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Данный выпуск Трудов посвящен памяти открывателя нового центра древневосточной цивилизации, основателя и постоянного руководителя Маргианской археологической экспедиции В.И. Сарианиди. Он состоит из трех разделов. В первый из них включены воспоминания друзей и коллег выдающегося археолога; во второй — описание и анализ новых находок и открытий, сделанных на известном памятнике эпохи бронзы Гонур-депе (2300-1600 до н.э.); а в третий — характеристика Гонура и других объектов Бактрийско-Маргианского археологического комплекса (БМАК) в сравнительном контексте с синхронными памятниками Центральной Азии и Ближнего Востока. Затрагиваются вопросы строительства и архитектуры, древней металлургии, мировоззрения населения, глиптики и сфрагистики, биоархеологических реконструкций, реставрации археологических предметов. Значительное место уделяется анализу торговых и культурных связей в пространстве Евразии, значению древней дельты Мургаба как перекрестка путей. Вводится в научный оборот ряд новых уникальных объектов эпохи бронзы, в том числе найденные и на Гонуре.

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This issue of Transactions is devoted to the memory of the discoverer of a new center of ancient oriental civilization, the founder and the permanent head of the Margiana archaeological expedition Victor Sarianidi. It consists of three sections. The first one included the memories of friends and colleagues about the outstanding archaeologist; the second one – description and analysis of new findings and discoveries made in the famous Bronze Age archaeological site Gonur Depot (2300-1600 BC); and the third one – the characteristics of Gonur and other objects of the Bactria-Margiana archaeological complex (BMAC) in a comparative context with synchronous monuments of Central Asia and the Middle East. The construction and architecture, ancient metallurgy, ideology, glyptic and sphragistics, bioarchaeological reconstructions, restoration of archaeological objects are affected. The significant attention is given to the analysis of trade and cultural relations in the Eurasian area, to the value of the ancient delta of the Murghab river as the crossroads. New series of unique Bronze age objects, including those have found at Gonur are introducing into scientific circulation.

ТРУДЫ МАРГИАНСКОЙ АРХЕОЛОГИЧЕСКОЙ ЭКСПЕДИЦИИ
ТОМ 6
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Foreword

The next, sixth volume of the Transactions of Margiana expedition we dedicate to the memory of its founder and permanent leader Viktor Ivanovich Sarianidi. The Editorial Board of Transactions has received a considerable number of texts, but to this volume we have selected only those that were directly linked to his name, with the development of his ideas or discussion on them, with the assessment of important discoveries of the scientist or his overall contribution to the historical science. All submitted for publishing texts on other issues, which were reviewed, will be published in the next volume. We had to thank the family of Viktor Ivanovich, his colleagues and friends including Georgiy Kotanov, Andrey Iliopulo, Georgiy Neopulo, Hristofor Topuzov, Georgiy Iliadis, Anastasios Vasiliadis, Odissey Zahariadis, Nikos Sidiropulos, Al'bert Yanakov, Konstantin Simeonidis, Irakliy Aslamazov, Fedor Karafulidis, Irakliy Aslanidis, Anesti Ksinopulo, Mihail Ksandopulos, Pavel Aslanov, Konstantin Shotidis, Pavlos Arzumanidis, Georgiy Martasidis and also MIN Byung-Hoon and Christina Yu for their invaluable financial support for the publication of this book.

Since many years the Margiana expedition carried out in the framework of the Agreement on Cooperation between the Institute of Ethnology and Anthropology of the Russian Academy of Sciences and the National Department for the Protection, Study and Restoration of Historical and Cultural Monuments of the Ministry of Culture of Turkmenistan, as well as the fact that archaeologists from Altai (Barnaul city) and Kemerovo state universities have begun to take an active part in the excavations of the recent years, the editorial board of the collection has been expanded. We very much hope that in the future it serve further the spread of information about the unique treasures that were kept and still keeps the Turkmen land. It is a great pity that whereas the book was prepared for delivery to the printing house, one of its main editors, friend and colleague of Victor Ivanovich Sarianidi – Pavel Mikhailovich Kozhin has passed away (18 July 2016). His valuable advice and rich erudition contributed in many ways to the fact that this serial publication was such what it is. The Editorial Board hopes to dedicate one of the following issues of the Transactions to the memory of that outstanding scientist.

Despite the fact that this volume is a memorial edition, the editors considered important to preserve the overall structure of the issues of the series. Therefore, the first section, as in the previous volumes, is connected with the name of Viktor Ivanovich, memories of him, the second is traditionally devoted to the works at Gonur Depe and to the finds made there and the third – to the cultural relations of Margush country and Bactria-Margiana Archaeological Complex (BMAK) that researchers have been able to trace.

Editorial board

M. Codebò, H. de Santis
Archeoastronomia Ligustica, Genoa, Italy

Alignments towards heavenly North Pole in Lothal (India), Turkmenistan and Egypt

1. ARCHAEOLOGICAL INTRODUCTION[1]

1.1. Murghab Delta sites

Turkmenistan is approximately 488 km^2 in size, 387 km^2 of which are covered by ten different types of deserts. The Parapamiz and Kopet Dagh mountain ranges and plateaus frame the country's south-western border. The main rivers are the Amu Darya, Tejen and Murghab. The source of the latter river lies in the Hindukush of Afghanistan and it transverses Turkmenistan from south to north and flows through the south-eastern part of the Karakum desert. Progressively dryer climatic conditions and resulting desertification have greatly reduced the extent of the Murghab's alluvial fan over the past five millennia. For this reason, the majority of archaeological sites are now located in the desert.

For the present research – i.e. to detect the orientation of the architectural structures in the ancient time and to have an idea of the employment of such techniques – we selected four archaeological sites:

a) The ancient capital during the Middle – Late Bronze Age (MBA) 2300 – 1500[2] BC Northern Gonur (On the Track of Uncovering a Civilization, 2010);

b) The Temenos[3] or Gonur South of the Late Bronze Age-LBA, 1950-1500 BC;

c) Togolok-21 (late Bronze Age LBA, 1950 – 1500 BC);

d) The Big Kiz Kala, Shahryar Ark palace and Imaret-Pavilion of Ancient Merv (Iron Age 2-IA 2, 900–550 BC – 1300 AD)[4].

1.2 Lothal

The Indus Civilization harbour-site of Lothal is located within a small *doab*[5] created by the confluence of the Bhogavo and Sabarmati rivers about 30 km before their flowing into the Gulf of Khambhat and the Arabian Sea (Gujarat, India). The urban settlement consisted of an acropolis, with the public and the ritual buildings; a lower town with the residential and the craft areas; a huge brick – lined water basin (220x40x4 m), variously interpreted as a water supply tank or a dockyard, that was discovered immediately to the East of the site.

