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## ARCHAEOLOGICAL ANALYSIS OF FOUR SILVER COINS FROM FOUR DIFFERENT MINTS OF INDEPENDENT SULTANS OF BENGAL

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Four silver coins from four different mints (Sunargawn, Satgawn, Chatgawn and Khalifatabad) of three different independent Bengal sultans from 1334 to 1538 AD have been analyzed by X-Ray Diffraction and EDS. Attempt has been made to understand the pattern of variation in composition of the coins of different periods from different geographical region from east to west within Bengal. The results have been compared with a previously analyzed coin of Ghiyath Al-din Mahmud of Husayin Shahi dynasty. Results of this study show that there is a variation in silver content from 86.70 - 94.39%. Lead, possibly from natural source of silver varied from 0.053 - 0.447%. Aluminum probably intentionally added to the alloy varied from 0.52 - 3.36%. Other elements such as Copper, Gold, Silicon, Iron, Bismuth, Zinc, Germanium, Ruthenium, Barium, and Cesium were also found in the coins.

**Keywords:** coins, Sunargawn, Satgawn, Chatgawn, Khalifatabad Bengal, X-Ray Diffraction and EDS

### Introduction

In recent years, Archaeologists, Historians and Numismatists have gathered much information about the mediaeval period of Bengal through historical documents, stone/metal inscriptions and coins. Coins are the most important and most authentic artifacts to line up the disorderliness in the chronology of the Bengal sultans. As there is a lack of contemporary written documents of the sultani period in Bengal, coins are the only elements to identify the monetary history, currency circulation patterns and economy. Till now most of the researchers have tried only to rebuild and diminish the confusions in the history of Bengal sultans. Some researchers have also come forward to study the metallurgical aspects of the currency system of the Bengal sultans. The minting technology, purification process of metals, mixing of different other elements with the metals for making the strength etc. can be discovered from Archaeometallurgical analysis of a coin (Hasan, 2013, p.192). As a pioneer, Monwar Jahan of Bangladesh National Museum attempted to determine the metallic composition of thirteen silver coins including eleven coins of Bengal sultans (Jahan, 1995, p.48). Later, Pranab Chattapaddhay elaborated Jahan's work and tried to find the sources of trade route of silver as a core element of striking coins (Chattapadhyay, 2011, p. 114). Jahan's work is important as a 1st step, but the sum of the percentages do not add up to 100%, he also didn't mention whether there were more elements (Chattapadhyay, 2007, p. 303).

Recently, John Deyell has reported analysis of 33 silver coins of independent Bengal sultans but his results show only the percentages of silver, not of any other elements (Deyell, 2010–11).

The present authors made an attempt to explore, through non-destructive testing methods, the composition of sultani coins to see if the non-destructive techniques could be used to investigate the composition of a large number of sultani silver coins effectively and precisely. One coin of Ghiyath Al-din Mahmud Shah of AH 933 issued from 'Da' mint was analyzed by both X-ray diffraction and EDS (Hasan et al, 2015). In continuation of that study, the analyses of four silver coins of four different mints have been analyzed by x-ray diffraction analysis and EDS.

### Descriptions and Experimental results of the Coins

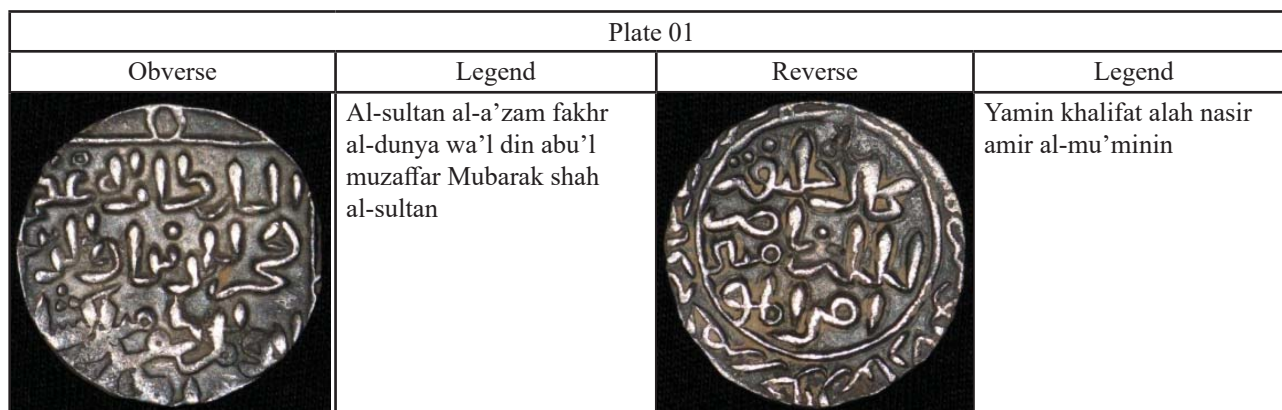
#### Sample 01

Sultan: Fakhr Al-Din Mubarak Shah, Date: 738AH, Mint: Hadrat Jalal Sunargawn.

