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# Investigation of Neolithic pottery from Ebrahimabad in the central plateau of Iran, utilising chemical–mineralogical and microstructural analyses

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## ABSTRACT

Prehistoric sherds recovered from Ebrahimabad, in the Central Plateau of Iran, were investigated using X-ray fluorescence (XRF), X-ray diffraction (XRD) and scanning electron microscope (SEM)/energy dispersive X-ray (EDX) analyses. The results showed a gradual evolution in production from Sialk I-type pottery to Sialk II-type pottery, eventually leading to the production of bulk red pottery. The relative similarity of composition, homogeneous microstructures and the presence of high-temperature phases demonstrated a high degree of specialisation in the selection of raw materials and control of firing temperature and atmosphere by the potters of Ebrahimabad in the late fifth to early sixth millennia BC, peaking in the final phase associated with Sialk II.

## 1. Introduction

In 2003 an international project was launched in order to study the socio-economic transformation of the Neolithic and Chalcolithic settlements within the Central Plateau of Iran. One of the main objectives was to study the evolution of craft specialisation and settlement patterns of pre-urban societies in the region (Coningham et al., 2004; Fazeli et al., 2007a). Multidisciplinary work was carried out to provide stratigraphic information and absolute dating, as well as to characterise the pottery excavated from three sample sites on the Central Plateau, namely Pardis, Ebrahimabad and Sialk, located on the Tehran, Qazvin and Kashan plains, respectively.

In this paper, the stratigraphic information and absolute dating, as well as characteristics of the pottery excavated from the Ebrahimabad site in 2006 (Fazeli et al., 2007b), will be discussed. Tepe Ebrahimabad is located on the Qazvin Plain in the Central Plateau of Iran, 20 km southeast of the city of Qazvin (Fig. 1).

The main geographical features of the Central Plateau of Iran include mountains, deserts and plains. According to geological studies, a great tectonic line separates the Central Plateau from the geological deposits to the south (Dewan and Famouri, 1968). Along this line eruptive rocks, such as andesite, and numerous springs are present in different areas. These springs have caused the deposition of travertine, a form of limestone, and sediments from the Palaeozoic, Mesozoic and Tertiary are also present (Dewan and Famouri, 1968).

The plains are mostly covered by water-transported alluvial sediments, and encompass a number of inter-montane areas and small

*kavirs* that can be divided into different micro-environmental zones (Fazeli, 2001, 14). Alluvial fans are the most extended sediments found across the plains. They are fan-shaped deposits formed where a fast-flowing stream flattens, slows down and spreads, for example at the exit of a valley onto a flatter plain. They are the main site of deposition in areas where mountains gradually wear away, over geological time spans, and basins are filled with sediment (Wilkinson, 2003, 76–78). Alluvial fans in the Central Plateau range in size from less than 1 km<sup>2</sup>, to massive fans measuring more than 2500 km<sup>2</sup>, for example Jajrud located on the Tehran Plain (Beaumont, 1972). The exact date of the appearance of alluvial fan sedimentation on the Central Plateau is not clear, but it has been suggested that optimum conditions for the formation of fans were initiated mainly during the glacial phases of the Pleistocene. Two major phases of alluvial deposition in Iran are recognised (Beaumont, 1972; Vita-Finzi, 1968): an earlier phase of deposition that probably began about 50,000 years ago and had ended by the fourth millennium BC; and a second phase that occurred during the Middle Ages. Because of the lack of data, it is impossible to estimate the thickness of the alluvial fans correctly. For example, in the Tehran Plain, which is a structural basin at the southern margin of the Alburz Mountains, formed by the down warping of Palaeozoic and Mesozoic sediments and Eocene volcanic materials (Beaumont, 1972), thick Miocene beds were laid down and, more recently, thick alluvial deposits from Jajrud (one of the main rivers in the region) flooding events have played a significant role in depositing large volumes of sediment over a short time period (Beaumont, 1972). These sediments consist mainly of fine-grained clays and silts, as well as coarse sands and

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Fig. 1. The location of the site of Ebrahimabad, Iran.

granules. Limited excavations on the Jajrud fan have revealed the existence of a deposit 275 m deep, but greater thicknesses might occur elsewhere (Beaumont, 1972). The plain of Qazvin is another large alluvial basin comprising volcanic rock formations filled with deep sedimentary layers composed of fine-textured alluvial soil that has been deposited since prehistoric times by downwash from the mountains.

