Short Communications

Pakistah J. Sci. Ind. Res., Vol. 15, Nos. 1-2, February-April 1972

X-RAY STUDIES ON TWO BAUXITIC ORES FROM KATTHA, PUNJAB

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(Received September 18, 1971; revised May 5, 1971)

One of the best deposits of bauxite in Pakistan is situated near Kattha in the Salt Range area, 16 miles north of Khushab in the Sargodha district. The total reserves are estimated to be over 5 million tons.[1] The ore samples were found to contain Al_2O_3 50–70%, SiO_2 10–20%, TiO_2 1–5% and Fe_2O_3 1–2%. Mineralogical studie[2,3] have shown that these ores contain boehmite with some kaolinite. Anatase, halloysite, gibbsite, diaspore, geothite and hematite are present in minor quantities. Recently three reports[4–6] have appeared on the properties of the above bauxite. One of them concluded, on the basis of acid solubility data, the presence of substantial amounts of diaspore with very little boehmite.[4] The other two reports have indicated, through X-ray studies, the presence of boehmite and dickite.[5,6] Thus the findings listed in these three[4,6] reports are contrary to those given in the author's earlier work.[2,3]

The purpose of this study is to discuss the controversial features and to present new data relating to the identification of mineral phases present in the bauxite. This will also contribute towards better understanding of the behaviour of ore in its industrial application.