Diameter: 24.687mm, Thickness: 02.80mm, Weight: 10.7g

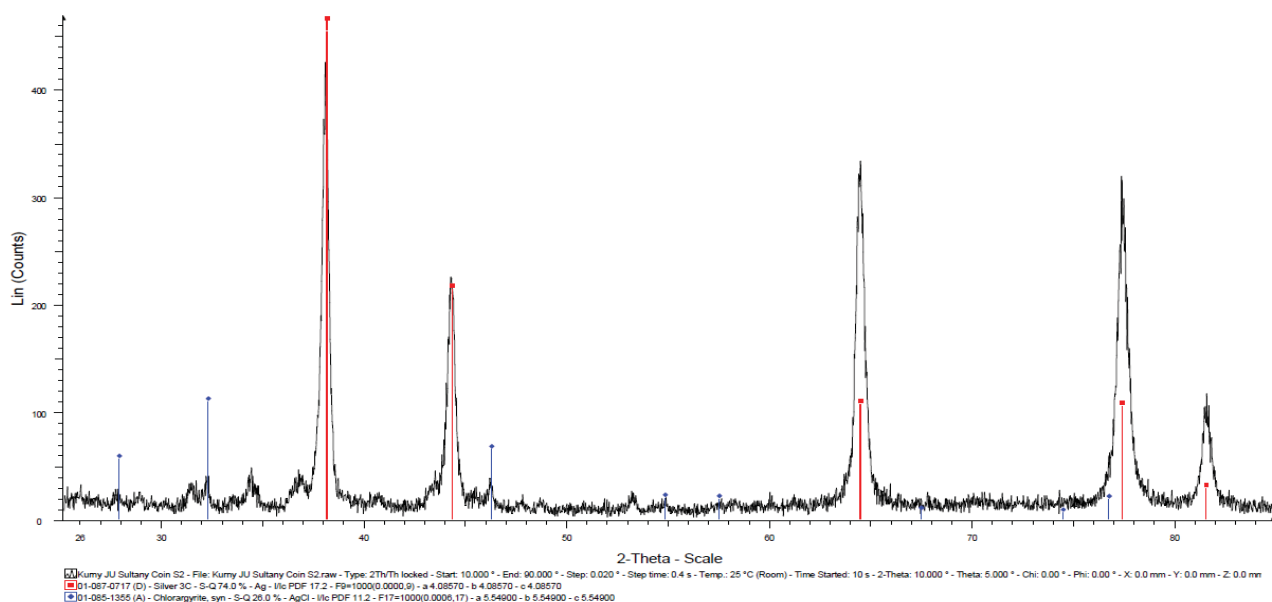
Fakhr Al-Din Mubarak Shah was the 1st sultan of Bengal who declared independence from Sunargawn against Delhi Sultanate and ruled over the eastern part of Bengal for over a decade. Although, Karim mentioned the starting date of Fakhr Al-Din Mubarak Shah as AH739 (Karim, 1960, p. 36), but both gold and silver coins bearing his name and minted in AH 734/1334 ACE (Goron, 2001, p. 166) have been found. However, no coin minted in between





AH 735–736 has been found. All the coins of this sultan were issued from mint Sunargawn (Shahnawaz, 1999, p. 81). He always used epithet 'Hadrat Jalal' (Honorable city) before the mint name on his coins (Karim, 2013, p. 326).

A coin dated AH 738/1337ACE (Plate 01) has been taken as a sample to understand the metal composition of the early independent sultan of Bengal at the initial stage of his rule.



X-ray diffraction pattern of Sample 01 (Plate 2)



The XRD pattern (Plate 02) shows Silver Chlorargyrite (AgCl). No other element approximately 74% silver, with an upper layer has been detected.

The EDS data of the sample 01

Elements	Ag	Cl	Al	Sn	Cu	Na	Au	Si	K	Pb	Ge	Ru
Percentage	86.70	03.32	02.11	02.62	01.44	01.09	0.90	0.69	0.69	0.35	0.046	0.043

