



Geochemical Characterization of the Upper Cretaceous Chandel Limestone, Manipur, NE India: Implication for Depositional Environment

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Abstract: Major oxides and trace elements concentration of the Chandel limestone, Manipur, India are analysed to establish the distribution pattern and mutual relationship of the elements and also to reconstruct the palaeo-depositional conditions. Among the major oxides, CaO is the dominant oxide followed by SiO₂ in the studied limestone. The dominance of CaO and low percentages of MgO suggest that mineral phase is calcite and there is absence of dolomitization. On the basis of Ca/Mg ratio the limestones are categorized as Magnesium and Pure Limestones. The higher percentage of Ca/Mg ratio in the limestones signifies lower salinity during the formation of limestones. Trace element Sr dominates over the other trace elements. The average Sr concentration indicates shallow marine depositional environment.

Keywords: geochemistry, Chandel Limestone, depositional environment, Indo-Myanmar basin, India

1. INTRODUCTION

The distribution and migration of chemical species during limestone formation were investigated by Stehli and Hower [1]. They showed that the Mg, Sr, Ba and Mn contents of limestones tend to decrease with limestone formation from starting materials. Therefore chemical analysis is of tremendous importance and aid in determining the distribution and mutual relationships of the various constituent elements of limestone. Such analysis also helps in classification and in determining the environmental conditions that prevailed during the deposition of the limestones [2]. Calcite is the principal constituent of the carbonate rocks of the study area which occurs in the form of calcite mud and sparry calcite. Present geochemical studies of limestones from Toupokpi, Nungpan, Nungphura, Chakpi and Beru area of Chandel district, Manipur (Fig.1) have been carried out through quantitative measurements of major oxides and trace elements. These type of studies were made by different research workers from time to time (e.g. [3], [4]).

II. GEOLOGICAL SETTING

The study area, Chandel district of Manipur is situated in the Indo-Myanmar basin and represents a complex geological terrain in a subduction zone setting. The limestones of the studied area occur in the form of cone/pyramid in the melange zone associated with Disang Group with thrust contact. In the study area carbonate rocks occupy the upper part of the Disang Group. "Reference [5]" identified both pelagic and benthic foraminifera from the Toupokpi area, one of the locality in which globigerina, globotrancana and pseudo-textularia were dominant which are equivalent to the fossils found in the upper part of Mahadek Formation or lower part of the Langpar Formation of Meghalaya.

III. METHODOLOGY

For major oxides and trace element analysis, the representative samples were crushed into pieces with agate mortar and pestle, and powdered by using an electrical pulverizer. Care was taken for contamination of dust, magnetic material etc. The rock powder of limestones, made up to 200 meshes, are analyzed by X-ray fluorescence spectrometry (XRF) using Axios PANalytical machine at SAIF (Sophisticated Analytical Instrument Facility), USIC (University Science Instrumentation Centre), Gauhati University. The concentration of major oxides were expressed as a weight percentage (wt. %) and trace elements in parts per million (ppm)

IV. RESULTS AND DISCUSSION

The analytical result of major oxides, loss on ignition (LOI) and trace elements concentration are presented in Table 1. The major oxides data can be used in different ways, especially calcium (Ca) and magnesium (Mg) concentrations are used in chemical classification of limestone. The major oxides present in the limestone samples are SiO₂, Al₂O₃, Fe₂O₃, Mn₂O₃, MgO, CaO, Na₂O, K₂O, TiO₂ and P₂O₅. The CaO is the dominant oxide (34.75-

55.99%) among all the oxides and it shows negative relations with $\text{SiO}_2\text{Al}_2\text{O}_3$ and MgO [Fig. 2(i-iii)]. The negative correlation of CaO with MgO , indicates the occurrence of Mg in non-carbonate minerals. The bivariate plots of SiO_2 with Al_2O_3 [Fig. 2(iv)] shows significant positive (+ve) correlation more than 60%, these relations have clear indications for terrigenous flux received from a continental crust during the deposition of the limestone. This positive correlation infers that the SiO_2 is controlled to some extent by clay minerals and also by quartz grains which are present as detrital clay size grains within mudstones or limestones. The Al_2O_3 content varies from 3.71% to 10.98% in the studied limestone. The bivariate plots of Al_2O_3 against K_2O and TiO_2 [Fig. 2(v-vi)] show weak positive. The positive correlations signify that these elements are associated with detrital phases. It is logical to state that the Al_2O_3 content is related to clay minerals and other insoluble silicate minerals. It also indicates that the sediments were derived from continental crust. The concentration of manganese oxide content in the studied limestones ranges from 0.05% to 0.26% with an average of 0.11%. The high concentration of Mn_2O_3 represents deposition in warm and humid climate, as reported by [6] where they found that carbonates which are deposited under such conditions show an average content above 0.07% and those under arid and protected condition should have less than 0.07%.

