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Boron in the carbonate rocks of the Kajrahat formation, Mirzapur district, Uttar Pradesh

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Abstract. Boron content has been determined in the acid insoluble fraction of the carbonate rocks of the Kajrahat formation. Their comparison with the boron content of the shales of known environment suggests brackish to marine salinity levels during deposition. The dolomites register higher salinity conditions than the limestones. The salinity of the basin may have changed at intervals.

Keywords. Boron; salinity; limestone; dolomites.

1. Introduction

The Kajrahat formation is the lower carbonate sequence of the Vindhyan Basin. With the objective of evaluating the palaeosalinity in respect of this formation, the insoluble residue fraction of 19 samples of limestones and dolomites representing a profile between a Dala and Obra (figure 1) have been analysed for boron. Boron has been determined (in triplicate) quantitatively with emission spectral analytical method using Be as internal standard.

The geology of the Dala-Obra area is given by Auden (1933) and Misra (1969). The base of the Vindhyans is marked by the basal conglomerate and Arangi formation (argillaceous) followed by the carbonate beds of Kajrahat formation. The latter is marked by regolithic deposits and porcellanites at the top.

2. Boron in the samples

The insoluble residue fraction of the carbonates is very fine grained and does not contain tourmaline. The feldspars constitute less than 1 % of the total rock. Therefore, whatever boron is present in the samples, is in the clay minerals. The adsorption of boron in clay minerals depends mainly upon the concentration of boron in the solution and the salinity (Harder 1961 and Brockamp 1971, 1973). Several experiments (Harder 1974; Fredrickson and Reynolds 1960) have demonstrated the reaction of boron with clay minerals. The literature cited by Wedepohl (1960) show that the marine sediments are rich in boron as compared to those of fresh water. In the absence of boron minerals like tourmaline, boron can be used as a salinity indicator.

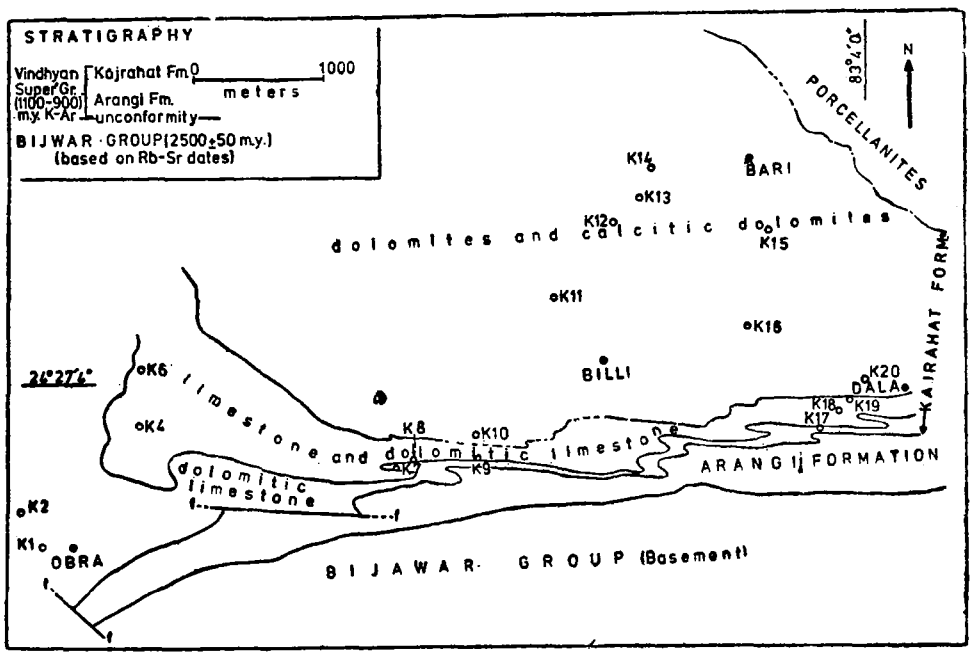

Figure 1. Map showing location of samples and major lithological boundaries. The arangi formation contains conglomerates, shales, quartzites and lenses of limestones and dolomites. The limestones and dolomites of Kajrahat formation also contain shales as minor constituents.

