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Geochemistry of Neoproterozoic arenites from the Murwara area, Katni District, Madhya Pradesh: Implications for provenance, weathering and Tectonic Setting

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ABSTRACT

Geochemical analysis in terms of major, trace and rare earth elements of the Neo-Proterozoic arenites of Rewa and Bhander Groups of the Vindhyan Supergroup from Murwara, Katni district, M.P., has been carried out to determine the provenance, weathering and tectonic setting. The arenites are rich in SiO_2 content but less in Na_2O, K_2O and CaO contents, suggesting the dominance of quartz and less amount of feldspars and rock fragments. Geochemically, these rocks are classified as quartz arenites to sub litharenite to sub-arkose. The CIA (75-98) and PIA values for these arenites and A-CN-K diagram indicates a high intensity of weathering in the source area. High LREE/HREE ratios, negative Eu anomaly and La/Sc, Th/Sc, Th/Co and Cr/Th ratio values suggest felsic source of these arenites. The discriminant diagram for these arenites indicates a quartzose sedimentary provenance. Ni vs TiO_2 and Th/Sc vs Sc bivariate plots indicate that the felsic rocks have been the source rock for these arenites. The discrimination diagrams based on log (K_2O+Na_2O) vs SiO_2 and Fe_2O_3+MgO vs TiO_2 contents show a passive margin setting. Whereas the results of new discriminant function multi-dimensional diagram for the high silica arenites reveals a change from collision to continental rift setting.

Keywords: Geochemistry, Arenites, Vindhyan Supergroup, Neoproterozoic, Katni

INTRODUCTION

Sedimentary rocks are the most useful rock type in deciphering the past conditions of the Earth surface. Clastic rocks are the important source of information because they are the residue left over, after a long and continued process of erosion and provide the valuable clues about their sources. Geochemistry of sedimentary rocks may be an addition to petrographic data when petrography does not provide any significant clue. Geochemistry becomes important tool in delineating the source of sediments, weathering, transportation, sorting and diagenesis (Bhatia, 1983; Cox and Lowe, 1995; Ramos-Vázquez et al., 2017). The use of geochemical data of sedimentary rocks to understand the sedimentary processes is increasing as the geochemistry and especially the trace element concentration is becoming a sensitive tool (Graver et al., 1996; Tawfik et al., 2017, 2018). Several REE's like La, Nd, Ce, Gd and trace elements such as Y, Th, Zr, Hf and Sc are being used as a tool to decipher the processes like provenance and tectonic setting because these elements are relatively less mobile during the process of erosion and transportation (Armstrong-Altrin et al., 2021, 2022; Sopie et al., 2023). Hence, these elements concentrate into the clastic residue and provide the clue regarding their parent material, tectonic setting and nature of source rocks (Bhatia and Crook, 1986; Condie, 1993; Yadav et al., 2022).

Additionally, the geochemical features of the clastic rocks also reflect the chemistry of authigenic minerals formed by the diagenetic changes. In this study, we made an attempt to delineate the provenance, weathering condition of source rocks and tectonic environment based on the geochemical composition of the Neoproterozoic arenites in the Murwara area, Katni district, eastern part of M.P. The objective of this study is to infer the provenance of arenites based on the geochemical composition.

GEOLOGY OF THE AREA

Murwara area, Katni district, Madhya Pradesh is bounded between latitude 23˚45' N to 24˚0' N and longitude 80˚24' E to 80 ˚30' E and falls in SOI Toposheet 64A/5 and aerially extended over 320 km2 (Fig.1).

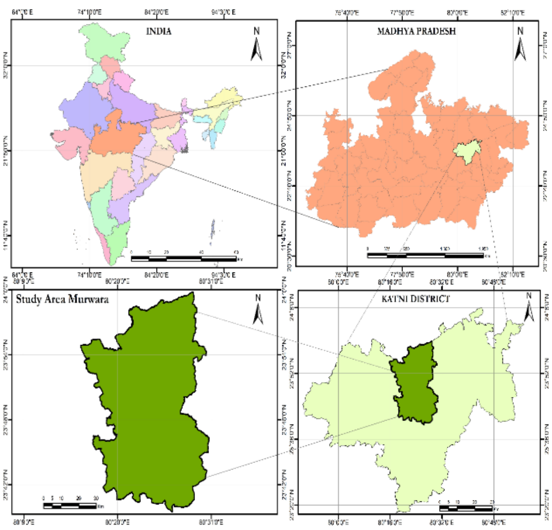

Fig. 1 Location map of the study area

The rocks belong to the Lower Vindhyan of Semri Group, Upper Vindhyan of Kaimur, Rewa and Bhander Groups, laterite and alluvium of the Quaternary age. More than half of the area is occupied by the laterite and alluvium, among the Vindhyans, the Upper Vindhyan occupy the larger part of the study area (Fig. 2), and are seen on the eastern side, whereas the Lower Vindhyans are present on either side of the faults, which are extending from north to south.

