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INVESTIGATION ON THE DOLOMITES AND LIMESTONES OF KAKUL, MIRPUR AND SHEIKHAN BANDI, HAZARA AREA, NWFP

Izhar H. Khan, M.A. Qazi, Fayyaz Mahmood and Saqib Ahmad

PCSIR Laboratories, Lahore-16

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Dolomitic rocks of Abbottabad formation of Cambrian age are widely distributed in an area of 50 km. in Hazara, with a thickness ranging from 130 to 900 m. The beds of the Abbottabad formation are divided into three zones comprising dolomite, siliceous dolomite and calcitic dolomite respectively. The Ca/Ca+Mg mole percent ranges from 48.5 to 52.0 and the SiO_2 ranges from 0.2 to 3.5 with an average of 1.6 % in most samples. The Fe_2O_3 ranges from 0.2 to 0.9 % and Al_2O_3 from 0.1 to 3.5 with an average of 1.05 %. The DTA examination indicated the genesis of dolomite from limestone by percolating pore solutions. The DTA curves showed a gradational shifting of peaks in high Mg-calcite to calcitic-dolomites to dolomites from 980 to 950°. The dolomites of Kakul, Mirpur and Sheikhan Bandi area were found to be of metallurgical and industrial grades.

Key words. Dolomites, Limestone, Kakul, Shaikhanbandi, Hazara. ns.

INTRODUCTION

Dolomite is an important mineral used in the manufacture of basic refractories for steel industry, basic magnesium carbonate, heat insulating material, epsom salt, fluxes, high magnesium lime and building materials. The increasing demand of dolomite and limestone in the indigenous industry, particularly those of steel and metal products, necessitates a detailed study of their occurrence and composition. The dolomites in the Kakul Mirpur area will attain significant importance with the development of infrastructure such as approach roads etc. developed for phosphate mining in the area. Dolomite mining may, therefore, become one of the economic by-product mineral resource of the region.

The presently available literature does not carry much information about the extent, grade, chemical and mineralogical characteristics of the Kakul-Mirpur, Sheikhan Bandi and other dolomite bearing areas of Hazara district. The dolomite in the area also shows appreciable variation with respect to the composition from place to place. The present study was undertaken in view of the overbearing importance of these deposits.

Geological setting. Carbonatic rocks of the Hazara area belong to "Abbottabad Formation" [1] of Cambrian age. The formation is important for its penecontemporaneous deposition of dolomites, cherts and phosphate in Hazara area.

Outcrops of dolomites and dolomitic limestones of the Abbottabad formation are seen on the Abbottabad-Rawalpindi roadside. The rocks are also found south-east of Abbottabad in Sheikhan Bandi area, west of Abbottabad in Sirban Hills and is consistently exposed in the north, extending from Kakul-Mirpur upto Garhi Habibullah (Fig. 1). The lithostratigraphic position of the Abbottabad formation is given by different workers (Table 1).

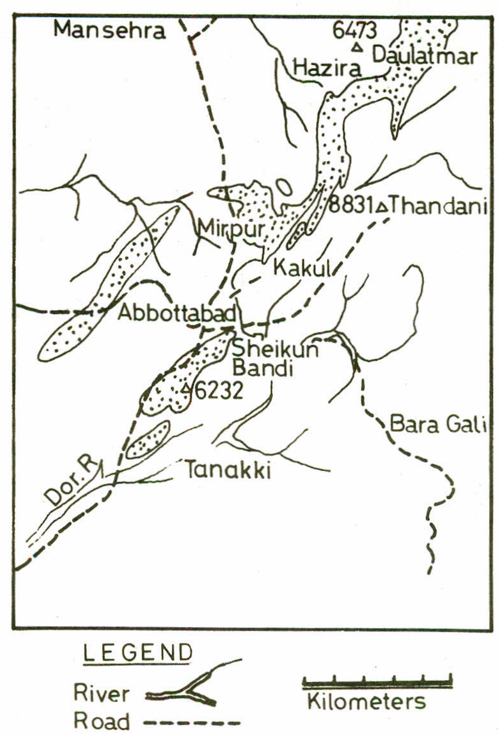

Fig. 1. Distribution of dolomitic limestone (dotted area) in S.E. Hazara.

Field studies. The area lying between Kakul and Mirpur (longitude $73^{\circ}\ 16'$ to $73^{\circ}\ 18'$ and latitude $34^{\circ}\ 12'$ to $34^{\circ}\ 19'$) mapped on 1.24000 scale showed the following major rock types:

(a) The alluvium, which is encountered as stream gravels and soils is mostly composed of consolidated gravels, boulders, reworked loose sand and silty clay.

