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Geochemistry of bauxites of Belgaum (Karnataka) and Yercaud (Tamil Nadu) areas

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Abstract. The major chemical components of bauxite deposits of Belgaum (76° 24′E : 15° 54′N) and Yercaud (78° 14′E : 11° 48′N) areas have been determined. A chemical continuity between parent rocks (zone I) to bauxites (zone IV) via clay (zone II) and laterites (zone III) clearly indicates that bauxites have been derived by *in situ* weathering of the respective parent rocks.

Keywords. Parent rocks; bauxites; *in situ* weathering.

1. Introduction

It is generally an accepted fact that the chemical composition of laterites, bauxites and associated clays is governed by various factors, viz, the amount of specific elements in the source rocks, the chemical association of specific elements with stable and unstable minerals during weathering, the intensity of drainage during weathering, and the relative enrichment of trace and minor elements in laterites and bauxites with respect to the crust (Valeton 1972).

The bauxites of Belgaum (76° 24′E : 15° 54′N), derived from basalts, and that of Yercaud (78° 14′E : 11° 48′N), derived from charnockites, were subjected to detailed geochemical analyses to determine the variations between them. Samples of bauxites, laterites, clays and source rocks have been collected in the vertical profiles of both the areas and analysed. The results are given in tables 1 and 2.

2. Geology of bauxite deposits

Sahasrabudhe (1978) gave an account of the geological distribution and reserves of bauxite deposits of the Belgaum region in detail. Later Balasubramaniam and Mora (1984) described the utilisation of bauxites from the Belgaum region. The bauxite deposits of Belgaum are located at comparatively low altitude, about 1025 mts from MSL, in the form of small discontinuous patches, irregular lenticular masses and covering the top of the small hillocks formed by basaltic rocks. Bauxite is massive, tough, compact and commonly exhibits oolitic to pisolitic texture. The presence of stalactitic structures of gibbsitic composition varying in length from 0·5 cms to 15 cms is noticed in some cavities near Hangarge about 8 kms due SW of Belgaum.

Subramanian (1975) described the bauxite deposits of Tamil Nadu in detail. Bauxites

Table 1. Chemical analyses of bauxites, laterites, clays and basalts from DBS Hangarge bauxite mine, Belgaum area.

Sample no.	Depth (mts)	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	Loss on ignition	FeO	CaO	MgO	NaO_2	K_2O	P_2O_5
B-1	0·3	3·88	51·08	12·00	3·36	27·40	0·37	0·50	—	0·10	0·08	0·109
B-2	2·0	2·12	56·48	8·57	6·25	24·92	0·50	0·23	—	0·30	0·05	0·119
B-3	3·3	2·29	48·34	20·00	4·17	23·36	0·12	0·43	0·2	0·10	0·31	0·015
B-4	5·0	2·16	52·83	10·75	3·08	29·56	0·37	0·62	0·81	0·08	Tra	0·064
B-5	6·6	1·50	56·10	8·00	3·34	29·24	0·50	0·41	—	0·18	0·20	0·013
B-6	10·0	2·82	45·70	25·71	4·79	18·56	0·37	0·51	—	0·24	0·31	0·080
B-8	12·0	3·12	44·71	21·14	6·25	21·78	0·24	0·50	0·21	0·10	0·42	0·061
B-9	13·3	2·20	57·50	3·71	3·47	31·72	0·24	0·30	0·20	0·10	0·05	0·001
B-10	16·6	4·68	52·86	4·71	4·18	30·12	0·24	1·24	0·51	0·18	0·11	0·039
B-11	18·3	3·24	54·73	4·71	4·47	30·86	0·24	0·51	—	0·10	0·25	0·001
B-12	20·0	1·21	60·10	2·85	5·12	29·72	0·12	0·23	—	0·20	0·10	0·027
B-13	22·0	3·20	56·32	6·48	3·79	28·52	0·37	0·31	—	0·21	0·18	0·033
B-14	23·0	2·52	55·00	5·20	5·56	27·64	0·24	1·34	0·58	0·10	0·21	0·052
B-27/1	23·6	37·00	39·26	8·57	2·78	12·76	0·12	—	—	0·02	Tra	0·040
B-27/2	25·0	42·42	32·96	5·71	2·05	15·60	0·12	—	—	0·03	0·05	0·046
B-27/3	26·3	42·40	27·55	9·37	2·05	15·48	0·12	0·62	—	0·03	0·21	0·047
B-52	27+	49·42	16·98	6·47	1·27	1·06	7·54	7·68	7·54	1·31	0·58	0·054

Sample nos. 1–14 laterites and bauxites; sample nos. 27/1, 27/2 and 27/3 clays; sample no. 52 average of six basalts.

Table 2. Chemical analyses of bauxites, laterites, clays and charnockites from hill no. 1 of Yercaud bauxite mine, Yercaud.

