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TALC-CHLORITE ROCKS IN ATTOCK SLATES

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Dark grey to whitish rocks from Attock Khurd, previously described as low grade soapstone, were found to contain talc with a subordinate amount of chlorite (penninite). Other impurities are quartz, calcite, dolomite, magnesite and pyrite. The mineral assemblage has in all probability resulted from magnesium-containing solution of hydrothermal origin acting on illite of the slate.

INTRODUCTION

Near Peshawar a large outcrop of dark slates occur from Khyber Agency to Attock. The extrapeninsular representative of the Vindhya's are thought to be largely present in the belt of unfossiliferous sedimentary rocks that lies between the crystalline rocks of the central and the younger rocks of the outer Himalayas [1]. The Attock slates are thus considered to be of Cambrian age. However, Taherkheli [2] believes that they are of Jurassic age. Few, limestones and sandstones' deposits are also enclosed in the slates. The slates are also permeated with trap intrusions.

At Kund (Fig. 1) near Attock Khurd small scale mining of dark grey to whitish soapstone has been continuing for years [3]. Formerly the material was used locally for soap-making and white-washing. At present it is consumed by the porcelain tile factory and as fillers in insecticide industries.

The present investigation was conducted in order to ascertain the mineralogy and chemistry of the materials.

OCCURRENCE

The main deposits of talc-chlorite are located near the Kund village (area ABCD, Fig. 1) as lenticular masses within the pelitic rocks. Some pits have been also opened up at about 800 m. north of the village Kati Miana, in the strike direction of Kund deposits. The strike of the rocks is almost East-West. Fresh slates are dark in colour and contain oxidized iron pyrites. Arenaceous and calcareous bands are also found within the slates. The limestones are sometimes dolomitic. Dolerite dykes are quite frequent.

The following samples were obtained from the area for the investigation:

K1, soapy slate, black but soft, collected from the railway

cutting about 20 m north of the railway crossing.

K2, highly weathered calcareous soapy slate from a zone about 60 cm thick, collected from the locality as above.

K3, slates with pyrite near K2.

K4, black slate adjacent to the sample K3.

K5 soft soapy rock with iron pyrite crystals, greyish-black saturated with water when fresh, becomes whitish grey with greenish sheen on drying, collected from one of the pits on the left side of the track.

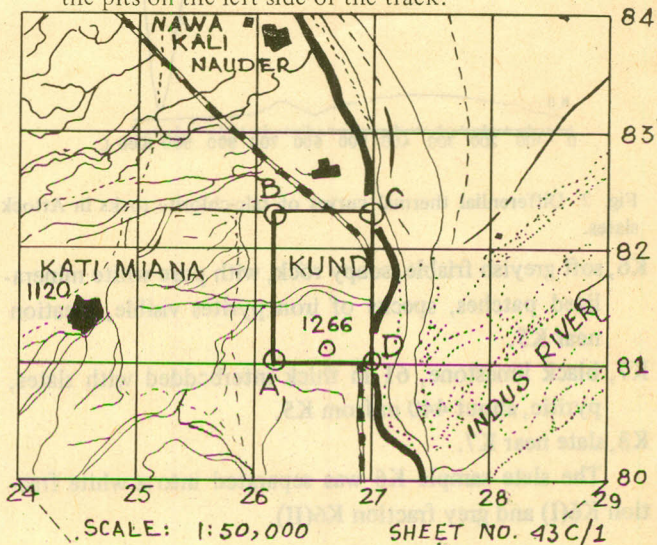


Fig. 1. Location map of talc-chlorite rocks in Attock slates.

