

CHEMICAL AND MINERALOGICAL CHARACTERISTICS OF LATERITIC IRON ORE DEPOSIT AT IYUKU, ETSAKO WEST LOCAL GOVERNMENT AREA OF EDO STATE, NIGERIA

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ABSTRACT

The lateritic iron ore deposit at Iyuku in Etsako West Local Government Area in Edo State, Nigeria was assayed chemically and mineralogically. The results of the chemical assay obtained are Fe₂O₃ (48.20 – 55.63%), Al₂O₃ (12.50 – 18.00%), SiO₂ (9.48 – 30.71%) CaO (0.36 – 0.41%), MgO (2.51 – 2.60%) moisture (1.21 – 1.77%) and L.O.I (4.08 – 8.35%). The mineralogical analysis indicates the predominant presence of goethite, haematite and halloysite, whereas, gibbsite and anatase were present as minor species.

KEY WORDS: laterites, goethite, haematite, halloysite, gibbsite and anatase.

INTRODUCTION

Laterite is the residual weathering products of rocks which contain oxides and hydroxides of iron and aluminium, Ludman et al (1982). The occurrence of laterites in soils of tropics and subtropics where there is high rainfall, intense leaching and oxidizing warm environment is well established Allen (1995). The formation of laterites arising from the oxidation and intense hydrolysis and leaching of minerals from feldspars and the ferromagnesium minerals is well known, Levin (1981). The wide variation in the colour of laterites due to the differences in the content of the iron minerals have been reported Onyeobi et al (1994). The occurrence of large deposits of laterites in Nigeria has been reported (Emofurieta et al (1995). The occurrence of important iron and aluminium minerals such as haematite (Fe₂O₃) and gibbsite (Al₂O₃.3H₂O) as constituents of laterites have been variously reported, Iwu (1973) and Meketta et al (1977). The current study of the laterite deposit at Iyuku, in Edo State, Nigeria, therefore, is to assess the chemical and mineralogical composition.

MATERIALS AND METHODS

2.3 SAMPLING

The samples were collected on profile basis in each site. The profiles were determined by colour variation, fault lines of cleavage and depth as described by Onyeobi *et al* (1994). A minimum of fifteen (15) samples were collected per depth. The samples in each profile were obtained by the use of geological hammer and spade and were packaged in polythene bags and transported to the laboratory.

2.4 SAMPLE TREATMENT The samples were air-dried in the laboratory.

2.5 SAMPLE PREPARATION

The samples collected were kept in the laboratory

and allowed to be air-dried. The samples were crushed by use of geological hammer and a laboratory sized jaw crusher. Grinding was carried out by use of two-roll mill and final grinding was carried out using laboratory mortar and pestle. The finely ground samples were stored in labelled containers.

i) Moisture Content

The samples (5g) were weighed in an analytical balance, in 100ml beakers heated at between 105-110°C in a Merment thermostated oven until constant weight were attained. The samples were kept in desiccators, cooled, and weighed again to obtain the weight loss which was calculated as percentage of moisture content. A minimum of three replicate determinations were carried out for each sample.

ii. Loss on Ignition (L.O.I)

This represents the total amount of volatile materials present in the samples. In order to determine the loss on ignition, the samples (5g) were weighed in an analytical balance in porcelain crucible, heated at between 400°C for four hours until constant weight were obtained. The samples were thereafter, cooled in the dessicator, weighed and the loss in weight was calculated as percentage of volatile matter present. A minimum of three replicate determinations were carried out for each sample.

iii. Atomic Absorption Spectrophotometer Determination

Chemical Assay

This involved the determination of the chemical make-up of the sample using Atomic Absorption Spectrophotometer. (Bulk Scientific 200A) as described by (Young R.S., 1977).

The determinations were carried out on dry samples which were obtained by taking some quantity of the test sample, heated at 105-110°C for one hour to remove moisture, cooled in a dessicator and thereafter kept in a sealed container. The test sample (1.0g) was weighed into a beaker, sufficient quantity of Aqua-regia ((3:1) HCl:

HNO₃ was added into the beaker and the mixture was heated to near dryness. 50% H₂SO₄ (10ml) was added and heated until the fumes of SO₂ were observed. De-ionised water was added and the solution stirred, and filtered. The filtrate (A) was kept. The solid residue (r₁) was fused with Na at 1200°C in a muffle furnace. Thereafter, HCl (1.5M) was added, warmed and the filtrate (B) was added to the initial filtrate (A). The residue (r₂) was kept for silica determination.

