Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2018, 10(5): 57-60

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Qualitative Determination of the Mineralogical Composition of Sandstone in Amasiri Stone Quarry, Ebonyi, Nigeria Using X-ray Powder Diffraction

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ABSTRACT

Qualitative determination of the mineralogical composition of sandstone in Amasiri Stone Quarry was performed using X-ray powder diffraction. The d-spacing's and relative intensities of the x-ray diffraction patterns of the composite sample was compared with the reference diffractogram from mineralogy database. The mineral odinite was identified to be present in the sandstone. The prominent d-spacing's are 7.18000 (100%), 3.58000(100%) and 1.488000(100%). Odinite is a monoclinic-domatic mineral containing aluminium, hydrogen, iron, magenesium, manganese, oxygen, silicon, and titanium. The chemical formula is (Fe^{3+}, Mg, Al, Fe^{2+}, Ti, Mn)2.5(Si, Al)2O5(OH)4. Cell Dimensions: a=5.373, b=9.326, c=7.363, Z=2; beta=104° V=357.99 Den (Calc)= 2.79. The identification of odinite mineral can be of economic importance because they have been widely used as a foundry-sand bond in the steelmaking industry as well as a binding agent in the manufacturing of iron ore pellets. They are also used to produce earthenware, stoneware and porcelain.

Keywords: X-ray; Powder diffraction; Amasiri; Odinite; Mineral; Clay

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INTRODUCTION

Clay minerals are a standout amongst the most various minerals yet all have a commonalty of grain sizes underneath 2 µm. Chemically, clays are characterized by crystal structure and chemical composition. Now and again fine grain dregs are erroneously depicts as clays, this is really a portrayal of the "clay-size fraction" as opposed to the mineralogy of the sediment. There are three crystallographic clay groups: platy clays (phyllosilicates), fibrous clay minerals, and amorphous clay. Phyllosilicates are the richest clay and are ordered in light of the layering of a tetrahedral and an octahedral layer. For most clays, the octahedral layer is comprises of Al^{3+}, Fe^{3+}, or $Mg(OH)_2$, however at times Zn^{2+}, Li^{+}, and Cr^{3+} can substitute too. Si^{4+} is ordinarily the focal point of the tetrahedral layer however Al^{3+} will regularly in part substitute and make charge awkwardness. Two-layer clays are made out of a tetrahedral layer and an octahedral layer (T-O) while three-layer clays contain an octahedral layer sandwiched by two tetrahedral layers (T-O-T). At the point when substitution of Al^{3+} for Si^{4+} makes charge lopsidedness, an interlayer cation will fill in the middle of tetrahedral layers to adjust the charge of the clay [1].

X-ray diffraction (XRD) examination is the fundamental instrument in the investigation of crystal structure of solid materials. It has been utilized since the start of the twentieth century in the investigation of various types of inorganic materials (metals, compounds, soils, minerals, rocks, concretes, and so forth), natural and organic particles. Despite the fact that the hypothetical essentials of x-ray crystallography is quite complex for non-academic users, phase identification is generally simple to use in

numerous research centers. Soils researchers have additionally utilized XRD investigation regularly keeping in mind the end goal to comprehend soil mineralogy (e.g., iron and aluminum oxi-hydroxides and earth minerals) and the association with its synthetic structure and component bioavailability for soil farming and ecological quality. With the expanding innovation of research center, utilization of XRD investigation in soil mineralogy has turned out to be more successful. The commonest strategy for subjective and quantitative mineral structure assurance in soils is the x-ray diffraction (XRD). Be that as it may, characteristic multi-mineral frameworks distinguishing proof is difficult chiefly because of overlapping peaks [2]. Qualitative discovery of quartz in Umudike, Nigerian, soils using an x-ray diffraction method have been reported [3]. XRD have been utilized for mineralogical measurement in the soil of Ndume Ibeku, Umuahia, Abia, Nigeria [4].

