Geochemical (REE and Trace elements) characteristics and tectonic setting discrimination of Permo-Carboniferous sandstone from Sikkim Lesser Himalaya, NE India

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Received 16 April 2020; accepted 14 January 2021; published 13 September 2021.

The geochemical (REE & traces elements) characteristics of Permo-Carboniferous sandstone has been taken into account to decipher tectonic setting and provenance of the Rangit Pebble Slate Formation of Sikkim Lesser Himalaya. The chondrite normalized REE pattern with Eu negative anomaly and a bivariate plot (Th/Co-La/Sc) clearly indicates that studied sediments were likely derived from upper crust felsic source. The average elemental ratio of traces elements La/Sc ($\sim$ 3.85), Th/Sc ($\sim$ 2.57), Cr/Th ($\sim$ 6.64), Th/Co ($\sim$ 2.52), La/Co ($\sim$ 3.74), and Eu/Eu* ($\sim$ 0.32) also shows close affinities with Upper Continental Crust. The trivariate plot (La-Th-Sc plot, Th-Sc-Zr/10 plot, & Th-Co-Zr/10 plot) and a bivariate plot (Ti/Zr-La/Sc) plotted on the field of passive tectonic region for the Rangit Pebble Slate Formation sandstone. A binary plot between the ratio of Th/Sc-Zr/Sc and Th/U-Th reflects the enrichment of zircon and weathering trend during sedimentary recycling. *KEYWORDS:* Geochemistry; provenance; tectonic setting; Sikkim Lesser Himalaya; India.

Citation: Priya, Raj Kumar, V. C. Tewari, and R. K. Ranjan (2021), Geochemical (REE and Trace elements) characteristics and tectonic setting discrimination of Permo-Carboniferous sandstone from Sikkim Lesser Himalaya, NE India, *Russ. J. Earth. Sci., 21,* ES5002, doi:10.2205/2021ES000756.

Introduction

The Pre-Pleistocene glacial record of Earth as a whole was reviewed by *Hambrey and Harland* [2011]. In this classical review they have covered almost all the glacial deposits of North and South America, Africa, Antarctica, Asia and Australia in East and West Gondwana land [*Tewari and Sial,* 2007]. Pre-Mesozoic global record of climate change of the earth was reviewed by *Histon et al.* [2013]. The Neoproterozoic global glaciations (Snow Ball Earth) has been recorded from western Lesser Himalaya of India [*Tewari,* 2001, 2010, 2012]. These are the main cryospheric events in the earth's history and well preserved in Indian subcontinent. The evidence of Late Paleozoic Gondwana glaciation is one of the important cryospheric event which have been documented from southern hemisphere. In, India it has been witnessed in both peninsular and extra-peninsular parts of Indian sub-continent. Rangit Gondwana Basin (RGB) of Sikkim Lesser Himalaya is one of the Himalayan Gondwana basin of eastern Himalaya in the Rangit window (Figure 1). Diamictites and boulder beds at the base of the Rangit Pebble Slate Formation shows the glacial environment based on field and petrography. The alternate bands of sandstone and shale overlying the glacial beds are influenced by the glacio-marine environment (Figure 2a, Figure 2b). The Rangit Pebble Slate Formation of the Sikkim Lesser Himalaya belongs to Lower Gondwana sequence and correlated with the Talchir For-

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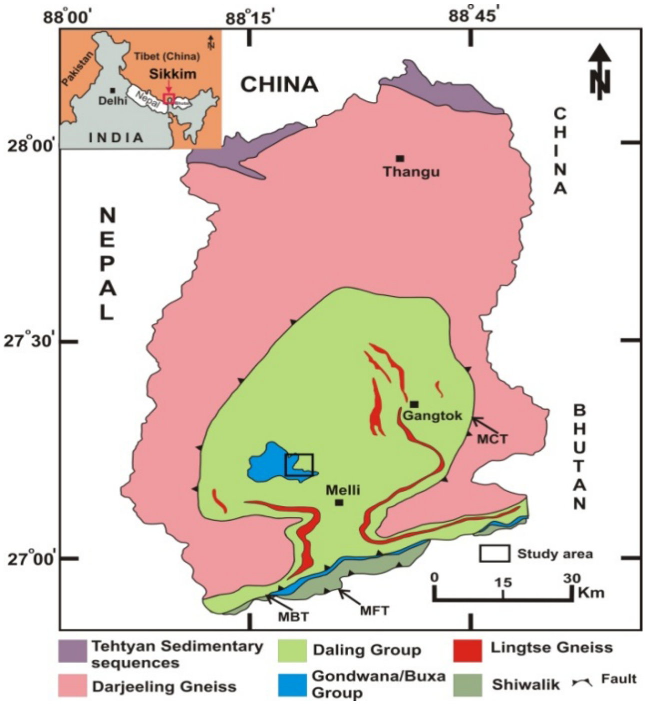

Figure 1. Geological map of the Sikkim Himalaya (after [*Chakarborty et al.,* 2016; *GSI,* 2012]).

mation of Gondwana master basin in Peninsular India [*Priya et al.,* 2019].

