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MINERALOGY AND CHEMISTRY OF BLOATING SLATE IN ATTOCK-CHERAT RANGE, NORTHERN PAKISTAN

M. A. Qaiser, Fazal A. Siddiqi, Nisar Ahmad, Mumtaz and Ahmad Hussain*

PCSIR Laboratories, Peshawar

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Mineralogy by XRD and Derivatography of twenty slate channel samples collected from Attock-Cherat Range is presented. The minerals identified in the rock are quartz, illite, chlorite, feldspar, pyrite, calcite and hematite. A composition diagram of chemical analyses is presented to show that all the samples studied are well within the area of bloating. Commercial use is also suggested.

Key words: Mineralogy, Bloating slate, Attock-Cherat range, Pakistan.

INTRODUCTION

Slate is a commercial term used for rocks employed in roofing and flooring of low cost houses. Geologically slate is a micro crystalline metamorphic rock, characterised by highly developed rock cleavage. It covers a multitude of construction uses from road sub-bases to roof tops. Broken slates can be used as paving. It is considered a very cheap filler for primers, undercoats and anti-fouling paints where the colour is not of primary consideration.

Extensive deposits of slate suitable for lightweight aggregate are found in Attock-Cherat range in northern Pakistan. Ahmad Hussain *et al.* [1] have described the geology and bloating property of the rock in the area. The rock deserves some attention regarding its detailed mineralogy and chemistry. The study presents mineralogy and chemistry of the slate as well as conditions for bloating.

Geology of the area. The slate deposits are located on the northern foothills of the Attock-Cherat Range in N.W.F.P. and the Punjab (Fig. 1). The area investigated for the present studies lies between latitude 33° 41′ 15″ N and 34° 01′ 10″N and longitude 71° 44′ 45″E and 72° 49′E. The slate belongs to Manki formation which is the oldest lighological unit of Late Precambrian age. It generally strikes in EW direction and dips from 45° – 60°N. However, this predominant trend and the dip direction change locally due to assymetrical folding.

The slate ranges from dark grey, dark green and black on the fresh surface while greyish and rusty brown on weathered surface. The slate is fine grained thin to medium bedded, highly fractured and jointed. Minute crystals of pyrite (Fe_2S) are widely disseminated in some parts of the slate.

The slate outcrop extends in nearly EW direction for a strike distance of about 33 kilometers with an average width of 4 kilometers. Therefore, its exposed reserves are in the order of several billion tons [1]. The area is well served with communication systems. The main railway line and Rawalpindi-Peshawar highway run close to the investigated area.

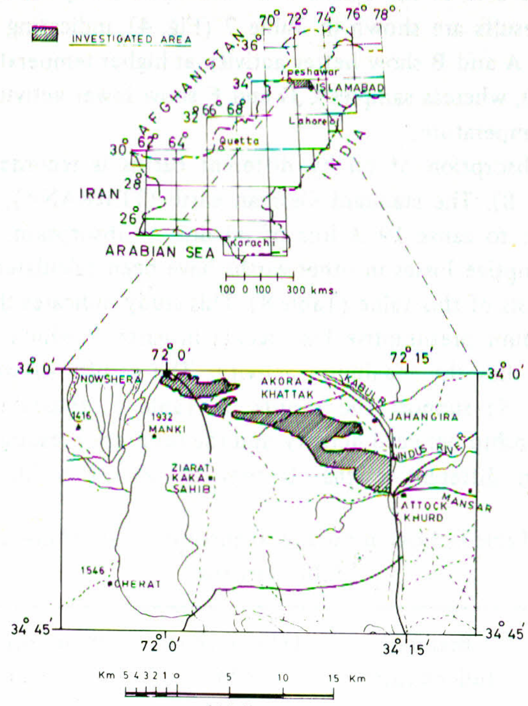

Fig. 1. Location map showing the investigated area.