Trace element data have been used to differentiate the shallow and deep water limestones. Shallow water and deep water carbonates also have relatively low Sr (100-400 ppm) and high Sr (500-3000 ppm) values respectively (e.g. [7], [8], [9]). The investigation of the geochemical criterion for the depositional environment of the Chandel limestones can be summarized in table 3. The average Sr concentration ranges from 286–660 ppm with an average of 439 ppm indicating a shallow marine environment of deposition [6]. The low concentration of Sr might also indicate the formation of limestone under low salinity condition. “Reference [10]” explained the effect of low water salinity on the depletion of strontium. Rb is one of the trace elements present in several common minerals in which it substitutes for potassium. Rb content in the present study area ranges from 60 to 103 ppm in the bulk limestone suggesting impure limestone. In general the concentrations of Rb in shale, sandstone and carbonate rocks are 140, 60 and 3 ppm respectively and impure limestone show higher Rb concentration than the pure limestone (e.g. [11], [12]).

V. GEOCHEMICAL CLASSIFICATION

The standard ratio of Ca/Mg utilized by Todd [12] for pure limestone and magnesium limestone is within the range of 100-39.0 and 38.0-12.3 respectively. The distribution of Ca/Mg and its reciprocal Mg/Ca ratio in the limestone of the studied area are found to vary from 17.51 to 70.19 and 0.01 to 0.05 respectively (Table 2). The low values of Mg/Ca ratio (0.01 to 0.05) indicate that the studied samples are not dolomitized, because dolomitization would necessarily cause a marked increase in the Mg/Ca ratio of the limestones [14]. Based on Ca/Mg ratios and the parameter used by Todd [13] the limestones found in Toupokpi, Nungpan, Nungphura, Chakpi and Beru falls within the standard range of “pure limestone” and “magnesium rich limestone” (table 2). Higher values of Ca/Mg ratio of the studied limestone indicates comparatively less evaporation of sea water and low salinity that prevailed during the formation of limestone in general.

VI. CONCLUSION

From the above discussion, it can be said that the Chandel limestones are of pure and magnesian limestone category which was deposited in a shallow marine environment. The Ca/Mg and Mg/Ca ratio of studied limestone indicates that the sediments were deposited in the depositional site characterized by less evaporation and low salinity. The climate was warm and humid during the time of deposition.

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Table 1: Major oxides, loss on ignition (LOI) percentages and trace element in ppm of studied limestones from Chandel district, Manipur.

*Sample No.	TO-1	TO-3	NU – 1	NU – 4	NPH – 2	NPH-4	CH – 2	CH – 3	BE – 21	BE - 22
Major elements										
SiO ₂	18.84	18.47	20.84	19.23	24.13	18.22	19.54	10.06	10.23	28.52
Fe ₂ O ₃	0.07	0.28	0.28	0.28	0.06	0.43	0.28	0.28	0.28	0.28
FeO	0.41	1.70	1.70	1.70	0.39	2.55	1.71	1.70	1.70	1.70
Al ₂ O ₃	6.80	6.13	6.68	5.87	10.98	5.88	6.01	3.71	5.91	9.82
CaO	42.27	51.96	50.96	49.99	34.75	47.06	48.41	55.23	55.99	36.03
MgO	1.48	1.29	1.41	1.63	1.20	1.26	1.42	1.05	0.96	2.44
TiO ₂	0.47	0.50	0.65	0.79	0.37	0.56	0.61	0.28	0.19	1.39
Mn ₂ O ₃	0.13	0.07	0.12	0.09	0.07	0.11	0.14	0.06	0.05	0.26
P ₂ O ₅	0.07	0.06	0.06	0.05	0.06	0.06	0.06	0.06	0.06	0.07
Na ₂ O	0.34	0.37	0.49	0.41	0.29	0.42	0.48	0.21	0.13	1.56
K ₂ O	2.01	0.81	0.94	0.62	1.19	0.84	0.92	0.47	0.65	0.82
S	0.01	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00
LOI	27.07	18.45	17.25	19.28	26.05	22.60	20.42	26.93	23.65	17.05
Trace elements										
Sr	457	460	459	425	432	384	321	286	510	660
Rb	72	83	90	74	84	96	87	103	58	60
Zn	67	80	85	82	94	97	92	107	56	48
Cu	58	65	70	65	51	69	3	27	58	60
Co	106	59	75	74	85	99	14	5	47	45
Ni	64	67	75	70	74	81	76	53	45	57
Cr	50	52	66	33	23	71	13	14	24	18