The archaeological site covers about eight hectares and was discovered in 1954, as the result of a systematic archaeological survey of the Saurashtra-Kathiawar Peninsula in the State of Gujarat, India.

The site was only partially excavated and documented in detail by S.R. Rao, an archeologist of the Archaeological Survey of India, between 1955 and 1962. An enormous corpus of data relevant to the structural setting of the site and its *material culture* was published, over almost thirty years, by S.R. Rao in different books and papers, but mostly in the official report of the excavations, published by the Archaeologi-

1 By Henry de Santis.

2 There are differences between the results that we gave in our previous paper (Cerasetti et al, 2013) and the results written in this paper. This difference is due to the different archeological times of the foundation and of the abandon of Gonur North and Gonur South. In our previous paper (Cerasetti et al, 2013) we used the times that the Italian Archeological Mission gave to us. In this paper we use the dates according to N. Dubova. Of course, different times provide different astronomical results.

3 The Temenos, as Sarianidi names it, is a great religious complex that may have served the entire region in the later Bronze Age.

4 Actually Merv is a group of sites of different periods and among them we have: Big Kiz Kala (6th century AD), an Abbasid semi-fortified two floors palace with corrugated walls; Seljuk palace (11th century AD) located at the center of Shahryar Ark, the citadel of the site of Sultan Kala; the Timurid Imaret Pavilion (16th century AD). For a complete description of the monuments of Merv see: Hermann, 1999.

5 *Doab* is a Hindi word that means neck between two rivers.

cal Survey of India in two separate volumes: vol. 1, about the environmental context and the structural features of the site (Rao, 1979), and vol. 2, which illustrates in detail the material culture found at Lothal (Rao, 1985).

The excavations, carried out by S.R. Rao, disclosed an urban settlement clearly ascribable to the Indus Civilization[6], which flourished on a local pre-Harappan chalcolithic site (Rao, 1979. P. 24–25). The site's occupation was divided into two main periods separated by a short break: Period A is dated since about 2450 to 1900 BC, perfectly matching to Phases 3B and 3C of Harappa (Rao, 1979. P. 28–33); Period B was related to the Late Harappan occupation dated from about 1800 to 1600 BC (Rao, 1979. P. 33–36).

In Lothal archaeologists found an *acropolis* raised upon a system of artificial boxes – like platforms that supported the public and the ritual buildings – and a *lower town* with the residential and craft areas. However, the most impressive structure is undoubtedly the huge water basin, covered with baked bricks and excavated by S.R. Rao immediately to the east of the site. According to the excavator (Rao, 1979. P. 63–64, 123–134; fig. 19), it was roughly trapezoidal, measuring 212,40 m on the western embankment, 209,30 m on the eastern one, 34,70 m on the southern one and 36,70 m on the northern one. The walls rise 1,80 m over their foundation level and about 1,00 m over the ground level, with their inner faces of the strictly vertical. According to S.R. Rao, a 12,20 m wide inlet was originally present in the northern embankment, while it was latter closed and replaced with a 7,00 m wide another one, opened at the southern end of the eastern embankment.

The debate about the function of this unique structure is still open and the different possible interpretations highly influence several other main archaeological questions about the site. The basin was originally interpreted by S.R. Rao as a dock for small boats that reached Lothal from the Gulf of Khambhat through the Sabarmati-Bhogavo river system (Rao, 1979. P. 125–134). This hypothesis was supported by several scholars. Later, other scholars considered it just a big reservoir for irrigation and/or drinking water, while others just rejected both theories without proposing any solid alternatives. In a recent paper, Rear Admiral Retd. S.C. Bindra (2003) evaluated all possible interpretations proposed of the Lothal basin in great detail. Considering the technical features of the structure and the rough environmental data available at the moment, he rejected the possible use of the basin for storing fresh water, in favor of its interpretation as an inland tidal dock (Bindra, 2003. P. 16–18).

2. ARCHAEOASTRONOMICAL SURVEYS[7]

We got all our measurements using the following tools: spherical surveyor's cross with direct reading of 5^c centesimal degrees[8]; gravity inclinometer with direct reading of 1°; radio-controlled clock repeatedly compared with the Italian Master Clock I.N.RI.M.; prismatic compass Recta with direct reading of 1° and $0{,}5^\circ$ estimated. The azimuths got using astronomical methods are free from magnetic influences.[9]

2.1 Turkmenistan

The outcomes of the archaeoastronomical surveys[10] that we present here concern structures and buildings of the following sites:

- Gonur North (lat. 38°12'50"N; long. 62°02'14"E; m 182 a.s.l.) (fig.1);
- Gonur South (Temenos) (lat. 38°12'33"N; long. 62°02'06"E; m 170 a.s.l.) (fig.2);

6 Named too: Indus – Saraswati Civilization ISC; Sindhu – Saraswat Civilization SSC (thanks to Ajinkya Sudhir Umbarkar).

7 By Henry de Santis.

8 In the centesimal scale, the circumference is subdivided into 400^c, i.e. 400 centesimal degrees, instead of 360°, i.e. sexagesimal degrees: $\alpha^\circ = \alpha^c \cdot (360/400)$; $\alpha^c = \alpha^\circ \cdot (400/360)$.

9 We urge our colleagues archaeologists to orientate the excavation maps using astronomical methods instead of magnetic methods (compass), because the first ones are much more accurate (they allow the orientation of the maps within an error's range of $\pm 1^\circ$ or better), free of magnetic influences and unchanging over the time (i.e., they allows archaeoastronomical researches also much time after the end of the excavations and the drawing of the maps). The simplest method is to determine the local meridian (i.e. the axis N – S, or $360^\circ - 180^\circ$ at the local (or true, or astronomical) noon (Codebò, 2014b. P. 149–152).

10 A special thanks goes to V.I. Sarianidi and N.A. Dubova for their kind support and the permission to measure the structures in Gonur North and South. We would like to thank also M.A. Mamedov, R. Denega and the staff of the Ministry of Culture of Turkmenistan for the help given to the Italian archaeological mission, B. Cerasetti and M. Tosi for the hospitality granted during the surveys.