EXPERIMENTAL

Twenty representative channel samples from the slate despots of the area understudy were analysed by X-ray powder diffraction (XRD) and derivatography (simultaneous DTA, TGA & DTG) techniques. The mineralogical

* Geological Survey of Pakistan, Peshawar

methods employed have been described elsewhere [2]. All the samples were chemically analyzed by wet chemical, UV spectrophotometry and flame photometric methods.

RESULTS AND DISCUSSION

X-ray powder diffraction. The XRD diffractograms of representative natural sample, HCl treated and glycolated samples are depicted in (Fig. 2). Conclusions regarding the mineralogy are summarized in (Table 1). For interpretation, the observed data of the samples are compared with that of Brown [3] and ASTM powder diffraction file [4]. The minerals identified are quartz (3.34, 4.26, 1.82A^{O}) illite (10.00, 4.48, 3.33, 2.51, 2.46A^{O}), chlorite (7.16, 4.80, 3.55A^{O}), feldspare most probably albite (3.18, 3.75, 3.21A^{O}) calcite (3.04, 2.28, 2.09A^{O}), pyrite (2.70, 1.63, 2.42A^{O}). heamatitle (2.53, 1.61, 1.48A^{O}). Reflection 2.77A^{O} could not be identified. The whole rock mineralogy is dominated by quartz and feldspar whereas clay mineralogy is dominated by illite and chlorite. Comparison of the intensities and spacings d(001), d(002) d(003) and d(060) with the reported spacings [5] indicates that clay is dioctahedral 1M illite and d(060) characteristic spacing at 1.54A^{O} of trioctahedral magnesium rich chlorite [3]. Some acid treated samples have been examined (dil. HCl for 2 hrs. at 80^{O}) to confirm the presence of chlorite. No reflections for chlorite were observed. All glycolated samples were also unaffected, indicating that chlorite and illite are non-expanding [5].

Derivatography. Simultaneous differential thermal analysis (DTA), differential thermogravimetry (DTG) and thermogravimetric (TG) curves of sample 1 and 11 are presented in Fig. 3). Samples 1 to 7 show similar DTA & DTG curves with little variation in TG loss percent. Samples

Table 1. Whole rock and clay mineralogy.

Sample No.	Whole rock mineralogy: Quartz	Albite	Calcite	Pyrite	Clay mineralogy: Hematite	Illite/ Chlorite
SL–1	++	+	+	+	+	++/+
SL–2	++	+	+	+	+	++/–
SL–3	++	+	+	+	+	++/+
SL–4	++	+	+	+	+	++/+
SL–5	++	+	+	+	+	++/+
SL–6	++	+	+	–	+	++/–
SL–7	++	+	+	+	+	++/+
SL–8	++	+	+	–	+	++/+
SL–9	++	+	+	+	+	++/+
SL–10	++	+	+	–	–	++/+
SL–11	++	+	+	+	+	++/–
SL–12	++	+	+	–	+	++/+
SL–13	++	+	+	+	+	++/+
SL–14	++	+	+	–	–	– /+
SL–15	++	+	+	+	+	++/+
SL–16	++	+	+	+	+	++/+
SL–17	++	+	+	–	–	++/+
SL–18	++	+	+	–	–	++/+
SL–19	++	+	+	–	–	++/+
SL–20	++	+	+	–	–	– /–

\+ Indicates the presence of minerals
++ Indicates presence of minerals in major amount
– Indicates the absence of minerals

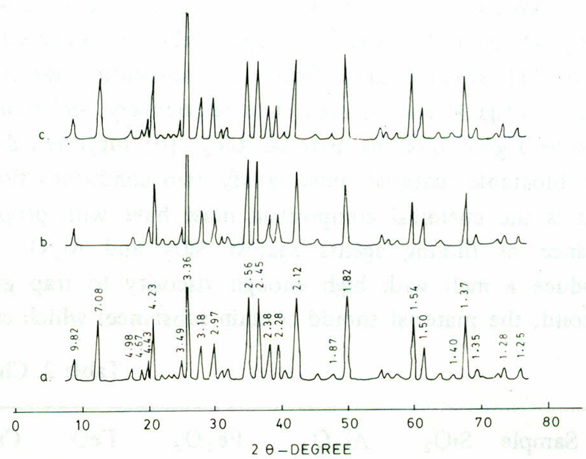

Fig. 2. XRD diffractograms. (a) natural sample. (b) HCl treated sample. (c) glycolated sample.