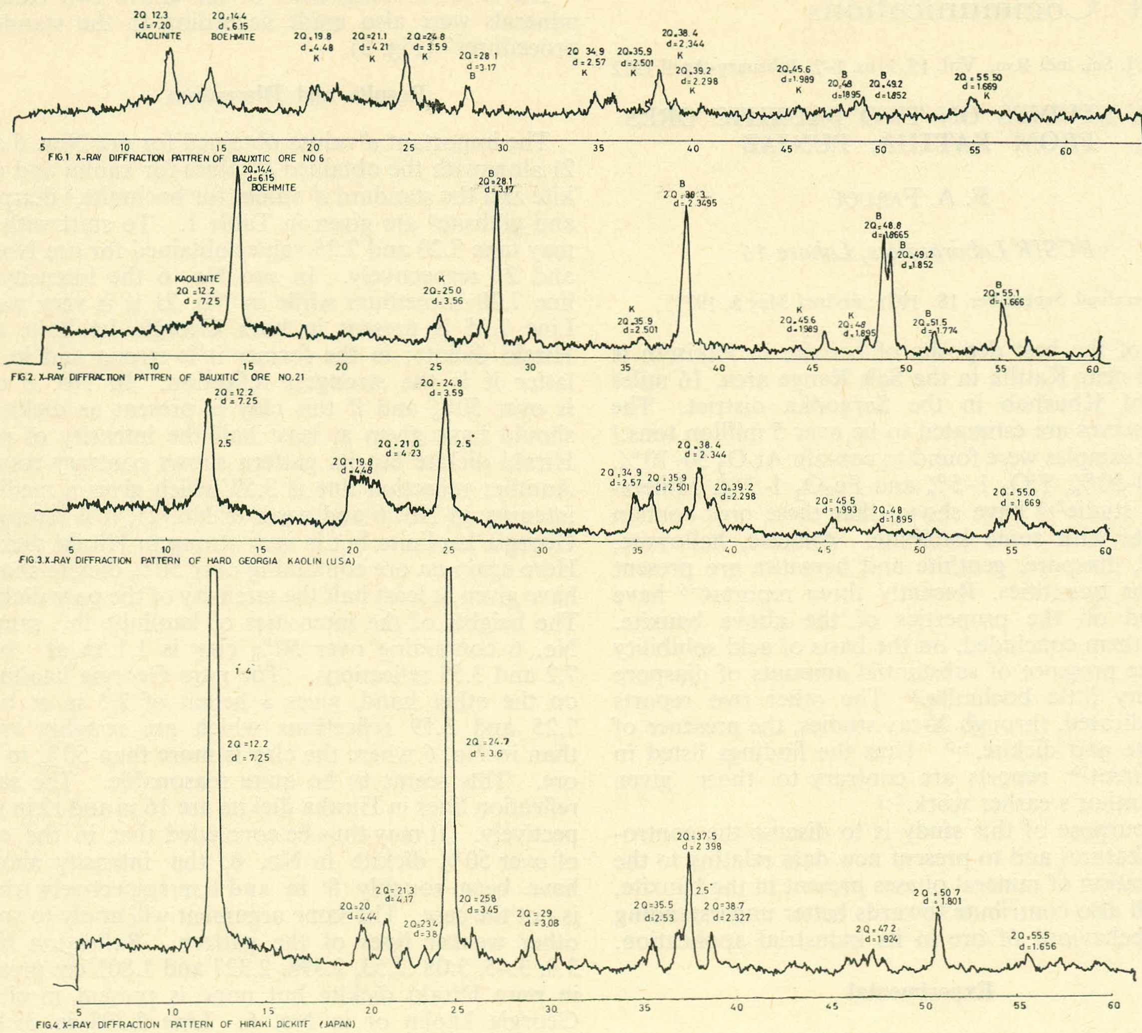
Experimental

In order to verify our previous identifications two representative samples were picked up from those already studied.[5] One of them No. 70-AH-6 contains 54.6% alumina and 26.8% silica and mineralogically it contains about 37% boehmite and 57% clay. The other sample No. 70-AH-21 contains 73.4% Al_2O_3 and 4.7% SiO_2. This gives about 80% boehmite and 10% clay. The basis for selecting these two particular samples for verification was to obtain the maximum amounts of clay (57%) and boehmite (80%) in the ores so that their nature could easily be identified by the X-ray method. Sample Nos. 6 and 21 were analysed by X-ray diffraction method and their patterns are shown in Figs. 1 and 2 respectively. In order to compare these results with those of the standard patterns of dickite (pure Japanese origin, Hiraki Mine) and Georgia kaolin (from Georgia, U.S.A.), the patterns of the latter two minerals were obtained (Figs. 3 and 4). All the above patterns were run with copper target and nickel filter. A 15-mA current and 35 kV volts were applied. The time was kept constant at 2.0 sec with the scan speed 2 mm and the chart sheet 20 mm/min.

The DTA investigations of the above two bauxite minerals were also made according to the standard procedures[7] (Fig. 5).

Results and Discussion

The important *d* values obtained for ore Nos. 6 and 21 alongwith the obtained *d* values for kaolin and dickite and the standard *d* values for boehmite,[8] diaspore and gibbsite[9] are given in Table 1. To start with we may take 7.20 and 7.25 values obtained for ore Nos. 6 and 21 respectively. In ore No. 6 the intensity of line 7.20 is medium while in No. 21 it is very weak. Line 7.25 is present in both Georgia kaolinite and Hiraki dickite; in the former it is strong and in the latter it is the strongest reflection. In No. 6 clay is over 50% and if this clay is present as dickite it should have given at least half the intensity of pure Hiraki dickite but its pattern shows contrary results. Another reflection line is 3.59 which gives a medium intensity in No. 6 and weak in No. 21, it is strong in Georgia kaolinite but is very strong in Hiraki dickite. Here again an ore containing over 50% dickite should have given at least half the intensity of the pure dickite. The heights of the intensities of kaolinite in sample No. 6 containing over 50% clay is 1.1 in at both 7.2 and 3.59 reflections. The pure Georgia kaolinite, on the other hand, gives a height of 2.5 in at both 7.25 and 3.59 reflections which are roughly twice than in No. 6 where the clay is more than 50% in the ore. This seems to be quite reasonable. The same reflection lines in Hiraka dickite are 16 in and 12 in respectively. It may thus be concluded that in the case of over 50% dickite in No. 6, the intensity should have been roughly 8 in and 6 in respectively which is not the case. The same argument will apply to some other weaker lines of the pattern. Reflection lines 3.8, 3.45, 3.08, 2.53, 2.398, 2.327 and 1.801 are present in pure Hiraki dickite but none is present in either Georgia kaolin or in No. 6. Line 2.398 in dickite is very clear and strong. This line is not at all present in kaolinite and in No. 6. Now coming to those lines of pure kaolinite which are present in No. 6 but are not visible in dickite, we may mention the *d* values 2.57, 2.50, 2.344, 2.298, 1.993 and 1.895. The respective values in No. 6 are 2.57, 2.50, 2.344, 2.98, 1.989 and 1.895. The fact that all these values are exactly the same as in kaolinite with a negligible difference between 1.993 and 1.895 is noteworthy. Other lines such as 4.48 and 4.21 present in the sample are identical with those of kaolin (4.48 and 4.23) whereas the corresponding lines in dickite are 4.44 and 4.17 which are not as close as those of kaolinite. The only two lines in No. 6, sharing with the dickite sample, are the values of 7.20 and 3.59 (vs. 7.25 and 3.6 of dickite). However, it may be noted that these values are also common with the kaolinite lines (7.25 and 3.59). As discussed earlier, if the patterns are examined keeping in view the intensities of the lines it will be quite clear that these are kaolinite lines and not of dickite. It is, therefore, concluded that bauxitic clay Nos. 6 and 21 both have kaolinite mineral and not dickite, as reported.[5,6]



