Pak. j. sci. ind. res., vol.37, no.11, November 1994

TALC DEPOSITS OF JURAGH AREA, DISTRICT SWAT, PAKISTAN

ABDUL GHANI, SHAGUFTA NASREEN AND KHALID QURESHI

PCSIR Laboratories, Jamrud Road, Peshawar, Pakistan

(Received February 9, 1994 ; revised July 24, 1994)

Good quality talc occur in the Juragh area of district Swat. The deposits lie in the western part of the suture (Lesser Himalayas, exposed in Pakistan) of the Indo-Pak plate in tectonic interaction with Eurasia in the north. The deposit is comprised of talc and antigorite while the country rocks are quartz-mica and dolomitic schists. The talc may have been developed by secondary processes undertaken by the action of hydrothermal solutions on metamorphosed calcareous sediments and impure marbles as well as retrogression during the Himalayan orogeny. The talc is suitable for utilization in a range of industries.

Key words: Talc,Juragh,Swat.

Introduction

Talc is the softest of minerals and is known to many due to its unique physico-chemical properties and long range of usage in everyday's life; ranging from the direct use in soft talcum and baby powder to the indirect use in tough ceramics. It is (when pure) a white flaky silicate of magnesium with a hydroxyl group. However, pure talc rarely exists and it usually contains one or more of (talc 35%) clinochlore (chlorite with F^{+2} and Mg), leuchtenhergite (Mg. chlorite with negligible Fe^{+2} amount), serpentine, dolomite, magnesite, tremolite, anthophyllite or actinolite, quartz and calcite etc. Material having more than 75% talc is sometimes called talcite. The soapstone and steatite are the massive varieties of talc; classified on the basis of their end-use. Steatite tends to mean a massive talc that is used in electroceramics and refractories while soaptone is massive talc that is cut into slabs for and often mixed petrologically with talc is pyrophyllite (a hydrous aluminium clay). It is even claimed that there are "talcs" that contain none of the mineral talc [1].

The major world producers of talc are China and USA, producing more than 1 m.tpa. The second row of major producers (with 0.4 m.tpa.) include India, Brazil and Finland while the total number of countries producing more than 100,000 tpa. are fourteen. The largest consumer of talc is the North America, followed by Europe and South Asia. The major consuming industries (in decreasing order of consumption) are ceramics, paint, paper, roofing, plastics, cosmetics, insecticides, refractories, rubber and others [1].

Indigenous sources. In Pakistan, the major occurrences of talc are Sherwan (Hazara), Derai (Swat), Parachinar (Kurram agency) and Jamrud (Khyber agency) [2]. Sherwan is the major source of talc since before independence meeting the indigenous demand to an extent. The Derai and Jamrud were once the appreciable sources of talc for indigenous industries but the mining in these localities has almost been extinct due to both poor quality and exhaustion of the deposits. The Kurram agency's occurrene is a large deposit of good quality talc that lacks the physical infrastructure for mining and transportation. However, the same is being developed by a private enterpreneur and it is hoped that the Kurram agency will turn with the passage of time into the top talc producing locality of Pakistan. Beside, the talc dolomite schists constitute matrix of Mingora Ophiolite Melange (Fig. 1) in Dir, Swat and Malakand areas. In about a dozen vicinities of these areas, there occurs good quality talc in extractable amounts. However, these showings are small and most of these have almost become exhausted after the extraction of a few hundred tonnes of talc.

