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FIELD AND COMPOSITIONAL STUDIES OF SEDIMENTARY IRONSTONE DEPOSIT IN UDUBO AREA, NORTHEASTERN, NIGERIA

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ABSTRACT

Field geological studies of the oolitic and pisolitic ironstone in the Udubo area indicate that they belong to the Lower Ironstone series of the Kerri-Kerri Formation. The ironstone is extensive and covers several kilometers of the subsurface of the study area. Petrographic studies indicate that the Fe-bearing minerals in the ironstone are haematite, magnetite and goethite. Quartz is in minor amount. Chemical studies indicate that the ironstone contains high Fe_2O_3 (>71%) and low SiO_2 (<19%) and P_2O_5 (<1.3%). The mineralogy and chemistry of the ironstone indicate that the ore can be beneficiated for use in the iron and steel industry. The presence of sedimentary structures and lamellibranch in the ironstone suggests that the ironstone is a product of alteration of sandstone deposited under shallow fresh water condition.

KEYWORDS: Oolitic ironstone, Upper Benue trough

INTRODUCTION

The study area lies within Longitudes 10°30 to 11°00' E and Latitudes 11°30'N to 12° 00'N on the Udubo sheet 85 and lies on the northwestern end of the Upper Benue trough and the western flank of the Chad Basin (Fig. 1).

The evolution, stratigraphy, biostratrigraphy and palaeogeography of the Upper Benue Trough have been studied (Furon 1963, Benkhelil 1989, Adegoke *et al.* 1986, Dike 1995). The northwestern end of the Upper Benue trough is known to consist of the continental sediments of the Kerri-Kerri Formation which are overlaid by lacustrine sediments of the Chad Formation (Ako and Osondu, 1986; Dike 1990, 1993). The Kerri-Kerri Formation consists of intercalations of clay, sandstone and ironstone (Adegoke *et al.*, 1986 and Dike, 1995). The sediments were deposited unconformably on the Paleozoic basement during the Paleocene (Ako and Osondu, 1986; Dike 1990, 1993). Elsewhere in the Upper Benue trough however the Bima sandstone, deposited during the Cretaceous, unconformably overlies the Paleozoic basement. According to Furon (1963), the Chad Basin is a tectonic depression beneath a NW – SE trending Air-Chad Trough, which later harboured an accumulation of a thick pile of sediments in the Paleocene – Tertiary Period. Ironstone deposit of this study occurs in the Kerri–Kerri Formation.

Phanerozoic oolitic, pisolitic and massive ironstones of sedimentary origin have been reported from Agbaja, Enugu, and Lokoja (Astier *et al.*, 1989). The ironstone of the Udubo area belongs to this group. This paper reports the result of field geological studies and geochemical analysis of the Udubo ironstone and highlights the economic potentials of the ore in the iron and steel industry.

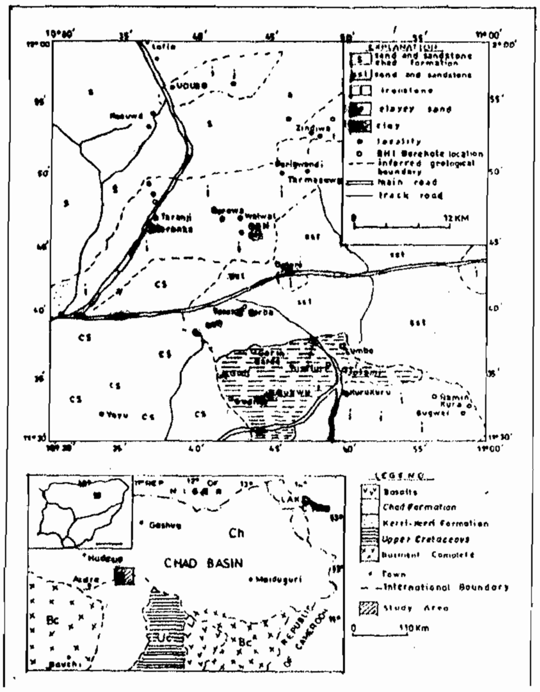

Fig. 1 . Geological map of Udubo area (after Adeoye, 2000).

