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Chemical composition and provenance of Chinese porcelain shards recovered from Old Goa, west coast of India

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ABSTRACT

During recent archaeological explorations at Old Goa, west coast of India, twenty three Chinese porcelain shards of the Ming (Middle to late 16th century), Qing (17th century) and late Qing period (late 17th century) have been recovered. In order to understand the nature and source of raw material and kilns, these shards were analysed for major elements with X-ray fluorescence (XRF), trace and rare earth elements by Inductively Coupled Plasma-Mass Spectrometer (ICP-MS). The analysis suggests that porcelain shards are siliceous in nature (SiO_2 ~ 70%) and contain high Al_2O_3 (21.6%), Rb (388 ppm) and Ba (160 ppm) but have low Sr (48 ppm). This composition suggests that the raw materials used for producing porcelain were silica, kaolinite and sericite which are characteristics of porcelains manufactured in Southern China. Comparatively, high Al_2O_3 (kaolinite) content in porcelains of the Qing Dynasty suggest improvement of quality, particularly mechanical strength, of Jingdezhen porcelain. In general, major element composition, trace metals, total rare earth elements (ΣREE-67 ppm) and their chondrite - normalized pattern of the Ming, Qing and late Qing period are nearly similar and appear to be made of identical raw materials.

1. Introduction

In archaeology, pottery plays an important role in reconstructing the history of human civilisation. The nature and type of pottery is determined by the chemical composition of the clay and the way it was prepared; the temperature at which it was fired; and the type of glazes used. Comparatively, ceramics are more durable than earthen pottery and never disintegrate either buried in subsoil or underwater, unless low fired, therefore ceramics are considered the best indicators of contacts both within and outside the country. Similar to ceramics, lithics are more durable and provide evidence for interchange. Other materials such as shell have also been identified as indicators of long distance interchange between Europe, West Asia and Africa.

The history of pottery making in China goes back to the Neolithic period. In the second half of 2nd century AD, porcelain was initially produced in the Yue kilns and its export started from the 7th century AD onwards to many parts of the world which gradually helped to establish trade and cultural contacts with China (Li, 1998; Lin, 1999; Ma et al., 2012). Moreover, travellers have left accounts of Chinese ceramics after visiting China. Suleiman (851 CE), the Arab merchant, visited China and observed manufacturing of porcelain made of fine clay at Guangzhou (Shen, 1996). Al-Biruni (973–1048 CE), detailed how the Chinese potters took care in the preparation and maturing of clay (Lane, 1950). Al-Biruni has further delineated the trade contacts between Africa and some part of India and China (Sastri, 1939). Marco Polo (1254–1324 CE) visited a porcelain factory in China in 1280 CE and commented that Chinese porcelain was exported all over the world and Indian traders were active in Quanzhou between 1280 and early 1290 (Christie, 1998).

The blue and white porcelain was first produced during the Yuan period (1279–1368 CE) and new decorative motifs and shapes were adopted. The Yuan ceramics provided a thread of tradition and innovation in the entire ceramic history of China (Valenstein, 1989). The blue and white porcelain reached its zenith during the Ming (1368–1644 CE) and Qing dynasties (1644–1911 CE). During the Ming Dynasty perfection in the blue and white wares was attained and changes were made in style of decorative motifs. Jingdezhen kiln was the main center of production of porcelain. Ming porcelain was an indelible high water mark in the history of world art (Savage, 1961). The Majority of decorative elements and symbols used in decorating Ming porcelain have originated from Chinese folklore, tradition, mythology, religious significance and history. Patterns of general decorations are hardly ever used. The qualities of the Ming blue and white porcelains were indisputably superior to those of all the other periods (Lion-Goldschmidt, 1978). In the maritime trade, Chinese porcelain was exported to many countries on overseas trade networks from the 7th–8th

