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Isomorphous substitution of aluminium in goethite in bauxite of Salem, Tamil Nadu—a preliminary study

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Abstract

X-ray diffraction and electron microprobe investigations on selected samples from bauxite of Salem district, Tamil Nadu, point out to the existence of solid solution of Fe and Al in goethite. The maximum Al substitution observed in goethite lattice was 33±2 mol%. The genesis of these alumino-goethites probably occurred in Al and KOH-rich milieu.

The paper embodies the preliminary investigations on the isomorphous substitution of aluminium in goethite. In iron minerals, Al generally replaces Fe and these form solid solutions [$(Fe_xAl_{(1-x)})O(OH)$] in goethite. Innumerable examples may be cited here in support of this natural phenomenon. Norrish and *Taylor (1961) reported 30 mol % Al substitution in soil goethite. Al substitution* to an extent of 9-17 mol % in pisolites of some Hungarian bauxites was noted by Bardossy (1968). Solymar (1969) carried out detailed studies on different Hungarian bauxites and concluded that Al substitutes for Fe in goethite in the range 4.8-24.4 mol %. Al substitution was observed by Mendelovici *et al* (1979) in Venezuelan laterites.

It is difficult to distinguish Al incorporated in the goethite lattice from that present in other minerals of bauxite. The chemical analysis gives total Al_2O_3 in bauxite irrespective of the mode of occurrence of Al in the crystal structure. Proper understanding of the exact mode of occurrence of Al in the constituent minerals of bauxite is essential in the smooth execution and planning of extractive procedures to be followed in alumina plants.

The results support the well-known Alumino-Goethite hypothesis. But the probability of aluminium entering into hematite lattice also cannot be ruled out. It is found that goethite is an ubiquitous iron mineral in the bauxite deposits of Shevaroy and Kolli Hills. Pure goethite nodules and pellets may even be observed in the bauxite deposits. The mineralogical and geochemical data of bauxite samples are presented in Tables I and II respectively. Hematite is found to be present in trace amounts. Therefore, if a little aluminium is getting incorporated in hematite structure, goethite being a major iron-component may be responsible for more aluminium substitution in its lattice. This non-extractable aluminium goes in red mud as waste product in the alumina plant of MALCO (Madras Aluminium Company Ltd.).

Three samples were selected for detailed investigations by X-ray diffraction and electron microprobe methods. It is practically difficult to detect displacement of the diffracted lines of goethite in presence of other minerals of bauxite and therefore, the goethite content in the samples was enriched by dissolving out the huge

EXPLANATION OF FIGURES

1. Electron picture of a typical region in an aluminous laterite, Kolli Hills. 210 ×.
2. FeKα X-ray distribution image of the area shown in Figure I. 210 ×.
3. AlKα X-ray distribution image of the area shown in Figure I. 210 ×.

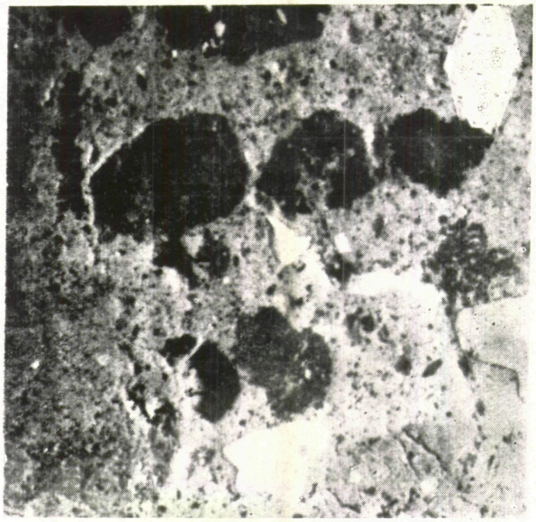

Figure 1

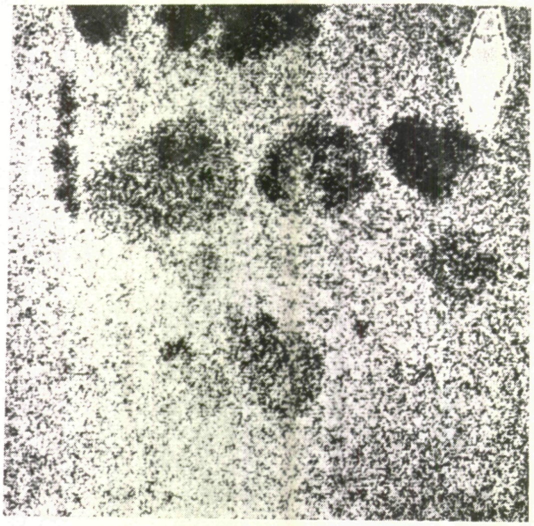

Figure 2.