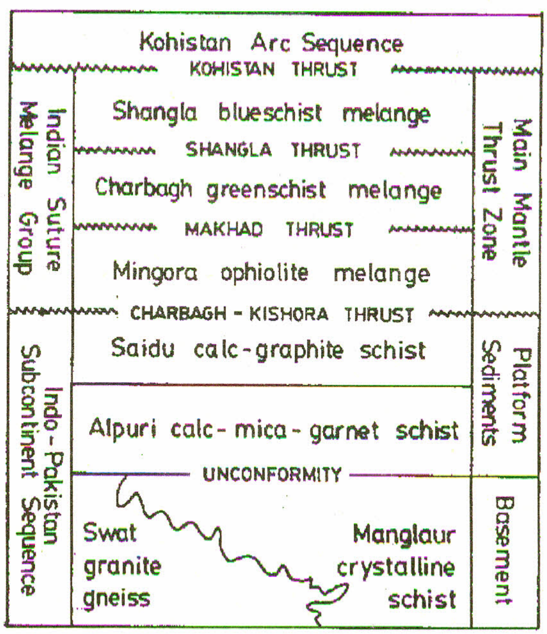

Fig. 1. Stratigraphy of Mingora area.

As a results of industrialization, the indigenous demand for talc has gained impetus and the local production is inadequate to fulfill. In consequence good quality talc is being imported from Afghanistan. To minimize the dependence of indigenous industries on the imported talc, there is a dire need for evaluation and development of the local sources. The present study is an attempt in this direction. This paper entails a discussion on the mineralogy, chemistry and industrial applications of talc of Juragh area, district Swat.

Geological setting. The Indo-Pakistan subcontinent is in tectonically collisional interaction with the Asian continent in north by the closure of a former ocean, called Tethys, along the Indus-Psangpo suture [3,4]. The Indus-Psangpo suture bifurcates into two in the east before entering Pakistan; the northern one is called Northern Megashear or Main Karakoram Thrust (MKT) while the southern one is known as Southern Megashear or Main Mantle Thrust (MMT). These thrusts sandwich an andesitic arc sequence, named Kohistan Island Arc, restricting the direct contact of Asia and Indo-Pak subcontinent in Pakistan [5,6]. The MMT and MKT are characterised by outcrops of ophiolitic and metavolcanic rocks [7,8]. Both of these megashears are comprised of suites of melange groups and the present study area is a part of the Indus suture melange (MMT).

The Indus suture melange group contains a complex sequence of imbricated melanges; largely composed of tectonic blocks of ophiolites, blueschists, greenshists, metavolcanics and metasediments in a matrix of sheared and variously metamorphosed sediments and serpentinites. All these rock assemblages are separated by faults of different ages. Lawrence *et al*. [9] have termed these rock units to be the remnants of the lithosphere of the Tethys ocean (including oceanic crust, volcanic arcs, trenches and continental margins) that once intervened between the Indian subcontinent and the Kohistan arc; developed either in association with the continental margin south of the Tethys. The significance of MMT has been interpreted by various workers in tectonic and geochemical perspectives [10-14]. The best exposure of MMT in Pakistan is betwen Besham (on the Indus) and Mingora (Swat) and has been divided stratigraphically into three fault-bounded melange units of different tectonic origins (Fig.I) by Kazmi *et al.* [15].

Local geology. The Juragh talc is a part of the Mingora ophiolite malange. It is a haphazardly shaped tectonic wedge of ophiolitic rocks comprising the vicinities of Mingora, Alpurai, Makhad and Kabal of Swat while westward it extends into the Shamozai and Asbanr areas of Dir. Stratigraphically it is composed of deformed and tectonised clasts of serpentinite, talc dolomite schist, metasediments, metabasalts, metachert, metagabbro and greenschists embedded in a highly tectonised and weathered mass of talc-dolomite schist and quartz-mica schist.

The talc of Juragh area is good to high in quality and occurs in a complexly interlayered mass of quartz-mica schists and dolomitic schists. These schists are earthy white and greenish white in colour, foliated and highly fractured. In the near vicinities of the deposit, these schists are poorly exposed due to heavy forestation and related weathering processes in the area. A complex combination of deformation processes like folding, faulting and fracturing etc. may be observed in these rocks. These features seem to be symbolic of the repeated episodes of deformation and metamorphism associated with the different stages of tectonic collision in the area. Due to this, great variations are observed in the dip and strike of the strata.