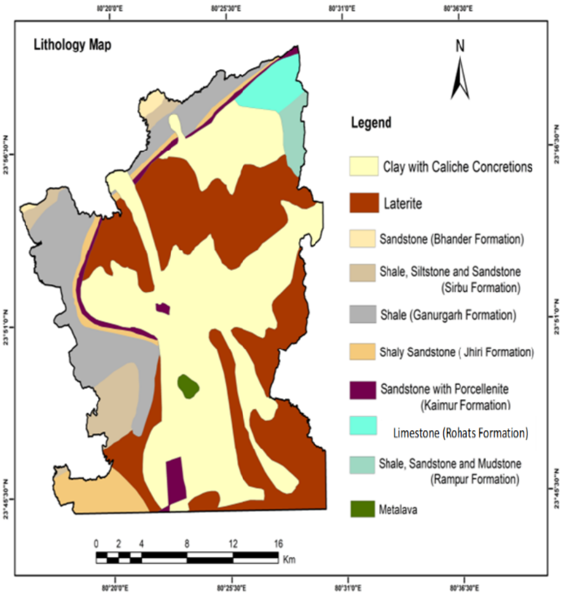

Figure 2 Geological Map of the Study Area (Interpreted from Remotely Sensed image and District resource Map, GSI).

The oldest rocks of Semri Group unconformably rest over the granite and metamorphics of the Bundelkhand and Mahakoshal Groups. These rocks of Semri Group include shale, sandstone and mudstones of the Rampura Formation. The shales are overlain the limestones. The limestones are thick to thinly bedded and also folded. Whereas the Upper Vindhyans observed in the area are sandstones with porcellinite of Kaimur shale and sandstone of Rewa Group, which are overlain by the Gunargarh shale and Sirbu sandstone and shale of the Bhander Group. Kaimur sandstone with porcellanite and sandstone of the Rewa Group are the dominant rock

types in the study area. These sandstones are thickly bedded, hard and compact mostly gently dipping but along fault planes these beds are more inclined, highly fractured and shared. Sandstones are with variety of primary sedimentary structures including wavy and current ripples, tabular and planar, cross-bedding, parting lineation and flute casts along with load and ball and pillow structures. Two almost parallel, N-S trending fault also present, the sandstone with porcellanite seems the most effected bed dislocated by these faults. Vindhyan rocks are overlain by the Laterite and Alluvium of Quaternary age.

METHODOLOGY

80 rock samples were collected during field visit, 12 sandstone samples were selected from the exposed rock surfaces along the stream, road and railway cuttings for chemical analysis. These samples were cleaned by washing with distilled water to avoid any contamination and then dried. These dried samples were powdered to -200 mesh size and sent for geochemical analysis. The major oxides, trace elements have been analyzed using HR-ICP-MS technique at the Geochemical Laboratory, National Geographic Research Institute (NGRI), Hyderabad. The instrument used is the AttoM HR-ICP-MS, a double focusing single collector instrument with forward Nier-Johnson analyzer geometry (Nu instrument, UK). For dissolution savillex pressure decomposition vessels (60ml.) (Savillex Corporation, Minnoetonka, Mn, USA) were used. Electronic grade Hydrofluoric Acid, AR grade HClO4, distilled HNO3 and HCl and lithium metaborate were used for the preparation of samples. For fusion a muffle furnace provided with silicon carbide tiles Kanthal heating elements with digital temperature controller (Max. temperature 1150˚C) was used. The standard reference material used for analyzing the rock samples are JG1a, JA1, JB2, BHUO1, UBN, SY3, JBD2, NOD-M, SARM-64 and PTC1A. Prior to analysis, the instrument was purged with a 2% HNO3 (V/V) solution for about an hour. The trace and REE data obtained by analyzing acidic (JG1a, JG1) and basic (JB2, BHOV1) reference materials through the HR-ICP-MS and the results of analysis are given in Tables 1, 2 and 3.

RESULTS AND DISCUSSION

Major elements

The major elements concentration in terms of wt.% of oxides of the arenites are listed in Table 1. On the Fe2O3/K2O vs SiO2/Al2O3 plot the samples are classified as quartz arenite to sub-arkosic arenites (Fig. 3a, after Herron, 1988). Similarly, based on the Pettijohn's (1972) diagram these arenites are classified as quartzose to sub-arkose type, which may be due to their relatively higher Al2O3 concentration (Fig. 3b).