Fig. 1. The settlement of Gonur-Depe with indication of measurements
(*photo by G. Davtian,* published with kindly permission of V.I. Sarianidi and N.A. Dubova)

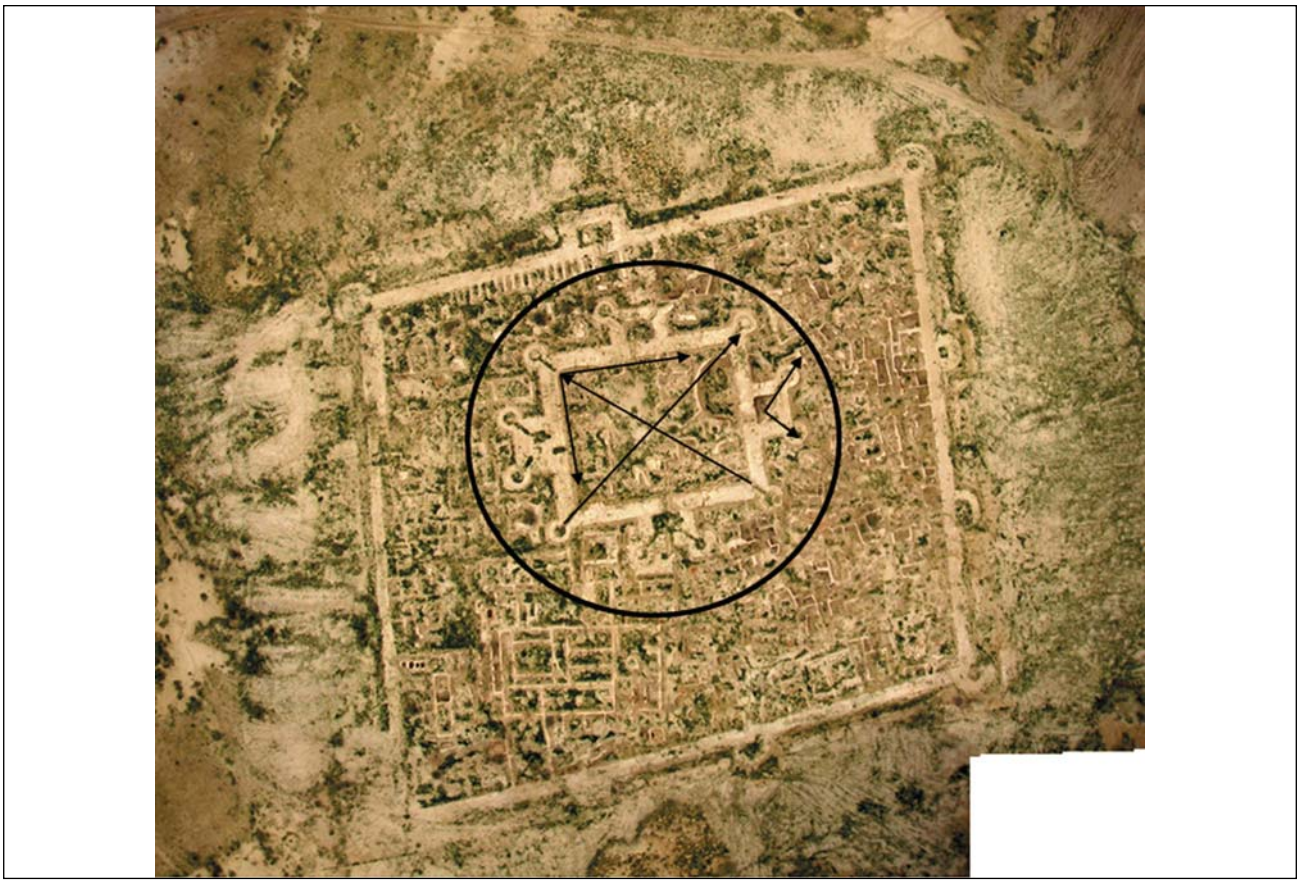

Fig. 2. The alleged observatory of Gonur South with indication of measurements
(*photo by G. Davtian,* published with kindly permission of V.I. Sarianidi and N.A. Dubova).

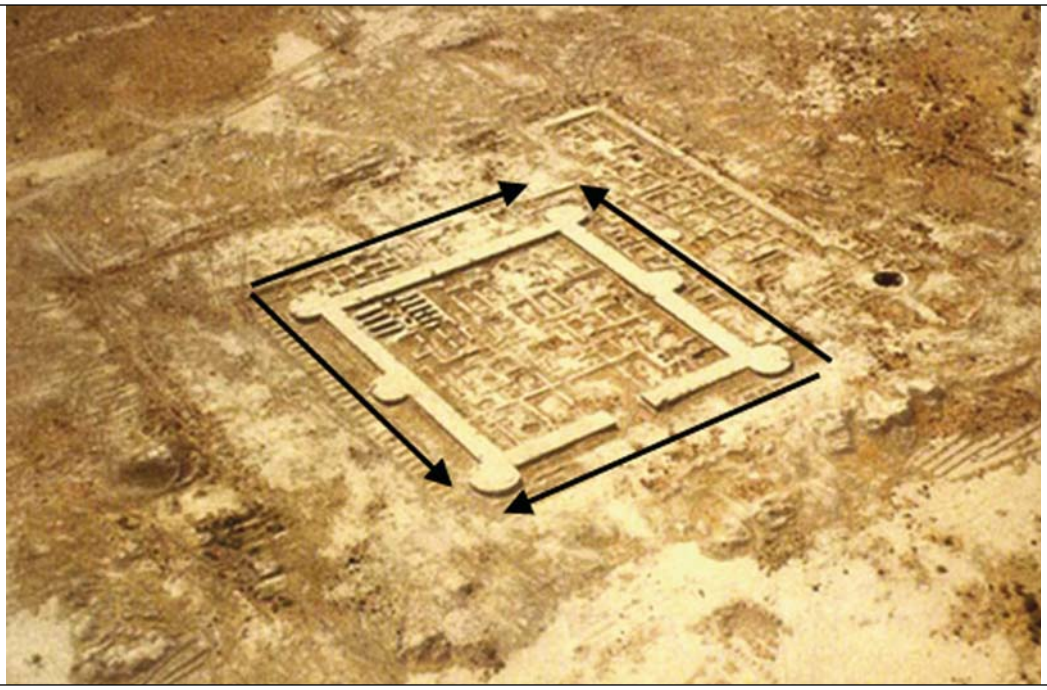

Fig. 3. The archaeological complex of Togolok 21 with indication of measurements (photo published with kindly permission of V.I. Sarianidi and N.A. Dubova).

- Togolok 21 (lat. 38°06'15"N; long. 61°59'38"E; m 188 a.s.l.) (fig.3);
- Ancient Merv.

