2249-555X
Volume : 1 Issue : 8 May 2012

Journal for All Subjects

www.ijar.in

Listed in International ISSN Directory, Paris.

ISSN - 2249-555X

Indian Journal of Applied Research

Journal for All Subjects

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Research Paper Applied Geology

Petrography and geochemistry of the host rock of sulphide mineralisation in Potin area, Subansiri district, Arunachal Pradesh, India

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ABSTRACT

The host ore mineralogy of the polymettallic sulphide mineralization around Potin area of Lower Subansiri district, Arunachal Pradesh, NE India has been reported. Mineralization in the area is both structurally controlled, confined to a shear zone of about 30 mts in width, traversing through Garnetiferous-quartz-biotite schist belonging to the Bomdila Group.

Mineralised fine porphyritic metapelites are silica poor (majority of samples contain <60% SiO_2*),* Al_2O_3 *enriched is (>10%);* K_2O *is 0.77% to 8.74%;* K_2O/Al_2O_3 *is 0.06% to 0.36% indicating significantly low alkali feldspar content in parent rock; CaO is erratic; higher* Fe_2O_3 *(Total) content of the rock;* P_2O_5 *ranges between 0.03 and 0.06 wt % Contrary to the general belief, this mineralised metapelites were emplaced in active continental margin and evolved in back arc setting-felsic plutonic detritus (Maynard, 1982) Trace element data of these metapelites show enrichment in high field strength elements(HFSE) such as Cr, Rb, Ni and V*

Tectonic discrimination diagram (Th/Ta-Ta/Yb and Th/Ta-Yb) suggests that the metapellitic rocks were emplaced in active continental margin. The metapellites are LREE (La, Ce, Nd) show enrichment and relatively flat HREE with positive Eu anomaly. Positive Eu anomaly supports the primary mantle derived oceanic hydrothermal activity (Nakamura, 1974)

(La/Yb) n of the metapelites are vary from 0.24 to 41.21, averaging 22.79 indicating high fractionation. HREE- fractionated pattern suggest that garnet could be a residual phase during the formation of the source rocks.

Keywords : Potin Area, Shear zone, structural control, geochemistry, tectonic setting, provenance and EPMA

Introduction

Exposures of mineralized zone are seen along Kimin-Ziro road section at the northern bank of Ranga river (Lat:27º19/N; Long: 93º48/E) and continue across the river bed to the Southern bank for a distance of about 300mts along its strike.

Mineralization in the area is both structurally and lithologically controlled. Structural elements include schistosity plane striking NE-SW dipping about 35º towards SE direction and shear planes developed often making low angle with the schistosity. Lithological variants appears to strictly confined to the pelitic schists or garnetiferrous chlorite-sericite-quartz schist belonging to the Palaeoproterozoic Potin Formation of Bomdila Group. Mineralization in the area is dominated by chalcopyrite, pyrite, pyrhotite, sphalerite with occasional occurrence of magnetite and arsenopyrite.

The present paper deals with the petrography and geochemistry of the host rock of the study area.

Geological Setting

The exposed lithology in and around Potin belongs to the crystallines of the lesser Himalaya and mainly consists of quartz mica schist and biotite gneiss resting over a narrow patch of Gondwana on a hidden thrust. The general foliation trend is ENE-WSW with moderate dip of 35º towards the SE direction. The tight isoclinal F1 folds have highly appressed limbs and thick hinges with axial plane dipping to the northwest. These folds are recline type. The second generation F2 folds have a coaxial relationship with the F1 folds and could be seen on cross section with fold axis plunging to NNW direction. The axial plane of F2 folds maintain near orthogonal relationship with F1 folds. The thrust parallel drag and thrust imbrication are also observed at places facilitating avenues for upward movement of mineralizing solutions. Cross fractures indicate a north-south trend and are indicative of southward movement of sequence and accommodation of stress.