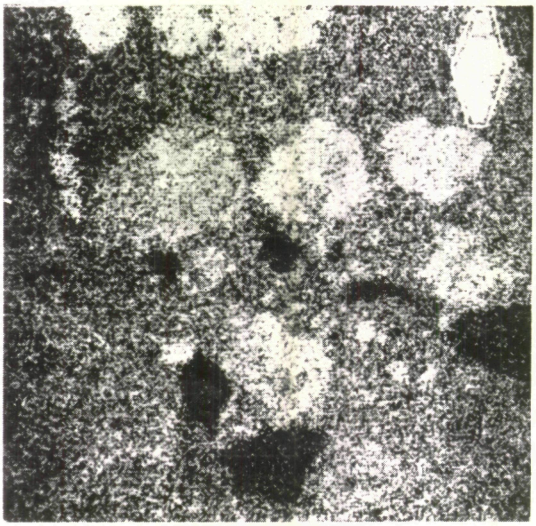

Figure 3.

TABLE I. Semiquantitative X-ray diffraction data of bauxite samples.

Sample No.	Rock Type	Constituents Detected					
		Major	Minor	Good amount	Considerable amount	Small amount	Trace amount
1. B2/19b	Bauxite	Gibbsite			Quartz	Goethite	*Kaolinite* Anatase Hematite
2. KHB_{2ob}	Aluminous Laterite	Gibbsite		Goethite, Kaolinite, Illite		Anatase, Hematite	

TABLE II. Microchemical analytical data of bauxite samples.

Sample No.	Elements	Line	Counts
1. B 2/19b	Na	KA	106
	Mg	KA	959
	Al	KA	28165
	Si	KA	116
	Ca	KA	213
	Ti	KA	23
	Fe	KA	203
2. KHB_{2ob}	Na	KA	134
	Mg	KA	604
	Al	KA	20999
	Si	KA	942
	S	KA	69
	Ca	KA	122
	Ti	KA	1544
	Fe	KA	32842

gibbsite content. The prepared samples were measured by a Philips X-ray diffractometer. The quantity of isomorphous substitution of aluminium content was determined by the displacement of all diffracted lines between 2θ (5°-55°) of goethite taking into censideration Thiel's (1963) results. It is found that the AlOOH content in goethite ($\alpha-FeOOH$) is 33 ± 2 mol% in a typical bauxite sample (B2/19b) from Shevaroy Hills and 27 ± 2 mol% in an aluminous laterite (KHB_{2ob}) from Kolli Hills.

From the energy dispersive microanalysis investigations of the polished specimen, KHB_{2ob}, *mainly iron-containing grains can be found beside gibbsite crystals.* In these iron-containing grains, there is a little quantity of aluminium too. Most probably, these grains are of alumino-goethite. From the microprobe investigations, it can be concluded that there are large areas with 50-100μm length and 20-55μm width where aluminium and iron can be found together (Figs. 1-3). Aluminium substitution to an extent of 1.24$\pm$0.54 atomic % is observed in a few geothites from Shevaroy Hills. Minimum aluminium concentration in geothites is recorded as 0.63 mol%. The aluminium content in the selected geothite grains of the polished samples was determined by point counting method. The raw X-ray intensity data were fed into the computer and Magic 4 computer programme was run at I.I.T., Madras to get accurate quantitative data by applying CORFAC (Correction factors-backscatter, ionisation penetration, absorption and fluorescence).

The occurrence of alumino-goethite in these bauxite samples throws light on the environment of formation of such goethite in the course of bauxitization and lateritization of the source rocks charnockites and leptynites. These goethites originated probably from solution enriched in KOH and Al at pH values found in soils. The influence of Al, OH, and temperature on the formation of iron oxides is given by Lewis and Schwertmann (1979). The crystallization of such goethite was relatively slow as Al retards the otherwise rapid nucleation of goethite. Studies in this line by electron microprobe, X-ray diffraction and infrared spectrophotometric techniques are in progress.

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