Original Research Paper

Volume : 5 | Issue : 8 | August 2016 • ISSN No 2277 - 8179 | IF : 3.508 | IC Value : 69.48

Shale Geochemistry from Kolhan Basin: Tectonic Implications

Geochemistry

KEYWORDS :

* Kasturi Bhattacharyya | iit, kharagpur * Corresponding Author

Subhasish Das | iit, kharagpur

ABSTRACT

An integrated provenance analyses were carried out for the Proterozoic Kolhan, in which the petrographic features of the sandstones (quartz arenite-subarkose) and the geochemical characteristics of shales were used to understand the paleotectonic and provenance histories. The petrographic features imply a source area dominated by granites and granitoid gneisses, tectonic quiescence and peneplain topography. The Kolhan shales are dominated by illite, quartz, and fine crystalline dolomite; the average chemical index of alteration (CIA) for Kolhan shale is 71.8, and indicative of a granitoid source with a modest amount of chemical weathering. High Al2O3/SiO2 and K2O/Na2O ratios reflect a derivation of sediments from stable cratons during tectonic quiescences; the sandstones indicate an arid-semiarid climate with low chemical weathering, whereas the shales are indicative of a modest amount of chemical weathering. This discrepancy is due to transport segregation that accounts for the high percentage of shale in the basin. The Al2O3/SiO2 and K2O/Na2O ratio do indicate that the clastics were deposited in a passive margin/cratonic margin.

Introduction:

The Kolhan Shale Formation lies unconformably over the Iron-Ore Formation and Singhbhum Granite and consists of basal Conglomerate,sandstone, impersistent Limestone and phyllitic shale with a general westerly dip of 5° to 10°. The maximum thickness of this Formation is approximately 300ft. The geological section along the river Gumua Gara near village Rajanka seems to be the best among all sections studied and may be taken as reference sections for the Kolhan Shale Formation of Singhbhum. Here Singhbhum Granite is overlain unconformably by nearly flat lying thin conglomerate, sandstone, thick limestone and phyllitic shale.

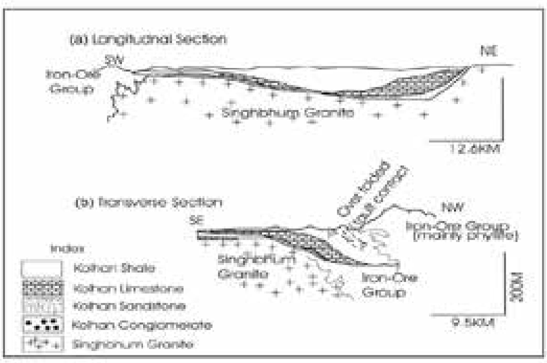

Fig.1.1:Longitudinal and transverse section along and across the Chaibasa-Noamundi Basin.

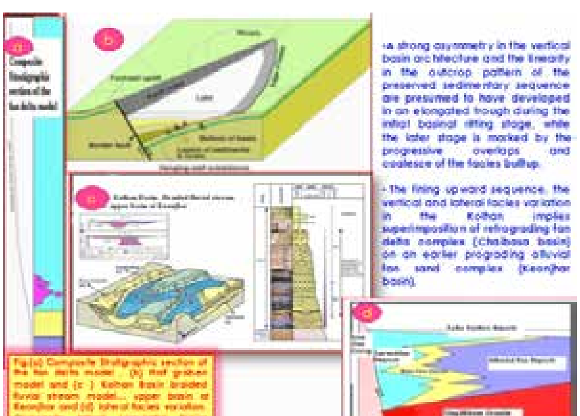

Fig.1.2 : The widespread occurrence of thin sandstone overlain by thick shale represents an asymmetry in vertical basin-fill architecture