Ebrahimabad is a small circular mound (250 × 250 m) situated about 8 m above the surrounding plain. In an excavation of Ebrahimabad in 2006, carried out by the University of Tehran, three stratigraphic trenches (I, II and III) were excavated in the central, west-central and eastern parts of the mound (Fazeli et al., 2009). Trenches I and II were excavated down to virgin soil, and all the excavated areas produced mud-brick walls and domestic structures such as ovens and fire pits.

Two types of pottery were recovered from Ebrahimabad, Sialk I buff ware and Sialk II red ware, which are widely distributed across the Central Plateau (Fig. 2a,b). Ghirshman first reported the existence of these pottery types following his excavation at the site of Sialk in 1936–38 (Ghirshman, 1938). Sialk ware continues to be a key cultural and chronological marker for the interpretation of the late prehistoric chronology of the Central Plateau (Table 1). Sialk I ware (dated to c. 5600–5200 BCE) is characterised by handmade, buff, painted pottery, decorated with simple black geometric motifs. The succeeding stage, Sialk II ware (dated to c. 5200–4600 BCE), is characterised by thin handmade, red, painted pottery, typically decorated with black motifs that include simple or composite geometric designs.

The presence of Sialk I pottery, with its main distribution in regions such as Kashan and Tehran, shows that by early sixth millennium BC there were cultural interactions between large areas of the Central Plateau (Marghussian et al., 2017). The excavation of Ebrahimabad (Fazeli et al., 2007b, 2013) was carried out in order to investigate the possible presence of Sialk I pottery in the Qazvin Plain, another area located on the Central Plateau. These excavations have revealed for the first time the presence of pottery characteristic of Sialk I and II in the Qazvin Plain, and provided an absolute chronology for the Qazvin Plain's Late Neolithic to Early Transitional Chalcolithic sequence (Fazeli et al., 2007b, 2010, 2013).

Since the start of archaeological studies in Iran, ceramics from the Central Plateau have been studied in a traditional manner, using descriptive and classification methodologies, based mainly on the colour and decoration of the pottery. Using more advanced techniques, such as chemical–mineralogical analyses and microstructural studies, to

characterise the newly excavated pottery from Ebrahimabad, as well as stratigraphic information and absolute dating, should help us gain a better understanding of the evolution of the processes behind these pottery styles, including changes in techniques and the organisation of ceramic production from the Late Neolithic to the Transitional Chalcolithic (c. 5700–4800 BCE) in this region.

To the authors' knowledge, the techniques used in the present study have not been used previously to characterise the prehistoric pottery of this region. By providing additional information on the evolution of the pottery process, the results of this study can help us address questions about the causes of the general chromatic change in pottery that occurred in the region from the Late Neolithic to the Transitional Chalcolithic, and reveal the relevance of this to the economic and cultural connections and interactions of the prehistoric communities living in the Central Plateau during that period.

## 2. Materials and methods

### 2.1. Sample selection

For the present study, 22 sherds from the Ebrahimabad site (Table 2), excavated in 2006 (Fazeli et al., 2009, 2013), were investigated. The sherds comprised two different assemblages of <sup>14</sup>C-dated Sialk-type pottery, an assemblage of 12 Sialk I sherds and an assemblage of 10 Sialk II sherds (Table 2). The samples for each assemblage had been randomly selected from the excavated pottery on the basis of their appearance (colour and decoration). The Sialk I pottery samples were selected from the excavated buff pottery group decorated with black-painted simple geometric motifs, and Sialk II samples from the excavated red pottery group decorated with black-painted simple or composite geometric motifs.

### 2.2. Typology

The excavated pottery was divided into a number of broad categories: jars (form J), bowls (form B), beakers (form BE), trays (form T), bases (forms F and R) and dishes (form D). Each of these categories was further subdivided, generally along the lines of having open or closed mouths (e.g. B1 and B3). A further subdivision was then made depending on whether the sides were steep or shallow (e.g. J1a and J1b). Fig. 3 depicts the main forms of excavated pottery from Ebrahimabad.

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