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EXCAVATIONS AND RESEARCHES AT SHAHR-I SOKHTA 2

Edited
Seyyed Mansur Seyyed Sajjadi
Enrico Ascalone

پژوهشکده باستان شناسی

UNIVERSITAS STUDIORUM LUPENSIS

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TEHRAN 2022

In the Name of God

Excavations and Researches at Shahr-i Sokhta 2

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ERSS ('Excavations and Researches at Shahr-i Sokhta') is a peer-reviewed series dedicated to the researches and excavations in eastern Iran, which gives account of studies of University of Salento and Iranian Center for Archaeological Research (= ICAR).

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Demographic Considerations Regarding the Settlement and Necropolis of Shahr-i Sokhta[1]

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1. Archaeological premise

The earliest archaeological investigations in Sistan were conducted by Sir Aurel Stein, who undertook preliminary research throughout the area, followed by subsequent journeys in Baluchistan and the Halil valley (Stein 1928; 1931; 1937). Previous work had been conducted by G.P. Tate, who drew the first detailed map of the area (Tate 1909; 1910-1912), subsequently used by E. Herzfeld in his surface reconnaissance in the regions of Rūd-i Biyaban and Rūd-i Sistan (Herzfeld 1916; 1931-32). After these pioneering steps, the first excavations were conducted by R. Ghishman in the 1930s in Nād ʻAlī (20 km south-east of Chakansur, in today's Afghanistan) (Ghirshman 1939; Ghirshman *et al*. 1959), followed by the work undertaken from 1951 to 1959 by J.-M. Casal in Mundigak, where a new cultural horizon was identified (Casal 1961; 1966). Meanwhile, in 1951 new information on the major settlements of the 3rd and 2nd millennia BC was gathered by the detailed surveys conducted by W.A. Fairservis throughout the region (Fairservis 1961).

1. Paragraphs 1 and 2 are by Enrico Ascalone and 3 and 4 by Pier Francesco Fabbri. The conclusions were written by both authors (E. Ascalone wrote the topographical and settlement notes, P.F. Fabbri wrote the anthropological notes).

Excavations began in Shahr-i Sokhta a few years later with the Italian mission headed by M. Tosi, who launched a new and intense season of research that lasted from 1967 to 1978, revealing the cultural horizons, chronological sequences and historical phases of the settlement (Tosi 1967; 1968a; 1968b; 1969a; 1969b; 1969c; 1969d; 1969e; 1970a; 1970b; 1971a; 1971b; 1971c; 1972a; 1972b; 1972c; 1972d; 1972e; 1973a; 1973b; 1974; 1975; 1976a; 1976b; 1976c; 1977; 1978a; 1978b, 1983). The excavations focused on separate sectors, yielding initial data on the topographical organisation of the settlement, which was occupied from the mid 4th to late 3th millennium BC. Six sectors were excavated: the so-called *Craftsmen's Area* (Mariani 1981; 1984; Foglini - Vidale 2000), the *Eastern Residential Area* (Biscione 1979; Cattini 2000; Fiandra - Pepe 2000), the *Central Residential Area* (Salvatori 1979; Salvatori - Vidale 1997), the *Monumental Area* (Mariani 1989), the necropolis (Piperno - Tosi 1975a; 1975b; Piperno 1976; 1977; 1978; 1979; 1986, Piperno - Salvatori 1982; 1983; 2007) and the industrial area, identified to the south of the funerary complex outside the settlement. On the basis of the investigations conducted and a new multidisciplinary approach to what was being unearthed, the Italian mission identified four periods of occupation, divided into a total of 10 cultural phases (Biscione *et al*. 1977; Salvatori - Tosi 2005; Ascalone 2021).

On the basis of more recent results the periods in Shar-i Sokhta can be divided as follows:

Shahr-i Sokhta I (ca. 3550-3000 BC): the ceramics show affinities with the *corpora* of Mundigak and eastern Baluchistan (especially the Quetta valley), while there are numerous decorative parallels with the ceramic horizons of Namazga III (Biscione 1973; 1974; 1984; Pracchia 1983; Sarianidi 1983). This period saw the appearance of so-called *Grey Streak-Burnished Ware* (seen in Yahya IVC-IVB6) and polychromatic fragments of Nal ceramics. While the cultural centre of gravity seems oriented towards Turkmenistan and Baluchistan, a tablet and cylindrical seals of clearly proto-Elamite origin were discovered, making it possible to establish a stratigraphic connection with Susa IIIA (levels 16-14A of the *Acropole*), Tall-i Malyan (Ancient and Middle Banesh period) and Yahya IVC (Amiet - Tosi 1978; Amiet 1979; 1983).

Shahr-i Sokhta II (ca. 3000-2600 BC): the second period is better known, thanks to the more abundant and more widespread architectural evidence, found in many sectors of the settlement (Biscione 1990; 1993). The ceramics follow the evolution of the previous period with new standardised morphologies that are close to the horizons of Namazga IV (Biscione - Bulgarelli 1983; Pracchia 1984), Bampur III-IV and Mundigak IV1-2. Intense relations with the so-called Turan culture are attested (Bulgarelli 1977; 1981; 1983; 1998; Biscione *et al*. 1981), with bronze and stone stamp seals showing a homogeneity not seen in the previous period (Baghestani 1997).

Shahr-i Sokhta III (ca. 2600-2400 BC): *Fine Black Painted Grey Ware* has clear parallels in Bampur IV2-3 (Wright 1989). The production technique of the individual artefacts also has analogies with what has been found in Baluchistan, while the glyptic *corpus* is highly similar to that of Margiana and Bactria (Ferioli *et al*. 1979; Fiandra 1981).