The measurements are based on the relative immutability of Sun's and Moon's seasonal positions on the skyline. This is not the case of the stars! Indeed, their positions change considerably (1° in 71,583 years; approximately: 1° in 72 years[11]) because of the precession of the equinoxes and it is necessary to develop long and complex calculations to reconstruct their secular movements. Moreover, possible settings in a row of stars must be estimated by probabilistic methods.

2.1.1 Gonur North

We measured this site from the structure of the internal walls surrounding the palace and the ruins of the palace. The East and West walls are oriented along the N – S line (i.e. the meridian), with a medium axes of 2°16' ↔ 182°16'. The northern side of the walls are oriented along the E – W line (i.e. the equatorial line) with an azimuth of 89°46' ↔ 269°46'. On the other hand, only the southern wall was built with a little digression (6,7°) in azimuth, quantifiable at about: 275°44'. This difference might be intentional and this subject deserves further research. The walls inside the ruins, as well as the palace, were built almost exactly in orientation with the four cardinal points (azimuth 0°41' ↔ 180°41' and 90°41' ↔ 270°41').

2.1.2 Gonur South (Temenos)

More interesting are the reasons of the building of this alleged observatory, because from the inside several Moon's positions and one Sun's specific position can be observed. In details:

- The internal walls are oriented approximately N – S – E – W, with an azimuth of 351° ↔ 171° and 81° ↔ 261°. These differences from meridian and equatorial axes are the result of a precise choice, carried out by the builders using positional astronomy. As we discussed briefly below, these orientations let the observers see many astronomical phenomena.

It was not possible to take astronomical measures of the more external walls because of the poor conservative state of these structures, but they reflect, basically, the orientations of the internal perimeter.

- Towers of the corners of the walls:

11 The speed of the equinoctial precession is 0°00'50.290966" J2000 per tropic year; i.e. approximately 0°00'50.29" per tropic year.

Fig. 4. The Big Kiz-kala fortress with indication of measurements (photo by H. De Santis).

a) **NW tower corner:** set to match the Moon at its northern utmost amplitude[12] (a.k.a. Moon Solstice or widest *Lunistice*)[13], a position that the satellite gets every 6798 days[14], when it gets its maximum declination: +29° about. It has been proved that this astronomical phenomenon was known in ancient times;

b) **NE and SW tower corners**: exactly the opposite; maybe they allow to observe the rising of a star or of a constellation. Further researches need to test the authenticity of these alignments;

c) **SE tower corner**: rise of the Moon at its southern utmost amplitude, the other position that it reaches every 6798 days, as we mentioned above, and when it gets its minimum declination: −29° about.

- Intermediate towers at the centre of each single side:

a) **N side.** NW tower: Moon setting at its northern utmost amplitude; NE tower: still doubtful at the moment;

b) **S side.** SW tower: still doubtful at the moment; perhaps stars; SE tower: Moon rising at its southern utmost amplitude;

c) **E side.** NE tower: still doubtful at the moment; perhaps stars; SE tower: Sun rising at winter solstice;

d) **W side.** NW tower: Moon setting at its northern utmost amplitude; NE tower: still doubtful at the moment.

It is possible to infer that the Temenos or Gonur South was used like a Moon and Sun observatory.

2.1.3 Togolok 21[15]

The astronomical survey of the town and external perimeter walls shows that they are oriented, almost exactly, towards the four cardinal points (azimuth 359°17' ↔ 179°17' and 90° 11' ↔ 270°11'). Therefore, it was possible to determinate: equinoctial axes, solstice rising/setting points and astronomical midday observing the culmination of the Sun above the horizon. More researches need about the intermediate positions 45°, 135°, 225°, and 315°.

2.1.4 Ancient Merv

The Big Kiz Kala (lat. 37°39'18"N; long. 62°09'09"E; m 242 a.s.l.) (fig. 4) was built to

12 The amplitude is the distance of rising (rising amplitude) and setting (setting amplitude) points of a heavenly body from the East and West cardinal points.

13 The Moon gets four *lunistices* (i.e. four standstills) in a time-range of 6798 days: two widest when its declination is about ±29° and two shortest when its declination is about ±18.18°. Widest and shortest lunistices follow one another every 3399 days, i.e. about 9 years. At the widest lunistices, the Moon rises and sets, every month, more north and more south, respectively, than the Sun. This is the most relevant orientation of the Chalcolithic necropolis of St. Martin de Corléans (3100–1900 BC) in Aosta, Italy (Cossard et al., 1991). At the shortest lunisitices, the Moon rises and sets closest to the Sun. Several European megalithic monuments are oriented towards the four lunistices.

14 6798 days are 18 years and 224 days, i.e. 18 years, 7 months and 12 days, i.e. 18.61 years.

15 Unfortunately, in our previous article «Archaeoastronomical surveys in Turkmenistan» (Cerasetti et all, 2013) photographs numbers 4–5 and 6–7 have been mutually inverted in printing: the ones number 4–5 are really et al, Shahryar Ark Palace and Imaret Pavilion and the ones number 6–7 are really Big Kiz Kala fortress.

Fig. 5 a, b. The Shahryar Ark palace (left side) and the Imaret-Pavilion (right side) (photos by H. De Santis).

match both the direction of the summer solstitial sunrising and the winter solstitial sun setting. It is possible to observe these positions through the big holes in the walls of the structure.

The minor axes of Shahryar Ark's building (lat. 37°40'20"N; long. 62°10'15"E; m 234 a.s.l.) (fig. 5a) are roughly oriented along the equinoctial line, with an azimuth of 96° ↔ 276°.

Finally, the Imaret Pavilion (lat. 37°38'27"N; long. 62°10'00"E; m 230 a.s.l.) (fig. 5b) does not match particular directions, but it was roughly built towards the summer solstitial sunrising and the winter solstitial sunsetting with an error of 6°.

2.2 India: Lothal[16]

The following measures of azimuth have been taken since 5 to 14 February 2009 in Lothal (lat. 22°31'23"N; long. 72°14'56"E; m 13 a.s.l.) (fig. 6):

Internal structures of the acropolis:
azimuth N – S 358°53' ↔ 178°53';
azimuth E – W 88°58' ↔ 268°58'.

Internal structures of the warehouses block:
azimuth N – S 359°20' ↔ 179°20';
azimuth E – W 89°28' ↔ 269°28'.

Water basin:
azimuth N – S 357°54' ↔ 177°54';
azimuth E – W 91°49' ↔ 271'49'.

Lower town:
azimuth N – S 347°12' ↔ 167°12';
azimuth E – W 74°36' ↔ 254°36'.