The average SiO_2 content (wt.%) in the quartz arenites is 91% with a maximum value of 96% and a minimum of 78.8%, the arenite with 78.81% of SiO_2 shows an abnormally high wt.% of Fe_2O_3 (i.e., 5.95). Average Al_2O_3 is 4.17%, with an exception of higher content of Al_2O_3 in two arenite samples that is, 9.68 and 8.39 which may be attributed to the K-feldspar present in these rocks. Less Na_2O wt.%. (average < 0.1) can be attributed to relatively small amount of sodic plagioclase in these

Table 1. The Major oxides and ratios calculated for the arenites in the Murwara area (wt. %)										
Rock Type	Arenites									
Samples	L1C	L3A	L3B	L4C	L5	L6	L7A	L8	L-11	L-12C
SiO_2	84.34	92.94	96.42	78.81	92.96	95.21	95.08	92.76	85.91	95.54
Al_2O_3	9.68	2.98	2.10	8.39	3.04	1.75	2.69	2.76	7.74	2.08
Fe_2O_3	2.25	2.44	1.00	5.95	2.45	1.72	0.55	3.01	1.95	1.40
MnO	0.02	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.07	0.06
MgO	0.15	0.00	0.00	0.40	0.00	0.01	0.06	0.01	0.86	0.12
CaO	0.05	0.01	0.01	0.07	0.01	0.01	0.01	0.02	0.58	0.07
Na_2O	0.01	0.01	0.01	0.03	0.01	0.01	0.01	0.01	0.10	0.02
K_2O	0.66	0.03	0.03	1.30	0.04	0.01	0.11	0.05	2.37	0.45
TiO_2	0.19	0.07	0.06	0.28	0.20	0.10	0.06	0.36	0.20	0.11
P_2O_5	0.09	0.03	0.03	0.05	0.04	0.03	0.03	0.02	0.04	0.04
CIA	95.9	98.6	98.2	86.4	98.4	98.7	95.7	97.9	75.8	81.6
ICV	0.34	0.86	0.53	0.96	0.89	1.06	0.30	1.25	0.79	1.07
SiO_2/Al_2O_3	8.71	31.22	45.89	9.39	30.54	54.28	35.39	33.61	1.16	1.05
K_2O/Na_2O	132.8	3.2	2.9	49.8	3.8	1.3	11.0	5.0	0.18	0.25
MgO/K_2O	0.23	0.13	0.10	0.31	0.05	0.77	0.54	0.12	0.66	3.35
Na_2O/K_2O	0.01	0.31	2.9	0.02	0.26	0.77	0.09	0.20	5.64	4.07
K_2O/Al_2O_3	0.07	0.01	0.01	0.15	0.01	0.01	0.04	5.0	0.31	0.22
Fe_2O_3/K_2O	3.39	76.09	34.55	4.59	64.37	132.46	4.97	60.20	75.74	115
Al_2O_3/TiO_2	50.4	40.2	36.2	29.9	15.1	17.7	46.3	7.7	36.2	211

arenites. Average K_2O wt.%. is up to 0.3, whereas this K_2O content is higher in the rocks with more Al_2O_3, which also indicates more amount of K-feldspars. Generally, Fe_2O_3 and TiO_2 contents reflect low Fe, Ti bearing heavy minerals in these arenites. This classification is consistent with the petrographic study (Fig. 4) as the petrographic study shows the dominance of quartz in these arenites and in a few rock sections feldspar of fresh as well as altered types are observed.

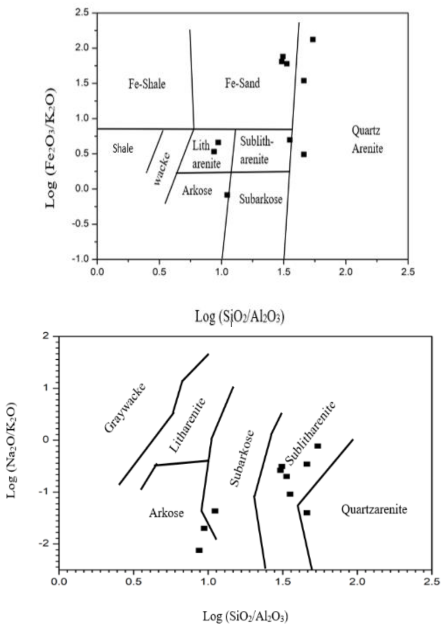

Fig. (3a). Log (Fe_2O_3/K_2O) vs Log (SiO_2/Al_2O_3) plot for the arenites (after Herron, 1988).
(3b) Log (Na_2O/K_2O) vs Log (SiO_2/Al_2O_3) plot for the arenites (after Pettijohn, 1972).