The general trend of schistose rocks is NNE-SSW dipping 40 º -70 º towards SE. Westerly dips are well defined and are more consistent towards the contact of the quartzite and mica schist, both on the hanging wall and footwall sides. Tentatively, it may be inferred that the quartzite and mica schist are younger and occur as alternating synclinal remnants on the two sides of semi-pelitic and more or less garnetiferous schist. It appears that although the whole schistose zone forms a synclinal part between the granitic mass, the schistose zone itself is internally folded.

Petrography of host

The sulphide mineralization is hosted by a NNE-SSE to NE-SW trending subvertical sheet about 30mts wide garnetiferous quartz-biotite schist sandwich between granite gneiss to augen gneiss.

Garnetiferous –quartz-biotite schist

Megascopic study reveals that the garnetiferous quartz-biotite schist is medium-to coarse-grained well foliated rock consisting quartz, biotite and garnet.

Microscopic study shows the following general assemblages of the rock as follows:

Garnet-quartz-biotite-chlorite + plagioclase + zircon + apatite (retrogressed assemblage: secondary-chlorite-muscovite-clinozoisite-epidote-sericite

One of the important features is that primary muscovite is absent in the assemblage except rare inclusions within garnet in a few thin sections (Fig. 4.1). Quartz is abundant matrix mineral and also occurs as tiny inclusions within biotite and garnet porphyroblasts constitute the internal schistosity (Si). Plagioclase (An16-18) is subordinate in the rock and localized in the quartz-rich parts as subidioblastic to xenoblastic grains. The style of occurrence of chlorite in the rock is interesting. Texturally two types of chlorite identified: the primary matrix chlorite subidioblastic to xenoblastic grains which defined the preferred orientation along with subidioblastic elongated biotite grains in biotite-rich layers (Fig. 4.2). The chlorite of second generation is irregular mass localized along the border/fractures of the matrix minerals and is abundant in the proximity of shear plane (Fig. 4.1, 4.3 and 4.4). Garnet is a ubiquitous mineral and seen as porphyroblasts which is heavily fractured and decomposed due to later deformation (Fig. 4.4). However, the question of the growth of garnet with respect to deformational episode is difficult to interpret but it forms a major metamorphic mineral similar to biotite. The porphyroblastic garnet appeared as highly fractured and often showing cracks in a net-vein-like mesh pattern. (Fig. 4.3 and 4.4). The cracks were later replaced by secondary chlorite during shearing. The randomly developed idioblastic garnet free from inclusions possibly developed in a static period after deformation event (Fig. 4.5).

Tentative correlation of the timing of growth of metamorphic minerals and deformational episodes

M1 assemblage	Pre- S1	Quartz, Muscovite,
M2 assemblage	Syn-S1	Biotite, Quartz, Chlorite, Garnet, Plagioclasae
M3 assemblage	Post-S1	Idioblastic Garnet, Biotite
M4 assemblage	Post-S1 post shearing	Ore minerals, sec. Chlorite, Clinozoisite-Epidote, Sericite, Muscovite

Geochemistry of host rock

The main point of interest in the chemistry of host rocks of the Potin area relates to the characteristics of the garnet bearing metapelites. In the present area, the host rock is garnetiferous quartz-biotite schist.

Major element geochemistry

The major oxide of the representative host rock samples of the Potin area are presented in Table No. 1. Mineralized fine porphyritic metapelites are silica poor (majority of samples contain <60% SiO_2), Al_2O_3 enriched is (>10%); K_2O is 0.77% to 8.74%; K_2O/ Al_2O_3 is 0.06% to 0.36% indicating significantly low alkali feldspar content in parent rock; CaO is erratic; higher Fe_2O_3 (Total) content of the rock; P_2O_5 ranges between 0.03 and 0.06 wt %; In Harker's variation diagrams of selected major elements, the Potin samples exhibit a wide range of SiO_2 and negative trends of TiO_2, Al_2O_3, Fe_2O_3, P_2O_5, MgO, CaO but K_2O are mostly scattered (Fig.5.1). In these samples higher concentration of K_2O than Na_2O which is related to modal content of plagioclase and K-feldspar. Higher molar Al_2O_3/CaO+Na_2O+K_2O(A/CNK=(1.08-1.78) of Potin samples supports the peraluminous nature. The A-CN-K plot is a useful tool to examine provenance and weathering histories. To achieve the same objective the CIA values of Potin samples were plotted in the Al_2O_3-(CaO+Na_2O)-K_2O triangular diagram (Fig. 5.3). This figure suggest that the metapelitic rocks of the study area might be gabbro or basaltic in composition. Contrary to the general belief, this mineralised metapelites were emplaced in active continental margin and evolved in back arc setting-felsic plutonic detritus (Maynard et al.,1982).

