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Original article

## Toward a fast non-destructive identification of pottery: The sourcing of 14th–16th century Vietnamese and Chinese ceramic shards



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### ABSTRACT

Vietnamese pottery appears to have been exported by the Indian Ocean Monsoon trade since medieval times. However, the number of identified Vietnamese stoneware/porcelain remains very small by comparison with Chinese productions (<0.1%) and the question of mis-assignment remains open. In order to evaluate the potential of on-site identification, an assemblage of 13 ceramic shards recently excavated from the medieval port site of Qalhāt (Omani coast) assigned to Vietnamese and/or southern Chinese productions by using stylistic/visual criteria has been qualitatively analysed with a portable X-ray fluorescence instrument and a transportable Raman spectrometer and compared with data recorded on a large variety of reference shards excavated from different kiln places of the Hong River bank, Central Viet Nam, and from the Cù Lao Chàm shipwreck. In the glaze/body, the zirconium, rubidium and titanium contents allow distinguishing between Vietnamese and Chinese ancient/modern productions. The potassium vs. calcium glaze content is also very efficient for the differentiation between the Chinese and Vietnamese origins. Measurements confirm ~80% of the assignments based on eyes examination. The manganese, Rare Earth and cobalt content also contribute to identify the production places. Comparison of the glaze sections and chemometrics are used for a final comparison of the production technology: slip, overglaze or underglaze décor, etc.

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## 1. Aim

### 1.1. Historical and methodological background

Chinese porcelains have been exported by land (Silk Road) and maritime trade routes during medieval period [1–5]. In terms of global history, as early as the 1st century CE, a series of long-distance maritime networks emerged, based on the seasonal shifting of the monsoon winds. Their development led to the progressive integration of different regions of the Indian Ocean. From the 7th century onward, specifically because of the parallel expansions of the Chinese empire of the Tang dynasty (618–907) and of the world of Islam, the Indian Ocean and China Sea were interconnected and formed the first cross-continental global systems [6–8]. It was through this very Afro-Asian maritime global

network that a regular westward trade by sea of oriental ceramics seems to have started around the 9th century [9,10]. Thanks to considerable efforts of archaeologists since these last decades, a very large quantity of Chinese and South-East Asian ceramic shards have been yielded and collected from archaeological sites located both in coastal and offshore regions of the western Indian Ocean and its subordinate seas. Due to their durable nature, a wealth of examples of ceramic shards survived in archaeological sites offer some very promising historical and anthropological information for studies both of global mercantile networks and of local and regional material cultures. Methodologically speaking, “style” approach – in terms of objects’ shape, form and decoration – has been generally used to assign dating and origin, while technical studies on these archaeological data have been most occasionally conducted on shards excavated in Ocean Indian trading posts [11,12].

In spite of its limits, stylistic analysis has revealed the multi-national nature of the oriental ceramics trade across the Indian Ocean. Regarding Vietnamese ceramics imported into the western Indian Ocean, shards of green-glazed stoneware found from the

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layer dated to the end of the 8th or the beginning of the 9th century – layer located under the foundation of the first mosque – on the port site of Siraf might originate from the Hong River bank region in Northern Viet Nam [13]. Nevertheless, scholars agree that it is only from the latter half of the 14th century that Vietnamese ware might be introduced into regular long-distance trade through the Indian Ocean because of a scarcity of Chinese wares from the 14th century; these imports will be maintained until the first decade of the 16th century, as an attest evidence from numerous port and shipwreck sites [14–16]. As well for other archaeological artefacts, studies related to the diffusion of Vietnamese wares are made until now exclusively by using stylistic and visual technical criteria [14–23]. To date, the proportion of Vietnamese pottery identified remains very weak (less than 0.1%) of Asian sherds found along Indian Ocean Coast, even for the time of the Ming exportation ban and the question of mis-assignment remains open. Because of the small number of concerned sherds and the ethic of conservation of artefacts in their excavation Country, the development of non-destructive, mobile analysis procedure is necessary.

Strictly speaking, identification of the origin of a shard is possible only when the shard in question can be matched with evidence from a production site. Fortunately, kiln site archaeology in China has developed considerably since the 1990s onwards. Several hundred kiln sites have been discovered or surveyed all over the country, and many important excavations have been undertaken on the sites that produced ceramics for overseas trade. The traditional insight of Chinese ceramic trade based on main kiln sites, such as Jingdezhen and Longquan kiln complexes, is most notably challenged by these new data. For instance, in relation with Vietnamese productions, generally identified from their grey body and specific décor style, numerous kiln sites in Southern China have provided sherds bearing usual features that are observed previously only on Vietnamese ware. For example, blue-and-white ware with a chocolate base is revealed from Yuxi or Jianshui kiln sites in the Yunnan Province [24–26] that look similar to the products produced in Chu Đâu, Viet Nam during the 14–15th century [27–30]. Furthermore, samples in green-glazed stoneware with firing-scars and/or sharing stylistic parallels with South-East Asian productions have been excavated or collected from a large number of sites located in the Fujian, Hunan, Guangxi, Guangdong and Yunnan Provinces [31]. Traditional style approach having been thus challenged by these new data, a cross-study of style and technology should be tested in order to find a new and promising scope to assign the origin more confidently.