For the purpose of comparison, the author has analysed five samples of the shales of Upper Carboniferous of West Germany, of which the environment of deposition is precisely known. They contain 75 ppm B in the non-marine shales and 140 ppm B in the marine shales. The boron data compiled by Harder (1974) indicate boron/illite ratio of about 1 for fresh water shales, 2 for brackish, 4 for marine shales, 7 for permian dolomites and 10 for permian saline clays of West Germany. Landergren and Carvajal (1968) have mentioned lower boron content (52 ppm B) in the clays of 6% salinity and more than 100 ppm B in the clays of 16 to 33·5% salinity. Out of the mineralogical constituents of the carbonate rocks of the Kajrahat formation, illite is the main mineral which contains boron. Therefore boron (ppm)/illite(%) ratio can safely be used for the interpretation of the boron data. The clay mineral determinations have been done with the help of infrared spectroscopy and x-ray diffraction.

The Kajrahat carbonate sequence in the Dala-Obra area is made up of limestones and dolomites. The lower part of the sequence is mainly limestones with thin bands of dolomites, whereas the upper part gradually becomes completely dolomitic. The boron/illite ratio in the limestones varies from 2 to 4 which is comparable to that in the brackish and marine water sediments. Wedepohl (1964) has determined boron content in the marine Kupferschiefer of West Germany, which shows a boron/illite ratio of 4. This ratio increases by a factor of 2 in the case of dolomites as compared with the limestones of Kajrahat formation. However at the top of the Kajrahat sequence, the boron content decreases. With the lower salinity the

Table 1. Boron and illite content in the carbonate rocks of the Kajrahat formation (Vindhyan basin)

Sample No.	% Illite	B ppm	B ppm/Illite %
	Kajrahat formation		
Dolomitic limestone:			
K 1	6·4	16	2·5
K 2	12·5	36	2·8
K 7	7	31	4·5
K 9	9·3	33	3·6
K 17	7·8	25	3
K 4	7·2	30	4·2
K 5	7	17	2·4
K 8	5·2	21	4
K 18	6·8	15	2·2
K 6	4·3	18	4
K 19	7·6	20	2·7
K 20	6·3	14	2·3
Calcitic dolomite:			
K 10	5·5	28	5
K 11	7·9	39	5
K 12	3·7	27	7·4
K 13	7·1	42	5·9
K 14	7·1	43	6
K 16	11·6	26	2
Dolomite			
K 15	9·7	46	4
Upper carboniferous shales (West Germany)			
Marine:			
648		145	
655		130	
663		130	
Non-marine:			
667		70	
672		80	

Note: The sample numbers of shales are from the laboratory catalogue of Geochemical Institute, Göttingen, West Germany.

formation of dolomite is not possible in normal marine condition, because to increase Mg/Ca ratio, some degree of evaporation is necessary in the case of normal marine water. Due to evaporation the salinity of water increases and so the incorporation of boron in illite becomes very high. The samples containing a low percentage of dolomite (samples K2 and K18) do not show appreciable increase in boron. Failure of boron as a salinity indicator in the samples containing dolomite cannot be explained by bringing in low boron illite to the site of deposition because the experiments have clearly shown that the incorporation of boron in illite is dependent upon the boron content of the solution. This means that the low boron content and illite

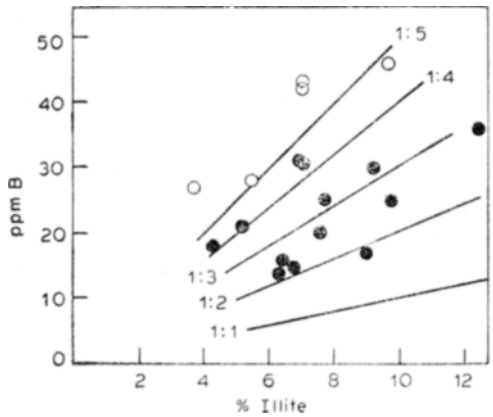

Figure 2. Plots of boron against illite of the dolomitic limestones (closed circles) and calcitic dolomites (open circles). The lines show different boron/illite ratios.

will further incorporate boron at the site of deposition if the solutions are high in boron content. The only other possibility is to consider conditions which have a control on boron while Mg/Ca ratio became optimum for dolomite formation.

3. Conclusion

The boron/illite ratio indicates two levels of salinity in the limestone deposits of lower Kajrahat carbonate sequence. The level of salinity gets doubled in the dolomites relative to the limestones. The variation in the boron content in one type of sediments like limestone is due to the intermixing of the low salinity waters. It is very likely that the source of sediments or the composition of water was excessively rich in Ca and Mg while boron content could not be as high as in a basin of normal marine salinity. This explains low boron values in some dolomite samples. Towards the top of the sequence, the salinity has increased as a result of evaporation. Harder's (1974) data indicate that dolomite formed from normal marine salinity waters has a B/illite ratio of nearly 7. The dolomites of the Kajrahat formation with a B/illite ratio of more than 5 may therefore be of marine salinity waters.

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