The talc is snow white to pale white in colour and occurs as tabular and lenticular bodies of various sizes. It is platy, foliated and thinly laminated. At very few places, beds of dolomitic schist of few centimeters to one meter thickness are observed. However, these are un-mappable on the scale used of the mapping. Due to abundant alluvium, the precise delineation of talc body is difficult in the vicinities where it is in direct contact with the alluvium. At such points, the talc seems to be most probably greater in extension than the mapped one (Fig.2).

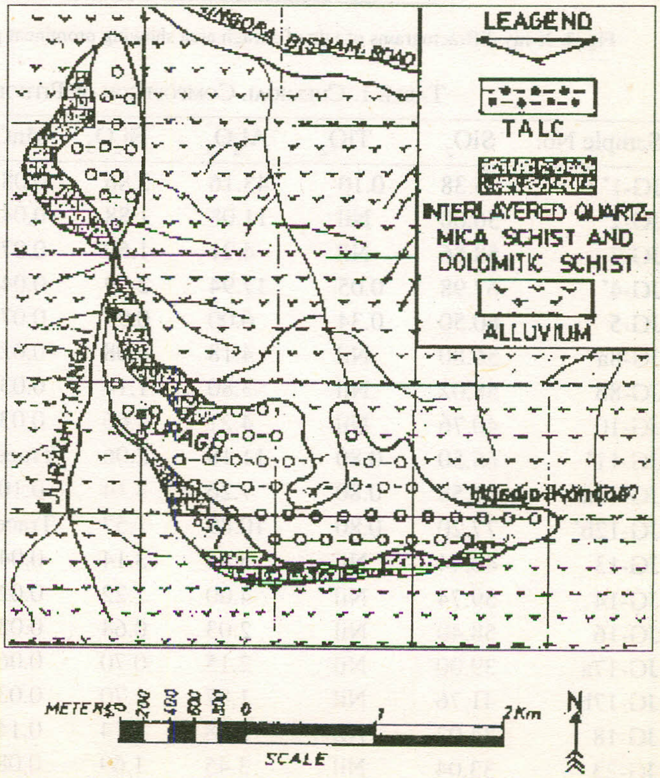

Fig. 2. Geological map of Juragh area, distt. Swat.

Experimental

Geological mapping of the area was carried out on a scale of 2.5 cm = 1 km. A total of 30 samples were collected of both talc and host rocks. Out of these 18 were sorted out and anlysed chemically by conventional and instrumental methods for MgO, SiO_2, Al_2O_3 and Fe_2O_3 etc. (Table.1).

For the mineralogical analysis, the representative talc samples were subjected to XRD (Reigoku X-ray diffraction unit, D/MAX-IIA) as these are not worth making thin sections. However, the host rocks were analysed mineralogically through microscopic thin section studies.

Mineralogy. The x-ray diffractiograms of the samples analysed (Fig.3) show that these are composed dominantly (upto 90%) of talc with maximum and larger number of peaks. The associated mineral with accessory amount is antigorite having a few and comparatively smaller peaks.

The host rocks of talc are of two types *viz.* quartz mica schist and dolomitic schist. The quartz-mica schist is an earthy white schistose rock with conspicuous mica specks having poor compaction. Petrographically it is a coarse-grained granoblastic-polygonal rock composed of (in order of abundance) quartz, muscovite and biotite with accessory rutile. The quartz is subindioblastic and has developed rings. The grains are platy and have acquired wavy boundaries infrequently. Muscovite occurs in the form of lamellae having frequent bends. The quartz has been moulded upon this bending. The biotite is

