New Results of Interdisciplinary Study of Bronze Age Settlements in Northwestern Crimea

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The research into the settlements on the Tarkhankut peninsula is the most relevant issue of the Crimean Bronze Age. More than forty new Bronze Age settlements have been discovered by means of complex interdisciplinary methods (analysis of satellite imagery, GPS routes for land exploration, magnetic and electromagnetic surveys, excavations). Oval structures were found on more than twenty new sites using non-invasive methods. By ethnographic similarities, they were interpreted as "livestock corrals" with stone foundations of walls. To test this hypothesis and to identify the time of existence, four settlements were excavated. It has been found that some settlements were repeatedly populated. Basic archaeological material and radiocarbon dating show that two settlements (Tarkhankut-18 and Tarkhankut-22a) existed in the final

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period of the Middle Bronze Age. They were left by communities of Babino culture. Based on the data of geochemical analysis of soil samples taken at a test pit 1 at Tarkhankut-18 settlement, the main function of this part can be defined as livestock enclosure-corral. Two other settlements existed in the Late Bronze Age. They were left by communities of Sabatinovka (Tarkhankut-H2) and Belozerka (Tarkhankut-H8) cultures. "Livestock corrals" are very close to structures unearthed on the sites of Hospital II and Gorodishche 11 km, which date to the Middle Bronze Age and are attributed to Kamensk culture of eastern Crimea. The structures of the Middle and Late Bronze Age found in Crimea are similar to synchronous objects from the Circumpontic region. It is indicative of the existence of specific non-burial stone architecture in the world of moving herders.

Keywords: Northern Black Sea Coast Region, Tarkhankut, Middle and Late Bronze Age, settlements, natural-scientific methods, livestock corrals.

Новые результаты междисциплинарного изучения поселений бронзового века в Северо-Западном Крыму

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Поиск и изучение бытовых памятников на Тарханкуте являются наиболее актуальной темой эпохи бронзы Крыма. В XX в. здесь было известно чуть более 10 поселений со слоями и находками позднего бронзового века, два из которых были раскопаны. Более 40 новых поселений эпохи бронзы, не имеющие прямых визуальных признаков, открыты благодаря комплексной междисциплинарной методике (анализ космических снимков, разведка по GPS-маршрутам, магнитная и электромагнитная съемки, раскопки в местах, выбранных по геофизическим данным). Неинвазивными методами более чем на 20 новых памятниках зафиксированы неизвестные овальные структуры, которые по этнографическим параллелям были интерпретированы как «загоны для скота» с каменными основаниями стен. Для проверки этой гипотезы, определения времени существования и культурной принадлежности на четырех поселениях проведены разведочные раскопки. Материалы проанализированы естественно-научными и традиционными археологическими методами. Выяснилось, что в древности некоторые поселения были заселены неоднократно. Основные археологические материалы и радиоуглеродные даты показывают, что два поселения (Тарханкут-18 и Тарханкут-22а) существовали на заключительном этапе среднего бронзового века и были оставлены сообществами культуры Бабино. По данным геохимического анализа образцов почвы из шурфа 1 на поселении Тарханкут-18 основную функцию этого участка можно определить как загон-стойло для содержания животных. Два других поселения существовали в позднем бронзовом веке и оставлены сообществами сабатиновской (Тарханкут-Н2) и белозерской (Тарханкут-Н8) культур. «Загоны для скота» с каменными основаниями стен находят близкие аналогии структурам на поселениях Госпиталь II и Городище 11 км, которые датированы средним бронзовым веком и отнесены к каменской культуре Восточного Крыма. Выявленные в Крыму структуры среднего и позднего бронзового века сопоставимы с синхронными объектами Циркумпонтийского региона, что свидетельствует о существовании в среде подвижных животноводов специфической непогребальной каменной архитектуры.

Ключевые слова: Северное Причерноморье, Тарханкут, средний и поздний бронзовый век, поселения, естественно-научные методы, загоны для скота.