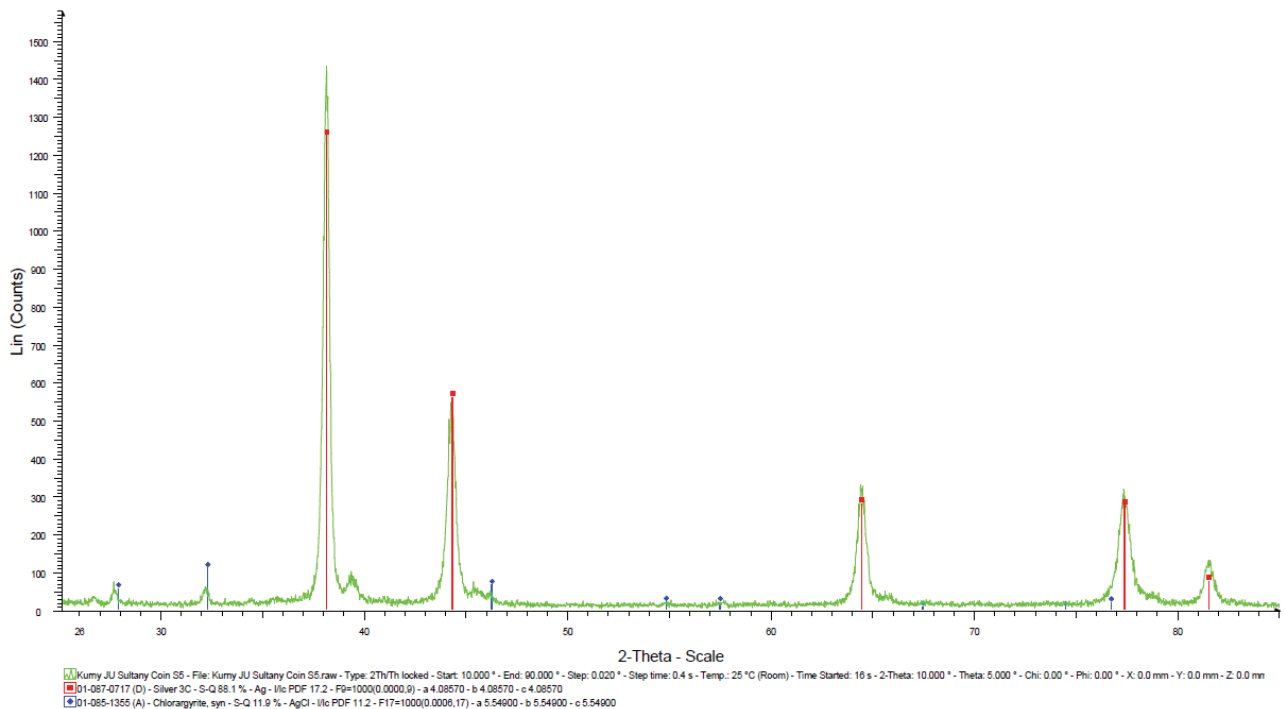
\* Only three digits after decimal have been counted. The sum may not be 100%.

**Sample 02** Diameter: 26.095mm, Thickness: 02.415mm, Weight: 10.5g  
 Sultan: Shams Al Din Ilyas Shah, Date: 754AH, Mint: Satgawn.

Plate 03			
Obverse	Legend	Reverse	Legend
	Al-sultan al-adil shams al-dunya wa'l din abu'l muzaffar ilyas shah al-sultan		Sikandar al-thani yamin al-khalifa (nasir) amir al-mu'minin

Shams Al Din Ilyas Shah was the 1<sup>st</sup> independent sultans of Bengal who conquered all the part of Bengal and combined the whole Bengal as a nation. As recognition, he was titled as Shah e Bangala or Shah e Bangalian (Sultan of Bengal). He issued coins from Firuzabad in AH 744 (Mukhopadhyay, 1988, p. 21) and then

he issued coins from Satgaon in AH 747 (Karim, 1999, p. 184). A coin of Satgawn with the date AH 754 (Plate 3) has been taken as a sample because Satgawn was the most south-western mint of Shams Al Din Ilyas Shah and that will allow knowing the metallic pattern of the coins of distant part of Bengal sultans.



XRD of Sample 02 (Plate 4)

The XRD data (Plate 4) showing the peak layer of Silver Chlorargyrite (AgCl). No other element has been detected.

## The EDS data of the sample 02

Elements	Ag	Cl	Al	Sn	Cu	Na	Au	Si	Zn	Pb	Ge	Ru
Percentage	88.06	01.46	02.48	02.48	0.78	01.36	01.18	01.95	0.06	0.13	0.058	0.035

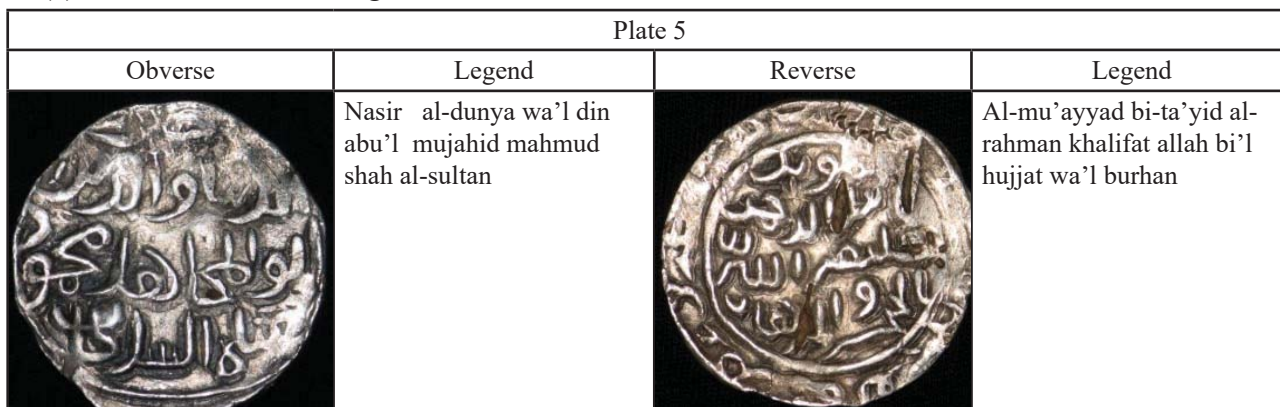
\*Only three digits after decimal have been counted. The sum may not be 100%.