Shahr-i Sokhta IV (ca. 2400-2300 BC): Reddish Ware seems to have spread more rapidly, with a loss of decorative features and a general impoverishment in terms of craftsmanship. Parallels are recognised in Namazga V and Yahya IVB. Shahr-i Sokhta seems to have participated actively in the extensive cultural interferences of the period, in which an integrated cultural system seems to have emerged in the mid 3rd millennium BC, involving the Indus and Oxus valleys, Jiroft and the Hirmand valley (Ascalone 2014; 2018).

Shahr-i Sokhta V (ca. 2100-2000 BC): the centre is partially reoccupied after a period of neglect in the area of the Burnt Building, this period is also documented in the settlement of Rūd-i Biyaban and in the Sistan region where BMAC material is widely attested. Modest amounts of new black-painted burnished grey ceramics also appear.

More recent and highly significant discoveries have been made during the new excavations conducted by the Iranian mission headed by S.M.S. Sajjadi, which began in 1997 and have yielded extraordinary evidence regarding the settlement's IV period (especially Areas 1, 20, 26 and 28) and the entire necropolis complex (Sajjadi 1999a; 199b; 2000; 2001a; 2001b; 2002; 2003a; 2003b; 2004a; 2004b; 2004c; 2005a; 2005b, 2006; 2014a; 2014b; Sajjadi - Moradi 2017).

2. Areas investigated and the periodisation of Shahr-i Sokhta

It is difficult to give a precise estimate of the size of the settlement during the four periods identified, although, as we will see, the data resulting from the surface reconnaissance conducted by the Italian mission in the 1960s and 70s are fundamental in this regard (see especially Salvatori - Tosi 2005 and Biscione *et al*. 1977).

The main areas excavated show an elaborate topographical layout during Periods II and III of the site, yielding a linear and uninterrupted stratigraphic sequence in the first half of the 3rd millennium BC. Unfortunately, the settlement's early formative period (Period I) is attested only in the *Eastern Residential Area* in the *House of the Foundation*, which has yielded an uninterrupted sequence up to Shahr-i Sokhta IV. It is difficult to verify, without systematic and extensive step trenches in the various sectors of the settlement, whether this fairly sporadic presence of the I period in Shahr-i Sokhta is in some way due to archaeological chance and/or the fact that, for obvious reasons, Period I ceramics are numerically far less frequent on the surface of the site. A detailed study of the grave goods of the necropolis that can link the stratigraphic sequences detected in the settlement with the ceramic horizons of the individual funerary complexes has yet to be conducted. In the meantime, the previous surveys by the Italian mission paint a rather homogeneous picture, although this has been slightly modified in the light of the most recent investigations, which have made it possible to propose a broader topographical layout than was previously thought for the final period of the settlement (Sajjadi - Moradi 2017).

The southern sector plausibly developed as area for processing stone, as indicated by the numerous finds gathered on the surface (fragments of jasper, chalcedony and flint). It lies to the south of the necropolis and has been generically dated to the settlement's final period, perhaps also the terminal stages of Period III, on the basis of the seriations of the ceramics gathered on the surface (Biscione *et al*. 1977: 81). The area does not seem to have yielded any evidence of the more ancient periods and specifically no ceramic horizon coeval with *Building 33*.

The residential area, within which lies the entire eastern sector of the settlement, including the *Burnt Building,* has an area of 16 hectares and is, to date, the only area in which all the site's periods of occupation are documented (Shahr-i Sokhta I-IV). In contrast, the area known as the *Central Quarters*, covering about 20 hectares, has yielded a habitational sequence that runs from Phase 8 (Period II) until Phase 3 (Period III), chronologically from about 3000 to about 2450 BC. The same chronological sequence has been verified for Area 33, which is not believed to have lasted beyond 2450 BC, indicating a close topographical and occupational fit with the above-mentioned *Central Quarters*.

In the same way, the so-called *Monumental Area*, in the northern part of the settlement, seems to provide evidence of occupation from the Period II to Period IV (Phases 8-1), while the *Craftsmen's Area*, located in the north-western corner of the site, yields a ceramic horizon that is fairly close to what has been found in the *Burnt Building* and can be reliably dated to the settlement's final phases of life.

This diachronic reconstruction of the settlement of Shahr-i Sokhta, which posits an initial settlement about 15.5 hectares in size that grew gradually until reaching its greatest extent around Phase 3 of Period III and then underwent a general collapse in the final phase (Shahr-i Sokhta IV, Phases 2-1) (Biscione *et al*. 1977: 84), must now be modified however to take account of the new evidence discovered by the Iranian mission headed by S.M.S. Sajjadi. Indeed, the excavations of new sectors have demonstrated Period IV occupation throughout the central part of the settlement, with the final phases of the settlement attested in Area 1 (levels A-E = Periods II and III and level F = Periods III and IV), Area 20 (Periods III and IV, with Phases 2 and 1 verified for the latter), Area 26 (Period IV, Phase 1) and Area 28 (Period IV, Phase 1) (Sajjadi - Moradi 2017).