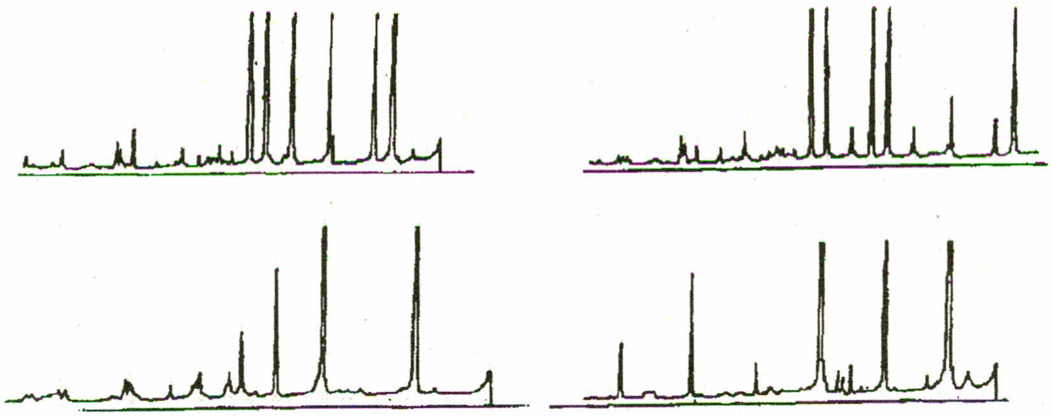

Fig. 3. X-ray diffractograms of talc of Juragh area showing prominent peaks of talc and antigorite. The smaller ones also show the same mineralogy.

TABLE 1. CHEMICAL COMPOSITION OF PITHOLOGIC UNITS OF JURAGH AREA, DISTRICT SWAT.

Sample No.	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	CaO	MgO	Na_2O	K_2O	L.O.I.	Total
JG-1*	35.38	0.10	43.16	2.86	0.08	1.48	6.01	0.04	0.02	10.86	99.99
JG-2	56.00	Nil	11.08	1.88	0.04	1.50	22.00	2.75	0.23	4.54	100.02
JG-3	58.56	Nil	4.21	1.50	0.07	Nil	30.18	0.12	0.06	3.64	98.34
JG-4*	67.98	0.05	17.94	2.29	0.04	0.71	5.35	2.25	0.20	3.14	99.95
JG-5	60.50	0.34	6.00	0.97	0.07	3.86	24.16	0.17	0.12	3.86	100.05
JG-8a	56.80	Nil	4.18	1.08	0.02	2.44	30.90	0.10	0.04	4.04	99.60
JG-8b	58.02	Nil	3.80	1.14	0.03	Nil	31.92	0.04	Nil	5.10	100.05
JG-10	40.76	Nil	4.21	1.66	0.03	1.83	39.00	0.01	Nil	12.92	100.42
JG-11*	65.50	0.80	11.18	2.06	Traces	Nil	15.32	2.20	0.28	2.95	100.29
JG-12a*	51.58	0.80	7.26	3.14	0.10	13.07	21.60	0.37	0.25	1.32	99.49
JG-12b*	77.20	0.80	10.89	1.57	Traces	Nil	3.00	1.70	2.80	1.03	99.99
JG-13	40.44	Nil	5.86	3.14	0.04	0.61	41.56	0.12	0.05	8.85	100.67
JG-14	59.74	Nil	4.00	1.22	0.02	0.98	29.65	0.04	Nil	4.65	100.30
JG-16	58.40	Nil	2.03	0.64	0.03	1.22	30.30	0.02	Nil	6.16	98.80
JG-17a	39.00	Nil	2.15	0.70	0.06	7.24	34.00	0.13	0.04	17.04	100.36
JG-17b	41.76	Nil	1.87	1.70	0.03	Nil	41.55	0.20	0.05	12.00	99.16
JG-18	34.02	Nil	2.78	1.14	0.14	8.50	29.58	0.15	0.09	22.80	99.20
JG-23	33.04	Nil	3.45	1.69	0.08	6.11	35.92	0.06	0.05	19.08	99.48

*Host rocks.

both in the form of fibres and polygons. The polygonal biotite has been altered partially to chlorite (clinochlore :). The fibrous form appears to be a juxtaposition over the existing texture and seems to have been developed later than the formation of muscovite; probably during a subsequent episode of metamorphism. Similarly the alteration of polygonal biotite to chorite points to some sort of retrograde matamorphism.