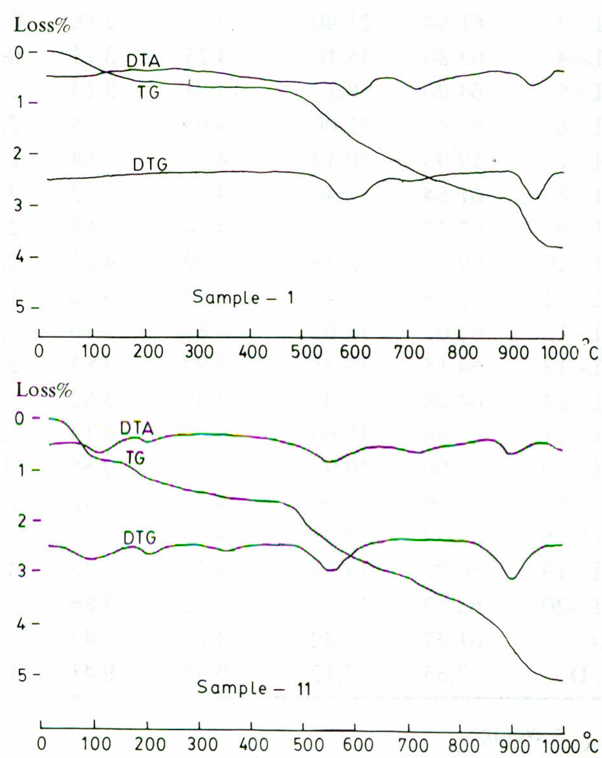

Fig. 3 Derivatograms of sample no. 1 & 11.

8 to 12 derivatograms are similar with little variation observed in TG loss except in samples 10, 17 and 19 which show loss about 6.5 percent. DTA curves of samples 1 to 7 are characteristic of illite with associated chlorite [3], whereas DTA curves of 8 to 20 show typical reaction of chlorite. DTG peak at 950^{o} in all samples is due to decomposition of calcite.

Chemical analysis. Chemical analyses are presented in (Table 2). The average percentage composition of the rock indicates SiO_2 61%, Al_2O_3 17.32% Fe_2O_3 4.27%, FeO 3.47% CaO 2.11%, MgO 4.43%, Na_2O 1.45% and K_2O 2.95% with a standard deviation of 2.65, 2.12, 0.49, 0.41, 1.00,1.45, 0.64, 0.58 and 1.09 respectively. Ahmad Hussain *et al.* [1] studied quick firing test, absorption test for bulk of original and bloated slate respectively, and found it to be a good bloating material.Riley [6] suggested that any bloatable material must satisfy two conditions first, that is the chemical compositon must have with proper balance of fluxing agents against SiO_2 and Al_2O_3 to produce a melt with high enough viscosity to trap gas. Second, the material should contain substances which can liberate a gas at the bloating temperature. The range of compositions for satisfying the first condition have been established by Riley [6] on a composition diagram. The chemical constituents of the samples are plotted (Fig. 4). All the samples satisfy the first condition. Almost all the samples contain calcite, pyrite and hematite, capable of