The Kolhan Sandstone-

The overlying Kohan Sandstone member is dominantly a fine grained (median= 3 phi) sub-arkose along with a considerable development of pure arenite (orthoquartzite of Pettijohn) and some quartzose arenite types (Protoquartzite of Pettijohn). Typical arkose and greywacke type sandstones are not found. The matrix is dominantly composed of illite-clay and there is not much corrosion of the various quartz types by the matrix. The quartz grains are rather well sorted, subrounded to subangular, with a moderate skewness (both +ve and –ve) and a moderate kurtosis. The heavy mineral content is low and the ZTR index is high. The high content of matrix is rather inconsistent with the high sorting values, roundness and mineralogical maturity of the sandstones (textural inversion). There is no evidence of the derivation of the matrix by secondary processes and the most likely sources are the clay-pellets, altered feldspar and detrital clay from the various types of source rocks. The general prevalence of iron oxides as a coloring agent and as a coating on quartz grains is observed through out the Kolhan, but locally the color is bleached.

The abnormal size-roundness relationship, the mineralogy, the slightly bimodal distribution, textural inversion and palaeontological studies (based on apposition fabric analysis and few structures like ripple marks and current beddings etc.) suggest not only a source area with complex lithology but more than one provenance type-presumably a Granitic to the east and northeast and an Iron Ore Formation type to the southwest and northwest of the basin. The shallowness of the basin is indicated by the general development of thin sequences of rocks, while the stability and generally subdued morphology of the source area is suggested by the slow transport of detritus containing very little fresh feldspar grains by the sluggish streams contributing sediments in moderate amount to the Kolhan Sea of the epicontinental type. While the basin was definitely shallow during the deposition of the sandstones, a somewhat restricted circulation (low energyenvironment) is suggested in the northern part of the basin from the distribution of the various sedimentary parameters in the entire basin.

Modal analysis of the Kolhan Sandstone:

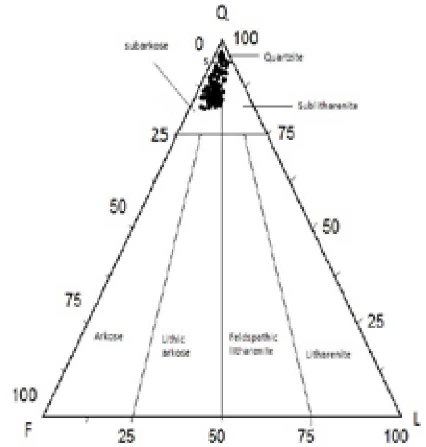

Fig. 2. (A) QFR plots (Folk, 1980): the clastics are mainly quartz arenite-subarkose.

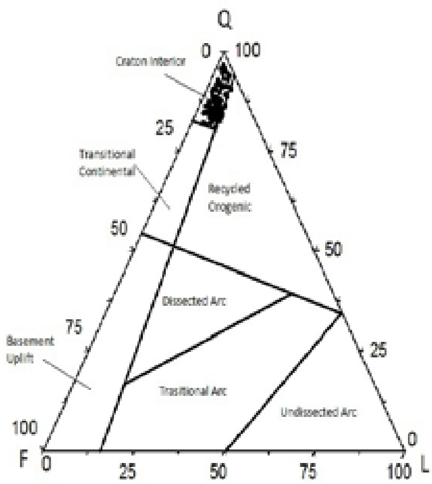

Fig. 2. (B) QFL plots (Dickinson, 1985): show that most of the samples fall in the zone of craton interior and few in the transitional continental zone.

Partial chemical analysis

The results of a partial chemical analysis ($SiO_{2,A}$l2 O3) of seven specimens of phyllitic shale are presented in Table 1 which also contains the partial analyses of sand size as well as silt clay size particles separated from the same samples .Although the data are limited ,the characteristics are summarized below :

The SiO2 content in he five samples of the shale analyzed varies from 43.33% to 73.52% . Only one sample, which also contains very low percentage of sand grade particles (3.78%), shows he low value of 43.33% which is much less than the Sio2 percentage (58.10 %) of average shale (Clarke,1924) this appears to be the only non-sandy silty shale, all the others being sandy types with Sio2 much above 58.10 %