The main objective of the present study is to understand the source area composition, tectonic setting and paleo-weathering conditions during deposition of the Rangit Pebble-Slate (RPS) Formation. We have analyzed the REE and traces elements of the Rangit Pebble Slate Formation of Sikkim Lesser Himalaya and interpreted the data to achieve this objective. The distributions of REE pattern, elemental ratio, bivariate plot (Th/Co vs La/Sc, Ti/Zr vs La/Sc, La/Th vs Th/Yb, and Th/Sc vs Zr/Sc) and a trivariate plot (La-Th-Sc, Th-Co-Zr/10 and Th-Sc-Zr/10) of traces elements have been significantly used to decipher the geochemical nature of provenance and discriminate tectonic setting of the studied sediments. A binary plot (Th/Sc vs Zr/Sc and Th/U vs Th) also have been used to measure the intensity of chemical weathering and sedimentary recycling.

Material and Methods

The systematic samples were collected from the Namchi–Sikkip area, Sikkim Lesser Himalaya studied area and powdered for the geochemical analysis. All the standard procedures have been followed for sample preparation [*Takahashi,* 2015]. Rare Earth Elements (REE) were analyzed using an Agilent 7700 Inductively Coupled Plasma Mass Spectrometer (ICP-MS) while traces element composition of the sample were determined by X-ray fluorescence (PANalytical, Axios^{max}) in the laboratory of Birbal Sahni Institute of Paleosceinces, Lucknow, India.

Table 1. General Stratigraphic Column of Sikkim Himalaya [after *Acharyya and Ray,* 1977; *GSI,* 2012; *Priya et al.,* 2019]

Era	Peroid	Formation	Lithology
PALAEOZOIC	Carboniferous-Permian	Damuda Formation (Gondwana Supergroup)	Fossiliferous sandstone, siltstone, shale,carbonaceous slate, coal
		Rangit pebble slate Formation (Gondwana Supergroup)	Diamictite, Pebble-slate,shale quartzite, siltstone, sandstone, dark claystones
PRECAMBRIAN	Proterozoic (Undifferentiated)	Buxa Formation (Daling Group)	Dolomite, Stromatolite bearing limestone, cherty quartzite, variegated slate
		Reyong Formation (Daling Group)	Green slate, phyllite, cherty quartzite
		Gorubathan Formation (Daling Group)	Quartzite, variegated slate, phyllite
		Central crystalline gneiss complex (Kanchenjunga gneiss)	Banded migmatite, augen bearing biotite gneiss, mica schist, sillimnite granite gneiss

Geological Setting of the Sikkim Lesser Himalaya

The extra-peninsular geological formations exposed in the Rangit Window of Sikkim Lesser Himalaya includes the stromatolitic cherty dolomite and shales of Meso-Neoproterozoic Buxa Formation, the topmost formation of the Daling Group given in Table 1 [*GSI,* 2012; *Schopf et al.,* 2008; *Tewari,* 2011]. The Paleo to Mesoproterozic Daling Group quartzites and phyllites underlie the Buxa Formation conformably in the Rangit window area [*Priya et al.,* 2019]. Daling Group is further subdivided into Gorubathan (lower) Formation and Reyong (middle) Formation (Table 1). The unconformably overlying Permo-Carboniferous Gondwana Group of rocks primarily consists of glacial diamictites, pebble slates, sandstones and coal beds [*Acharyya and Ray,* 1977; *GSI,* 2012; *Priya et al.,* 2019]. The Damuda Group of the upper Gond-