**Sample 03**

Sultan: Nasir Al Din Mahmud Shah, Date: 84(?) AH, Mint: Arsah Chatgawn.

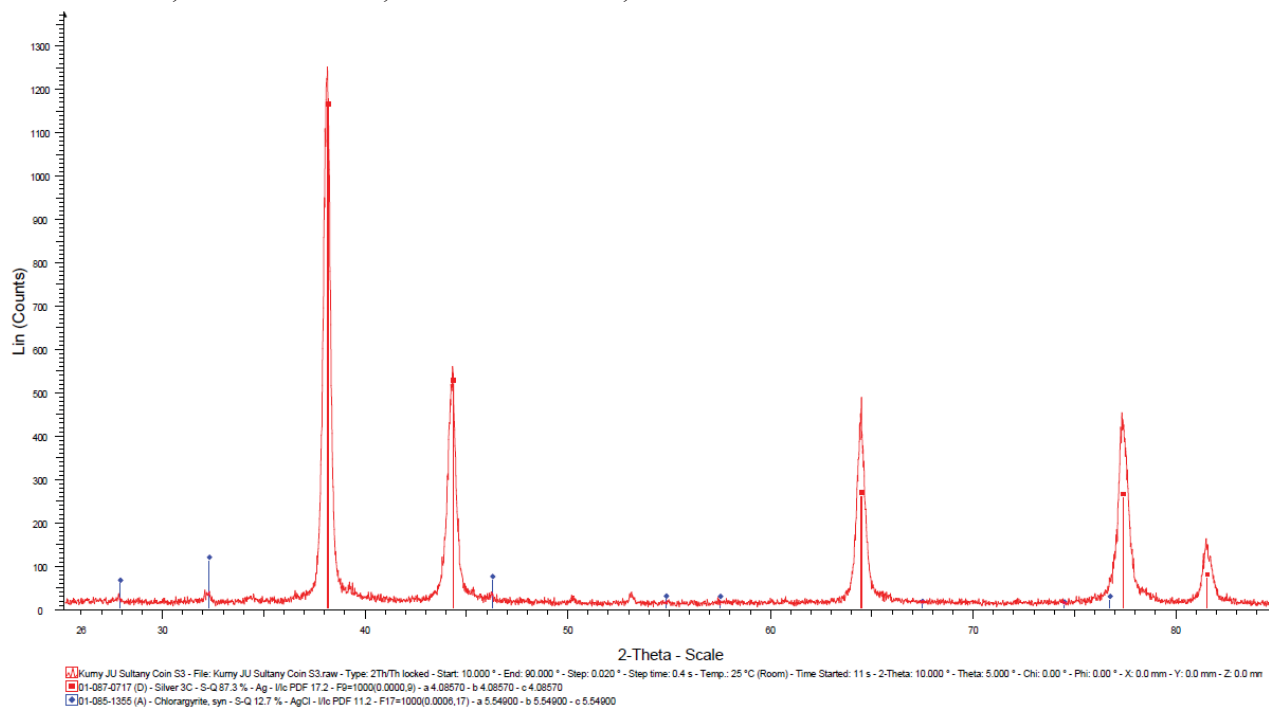
Diameter: 30.28mm, Thickness: 02.074mm,

Weight: 10.4g



Nasir al Din Mahmud Shah ruled over Bengal independently for the longest period of time (AH 837–864). An inscription of Gaur indicates that he transferred capital from Firuzabad to Gaur (Ray, Gaur). He issued coins from Khazanah, Dar-ul-Darb, Firuzabad, Satgawn, Nasirabad, Dakhil Banjalia, Khalifatabad, Muazzamabad, Muhammadabad,

Sabtahara (Goron, 2001) and Dakhil ba-takhtgah (Hussein, 2003, p. 118). He also issued coins from Chatgawn, the most south-eastern mint of Bengal. As the mint's location is completely opposite to the previous sample and nearly hundred years of difference, we have chosen a coin of 74(?) from Chatgawn mint.



XRD of Sample 03 (Plate 6)

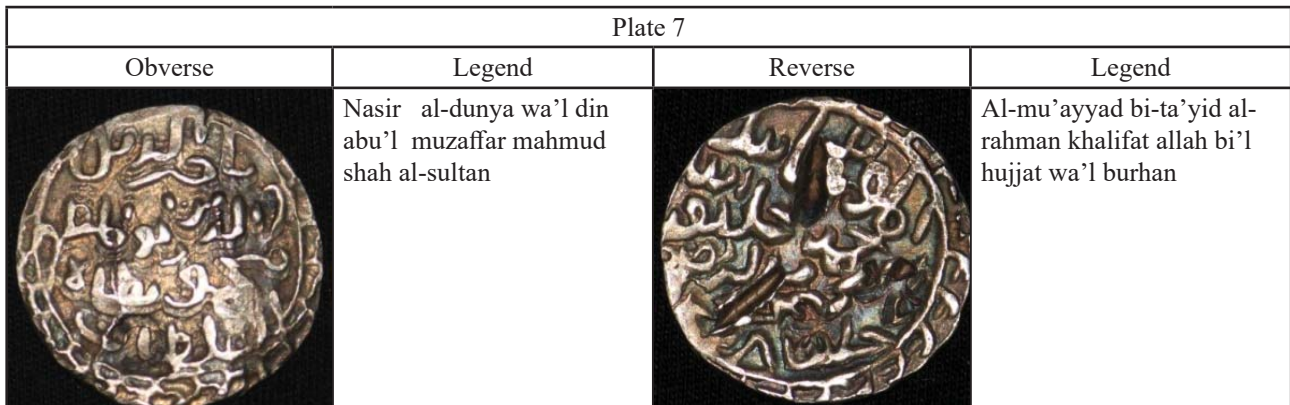
The XRD data (Plate 6) showing the peak layer of Silver Chlorargyrite (AgCl). No other element has been detected.