3. Estimates of the population

In order to estimate the number of inhabitants of a site, reference is usually made to indicators linked to the number and dimensions of the dwellings, as well as the size of the site itself and the area used by the site (Site Catchment analysis,

Chamberlain 2006). Very often, for these indicators to be usable in archaeology, they have to be assessed with reference to a modern-day sample. It is widely held that estimating the population of a site on the basis of the population of the necropolis is a rather unreliable approach that generally results in lower estimates than are produced by other methods (Peroni 1994; Bietti Sestieri 1996). This is not because the method is unreliable in itself (Hilpert - Zimmermann 2008). On the contrary, according to Peroni (1994: 225) "If we wish to remain on a truly firm footing, there exists only one type of evidence that can be relied on for assessing the demographic weight of a given community: funerary (our translation)". Rather, it is because reliability requires the fulfilment of a number of criteria that are rarely met all together. According to Peroni, the main criteria are the following: the necropolis must have been excavated in its entirety, it must be the only one and it must have been used by the whole of the population. Another requirement, in our view, is that the human remains are in a good state of conservation regardless of individual age, gender, type of burial and topographical position inside the necropolis.

4. The necropolis of Shahr-i Sokhta

After almost 50 years of research, the only known necropolis today in Shahr-i Sokhta was discovered in September 1972 by the Italian mission, which in successive excavation campaigns found 220 burials. Descriptions of the human remains were published by E. Pardini and colleagues (Pardini - Sarvari-Negahban 1976; Pardini 1977; 1979; Pardini - Lombardi Pardini 1990; 1992; 1997; Mannucci *et al.* 1985). Another 52 individuals were analysed, after the Italian excavations ended, by Macchiarelli and Passarello (1988). About 900 burials were excavated during the Iranian excavations of 1997-2015 (Sajjadi 2015a), of which 525 were anthropologically studied by Forunzafar (2010). The Italian excavations were mainly directed at the northern and central areas of the necropolis, whereas the Iranians concentrated on the central area, with limited assays to the north and south. In this paper we propose to assess whether it is possible, considering the data provided by the authors who originally studied the

skeletal remains and estimated the size of the necropolis, to obtain an estimate of the size of the population that inhabited the site during its roughly 14 centuries of existence.

Assuming that Shahr-i Sokhta had only one necropolis – in 50 years of research no other burials have been discovered in the settlement – this would mean that Peroni's criterion (1994) of it being used by the whole population was met. The necropolis has not been completely excavated, but knowing its physical extent and having excavated a rather large sample of it, including a total of more than 1,100 burials, it is possible to calculate the area in m2 occupied by each burial and extend it to the necropolis as a whole. Unfortunately, the fourth requirement, i.e. that all the human remains be in a generally good state of conservation, is not met. As we have been able to verify in person, the state of conservation of the human remains in the necropolis of Shahr-i Sokhta is highly variable: some skeletons are in an excellent condition, with even part of the hair still present (Lorentz 2010), while others are reduced to corroded and indeterminable fragments. In the sample considered by Sajjadi (2014a), 153 skeletons out of 596 (24%) were not studied due to their very poor state of conservation. The state of conservation varies in relation to the topography of the necropolis and the depth of discovery of the burials (Sajjadi 2005b). Therefore, the decay may have selectively affected certain phases of use of the necropolis and certain types of tomb, while the average density of the burials and the number of individuals per burial is clearly the result of a conservative estimate.

In a small sample (n=138) of skeletons whose age was determined at least qualitatively, drawn from Sajjadi *et al.* (2003; 2006) and Lorentz (2008; 2010), we have only 6 (51‰) children of less than a year (Macchiarelli - Passarello 1988), while in a sample (n=237) from the Italian excavations we find 22 individuals of less than a year (93‰). The raw demographic parameters based on the sum of the two samples (see Table 1) indicate an infant mortality (D0-1) of 77‰, mortality before the age of 5 (D0-4) of 189‰ and a ratio of non-adults to adults (D0-19/D0+) of 387‰. From the sample of Sajjadi (2015a), it is not possible to derive the ages by numerical class, because the individuals are assigned to qualitative

classes (*newborn*, *child*, *male*, *female*), although the ratio of non-adults to adults (D0-19/D0+) is 488‰. These data are simply not consistent with Bronze Age demographics. For example, Masset (1976), on the basis of parish registers in France under the Ancient Régime, found an under-5 mortality rate of 500‰-550‰, and a ratio of non-adults to adults of 500‰-620‰. It is clear that among the skeletal remains that were sufficiently well conserved to allow determination of the age of death, individuals of low age, dying below the age of 5, are under-represented. Regarding the older age classes, in the Shahr-i Sokhta sample as a whole the ratio of 5-9 to 10-14 years old (D5-9/D10-14, see Table 1) is 2.5. According to Bocquet and Masset (1977) in archaeological samples the ratio is almost always above 2, indicating that the 5-9 age class is not under-represented and thus does not need to be estimated.

The general scarcity of remains of very young individuals, and of infants (0-1 years) in particular, in archaeological samples requires the use of indices that estimate the demographic parameters of a skeleton population without taking account of the unrealistic percentage of infants discovered (Bocquet-Appel - Masset 1982, Bocquet-Appel - Naji 2006). The index (d) is derived from the ratio of juvenile individuals (aged 5-19) to all individuals aged 5 and above, i.e. d = D5-19/D5+. The index is calculated on the basis of the remains of individuals who have a greater probability of resisting diagenesis. The index is closely correlated with certain demographic parameters, which can thus be estimated using samples in which children are highly under-represented, so as to avoid including extremely low infant mortality values recorded in the archaeological samples in the calculations. This method is based on the hypothesis, that of the null growth rate, which is generally very difficult to verify in an archaeological population. In the specific case of Shahr-i Sokhta we have at least two indicators that the opposite is true: since the site existed for about 14 centuries and was then completely abandoned, for it to have had a stationary population its inhabitants must have all moved there at the same time, remaining at the site until they just as suddenly all left together, not a plausible hypothesis. The archaeological data suggest that the settlement varied in extent, and did not occupy the entire site

for the whole of its duration. This variation in physical area is assumed to have reflected variation in the size of the population and thus a growth rate that was not null (Biscione *et al.* 1977, Salvatori - Tosi 2001). In our favour is the long duration of the occupation of the site, about 14 centuries. In such a long period it is probable that variations in the growth rate, positive and negative, cancelled each other out, producing a growth rate near zero (Bocquet-Appel - Masset 1977). Salvatori and Tosi (2001: 189, fig. 12) present a graph that estimates the size of the settlement on the basis of surface discoveries, which show growth during the first half of the site's occupation and shrinkage in the second. If this is correlated with the population, our hypothesis of long-term null growth in the period is not too far from the truth. More recent data seem to refute this hypothesis however, indicating that in its later phases, the settlement actually occupied a much larger part of the site (Tab. 1).