Figs. 1–4

Now examine the case of boehmite versus diaspore. The very strong reflection line of pure boehmite given in literature[8] is 6.12. The corresponding lines in bauxite No. 21 containing 73% Al_2O_3 (80% boehmite) shows strong intensity at 6.15 and medium intensity in No. 6 (containing 30–40% boehmite). This line is completely absent in diaspore and gibbsite[9] and the patterns of Nos. 6 and 21 are flat at these points. Similar is the case with lines 3.16, 2.355/2.341 and 1.859/1.845 which are all strong in 100% boehmite. Their corresponding lines in No. 21 (80% boehmite) are 3.17, 2.35 and 1.866/1.852, all strong; and in No. 6, 3.17, 2.344 and 1.852 as weak, medium and very weak, respectively, signifying the decreasing boehmite content (30–40%). It may be found from the ASTM powder diffraction files[8] that all these reflection lines are completely absent in both diaspore and gibbsite. The strong lines of diaspore 3.98, 2.56, 2.31 and 2.07 are all absent in both Nos. 6 and 21. Similarly, the strong lines of gibbsite 4.85, 2.46 and 2.38 are also not traceable in the patterns of

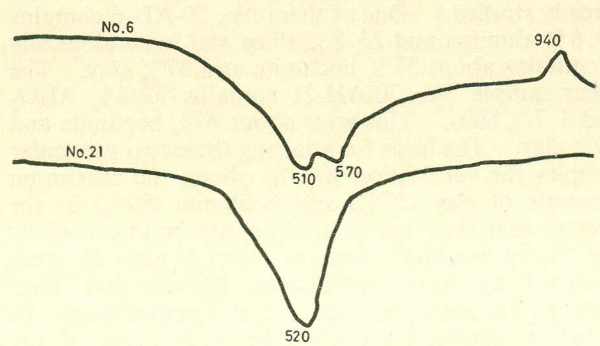


Fig. 5

Nos. 6 and 21. It is thus fair enough to conclude that bauxitic ores Nos. 6 and 21 both contian mineral boehmite and not diaspore as reported.[4]

In order to strengthen the above X-ray findings, the DTA results obtained in Fig. 5 are briefly discussed below. The prominent endothermic peak for dickite is in the range of 650-700°C[7] whereas in case of kaolinite it is around 600°C. The peak temperature of 570°C

TABLE 1. X-RAY DIFFRACTION DATA.