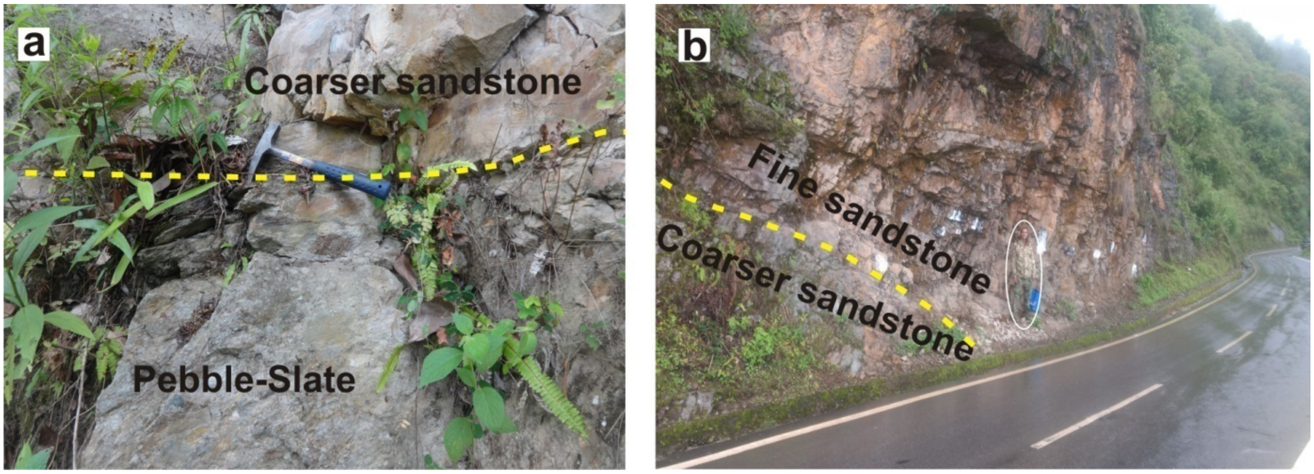

Figure 2. Field photograph depicting the Rangit Pebble Slate sequence in Sikkim Lesser Himalaya (a) alternate band of pebble-slate and coarser sandstone and (b) alternate band of coarser and fine sandstone.

wana mainly consists of phyllite, quartzite, variegated slates and dolomites [*GSI,* 2012]. However, the dolomite is integral part of the underlying Buxa Group [*Tewari,* 2011]. Gondwana Group/Damuda Group of rocks (Carboniferous–Permian) is unconformably overlain by the stromatolitic and microfossiliferous cherty carbonate rocks of the Buxa Group [*Priya et al.,* 2019; *Schopf et al.,* 2008; *Tewari,* 2011]. The Gondwana group of the sediments is the youngest stratigraphic unit in the Sikkim Lesser Himalaya which consists of two major formations i.e. Rangit Pebble Slate (RPS) Formation and Damuda Formation. The lower litho units mainly consists of pebble-slate, diamictites, coarser sandstone and olive-green shale. The upper Gondwana sediments (Namchi Sandstone) constitute the alternate bands of sandstone, fossiliferous shale and coal beds [*Priya et al.,* 2019; *Raichudhari,* 2002].

The Rangit Pebble Slate Formation is exposed along Namchi-Sikkip road in South Sikkim. The Rangit Pebble Slate Formation belongs to the lower litho units of Gondwana Group. The Rangit Pebble Slate Formation is chiefly consists of glacial diamictite, boulder beds, pebble-slate, alternate band of sandstone and shale (Figure 2a, Figure 2b). The Rangit Pebble Slate sequence of the Sikkim Lesser Himalaya is tectonically disturbed, highly complex folding and over thrusting can be seen along the Namchi–Jorethang, Namchi–Sikkip and Namchi–Damthang road sections [*Priya et al.,* 2021a; 2021b].

Provenance and Tectonic Setting

Trace and Rare earth elements (REE) is one of the most important geochemical tools which has been widely used to deciphering the sediment provenance, tectonic setting and depositional environment of any sedimentary geological Formation [*Bhatia,* 1983; *Taylor and McLennan,* 1985]. Due to less mobility and highly resistant to the chemical weathering, some elements like Sc, Zr, Cr, Co, Th, V, and La are preserved as a geochemical signature to indicate the source of parents' materials [*McLennan et al.,* 1983]. The dominance of Sc, V and Co traces elements is higher in mafic source rock than felsic rock [*Bhatia and Crook,* 1986; *Taylor and McLennan,* 1985]. The lower abundance of V, Sc and Co in all samples of RPS Fm. sandstones strongly suggests and confirms that these sandstones were derived from felsic source rock. The elemental ratio of traces elements such as La/Sc, Th/ Sc, Cr/Th, Th/Co, and La/Co (Table 2) helps to distinguish and constrain the geochemical nature of the provenance [*Culler,* 2000; *Taylor and McLennan,* 1985].

The value (elemental ratios) of studied samples of RPS Fm. sandstones shown more affinities towards felsic rocks derivation (Table 2). The high value of Th/Co and La/Th ratio in all studied samples have shown the enrichment of Th and La which significantly indicates that RPS Fm. sandstones were substantially derived from a felsic source. A bivariate plot between the ratio of Th/Co vs

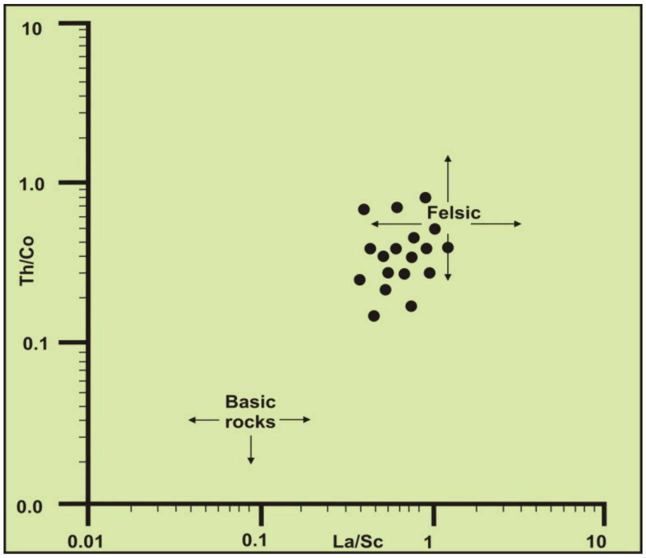

Figure 3. Bivariate plot of Th/Co versus La/Sc showing the felsic provenance of the studied sediments (after [*Cullers,* 2002]).