(b) Daulatmar limestone which is equivalent to middle Jurassic limestones in other areas is exposed on the south-eastern side of the mapped area. It is fine textured, medium bedded greyish brown limestone, which forms high peaks and steep slopes on denudation. The upper contact of the limestone is faulted and it rests on sandstone and siltstone of Hazira (Galdanian) formation.

(c) Pale brown, sandy and silty beds of Hazira (Galdanian) formation of about 100 meters thickness lie between Jurassic limestone and Abbottabad formation. The bed is glauconitic in nature in the Reshian area whereas the Dakhan area shows it to be 4 to 5 m. thick intercalations of dolomitic shale, dispersed phosphorite and ferruginous shales.

(d) The Abbottabad formation includes buff, black, gray, reddish or greyish white dolomite and dark gray limestone in the Kakul-Mirpur area. The thickness of the Abbottabad formation is variable, being 450m in Mirpur, 660m in Sirban hills and Kakul, 900m in Tanol and Muzaffarabad and 100-130m in Garhi Habibullah.

The limestone is fine-grained, medium to thick bedded and grading into dolomite of various shades. Recrystallised, secondary, coarse grained dolomite and phosphorite bearing dolomite also occur in the upper portion of the formation. On regional scale, the Abbottabad formation consists mainly of dolomite, quartzite and phyllite with variable lithologic changes in different places. The upper and lower contact of the formation generally appear to be unconformable, however, at places it is difficult to distinguish transitional contact due to lithological zones in the beds or cyclic depositional characters.

The mapping of the Kakul area has shown a general structure consisting of a syncline and an anticline (Fig. 2), plunging towards the north. At places, small scale faulting have distorted these folds. On the basis of field observations, both of these folds can be related to major Garhi Habibullah syncline as subsidiary folds. The axial trends of smaller folds in the Kakul-Mirpur area is nearly parallel with that of the major syncline.

The Abbottabad formation can be further divided into zones with variable thicknesses in different areas. In the Kakul area there is a 300 m. zone of medium to thick bedded, massive, grey to pink dolomite grading sometimes to dolomitic limestone at the base. A zone of 200 m. siliceous massive grey dolomite with intercalation of argillaceous sandstone lies on top of thick bedded dolomite. The top 100 m. is a zone of grey to light pink, hard

