Trace Elements in Trona Deposits of North East of Nigeria

+**A. I. INEGBENEBOR and *A. O. INEGBENEBOR

*Mechanical Engineering Department, University of Maiduguri, Maiduguri
**Chemistry Department, University of Maiduguri, Maiduguri
Correspondence Author

Abstract

This paper reports the composition of elements in trona samples from localities in North Eastern zone of Nigeria. A total of thirteen samples were analysed for Na, K, Zn, Pb, Al, Mg, Ca, Fe, S, and P. All the samples contained sodium, lead, aluminium, calcium, phosphorus and carbondioxide. The samples contained between 37 – 43% Na_2O, 32 – 37% CO_2 and 15 – 19% H_2O. The grey samples code DTRBO1, DTRBO3, DTRYO1 and DTRYO5 contain high % of calcium and zinc. Yobe sample code DTRYO5 has low amount of sulphate of 0.75%. The trace elements in trona from the deposits are related to the secondary minerals that may be expected in these ore areas.

Keywords: *- Composition of elements, Trona samples, North Eastern Zone.*

Introduction

Trona, $Na_3(CO_3).2H_2O$, otherwise known as potash or kanwa, is a secondary mineral in gozzans of metallic ore deposits as weathering product of primary iron containing mineral (Palache et al, 1951; Rose and Sutir, 1971; Sherman, 1952). It occurs in saltpans and dry lakebeds, ascending ground water may have deposited it. This mineral is dark coloured and occurs as aggregates in desert soils. It may be found with other secondary minerals.

Potash or kanwa as it is known in North East of Nigeria formed mainly as thick bed deposits at Lake Chad and Yobe troughs. Trona deposits have also been reported in many of the interdunal oasis in the Northern part of Yobe State. Detailed description of the deposits listed in Table 1, especially those of Yobe State have been given by Nkeweurem (1994). Trona from these deposits vary widely in their colours, habits and compositions (see Table 1 and 2).

The literature on the proper identity of the Trona of North East of Nigeria is rather scanty. Therefore this paper sets to report the elements of trona in these ore areas. In addition this work attempts to relate other elements such as Zn, Pb, Al, P etc. to the secondary minerals that may be expected in the deposits in the North East zone.

Methodology

Sample Collection

The curatorial information including the places of collection of each sample analysed is given in Table 1. Thirteen samples were analysed. Identity of each of the samples in Table 1. were revealed through oral interview of indigenes (Table 1) of North East and confirmed by Geology department of the University of Maiduguri.

Table 1: Properties of Kanwa From North East of Nigeria

S/NO	SAMPLE CODE	DESCRIPTION
1.	DTRBO1	Trona, Hausa–Kafikafi; greasy grey massive aggregates
2.	DTRBO2	Trona, Hausa–Gurro; Kanuri- Zarau; grey massive aggregate
3.	DTRBO3	Trona, Hausa–Wadudum Farin Kanwa; Kanuri–Sutair, whitish grey aggregates, massive.
4.	DTRBO4	Trona, Hausa–Nuku, massive aggregates, brownish–Yellow, dull
5.	DTRBO5	Trona, Hausa–Gasaba; Kanuri–Arou; mirror, grayish–yellow crystal, luminescence non transparent, occurs in about 21m length at the location
6.	DTRBO6	Trona, Hausa–Jam Kanwa; kanuri–klekieme; grey uneven massive
7.	DTRBO7	Trona, Hausa–Morso, irregular masses, greyish white aggregates
8.	DTRYO1	Trona, Hausa–Mangul; brownish–grey with characteristic brownish – red dark.
9.	DTRYO2	Trona, Kanuri–Manda cheu; massive grey to yellow aggregates.
10.	DTRYO3	Trona, Kanwa; grayish–white aggregates.
11.	DTRYO4	Trona, kanwa; dark–grey greasy massive.
12.	DTRYO5	Trona, potash; light–grey, uneven aggregate
13.	DTRLO1	Trona, Hausa–kanwan libiya; massive grey aggregates.

DTRB1–7 are samples from Borno State
DTRY1–5 are sample from Yobe State

Extraction

The trona sample (10.01g) was added to 70cm³ of 1moldm⁻³ aqueous NH_4OAl in a volumetric flask (100cm³) at a temperature of 300°K with vigorous shaking, for 24 hours and was made to volume. The samples were equilibrated in the solution, which were 10^{-3} mol dm^{-3} $CaCl_2$. Preliminary experiments established the time taken to reach equilibrium in each case. However the solution were equilibrated for up to 16 weeks. This is twice as long as appeared necessary to reach equilibrium. The content of the flask was filtered through prewashed filter paper (Whatman fibre glass, 0.3μ). This is the stock solution. The solutions were used for the analytical determination of pH and dissolved metals. The parent phases filtered were kept for further analysis.