The combined filtrate (A + B) was heated to boiling, solid NH₄Cl was added, two drops of methyl red indicator was added and conc. aqueous ammonia solution was added dropwise until all the ammonium hydroxide elements was precipitated (P₁) and filtered. The filtrate (C) from the above was kept for alkaline-earth metal determination.

The precipitate (P₁) from the above was dissolved in HCl (1.5M), warmed and reprecipitated (P₂) to remove any occluded alkaline earth metal. The filtrate (D) was added to the previous filtrate (C). The filtrate (D + C) was transferred into a 250ml volumetric flask, and de-ionised water was added to make up to the mark. Aliquot of this was taken for Ca, Mg, Ni, Mn and Cr..... determinations.

The precipitate from above (P₂) was dissolved in warm HCl (1.5N), filtered and transferred to a 25Gm volumetric flask and de-ionised water was added to make up to the mark (Solution X). Aliquot of solution X was taken for the determination of Fe, Al, Ti, P.V. Replicate preparations were made.

For the Atomic Absorption Spectrophotometer determination of aluminum and titanium, nitrous oxide - air flame was used whereas the air-acetylene flame was used for the determination of the other elements. The amount of each element present was expressed as percentage of the oxide of the metal.

SILICA DETERMINATION

The total silica was determined using the standard method (ASTM, 1965). The residue from the acid digestion of the samples, was taken into a platinum crucible, ministered with concentrated sulphuric acid and evaporated to dryness. This was taken into a muffle furnace, heated at temperature of 1200°C for 20 minutes, cooled in a dessicator and weighed. Thereafter 2 drops of H₂SO₄ (1:1) was added followed by addition of hydrofluoric acid (10ml), and the content was evaporated to dryness on a hot plate. This was taken back to the muffle furnace and ignited at 1200°C for 20 minutes, cooled and reweighed. The difference in weight represents the total silica present. Replicate determinations were carried out.

MINERALOGICAL ANALYSIS

The samples were pulverized to fine particles (≤ 2µm) and were subjected to X-ray diffraction using Phillips X-ray Diffractometer PW 1800 with Cu, K_α radiation source. The generator operating conditions were 40KV and 5SmA. The Diffractograms obtained were compared with the standard X-ray powder diffraction file published by the Joint Committee on the Power Diffraction Standards (JCPDS) for the identification of the different mineral species.

RESULTS AND DISCUSSIONS

TABLE 1: RESULT OF THE CHEMICAL ASSAY OF LATERITE IN IYUKU

DEPTH (M)	IYUKU 1 0-1.0	IYUKU 2 1.0-2.5	IYUKU 3 2.5-3.2	MEAN	STANDARD DEVIATION
Moisture (%)	1.77	2.13	1.21	1.70	0.46
L.O.I (%)	8.35	8.04	4.08	6.82	2.38
Fe ₂ O ₃ (%)	59.00	59.70	48.20	55.63	6.45
Al ₂ O ₃ (%)	18.00	15.25	12.50	15.25	2.75
CaO (%)	0.38	0.41	0.36	0.38	0.03
MgO (%)	2.60	2.51	2.60	2.57	0.05
Cr ₂ O ₃ (%)	0.02	0.01	0.03	0.02	0.01
V ₂ O ₅ (%)	0.01	0.01	N.D	0.01	0.00
MnO ₂ (%)	0.16	0.10	0.06	0.11	0.05
Ni ₂ O (%)	0.02	0.01	0.05	0.03	0.02
P ₂ O ₅ (%)	0.01	N.D	N.D	0.01	0.00

SiO ₂ (%)	9.48	11.66	30.71	17.28	11.68
TiO ₂ (%)	0.02	0.02	0.01	0.02	0.01
$\frac{SiO_2}{Al_2O_3 + Fe_2O_3}$	0.29	0.37	1.21	0.62	