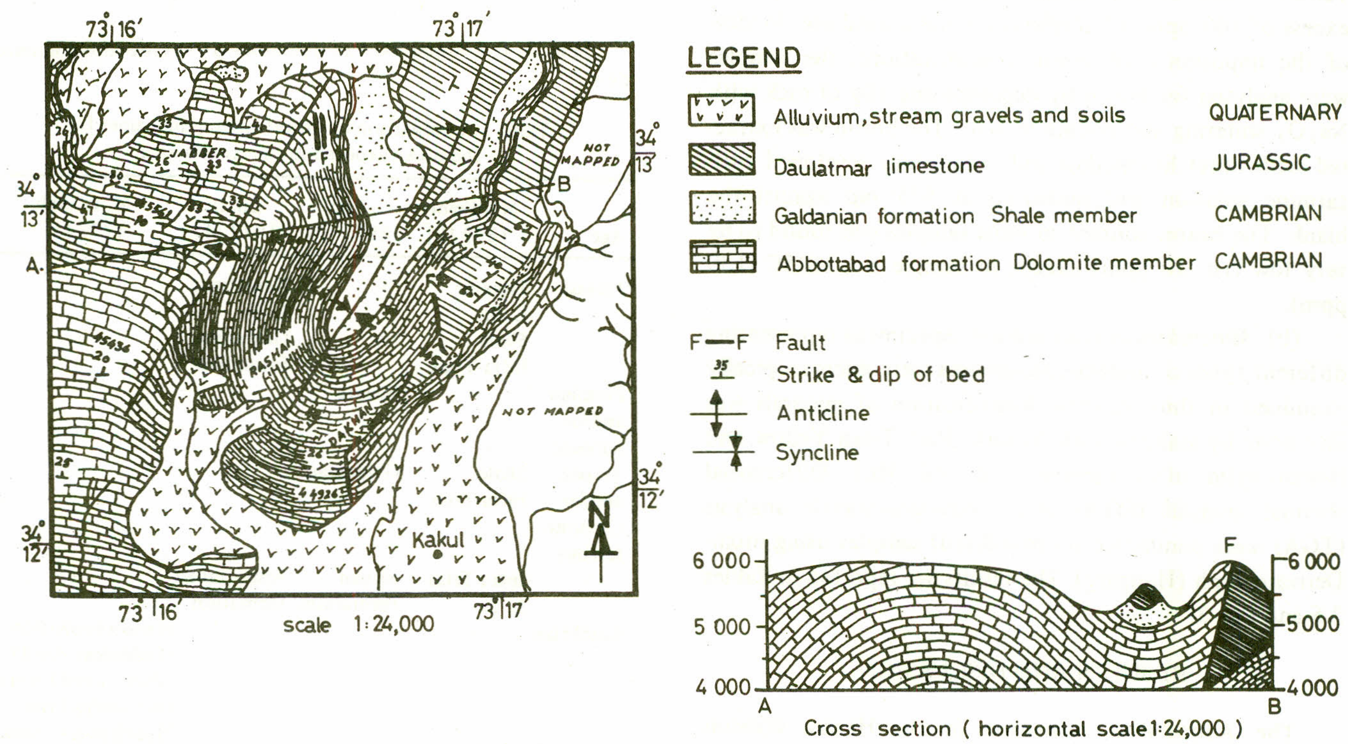

Fig. 2. Geological map of the Kakul area.

medium to thick bedded dolomite with some cherty lenses. In the Mirpur area the lower 135m are greyish-orange to pink, medium to thick bedded dolomite and hard to massive dolomitic limestone. The middle 350 m zone is light pink to yellowish brown dolomite incorporating shale and argillaceous material. The upper 80 m zone is light to medium grey dolomite with pinkish gray cherty beds and lentiles.

In the Sirban area the basal zone of dolomite and dolomitic limestone is buff coloured, medium to thick bedded, sometimes brecciated with few silty intercalations. The dolomite grades into middle zone of 50 m of hard, massive light brown to grey quartzose sand stone. The upper zone of 120 m is light grey to white, hard, thick bedded to massive dolomite with cherty lentiles.

EXPERIMENTAL

(a) *Chemical compsotion.* Samples were collected from upper, middle and basal zones of the dolomitic beds of Kakul, Mirpur and Sheikhan Bandi areas and analyzed using conventional chemical methods [7]. The SiO_2 was determined in hydrochloric insoluble portion by the HF evaporation method. Al_2O_3 was found by the ammonia precipitation method and Fe_2O_3 was determined by titration with $K_2Cr_2O_7$.CaO and MgO were estimated by titration with EDTA after R_2O_3 precipitation and separation. The results of chemical analysis are summerized in Tables 2 and 3. The content of boron in dolomite in excess of 100 ppm is harmful for metallurgical use. In view of the importance of boron concentrations, the samples were analysed for boron by decomposing 10g of rock with Na_2O_2 sintering and baking in acid. The boron was extracted with ethyl hexanediol and colour was developed with carmine solution and measured at 575 mμ against the blank. The boron content in most samples was found to be very low (i.e. 10 ppm) except in sample No. MR5C (130 ppm).

(b) *Mineralogical examination.* Specimens representing different types of mineral assemblages were microscopically examined in thin sections. Identification of minerals was also done by staining with Alizarin Red, Titan Yellow and Hematoxylin after etching with dil. HCl. Differential thermal analysis (DTA) and thermogravimetric analysis (TGA) were conducted on powdered) samples using mom-Derivatograph (Hungary). The results are reported in Tables 2-5 and Fig. 3.

RESULTS AND DISCUSSION

The Abbottabad formation in the Hazara division extends for about 50 km between Tannaki near Abbottabad in the west to Garhi Habibullah in the east. The thickness range is between 100 and 900 m. Generally the beds are more than 500 m thick with three lithological