Introduction

Crimean Bronze Age settlements were addressed in an integrated manner only in the mid-20th century which allowed checking them against archaeological materials from the Northern Black Sea coast and the whole Southern half of Eastern Europe. There were differentiated main Bronze Age communities: Yamnaya (Pit Grave), Catacomb-grave, Srubnaya (Timber-grave), Sabatinovka and Belozerka cultures[1]. Crimean materials were systematized and summarized in monographs by V. A. Kolotukhin[2] and G. N. Toshchev[3] as well as in numerous works by A. E. Kislyi[4].

S. N. Bratenko included Bronze Age settlements known in the East of Crimea into the Kamensk-Leventsovsk group[5] or culture (with the eponymous site of Leventsovsk fortification on the Lower Don). It is synchronous and relative to the Babino culture[6]. The Late Bronze Age in Crimea is represented by a number of successive archaeological cultures — the Srubnaya (Timber-grave), Sabatinovka and Belozerka ones. As G. N. Toshchev found out, although sites of the Srubnaia (Timber-grave) culture are disseminated throughout the whole peninsula, they are represented only by burials[7].

V. A. Kolotukhin conducted investigations in the North-West of Crimea. A little more than ten Bronze Age settlements were known here in the 20th century[8]. He excavated two settlements — Burun-Eli (1300 m^2) and Bai-Kiiat (2100 m^2) — in northern Tarkhankut[9]. He estimated the time of existence of the Burun-Eli settlements (developed stage of the Sabatinovka culture, from the second half of the 14th century BC) and Bai-Kiiat (the Belozerka culture, the 12th–9th centuries BC) using traditional archaeological methods —

[1] *Shul'ts P. N.* O kompleksnykh istoriko-arkheologicheskich i paleograficheskich issledovaniiach v Severnom Krymu // Izvestiia Krymskogo otdeleniia Geograficheskogo obshchestva SSSR. Simferopol, 1953, no. 2. P. 121; *Popova T. B.* Plemena katakombnoi kultury. Moscow, 1955. P. 11–13, 69; *Krivtsova-Grakova O. A.* Stepnoe Povolzh'e i Prichernomor'e v epokhu pozdnei bronzy. Moscow, 1955. P. 106–109, 159; *Leskov A. M.* Kirovskoe poselenie // Drevnosti Vostochnogo Kryma (Predskifskii period i skify). Kiev, 1970. P. 7–59; *Deopik D. V.* Klassifikatsiia i statisticheskii analiz keramicheskogo kompleksa poseleniia u s. Kirovo // Ibid. P. 60–98.

[2] *Kolotukhin V. A.:* 1) Gornyi Krym v epokhu pozdnei bronzy — nachale zheleznogo veka (Etnokulturnye protsessy) // Materialy po arkheologii Kryma. Kiev, 1996. P. 50, 60 ff., 87; 2) Pozdnii bronzovyi vek Kryma. Kiev, 2003.

[3] *Toshchev G. N.:* 1) Krym v epokhu bronzy. Zaporozhie, 2007; 2) Krym v epochu bronzy. Tavrika v III–II tys. do n. e. Saarbrücken, 2011.

[4] *Kislyi A. E.:* 1) Kamenskaia kultura Vostochnogo Kryma // Naukovi pratsi istorichnogo fakultetu Zaporizhkogo natsionalnogo universitetu. 2000. No. IX. P. 206–228; 2) Gleiki II — novyi pamiatnik na arkheologicheskoi karte Kryma // Starozhitnosti stepovogo Prichornomor'ia i Krimu. 2004. No. XI. P. 116–120; 3) Naselenie i pamiatniki kamenskoi kultury Vostochnogo Kryma // Stratum Plus. 2005. No. 2. P. 93–126; 4) Osnovi risi kam'ianskoi kulturi Skhidnogo Krimu // Arkheologiia. 2006. No. 3. P. 21–34; 5) O stenakh (spetsialnye postroiki kamenskoi kultury Vostochnogo Kryma) // Drevnosti Bospora. 2016. No. 20. P. 269–288; 6) Egalitarnost i neravenstvo. Nauchnye teorii i plemena epokhi bronzy Severnogo Prichernomoria // Istoriia i arkheologiia Kryma. 2019. No. X. P. 9–36.