Sample no.	Depth (mts)	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	Loss on ignition	FeO	CaO	MgO	Na_2O	K_2O	P_2O_5
S-1	0·3	3·00	50·58	18·85	1·39	23·72	0·37	0·13	0·01	0·04	0·02	0·05
S-2	2·0	4·98	50·43	12·57	1·39	27·38	0·25	0·14	0·01	0·09	0·04	0·033
S-3	3·3	5·02	55·72	2·58	1·21	32·88	0·12	0·11	0·20	0·02	0·02	0·027
S-4	5·0	2·54	47·29	20·57	1·15	25·72	0·75	0·15	—	0·30	Tra	0·270
S-5	6·0	3·66	51·18	11·42	1·25	28·68	1·00	0·14	0·02	0·10	0·02	0·047
S-6	8·3	3·40	52·09	8·57	1·21	31·12	0·37	0·40	0·02	0·20	0·05	0·001
S-8	10·0	3·30	40·45	25·71	1·20	25·76	0·50	0·20	0·01	0·50	0·04	0·051
S-10	12·0	6·10	49·97	12·00	1·15	26·68	1·00	0·15	0·02	0·10	Tra	0·705
S-12	12·6	4·12	42·43	26·28	1·10	22·44	0·50	0·42	0·03	0·50	Tra	0·132
S-14	13·3	6·94	49·43	10·57	1·29	26·84	2·00	0·12	—	0·20	Tra	0·132
S-14/1	15·0	42·98	33·11	2·28	1·01	18·00	0·12	—	—	0·05	0·04	0·038
S-14/2	18+	60·58	17·84	4·64	0·80	1·04	3·64	6·47	3·37	1·14	0·10	0·024

Sample nos. 1–14 laterites and bauxites; sample no. 14/1 average of two clays; sample no. 14/2 average of six charnockites.

of the Yercaud area are confined to the particular geomorphic horizons between 1679 mts and 1803 mts of the mighty hill ranges formed by the charnockite suite of rocks. They occupy the peaks of the hillocks which have characteristic flat topped surfaces. Generally, bauxite occurs as small lenses, lenticular masses and patches of bauxites and aluminous laterites occur in laterite with gradational borders. The colour of the bauxite varies from yellowish brown to reddish brown and it is of the lateritic type.

3. Analytical method

For chemical analyses samples have been crushed to −230 mesh. From these samples 0·2 gms of powder were taken and digested in teflon bombs. Alumina, titania, iron, calcium and magnesium were determined by using AAS (Verion 575 Techron Pvt, Australia). Sodium and potassium were determined by a flame photometer (Systronics) and phosphorus by a UV spectrophotometer (Verion 634 Techron Pvt, Australia). For digestion of rocks, 5 ml of 40 % HF, and for clays, laterites and bauxites 5 ml of HF and 1 ml of H_2SO_4 were used and heated at 150°C for one hour. After digesting, 50 ml of saturated boric acid were added and made up to 100 ml by adding distilled water. International rock standard and bauxite (BX-N) were used for reference. The analytical error was 1–8 %.

4. Results

Tables 1 and 2 clearly indicate that bauxites of the Belgaum area contain high proportions of alumina (44·71–60·10 %) and titania (3·36–6·25 %), low amounts of silica (1·21–4·68 %) and iron (2·85–25·71 %), and comparatively low phosphorus (0·001–0·119 %). Those of the Yercaud area contain comparatively low quantities of alumina (40·45–55·72 %) and titania (1·01–1·39 %), and high quantities of silica (2·54–6·94 %), iron (2·58–26·28 %) and phosphorus (0·001–0·705 %). There is not much variation in quantities of FeO, CaO, MgO, Na_2O and K_2O in both the areas. A positive correlation is noticed between Al_2O_3–TiO_2 and Al_2O_3–loss on ignition and negative correlation between Al_2O_3–SiO_2 and Al_2O_3–Fe_2O_3. Further Al_2O_3, TiO_2 and Fe_2O_3 decrease and SiO_2 increases with depth in both the areas.

4.1 *SiO_2–Al_2O_3–Fe_2O_3 system and the weathering line*

The average chemical composition of the parent rocks of the Belgaum (basalts) and the Yercaud (Charnockites) areas together with mean values in the weathering layers in laterite profiles are plotted in the triangular diagram of SiO_2–Al_2O_3–Fe_2O_3 (figure 1). Weathering lines in both the areas indicate a process of desilicification, followed by deferrification and a gradual increase in alumina. The trends of weathering lines for both Belgaum and Yercaud profiles closely correspond with those obtained for the laterite profiles derived from the basaltic rocks of Montenia, Madagascar (Schellmann 1977).