3) ARCHAEOASTRONOMICAL DISCUSSION[17]

3.1) During our surveys in Lothal (Codebò et al, 2013) and in Turkmenistan (Cerasetti et al, 2013) we noted that the axes of the buildings, 25th century BC old, were oriented towards the cardinal point North with a little gap. It is well known that the five Pyramids of the 4th Pharaonic dynasty[18] in Egypt (and one of the 3rd dynasty), of the 26th century BC, are very well oriented towards the heavenly North Pole, as we summarize in tab. No. 1 (according to Cimmino, 1990. P. 152; Magli, La Porta, 2003. P. 158; Magli, 2005. P. 373), with a gap less than 0°15'±0.2' (Belmonte, 2001). Such precision opened a wide debate among scholars on how it was possible to obtain it. Discarding assumptions that do not offer sufficient guarantees of adherence to the scientific method, it seems at present that the best theory able to explain such precision is the observation of the simultaneous culmination (lower or upper or both) of a couple of circumpolar stars. It seems that this method is conditioned only by the limit of the human vision (Magli, 2005. Ch. 18)[19].

16 We would like to thank the Italian archaeological mission, M. Tosi and D. Frenez, for the hospitality granted during the surveys.
17 By Mario Codebò.
18 2630 – 2510 BC according to Cimmino 2003, pp. 74 and 468; 2650 – 2400 BC according to Magli & La Porta 2003, p. 37.
19 As some authors pointed out, the accuracy of the alignments towards the North Pole of the six pyramids converges at the Cheops's pyramid, according to their traditional dating from the oldest one to the newest one, and then it diverges, again. Besides the classical explanations (i.e. the equinoctial procession), we wish point out that the accuracy of the Cheops's pyramids is at the limit (3'–4') of the resolutive power (i.e. the power to distinguish two very little points) of the human eye by night because the pupils are dilated (Ferreri, 1989. P. 36 – 37): it is likely that Egyptian builders could not get greater accuracy. Therefore, if the sequence of the datings of the pyramids is right, we can also think that progressive accuracy from the oldest and the less accurate – the Meidum pyramid – to the most accurate and newest – the Cheops's pyramid – was the attempt to get the greatest possible accuracy and when it was got this interest diminuished up to disapear completely.

Table 1

Gaps from the heavenly North Pole of the pyramids of 3rd – 4th dynasty

Pyramid	Resort	Pharao	Cimmino, 2003	Magli, La Porta, 2003; Magli, 2005 (East side)[20]
Meidum	Meidum	Huni (3rd dynasty)		–20.6' ±1.0'
Double Slope	Dahshour	Snofru (4th dynasty)		–17.3' ±0.2'
Red Pyramid	Dahshour	Snofru		–8.7' ±0.2'
Great Pyramid	Giza	Cheops – Khufu (4th dynasty)	+3.1'	–3.4' ±0.2'
Chephren	Giza	Chephren – Ka'fra (4th dynasty)		–6.0' ±0.2'
Mikerinos	Giza	Mikerinos – Menkaure (4th dynasty)		+12.4' ±1.0'

For our surveys in Lothal, Gonur North, Gonur South and Togolok 21, we calculated:

1) the date of the spring aequinox[21] of the year that archaeologists believe it more likely for the «building», using the Javascript software *Equisol* that Agostino Frosini[22] compiled using the formulae of the chapter 20 of two books of Jean Meeus (Meeus, 1988, 1990)[23];

2) Right Ascension α, Declination δ and Polar Distance *PD*[24] of Thuban (α Draconis, mag. 3,65), that was the visible North Polar Star in the 3rd millennium BC[25] at each spring aequinox using the software Solex 11,0 by Aldo Vitagliano[26] because of its greater precision due to the use of numerical integration, instead of the classical formulae of Newcomb[27] (Meeus, 1988; 1990. Ch. 14, 15,16)

Then, we calculated the *maximum digression*[28] of Thuban for each spring aequinox of the years 2550, 2450, 2400, 2300, 2250, 1950, 1900, 1800, 1600, 1550, 1500 BC. Of course, Thuban also gets an azimuth of 0° when it culminate the upper and the lower meridian. But because in 25th – 24th century Thuban was not exactly on the North Pole and therefore it performed a small orbit around the North Pole, we thought that the builders might have directed more eas-

20 There is a complex and controversial theory of Kate Spence about the W – E shift of orientation of the Giza Pyramids that involves the simultaneous meridian transit of two circumpolar stars (Kochab, i.e. β Ursae Majoris and Mizar, i. e. ζ Ursae Majoris or Phecda, i.e. γ Ursae Majoris and Megrez, i. e. δ Ursae Majoris). It is described and debated in details in: Belmonte, 2001; Magli, 2005; Castellani, 2009.

21 The choice of this day is obviously fictitious, necessitated by the needs of astronomical calculation that requests year, month, day, hour, minutes and seconds of time. It would be equally possible to select any other day of the year.

22 All the software of Agostino Frosini are free downloadable in the URLs http://archaeoastronomy.it/download and http://www.webalice.it/agostino.frosini/Archaeoastronomy%20Program/pagina_iniziale.html .

23 In order to allow to the readers to compare these results with the results that we printed in our previous papers (Cerasetti et al, 2103; Codebò et al, 2013), we use here the same calculation procedures and algorithms, although using only the software Solex the results are a little more accurate.

24 α: the distance of a heavenly body from the vernal point ♈; δ: the distance of an heavenly body from the heavenly equator; PD: the distance of a heavenly body from the pole, or, that is the same, the complement to 90° of δ (90° – δ). All results are rounded off to the unity (without decimals).

25 According to Meeus 2009, pp. 353-363, Thuban was the visible North Polar Star from the 3860 BC to 1820 BC.

26 Free downloadable in the URL http://chemistry.unina.it/~alvitagl/solex/ . Although in the meantime prof. Vitagliano provided the new version Solex 12,0, we chose to use here the "old" version Solex 11,00 in order to provide consistent and comparable results with our previous ones (Cerasetti et al, 2013).

27 At a distance of some thousands of years Newcomb's formulae accumulate big errors. We created the JavaScript softwares *FK4 B1900.0* and *FK4 B1950.0* with the formulae of Newcomb (Codebò, 2011, 2013; Frosini, 2012).