*Samples with prefix TO are from Toupokpi, NU from Nungpan, NPH from Nungphura, CH from Chakpi and BE from Beru area

Table 2: Chemical classification of studied limestones from Chandel district, Manipur.

Sl. No.	*Sample No.	CaO %	Ca%	MgO %	Mg %	Ca/Mg	Mg/Ca	Nomenclature (after Todd, 1966)
1	TO-1	42.27	30.21	1.48	0.89	33.94	0.02	Magnesian Limestone
2	TO-3	51.96	37.13	1.29	0.77	48.22	0.02	Pure Limestone
3	NU-1	50.96	36.42	1.41	0.85	42.84	0.02	Magnesian Limestone
4	NU-4	49.99	35.72	1.63	0.98	36.44	0.02	Magnesian Limestone
5	NPH-2	34.75	24.83	1.20	0.72	34.48	0.02	Magnesian Limestone
6	NPH-4	47.06	33.63	1.26	0.75	44.84	0.02	Magnesian Limestone
7	CH-2	48.81	34.88	1.42	0.85	41.03	0.02	Magnesian Limestone
8	CH-3	55.23	39.47	1.05	0.63	62.65	0.01	Pure Limestone
9	BE-21	55.99	40.01	0.96	0.57	70.19	0.01	Pure Limestone
10	BE-22	36.03	25.75	2.44	1.47	17.51	0.05	Magnesian Limestone

*Samples with prefix TO are from Toupokpi, NU from Nungpan, NPH from Nungphura, CH from Chakpi and BE from Beru area

Table 3: Depositional Environment of Chandellimestone, Manipur

Locality of the limestone deposits	Average Sr (ppm) content	Flügel and Wedepohl (1967); Bausch (1968)	Depositional Environment
		100 – 400 ppm shallow marine; 500 – 3000 ppm deep marine	
Toupokpi	458		Shallow marine
Nungpan	442		Shallow marine
Nungphura	428		Shallow marine
Chakpi	303		Shallow marine
Beru.	585		Deep marine