N.D = Not Detected

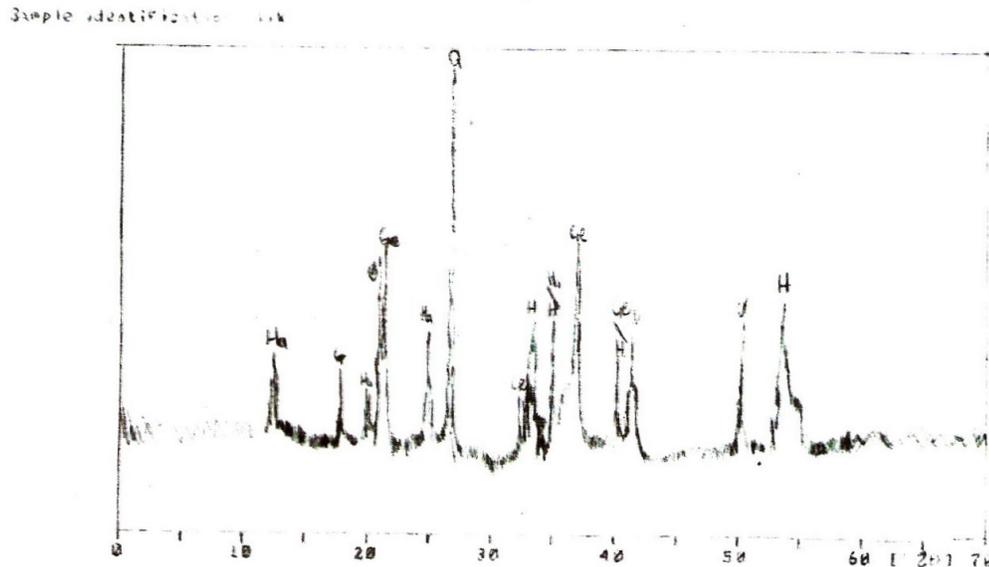


Fig 1: X-Ray Diffractogram of Laterite in Iyuku

Ha = Halloysite, Ge = Goethite, H = Haematite, Q = Quartz,
G = Gibbsite

The results of the chemical assay of the Iyuku lateritic iron deposit is as presented in table 1. The results obtained were as follows: moisture content (1.01 – 1.70%), loss on ignition (L. O. I.), (4.08 – 8.35%) Iron (iii) oxide (48.2 – 59.00%) aluminum oxide (12.5 – 18.00%) silica (9.48 – 30.71%), magnesium oxide (2.51 – 2.60%) calcium oxide (0.36-0.41%). The oxides of chromium, vanadium, manganese, nickel, titanium and phosphorus were present in trace quantities. The mineralogical studies (fig. 1) revealed the presence of goethite and haematite as the main minerals of iron, gibbsite (Al₂O₃.3H₂O) as the aluminum mineral, halloysite as the clay mineral present, α-quartz (SiO₂) and anatase (TiO₂) were equally detected. The results obtained for the moisture content did not show any predictable pattern. However, there was a progressive decrease in the values of the loss of ignition. (L. O. I.) with depth. This can be attributed to the decrease in the carbonaceous materials with increase in depth as the loss on ignition largely represents the volatile matter constituent of organic origin. It was observed that at certain levels, whereas the values of iron oxide decreased with increasing depth, the value of aluminum progressively decreased with increase in depth, but the values of silica progressively increased with depth. This could be attributed to the fact that while the iron minerals

decreased in values the clay mineral content of the deposit increased with depth. The higher value of magnesium oxide compared to calcium oxide must be due to the higher solubility of the latter in solution. The occurrence of goethite and haematite as major products of weathering accompanied by kaolinite and low gibbsite and anatase in Nigeria has been reported by Zeese et al (1994). They observed that the presence or absence of other mineral types usually associated with weathering indicates the differences in the parent rock types or weathering environment. The aluminum mineral, gibbsite though identified, appears to be a minor specie. The aluminum oxide present was predominantly of the clay (halloysite) constituent as the ratio of the percentage of silica and aluminum oxide approximates 1:1 which is common with clay of kaolinite type (Jorge et al 2003). The presence of haematite as part of the iron mineral is consistent with the observed mineralogical pattern already predicted by Schellman (1994). Both goethite and haematite are weathering products of the same rock. This view is further supported by the presence of anatase, a titanium mineral (TiO₂) which accompanies the iron minerals as weathering products of some rock type. The occurrence of both iron minerals as weathering products has long been reported by mudrinic et al (1969) and the

conversion of haematite to goethite by weathering has equally been reported, Bedarida et al (1971). The ∞ -quartz (SiO_2) present in the deposit is likely more as constituent of the clay rather than discrete quartz. The ratio of silica to the combined oxides of iron and aluminum confirms the deposit as lateritic in nature as predicted by Fey et al (1977).

CONCLUSION

The laterite iron ore deposit at Iyuku, contain high quantity of iron oxide, low quantity of aluminum oxide and moderate quantity of the clay mineral. The deposits consist essentially of goethite and haematite as iron minerals, and halloysite as the clay mineral. The aluminum mineral gibbsite and titanium mineral anatase were present as minor species.

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