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METHODOLOGY

Field geological mapping including detailed examination of data from three hand-dug wells and drill cores in the study area were undertaken (Figs. 1 and 2). Selection of representative samples was based on their positions in the stratigraphic column, colour, texture, purity and abundance. Polished sections of representative samples were prepared and studied under the microscope (Figs3 and 4). Whole rock geochemical analysis of selected samples (Table 1) was undertaken with the use of the Atomic Absorption Spectrophotometry (AAS) at the Institute of Agricultural Research, Ahmadu Bello University, Zaria.

FIELD STUDIES

Data from drill cores indicate that five (5) lithostratigraphic units of the Kerri-Kerri Formation exist in the study area. These are pebbly sand (bottom), clay, sandstone and unconsolidated sand (top). Ironstone deposit occurs at two horizons; first, at the contact between clay and sandstone (the Lower Ironstone) and on top of the sandstone (the Upper Ironstone). Examination of wells and drill cores indicates that the ironstone horizons are not continuous. Two bore holes at Bugwei and Taranji reveal that the Lower Ironstone is up to 742m thick. On the other hand, the bore hole at Kuru-Kuru indicates that the Upper Ironstone is only about 10m thick. Field observation indicates that the Lower Ironstone is oolitic consisting of brown well-formed spheroidal or ellipsoidal bodies while the Upper Ironstone is massive and pisolitic (Fig. 3). At Kuru-Kuru, the Upper Ironstone horizon occurs inter-bedded with fine lamina of sand. At Walwal, it is cross-bedded and contains silicified wood and lamellibranchs. Also, the Upper ironstone is gritty and vesicular and commonly contains poorly formed goethite in a yellowish sandy matrix.

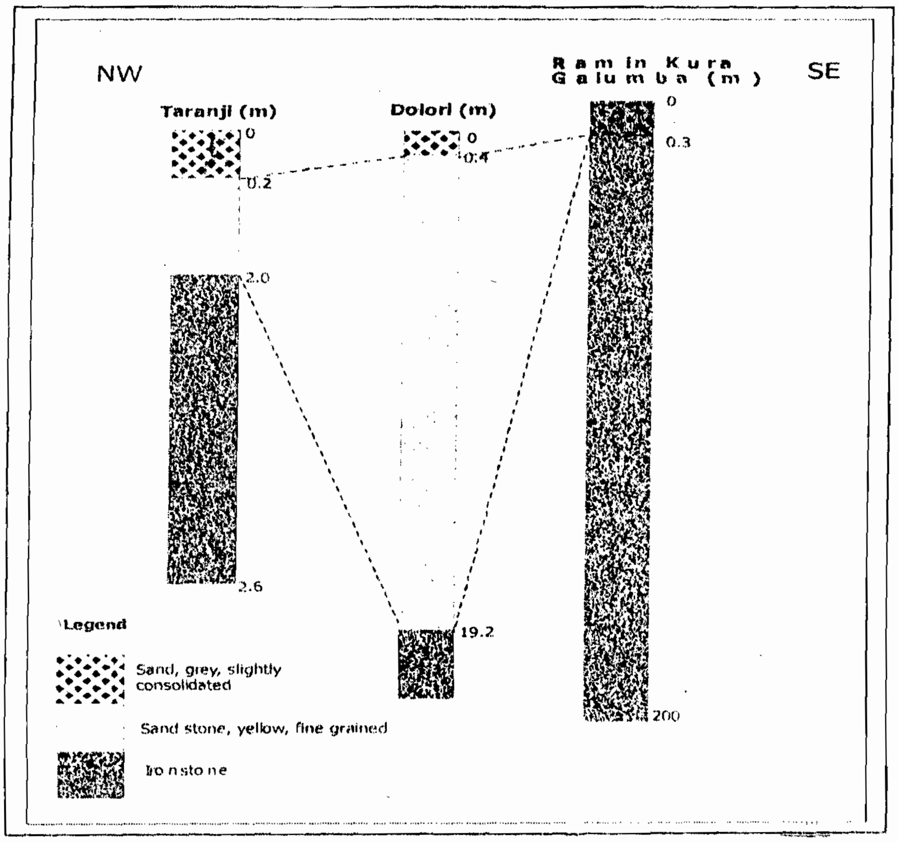

Fig. 2: Composite well sections across localities in Udubo sheet 85

PETROGRAPHY

Microscopic examination of samples indicates that the essential minerals in the ironstone are haematite and goethite. The minor minerals are quartz, magnetite, muscovite, feldspar and montimorillonite. Haematite is present as euhedral grains with yellow colour (Fig.4). Pleochroism and birefringence are weak. Goethite occurs as large subhedral grains surrounded by rounded to sub rounded quartz crystals (Fig.3). Quartz is common in the groundmass as rounded to sub-rounded grains in all samples. Samples from Kuru - Kuru contains more grains of quartz compared to those from other locations.