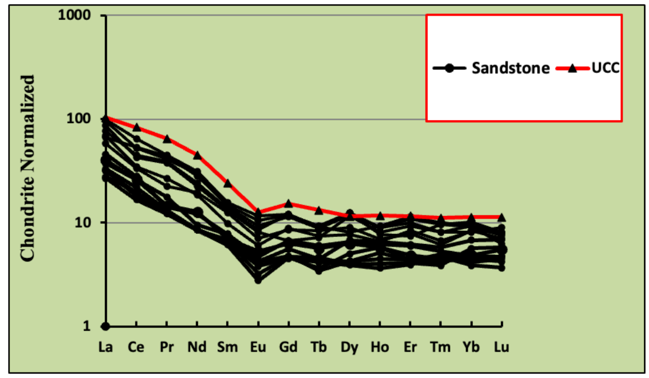

Figure 4. Chondrite-normalized REE pattern for RPS Fm. sandstone and comprehensive comparison with Upper Continental Crust (UCC) value (after [*Taylor and McLennan,* 1985]).

La/Sc and La/Th vs Th/Yb (Figure 3, Figure 5) also indicates that all studied sediments of Rangit Pebble Slate Formation were derived from the felsic source.

The total REE concentrations in the studied sample of Rangit Pebble Slate Formation sandstone ranged from 44.1 ppm to 169.57 ppm (Table 3) and were being normalized with normalizing factors of upper continental crust [*Taylor and McLennan,* 1985]. In contrast, the high value of LREE/HREE ratio with negative Eu anomalies advocate felsic source rocks while mafic and/or ultramafic rocks have low LREE/HREE ratios with no or positive Eu anomalies [*Taylor and McLennan,* 1985]. The REE distribution pattern of studied samples compared with UCC and shown the enrichment of light REE with a negative Eu anomaly (Figure 4).

The traces elements such as Sc, Co, La, Th, Ti and Zr play a significant role in deciphering the tectonic setting of clastic sedimentary rock. In the present study, triangular plots given by *Bhatia and Crook* [1986] have been used to discriminate the tectonic setting. The content of elements in the studied samples was converted into percentage and each axis of equilateral triangular plots equally divided into percentage (i.e. 0–100%). The four distinctive tectonic settings i.e. Oceanic island arc (A), Continental island arc (B), Active continental margin (C) & Passive margin (D) are recognized on the triangular plot of La-Th-Sc, Th-Co-Zr/10 and Th-Sc-Zr/10. The differentiated tectonic environment (i.e. A, B, C, D) are demarcated on the basis of previous study done by *Bhatia and Crook* [1986] which indicate the relative dominance of traces elements in each of trivariate plots (Figure 7a, Figure 7b, Figure 7c). The high value of Th/Sc ratio in the ternary plot of La-Th-Sc (Figure 7a) depicted the passive margin setting. The similar passive setting of the tectonic environment is also evident from triangular plot of Th-Co-Zr/10 and Th-Sc-Zr/10 (Figure 7b, Figure 7c). A bivariate plot between the ratio of Ti/Zr and La/Sc also imply passive tectonic setting (Figure 6). All these plots reflect the enrichments of Th & Zr elements and depletion of Sc element in studied sediments of Rangit Pebble Slate Formation which indicate that these sediments were derived from the felsic provenance. The ratio of Th and U (Th/U) reflects the signature of weathering and sedimentary recycling

Table 2. Comparative Study of the Elemental Ratios of Permo-Carboniferous Rangit Sandstone With Studied Sediments of Felsic Rock, Mafic Rocks and the Upper Continental Crust (UCC)

Elemental Ratio	RPS Fm. Sandstone	Felsic sources[a]	Mafic sources[a]	UCC[b]
La/Sc	1.53–6.49	2.50–16.3	0.43–0.86	2.21
Th/Sc	1.03–5.26	0.84–20.5	0.05–0.22	0.79
La/Co	1.05–5.68	1.80–13.8	0.14–0.38	1.76
Th/Co	0.57–12.2	0.67–19.4	0.04–1.40	0.63
Cr/Th	3.23–13.5	4.00–15.0	25.00–50	7.76
Eu/Eu*	0.21–0.47	0.40–0.94	0.71–0.95	0.63

[[a] *Culler,* 2000; [b] *Taylor and McLennan,* 1985].