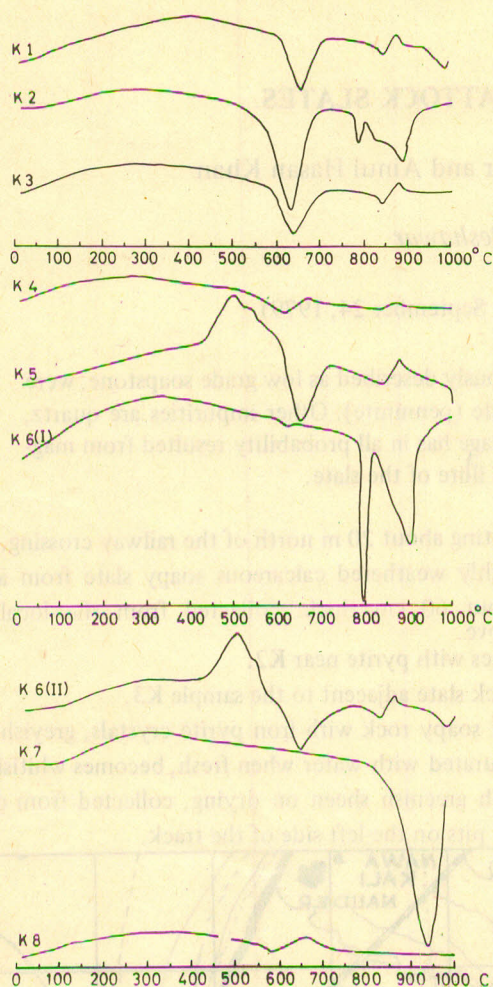


Fig. 2. Differential thermal curves of talc-chlorite rocks in Attock slates.

K6, soft greyish friable, soapy rock, with pure white mineralized patches, specks of iron pyrites visible, location near K5.

K7, black limestone, 61 m thick interbedded with slates, pyritic, about 440 m from K5.

K8, slate near K7.

The slate sample K6 was separated into a white fraction K6(I) and grey fraction K6(II).

MINERALOGY

The samples were examined by differential thermal analysis, X-ray diffraction and chemical techniques.

Differential Thermal Analysis. The differential thermal curves (Fig. 2) for samples K1, K2, K3, K4, K5 and K6(II) show the characteristic reaction for chlorite. The sample K2 also contains the endotherms of dolomite and the samples K5 and K6(II) have marked similarity with exothermic peaks at about 500°C which may be due to the decomposition of FeS_2 to $\text{FeS} + \text{S}$ and oxidation to sulphate. Samples K6(I), K7 and K8 contain dolomite, calcite and illite

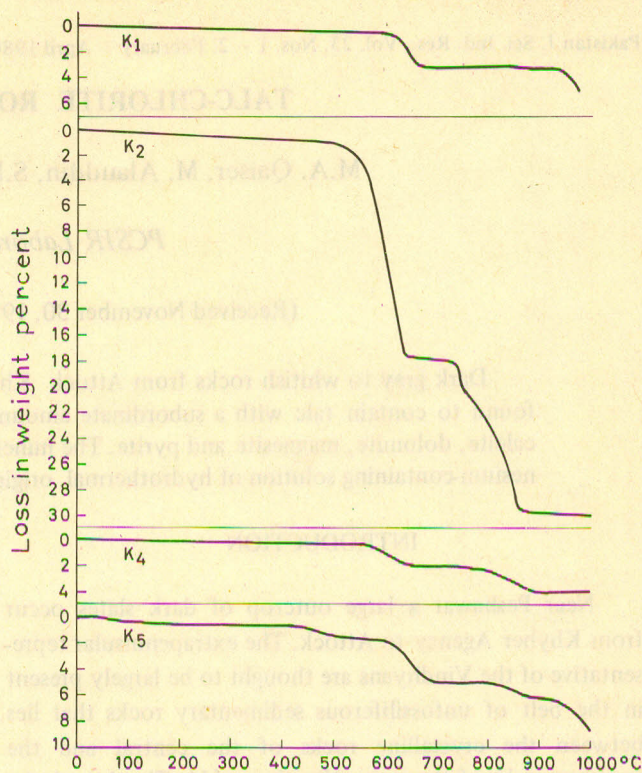


Fig. 3. Thermogravimetric curves of talc-chlorite rocks in Attock slates.

respectively.

Thermogravimetric Analysis. Figure 3 reproduce the thermogravimetric curves for samples K1, K2, K4 and K5. The loss due to chlorite is prominent in all the curves at about 600°C.

X-Ray Diffraction. X-ray analysis were made on all the untreated samples (Table 1). Some of the samples have been examined after acid (dil HCl for 2 hr at 80°C) and ethylene glycol treatments. Absence of chlorite reflections in acid-treated samples confirms that the chlorite has been decomposed. All the samples remained unaffected by the glycol treatment.