The EDS data of the sample 03

Elements	Ag	Cl	Al	Sn	Cu	Na	Au	Si	K	Pb	Fe	Bi	Ge	Ru
Percentage	91.24	1.32	0.52	2.66	0.9	0.83	0.32	0.95	0.73	0.1	0.21	0.14	0.02	0.042

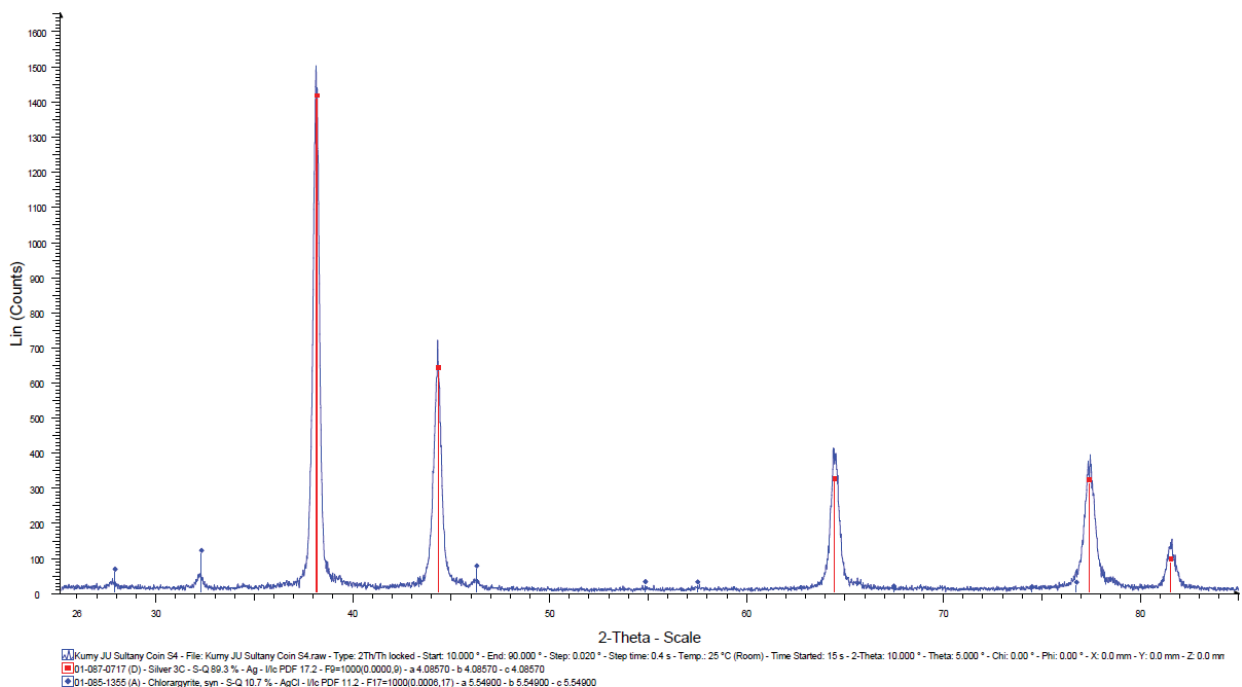
\*Only three digits after decimal have been counted. The sum may not be 100%.

**Sample 04** Diameter: 23.985mm, Thickness: 02.957mm, Weight: 10.5g  
 Sultan: Nasir Al Din Mahmud Shah, Date: 846AH, Mint: Khalifatabad



Khalifatabad appeared as a mint on coins during the region of Sultan Nasir Al Din Mahmud Shah. Till now the 1st date found from mint Khalifatabad is AH 846 (Karim, 2013, p. 329). This mint town has been identified with the ruins of Khan Jahan in Bagerhat District (Jahan, 1953,

p. 226). Khalifatabad was the most remote mint town surrounded by Sundarbans, that's why it has been taken as a sample (Plate 7) to identify the metal composition of this mint during the middle period of the Independent sultanate of Bengal.



XRD of Sample 04 (Plate 8)

The XRD data (Plate 8) showing the peak layer of Silver Chlorargyrite (AgCl). No other element has been detected.

The EDS data of the sample 04

Elements	Ag	Cl	Al	Sn	Cu	Na	Au	Si	Pb	Ge	Ru	Bi	Ge	Ru
Percentage	87.63	01.14	02.94	02.55	02.03	01.04	01.05	0.79	0.44	0.056	0.043	0.14	0.02	0.042

\*Only three digits after decimal have been counted. The sum may not be 100%.