D0-19 = individuals dying before 20 years of age (non-adults); D20+ = individuals dying at least 20 years of age (adults); D0+ = total individuals; D0-1 = individuals dying before one year of age (infant mortality); D2-4 = individuals dying at more than one year of age and less than five; D5-9 = individuals dying at more than 5 years of age and less than 10; D10-14 = individuals dying at more than 10 years of age and less than 15; D15-19 = individuals dying at more than 15 years of age and less than 20. The totals for sample 1 are not equal because for two young individuals the age was not determined.

The following estimates of the number of burials present in the necropolis of Shahr-i Sokhta, distributed over an area of 20-25 hectares (Sajjadi 2015a) have been made: more than 19,000[2] (Piperno - Tosi 1975); 18,000 (Bonora *et al.* 2000); 22,000 (Piperno 1976); 31,000-37,500 (Sajjadi - Forunzafar 2001; Sajjadi *et al.* 2003); and 37,500-40,000 (Sajjadi 2015a). We decided to use the higher figure, 40,000, which takes account of the more recent excavations in the necropolis.

The population of the necropolis cannot be derived directly from the number of supposed burials, because not all the graves identified are single-occupancy.

2. In reality, on the basis of the data presented in the article, which posits 1 burial every 12.75 m2 in a necropolis 21.5 ha in size, there should be 16,863 burials.

	1 Sample		2 Sample		1+2 Samples	
	n	‰	N	‰	N	‰
$_{19-}D_0$	39	279	108	156	147	390
$_{+}D_{20}$	101	721	129	544	230	610
$_{+}D_0$	140		237		377	
$_{+}D_0/_{19-}D_0$		268		456		387
$_{1-}D_0$	7	51	22	93	29	77
$_{4-}D_2$	9	65	33	139	42	112
$_{9-}D_5$	9	65	26	110	35	93
$_{14-}D1_0$	9	65	5	21	14	37
$_{19-}D_{15}$	3	22	22	93	25	67
$_{+}D_{20}$	101	732	129	544	230	613
$_{+}D_0$	138		237		375	
$_{+}D_0/_{19-}D_0$		268		156		387
$_{14-}D_{10}/_{9-}D_5$		1000		520		250
$_{+}D_5/_{19-}D_5 = D_5$		172		291		243

Tab. 1: raw demographic parameters drawn from: sample 1, Sajjadi *et al.* (2003; 2006) and Lorentz (2008; 2010); sample 2: Macchiarelli - Passarello (1988).

On the basis of the data derived from a sample of 324 burials containing 468 individuals (Sajjadi *et al.* 2003; 2006; 2008; 2015b; Salvatori 2007), there are 282 single burials (87.04%), 34 multiple burials (12.96%) and an average of 1.44 individuals per burial (Fig. 1). Figure 1 shows that the only burial with more than 10 individuals contained 68 individuals, while no other multiple burial contained more than 8. The presence of this burial (n° 2301 in Square IPB) significantly affects the ratio of 1.44 individuals per burial. Indeed, removing it from the sample, the ratio falls to 1.24. Another burial, n°1003 in Square GTT, not included in our sample, contained at least 13 individuals (Piperno - Salvatori 1983), but its inclusion would have not unduly influence the ratio, which would increase from 1.44 to 1.48 if we also count n° 2301, and from 1.24 to 1.27 if we exclude it. Burials with such a high number of individuals as n° 2301 are probably highly exceptional in Shahr-i Sokhta, and its inclusion in the sample to determine the average number of individuals per burial would cause more harm than its exclusion. If we consider 40,000 burials with an average of 1.24 individuals per

burial, we have an estimated total of 49,600 individuals. Even admitting that there are another 10 burials with a similar number of individuals to n° 2301 (i.e. with an average of 60 individuals), the total would be 50,200, corresponding to a variation in the total number of individuals of just 1.01%. If in contrast we use the average of 1.44 individuals per burial, there would be an estimated 57,600 individuals, but if we again suppose the presence of 10 burials with a total of 600 individuals, the correct total would again be 50,200 and we would have thus overestimated the population by 14.7%. For these reasons we shall use the average of 1.24 individuals per burial and 40,000 burials, corresponding to an estimated total for the necropolis of 48,800 individuals.

From Sajjadi *et al.* (2003; 2006) and Lorentz (2008; 2010) we derived a sample of individuals (n = 138) whose age was determined at least qualitatively, i.e. including those classed only as adults (23 out of 138), and on the basis of these we calculated the value of the d-index (Tab. 2).

Before using the calculated ratio, d = 17.21, it is necessary to assess whether it is reliable. To this end we will adopt the criteria proposed by Barbiera and Dalla Zuanna (2007) in their demographic analysis of Italian medieval necropoleis (Tab. 3).