Compositional analysis and technical insight in the body microstructure and glaze nanostructure are time and sample consuming. Although Chinese porcelains have been extensively studied by a variety of archaeometric and ceramic methods since a long time [32–52]. However, these studies have been conducted at the laboratory using heavy instruments (see above references) and many measurements require a preparation of the sample. The availability of portable XRF instruments makes possible the non-invasive, fast analysis of the body, glaze and pigment-rich area of many samples, offering a more representative view of the technology. However, a large debate is carried out in the abundant literature because of the qualitative character of the measurements [53–60]. Some groups are searching to establish the accurate composition of a very limited number of selected samples using fixed instruments but the representativity of the selected samples can be questioned. However, such approach, valid for glass artefacts, intrinsically homogeneous and with limited production places, does not reflect the intrinsic dispersion of ceramic productions in one place at one time because of the intrinsic dispersion of the raw material composition, even in a quarry. Furthermore, the technical requirements (paste plasticity, mechanical strength of the green body, sintering temperature window, temperature gradients in the

kiln, glaze wettability, glaze-body thermal expansion mismatch... ) make mandatory the assemblage of different raw materials. And the others are trying to determine qualitative sourcing criteria using data obtained from the non-destructive portable XRF (pXRF). This technique allows studying a large number of samples that give a statistic view of the production variability.

Previous studies [55,56,58,59] demonstrated that pXRF was a both primary and complementary method in qualitative and semi-quantitative analysis of porcelain, stones and other ceramic materials. In order to evaluate the potential of this instrument prior to the action of on-site analysis campaigns, 13 samples assigned to the Vietnamese and/or southern Chinese productions (among 40 found) were imported to France with authorization of the Ministry of Heritage and Culture of the sultanate of Oman (monocolour-glazed stoneware, blue-and-white ware, and underglazed brown painting stoneware). The total number of Asian origin sherds found is 4000 but most of excavated sherds (~90,000) have local or regional origin. Representative sherds collected from kilns sites in Viet Nam (for instance those from the Chu Đâu, My Xa and Ha Lan kilns sites, Hong River bank region; Ngu Hanh Son, Da Nang, Central Viet Nam), as well as with those from the Cù Lao Chàm shipwreck cargo have been selected as references. The later groups of samples have been previously studied by different techniques [27,29,30,61–63]. Modern samples of different origin as well as ancient Chinese porcelains with good pedigree were also considered in order to make sure that the parameters characteristic of Vietnamese productions are specific, not common to sherds of other origins. Major, minor and traces element contents, characteristic of raw materials (sand, kaolin/clays, feldspar) and/or production process (Fe) as well as colouring ores will be discussed. The comparisons of the microstructure and of the Raman fingerprint of the different glazes will be used to ascertain the artefact belong to Vietnamese kilns or not. Obviously the information on elemental composition given by mobile XRF measurements remains qualitative and do not have the same reliability of measurements performed on sample prepared for the analysis and studied with bigger instruments and adapted procedures. In order to assess the identification on technological criteria the composition parameters will be selected and discussed with respect to the raw material compositions.

### 1.2. The port site of Qalhāt

Qalhāt (22° 41' 40" N; 59° 22' 30" E) is one of the most impressive archaeological sites of Oman, with a huge area of ruins of about 35 ha. It is located on the coast of Al-Sharqiyyah province, 20 km north of the city of Sūr. According to literary sources, the port, created around the 11/12th centuries, was the twin city of Hormūz during the 13th to 15th centuries. Hormūz ports are mentioned in old Chinese sea-route maps, e.g. the so-called *Zheng He hanghai tu* [5]. It was supplanted by Muscat as the chief port of Oman in the fifteenth century and was probably devastated by an earthquake at the end of the century. However, it was still one of the main coastal cities of Oman when the Portuguese sacked it in 1508. It subsequently became a station for the Portuguese fleet and was then permanently abandoned in the second half of the sixteenth century [64,65]. The Qalhāt Project started since 2008 is under the authority of the Ministry of Heritage and Culture of the sultanate of Oman and the French archaeological Committee of the Ministry of Foreign Affairs and the National Centre for Scientific Research (CNRS-UMR8167). The objectives of the Qalhāt Project are manifold. First, to provide information on the history of Qalhāt itself, its foundation, rise and decline, and on the local economy, exchange networks of the harbour, and the part it played in the Indian Ocean trade, especially during the Hormūzī period which is still poorly documented. Secondly, to provide information on the layout of a

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