The dolomitic schist is compact, green coloured and schistose having abundant micaceous specks. Under the microscope, it is having a fine to medium grained and granoblastic-polygonal texture. It consists of (in order of abundance) dolomite, biotite and muscovite. The dolomite is decusate (sub-idioblastic) and is dominantly fine grained with the development of characteristic rings. The muscovite is platy and fine to medium grained, having a porphyroblastic relationship with the biotite. The biotite circumfering the muscovite porphyroblasts seems to have been developed at the expense of muscovite.

Results and Discussion

The lithology of most of the northwestern Pakistan has been attributed to the formation of a basin, termed lesser Himalayas basin; a source of lesser Himalayas (consisting of schists, gneisses, marbles and amphobolites) which constitute the major part of the northern boundary in Indo-Pak. plate along the Main Mantle Thrust (MMT) [14]. This is a transformed scenario and the actual margin has probably been subducted deep below the suture [16]. The formation and stratification of the said lithology have been assigned an origin through a series of complex phenomena like intrusion of flood basalts over a gneissic basement during rifting in a former ocean (Paleotethys), deposition of calcareous sediments and impure marbles by the breakdown of the reefs flourishing in the basin and their submergence, magmatism during the early phase of deposition, marine transgression resulting in the formation of black shales, passive margin sedimentation and Barrovian metamorphsim and retrongression during the Himalayan orogeny. All these processes have also been assumed to be accompanied by local and regional alterations like mylonitization, metasomatism and thermal and hydrothermal activities [14-24].

The field investigation of Juragh talc and host rocks (including a reconnaissance visit of the surrounding areas) and the laboratory studies limelight a possible petrogenetic model for the talc. The talc seems to have developed by the interaction of some hydrothermal solution enriched in MgO with the metamorphosed calcareous sediments and impure marbles (both contain muscovite and some quartz, graphite, garnet and tremolite/actinolite in addition to calcite/dolomite). This interaction might include addition and removal of and redistribution of elements in SiO_2, MgO, Al_2O_3, Na_2O, Fe_2O_3 and even TiO_2 (Table 1). Due to uncertainty in the age of carbonates, it is difficult to codify whether this interaction was affiliated to granitic intrusions in the vicinity or took place during the amphibolite facies or later retrogressive metamorphism. However, certain mineralogical features are conclusive and advocate multiple changes, e.g. the juxtapositional texture and porphyroblastic interaction of biotite with muscovite suggest addition and removal of certain components. Similarly the formation of antigorite, the moulding of quartz over the broken surfaces and bends of muscovite lamellae by recrystalization and the alteraction of biotite to chlorite may indicate retrogression.

Industrial uses. The talc has a range of industrial uses depending upon characteristics like colour, hardness, slip, grain shape, grain size, sheen, chemical composition and resistance, hydrophobicity and organophilicity etc. Most of these properties depend to a great extent upon composition (both chemical and mineralogical) with exceptions like grain size which are a subject of mechanical treatment before direct industrial use. As for as composition is concerned, talcs of desired compositions(if in situ composition deviates) for specific industries are obtained through various physio-chemical treatments like froth flotation. The talc under study seems suitable for use in the following industries:

1.Due to absence of any hard mineral, Juragh talc is suitable for paper and pulp industry where talc is used for pitch control, as a filler and as a coating agent.

2.As it is asbestose and chlorite free, mainly magnesium silicate and low in iron, manganese and other impurities (that could discolour the product), it is worthy for electroceramics and glazes.

3.Low iron and other degrading impurities content, softness and odourlessness are some of the qualities of Juragh talc needed in pharmaceuticals and cosmetic industries.

4.Low corbonate cotent, high quality, white colour and less impurities make it suitable for emulsion and anticorrossive paints.

5.It is also good for automobile industry due to high quality, which is rather a sensitive segment in terms of utilization. However, it is not suitable without beneficiation for polyester, nylon, rubber, polypropyle and other polymers due to presence of iron.