Table 3. Chemical Composition (REE & Traces) of Permo-Carboniferous Sandstone, Sikkim Lesser Himalaya, India

REE (ppm)	Rsd1	Rsd2	Rsd3	Rsd4	Rsd5	Rsd6	Rsd7	Rsd8	Rsd9
La	31.81	33.56	74.83	76.98	51.67	25.19	71.29	26.86	46.88
Ce	61.29	51.21	50.29	43.15	41.05	33.31	32.11	24.97	26.95
Pr	6.14	6.06	5.69	5.37	5.17	3.69	3.08	2.01	1.96
Nd	22.21	19.91	21.03	17.05	16.12	13.23	14.02	9.07	8.61
Sm	3.11	2.16	3.03	2.16	1.02	2.28	2.01	1.62	1.01
Eu	1.01	0.91	0.81	0.75	0.71	0.53	0.61	0.52	0.41
Gd	3.01	3.04	2.21	3.02	2.07	2.71	2	1.74	2.06
Tb	0.53	0.54	0.51	0.51	0.42	0.43	0.49	0.33	0.35
Dy	3.09	4.76	4.73	4.56	4.42	2.95	3.41	2.39	2.51
Ho	0.79	0.76	0.66	0.76	0.69	0.56	0.59	0.49	0.53
Er	2.84	2.73	1.85	2.48	2.31	2.08	1.96	1.21	1.49
Tm	0.36	0.35	0.35	0.29	0.29	0.24	0.22	0.16	0.19
Yb	2.34	2.51	3.29	4.82	6.97	4.04	5.91	6.21	4.88
Lu	0.3	0.31	0.29	0.24	0.34	0.31	0.27	0.21	0.18
Σ REE	138.83	128.81	169.57	162.14	133.25	91.55	137.97	77.79	98.01
Traces (ppm)									
Sc	3.83	4	11.02	13.07	6.16	7.09	7.21	4.18	6.06
Rb	0.24	1.34	0.84	0.8	0.26	1.54	0.29	1.49	0.34
Ba	0.3	0.98	0.78	0.71	1.01	1.18	1.18	0.82	0.63
Th	5.13	6.1	12.28	19.16	26.73	9.36	21.76	22.21	17.09
U	1.13	1.89	3.02	2.69	2.82	1.31	2.86	1.97	2.98
Cr	66.81	82.32	116.22	161.23	169.07	107.03	122.62	93.26	89.17
Co	9.07	5.62	9.14	8.61	2.18	13.23	4.24	13.23	14.16
Sr	1.25	0.15	0.12	0.62	0.12	0.23	0.16	0.14	0.05
Nd	0.42	0.7	0.5	0.23	0.66	0.62	0.56	0.5	0.47
P	0.69	0.12	0.9	0.25	0.75	0.81	1	0.56	0.87
Hf	0.02	0.18	0.14	0.11	0.05	0.22	0.17	0.18	0.05
Zr	149	136	141	118	147	139	111	91	116
Ti	115	226	424	346	538	478	642	562	654
Tb	0.81	1.42	1.22	0.45	1.16	1.12	0.98	0.95	0.86
Eu/Eu*	0.33	0.35	0.31	0.29	0.46	0.21	0.30	0.31	0.27
La/Sc	8.31	8.39	5.93	5.89	8.39	3.11	9.89	6.13	7.74
Th/ Sc	1.34	1.53	0.97	1.47	4.34	1.16	3.02	5.07	4.47
La/Co	1.08	4.09	3.52	3.26	14.53	1.90	5.02	2.03	2.60
Th/Co	0.57	1.09	1.34	2.23	12.26	0.71	5.13	1.68	1.91
Cr/Th	13.02	13.50	9.46	8.41	6.33	11.43	5.64	4.20	3.29
La/Sc	8.31	8.39	6.79	5.89	8.39	3.55	9.89	6.43	7.74
Th/Yb	2.19	2.43	3.73	3.98	3.84	2.32	3.68	3.58	3.50
Ti/Zr	0.77	1.66	3.01	2.93	3.66	3.44	5.78	6.18	5.64
La/Th	6.20	5.50	6.09	4.02	1.93	2.69	3.28	1.21	2.74

Table 3. Chemical Composition (REE & Traces) of Permo-Carboniferous Sandstone, Sikkim Lesser Himalaya, India

