

# Determination of Mineralogical Contents of a Bangle Shard from an Indus Valley Settlement through X-ray Diffraction Analysis

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The mineralogical make up of clay used in a bangle shard (Fig. 1) collected from Harrappa, an Indus Valley settlement now located in Pakistan has been determined using XRD testing carried out on 'Philips X'Pert PRO X-ray diffractometer' available in Geoscience Advance Research Laboratories (a facility of Geological Survey of Pakistan) in Islamabad. XRD analysis shows that the mineralogical make up includes montmorillonite  $((\text{Na,Ca})_{0.33}(\text{Al,Mg})_2(\text{Si}_4\text{O}_{10})(\text{OH})_2 \cdot n\text{H}_2\text{O})$ , gypsum  $(\text{CaSO}_4 \cdot 2\text{H}_2\text{O})$ , and quartz  $(\text{SiO}_2)$ . The X-ray diffractogram was developed using PW3050/60 goniometer. The generator settings were 30 mA/40 kV with  $\text{CuK}\alpha$  radiation of  $\lambda = 1.5406 \text{ \AA}$ . Continuous scanning was carried out from 10.01 as  $2\theta$  start position to 79.99 as  $2\theta$  end position, with a step size of 0.02 and step time of 1 s.



Fig. 1 Bangle shard photographed with Pakistani one rupee coin as reference. Diameter: 0.95-1 cm, length: 5.65 cm or about  $2/5^{\text{th}}$  of the complete bangle.

## XRD Testing Parameters and Results

### 1(a) Anchor Scan Parameters

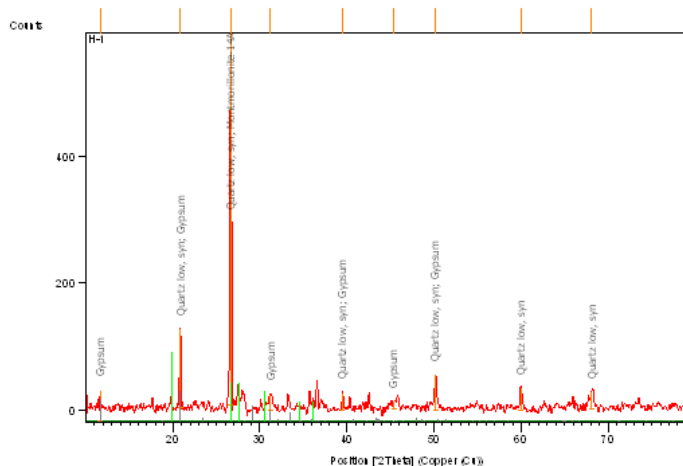
Dataset Name: H-1  
File Name: C:\X'Pert Data\2011\May\H-1.xrdml  
Comment: Material analysis for universities  
Configuration=Flat Sample Stage, Owner=User-1, Creation date=2/5/2008 9:32:46 AM  
Goniometer=PW3050/60 (Theta/Theta); Minimum step size 2Theta:0.001; Minimum step size Omega:0.001  
Sample stage=PW3071/xx Bracket

Diffractometer system=XPERT-PRO  
Measurement program=material analysis, Owner=User-1, Creation  
date=3/28/2008 10:27:40 AM

synthetic material

Measurement Date / Time: 5/6/2011 9:25:21 PM  
Operator: Geoscience  
Raw Data Origin: XRD measurement (\*.XRDML)  
Scan Axis: Gonio  
Start Position [°2Th.]: 10.0100  
End Position [°2Th.]: 79.9900  
Step Size [°2Th.]: 0.0200  
Scan Step Time [s]: 1.0000  
Scan Type: Continuous  
Offset [°2Th.]: 0.0000  
Divergence Slit Type: Fixed  
Divergence Slit Size [°]: 0.5000  
Specimen Length [mm]: 10.00  
Receiving Slit Size [mm]: 0.1000  
Measurement Temperature [°C]: 25.00  
Anode Material: Cu  
K-Alpha1 [Å]: 1.54060  
K-Alpha2 [Å]: 1.54443  
K-Beta [Å]: 1.39225  
K-A2 / K-A1 Ratio: 0.50000  
Generator Settings: 30 mA, 40 kV  
Diffractometer Type: 0000000011037156  
Diffractometer Number: 0  
Goniometer Radius [mm]: 240.00  
Dist. Focus-Diverg. Slit [mm]: 100.00  
Incident Beam Monochromator: No  
Spinning: No

### 1(b) Graphics



## 2(a) Peak List

Pos.[°2Th.]	Height[cts]	FWHM[°2Th.]	d-spacing[Å]	Rel.Int.[%]	Tipwidth[°2Th.]	Matched by
11.6307	48.56	0.0150	7.60871	8.23	0.0180	01-072-0596
20.8542	124.13	0.1771	4.25968	21.05	0.2125	03-065-0466;01..
26.6610	589.75	0.1968	3.34364	100.00	0.2362	03-065-0466;00..
31.2494	25.46	0.4723	2.86237	4.32	0.5668	01-072-0596
39.5060	28.61	0.2362	2.28111	4.85	0.2834	03-065-0466;01..
45.3856	11.54	0.9446	1.99833	1.96	1.1336	01-072-0596
50.2031	55.70	0.1968	1.81729	9.44	0.2362	03-065-0466;01..
59.9984	35.04	0.2362	1.54191	5.94	0.2834	03-065-0466
68.1453	27.77	0.5760	1.37494	4.71	0.6912	03-065-0466

## 2(b) Pattern List

Visible	Ref. Code	Score	Compound Name	Displ.[°2Th]	Scale Fac.	Chem. Formula
	03-065-0466	72	Quartz low, syn	0.000	0.962	SiO <sub>2</sub>
*	00-013-0259	5	Montmorillonite-14A	0.000	9.948	Na <sub>0.3</sub> (Al,Mg) <sub>2</sub> ..
*	01-072-0596	11	Gypsum	0.000	0.077	Ca(SO <sub>4</sub> )(H <sub>2</sub> O)..

## 2(c) Graphics