28 The *maximum digression* is the maximum distance that a circumpolar star gets from the local meridian. These stars do not transit at the *prime vertical* (which is the maximum circle crossing the cardinal point East, the Zenith, the cardinal point West and the Nadir); they never rise nor set and, therefore, they ever revolve around the heavenly poles. The "list" of the circumpolar stars changes in the millennia because of the equinoctial precession. This is the formula to calculate the maximum digression: $\text{sen } Z = \cos \delta \cdot \sec \varphi$, being Z the azimuthal angle, δ the star's declination (of the time) and φ the local latitude. If latitude is North, the star's azimut is equal to Z if the star is at East and is equal to 360° - Z is the star is at West. If the latitude is South, the star's azimut is equal to 180° - Z if the star is at East and is equal to Z – 180° if the star is at West.
A star is circumpolar when the sum of the its declination's absolute value plus the latitude of the observer is equal or more than 90° and declination and latitude have the same mathematical sign: $|\delta| + |\varphi| \geq 90°$.

ily their alignments to the azimuth of Thuban's Maximum Digression.

At least, we compared – each other – the azimuths measured "on the field" and the maximum digression (E or W)[29] of Thuban. We omitted in this study Ancient Merv because it is out of our range of investigation time.

At 12 April 2550 BC, UT 21:33:40, JD[30] 790137.3983908399[31] (spring aequinox), Thuban's equatorial coordinates were α 12h22m44s and δ +88°35'43". Its PD was 1°24'17". Its maximum digression was 1°37'18"E and 358°22'42"W. It is clear that the orientation of the Great Pyramid, with a gap less than 0°15', was towards the heavenly North Pole directly and not towards Thuban.

At 12 April 2450 BC, UT 02:21:50, JD 826661.5985007524, Thuban's equatorial coordinates were α 12h20m11s and δ +88°02'09". Its PD was 1°57'51". Its maximum digression in Lothal was 2°07'35"E and 357°52'25"W.

At 11 April 2400 BC, UT 04:27:46, JD 844923.6859598407, Thuban's equatorial coordinates were α 12h20m00s and δ +87°45'04". Its PD was 2°14'56". Its maximum digression in Gonur Depe was 2°51'46"E and 357°08'14"W.

At 10 April 2300 BC, UT 09:17:27, JD 881447.8871289854, Thuban's equatorial coordinates were α 12h20m22,914s and δ +87°11'29,59". Its PD was 2°48'30,41". Its maximum digression in Gonur Depe was 3°34'31,12"E and 356°25'28,88"W.

At 10 April 2250 BC, UT 11:24:23, JD 899709.9752674614, Thuban's equatorial coordinates were α 12h20m48s and δ +86°54'26". Its PD was 3°05'34". Its maximum digression in Lothal was 3°20'54"E and 356°39'06"W.

At 08 April 1950 BC, UT 01:25:00, JD 1009282.5590385204, Thuban's equatorial coordinates were α 12h25m36s and δ +85°13'24". Its PD was 4°46'36". Its maximum digression was:

a) in Gonur South 6°06'00" E and 353°55'00"W
b) in Togolok 21 6°04'29"E and 353°55'31"W

At 07 April 1900 BC, UT 03:38:15, JD 1027544.6515674359, Thuban's equatorial coordinates were α 12h26m45s and δ +84°56'27". Its PD was 5°03'33". Its maximum digression in Lothal was 5°28'41"E and 354°31'19"W.

At 06 April 1800 BC, UT 08:28:48, JD 1064068.8533363591, Thuban's equatorial coordinates were α 12h28m38" and δ +84°23'00". Its PD was 5°37'00". Its maximum digression in Lothal was 6°04'55"E and 353°55'05"W.

At 04 April 1550 BC, UT 20:13:56, JD 1155379.3430125397, Thuban's coordinates were α 12h34m16s and δ 82°59'09". Its PD was 7°05'51". Its maximum digression in Gonur North, Gonur South and Togolok 21 is showed in table 5.

3.2) For Lothal (Tab 2. No. 2–3) we got by archaeologists three dates: the foundation 2450

Table 2

Lothal's foundation (12 April 2450 BC, UT 02:21:50)

Settlement	Dating	Settlement's azimuth	Difference with the North Pole[32]	Thuban's Maximum Digression	Difference[33]	Thuban's Polar Distance[34]
Water basin	2450 BC	357°54'	-2°06'00"	2°07'35"E 357°52'25"W	0°01'35"	1°57'51"
Acropolis	2450 BC	358°53'	-1°07'00"	2°07'35"E 357°52'25"W	1°00'35"	1°57'51"
Warehouses	2450 BC	359°20'	-0°40'00"	2°07'35"E 357°52'25"W	1°27'35"	1°57'51"
Warehouses	2250 BC[35]	359°20'	-0°40'00"	3°20'54"E 356°39'06"	2°40'54"	3°05'34"
Lower town	2450 BC	347°12'	12°48'00"	2°07'35"E 357°52'25"W	10°40'25"	1°57'51"

29 Maximum Digression East if the building's azimuth is East. Maximum Digression West if the building's azimuth is West.
30 JD means Julian Day that is a system of time computation invented by Joseph Scaliger in 16th century in order to make easier the astronomical calculations. It begins from 1 January 4713 BC, at the noon, and goes on nonstop today yet.
31 Please note that, according to the Système International d'Unités SI, the comma must be used to separate the decimals and that the point (or dot) is only a license.
32 The difference between the heavenly North Pole – that is, by definition, 360° or 0° – and the settlement's azimuth.
33 The difference between the measured azimuth and the maximum digression of Thuban in the same direction: E or W.
34 Thuban's polar distance is the difference between the latitude of the North Pole 90° and the Thuban's declination in that time.
35 Uncertain dating.

Tabl. 2 bis.

Lothal's abandonment (equinox 07 April 1900 BC, UT 3:38:15)

Settlement	Settlement's azimuth	Difference with the North Pole	Thuban's Maximum Digression	Difference	Thuban's Polar Distance
Water basin	357°54'	-2°06'00"	5°28'40"E 354°31'20"W	3°22'40"	5°03'32"
Acropolis	358°53'	-1°07'00"	5°28'40"E 354°31'20"W	4°21'40"	5°03'32"
Warehouses	359°20'	-0°40'00"	5°28'40"E 354°31'20"W	4°48'40"	5°03'32"
Lower town	347°12'	12°48'00"	5°28'40"E 354°31'20"W	-7°19'20"	5°03'32"

BC; the construction of the warehouses 2250 (but it is a dating of old excavations, reliability and accuracy of which are therefore questionable) and the abandonment 1900 or 1800 BC.