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REE (ppm)	Rsd10	Rsd11	Rsd12	Rsd13	RMd14	RMd15	Rsd16	RMd17	RMd18
La	60.72	11.64	38.08	11.76	13.21	9.87	25.56	34.82	35.08
Ce	24.87	18.63	21.07	17.21	19.07	16.01	41.05	24.87	26.95
Pr	2.42	1.73	1.81	1.68	1.71	1.67	5.17	2.42	1.96
Nd	6.79	6.04	6.12	6.03	6.11	6.09	15.02	6.79	9.01
Sm	1.79	1.41	1.52	1.06	1.54	1.51	1.02	1.79	1.01
Eu	0.42	0.54	0.36	0.49	0.48	0.38	0.51	0.41	0.42
Gd	1.03	1.41	1.46	1.03	1.43	1.39	1.24	1.03	2.06
Tb	0.26	0.21	0.2	0.25	0.27	0.24	0.39	0.24	0.36
Dy	2.59	1.92	1.61	1.63	1.52	1.49	4.41	2.46	2.51
Ho	0.56	0.49	0.44	0.38	0.34	0.31	0.69	0.56	0.44
Er	1.54	1.09	1.07	1.09	1.02	0.98	2.03	1.26	1.38
Tm	0.21	0.17	0.18	0.15	0.14	0.17	0.29	0.21	0.19
Yb	5.89	2.84	2.11	4.16	2.41	1.96	5.92	3.69	1.88
Lu	0.26	0.17	0.16	0.18	0.22	0.14	0.22	0.23	0.15
Σ REE	109.35	48.29	76.19	47.1	49.47	42.21	103.52	80.78	83.4
Traces (ppm)									
Sc	6.81	2.03	7.87	5.83	5.98	6.02	4.46	3.06	4.72
Rb	1.37	0.36	0.61	0.53	0.78	1.55	0.83	0.57	0.81
Ba	0.46	0.87	0.98	0.97	1.22	1.1	0.56	1.02	0.41
Th	20.03	8.38	4.78	9.16	6.13	5.99	22.21	13.02	4.87
U	2.96	1.99	0.9	1.04	1.39	0.95	1.87	1.05	0.67
Cr	41.69	51.81	27.23	58.23	39.11	28.33	85.17	42.05	28.33
Co	9.84	11.06	7.04	2.26	4.18	3.13	6.03	6.79	2.53
Sr	0.03	0.13	0.18	0.15	0.23	0.04	0.02	0.05	0.12
Nd	0.73	0.27	0.35	0.35	0.31	0.25	0.41	0.32	0.54
P	1	0.5	0.81	1.06	0.37	0.44	0.12	0.42	0.22
Hf	0.15	0.21	0.22	0.35	0.27	0.15	0.19	0.07	0.15
Zr	89	126	81	151	79	152	109	98	114
Ti	258	522	654	463	466	567	651	632	524
Tb	1.58	0.55	0.64	0.62	0.58	0.5	0.71	0.29	0.38
Eu/Eu*	0.30	0.38	0.24	0.47	0.32	0.26	0.45	0.29	0.27
La/Sc	15.94	5.73	4.84	2.02	2.21	1.64	4.68	11.38	7.43
Th/ Sc	5.26	4.13	0.61	1.57	1.03	1.00	4.07	4.25	1.03
La/Co	2.51	1.05	1.72	5.20	3.16	3.15	4.24	2.48	5.68
Th/Co	2.04	0.76	0.68	4.05	1.47	1.91	3.68	1.92	1.93
Cr/Th	2.08	6.18	5.70	6.36	6.38	4.73	3.83	3.23	5.81
La/Sc	8.92	5.73	4.84	2.02	2.21	1.64	5.73	11.38	7.43
Th/Yb	3.40	2.95	2.27	2.20	2.54	3.06	3.75	3.53	2.59
Ti/Zr	2.90	4.14	8.07	3.07	5.90	3.73	5.97	6.45	4.60
La/Th	3.03	1.39	7.97	1.28	2.15	1.65	1.15	2.67	7.20

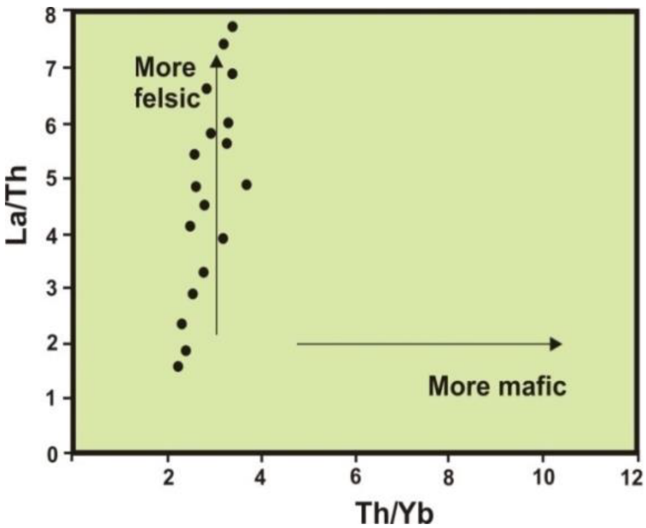

Figure 5. A bivariate plot (La/Th vs Th/Yb) for the Permo-Carboniferous sandstone of Rangit Pebble Slate Formation, Sikkim Lesser Himalaya (after [*Taylor and McLennan,* 1985]).