Powder diffraction is routinely utilized as a unique finger impression distinguishing proof procedure of different solid materials in the research industry. It is a cutting edge, quick, shoddy and non-dangerous method for subjective and quantitative examination of crystalline compounds; around 95% of every solid material in the soil is crystalline. At the point when x-ray collides with a crystalline substance or powder, a diffraction design called a diffractogram is created and can be evaluated. Data obtained from these patterns are phase composition, of a sample, crystal structure, amount of amorphous (OM) content, miniaturized scale strain, size and orientation of crystallites. XRD has turned into an imperative technique for materials examination portrayal and quality control. The angle and power of the diffracted beam recorded by an identifier frames a diffraction pattern, which gives data about a sample. The diffraction pattern for every phase is as extraordinary as a unique finger impression [5].

The aim of this study is the qualitative identification of Amasiri Stone Quarry in Amaokpu Ezeke Amasiri community in Afipko North Local Government Area, Ebonyi State, Nigeria by x-ray diffraction.

MATERIALS AND METHOD

Depiction of the Study Area

Amasiri Stone Quarry is situated in Amaokpu Ezeke Amasiri in Afipko North Local Government Area, Ebonyi State, Nigeria. Coordinates: 5°55'0"N 7°52'54"E.

Sample Collection

Sandstone samples were gathered from 26 distinct areas in Amasiri stone quarry. The 26 samples were blended, granulated and mixed together to form a composite sample. The composite sample were stuffed in a little plastic pack and named. The composite sample were stressed to evacuate the stringy and undesired materials with the assistance of 2 mm strainer and dried by warming to expel dampness and after that grounded to make homogenous before x-ray powdered diffraction investigation. Chemical treatments such as H_2O_2, iron and aluminum oxy-hydroxides, dithionite-citrate-bicarbonate were not applied to the crude samples in order to eliminate organic matter [6,7] because chemical treatments may change the clay minerals and all the more particularly blended layer species [8].

Qualitative Phase Analysis

X-ray diffraction patterns were made with a monochromatic x-ray diffractometer framework XPERT-PRO with beta channel CuK1 radiation wavelength of 1.54056 Å and computerized opening. The diffractometer was set to examine between an arrangements of 2θ degrees from 0 - 85°. Step estimate (2θ) 0.0670, filter step time (s): 29.8450, examine type: constant. Subjective stage investigation was utilized for the investigation of crystal structure and unknown phases of sandstone.

RESULTS AND DISCUSSION

The selected d-spacing and relative intensities of the diffractogram is presented in Table 1. The x-ray diffractogram of composite sandstone sample is presented in Figure 1.

Table 1: Selected d-spacing (Å) and relative intensity (%) of Amasiri sandstone quarry x-ray diffractogram

2θ (°)	d (Å)	Intensity (%)	h	k	l
12.3172	7.1800	100	0	0	1
19.8010	4.4800	80	0	2	0
24.8501	3.5800	100	0	0	2
34.9517	2.5650	80	-2	0	1
35.8613	2.5020	80	2	0	0
37.6687	2.3860	80	0	0	3
38.4209	2.3470	90	-2	0	2
40.8737	2.2060	10	2	0	1
45.5695	1.9890	40	-2	0	3
51.0068	1.7890	40	0	0	4
55.0781	1.6660	50	3	0	0
59.9811	1.5410	10	1	1	4
62.3510	1.4880	100	0	6	0
63.7831	1.4580	30	2	2	3
65.0823	1.4320	20	-1	5	3
68.1398	1.3750	10	0	6	2
70.2364	1.3390	10	-2	2	5
72.0304	1.3100	10	2	0	4
73.5263	1.2870	30	-2	6	1
75.0225	1.2650	10	-1	6	3
76.1539	1.2490	5	4	0	0
77.1010	1.2360	30	1	7	0
80.3502	1.1940	10	0	0	6