The three criteria are met and we can therefore estimate, using the index, certain demographic parameters of the population being studied. We will use both the "West" and the "South" family models proposed by Coale and Demeny (1983) which are considered the most suitable for populations like ours (Tab. 4).

Life expectancy is practically identical in the two families: 22.4 years for West and 22.3 years for South. Macchiarelli and Passarello (1988) found a similar value, 22.69 years, in their sample of 134 individuals, which are not included among those used by us here, previously analysed by Pardini. Comparison with the data arising from our sample (n = 138) (Sajjadi *et al.* 2003; 2006; Lorentz 2008; 2010) confirms the extreme under-representation of the younger age classes (<5 years), which make up only 116‰ while they should be almost 600‰. In the sample (n = 237) that Macchiarelli and Passarello (1985) derived from Mannucci *et al.* (1985), there are also few individuals aged less than 5 with respect to the almost

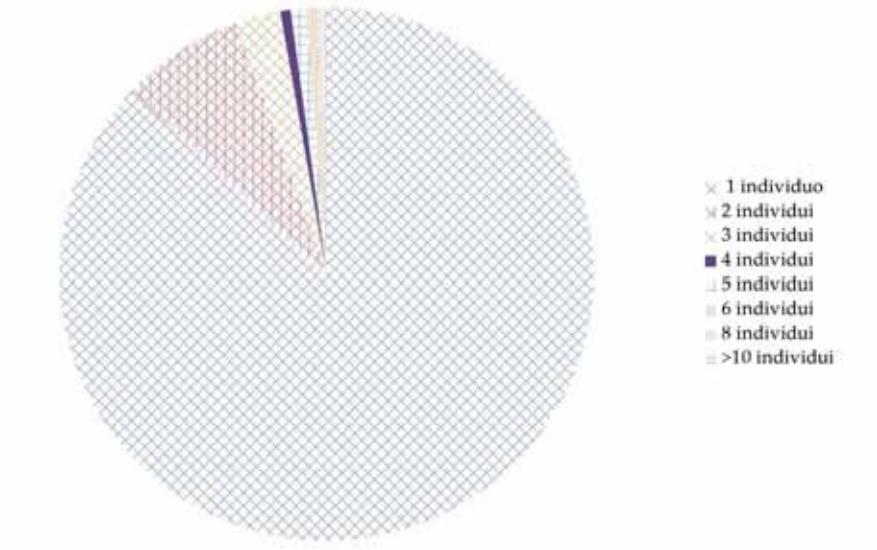

Fig. 1: number of individuals per burial in the necropolis of Shahr-i Sokhta in a sample (n = 290) taken from Sajjadi *et al*. (2003; 2006; 2008).

Age	n°	‰
Newborns	7	51
D1-4	9	65
D5-9	9	65
D10-14	9	65
D15-19	3	22
D20+	101	732
Total	138	1000
D5-19	21	
D5+	122	
D = D5-19/D5+	17.21	

Tab. 2: demographic composition of a sample from the necropolis of Shahr-i Sokhta, from Sajjadi *et al.* (2003; 2006) and Lorentz (2008; 2010) and calculation of the d-index (d = D5-19/D5+), Bocquet-Appel - Naji (2006).

Barbiera and Dalla Zuanna (2007)	Shahr-i Sokhta
30>d>10	17.21
%20> Skeletons of indeterminate age	23/138 = 17%
40<Samplen	138 = n

Tab. 3: criteria for judging the reliability of the juvenile index according to Barbiera and Dalla Zuanna (2007) and values observed in the sample from the necropolis of Shahr-i Sokhta.

d			West	South	Average of samples from Shahr-i Sokhta
17.21	q_0	Infant mortality	345.5	287.9	77
17.21	$_{4}q_1$	Mortality from 1 to 4 years	226.6	310.6	112
17.21	$_{9}q_5$	Mortality from 5 to 9 years	61.3	74.1	93
17.21	m	Raw mortality	42.4	42.2	
17.21	e_0	Life expectancy	22.4	22.3	

Tab. 4: estimate of certain demographic parameters (in ‰) for the population of Shahr-i Sokhta considering a d index of 17.21 (Bocquet-Appel - Naji 2006), adopting Coale and Demeny's West and South families (1983), compared with the average of the values observed in: sample 1 (n = 138) drawn from by Sajjadi *et al.* (2003; 2006) and Lorentz (2008; 2010) and sample 2 (n = 237) derived from Macchiarelli - Passarello (1985); Mannucci *et al.* (1985).

600‰ expected, despite being double the previous sample, reaching 232‰. If in contrast we consider the values for individuals dying in the 5-9 age group, the percentages observed in the skeleton samples from Shahr-i Sokhta and those predicted by means of the d index are similar, lying between 50‰ and 100‰, confirming the indication derived from the ratio $D_{5\text{-}9/D10\text{-}14.}$

Assuming the maximum estimated number of burials (n = 40,000) and 1.24 individuals per burial (Fig. 2), the necropolis should contain 49,600 conserved individuals, i.e. individuals whose remains are still in a condition that might enable at least a qualitative determination of their age. Of these, considering that children under 5 years of age on average make up 189‰ of the known skeletal samples, we would expect to find the remains of about 9,400 children under five 5 years of age and about 40,200 individuals dying at 5 years of age or over. Based on the estimated number of individuals aged at least five, we calculated the expected number of individuals aged less than five by means of the statistical parameters for West and South families shown in Table 3 obtained using a d index

of 17.21. Considering about 40,200 dead individuals aged at least 5, we would expect to see many more dead individuals aged under five than the roughly 9,400 estimated to be sufficiently well conserved to allow determination of age: about 53,800 and 59,900 for the West and South families respectively, while the total population of the necropolis would be about 94,000 for the former and about 100,000 for the latter (see Tab. 5). The two values are very close and therefore we will use the average of the two, about 97,000.