It is clear that the Water Basin has the closest alignment towards Thuban. It is well known that the different structures of Lothal were built in different times that unfortunately are not well known by the archaeologists. For the warehouses we got two different dates of foundation – 2450 and 2250 BC – but the second one is not sure because of the low accuracy of the old excavations. The first date shows a better according with the azimuth of Thuban at its W maximum digression. The impossibility to get accurate dating of the single structure is a misfortune, because the differences of the measured azimuth might show the alignment towards Thuban in different times, *chasing* its shifting over the time. Someone could be tempted to use this *azimuth–shift* as an astronomical method of dating, but it is a «dangerous» operation because of several reasons: we are not sure that the differences of measured azimuths are surely due to the *azimuth–shift* over the time; different azimuths may be the effect of errors of measurement or of deterioration of the buildings, etc. During the 13th meeting of the Istituto Internazionale di Studi Liguri (International Institute of Ligurian Studies), which occurred in Genoa and in Sanremo (Italy) in 2002 (Codebò, de Santis, 2009) the question was debated and the conclusion of the majority of participants was that it is not possible to date ancient monuments with astronomical methods[36]. The question, anyway, is still open.

A separate problem is posed by the Lower Town, whose azimuth differs from Thuban's Maximum Digression well 10°: it is evident that the Lower Town was not aligned towards Thuban. We looked for the time in which the azimuth of maximum digression of Thuban corresponded to the azimuth of the Lower Town and we found about 1000 BC, but archaeological evidences show that the city was abandoned in 1900–1800 BC[37]. Therefore, the azimuth of the Lower Town had no astronomical significance, at least as alignment towards the North Pole.

At the time of the abandonment of Lothal (about 1950 BC) Thuban's coordinates were α 12h25m36s, δ +85°13'24" (at the spring equinox 08 April 1950 BC, UT 1:25:00, JD 1009282, 5590385204 (tabl. 2 bis).

Because of the "big" difference between the settlement's azimuths and the maximum digression of Thuban at the time of the abandonment of Lothal, people *must* necessarily have noticed that the whole heavenly sphere was changed: Thuban shifted from its original alignment buildings' axes more than 3°!

3.3) When Gonur North was founded in 2300 BC, Thuban's coordinates at 10 April 2300 BC, UT 09:17:27, JD 881447,8871289854 (spring equinox), were α 12h20m23s and δ +87°11'30"; PD 2°48'30"; maximum digression 3°34'31"E and 356°25'29"W. Therefore the measured azimuth 2°16' of Gonur North's East and West walls differs by –1°18'31" from

36 But, please, see the different opinion of Karen Tokhatyan (2009. P. 83-87) and of Paris Herouni (2004. P. 39-46; 2009. P. 88-95) and the respective debate following their reports (2009. P. 96-97).

37 At 06 April 1800 BC Thuban's equatorial coordinates were RA 12h28m38s and δ +84°23'00". Its PD was 5°37'00" and its maximum digression was 6°04'55"E and 353°55'05"W.

Thuban's E maximum digression (Tabl. 3): the concordance is similar to the one of Lothal's acropolis and warehouses but less than the water basin[38]. But the concordance of the azimuths of the walls inside the ruins and of the palace is, again, very close with the azimuth of heavenly North Pole. Moreover, the walls inside the ruins and the palace have azimuths very close towards the East and West cardinal points (tabl. 3).

Assuming that Gonur South and Togolok 21 were founded in 1950 BC., tabl. 4 shows the correlation of Thuban's coordinates α 12h35m16,619" and δ 82°42'33,07" with the azimuth of these two settlements at the date of the equinox 8 April 1950 BC, UT 01:25:00, JD 1009282,5590385204. It is plain that Gonur South was not oriented neither toward the heavenly North Pole nor towards the maximum digression of Thuban, but it is oriented towards solstices and lunistices (Cerasetti et al, 2013) and, therefore, it cannot be oriented towards the four cardinal points. We think that the original target of the builders was to study Sun's and Moon's movements, probably for religious aims. According to this point of view, we think that the so closest alignment of Gonur South towards the North Pole – with an error of only 4'20"! – at the time of its abandonment (tabl. 5) is a mere coincidence. Indeed, also if we suppose that the builders were able to calculate the motion of precession, they should not have known already when Gonur South was abandoned.

On the contrary, Togolok 21 was oriented towards the heavenly North Pole with an accuracy greater than the one allowed by Thuban (like-

38 Please, note that the concordance between the Gonur Depe's azimuth 02°16' and Thuban's Maximum Digression is better (only 0°35'40") using the foundation time (2400 BC) gave to us by the Italian Archeological Mission (Cerasetti et al, Codebò, de Santis 2013).

Table 3

Gonur North's foundation (10 April 2300 BC. UT 09:17:27)

Settlement	Settlement's azimuth	Difference with E and W cardinal points	Difference with the North Pole	Thuban's Maximum Digression	Difference	Thuban's Polar Distance
E and W walls	2°16'		2°16'	3°34'31"E 356°25'29"W	-1°18'31"	2°48'30"
North walls	89°46' ↔ 269°46'	-0°14'				
Internal walls and palace	0°41' ↔ 180°41 90°41' ↔ 270°41'	+0°41'	0°41'	3°34'31"E 356°25'29"W	-2°53'31"	2°48'30"

Table 4

Gonur South's and Togolok 21's foundation (08/04/1950 BC, UT 01:25:00)

Settlement	Settlement's azimuth	Deviation from North Pole	Thuban's Maximum Digression	Difference	Thuban's Polar Distance
Gonur South	351°	-9°00'00"	6°04'30"E 353°55'31"W	-2°55'31"	4°46'36"
Togolok 21	359°21'	-0°39'00"	6°04'30"E 353°55'31"W	5°25'29"	4°46'36"

Table 5

Gonur North's, South's and Togolok 21's abandonment (4/4/1550 BC, UT 20:13:56)

Settlement	Settlement's azimuth	Deviation from North Pole	Thuban's Maximum Digression	Difference	Thuban's Polar Distance
Gonur North	2°16'	2°16'	8°56'29°E 351°03'32"W	-6°40'29"	7°00'51"
Gonur South	351°	-9°00'00"	8°56'27"E 351°03'33"	-0°03'33"	7°00'51"
Togolok 21	359°21'	-0°39'00"	8°55'40"E 351°04'20"W	8°16'40"	7°00'51"

wise the Egyptian pyramids and parts of Gonur North).

When Gonur Depe (North and South) and Togolok 21 were abandoned during 16th BC[39], Thuban's coordinates at the spring equinox 04 April 1550 BC, UT.20:13:56, JD 1155379,3430125397, were: α 12h34m16,174m and δ 82°59'08,88". Tabl. 5 shows the relation between azimuth settlements, heavenly North Pole and Thuban's maximum digression.