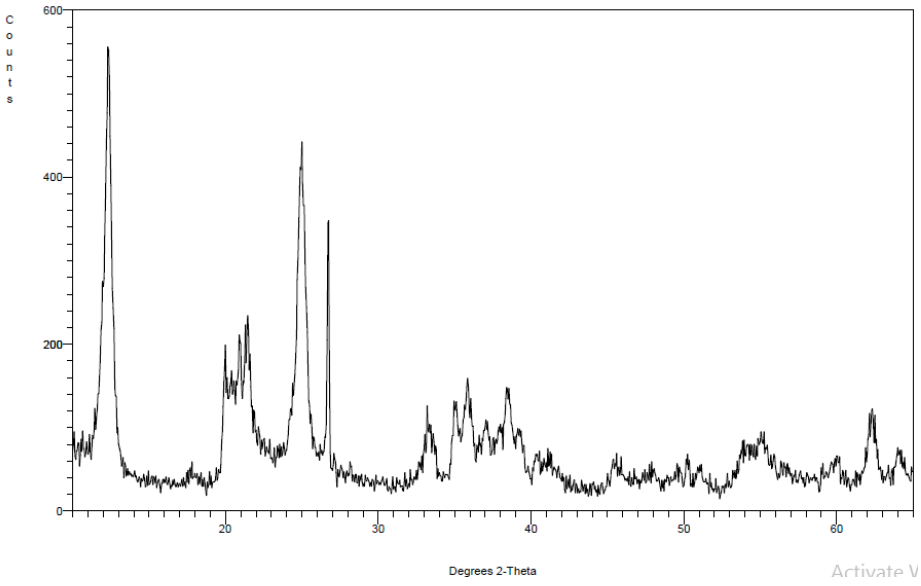

Figure 1: X-ray diffractogram of sandstone in Amasiri Stone Quarry, Ebonyi State

Figure 1 is an x-ray powder diffractogram produced during x-ray scan. The set of d-spacing (the distance between adjacent planes of atoms), which represent the unique "fingerprint" of the mineral. The three d-values or d-spacing in the highest peaks areÅ7.18000 (100%), Å3.58000 (100%) andÅ 1.488000 (100%), these d-values were keyed in to mineralogy database [9]. An examination was made between the d-spacing in the diffractogram of sandstone test and that of the mineralogy database. Odinite mineral was identified in the sample. Odinite is a monoclinic-domatic mineral containing aluminium, hydrogen, iron, magenesium, manganese, oxygen, silicon, and titanium Chemical Formula: $(Fe^{3+}, Mg, Al, Fe^{2+}, Ti, Mn)_{2.5}(Si, Al)_{2O5}(OH)_{4.}$

It is named after Dr. Gilles Serge Odin who did the majority of the spearheading chip away at this new mineral. Odinite is assessed to be a minor part (0.1-10%) of sediment that cover more than 100, 00 km^2 of the present day ocean depths [10]. The odinite is blended in the residue with quartz sand, frequently with an expansive part of carbonate bioclasts, in addition to littler measures of clay minerals and other detritus, and is most clear at shallow profundities in territory where the detrital sedimentation rate is low. The environment is believed to be in marine waters at the dregs water interface [10] where there is normal salinity.

As per the mineralogical arrangement of clay minerals, Odinite is among the three fundamental groups of clay minerals. Because of their particular properties, e.g, high capillarity, solidifying, versatility, high level of swelling, clays are broadly utilized as a part of different enterprises. For instance in light of their phenomenal colloidal properties they are frequently utilized as boring liquids for oil and gas and also to grease up and cool the cutting devices in boreholes, to evacuate cuttings and help prevent blowouts. The likelihood of swellings enables them to possess an essential part in mining and topography while the high swelling clay is exploited in the construction company. They have been broadly utilized as a foundry-sand bond in the steelmaking business and in addition a coupling operator in the assembling of iron mineral pellets. They is likewise used to create pottery, stoneware, and porcelain.

CONCLUSION

X-ray powder diffraction is non-destructive, easy sample preparation and a fast technique which has high accuracy for d-spacing calculations. The qualitative mineral analysis technique described in this work allows us to measure accurately mineral compositions of sandstone, including clay mineral content. Therefore powder x-ray diffraction technique is a key analytical technique in the growth and development of Science and Technology. X-ray powder diffraction is recommended for fast but precise and reliable effective method of identifying and characterizing the minerals in fine-grained minerals and other substances present mixtures of minerals and also to identify any crystalline substance. X-ray powder diffraction is also recommended because it is rapid, low cost, cheap and non-destructive technique for quantitative and qualitative analysis of crystalline compounds.

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