Considering a population (P) of 97,000 individuals, a duration of use (T) of 1400 years and a life expectancy at birth (e0) of 22.35 years, the average population (pmed) can be directly calculated using the formula

pmed = P*e0/T = 1550

A		Estimated burials	40,000	
B		Individuals per burial	1.24	
C		Population of the necropolis	49,600	
D	q0-4	Individuals aged less than 5 years	18.9%	
E	q0-4	Estimated individuals aged less than 5 years	9,391	
F	q5+	Estimated individuals aged more than 5 years	40,209	
			West	South
G	q0-4	Expected individuals aged less than 5 years	53,800	59,900
H	q0+	Expected necropolis total	94,000	100,000

Tab. 5:
A) Estimated burials, (Sajjadi 2015a); B) Individuals per burial, based on a sample of burials (n = 290) taken from Sajjadi *et al.* (2003; 2006; 2008); C) Population of the necropolis = A) * B)
D) Percentage of individuals aged less than 5 years in the skeletal samples from Shahr-i Sokhta (Tab. 3); E) Estimated number of individuals aged less than 5 years estimated in the population of the necropolis, C) * D); F) Estimated number of individuals aged at least 5 years in the population of the necropolis, C) – E); G) Expected number of individuals aged less than 5 years given an adult population of 46,700 individuals based on the estimates produced using the d index (Table 4); value rounded up to the nearest hundred; H) Expected total population of the necropolis, F) + G); value rounded up to the nearest hundred.

or by introducing a correction factor (k = T/10, Sellier 1989) and using the formula:

pmed = k+P*e0/T = 1689

The population of Shahr-i Sokhta is unlikely to have remained constant during the occupation of the site. Salvatori and Tosi (2001) have published a graph in which the size of the part that was actually inhabited is estimated on the basis of the surface discoveries. Considering an average population of 1550-1700 inhabitants, with an initial and final population of about 75 individuals, we simulated the likely population of the site by supposing that it followed a similar pattern to that of the size of the settlement. We assumed a growing rate of increase of the population in the initial six centuries (i.e. 0.50% in the first two centuries, 0.75% in the next two and 1.00% in the next two), followed by zero growth in the two central centuries and a symmetrical decrease in the six final centuries (Fig. 2). On the basis of this simulation, the population of the site at its zenith would have been about 6800 (average 1550) or 7400 inhabitants (average 1700). These rates of growth are high however. Assuming lower rates, i.e. 0.25%, 0.50%

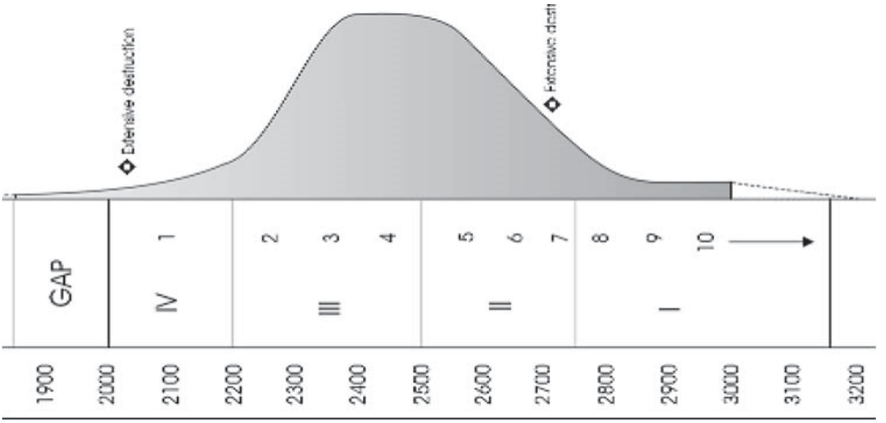

Fig. 2: above: size of the settlement on the basis of superficial discoveries, from Salvatori and Tosi (2001: 189, fig. 12). Below: site population trend assuming that it reflects that of the size of the settlement, starting from an initial population of about 75 individuals and maintaining an average population of about 1550 individuals over 14 centuries. Figures not to scale.

and 0.75%, to obtain the same average of 1550 inhabitants the initial population would have had to be 275 inhabitants, reaching a maximum population of about 5800 inhabitants in the two central centuries. On the basis of these and other simulations we performed, we believe that with a total population of 97,000 for the site's entire duration of 14 centuries, the peak population in the central centuries would have been somewhere between 5000 and 10,000 inhabitants.

The annual population growth rates that we use here are much higher than the reconstructed global average for prehistoric populations, which is about 0.04% (Goldewijk *et al.* 2010; Zahid *et al.* 2016). Having said this, we stress that the latter rate is – precisely – global, calculated for the Holocene as a whole, which cannot be used to describe the population dynamics in specific areas and periods such as those examined here. However, since such high annual rates of increase as suggested here are unlikely to have resulted from the natural intrinsic growth of the starting population (which would have required a considerable fall in infant mortality for example), we must assume that the rapid rise and fall in the population was largely the result of migration between the settlement and outlying areas.