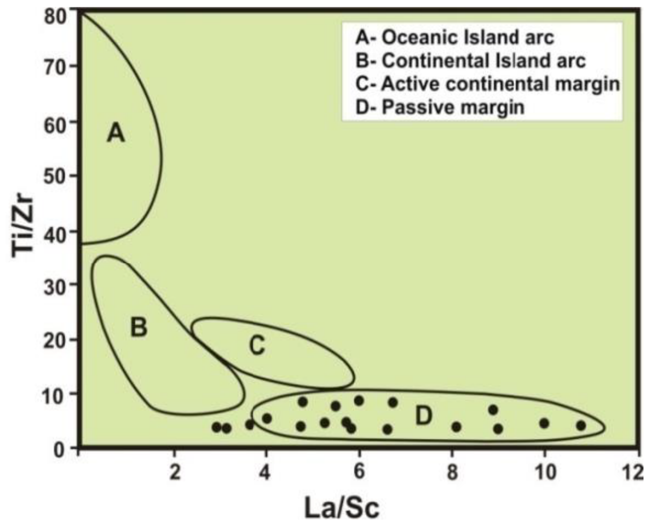

Figure 6. A bivariate tectonic setting discrimination diagram for sandstone of RPS Fm. (after [*Bhatia and Crook,* 1986]).

histories due to loss of U^{4+} during sedimentation [*Taylor and McLennan,* 1985]. If the ratio value of Th/U is higher than 4.0 then, it is considered to be result of high intensity of weathering and/or sediment recycling in the provenance area [*Rahman and Suzuki,* 2007]. In the present study, a binary plot between the ratio of Th/U vs Th and Th/Sc vs Zr/Sc have been used to shown the weathering trend and sedimentary recycling for the RPS Fm. sandstone (Figure 8, Figure 9). The elemental ratio (Th/U) of RPS Fm. sandstones ranges 3.17 to 7.39 with an average of 4.8 which implies that these sediments were influenced by weathering and sedimentary recycling (Figure 8). Furthermore, a binary plot between the ratios of Th/Sc and Zr/Sc is another reliable indicator has been used to measure the role of sorting and sedimentary recycling [*McLennan et al.,* 1983]. The addition of zircon in studied sample significantly correlated with a bivariate plot of Th/Sc vs Zr/Sc which might be the consequences of sedimentary recycling (Figure 9).

Results and Discussion

The distributions of rare earth element (REE) and traces elements of clastic sedimentary rock have been broadly applied for characterizing the provenance and tectonic setting discrimination [*McLennan et al.,* 1993]. The elemental ratios (Table 2) of trace elements have been positively used for the comparative study with felsic source, mafic source and UCC to interpret the geochemical nature of sediment. The dominance of Th and Zr elements in the studied sediments strongly indicate felsic provenance which has been depicted through a binary plot of Th/Co vs La/Sc and La/Th vs

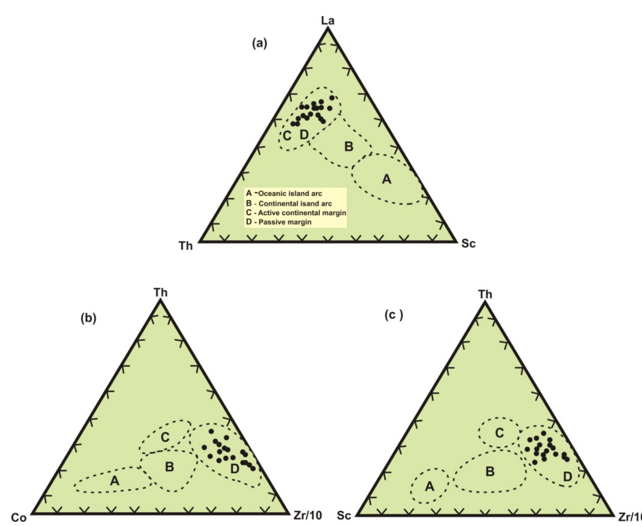

Figure 7. A ternary plot (a, b & c) for tectonic setting showing the passive tectonic environment for Permo-Carboniferous sandstone of Rangit Pebble Slate Formation, Sikkim Lesser Himalaya (after [*Bhatia and Crook,* 1986]).