Techniques

The pH was measured using pH meter, WTH521 fitted with metrohm EA120 combination electrode. Filtered aliquots 0.5μ Millipore, were analysed for the metal species listed in Table 2 by AAS analysis using a perkin Elmer 400 spectrophotometer. Triplicate analyses from each experimental run were carried out.

Before the measurements of calcium and magnesium species, different approaches were adopted to obtain these metals in solution. This is because of complex formation of these metals with other elements. To determine calcium, the stock solution ($10cm^3$) was pipetted into a conical flask ($250cm^3$). Distilled water ($50cm^3$) was added followed by NH_4OH ($1M, 20cm^3$); KCN, $K_4Fe(CN)_6$ ($1:1:50cm^3$) and EDTA (0.1M 10 drops) were added in this order. Sodium hydroxide (10%) was added until the pH becomes 12 on meter reading. The mixture was titrated against EDTA to a reddish violet colour using murexide powder as indicator.

For the determination of magnesium, the stock solution was treated as for calcium except that, this mixture was allowed to stand for 10 minutes and titrated to a permanent blue colour with EDTA (0.01M) using Erochrome black T indication (EBT). The measurements of calcium and magnesium were carried out in the way described above using AAS analysis.

The measurements of sulphate and carbonate were determine using chromatographic methods Banfield *et al* (1988). Phosphate was determined in the filtrate using the method of Liu and Chen (1981)

Results and Discussion

Table 2 lists thirteen chemical analysis for Trona samples from the troughs of Lake Chad areas of Borno and Yobe States of Nigeria together with sample code DTRL01 from Libya in North Africa. The sample DTRL01 has been included for the sake of comparison with Nigeria samples DTRBO1, DTRBO2, DTRBO3, DTRBO4, DTRBO5, DTRBO6, DTRBO7 from Borno State, and DTRYO1, DTRYO2, DTRYO3, DTRYO4, DTRYO5 from Yobe State. The curatonal notes in Table 1 includes the local names and the places of collection. Table 2 gives the average analyses for the samples together with the number of point count analyses used in each determination in parenthesis.

Table 2: Composition of Different Types of Kanwa

% Constituents

SAMPLE CODE	pH	Na_2O	K_2O	ZnO	PbO	Al_2O_3	Mg0	Ca0	Fe0	SO_4	PO_4	CO_3	H_2O	TOTAL
DTRBO1 (2)	8.51	36.80	0.95	1.95	3.50	1.90	1.50	4.60	2.40	1.80	3.20	32.20	16.50	107.30
DTRBO2 (4)	8.50	40.80	1.10	0.80	2.30	Nd	1.40	3.50	0.90	Nd	2.20	34.3	15.20	102.90
DTRBO3 (3)	8.50	40.60	1.80	1.20	2.70	1.30	2.60	3.10	Tr	1.03	3.20	33.20	16.40	107.13
DTRBO4 (2)	8.40	41.20	1.45	Tr	5.20	0.80	2.20	0.50	1.01	Nd	3.30	34.50	15.50	105.66
DTRBO5 (2)	8.30	37.50	1.60	Tr	4.10	1.20	Tr	3.35	1.0	1.10	3.40	33.80	16.70	103.75
DTRBO6 (2)	8.50	36.20	1.80	Nd	2.90	0.88	1.80	3.01	1.50	1.20	1.50	33.90	16.50	101.19
DTRBO7 (2)	8.38	39.20	1.10	0.50	1.52	1.85	Tr	2.96	.20	Tr	1.80	30.10	15.10	96.33
DTRY01 (2)	8.37	35.40	3.01	1.51	2.30	1.10	3.50	3.00	2.80	Nd	1.70	35.90	17.00	107.22
DTRY02 (3)	8.35	38.50	1.70	0.40	1.40	2.10	1.30	0.50	1.95	Nd	3.80	33.30	16.90	101.65
DTRY03 (4)	8.50	40.90	1.60	1.03	1.35	0.80	1.45	1.65	0.90	Tr	1.42	36.10	17.20	104.1
DTRY04 (3)	8.50	40.90	2.25	Nd	1.30	0.70	2.10	1.70	1.30	Tr	2.53	35.50	18.90	107.18
DTRY05 (3)	8.70	41.10	1.30	1.15	0.65	0.85	1.80	3.15	1.05	0.75	3.30	35.80	16.50	107.4
DTRL01 (1)	8.45	42.30	Nd	Nd	0.84	0.60	1.28	2.15	Tr	Nd	1.83	35.70	18.50	103.2

Tr. = Trace; nd = Not Detected

The number in parenthesis (with sample code) is the number of point count.

The variety of colours, textures and habits of Trona reported from Lake Chad troughs areas of Borno and Yobe States of Nigeria is remarkable. (see Table 1.).

However, reference to these observations (Table 1.) and chemical compositions in Table 2 may permit Trona varieties to be classified and to recognize other secondary minerals that might be present, due to their colours and elemental contents. In this respect the curatorial notes and the composition in Table 2 is informative.