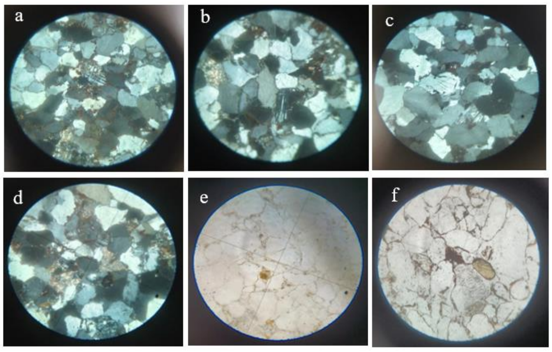

Figure 4. Photomicrographs of arenites of the Murwara area under crossed Nicol's (a, b, c, d) and plane polarized light (e, f) (10x)

Trace Element concentrations

The trace element contents of the arenites of Murwara area are listed in Table 2. Compared with that of the average upper continental crust (UCC) values the concentration of most of the trace elements is low. The average concentrations of trace elements lie between 0.1 and 1 (Fig. 5). Similarly, few elements like Rb, Ni, Cr, and Co are less

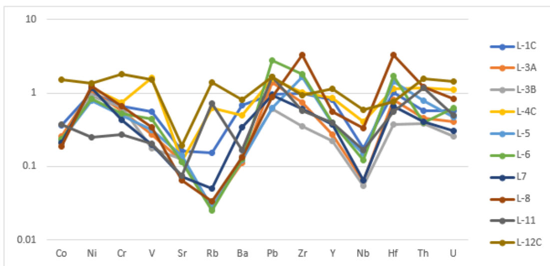

Fig 5. Spider plot for the trace elements of arenites from the Murwara area, normalized against UCC (Taylor and McLennan, 1995)

abundant, whereas concentrations of Zr and Ba are higher relative to UCC.

Rare Earth Element concentrations

Analysed values of REE (Table 3) and the chondrite normalised pattern is shown in Fig. 6. The ∑REE for the arenites varies between 62.72 to 176 (Table 3). The REE contents in the arenites are less than the average values for sandstones. The slightly higher LREE and the negative Eu show that the rocks contain less amount of Calcium in these arenites as these rocks do not contain much calcic plagioclase.

PROVENANCE

Provenance defines the origin of sediments and the composition of source rocks dominantly controls the composition of sediments derived from them (Taylor and McLennan, 1985; Bessa et al., 2021; Madhavaraju et al., 2021). Geochemistry of the sedimentary rocks is a valuable tool for the delineation of provenance (Bhatia, 1983; Gotze, 1998; Yang et al., 2004; Kettanah et al., 2021). Feng and Kerrich (1990) proposed the HFSE (High Field Strength Elements) such as Zr, Hf, Nb, Y, Th and U enriched in felsic rocks as they preferentially partitioned into the melts during crystallization and due to their highly immobile nature they remain in rocks and reflect the provenance. However, processes like weathering, transportation, diagenesis, etc. can affect the chemical composition (Cullers et al., 1987; Wang et al., 2018; Bela et al., 2023).

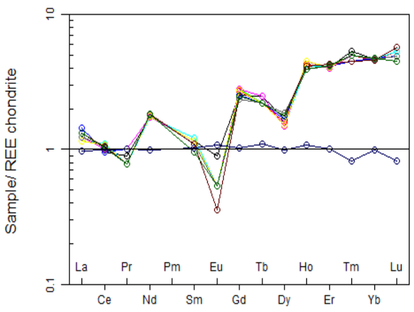

Fig 6. Chondrite normalized REE Spider plot for the arenites of Murwara area (After Anders and Grevesse, 1989).

REE, Th and Sc are widely used to infer the composition of crustal rocks as the distribution of these elements is least affected by physical process like diagenesis and metamorphism and by the heavy mineral fractionation than that of elements like Zr, Hf and Sn (Bhatia and Crook, 1986). Different igneous source rocks and their weathering products show different concentrations of trace and REE. REE and Th show higher abundance in felsic source whereas Co, Cr and Cs concentrated in mafic igneous source and in their weathered products. Ratios such as La/Sc, Th/Sc, Th/Co and Cr/Th are different in felsic and mafic source rocks and may provide information about the provenance of sedimentary rocks (Wronkiewicz and Condie, 1989; Ramos-Vázquez et al., 2022). In the present study these ratios are calculated and compared with the values for sediments derived from felsic and mafic sources and UCC values (Table 4), suggesting that these arenites were probably derived from a felsic source. LREE /HREE ratios and Eu anomaly are also widely used to infer the source of sedimentary rocks and provenance (Cullers and Graf, 1984; Banerji et al., 2022; Nayak and Singh, 2022). In the present study, higher LREE/HREE ratio (21.11) and negative Eu anomaly indicate a possible felsic source rock.