Table 1 Partial chemical analysis of the Kolhan Shale

Sample Nos	Sand size fraction		Silt Clay Fraction		Total Bulk Sample	
	SiO_2%	Al_2O_3%	SiO_2%	Al_2O_3%	SiO_2%	Al_2O_3%
10	63.80	13.80	69.20	9.20	68.52	9.64
11	66.50	13.80	69.20	13.20	68.70	12.96
12	63.39	15.15	78.40	10.20	73.52	11.31
13	55.60	14.20	42.39	13.22	43.33	13.25
16	66.50	12.20	67.40	15.10	66.92	16.09
19	72.28	10.96	67.20	12.64	Not analyzed	
20	66.50	10.50	60.22	27.02	Not analyzed	

1. Silicification is indicated by the high percentage of silica. This is also evidenced by the microscopic study and the field occurrence of quartz veins in the shales.
2. The Al2 O3 content varies between 9.64 to 16.09percent. The low value of 9.64 % in two of the specimensmay be either due o the preponderance of low alumina clay mineral (glauconite) or due to the presence of someother low alumina nonclay minerals . A feature in the sand fraction of these shales is the moderate content of alumina which may be either due to the presence of feldspar or more probably iron rich chlorite (prochlorite).The colour of the wet sediment signifies presence of iron rich minerals . Thin section studies do not betray the feldspar probably because of its similarity with quartz , but the examination of the sandy fraction does confirm chlorite and limonite.
3. Limited data do not permit to draw any conclusion regarding the type of clay minerals present and the value of 15% may be produced by combination in suitable proportions of two or more of the commonly occurring clay minerals : illite, chlorite, montmorillonite and kaolinite. The last two minerals are not in sufficient quantity, a surmise which is supported by the X-ray analysis .

X-ray diffraction studies

The preliminary X-ray investigation of the clay portion (<2 micros) of a number of shales revealed the presence of illite (10 Ao) , chlorite (13.6 Ao) and certain mixed layer clay minerals while that of quartz (clay-size) and talc is doubtful . The high alumina content of the silt clay fraction is in agreement with the results of X-ray analysis.

Inference from Shale geochemistry

The Kolhan shales are dominated by illite, quartz, and fine crystalline dolomite; the average chemical index of alteration (CIA) for Kolhan shale is 71.8, and indicative of a granitoid source with a modest amount of chemical weathering. The Al2O3/SiO2 and K2O/Na2O ratio is high which reflects a derivation of sediments from stable cratons during tectonic quiescences. The sandstones indicate an arid-semiarid climate with low chemical weathering, whereas the shales are indicative of a modest amount of chemical weathering. Transport segregation is the cause of this discrepancy that accounts for the high percentage of shale in the basin. The Al2O3/SiO2 and K2O/Na2O ratio do indicate that the clastics were deposited in a passive margin/cratonic margin. The petrographic features imply a source area dominated by granites and granitoid gneisses, semi-arid to arid climate, tectonic quiescence and peneplain topography.

Conclusion

The sandstone petrography and the shale geochemistry clearly indicates that the Kolhans had both IOG and Singhbhum granite as the source rocksWhereas sandstone petrography suggests a peneplained craton, dry climate, and very limited chemical weathering, the shale geochemistry (CIA) indicates a moderate-to-intermediate degree of chem-

Volume : 5 | Issue : 8 | August 2016 • ISSN No 2277 - 8179 | IF : 3.508 | IC Value : 69.48

ical weathering. As pointed out above, unaltered feldspars and well rounded quartz and feldspar grains in conjunction with low latitude suggest that the Kolhan Formation was deposited in a arid to semi-arid climate. In such a climatic setting, unaltered feldspars would become concentrated in sandy deposits of braided streams and may also undergo inland reworking, whereas fine detritus and clay (from feldspar weathering) would be carried to the basin as suspended load, thus leading to a separation between intensely (clay fraction) and incompletely weathered (sand fraction) material. Therefore intensities of chemical weathering indicated by shales will tend to be higher than those indicated by sandstones. It appears therefore that for realistic estimates of source area weathering conditions the data from shales and sandstones should be considered in conjunction.

Reference

1. Folk, 1980. Petrology of Sedimentary Rocks. Austin, Texas: Hemphill Publication Company, 182p.