5.3 Trace Element Geochemistry

The analytical trace element data of the study area is shown in Table No. 2. It is apparent from the trace element data the host rocks are characterized based on the limited information available on trace element contents, it appears that the present metapelites are higher in Cr(59.486-395.339) ppm, V(35.009-99.061)ppm, Ba(132.655 -643.859)ppm and Rb(5.289-117.318)ppm and lower in Sr. (23.756 -63.349) ppm. In terms of trace elements, the present garnet bearing metapelites appear to have high Cr, V, Ba and Rb and low Sr.

Garnetiferous metapelites are characterised by high HFS elements e.g. Zr, Nb etc. REE, Y; strongly enriched in Cr, Ni, and V; Zr content varies between 2.596 – 27.136 ppm; Nb content ranges from 2.637-16.064 ppm.

The LILE

Ba varies between 132.655 – 643.859 ppm which is relatively high(Table No 2); enriched Rb content (average is 115.75ppm); low values of Sr (23.756 – 63.349)ppm with the mean of 58.07 ppm); La (5.603 – 27.71 ppm) and Ce (10.901 – 40.758 ppm); the Ga content of the rocks (13.384 – 26.315ppm); Cu content is abnormally high (20.136ppm -632.061ppm).

Trace element data of these metapelites show enrichment in high field strength elements (HFSE) such as Cr, Rb, Ni and V.

In Harkers's variation diagrams Ba, Sr with SiO_2 in Potin samples show negative correlation (Fig. 5.3).

Tectonic discrimination diagram (Th/Ta-Ta/Yb and Th/Ta-Yb) suggests that the metapellitic rocks were emplaced in active continental margin (Fig. 5.4).

REE distribution

The analytical REE data of the samples area is shown in Table No. 3.

The host rocks of the area are LREE (La, Ce, Nd) show enrichment and relatively flate HREE with positive Eu anomaly. Positive Eu anomaly supports the primary mantle derived oceanic hydrothermal activity (Nakamura, 1974) (Fig. 5.5).

$(La/Yb)_n$ of the metapelites are vary from 0.24 to 41.21, averaging 22.79 indicating high fractionation. HREE-fractionated pattern suggest that garnet could be a residual phase during the formation of the source rocks.

Discussion

On the basis of present geochemical studies several important issues of the host rocks of study area are to be discussed.

The major, trace and REE compositions of the host rocks offer clues on several important aspects such as trend of original basin configuration, tectonic environment and metamorphic signature i.e. selective depletion of the metamorphic rocks during epidote-amphibolite facies.

The well defined basinal configuration is reflected from the K_2O/Na_2O-SiO_2/Al_2O_3 tectonic discrimination diagram (Fig.5.2.). On this diagram, the data are plotted in active continental margin and evolved arc setting in back arc basin (Maynard, 1982) (Fig. 5.2.)

The Al_2O_3/TiO_2 ratios of the studied samples range from 15.89 to 28.45, with averaging value 24.88, suggesting that they are derived predominantly from mafic rocks not acid rocks (Gritty et al, 1996)

The average K_2O/Al_2O_3 value (0.27) indicate that minimal alkali feldspar in parent rock (Cox et.al, 1995)

The degree of differentiation of LREE from HREE is a measure of the proportion of felsic to mafic components in the source areas, and Eu anomaly also may offer information about provenance.

