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Research Paper

Provenance, Weathering and Tectonic Setting of Talchir Formation in Parts of Son Valley Sub Basin Chhattisgarh, India During Late Paleozoic Era: Petrological and Geochemical Evidences

Geology

KEYWORDS : Talchir, Son valley, Provenance, Weathering, Tectonics, Palaeozoic

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ABSTRACT

*The Talchir Formation (Permo-carboniferous) is the lowermost unit of Gondwana Supergroup which rests unconformably over the Precambrian basement of Indian peninsula. Modal analysis and geochemistry of Talchir sandstones and shales of Chirimiri area, Son valley sub basin, Chhattisgarh, is carried out to know nature of provenance and its composition, weathering condition and tectonic setting of both source area and depositional basin. These characters are determined with the help of QtFL parameter, and bivariate plot between TiO2 vs Zr, geochemical proxies [A/ACNK)*100] and ratio of major oxide K2O/Na2O vs SiO2 have been utilised to achieve this aim. The petrochemical attributes of the clastic rocks of Talchir Formation suggest that these sediments have been derived from continental block having rocks of mixed composition which was subjected to moderate weathering during late Palaeozoic time. These sediments were deposited in basin situated at passive margin.*

Introduction

Synthesis of compositional and textural properties of sediments and information from other lines of evidence help in interpreting the characters of source area (Pettijohn, F. J., Potter, P. E., and Siever, R., 1987). The provenance of sandstones has traditionally been elucidated by modal composition using classical petrographic techniques. But sandstones with a significant amount of finer fraction may not be suitable for such study. In such kind of sandstones geochemical abundances, especially ratios of trace elements, which are present in finer grade material, may provide crucial information about the provenance (Cullers, R.L. and Stone, J., 1991; Cullers, R.L. and Berendsen, P., 1998).

Weathering involves the conversion of unstable minerals, mainly feldspars and micas into clay. The bulk chemical changes that take place during weathering processes provide an insight to understand past climatic conditions (Nesbitt, H. W., Markovics, G., and Price, R.C., 1980; Nesbitt, H. W., and Young, G. M., 1982; Nesbitt, H. W., and Young, G. M., 1982; Nesbitt, H. W., and Young, G. M., 1984). Chemical index of alteration (CIA) is a good measure to assess the degree of chemical weathering of the source terrain (Nesbitt, H. W., and Young, G. M., 1984, 1989). Plate tectonics controls the characteristics of the detrital grains and chemistry of sandstones (Dickinson, W.R., and Suczek, C.A., 1979; Dickinson, W. R., Beard, L. S., Brakenridge, G. R., Erjavee, J. R., Ferguson, R. C., and Inman, K. F., 1983; Bhatia, M.R., 1983; Roser and Korsch, 1986). Bivariate plot of K_2O/Na_2O ratio versus SiO_2 demonstrates three tectonic setting of sedimentary basins (Roser and Korsch, 1986). In the present study of sandstones and shales of Talchir Formation of Chirimiri area, petrographic and geochemical proxies have been employed to identify the provenance, weathering and tectonic setting of the depositional basin of these sediments.

Geology of the study area

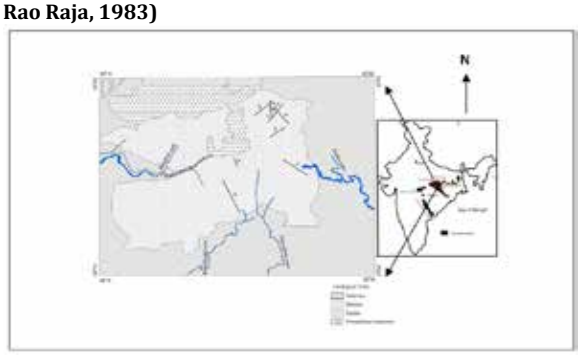
Study area is situated in the vicinity of Chirimiri coalfield ($23^0$8'-$23^0$15'N: $82^0$17'-$82^0$25'E) Koriya district, Chhattisgarh. Chirimiri coalfield is located in the Son-Mahanadi graben which is one of the largest intracratonic rift basins of peninsular India. It is surrounded by unclassified Precambrian rocks. The basin is a failed rift which diagonally cuts three major cratons namely Bastar, Singhbhum and Chotanagpur terrain (Figure1). Tectonically, the Son-Mahanadi basin has been divided into three blocks, each separated from the other by ENE-WSW trending prominent ridges. The blocks are Son Graben, Hasdo-Arand High and Mahanadi Graben. Contrasting nature of sediments and structural characters of the rocks suggest that each of these blocks has different sedimentation and tectonic history (Dotiwala, Sucheta, Pangtey, 1997).

In Chirimiri area (Hasdo-Arand sub basin), Talchir Formation is exposed along stream channels (Figure 2). The basal units of the formation are olive green sandstones with thinly laminated shales and unstratified medium grained sandstone succeeded by lemon yellow alternate beds of shale and sandstone. Table 1 presents the stratigraphic succession of Talchir Formation in Chirimiri area.