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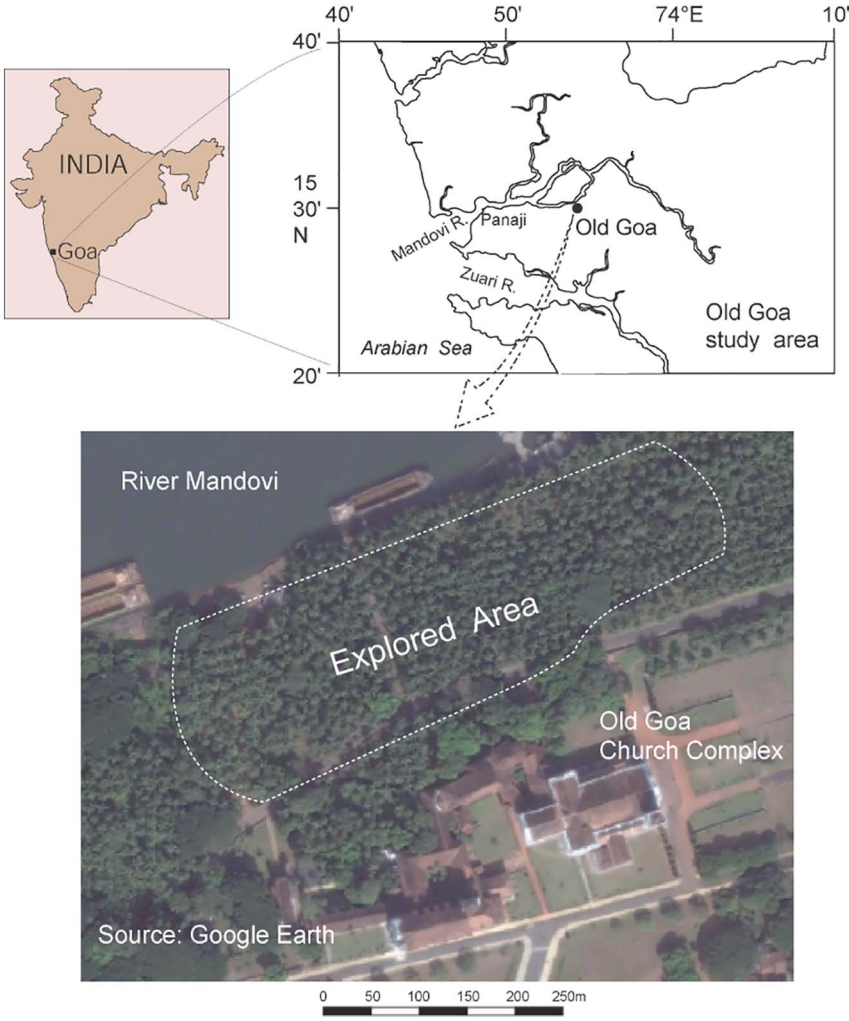

Fig. 1. Figure showing exploration area of Old Goa, Goa.

centuries and this trade increased substantially from the 13th century onwards to the Middle East, East Asia and Europe along the Indo-Chinese coast with ships sailing through the Malacca Straits and into the Indian Ocean. From there, traders delivered ceramics to markets in Sri Lanka and India, throughout the Persian Gulf region and along the East African coast. Besides other cargo, Chinese porcelain was the main consignment on ships and this has been confirmed from the exploration of shipwrecks in the seas around Southeast Asia. For instance, the Belitung shipwreck of 826 CE is the earliest known wreck on the Maritime Silk Route off Sumatra, Indonesia, carrying Tang Dynasty ceramics (618–907 CE) (Flecker, 2001, 2008; Guy, 2010). Thousands of Chinese ceramics have been recovered from the *Intan*, a 10th century shipwreck off the Java Sea (Flecker, 2002). Moreover, Chinese porcelain has been recovered from several shipwrecks of later periods, where the ceramics were carried either as a part of cargo or used daily onboard. In the Indian context, Chinese ceramics has been recovered from land and shipwreck sites datable to the post 10th century AD onwards. From the medieval period onwards Chinese porcelain became more common in almost every site in India and there are hardly any sites without it (Muhammed, 1994).

The process of development of porcelain in north and South China is closely bound with the use of different raw materials. Rich deposits of porcelain stones (porcelain stone is a natural stone/rock and its chemical composition is nearly similar to porcelain) in South China were used for manufacturing of the characteristic siliceous southern Chinese porcelain wares. In the case of northern Chinese porcelain, different types of clay were found which are characterized by high Al content (Guo, 1987). It has been observed that the composition of ceramics is based on the nature, quality and quantity of raw materials available in the region. The nature, types and provenance of raw material, the production processes such as washing and mixing of raw material, and period all influence the chemical composition of Chinese porcelain (Yin et al., 2000; Wu et al., 2000; Li et al., 2003). The elemental concentration in porcelains can be achieved by the most common analytical techniques: namely X-ray fluorescence (XRF), energy dispersive X-ray fluorescence (EDXRF), neutron activation analysis (NAA), electron probe micro analysis (EPMA) and proton-induced X-ray emission (PIXE) (Li et al., 2000; Cheng et al., 2002; Li et al., 2003, 2005; Leung et al., 2000). The major element composition of the raw material used in porcelain may not vary much, whereas trace element concentration vary considerably and those can be analysed on Inductively Coupled Plasma-Mass Spectrometer (ICP-MS) because of the excellent accuracy, precision and detection limits of this technique (Li et al., 2003, 2005). The ICP-MS has capability to analyse over 40 elements with very small sample weight (10–50 mg) within 3 to 4 min. In the Indian sub-continent, large quantities of Chinese porcelain, both shards and complete specimens, have been recovered during archaeological studies; however no attempt has been made in the past to understand their chemical composition, nature of raw materials and provenance based on chemical composition. Therefore, for the first time an attempt has been made to analyse major elements with XRF, and trace and rare earth elements on ICP-MS of twenty three Chinese porcelain shards collected from Old Goa during recent exploration, mainly to understand the raw materials used in manufacturing and their provenance.