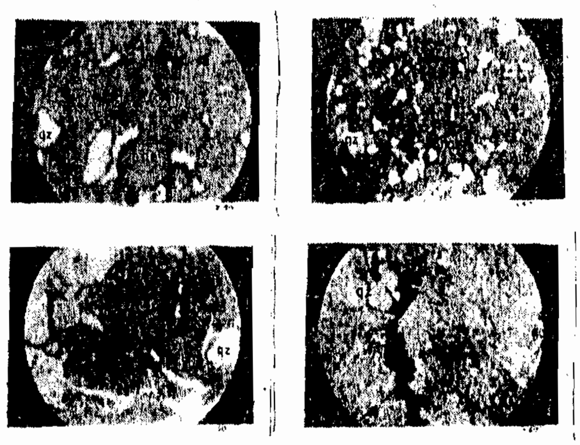

Fig. 3. Photomicrograph of oolite (a & b) and goethite (c &d) from Udubo area showing rounded concretions of haematite (hae). sub-angular quartz (qz), magnetite (mgt) and goethite (goe).

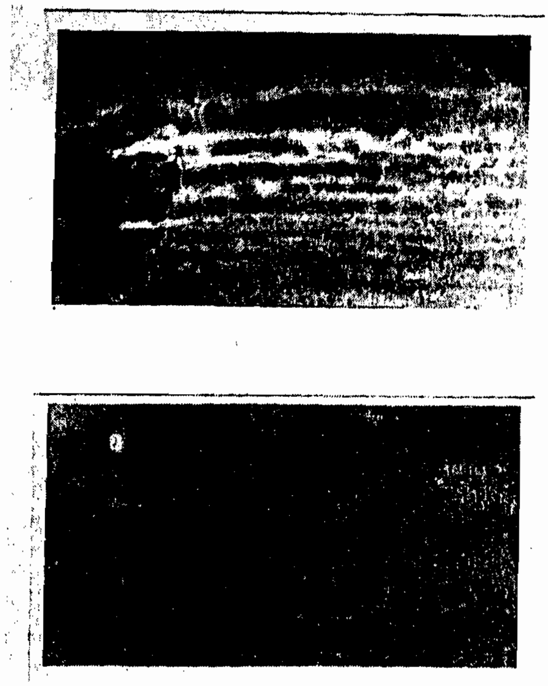

Fig. 4: Photomicrograph (ore microscopy) of the ironstone showing the characteristic yellow colour of haematite. Note the subhedral quartz in the ground mass.

Geochemistry

Chemical analysis indicates that the ironstone contains variable amounts of Fe_2O_3 (71.39 – 76.54%), SiO_2 (13.84 – 18.29%) and Al_2O_3 (4.82 – 5.93%). K_2O, Na_2O, P_2O_5 and MnO are in minor quantities (Table 1). Results indicate that the Bugwei ironstone is the richest in $Fe_2O_{3\,(total)}$ and has lower SiO_2 than the other locations.

Table 1: Chemical Composition of Ironstone in Udubo area

	Location						Reference		
Oxide	*Bugwei	*Zindiwa	*Taranji	*Walwal	*Kuru-Kuru	Udubo	1	2	3
SiO_2	13.84	13.85	15.57	17.13	18.29	15.74	7.14	7.23	40.02
TiO_2	0.01	0.01	0.03	0.05	0.00	0.02	0.53	0.98	0.14
Al_2O_3	5.71	5.72	5.93	5.87	4.82	5.61	10.18	14.34	3.93
Fe_2O_3(t)	76.54	76.27	74.87	73.87	71.39	74.59	71.28	67.68	54.66
CaO	0.06	0.15	0.10	0.04	0.06	0.08	0.33	-	0.59
MgO	0.03	0.07	0.03	0.00	0.25	0.08	0.18	0.52	0.36
K_2O	0.55	0.50	0.70	0.70	1.20	0.73	-	-	0.16
Na_2O	1.22	1.44	1.02	1.50	1.29	1.29	-	-	0.40
MnO	0.80	0.74	0.81	0.30	1.90	0.91	0.05	0.44	0.05
P_2O_5	1.20	1.22	0.81	0.60	0.79	0.92	2.45	1.12	0.30
Total	99.96	99.97	99.97	99.80	99.99	99.97	92.23	92.31	100.61