Table.1 Stratigraphic succession of Talchir Formation in Chirimiri, Koriya district, Chhattisgarh (simplified after C.S. Raja Rao, 1983).

Age	Formation	Lithology
Upper Cretaceous to lower Eocene (?)	Deccan Traps	Basic flows, dykes and sills.
Lower Permian	Barakar	Essentially sandstone with subordinate Shales and coal seams (230m to 435m).
Upper Carboniferous to Early Permian	Talchir	Predominantly olive green shales and Medium to fine grained sandstone.
	UNCONFORMITY	
Precambrian basement		Granite, Gniesses and Quartzite

Figure 1: Map showing geology of the study area Chirimiri in parts of Son-Mahanadi basin, Chhattisgarh India (C. S. Rao Raja, 1983)



Material and Methods

Representative samples sandstone and shale belonging to Talchir Formation have been collected at an interval of 1m along the stream sections in and around Chirimiri town. Out of total 50 only 29 fresh sandstones samples were selected for petrographic study. Thin sections were prepared and studied for modal composition under petrologic microscope. About 350 points per thin sections were counted using Gazzi-Dickenson's method (R. V. Ingersoll, T. F. Bullard, R. L. Ford, J. P. Grimm, J. D. Pickle and S. W. Sares, 1984). Because of their fine grain nature samples of shales were not examined under microscope. The counted grains of sandstone were recalculated into percentage and summarised in Table 2. Small chips of only 26 out of

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29 sandstones and 3 shale samples were powdered in a grinder upto -200 meshes. Fused disc shape pellets were prepared and XRF analysis carried in the laboratories of National Institute of Oceanography, Goa. The trace elements and rare earth elements (REE) concentration of these studied Talchir samples were determined using open Acid-digestion method at National Centre of Antarctic and Ocean Research, Goa.

Table 2 average values for Petrographic data of QtFL for sandstones and geochemical data analysed for Sandstones and shales of Talchir Formation in study area. Samples of Bhukbhuki nala designated as (BK) are the shales

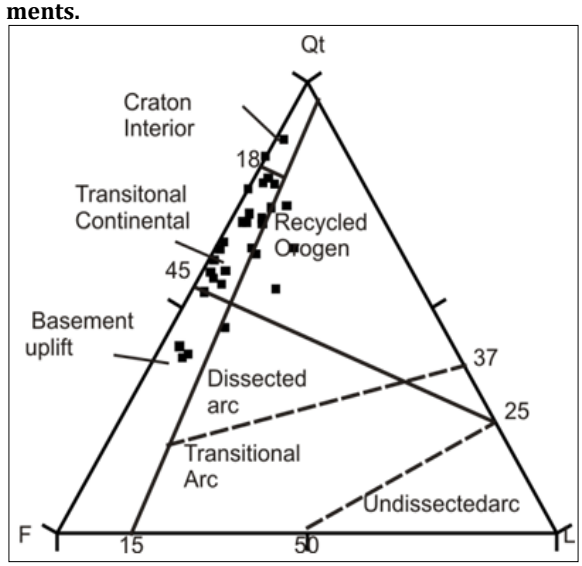
S.No	Qt	F	L	S.No	CIA	TiO_2	Zr	K_2O/Na_2O	SiO_2
NT1	60	38	1	NT1	64	0	35	1	77
NT2	58	40	2	NT2	62	1	33	1	77
NT3	52	43	4	NT3	65	1	92	1	78
NT5	55	39	5	NT5	66	1	20	1	78
NT7	54	29	17	NT6	67	1	23	1	77
NT8	69	28	3	NT7	66	1	24	2	77
NT9	69	25	7	NT8	61	0	34	1	79
NT10	76	24	0	NT9	62	0	112	1	80
NT12	58	37	5	NT10	61	0	77	1	79
NT13	84	16	0	NT12	60	0	101	1	79
NT14	63	36	1	KN1	60	1	162	1	75
KN3	57	40	3	KN3	60	1	84	1	75
GN1	77	18	7	GN1	59	1	46	2	80
GN2	72	21	6	GN2	63	1	66	2	79
GN3	70	24	9	GN3	63	1	52	2	78
GN4	62	29	2	GN4	62	1	52	2	81
GN5	78	20	8	GN5	63	0	92	2	78
GN6	74	17	4	GN6	61	1	63	2	79
GN7	69	28	3	GN8	61	1	90	2	79
GN8	79	18	7	GN9	60	0	59	2	79
GN9	63	29	3	GN10	60	1	67	2	81
GN10	71	26	2	GN11	49	0	83	2	78
GN11	87	11	9	BBK1	64	1	146	2	72
BBK1	49	42	3	BBK2	63	1	150	2	73
BBK3	53	44	6	BBK4	64	1	172	2	71
BBK4	70	24	6	BBK5	52	0	139	2	82
BBK5	41	53	6	BK1	63	0	175	1	73
BBK6	39	56	3	BK2	63	0	180	1	74
BBK7	63	34	3	BK3	62	0	195	1	72