A discriminant function diagram (Roser and Korsch, 1988) also allows to discriminate the provenance into major groups viz. mafic igneous, intermediate igneous, felsic igneous and quartzose sedimentary provenance (Fig. 7). In this diagram the arenites are plotting in the quartzose sedimentary provenance.

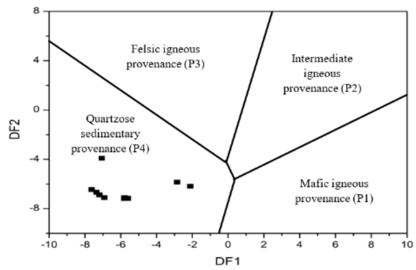

Figure 7. Provenance discriminant function plot for the arenites of Murwara area (After Roser and Korsch 1988). F1 and F2 refer to -1.773TiO2 + 0.067Al2O3 + 0.76FeO* - 1.5MgO + 0.616CaO + 0.509Na2O – 1.224K2O – 9.09 and 0.0445TiO2 + 0.07Al2O3 – 0.25FeO* - 1.142MgO +0.438CaO + 1.475Na2O + 1.426K2O – 6.861, respectively

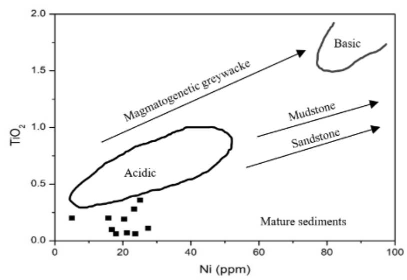

Figure 8. TiO_2 vs Ni bivariate plot for the arenites of Murwara area (after Floyd et al., 1989)

To delineate the possible source of the arenites of Murwara area binary diagram between TiO_2 (wt.%) and Ni is plotted as Fig. 8 (after Floyd et al., 1989) which revels that arenites are falling close to acidic source field. Among the ferromagnesian suite of trace elements Cr, Ni, Co and V show similar behaviour in magmatic process and their abundance indicate the mafic source rock (Armstrong- Altrin, 2004). In the studied arenites the concentration of Cr, Ni, Co and V elements (Table 2;) is low suggesting felsic rocks as source of these rocks.

Table 2. Trace element concentrations in arenites from the Murwara area (in ppm)										
Arenites										
Elements	L1C	L3A	L3B	L4C	L5	L6	L7A	L8	L-11	L-12C
Sc	3.52	1.39	1.15	7.70	1.98	3.30	2.10	3.13	2.93	15.91
V	33.80	16.21	10.47	97.44	18.82	26.19	11.94	20.39	12.33	90.28
Cr	22.84	20.07	22.20	25.80	17.46	18.57	14.83	23.05	9.41	63.82
Co	3.62	2.57	2.31	2.08	2.30	2.35	2.08	1.85	3.74	15.02
Ni	20.34	21.19	17.98	23.30	15.76	16.76	23.61	25.06	5.02	27.41
Cu	17.73	18.23	20.89	40.90	15.62	21.80	16.70	23.10	8.53	30.68
Zn	37.20	40.45	53.45	43.00	29.80	25.77	36.60	28.45	19.22	79.04
Ga	5.51	2.63	1.86	9.89	2.57	2.19	2.51	2.53	5.37	19.13
Rb	17.16	3.24	3.11	70.75	3.10	2.83	5.58	3.77	79.57	157
Sr	56.43	41.16	44.41	41.83	49.64	40.54	25.29	22.61	26.26	67.98
Y	17.82	6.01	4.86	18.69	8.38	8.58	8.22	12.08	8.62	24.81
Zr	185.88	141.78	67.69	194.2	318.10	337.9	115	616.6	109.9	176.82
Nb	4.45	1.58	1.36	10.01	3.71	3.05	1.61	8.18	4.13	14.67
Cs	0.90	0.27	0.27	3.88	0.23	0.24	0.50	0.26	-	-
Ba	375	61.88	75.25	273	67.09	69.61	186.1	72.50	91.7	442.2
Hf	5.96	4.62	2.16	6.65	8.25	9.88	3.78	19.05	3.25	4.48
Ta	0.76	0.16	0.12	0.79	0.32	0.30	0.35	0.89	19.85	38.72
Pb	19.02	27.76	12.05	31.65	12.62	55.03	18.39	17.55	32.59	33.09
Th	6.05	4.92	4.07	12.57	8.33	4.23	4.38	12.80	12.60	16.67
U	1.58	1.14	0.71	3.12	1.30	1.74	0.85	2.30	1.39	4.02
Th/Sc	1.72	3.52	3.54	1.63	4.20	1.28	2.08	4.09	4.29	4.15
Th/U	3.83	4.32	5.70	4.02	6.38	2.43	5.16	5.56	9.04	1.11
Th/Co	1.67	1.91	1.76	6.03	3.62	1.79	2.11	6.89	3.37	1.11
La/Sc	5.51	10.20	10.21	2.50	7.87	5.46	7.22	5.24	10.04	0.07
La/Co	5.36	5.55	5.08	9.24	6.78	7.66	7.31	8.84	7.87	0.07
Cr/Th	3.77	4.08	5.45	2.05	2.09	4.39	3.38	1.80	0.75	2.33
Cr/Ni	1.12	0.95	1.24	1.11	1.11	1.11	0.63	0.92	1.88	2.33