4. CONCLUSIONS

It must be clear that the following conclusions are not a closing demonstration but rather a working hypothesis on which it will be necessary to carry out careful researches for a long time.

It is obvious that the six Egyptian pyramids[40], the Water Basin of Lothal, the inner walls and the palace of Gonur North and Togolok 21 were oriented towards the true heavenly North Pole with an accuracy[41] better than the one allowed by the contemporary north polar star Thuban, whereas Lothal's Acropolis and Warehouses (not the lower town) and Gonur North's east and west walls were oriented towards Thuban's maximum digression (i.e. with the help of the contemporary polar star). We have not yet enough data to distinguish possible differences between the alignments of successive phases of building. But what emerges clearly is that in all these settlements the builders looked for the same orientations towards the North, although using different methods: the orientation towards North – and therefore towards the four cardinal points – was the preferred one in this wide area, unlike it happened contemporary in Europe where orientations towards North and cardinal points are quite absent and where copper aged civilizations preferred orientations towards sunrises, sunsets, moonrises, moonsets, solstices, equinoxes, lunistices (Hoskin, 2006), and neglected the observation of the motion of the stars[42], although with some exceptions[43]. Orientations towards cardinal points became more frequent during the 1st millennium BC (Sassatelli, 1992).

But the most intriguing, unexpected, deduction following from our researches in Lothal, Gonur Depe and Togolok 21 is the fact that, at the time of the abandonment of the towns (table

39 From 1811 to 691 BC the polar star was κ Draconis. But it was not a "good" polar star: indeed, its least distance from the true North Pole was 4°42' in 1311 BC (Meeus, 2009. P. 358).

40 In Cheops' pyramid there are four ducts: two, opened, from the King's Room and two, close, from the Queen's Room, all towards South and North sides of the pyramid. South and North ducts from the King's Room are respectively oriented towards the belt of Orion and Thuban. South and North ducts from the Queen's Room are respectively oriented towards Sirius – Sothis and probably Kochab (β Ursae Minoris). This allowed to Robert Bauval to propose the dating 2450 BC±25 for the Great Pyramid (Magli, 2005. P. 359). Also the statue of the *Serdab* – i.e. the place in which occurred the ceremony of the *Mouth's Opening*, essential for the «post mortem» survival of the Pharao – of the Pharao Djoser «looked to» the North Pole through two little holes. Because the two regions of the North Pole and of Sirius and Orion – this last is the *Duat*, i.e. the «Kingdom of the Dead» – were the heavenly region that the Pharao had to get to revive, according to the «Texts of the Pyramids», Giulio Magli interprets the pyramids of the 3rd and 4th dynasty – and especially the Great Pyramid, as «astronomical machines» for the rebirth of the Pharao (Magli, 2005. Ch. 4, 17, 18). If this hypothesis is verified, it could provide a logical explanation of why any mummy was never found in these pyramids: immediately after death, the pharaoh's mummy could be put in either or in both of the rooms — the king's one and the queen's one – just the time required for the Akhu – I.e. the immortal soul – of the king reached the heavenly North Pole and the Duat through the ducts on them oriented. After this ritual time, the mummy could be removed from the rooms of the pyramid and placed in its tomb, where the Khat and Ka – i.e. the mummy and the «double» of the dead pharaoh – would rest forever.

41 The methods to get such accuracy may be the same ones described for the six pyramids. Please reed: Belmonte, 2001; Magli, 2005; Castellani, 2009

42 But Egypt had both solar and stellar cults (Magli 2005, p. 349).

43 These are the others monuments (not all of the III Mill. BC) with orientations towards the four cardinal points: Carahunge (Herouni, 2004); the quadrangular cromlech of Crocuno in French Brittany, 3000–1500 BC (Hadingham, 1978); Callanish south standing stones row in the Scottish isle of Lewis, 1500 BC. (Hadingham, 1978; Burl, 1983, 1988, 1993; Proverbio, 1989; Ruggles, 1999); the Campuriundu stones circle in Finale Ligure, Italy (date unknown) (Codebò, 1997); the dolmens – with their corridors — of Roccavignale, Savona, Italy (date unknown) (Codebò, 1997); the Etrurian town of Marzabotto – 5th century BC – in Italy (Sassatelli, 1992). More other, during the proofread, we received news about two other monuments of the III Mill. BC N-S oriented: Poggio Rota (Grosseto, Italy), studied by A. Gaspani, and some sites of Giordania, studied by Andrea Polcaro. Here we have neither the time nor the space to discuss them. Few European monuments have alignments towards stars: the copper aged – III Mill. BC – necropolis of Saint Martin de Corléans in Aosta (Cossard et al., 1991), Callanish – II Mill. BC – (Proverbio, 1989. P. 151) and few other (Hoskin, 2006. Ch. 3, 4).

n. 5), Thuban had manifestly shifted from its original alignments with buildings and towns. People could not fail to notice it! This shifting, together with the shifting of the sunrise/sunset points through the Zodiac[44], showed to them that the heavenly sphere was not always the same through centuries, but it rather changed. We think that this manifest change allowed to the ancient people to realize the existence of the equinoctial precession – the consequences, even if not the causes! – at least 2000 years (and maybe more) before Hipparchus (Codebò, 2014).

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44 30° wide (a modern astrological constellation) every 2147,5 years.

45 First results of the archeological excavations at Gonur Depe and Togolok 21 are described in: Сарианиди Древности страны Маргуш. Ашхабад, 1990 (Sarianidi V.I. Drevnsoti strany Margush, Ashgabat, 1990), that we could not read because of our ignorance of the Russian language.

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Fig. 6 for the article by M. Codebo & H.de Santis.
The settlement of Lothal (A acropolis; B warehouse block; C water basin; D Lower Town)
(photo by Archaeological Survey of India).

Рис. 1 к статье Н.М. Виноградовой и С. Бобомуллоева.
Могильник Фархор.
Общий вид погр. 19.

Fig. 3 for the article by A. Benoit.
Axe with flared blade and scene of predation in a mountain landscape on the heel of the socket, repeated on each side.
Detail view of the first side.

Рис. 2 к статье Н.М. Виноградовой и С. Бобомуллоева.
Могильник Фархор.
Каменный светильник из погр. 19.

Рис. 3 к статье Н.М. Виноградовой и С. Бобомуллоева.
Могильник Фархор. Погр. 19.
Каменные бусины, найденные около правой ноги.