*Data given are average values of four samples from each location, this study.
Udubo is the average of all Udubo ironstone values. 1 Agbaja pisolitic Ironstone (Jones, 1955). 2 Nsude Ironstones (Ezepue and Mogbo, 1993), 3 Precambrian banded iron formation from Itakpe Hill, Nigeria (Olade, 1978)

Table 1 shows that the average content of Fe_2O_3 in the ironstone in the Udubo area (74.59%, Fe_2O_3) is higher than those of the Nsude and the Agbaja sedimentary ironstone deposits with 67.68% and 71.28% Fe_2O_3, respectively. The Fe_2O_3 content is also higher than the average composition of 54.66% Fe_2O_3 of the Precambrian ironstone deposits from the Itakpe hills. Al_2O_3 and P_2O_5 contents in the Udubo ironstones are however comparable to the values reported from Agbaja (Jones, 1955).

DISCUSSION

Ironstone is ubiquitous and widely distributed in rocks of various geological ages and types. Known deposits, associated with basement and sedimentary rocks, have been exploited for the iron and steel industry, recovery of associated metals base and construction. The basement ironstone, also called the Banded Iron Formation or the Precambrain Ironstones, are associated with magmatic and contact metamorphic processes. Sedimentary ironstones in Nigeria are post Paleozoic and occur as oolites, pisolites and massive bodies. Though the sedimentary ironstones are widespread, mining activities are concentrated in the basement group, which holds the world's largest reserves of ironstone.

In Nigeria, for example, proven reserves of ironstone are at Itakpe, within the basement complex rocks. The Itakpe iron ore deposit is believed to be a product of a combined magmatic and metarmorphic processes (Olade 1980, Ajibade 1988, Woakes 1988). Recently, however, workers have studied the potentials of the sedimentary ironstone deposits for the iron and steel industry because of their high Fe content and ease of mining and beneficiation.

Large deposits of oolitic ironstone have been reported from Lokoja, Agbaja and Bida in the Middle Niger Basin (Jones 1958, Astier *et al.* 1989). Some of these occur mainly as laterite and have been mined for the construction industry. They are distinctively different from ironstone deposits associated with cherts and dolomites at Muro hills deposit (Moutoh *et al.*, 1988) or those associated with ferruginous quartzites at Itakpe hills (Olade, 1980 and Woakes, 1988) or the schist belts of NW Nigeria (Ajibade, 1988). Rather, the field and chemical compositional studies of the ironstone deposit of this study compare closely with the Nsude ironstone deposit, near Enugu, Anambra Basin (Ezepue and Mogbo, 1993) and the Agbaja ironstone deposit, near Lokoja, Middle Niger Basin. This study indicates that the Bugwei, Taranji, Walwal and Kuru-Kuru ironstone deposits in Udubo area contain high $Fe_2O_{3\,(total)}$ (>71%), and low SiO_2, Al_2O_3 P_2O_5 and TiO_2. This concentration indicates that the ironstone deposits in Udubo area meet the specification for use in the iron and steel industry, which are 25 – 35% Fe, <0.3% sulphur, and <0.4% phosphorus (Whitten and Brooks, 1972). The Taranji ironstone is the largest of the deposits in this study. It should therefore be further investigated for possible exploitation for use in the iron and steel industry on a small scale. The occurrence of fine lamina of sand and iron bedding on the ironstone at Kuru-Kuru, Yanda and Dolari indicate deposition under fluviatile condition.

CONCLUSION

Field geological investigations show that the Lower ironstone series of the Kerri – Keri Formation in Udubo area form a huge oolitic sedimentary deposit. Microscopic studies indicate that haematite is the essential mineral while goethite, magnetite and detrital quartz are in minor quantities. The ironstone contain high Fe_2O_3 (>71%) SiO_2 (>19%) but low in Al_2O_3, MnO and TiO_2. It is recommended that the Taranji outcrop be further investigated for exploitation on a small scale since it is the most promising among the deposits of the Udubo area.

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