The grey samples, DTRBO1, DTRBO2, DTRYO1 and DTRYO5 (Table 1) contain high amounts of calcium and zinc up to 4.6% and 1.95% (Table 2). Iron upto 2.8% is also reported in these samples. Oxidized iron may be partly responsible for the dark colour of trona in these environments.

Trona major elemental composition at the areas studied ranges between 37 – 43% Na_2O, 32–37% CO_3 and water content 15-19% (see Table 2). Although these values in Table 2 are in close agreement with the reported composition Nkewueurem (1994) they are below the percentage composition of Palache *et al* (1951). In the North-East of Nigeria due to high temperature (upto 46^oC) experience in these areas where evaporation exceed precipitation and moisture may be lost from the trona beds, which will leave other saline related conditions and precipitation of other salts and efflorescene results. Such conditions are usually accompanied by loss of fines compounds from the surface by wind action, leaving pavement of massive aggregates. This may be responsible for the reasonable high amounts of K_2O, CaO and SO_4 of 1.80, 4.60 and 1.8% respectively (Lake Chad samples), reported from samples in Table 2. Moreover different secondary minerals of the same metal may form under a variety of chemical conditions, thereby leading to a great diversity of minerals species (Palache *et al*, 1951; Montimer, 1942). Thus, under certain conditions of pH, CO_3, PO_4, SO_4, and pressure and other metals concentration (see Table 2) trona (Kanwa) will be the principal product. Whereas, under other oxidized condition other secondary minerals may be in association. Therefore, at these locations in Table 1, the trona may be expected to occur in association with other secondary minerals, such as iron magnesium phosphates, kainite, $MgSO_4$ $KCl.3H_2O$, carnallite, $KMgCl_2$. $5H_2O$ and polyhalite $K_2CaMg(SO_4)_4$. $2H_2O$ (Montimer, 1942; Garrels and Christ, 1965). Generally in these environments phosphates may be derived from FePS or other phosphorus containing sulphosalts because wide range of secondary phosphate and carbonates display a wide range of stoichiometries even when the only other anion present in the lattice is hydroxide and only one metallic cation is involved (Palache et al, 1951; Rose and Sutir, 1971, 1971; Nriagu and Moore, 1984; Fleicher, 1987).

Conclusion

It can be concluded that the formation of minerals containing P,S,C and other trace elements in Table 2. is possible through the formation of Ca,Mg,K, Al and Fe containing secondary minerals and other associated secondary minerals such as Kainite, Carnallite, polyhalite and some apatites.

Reference to colours, texture and habits of Trona from these reported locations and the chemical composition may permit Trona varieties to be classified to various uses.

The formation of Trona and associate minerals can also play a significant role in limiting metal concentration in waters in the studied areas.

REFERENCE

Banfield F. S., Meek, D. M., and Lawden, G. F., Technical report, Water Research Centre, Medmenham Laboratory, Harlow U.K. Tr 76, pp20-30 1988.

Dida R. and Reji L., Minerals of the World, the Hamlyn publishers, group Ltd. 356-452, 1986.

Einsele W., Uber chemische and killoidchemische vorgange in Einsenphosphat, Systemen unter Limnochemischen and Limnogeology ischen Gesichtspunkten, Arch. Hydrobiol. 33, 361-387, 1938.

Fleicher M., Glossary of mineral species, 5th Edn. (Mineralogical Record Inc, Tucson 80-96, 1987.

Garrels, R. M. and Christ, C. L. Solution, Mineral and Equilibria Harper and Row, New York, pp130-170 1965.

Liu, F. and Chen, D., Fen His Hua Hsueh, 9, 374 -5 (in Chinese); Anal Abstr., 42, 2B 130, 1981.

Montimer C. H., The exchange of dissolved substances between mud and water in lakes, J. Ecol., 29, 280-329. 30, 147-201. 1942.

Nkeweurem, O. T. Detailed investigations of Trona Deposits in Yusufari, Yunusari, Nguru, Bade, Dapchi, Geidam areas. Yobe State Nigeria, University of Maiduguri Geology Department, Monograph No. 0/1994, 1117-6385., 1994.

Nriagu J. O. and Moore, P. B., eds phosphate Minerals, springer verlag, Berlin, pp180-230, 1984.

Palache C, Berman H. and Frondel C Dana's system of mineralogy Vol. 2; John Wiley pp. 320-405, 1951.

Rose A. W. and Sutir N. H.; Major elements content as a mean of allowing for background variation in stream - sediment geochemical exploration, Toronto symposium. volume 587-593., 1971.

Sherman, G. D., The genesis and morphology of the alumina pich laterite and laterite clays. In "Problems of clay and laterite Genesis" (A. F. Frederickson, ed), Am. Ist. Mining Eng., New York 154-156, 1952.