The number of inhabitants per hectare of a settlement is estimated on the basis of the few ethno-archaeological studies of the number of inhabitants in modern-day rural villages in the Middle East. According to Kramer (1979), a Kurdistan village of 15 hectares had a population of 1500-2000, with a density per hectare of 100-133. Based partly on the same data used by Kramer (1979), Aurenche (1981) observed that in villages of more than 10 hectares in size, the average density is 53.3 inhabitants/hectare, but the figure is highly variable (3-181 inhabitants/hectare). Sumner (1989) studied the population of rural villages in the basin of the river Kur in Iran, which have an average density of 160 inhabitants/ha, but here too the variability is high (50-400 inhabitants/hectare). A recent study determined the number of inhabitants per hectare in a small number (n = 3) of rural villages in Sistan today (Abbasi *et al.* 2017), finding an average of 38 inhabitants/hectare, close to the minimum values recorded in previous works. The value recorded in modern villages near Shahr-i Sokhta does not necessarily provide a more reliable estimate of the density of the settlement than the previously cited studies because

the current environmental conditions of Sistan are probably different from those of the period in question.

Estimates of the number of inhabitants of a site based not on the overall size of the settlement but the size of the inhabited area and its subdivision into dwelling units (for which an average number of residents is assumed) generally produce higher population densities than ethnographic methods. Analysing the literature on the topic relative to Mesopotamia, for sites with inhabited areas ranging from 0.3 to 65 hectares in size, Wossink (2009) found densities that varied from 115 to 1050 inhabitants per hectare, with an average of 456.

The settlement of Shahr-i Sokhta was once believed to have occupied an area of about 151 hectares (Piperno - Tosi 1975), although this estimate has risen to 200 hectares on the basis of the ongoing research (Sajjadi 2014a). Considering the higher value, in the two centuries when the population was at its height, i.e. 5000-10,000 inhabitants, a density of 25-50 inhabitants per hectare would be close to the minimum values recorded in the modern-day settlements (Aurenche 1981, Kramer 1979; and Sumner 1989), and would include the value of 38 inhabitants per hectare recorded in the villages of Sistan today (Abbasi *et al.* 2017). Considering only the maximum *built* area, i.e. 120 hectares (Biscione *et al*. 1977), the density would be 41.5-83 inhabitants per hectare, within the variability of the cited samples.

If in contrast we assume the indications regarding the greatest extent of the inhabited area of the site in its final phases (see Ascalone in this volume; fig. 3), and we accept that they indicate the continuing presence of a high number of inhabitants in this period, then the maximum number of inhabitants would probably be close to the lower limit of the range previously proposed (5000-10000 inhabitants).

5. Conclusions

Before tackling the aspects arising from the anthropological analyses performed during the first two excavation and research campaigns at Shahr-i Sokhta, certain considerations of a preliminary and non-exhaustive nature can be made regarding the occupation of the settlement during its lifetime.

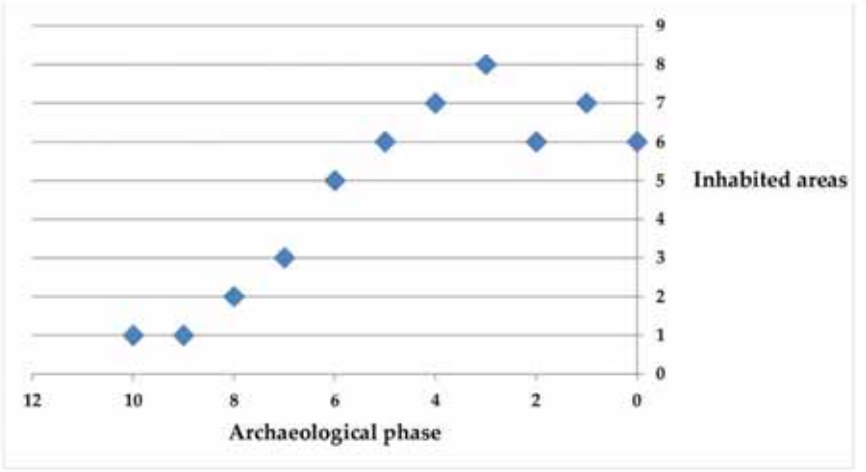

Fig. 3: size of the settlement on the basis of data from Ascalone (present paper).

Preliminary topographical and demographic observations

Despite the successful excavations conducted by the Italian and Iranian missions, the size of the site and the task still remaining make it hard to fully determine the exact extent and topographical organisation of Period I in Shahr-i Sokhta. Phases 10-8 have been verified only in the eastern residential area, specifically in the sequences of the *House of the Foundations*, which have yielded clear references to the material culture of Namazga III and more western Proto-Elamite elements. Period I appears to be absent from all the remaining parts of the settlement, although, as previously mentioned, the virgin soil of the site has not been reached in all sectors. On the basis of the initial analysis, supported by the sequences of the *Central Quarters*, it appears plausible that the passage from Period I to Period II was also marked by a westward shift in the occupation of the site, towards the current depression which in the past is believed to have been a lake, presumably of salt water[3]. The sequences identified have yielded evidence of Periods II and III throughout the settlement, confirming the demographic growth indicated

3. Palaeo-botanical analyses of core samples taken from the depression will be conducted by G. Fiorentino in order to obtain information with which to reconstruct the palaeo-environment of Shahr-i Sokhta and understand the relationship between the inhabited sectors and the depression.

by previous studies, which in the first half of 3rd millennium BC made Shahr-i Sokhta one of the biggest settlements in the Near and Middle East.