The values of the $(La/Yb)_n$ of the host rock of the study area varies from 0.24 to 41.21(table) averaging 22.79 indicating high fractionation. HREE-fractionation pattern suggest that garnet could be a residual phase during the formation of the source rocks. The REE patterns of the samples have the signatures of LREE enriched (mean $(La/Yb)_n$ is 22.79) and Chondrite normalized REE (Nakamuara, 1974) shows positive Eu anomaly (Eu/Eu*= (1.32-2.20) indicating the primary mantle derived oceanic hydrothermal activity. The oceanic hydrothermal waters typically are greatly enriched in Eu, a consequence of plagioclase break down during fluid/rock interaction. The middle–Archaean Kalyadi cherts from Dharwar craton are characterized by moderate total REE (ppm), La enrichment and flat to depleted HREE patterns indicate a mantle derived volcanogenic hydrothermal origin (Subba Rao and Naqvi, 1997). Strong negative Sr and Ba anomalies together with Positive Eu anomaly in the area indicate either the fractionation of plagioclase or retention of plagioclase in the source during partial melting. The samples were relatively focused on the overlap of sedimentary rock. So there might be accession of hot-water sedimentation during the period of the formation of host rock of ore mineralization (Allgre, 1978 and Kunzendorf, 1988)

The host rocks of ore mineralization were metamorphosed under epidote-amphibolite facies conditions. The deformation and metamorphism of the country rocks might have been taken place during the Tertiary Himalayan Orogeny. In summary, the geochemical character discussed above indicate that the host rocks posses a oceanic deep seated hydrothermal character and represent melt from low melting of upper mantle where garnet remains as a restitic phase and they were in sedimentary origin.

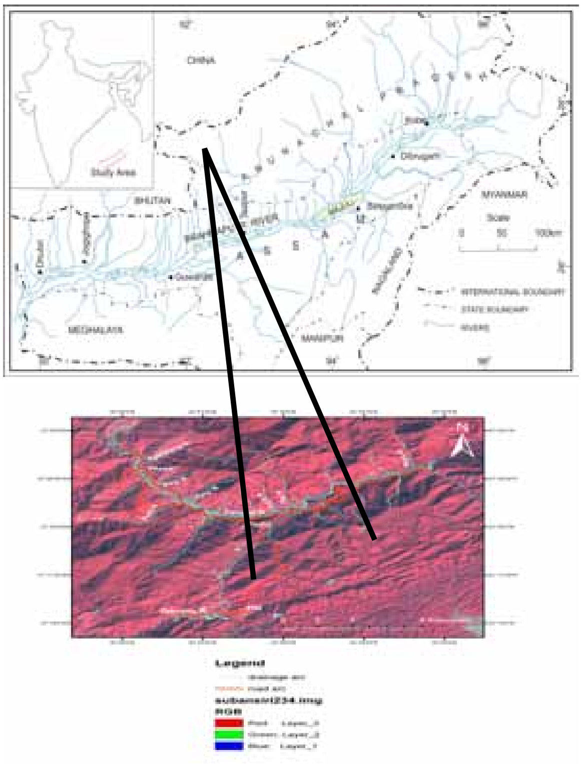


Fig. 1 Location map of the study area

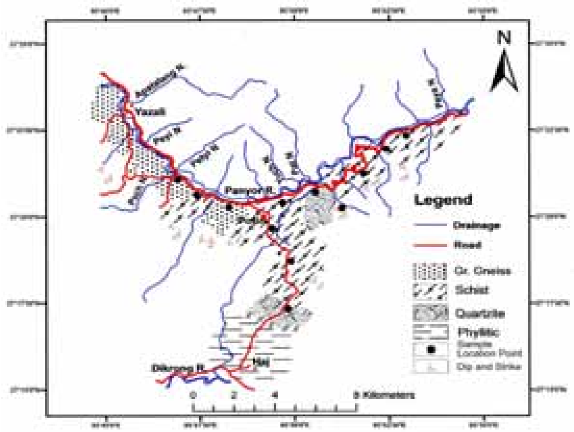


Fig. 2 Geological Map of the Study Area

Fig. 3 Shear zone featuring mineralization. Note that schistosity (S2) strikes N-S to NE-SW dipping SE. (Location near 53 km post)