Th/Sc vs Sc bivariate plot also provides information about the source of terrigenous sedimentary rocks (McLennan and Taylor, 1991; Cullers, 2002). The ratios Th/Sc and the elemental concentration of Sc are plotted in Fig. 9 to decipher the source rock. For comparison these values (Th/Sc

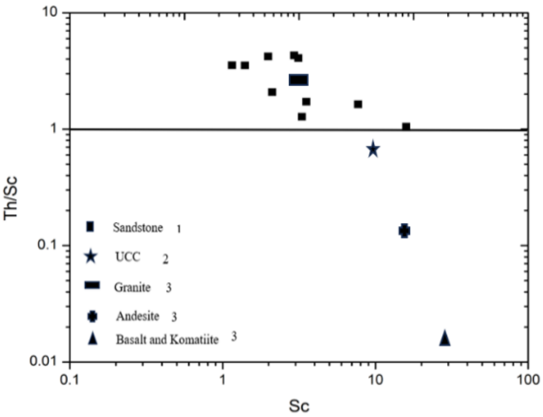

Fig 9. Th/Sc-Sc bivariate plot for the arenites of the Murwara area. [1]study area, [2]upper continental crust (UCC; McLennan, 2001) and [3]Condie (1993).

vs Sc) of the studied arenites are plotted together with UCC (McLennan, 2001) values, Archaean granite, Andesite, Basalt + Komatiite (Condie, 1993), which confirms that the source of arenites is a felsic rock.

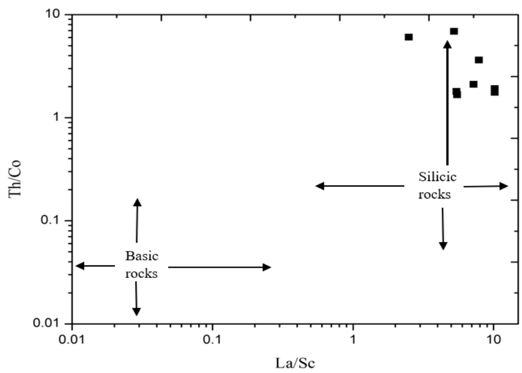

Figure 10. Th/Co vs La/Sc bivariate plot for the arenites of Murwara area (after Culler, 2002)

Th/Co vs La/Sc bivariate plot proposed by Cullers (2002) also reaffirm the silicic source of these rocks (Fig. 10).

WEATHERING OF SOURCE ROCKS

The duration and intensity of weathering in sedimentary rocks can be evaluated by examining the relationship between alkali and alkaline earth elements (Nesbitt and Young, 1982, Nesbitt et al., 1996). Feldspars are the most dominant phase actively participate in weathering, during weathering calcium, sodium and potassium atoms largely remove from feldspars (Nesbitt et al., 1980). To assess the degree of weathering most effective measures are chemical index of alteration (CIA

Nesbitt and Young, 1982) and plagioclase index of alteration (PIA; Fedo et al., 1995) CIA is calculated using the formula: CIA = [Al2O3/ (Al2O3 + CaO* + Na2O +K2O)] × 100 where, concentrations are in