From the X-ray powder data the following conclusions regarding the mineralogy may be made (three main reflections of standard minerals from ASTM Index are given in the bracket).

K1, talc (9.34, 3.12, 4.66) with subordinate amount of chlorite (7.19, 4.80, 3.60).

K2, talc, chlorite, magnesite (2.74, 2.10, 1.70), calcite (3.04, 2.29, 2.10) and dolomite (2.89, 2.19, 1.79).

K3, quartz (3.34, 4.26, 1.82), chlorite and calcite.

K4, quartz, chlorite and illite (10.0, 4.48, 3.33).

K5, talc and chlorite.

K6(I), talc and dolomite.

K6(II), talc and chlorite.

K7, calcite.

K8, quartz, chlorite, illite and pyrite (1.63, 2.71, 2.42).

Chemical Analysis. Chemical composition data for sam-

Table 1. X-ray diffraction powder data (Debye-Scherrer camera 114 mm dia; radiation (CuK) 1.54 Å exposure time 6 hr; (35 kV, 18mA).

K1 d(Å)	I	K2 d(Å)	I	K3 d(Å)	I	K4 d(Å)	I	K5 d(Å)	I	K6(i) d(Å)	I	K6(ii) d(Å)	I	K7 d(Å)	I	K8 d(Å)	I
—	—	—	—	—	—	—	—	13.59	20	—	—	14.48	70	—	—	—	—
9.30	90	9.30	25	—	—	9.32	2	9.50	25	9.35	50	9.30	80	—	—	9.82	2
7.19	10	7.08	20	7.08	10	7.08	5	7.08	10	—	—	7.13	70	—	—	7.08	10
—	—	4.69	20	4.79	5	4.79	2	4.79	15	4.73	60	—	—	—	—	—	—
4.57	80	4.61	1	—	—	4.51	5	4.55	5	4.59	10	4.57	30	—	—	4.43	2
—	—	—	—	4.27	15	4.24	20	—	—	—	—	—	—	—	—	4.25	25
—	—	—	—	4.04	2	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	3.78	5	—	—
3.57	10	3.56	30	3.56	25	3.53	2	3.56	35	—	—	3.56	60	—	—	3.53	1
—	—	—	—	3.36	100	3.36	100	3.30	1	—	—	—	—	3.35	15	3.35	100
—	—	3.26	1	3.20	5	—	—	—	—	—	—	—	—	—	—	3.20	1
3.13	80	3.13	40	—	—	3.18	20	3.13	50	3.11	70	3.12	100	—	—	—	—
—	—	3.02	40	3.02	3	3.00	2	—	—	—	—	—	—	3.02	100	3.02	1
—	—	2.88	25	2.81	1	—	—	2.84	1	2.88	100	2.84	5	—	—	—	—
—	—	—	—	—	—	—	—	2.71	1	—	—	—	—	—	—	—	—
2.60	5	2.57	50	2.57	1	2.58	20	2.59	1	—	—	2.59	30	—	—	2.59	10
—	—	—	—	2.54	1	—	—	2.54	3	—	—	—	—	—	—	—	—
2.48	15	2.49	5	2.45	5	2.46	8	2.49	1	2.48	20	2.46	30	2.49	15	2.46	10
—	—	—	—	2.39	1	2.39	4	2.39	1	2.42	5	—	—	—	—	2.39	1
2.23	5	2.28	1	2.28	3	2.28	1	2.25	1	—	—	2.25	5	2.28	25	2.29	10
—	—	2.18	5	—	—	—	—	—	—	2.19	30	—	—	—	—	—	—
—	—	2.11	5	2.13	1	—	—	—	—	—	—	2.10	25	—	—	2.01	10
2.01	10	2.01	5	2.00	1	1.96	20	2.00	10	2.01	20	2.01	50	2.09	30	—	—
—	—	—	—	—	—	—	—	1.87	1	—	—	1.87	10	1.87	30	—	—
—	—	—	—	1.82	10	1.81	25	1.83	1	1.79	30	1.82	10	—	—	1.82	15
—	—	1.71	25	—	—	—	—	1.63	1	—	—	—	—	1.60	1	1.66	20
—	—	—	—	—	—	—	—	1.56	2	—	—	1.56	15	—	—	—	—
1.53	60	—	—	1.54	10	1.54	12	1.54	5	1.52	8	1.53	40	—	—	1.54	12
—	—	—	—	—	—	1.50	1	1.50	3	1.46	8	1.50	15	—	—	—	—
—	—	—	—	—	—	—	—	—	—	1.43	5	—	—	1.44	2	—	—
—	—	—	—	1.37	5	1.37	5	1.39	4	1.38	10	1.39	40	1.42	1	1.37	1
—	—	—	—	—	—	—	—	1.32	1	—	—	1.31	7	—	—	—	—
—	—	—	—	—	—	—	—	1.29	1	—	—	1.29	7	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.20	1
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.18	1