However, despite the limited reach of the research and what still remains to be done, the most recent excavations by the Iranian mission allow preliminary considerations on the subsequent period (i.e. Period IV, Phases 2-1) that do not align with what has so far been proposed on the basis of the research conducted in the last century (Sajjadi - Moradi 2017: 167). Specifically, the investigations in Areas 1, 20, 26 and 28, topographically located in the central part of the settlement (between the *Monumental Area* and the *Eastern Residential Area*), seem to show that the settlement of Shahr-i Sokhta was more extensive in its final phases than what has so far been imagined. The assumption that Shahr-i Sokhta in Period IV covered an area of just 5 hectares, as a result of a collapse marking the end of Phase 3 (Biscione *et al*. 1977: 84), does not seem to be at all confirmed by the new Iranian research on the ground. Although not detected on the eastern edge of the depression (the *Central Quarters*, *Building 33* and the *Monumental Area*), Period IV does seem however to have unfolded along the entire central spine of the settlement, greatly exceeding the previous determinations, according to which Phases 2-1 were marked by almost total abandonment (Tab. 6). Period IV is also widely documented throughout the southern area, which was probably used for the processing, transformation and production of stone tools. It therefore seems to have unfolded across a significant area, involving almost all of the main topographical sectors of the site.

These preliminary assessments provide the basis for introductory considerations in a diachronic key regarding the urban development of Shahr-i Sokhta during the 3rd millennium BC. Indeed, although it would be entirely premature to gauge the extent of the settlement during Shahr-i Sokhta I, given the fairly limited nature of the excavations (which were aimed at reaching the deeper layers in the sectors thus far investigated), it does however seem possible to propose that the settlement grew strongly in Periods II and III, whose cultural horizons are present across the surface of the site and in the individual areas investigated. In the same way, the

	10	9	8	7	6	5	4	3	2	1	0
Southern area											
Eastern Residential Area											
Burnt Building											
Central Quarters											
Building 33											
Building 1											
Monumental Area (including Area 20)											
Craftsmen's Quarters											
Area 21 and 26											
Area 28											

Tab. 6: diachronic analysis of the individual excavated areas.

contraction accompanying the transition from Period III to Period IV seems to be extensively documented in Area 33 and the *Central Quarters*, without however confirming the more generalised collapse of the settlement, which, according to the estimates in Salvatori - Tosi 2005 and Biscione *et al*. 1977, saw the inhabited area shrink by up to 94%.

These new estimates concerning Period IV open up new fields of investigation that cannot be tackled here. However, at this point it is legitimate to ask (1) what effectively happened at the end of Period IV when the occupation of the settlement ceased and (2) what exactly prompted the inhabitants of Shahr-i Sokhta, at the end of Period III, to shift the settlement's centre of gravity away from the large central depression, abandoning the buildings of Area 33 and the so-called *Central Quarters*, in a period that is also marked by a drastic change in the settlement's ceramic horizons.

On the basis of what has been written and verified, the radical changes in the pattern of settlement accompanying the passage from Period III to Period IV, the reasons why Phases 2-1 are not found in the eastern sector adjacent to the lake (now a depression), and the reasons for the shift towards the remaining part of the settlement (the central and eastern sectors) will be among the objectives of future research. This research will seek, where possible, to determine whether the aforementioned shift can be explained with reference to changes in the relationship between the settlement and the lake, reflecting socio-economic

developments among the inhabitants and/or groups that occupied the *Central Quarters* and *Building 33*.

Preliminary anthropological observations

Considering the uneven state of conservation of the human remains with regard to age, analysis of the anthropological data associated with the site's only known necropolis suggests that about 97,000 individuals were buried there, and hence that the average population of the site in its 14 centuries of existence was about 1550 inhabitants. Estimates of the settlement's size on the basis of surface discoveries (Salvatori - Tosi 2001; 2005) indicate that the population of Shahr-i Sokhta would have reached a maximum of between 5,000 and 10,000 inhabitants in the centuries of its greatest development. During this period the built-up area of 120 ha would have had a population density of 41.5-83 inhabitants/hectare. Estimating the number of inhabitants of Shahr-i Sokhta with reference to the necropolis produces reasonable results if based on a reconstruction of its real population, but not if we refer only to the number of individuals whose state of conservation allows us to estimate their age. The claims of Peroni (1994) and Bietti Sestieri (1996), expressed without reference to concrete cases, that estimating a site's population from the population of the necropolis generally produces lower estimates than those produced using other methods is probably due to the fact that the conserved population of the necropolis, which apart from exceptional cases, is necessarily lower than the real number of individuals buried there.

Many estimates and hypotheses have emerged in the course of the work and it is not possible to provide an objective assessment of their reliability. We started from the data on the maximum size of the necropolis, which may have been larger than what is believed or what is currently verifiable. As Piperno and Tosi (1975) point out, the southern area of the site, where the necropolis lies, has been affected by intense erosion. We argue that the density of burials, the average number of individuals per burial and the degree of conservation of the bones in the excavated areas can be extended to the whole of the necropolis, but according

to Sajjadi (2005b) the conservation of the bones also depends on the topography. We used palaeo-demographic data obtained from studies by a range of authors using a variety of methods, meaning that the data are not always comparable. We also used palaeo-demographic indicators that should ideally be employed when considering stationary populations, while this was clearly not the case in Shahr-i Sokhta, assuming that in the long term the oscillations would have cancelled each other out. Significant errors in any of these estimates would have grave consequences for the proposed values, which must therefore be understood as rough indications based on the evidence available at the time.

In the future it will be interesting to compare our values with those obtained from other indicators independent of the necropolis, such as the size of the area that was actually inhabited and the number of dwellings in the site, since the use of independent indicators is the best way to obtain more precise palaeo-demographic estimates for a site (Chamberlain 2006).

In conclusion, we share Sajjadi's appeal (2003: 94, note 6) for prudence with regard to estimates of the number of burials *"...all these statistics must be considered only as a temporary attempt..."*, and we advise similar prudence in the use of the figures we propose.

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