Table 3. Rare Earth Elements concentration in arenites of the Murwara area

Elements	L1C	L3A	L3B	L4C	L5	L6	L7A	L8	L-11	L-12C
La	19.44	14.27	11.75	19.26	15.60	18.06	15.21	16.41	19.85	38.72
Ce	33.9	34.5	28.3	33.1	37.7	37.7	36.3	36.4	40.4	77.1
Pr	4.68	3.86	3.19	5.07	4.21	5.7	4.2	4.2	4.3	8.7
Nd	17.2	14.3	11.8	20.3	15.9	22.9	16.6	15.2	14.8	29.7
Sm	3.83	2.71	2.35	4.56	3.56	5.00	3.52	3.00	2.82	5.17
Eu	1.02	0.43	0.40	0.84	0.62	1.01	0.68	0.54	0.36	0.97
Gd	4.60	1.80	1.64	4.24	2.64	3.85	2.85	2.43	2.01	4.37
Tb	0.78	0.26	0.25	0.69	0.40	0.64	0.43	0.45	0.34	0.67
Dy	3.79	1.30	1.11	3.49	1.82	2.56	1.94	2.40	1.78	3.86
Ho	0.67	0.23	0.19	0.67	0.31	0.35	0.32	0.46	0.36	0.82
Er	1.84	0.65	0.50	1.99	0.87	0.91	0.87	1.37	1.06	2.52
Tm	0.29	0.11	0.09	0.33	0.15	0.15	0.14	0.25	0.14	0.44
Yb	1.80	0.74	0.56	2.26	0.97	1.03	0.87	1.65	0.94	2.85
Lu	0.27	0.12	0.08	0.36	0.16	0.17	0.13	0.27	0.17	0.41
LREE/HREE	251.9	178.5	152.2	257.3	204.5	254.6	204.9	207.5	212.6	413.3
∑REE	0.09	0.20	0.23	0.10	0.15	0.10	0.14	0.16	0.21	0.08

Table 4. Range of elemental ratios of arenites of this study compared to the ratios from felsic rocks, mafic rocks and average UCC (Taylor and McLennan, 1985)

Elemental ratios	Range of arenites of this study	Range of sediments from felsic sources	Range of sediments from mafic sources	UCC
Th/Sc	0.66-4.20	0.84-20.54	0.50-0.22	0.79
La/Sc	2.50-10.21	2.50-16.3	0.43-0.86	2.21
Th/Co	1.67-6.89	0.67-19.4	0.04-0.40	0.63
Cr/Th	1.80-5.44	4.00-15.0	25-500	7.76

*Culler (1994, 1998, 2000); Cullers and Podkovyrov (2000)
** McLennan (2001); Taylor and McLennan (1985).

molecular proportion and CaO* is the amount of CaO incorporated in the silicate fraction of rock.

The CIA values calculated for the arenites of the present area (Table 1) vary from 75 to 98 and values of Al2O3-(CaO*+ Na2O)- K2O plotted in the A-CN-K triangular diagram (Fig. 11).

In this diagram, the arenite samples plot close to the Al2O3 rich in kaolinite, illite field suggesting a high degree of chemical weathering in the source area. A high degree of chemical weathering in the source region may be inferred from the petrographic observations. The arenites are composed of quartz as a mineral present up to 90%, high % of quartz is attributed to high intensity of weathering. The values of PIA calculated (Table 1) also, high and consistent with the values of CIA.

The ratio Th/U in sedimentary rocks is also important because weathering, recycling and removal of U during weathering by the oxidation results an increase in this ratio (Armstrong- Altrin et al., 2004; Chougong et al., 2021). This high ratio between 3.8 to 6 is attributed to removal of U during weathering and suggesting a high degree of weathering.

Intense chemical weathering is the result of humid climate. A bivariate plot between SiO_2 vs (Al_2O_3 + K_2O+ Na_2O) proposed by Suttner and Dutta (1986), was plotted for the present area (Fig.

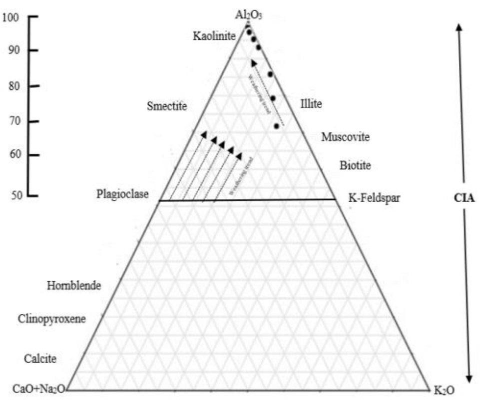

Figure 11. A-CN-K diagram for the arenites of Murwara area (Nesbitt and Young, 1982)

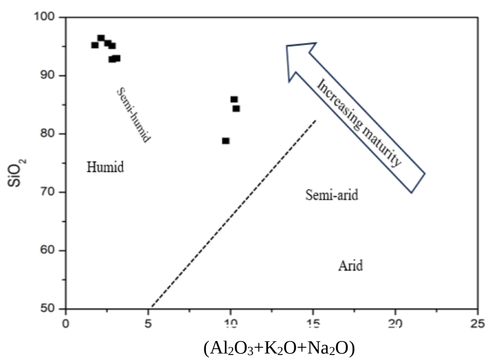

Figure 12. Bivariate plot of SiO_2 vs (Al_2O_3+K_2O+Na_2O) for the arenites of Murwara area. (Suttner and Dutta, 1986).