Besides, with the help of high and sophisticated technology, a new range of talcs, called "super talcs", has emerged; some already introduced in market. These super talcs have induced more sophistication to the end products. These talcs provide opacity, hiding, film integrity and chemical resistance in both water-base and solvent-based coating; making these high choice for tomorrow's ceramic engines [25].

References

1. John Burger, Industrial Minerals, No.280 (1991), pp.17-26.
2. Ali H. Kazmi and S. Ghazanfar Abbas, A Brief Review of the Mineral Wealth of Pakistan, Special Volume, (Geological Survey of Pakistan 1991).
3. J. F. Dewsy and C.A. Burke. Geology, **81**, 683 (1973).
4. P. Molnar and P. Tapponier, Science,**189**, 419 (1976).
5. R. A. K. Tahirkheli, Geol.Bull.Univ.Pesh., **11**, 1 (1979).
6. R. A. K. Tahirkheli, Geol.Bull.Univ.Pesh., **13**, 36 (1980).
7. J. Stocklin, Soc.Geol.France Mem.Ser., **8**, 333 (1977).
8. A. Gansser, The Geodynamic History of the Himalayas. Ir "Zargos-Hindukush-Himalayan Geodynamic Evolution (H. Gupta & F. Delny Eds), American Geophys. Union, Geodynamic Series 3, (1981) pp.111-121.
9. R. D. Lawrence, A. H. Kazmi and L.W.Snee, Geological Setting of the Emerald Deposits,. In "Emeralds of Pakistan" (A.H. Kazmi & L.W. Snee eds.), Geol.Sur.Pak., Van Nostrand Reinhold, New York, (1989), pp.13-39.
10. M. Q. Jan, Geol.Bull.Univ.Pesh., **9-10**, 16 (1977).
11. M. Q. Jan and R.F. Symes, Mineralogical Magazine, **41**, 537 (1977).
12. R. A. K. Tahirkheli, M. Mattauer, F. Proust and P. Tapponier, The Indian-Eurasina suture zone in northern Pakistan; *Geodynamis of Pakistan* (A.Farah & K. A. Dejong Eds.), (Geol.Surv.Pak., Quetta, Pakistan 1979), pp.115-130.
13. C. Kazmer, S. S. Hussain and R. D. Lawrence, The Kohistan-Indian Plate Suture Zone at Jawan pass, Swat, Pakistan. Geol. Soc. America, Abstracts with programmes, **156**, 609, (1983).
14. Munir Humayun, Geol.Bull. Univ.Pesh., **19**, 83 (1986).
15. A. H. Kazmi, R. D. Lawrence, H. Dawood, L. W. Snee and S. S. Hussain, Geol.Bull.Univ.Pesh., **19**, 83 (1986).
16. L. L. Malinconico Jr., Structure of the Himalayan suture zone of Pakistan: Interpreted from Gravity and Magnetic Data. Ph. D. Thesis, (unpubl.) datmouth College USA, (1982).
17. H. Maluski and P.Matts, Tectonics **3**, 1, (1984).
18. Munir Humayun, Geol.Bull.Univ.Pesh., **18**, (1985).
19. P. S. Rosenberg. The Structure and Metamorphic Petrology of the Karakar pass area, Buner, Pakistan. M.S.Thesis, (Unpubl.), Oregon State University, USA, (1985).
20. K.W.Staufer, Geol.Soc.Amer.Bull., **79**, 1331 (1968).
21. M. P. Coward, M. Q. Jan, D. T.Rex, M. Thirwall and B.F. Windley, Geol.Soc.Lond., **139**, 299, (1982).
22. F. A. Shams, Geol.Bull.Punj.Univ., **3**, 18, (1963).
23. C. T. Klootwijk, *Geodynamics of Pakistan* (A.Farah & K. A. Dejong Eds.), (Geological Survey of Pakistan 1979), pp.41-80.
24. M. J. Rickard and L. Belbin, Tectonophysics, (1979), pp.52-55.
25. Ronald W. Grexa, Industrial Minerals, No.237, (1987).