Table 2. Chemical analyses

Chemical Composition	K1 (%)	K2 (%)	K4 (%)	K5 (%)
SiO ₂	48.44	20.20	60.40	40.90
Al ₂ O ₃	12.08	4.60	21.30	12.63
Fe ₂ O ₃	0.40	2.03	0.08	3.19
FeO	1.65	1.93	3.51	2.15
MnO	Nil	Trace	Trace	—
TiO ₂	0.25	0.22	0.43	0.30
CaO	0.13	9.02	0.51	0.21
MgO	29.21	32.01	5.92	28.19
Na ₂ O	Nil	Nil	1.52	—
K ₂ O	Nil	Nil	1.37	—
P ₂ O ₅	Nil	Trace	Trace	—
H ₂ O	0.11	0.13	0.08	0.27
H ₂ O ⁺	7.64	2.28	4.04	10.96
CO ₂	Nil	28.07	Nil	—
SO ₃	0.42	Nil	0.51	—
S	—	—	—	2.31
Total:	100.33	100.49	99.79	101.11
Less O=S				0.82
				100.29

Table 3. Calculated mineral composition.

	K1	K2	K4	K5
Mg ₆ Si ₈ O ₂₀ (OH) ₄	62.37	26.68	—	51.86
Fe ₁₂ Si ₈ O ₂₀ (OH) ₁₆	4.17	1.56	6.10	1.70
(Mg,Al) ₁₂ Si ₈ O ₂₀ (OH) ₁₆	30.54	11.63	19.09	31.86
K ₂ Al ₄ (Si ₆ Al ₂)O ₂₀ (OH) ₄	—	—	11.54	—
Na ₂ Al ₄ (Si ₆ Al ₂)O ₂₀ (OH) ₄	—	—	18.79	—
SiO ₂ (quartz)	—	—	39.91	—
CaCO ₃	—	8.78	—	—
MgCO ₃	—	29.05	—	—
FeCO ₃	—	3.10	—	—
CaCO ₃ ·MgCO ₃	—	16.26	—	—
CaSO ₄	0.31	—	0.85	—
MgSO ₄	0.35	—	—	—
FeS	—	—	—	6.35
Excess SiO ₂	0.81	—	—	—
Excess Al ₂ O ₃	—	—	1.78	—
Excess MgO	—	1.68	—	1.82
Excess CaO	—	—	0.15	0.21
Excess TiO ₂	0.25	0.22	0.43	0.30
Excess H ₂ O	0.11	0.13	0.08	3.72
Total	98.91	99.09	98.72	97.82

ples K1, K2, K4 and K5 are given in Table 2 and calculated norms in Table 3.

The calculated composition have been based on information available from X-ray and TGA, and on the as-

sumption that sulphur is present as FeS, sulphate as CaSO₄ and MgSO₄, CO₂ as CaCO₃, MgCO₃, CaCO₃, MgCO₃ and FeCO₃. Titania is assumed to be present as rutile or anatase.

The iron left after calculating FeCO₃ (if any) was assigned to Fe₁₂Si₈O₂₀(OH)₁₆. Soda and potash were assigned to Na₂Al₄(Si₆Al₂)O₂₀(OH)₄ and K₂Al₄(Si₆Al₂)O₂₀(OH)₄ respectively. After calculating paragonite and muscovite the alumina left over was assigned to form penninite [(Mg₈Al₄)(Si₄Al₄)O₂₀(OH)₁₆]. The magnesia left at this stage was assigned to talc [Mg₆Si₈O₂₀(OH)₄].