### Comparative Metal content of the five coins

A comparative compositional analysis of elements of four silver coins of the Bengal sultans of three different rulers from four different mints

from Eastern to the western part of Bengal along with previously analyzed coin of Ghiyath Al-din Mahmud Shah of AH 933 from 'Da' mint (Hasan et al., 2015) is given below:

Chart: A (shown data in the continuation of time for both eastern and western mint)

Elements	Sample 01 Sunargawn AH 738	Sample 02 Satgawn AH 754	Sample 03 Chatgawn AH 84(?)	Sample 04 Khalifatabad AH 846	Ghiyath Al-din Mahmud Da (B'dr Shahi type) AH 933
Argentums (Ag)	86.70	88.06	91.24	87.63	94.39
Chlorine (Cl)	03.32	01.46	01.32	01.41	-
Aluminum (Al)	02.11	02.48	00.52	02.94	03.36
Stannum (Sn)	02.62	02.48	02.66	02.55	-
Copper (Cu)	01.44	00.77	00.905	02.03	00.273
Sodium (Na)	01.09	01.36	00.83	01.04	-
Aurum (Au)	00.90	01.18	00.316	01.05	00.989
Potassium (K)	00.69	-	00.73	-	-
Silicon (Si)	00.69	01.95	00.953	00.79	00.70
Lead (Pb)	00.354	00.13	00.102	00.447	00.053
Iron (Fe)	-	-	00.218	-	00.151
Bismuth (Bi)	-	-	00.142	-	-
Zinc (Zn)	-	00.06	-	-	-
Germanium (Ge)	00.043	00.05	00.0193	00.056	-
Ruthenium (Ru)	00.043	00.03	00.0420	00.043	-
Barium (Ba)	-	-	-	-	00.042
Cesium (Cs)	-	-	-	-	00.042

### Comparative Analysis

Deyell reported that silver tanka of Bengal sultans are almost pure silver containing from 96–99% (Dayell, 2012–13, pp. 133–137) but

he arrived at this conclusion by misinterpreting incomplete analysis chart of Jahan's thesis (Jahan, 1995, p. 53) cited from another source which we have reported in our previous paper (Hasan et al,

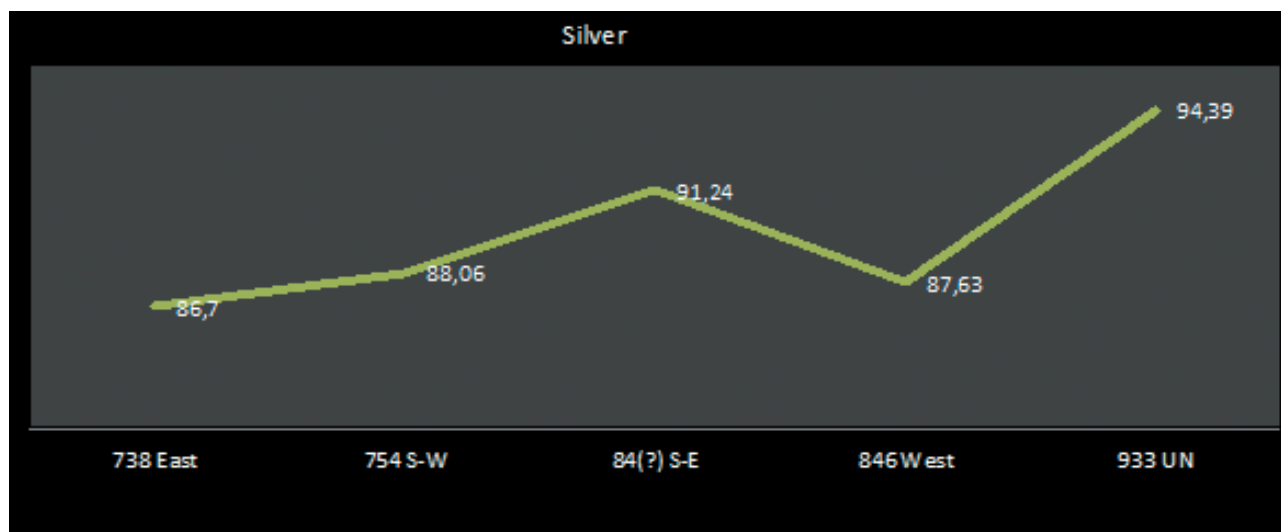
2015). The XRD data of each coin shows the presence of Silver Chlorargyrite (AgCl) on the surface, which is normally caused by corrosion. The presence of AgCl proves that the coins didn't go through any heating process in modern period and has preserved its original features (Chattopadhyay, 2013, p. 100). That's why EDS analysis of each coin shows the presence of Chlorine in small percentage.