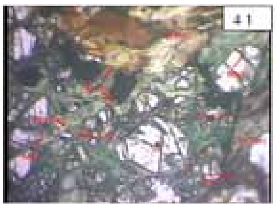
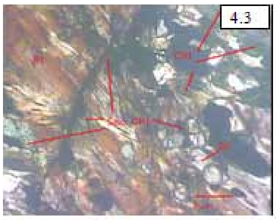
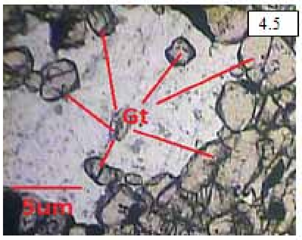
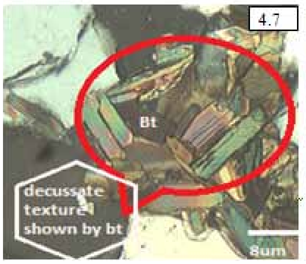


Fig.4.1 Rare tiny inclusion of muscovite within relict garnet grain (upper right). Net-vein like mesh texture in the garnet due to heavy fracturing, the fracture plane being occupied by secondary chlorite (Polarised Light).







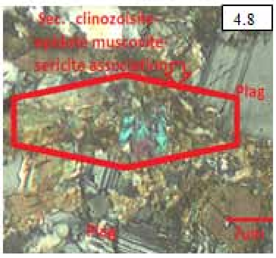


Fig.4.2 Preferred orientation displayed by biotite and chlorite defining S1 schistosity (polarised light)

Fig.4.3 Development of secondary chlorite along the border of biotite and garnet in the vicinity of shear zone (Polarised Light)

Fig.4.4 Decomposition of garnet into secondary chlorite, garnet shows mesh texture (Polarised light)

Fig. 4.5 Idioblastic to sub idioblastic randomly developed grains of garnet in

Quartz-rich layer. Note that garnet is free from inclusions (Polarised Light)

Fig. 4.6. Slender crystals of biotite in aggregates displaying preferred orientation of the rocks (Polarised Light)

Fig. 4.7 Randomly developed idioblastic aggregates of biotite shows the granoblastic polygonal fabric (decussate texture) indicating their formation in a static period

Fig. 4.8 Alteration of plagioclase into secondary clinozoisite-epidote-muscovite-sericite association during retrograde cooling. Note that the decomposition takes place in the vicinity of shear zone (Cross Nicols)

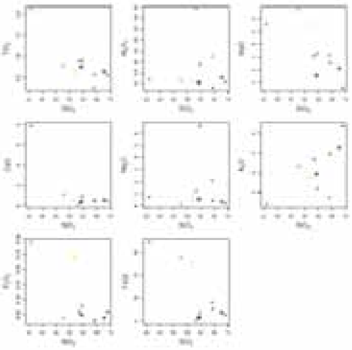


Fig. 5.1 Variation diagram of major oxides

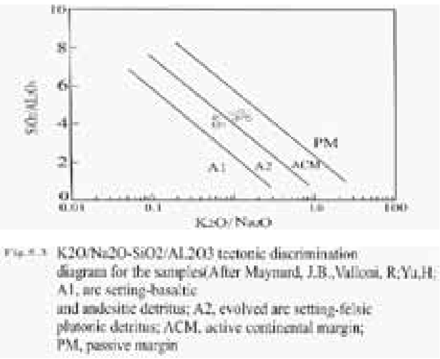


Fig.5.3 K2O/Na2O-SiO2/AL2O3 tectonic discrimination diagram for the samples(After Maynard, J.B.,Valloni, R;Yu,H; A1, arc sering-basaltic and andesitic detritus; A2, evolved arc setting-felsic plutonic detritus; ACM, active continental margin; PM, passive margin

Fig. 5.2 K2O/Na2O-SiO2/Al2O3 tectonic discrimination diagram for the samples. A1, arc setting-basltic and andesitic detritus; A2, evolved arc setting-felsic plutonic detritus; ACM, active continental margin; PM, passive margin (After Maynard et al.,1982)