12) reveals the humid conditions in the area which also favours intense chemical weathering.

TECTONIC SETTING

A discrimination diagram proposed by Roser and Korsch (1986) to delineate the tectonic setting of clastic sedimentary rocks, the diagram is plotted using log (K2O /Na2O) vs SiO2. Here, in this diagram the parameters used have been recalculated to 100%, on the CaO and LOI free basis, before plotting. This diagram (Fig. 13) clearly indicates a passive-margin setting of the arenites. The results show that these arenites were deposited at a passive-margin tectonic setting.

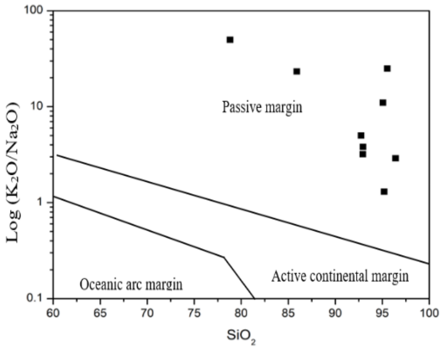

Figure 13. Tectonic discrimination diagram SiO_2 vs Log (K_2O/Na_2O) for the arenites of Murwara area (after Roser and Korsch, 1986)

Another multi-dimensional diagram for tectonic discrimination of siliciclastic sediments for high silica rocks (Verma and Armstrong-Altrin, 2013) have been plotted for the present arenites (Fig.14) the diagram is plotted between DF1 and DF2 functions calculated for the respective equations for high [(SiO2)adj =>63%-≤95%)].

DF1(Arc-Rift-Col)m1=(-0.263×ln(TiO2/SiO2)adj) +(0.604×ln(Al2O3/SiO2)adj) + (-1.725×ln (Fe2O3/SiO2)adj) + (0.660×ln(MnO/SiO2)adj) + (2.191×ln(MgO/SiO2)adj)(0.144×ln (CaO/SiO2) adj) + (-1.304×ln(Na2O/SiO2) adj) + (0.054×ln(K2O/SiO2) adj) + (-0.330×ln (P2O5/SiO2) adj) + 1.588

DF2(Arc-Rift-Col)m1 =(-1.196×ln(TiO2/SiO2)adj) + (1.604×ln(Al2O3/SiO2)adj) + (0.303×ln (Fe2O3/SiO2)adj) + (0.436×ln(MnO/SiO2)adj) + (0.838×ln (MgO/SiO2)adj) + (-0.407×ln (CaO/SiO2)adj) + (1.021×ln(Na2O/SiO2)adj) + (-1.706×ln(K2O/SiO2)adj) + (-o.126× ln(P2O5/SiO2) adj) -1.068

Data used has been adjusted to 100% on an anhydrous basis and Fe is taken as Total Fe2O3. This plotting reveals the present studied arenites plot in the collision and continental rift tectonic setting.

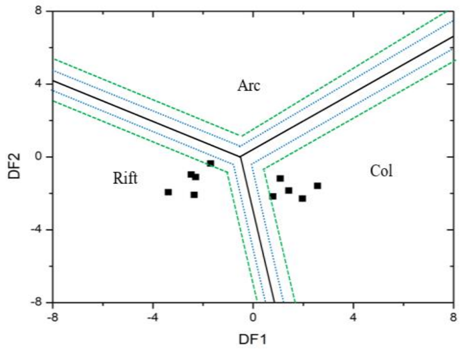

Figure 14. New discriminant-function multi-dimensional diagram for high silica arenites of the Murwara area (After Verma and Armstrong-Altrin, 2013).

CONCLUSIONS

The arenites of the Kaimur, Rewa and Bhander Groups belonging to Vindhyan Supergroup in the Murwara area have been assessed for the first time in terms of geochemistry. The major element analysis reveals the dominance of silica and less concentration of K2O, Na2O contents indicate that these rocks vary between quartz arenites and sub-lithic, with dominance of K-feldspar over plagioclase. Some samples are classified as sub-arkosic. The high CIA values reflect the extensive weathering in the source region and PIA values also confirm the high weathering conditions. REE pattern, high LREE / HREE ratios and less concentrations of trace elements like Ni, Cr, Co and V reflect the felsic source for these arenites. Discriminant function diagram shows quartzose sedimentary provenance and the bivariate plots between Ni vs TiO2, Sc vs Th/Sc and La/Sc vs Th/Co also suggest silicic source for these Neo-Proterozoic arenites of the Vindhyan Supergroup. The DF1-DF2 multi-dimensional tectonic discrimination diagram shows the continental collision to continental rift settings. Based on the results of this study it can be concluded that the arenites of the area might have been derived by the granitic rocks of the Bundelkhand Massif.

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