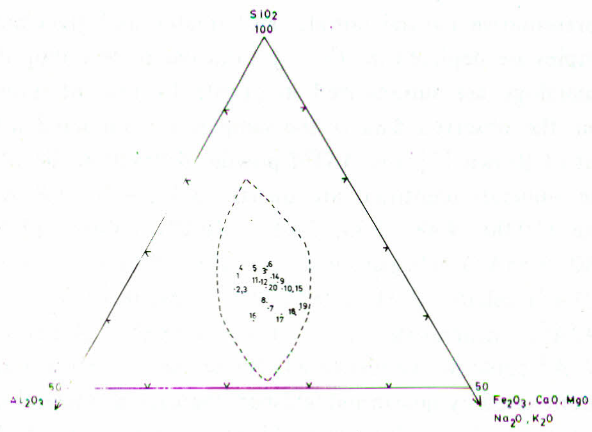

Fig. 4. Composition diagram

Table 2. Chemical analyses of slate.

Sample No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	P_2O_5	MgO	Na_2O	K_2O	L.O.I.	Total
SL–1	63.22	19.10	3.61	2.95	0.90	tr	1.10	0.72	3.35	5.02	100.01
SL–2	61.41	21.06	3.61	2.95	0.80	tr	1.04	0.95	3.30	5.35	100.46
SL–3	61.64	21.40	3.52	2.88	0.80	–	1.28	0.96	2.87	4.72	100.07
SL–4	63.86	18.10	4.25	3.11	0.90	tr	1.60	0.46	2.56	5.22	100.06
SL–5	64.00	18.13	3.81	3.13	1.90	tr	1.02	0.61	3.03	4.42	100.08
SL–6	63.42	15.00	4.65	3.75	2.20	–	1.04	1.00	2.99	4.54	98.59
SL–7	59.96	18.17	4.45	3.64	2.26	–	1.61	1.69	4.70	3.72	100.20
SL–8	61.54	17.46	4.43	3.62	3.28	–	1.67	1.62	3.43	3.58	100.63
SL–9	62.27	15.17	4.44	3.63	2.11	tr	3.02	1.71	3.09	4.06	100.50
SL–10	59.77	15.28	4.92	4.01	2.20	–	2.62	1.75	2.89	6.37	99.81
SL–11	62.58	17.46	3.90	3.18	1.80	tr	2.57	1.48	3.14	3.57	99.68
SL–12	62.07	18.02	3.87	3.16	1.75	tr	2.06	1.27	3.10	4.13	99.40
SL–13	64.15	15.35	4.73	3.87	2.40	–	1.29	1.18	3.11	3.72	99.80
SL–14	64.08	16.05	4.69	3.82	1.32	–	2.36	1.41	2.98	4.06	100.77
SL–15	61.66	15.60	3.07	4.14	2.14	tr	3.07	2.11	2.27	4.09	100.15
SL–16	57.00	20.91	3.55	2.89	3.50	–	3.22	1.85	2.75	3.40	99.11
SL–17	56.36	17.05	4.18	3.42	1.77	–	4.64	3.16	2.63	6.46	99.97
SL–18	56.39	14.93	4.73	3.86	4.24	–	6.06	1.59	1.96	5.93	99.69
SL–19	56.91	14.57	4.21	3.43	4.01	tr	5.25	2.39	1.99	6.79	99.55
SL–20	62.77	17.57	4.72	3.86	2.12	tr	2.02	1.39	2.78	3.23	100.46
$\bar{x}$	61.25	17.32	4.27	3.47	2.11	–	2.43	1.45	2.96	4.62	99.98
S. D.	2.65	2.12	0.49	0.41	1.00	–	1.45	0.64	0.58	1.08	0.53

$\bar{x}$ = average
S.D.= Standard deviation

liberating CO_2, SO_2 and CO_2 respectively to satisfy the second condition.

CONCLUSION

The slate deposits of Attock-Cherat Range have suitable mineralogical and chemical composition for bloating purpose. It can be utilized for the production of lightweight aggregate in addition to a multitude of constructions from road sub-base to roof tops. The deposits are ideally located with regards to infrastructure facilities and potential consumption centres.

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