#### Silver Percentages

EDS analysis shows that percentage of silver in the coins of Bengal sultan has increased over the years (Graph 1). In Sample 01, the percentage of silver is little low. Fakhr Al-Din Mubarak ruled over only the eastern part of Bengal. In his early period of ruling, he struck coins hastily, that may be the reason of his coins containing less silver. This hastiness has been reflected on the calligraphic pattern of the coin. In continuation, Bengal was independent for next

200 years. So, it can be assumed that the stability of the political situation encouraged trade and commerce and increased the economic wealth of the country. It developed trade relations with other kingdoms of the east and imported silver as a surplus in overland and sea trade from places like Yunnan in the South-west, the northern Shan states of China, and eastern Burma where silver mines existed and silver was produced, refined and exported (Hussain, 2013, p. 284). In mediaeval period, price of silver against cowries decreased in Bengal; the price of silver in Bengal was even five times less than the price in Malacca; on the other hand, price of gold in Bengal was six times higher than Malacca (Haider, 2015, p. 99). Sample 03 from the eastern mint Chatgawn contains over 90% silver which indicates our previous assumption of having higher percentage of silver in eastern mints than westerns (Hasan et al, 2015).

**Graph 1: Graph of the percentage of silver of the coin from early to later period of Bengal sultans from East to west:**



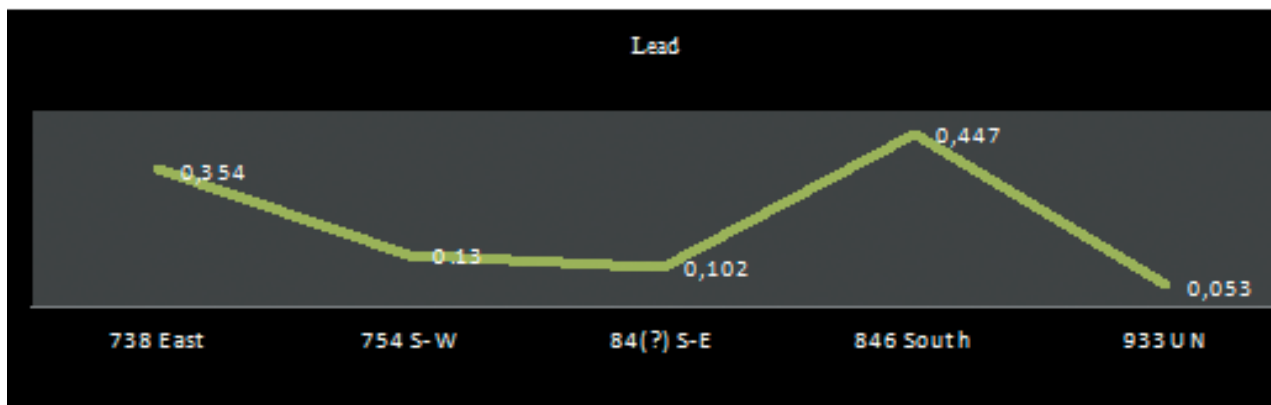
#### Percentages of Lead and the presence of Aluminum

The percentages of Lead are present in all five coins but in very low quantity (Chart A), less than 0.5%. In south and south-east Asia, silver is refined from lead ore. In mediaeval period, for purifying silver a quantity of adulterated material was put together with a proportionate amount of lead (Mukherjee, 1988, p. 25). According to Ain-i-Akbari (a Mughal writing), one-fourth of lead was put on the top of silver in a hole to make silver bullion for coinage (Allami, 1873, p. 22). If the same method was applied during sultani

period, then coins should contain a remarkable amount of lead. But all the five coins from our experiment showed only a very less amount (Graph 02) of lead which perhaps came as a primary element of ore with silver.

It is interesting to have a good percentage of aluminum in all the coins (Graph 03), 0.52–3.36%. Aluminum does not exist as a major or minor element in any of the natural sources of silver of south-east China and Burma (Soe, 1990, p. 12). Silver is a soft metal and its need to mix up with other material to increase its hardness while making any object. So, it

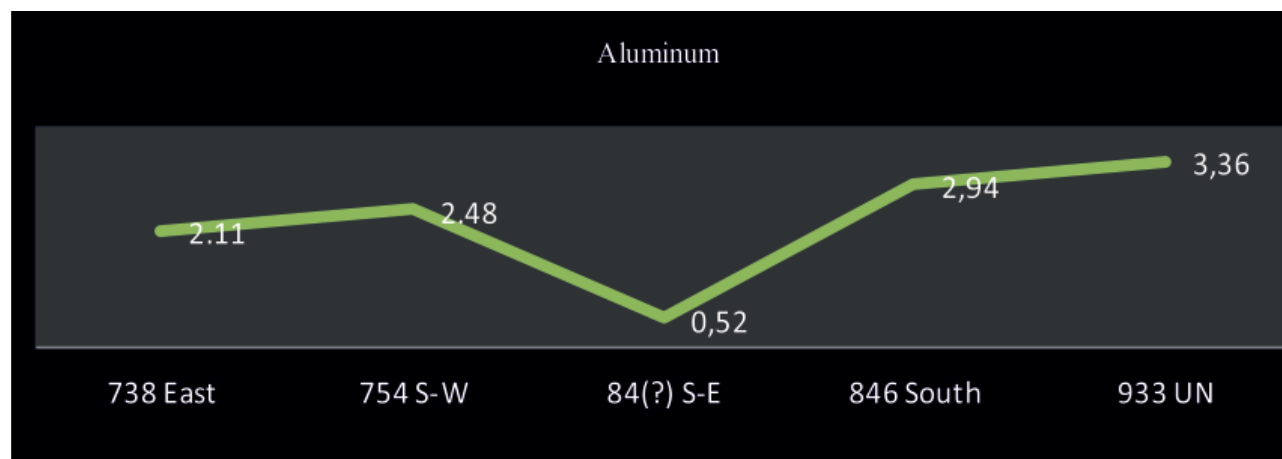
**Graph 02: Graph of the percentage of Lead in the silver coin from early to later period of Bengal sultan from east to west**



demands special concentration to re-investigate about the intentionally added material with silver in minting process because the major natural

sources of silver like galena and Sphalerite do not contain aluminum.