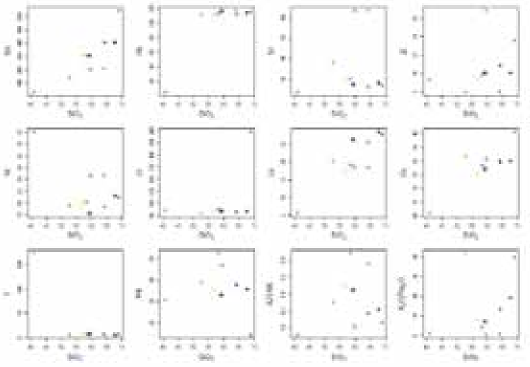


Fig. 5.3 Variation diagram of trace elements

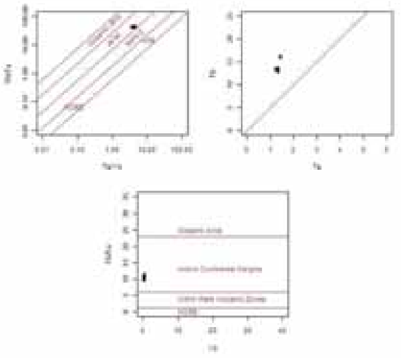


Fig. 5.4 Tectonic discrimination diagrams

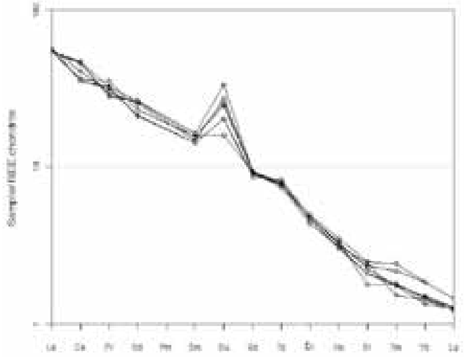


Fig. 5.5 Chondrite-normalised plot of REE (normalized after Nakamura, 1974)

Table No. 1: Major oxides composition of host rock from the study area

Sample	PS M1	PS M2	PS M3	PS M4	PS M5	PS M6	PS M7	PS M8	PS M9	PS M10
SiO2	64.11	59.56	52.68	44.87	58.35	56.67	68.85	58.35	56.67	68.85
TiO2	0.26	0.9	0.79	0.85	0.9	0.64	0.57	0.9	0.64	0.57
Al2O3	17.01	15.56	12.56	12.87t	25.61	12.44	12.34	25.61	12.44	12.34
Fe2O3	10.09	7.37	21.09	24.85	5.52	19.9	6.99	5.52	19.9	6.99
MnO	0.09	0.1	0.33	0.31	0.03	0.38	0.08	0.03	0.38	0.08
MgO	3.11	3.29	6.72	5.57	3.09	5.44	0.59	3.09	5.44	0.59
Na2O	2.05	6.6	0.11	0.72	1.19	0.44	0.22	1.19	0.44	0.22
K2O	1.4	2.35	4.6	0.77	5.33	3.54	8.74	5.33	3.54	8.74
P2O5	0.03	0.08	0.04	0.29	0.06	0.24	0.06	0.06	0.24	0.06
CaO	0.54	0.87	1.07	0.95	0.13	0.55	0.42	0.13	0.55	0.42
Total	98.69	96.68	99.99	96.22	100.21	100.24	98.86	100.21	100.24	98.86