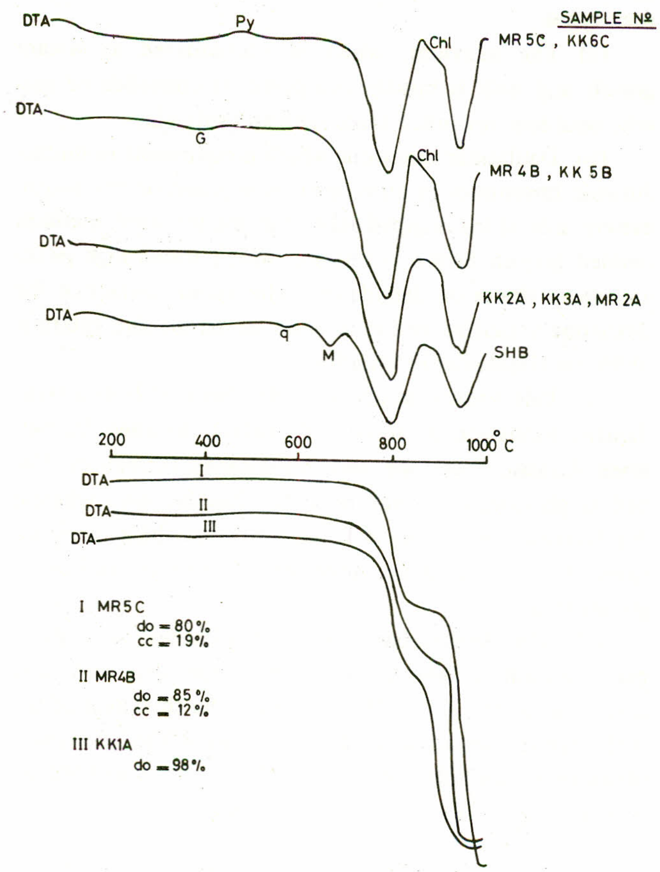

Fig. 3. D.T.A and TGA of dolomites (Py=pyrite; do=dolomite; cc =

Table 1. Comparison of lithostratigraphic names for the rocks exposed in the Hazara area.

Age	Middlemiss 1899 [2]	Latif 1972 [3]	Bhatti 1977 [4]	M. I. Shah 1977 [1]
Jurassic	Triassic L. St.	–	Daulatmar L. St	–
–	Shale Infra-Trias	–	Galdanian formation	–
Permian and/or Jurassic	–	Hazara	–	–
Triassic and/or Carboniferous	Shale Infra-Trias	Galdanian	–	–
–	Infra-Trias L. St.	Sirban formation	Abbottabad formation	–
Cambrian	–	–	–	Hazara formation (Galdanian-Latif), Abbottabad formation (Infra-Trias Middlemiss) (Abbottabad Group-Latif)

zones representing changes in depositional characteristics. The penecontemporaneous deposition of dolomite, chert and phosphate in upper zone suggests shallow water conditions. The original limestone is completely changed into dolomite of good grade in this zone. The basal zone show a composition ranging from high magnesium limestone to dolomitic limestone and occasionally to dolomite. This zone is characterized by fine to medium-grained dolomite

Table 2. Chemical analyses of Kakul dolomite (A-Upper zone, B-Middle zone, C-Lower zone)

	KK 1A	KK 2A	KK 3A	KK 4B	KK 5B	KK 6C	KK 7C
SiO_2	0.3	3.1	3.5	1.1	10.2	0.6	0.1
Al_2O_3	0.1	1.4	0.2	3.5	2.4	1.1	1.7
Fe_2O_3	0.2	0.4	0.3	0.6	0.6	0.3	0.3
MgO	21.5	20.1	20.9	20.6	18.5	10.2	50.4
CaO	30.1	30.1	29.1	29.2	26.6	43.2	50.4
LOI	47.2	45.1	46.0	45.1	41.6	44.6	43.6
Mineralogy (calculated)							
Dolomite	98.5	92.5	96.1	94.8	85.1	46.9	18.4
Calcite	0.5	2.6	–		1.7	51.1	79.5
Quartz	0.3	3.1	3.5	1.1	10.2	0.6	0.1
Molar % Ca/Ca+Mg	50.2	51.3	50.0	50.0	50.9	75.0	89.8

Table 3. Chemical analyses of Mirpur (MR) and Sheikhan (SHB) dolomites (A-Upper zone, B-Middle zone, C-Lower zone)

	MR 1A	MR 2A	MR 3A	MR 4B	MR 5C	MR 6C	SHB-A	SHB-B
SiO_2	0.2	0.2	2.3	0.9	0.2	0.4	1.8	0.5
Al_2O_3	0.3	0.7	0.9	1.1	0.4	0.8	0.2	1.0
Fe_2O_3	0.2	0.5	0.9	0.4	0.2	0.3	0.2	0.5
MgO	21.5	20.7	20.0	18.5	17.3	20.5	21.0	22.0
CaO	30.3	31.1	30.1	32.9	35.2	31.1	29.8	29.1
LOI	47.6	47.1	45.5	46.3	46.7	46.9	46.5	47.1
Mineralogy (calculated)								
Dolomite (Do)	98.9	95.2	92.0	85.1	79.6	94.3	96.6	*
Calcite (Cc)	0.4	4.4	3.9	12.5	19.6	4.2	1.4	*
Quartz	0.2	0.2	2.3	0.9	0.2	0.4	1.8	0.5
Molar % Ca/Ca+Mg	50.2	51.6	51.9	56.0	59.2	52.0	50.7	48.5