**Graph 3: Graph of the percentage of Aluminum in the silver coin of the Bengal sultans from early to later period from east to west:**



#### **Presence of other elements:**

The coins contain tin (Sn), copper (Cu), gold (Au), sodium (Na), potassium (K), silicon (Si), iron (Fe), bismuth (Bi), zinc (Zn), germanium (Ge), ruthenium (Ru), barium (Ba), cesium (Cs). Silver mainly produced as a byproduct of gold, copper, zinc and lead refining. So, these elements can present in a low percentage in the purified silver. Germanium (Ge) and tin (Sn) is minor elements of Sphalerite. Copper is found in galena as a minor element. There are many natural sources of Galena and Sphalerite in Burma and south-east China but individual data of those mines is not present or out of our reach.

#### **Conclusion**

Although it is not possible to arrive at a conclusion about the metallurgy of the coins of Bengal sultans by metallurgical analysis of only five silver coins, these data has indicated that more elaborate investigation with a large number of coins could be helpful to arriving in a conclusion.

#### **Acknowledgement**

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**АРХЕОМЕТАЛЛУРГИЧЕСКИЙ АНАЛИЗ ЧЕТЫРЕХ СЕРЕБРЯНЫХ  
МОНЕТ С ЧЕТЫРЕХ МОНЕТНЫХ ДВОРОВ СУЛТАНОВ БЕНГАЛИИ**

**Мухаммед Абу Аль Хасан, А.С.В. Курны**

Четыре серебряные монеты четырех различных монетных дворов (Сонаргаон, Сатгаван, Чатгаван и Халифатабад) трех независимых султанов Бенгалии 1334 - 1538 гг. н.э. были проанализированы с применением методов рентгеновской дифракции и энергодисперсионной рентгеновской спектроскопии. Авторы предприняли попытку обоснования закономерности изменения состава монет, отчеканенных в отдельные исторические периоды в различных географических регионах, расположенных с востока на запад на территории Бенгалии. Полученные сведения были сопоставлены с результатами проведенного ранее анализа монете Гийас ад-дина Махмуда из династии Хусайн Шахи. Результаты исследования демонстрируют различное содержание серебра от 86,70% до 94,39%. Содержание свинца варьируется от 0,053% до 0,447%, что может быть обусловлено природным источником серебра. Алюминий был вероятно добавлен в сплав намеренно в количестве от 0,52% до 3,36%. В монетах были также обнаружены другие элементы, такие как медь, золото, кремний, железо, висмут, цинк, германий, рутений, барий и цезий.

**Ключевые слова:** монеты, Бенгалия, Сонаргаон, Сатгаван, Чатгаван, Халифа-табад, рентгеновская дифракция и энергодисперсионная рентгеновская спектроскопия

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АКИО – Ананьинская культурно-историческая область  
АКР – Археологическая карта России  
АН РТ – Академия наук Республики Татарстан  
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ЛГУ – Ленинградский государственный университет  
МАРТ – Музей археологии Республики Татарстан ИА АН РТ  
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НМ РТ - Национальный музей Республики Татарстан.  
ОГИК – Омский государственный историко-краеведческий музей  
ПГГПУ – Пермский государственный гуманитарно-педагогический университет  
ПГУ – Пермский государственный университет  
ПСРЛ – Полное собрание русских летописей. СПб, Л., М.  
ПФИЦ УрО РАН - Пермский федеральный исследовательский центр, Уральское отделение  
Российской академии наук  
РА – Российская археология. М.  
РАН – Российская академия наук  
РАНИОН – Российская Ассоциация научно-исследовательских институтов общественных  
наук  
РАО – Российское археологическое общество  
РФА – рентгенофлуоресцентный анализ  
СА – Советская археология. М.  
САИ – Свод археологических источников. М.  
СГАИМК – Сообщения ГАИМК. Л.  
СНЦ РАН – Самарский научный центр Российской академии наук  
СПбГУ – Санкт-Петербургский государственный университет  
СПФ АРАН – Санкт-Петербургский филиал Архива РАН  
ССАЭ – Сейминско-Суджинская археологическая экспедиция  
СССР – Союз Советских Социалистических Республик  
ТАССР – Татарская Автономная Советская Социалистическая Республика  
ТМАЭ – Труды Марийской археологической экспедиции. Йошкар-Ола.  
УАВ – Уфимский археологический вестник. Уфа  
УдГУ – Удмуртский государственный университет.  
УИИЯЛ УрО РАН – Удмуртский институт истории, языка и литературы УрО РАН  
УрО РАН – Уральское отделение РАН  
ЯрГУ – Ярославский государственный университет

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