Table No. 2
Trace element analytical data on host rock from the study area

Sample	PS M1	PS M2	PS M3	PS M4	PS M5	PS M6	PS M7	PS M8	PS M9	PS M10
Sc	13.407	13.367	12.037	12.237	9.962	13.407	13.547	13.037	20.598	10.962
V	92.725	91.921	99.061	98.061	63.688	92.725	90.921	96.061	35.009	64.688
Cr	67.63	69.287	59.486	60.486	395.339	67.63	68.287	60.486	73.132	95.339
Co	5.612	5.673	5.38	6.38	30.319	5.612	6.673	6.38	33.885	32.319
Ni	24.756	24.686	19.641	22.641	20.989	24.756	22.686	21.641	32.078	21.989
Cu	20.136	20.496	21.701	20.701	632.061	20.136	21.496	23.701	5.038	32.061
Zn	39.409	40.015	57.495	50.495	61.481	39.409	41.015	47.495	69.626	51.481
Ga	26.259	26.315	25.967	26.967	13.384	26.259	25.315	26.967	18.535	16.384
Rb	117.318	117.031	112.181	114.181	115.495	117.318	115.031	113.181	5.289	114.495
Sr	63.323	63.349	38.077	50.077	27.177	63.323	65.349	58.077	23.756	26.177
Y	5.985	5.922	5.532	6.532	18.966	5.985	6.922	4.532	17.039	19.966
Zr	5.07	27.136	4.98	5.98	2.596	5.07	27.136	21.98	8.471	8.596
Nb	15.465	15.798	16.064	15.064	13.244	15.465	12.798	13.064	2.637	12.244
Cs	1.923	1.877	1.909	1.709	2.727	1.923	1.577	1.609	0.143	2.767
Ba	206.387	205.825	144.499	145.499	643.859	206.387	204.825	143.499	132.655	643.859
Hf	0.176	0.206	0.106	0.110	0.078	0.176	0.106	0.126	0.818	0.578
Ta	1.414	1.422	1.3	1.5	2.944	1.414	1.622	1.41	0.156	12.94
Pb	10.932	11.049	10.882	11.882	4.57	10.932	11.149	11.882	11.901	10.57
Th	15.966	16.089	13.795	12.795	10.509	15.966	14.089	14.795	11.384	11.509
U	1.549	1.487	1.126	1.226	1.798	1.549	1.687	1.526	1.268	1.698

Table No. 3
REE analytical data on host rock from the study area

Sample	PS M1	PS M2	PS M3	PS M4	PS M5	PS M6	PS M7	PS M8	PS M9	PS M10
La	18.436	18.577	20.277	21.245	27.71	18.436	18.577	20.277	5.603	27.71
Ce	30.464	30.738	31.657	32.901	40.758	30.464	30.738	31.657	10.901	40.758
Pr	3.568	3.64	3.979	2.638	3.614	3.568	3.64	3.979	1.638	3.614
Nd	13.272	13.444	14.548	17.818	16.7	13.272	13.444	14.548	7.818	16.7
Sm	2.883	2.881	3.187	3.537	3.314	2.883	2.881	3.187	3.537	3.314
Eu	1.562	1.564	1.224	1.424	2.578	1.562	1.564	1.224	0.688	2.578
Gd	2.479	2.386	2.54	2.591	3.928	2.479	2.386	2.54	7.591	3.928
Tb	0.366	0.387	0.37	0.354	0.616	0.366	0.387	0.37	2.739	0.616
Dy	1.647	1.686	1.615	1.123	3.225	1.647	1.686	1.615	28.674	3.225
Ho	0.224	0.243	0.228	0.234	0.649	0.224	0.243	0.228	3.914	0.649
Er	0.523	0.555	0.499	0.532	2.133	0.523	0.555	0.499	13.341	2.133
Tm	0.065	0.072	0.052	0.064	0.329	0.065	0.072	0.052	1.729	0.329
Yb	0.401	0.403	0.328	0.524	1.656	0.401	0.403	0.328	15.695	1.656
Lu	0.049	0.049	0.043	0.045	0.225	0.049	0.049	0.043	2.059	0.225
Eu/ Eu*	1.80	1.83	1.32	1.44	1.60	2.74	2.16	2.33	1.06	1.65
(La/ Yb)n	30.65	30.73	37.76	38.74	37.64	38.51	38.93	41.21	38.75	37.65

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Printed at Unique Offset, Novatsing Rupam Estate, Opp. Abhay Estate, Tavdipura, Shahibaug, Ahmedabad