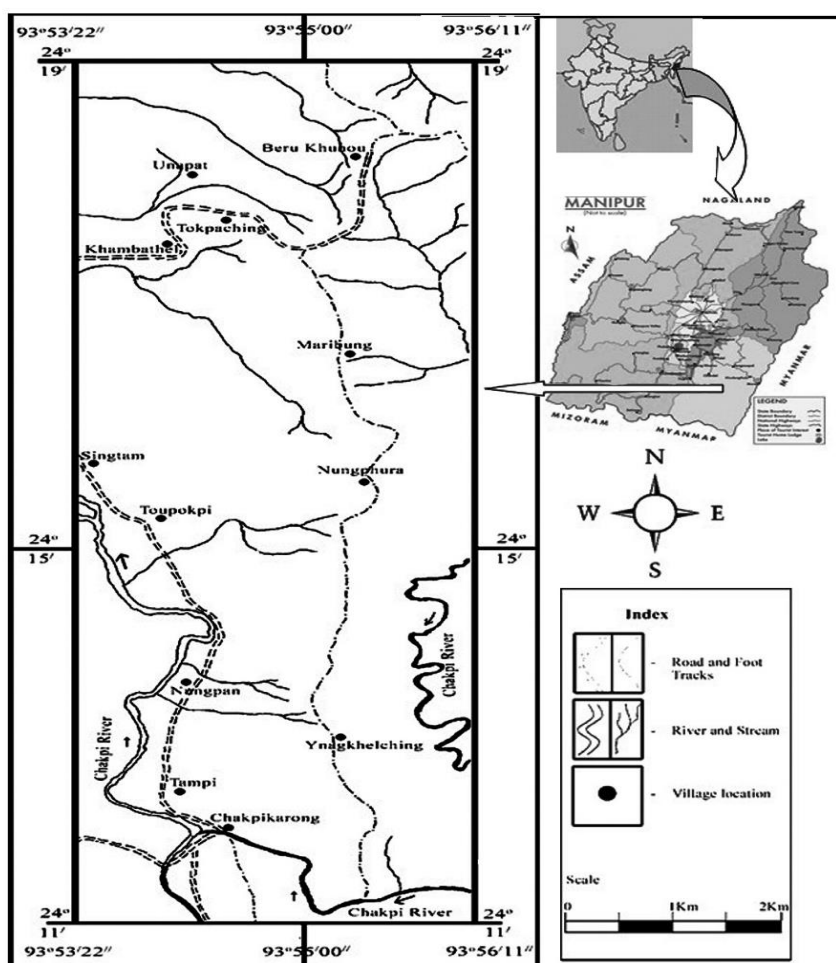


Figure 1: Location map of the study area

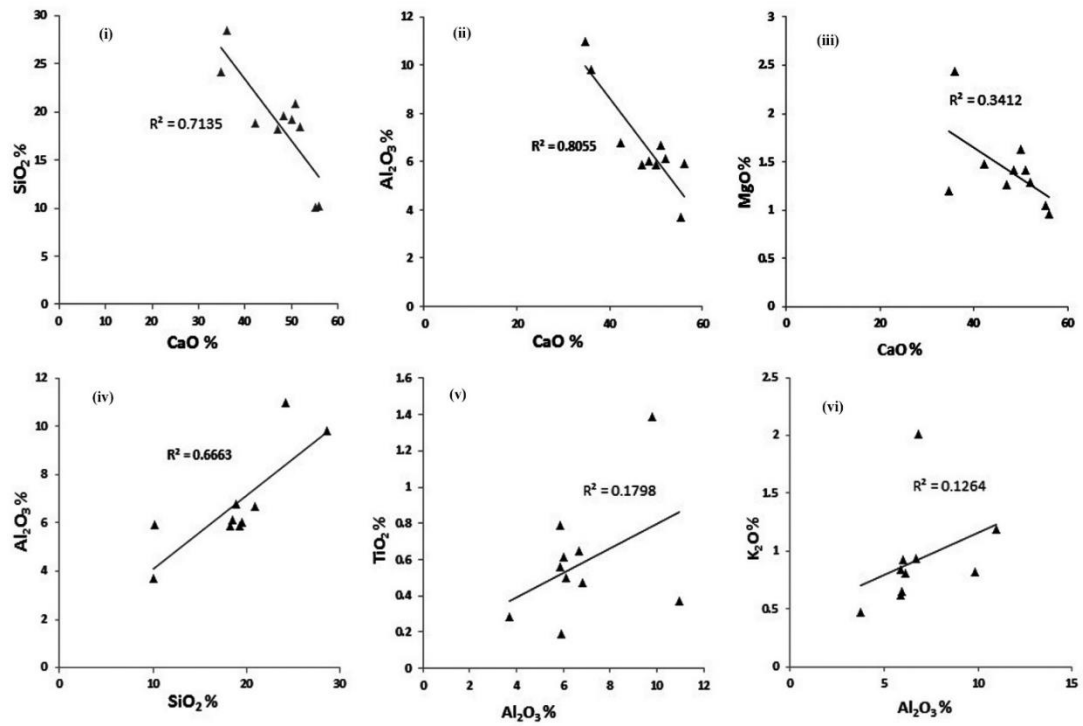


Figure 2: Bivariant scatter plots among the major oxides of Chandel limestones (i) CaO versus SiO_2 (ii) CaO versus Al_2O_3 (iii) CaO versus MgO (iv) SiO_2 versus Al_2O_3 (v) Al_2O_3 versus TiO_2 (vi) Al_2O_3 versus K_2O