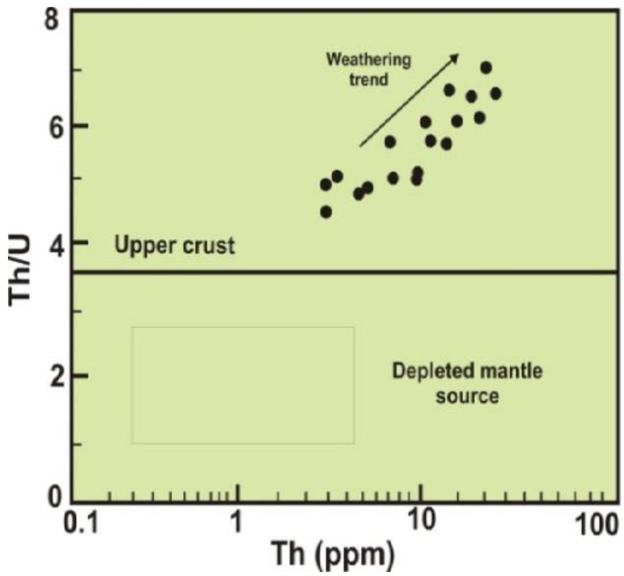

Figure 8. Binary plot of Th/U versus Th for the RPS Formation sandstone (after [*McLennan et al.,* 1993]).

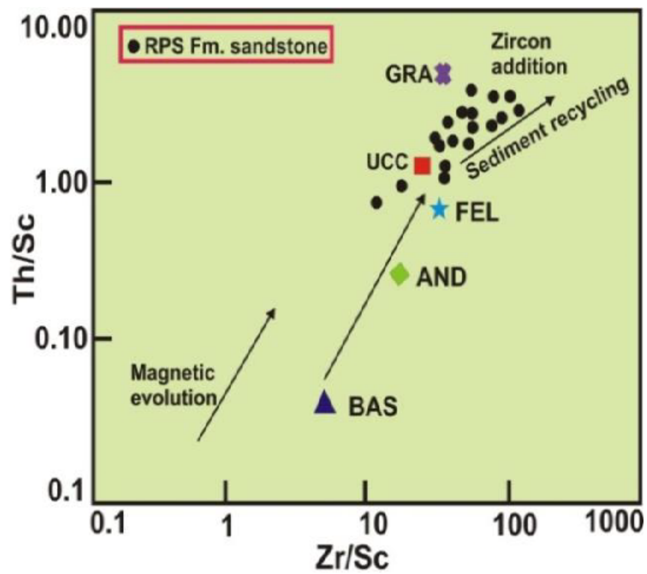

Figure 9. Binary plot of Th/Sc versus Zr/Sc for the RPS Fm. sandstones (after [*McLennan et al.,* 1993]). Different geometry symbol indicate the average composition of basalt (BAS), andesite (AND), felsic (FEL), granite (GRA) and upper continental crust (UCC).

Th/Yb (Figure 3, Figure 5). The REE distribution pattern of studied samples shows the enrichment of light REE with a negative Eu anomaly which implied the felsic rich source derivation (Figure 4). The triangular plot of La-Th-Sc, Th-Co-Zr/10 and Th-Sc-Zr/10 (Figure 7a, Figure 7b, Figure 7c) indicate the passive margin tectonic environment of deposition. A typical weathering trend depicted by the bivariate plot of Th/U vs Th/U and Th/Sc vs Zr/Sc strongly supports the role of weathering and sedimentary recycling during the sedimentation of RPS Formation (Figure 8, Figure 9).

Conclusion

The Permo-Carboniferous sandstone of the Rangit Pebble Slate Formation of Sikkim Lesser Himalaya has been studied to decipher its geochemical characteristics through REE and trace elements. The discrimination diagram for provenance and tectonic setting, elucidate that these sediments were derived from felsic rich provenance (continental) and were deposited in a passive continental tectonic setting. The combined results of both REE and trace elements indicate the felsic source which may have been derived from high grade metamorphic rocks and plutonic igneous rocks of Peninsular Craton i.e. Chotanagpur Granite Gneiss Complex (CGGC), Shillong-Meghalaya Gneissic Complex (SMGC) and Proterzoic Himalayan granites and gneisses rock . The higher LREE pattern with negative Eu anomaly and elemental ratios of trace elements of Rangit Pebble Slate Formation sandstone strongly suggest that these sediments are enriched with felsic source rock and closely associated with upper continental crust (UCC). A typical weathering trend depicted by Th/Sc vs Zr/Sc and Th/U vs Th plot suggested that these sediments were strongly influenced by weathering and sedimentary recycling during sedimentation.

Acknowledgment. The authors are thankful to the Head of Department, Sikkim University for his constant support and providing infrastructural facilities. Director, Birbal Sahni Institute of Palaeoscience, Lucknow, India is thanked for providing the facilities of the geochemical laboratory of the Institute. We are grateful to Dr. N. Wanjari for discussions and suggestions. Anonymous reviewer is thanked for constructive comments and valuable suggestions to improve themanuscript. R.K.P. thanks Sikkim University for award of research fellowship to carry out this research.

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