*Calculation of dolomite and calcite percent not done for SHB-B as it contains magnesite.

of grey to buff colour. The colour change is explained by the fact that dolomite usually accommodate some iron in its structure, whereas calcite does not accommodate. This accounts for dark grey colour and presence of pyrite in limestone which changes into buff or pinkish colour by substitution of Mg by Fe in dolomite. The high standard deviation in the results of petrochemical examination methods which employs the reaction with free iron of limestone may be due to the transitional nature of carbonatic rocks in basal zones.

The Ca/Ca+Mg mole percent of dolomites and dolomitic limestones ranges from 48.5 to 52.0 and SiO_2 ranges from 0.2 to 3.5 with an average of 1.6 in most samples. The Fe_2O_3 ranges from 0.2 to 0.9 and Al_2O_3 from 0.1 to 3.5 with an average of 1.05 %. Dolomite samples with R_2O_3 within 1-2, SiO_2 0.4-2 % and MgO % not less than 19 % can be used in metallurgical industries and steel mills as refractory after dead burning.

The mineralogical composition of the carbonates was shown by thermogravimetric analysis. Whole range of peak

Table 4. Mineralogical composition of dolomites

Area	Zone	Mineralogy
Kakul	Upper zone	Dolomite, quartz.
	Middle zone	Dolomite, quartz, clay
	Lower zone	Calcite, magnesium-calcite, pyrite.
Mirpur	Upper zone	Dolomite, quartz, ankerite
	Middle zone	Dolomite, quartz, goethite, clay
	Lower zone	Dolomite, magnesium-calcite.
Sheikhan Bandi	Upper zone	Dolomite, quartz, calcite, magnesite.

Table 5. Results of DTA and TGA analyses

Sample No.	Peak tempera-	Minerals
KK 2A, KK 3A	800 & 930 Endo	Dolomite.
MR 2A	575 Endo (faint)	Quartz
MR 4B, KK 5B	785 & 960 Endo	Dolomite (+ calcite)
	350 Endo (large)	Goethite/limonite
	820 & 840 Endo and Exo	Clay or chlorite
SHB-B	700 Endo	Magnesite
	910 Endo	$CaCO_3$ of dolomite
	575 Endo (faint)	Quartz
MR 5C, KK 6C	980 Endo	Calcite (non-dolomitized)
	340 & 465 Exo	Pyrite
	765 Endo	$MgCO_3$

shifting of $CaCO_3$ and $MgCO_3$ component was shown by different dolomitic samples which indicates a composition range from magnesian-calcite to dolomite. In completely dolomitized samples the $CaCO_3$ peak shifts to 900^o from 980 as found in calcite, and $MgCO_3$ peak shifts from 700^o as found in pure magnesite to 785^o! The DTA of magnesian-limestone (MR 5C, KK 6C) show strong endothermic peaks of $MgCO_3$ and $CaCO_3$ components at 765 and 980^o respectively. This suggest that the incorporation of Mg^{++} in limestone forms incipient dolomite phase (as $MgCO_3$ peak corresponds to dolomite and not magnesite) in calcite matrix. In dolomitic-limestone (MR 4B) the character of $CaCO_3$ peak is that of dolomite and calcite mixture, as the superimposition of dolomite (900-930^o and calcite (980^o) peak can be inferred from a disproportionate enlangement of the resulting peak around 960^o.

Late diagenetic dolomite which is more common in nature is formed at a later stage after the burial of limestone sedimants by the action of Mg-bearing natural pore solutions in the earth crust. On experimental phase equilibrium studies and on the basis of the average composition of pore solutions, Usdowski [5] showed that the formation of dolomite in the earth crust has probability of 61 % as compared to 3 % of magnesite. The pore solutions in the Kakul Mirpur area correspond to average natural composition and not as rich in Mg^{++} contents as in the nearby Sherwan area. This has also been suggested in a previous paper by the authors [6].

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