Sample No. 6		Sample No. 21		Boehmite		Kaolin		Dickite		Diaspore		Cibbsite	
d values	Intensity	*d* values	Intensity	*d* values	Intensity	*d* values	Intensity	*d* values	Intensity	*d* values	Intensity	*d* values	Intensity
7·20	M	7·25	VW	—	—	7·25	S	7·25	VVS	—	—	—	—
6·15	M	6·15	S	6·12	VS	—	—	—	—	—	—	—	—
4·48	W	—	—	—	—	4·48	M	4·44	M	4·7	VW	4·85	VS
4·21	W	—	—	—	—	4·23	M	4·17	M	—	—	4·37	S
—	—	—	—	—	—	—	—	3·8	W	3·98	VS	—	—
3·59	M	3·56	W	—	—	3·59	S	3·6	VVS	—	VS	—	—
—	—	—	—	—	—	—	—	3·45	W	—	—	3·32	W
3·17	W	3·17	S	3·16	S	—	—	—	—	3·21	VW	3·19	VW
2·57	W	—	—	—	—	2·57	M	—	—	2·56	S	—	—
—	—	—	—	—	—	—	—	2·53	M	—	—	—	—
2·501	W	2·501	W	—	—	2·501	M	—	—	—	—	2·46	S
—	—	—	—	—	—	—	—	2·398	S	—	—	—	—
2·344	M	2·35	S	2·355	S	2·344	M	—	—	—	—	—	—
				2·341	S								
—	—	—	—	—	—	—	—	2·327	M	2·355	VW	2·38	S
2·298	VW	—	—	—	—	2·298	W	—	—	2·31	S	—	—
1·989	VW	1·989	W	1·977	W	1·993	W	—	—	2·13	M	2·29	VW
										2·07	M	2·045	M
—	—	—	—	—	—	—	—	1·924	VW	—	—	1·993	W
1·895	VW	1·895	VW	—	—	1·895	VW	—	—	—	—	1·917	W
—	—	1·866	S	1·859	S	—	—	—	—	—	—	—	—
1·852	VW	1·852	S	1·845	S	—	—	—	—	—	—	—	—
—	—	1·774	W	1·766	W	—	—	1·801	M	1·73	M	1·8	M
1·669	VW	1·666	M	1·660	M	1·669	W	1·6560	W	1·635	S	1·75	M
												1·685	M

VS very strong, S strong, M medium, W weak and VW very weak

of No. 6 confirms that the ore contains kaolinite and not dickite. The clay peak has slightly been depressed mainly due to the presence of 37% of boehmite in the ore. The boehmite peak has been indicated by 510°C endothermic peak. The exothermic peak at 940°C seen in No. 6 is indicative of the presence of both kaolinite and dickite. This peak in No. 21 is absent because of the small amount of clay (10%) present. The endothermic peaks of the two mineral constituents, i.e. boehmite and diaspore, overlap with no clear differentiation. Diaspore peaks have been observed by independent observers[10] in the range of 510–590°C; for boehmite the range observed is 510–600°C. Sample No. 21 shows an endothermic peak at 520°C which indicates the presence of either boehmite or diaspore or a mixture of the two. As a rule, it is always advisable not to bank on the DTA results as far as the identification of boehmite and diaspore is concerned.

The dickite clay mineral is relatively rare and the usual clay mineral associated with deposits of the oxides or hydroxides of aluminium has been reported[11] as kaolinite.

Conclusions

The author on the basis of his careful X-ray studies partially supported by DTA has come to the following firm conclusions: (1) Khushab bauxites contain mineral boehmite as the main constituent of the ore and that diaspore or gibbsite are not present in the ore. (2) Apart from boehmite, which is the main constituent of the ore, the bauxites contain mineral kaolinite in appreciable quantities and not dickite. (3) Dickite is a less common mineral than kaolinite and is seldom found in large deposits.

Acknowledgement. The author wish to thank Dr. Okuda of the Technical University, Japan for providing the X-ray patterns and Mr. Saadi for carrying out the DTA.

References

1. F.A. Faruqi, M.W. Qureshi and M. Ashraf, Punjab University Geol. Bull. No. 9, 1970.
2. F.A. Faruqi, Pakistan J. Sci. Ind. Res., **13**, 185 (1970).
3. F.A. Faruqi, N.A. Chohan and M. Ashraf, J. Econ. Geol., **67** (1), 103 (1972).
4. M. Safdar, two unpublished reports(1970) submitted to Mineral Development Board, Panjab.
5. S.N. Khan and A. Husain, Geological Survey of Pakistan Information Bulletin No. 37, November 1970.
6. S.N. Khan, Geological Survey of Pakistan Information Bulletin No. 39, July 1971.
7. R.C. Mackenzie, *The Differential Thermal Investigations of Clays* (Min. Soc., London, 1957).
8. H.E. Swanson, R.K. Fuyat and G.M. Ugrinic, Nat. Bur. St. (U.S.) Cir. No. 539, **3**, 38(1954).
9. ASTM Bull., Powder Diffraction Files (1963) Philadelphia, U.S.A.
10. R.C. Mackenzie, D.T.A. Data Index Card (1962), London.
11. R.E. Grim, *Clay Mineralogy* (McGraw Hill, New York, 1968), second editiion, p. 570.