Results and Discussion

Provenance and Weathering

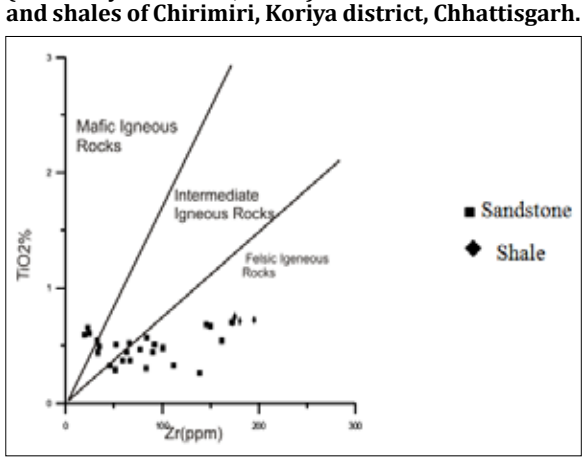
The QtFL ternary diagram (Dickinson, et al., 1983) of sandstones of Talchir Formation of Chirimiri area (Figure 2) suggests that the majority of these sediments were derived from transitional continental region of continental block. However, a few samples indicate recycled orogen and basement uplift as their source.

Figure 2: Triangular diagram QtFL of Talchir sandstone for Provenance (after Dickinson et. al., 1983) where Qt = total quartz, F = feldspar, L = lithic fragments.



Relationship among alkali and alkaline earth elements are indicators of the intensity and duration of weathering in sedimentary rocks (Nesbitt, H. W., and Young, G. M., 1982). The Chemical Index of Alteration (CIA) has a range which defines intensity of weathering. The equation of CIA is $[Al_2O_3/ (CaO+Na_2O+K_2O)]$ *100 (Nesbitt, H. W., and Young, G. M., 1982) .The equation is used to calculate the weathering intensity of sandstones and shales of the study area. Where the oxides are expressed as molar proportions and CaO represents the Ca in silicate fractions only. These values range from 49 to 67 in sandstones and from 62 to 63 in shales. These values are greater than the CIA values of upper continental crust (UCC). This indicates that the under discussion Talchir sandstones and shales were derived from rocks whose chemical compositions are similar to UCC under moderate weathering conditions. The TiO_2 vs. Zr plot (Figure 3) of Hayashi et al., (1997) suggests that most of the studied Talchir sandstones and shales have a source in felsic and intermediate igneous rocks, whereas only three of these analysed samples show their derivation from mafic igneous rocks.

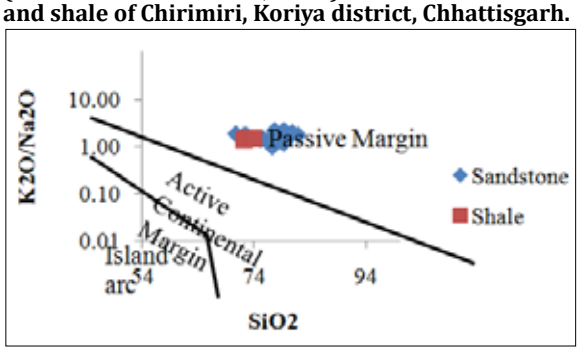
Figure 3: Bivariate plot between TiO_2 wt % vs. Zr ppm (after Hayashi et al., 1997) for Talchir sandstones and shales of Chirimiri, Koriya district, Chhattisgarh.



Tectonic setting

The bivariate plot K_2O/Na_2O vs. SiO_2 (Roser and Korsch, 1986) shows (Figure 4) that Talchir sandstones and shale samples, collected from Chirimiri area were deposited at the edge of passive continental margin. This observation supports the earlier inference that these clastics have been derived from transitional continental region of continental block (Figure 2).

Figure 4: Bivariate plot between K2o/Na2O vs SiO_2 (after Roser and Korsch, 1986) for Talchir sandstone and shale of Chirimiri, Koriya district, Chhattisgarh.



Conclusion

Modal composition and geochemical characters of Talchir sandstone and shale samples collected from Chirimiri area, Koriya district, Chhattisgarh, India, show that they were derived from transitional continental block provenance and deposited in a passive margin basin. The Chemical Index of Alteration (CIA) values ranging from 49 to 67 in sandstones and 62 to 63 in shales; are greater than CIA value of UCC (i.e. 50). This shows that the detritus for these Talchir sediments were subjected to moderate weathering conditions and the source rocks have similar chemical composition to UCC. The provenance of these clastics was predominantly felsic with minor intermediate and mafic components.

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