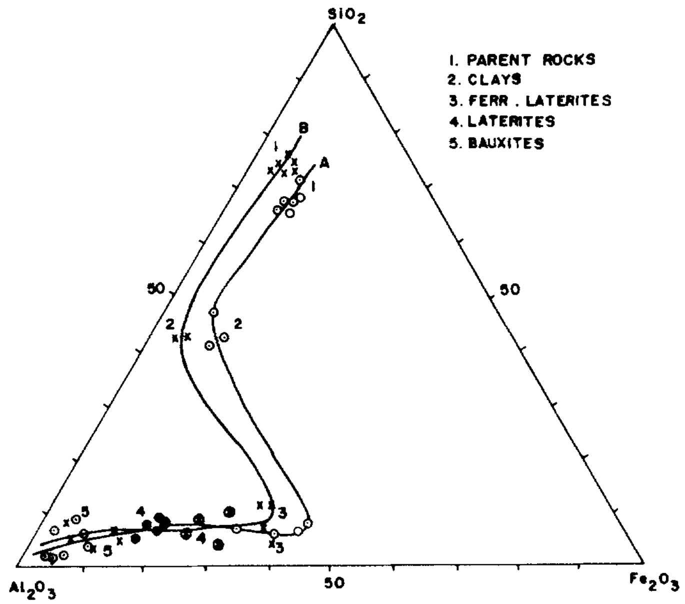

Figure 1. Triangular diagram between SiO_2, Al_2O_3 and Fe_2O_3 for bauxitic profiles of Belgaum (A) and Yercaud (B) areas.

Table 3. Ratio of major chemical constituents in parent rock and their lateritized products of Belgaum area

Substance	Fe_2O_3/Al_2O_3	SiO_2/Al_2O_3	SiO_2/Fe_2O_3	TiO_2/Al_2O_3	TiO_2/Fe_2O_3
Basalts	0·381	2·91	7·63	0·070	0·109
Clays	0·23	1·202	5·20	0·071	0·29
Laterites	0·19	0·055	0·25	0·084	0·42
Bauxites	0·057	0·038	0·66	0·108	1·90

4.2 *Major element ratio in profile section*

The bulk chemical ratios of major elements for different parts of the laterite profiles of Belgaum and Yercaud areas are given in tables 3 and 4 respectively. From these two tables the following observations are made.

Belgaum area. (i) The ratio of Fe_2O_3/Al_2O_3 decreases from basalts (0·381) to clays (0·238) to laterites (0·19) and to bauxites (0·057).

(ii) The ratio of SiO_2/Al_2O_3 decreases from basalts (2·91) to clays (1·201) to laterites (0·055) and to bauxites (0·038).

(iii) The ratio of SiO_2/Fe_2O_3 decreases from basalts (7·63) to clays (5·20) to laterites (0·25) and increases in bauxites (0·66).

(iv) The ratio of TiO_2/Al_2O_3 increases from basalts (0·070) to clays (0·0701) to laterites (0·084) and to bauxites (0·180).

Table 4. Ratio of major chemical constituents in parent rock and their lateritized products of Yercaud area

Substance	$\frac{Fe_2O_3}{Al_2O_3}$	$\frac{SiO_2}{Al_2O_3}$	$\frac{SiO_2}{Fe_2O_3}$	$\frac{TiO_2}{Al_2O_3}$	$\frac{TiO_2}{Fe_2O_3}$
Charnockites	0·26	3·46	13·06	0·05	0·17
Clays	0·07	1·28	18·63	0·44	0·031
Laterites	1·63	0·49	0·31	0·04	0·03
Bauxites	0·31	0·09	0·30	0·03	0·07

(v) The ratio of TiO_2/Fe_2O_3 increases from basalts (0·109) to clays (0·29) to laterites (0·42) and to bauxites (1·90).

Yercaud area: (i) The ratio of Fe_2O_3/Al_2O_3 does not show any linear variations.

(ii) The ratio of SiO_2/Al_2O_3 decreases from charnockites (3·46) to clays (1·28) to laterites (0·49) and to bauxites (0·09).

(iii) The ratio of SiO_2/Fe_2O_3 increases from charnockites (13·06) to clays (18·63) and decreases rapidly to laterites (0·31) and to bauxites (0·30).

(iv) The ratio of TiO_2/Al_2O_3 decreases from charnockites (0·05) to laterites (0·04) to bauxites (0·03) and increases in clays (0·44).

(v) The ratio of TiO_2/Fe_2O_3 decreases from charnockites (0·17) to clays (0·031) to laterites (0·030) and increases only in bauxites (0·07).

5. Conclusions

Bauxite deposits of the Belgaum area are characterised by high alumina, titania and low iron, silica and phosphorus contents whereas the Yercaud area bauxites contain comparatively low alumina, titania and high iron, silica and phosphorus. The triangular diagram of SiO_2–Al_2O_3–Fe_2O_3 indicates the process of desilicification, followed by deferrification, the alumina increasing gradually in both the areas, which resembles the laterite profile derived from the basaltic rocks of Mantenia, Madagascar (Schellmann 1977). The continuity between source rocks and bauxites via clays and laterites and the ratios of Fe_2O_3/Al_2O_3, SiO_2/Al_2O_3 and SiO_2/Fe_2O_3 decrease and those of TiO_2/Al_2O_3 and TiO_2/Fe_2O_3 increase from source rocks to clays to laterites to bauxites which clearly indicates that bauxites have been derived by *in situ* weathering of the respective parent rocks of both the areas.

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