Table 4 clearly shows that chlorite is present in all the four samples and varies between 13.19 – 34.71%. The samples K1, K2 and K5 contain talc between 26.68 – 62.37%. The slate sample K4 does not contain talc but contains about 39.91% free quartz.

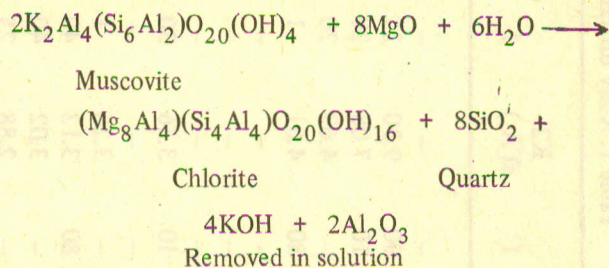
The sample K2 is rather unique; it contains not only talc and chlorite but also calcite (8.78%), magnesite (29.05), siderite (3.10%) and dolomite (16.26%).

ORIGIN

The parent material for the formation of the mineral assemblage seems to be the greyish-black slate containing quartz and mica mineral (illite). The nearby slates are permeated by basic igneous rocks. The slates near the mineralized zone contain some chlorite and are free from talc. The mineralized zone contains talc, chlorite, sometimes dolomite, magnesite and also calcite.

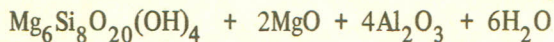
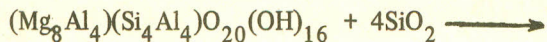
The chlorite group mineral has been accepted to be derived by the aggradation of less organized sheet mineral celadonite, by the degradation of preexisting ferrogmagnesian minerals, and by crystallization from dilute solution of their components [4].

Chlorite group minerals are common constituents of Attock slates – from Khyber to Attock [5]. However, talc is the abundant fraction of the mineralized zone with chlorite in subordinate amount. It seems that magnesia containing hydrothermal solution must have converted some of the muscovite and paragonite into chlorite, as in sample K4, with the following probable reaction:



However, under certain condition all the mica minerals

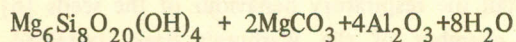
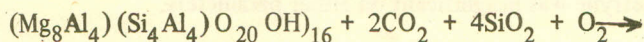
were assimilated with the formation of talc and chlorite as in samples K1, K2 and K5, with the following reaction:



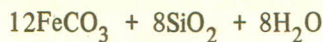
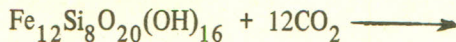
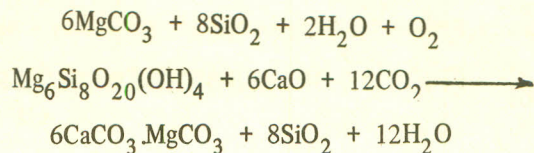
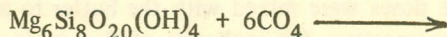
Talc

Removed in solution

At lower temperatures chlorite may be converted to talc by CO₂ metasomatism [6] and in presence of excess of CaO and CO₂ talc is unstable. As the sample K2 contains talc, chlorite, dolomite, calcite, magnesite and siderite, the reactions may be expressed as follows:



Removed in solution



REFERENCES

1. D.N. Wadia, *Geology of India* (Macmillan, London, 1957), p. 134.
2. R. A. K. Tahirkheli, *Geol. Bull. Univ. Peshawar*, **5**, 1 (1970).
3. A. L. Coulson, *Rec. Geol. Surv. Ind.*, Vol., **75**, Prof. Paper No. 2 (1940).
4. W. A. Deer, R. A. Howie and J. Zussman, *Rock Forming Minerals* (Longmans, London, 1967), vol. 3, p. 158
5. A. H. Khan, M. Nisar and A. Babar. A Note on Attock Slates (in preparation).
6. F. J. Turner, *Geol. Soc. Am., Mem.*, **30**, 132 (1948).