[5] *Bratchenko S. N.* Kamensko-liventsovskaia gruppa pamiatnikov // Arkheologiia Ukrainskoi SSR. Vol. 1. Kiev, 1985. P. 458–462.

[6] *Bratchenko S. N.* Leventsovskaia krepost. Pamiatnik kultury bronzovogo veka. Kiev, 2012. P. 163 ff.

[7] *Toshchev G. N.* Krym v epokhu bronzy. P. 173 ff.

[8] *Kolotukhin V. A.*: 1) Poselenie Burun-Eli v Sevego-Zapadnom Krymu // Drevnosti stepnogo i predgornogo Kryma. 1990. No. I. P. 137–144; 2) Kimmeriitsy i skify Stepnogo Kryma (Podkurgannye pogrebeniia Stepnogo Kryma nachala zheleznogo veka). Simferopol, 2000; 3) Pozdnii bronzovyi vek Kryma; *Kopeva T. A.* Katakombnaia kultura na territorii Kryma (istoriia izucheniia i issledovanii) // Materialy po arkheologii, istorii i etnografii Tavrii. 2011, no. XVII. P. 3–29.

[9] *Kolotukhin V. A.* Pozdnii bronzovyi vek Kryma. P. 102–114.

systematization and classification of materials as well as comparative analysis with finds from the neighbouring territories[10].

Completely new data about the Crimean Bronze Age was obtained in the 21st century[11]. During large-scale excavations near "Tauria" highway in 2017–2018, layers of the final period of the Middle and Late Bronze Age in three settlements in eastern Crimea were studied[12]. Over the past one and a half decades complex large-scale non-invasive investigations have been conducted. Thus, more than forty new settlements have been discovered. The total number of settlements known is more than sixty. One third (more than 20) of these settlements has special structures named "double stone livestock corrals"[13]. On the modern daylight surface, they are not directly visible and can only be identified by denser vegetation (see below). Chronological position of such sites was initially defined widely — "before the beginning of the Greek colonization"[14].

All these circumstances required conducting field archaeological research into the new settlements in the North-West of Crimea to check the presence of the structures with stone wall bases, to gather information about their functions, to define the time of existence and cultural affiliation. The investigations are important because there is almost no data on the Middle Bronze Age cultures in this part of Crimea. Late Catacomb-grave "Yevpatorian" group is set apart only based on burial sites. Cultures and groups of post Catacomb-grave cluster here are yet unknown[15]. Equally important is the creation of a database of natural-scientific analysis of Bronze Age materials of the peninsula.

Discovery of the settlements: Methods and results

Since 2007 archaeological explorations of the Bronze Age settlements in the North-West of Crimea have been conducted using multidisciplinary approach that combines

[10] *Kolotukhin V. A.*: 1) Poseleniie Burun-Eli v Sevego-Zapadnom Krymu. P. 139; 2) Kimmeriitsy i skify Stepnogo Kryma. P. 526–553; 3) Pozdnii bronzovyi vek Kryma. P. 56.

[11] *Toshchev G. N., Kashuba M. T.* Poltora veka izucheniia bronzovogo veka Kryma: otvety i voprosy // Neizvestnye stranitsy arkheologii Kryma: ot neandertaltsev do genueztsev. St. Petersburg, 2017. P. 54–57.

[12] *Beilin D. V., Kislyi A. E., Mikhailov A. M., Rogudeev V. V., Sharapa A. V., Iurochkin V. Iu.* Raskopki poseleniia epokhi bronzy Gospital II v g. Kerchi (predvaritelnoe soobshchenie) // Drevnosti Bospora, 2018, vol. 23. P. 9–35; *Bonin A. V., Buravlev S. A., Ermolin S. A.* Raskopki poseleniia bronzovogo veka Lugovoe Severo-Zapadnoe 2 v Vostochnom Krymu // Krym — Tavrida. Arkheologicheskie issledovaniia v Krymuv 2017–2018 gg.: v 2 vol. Vol. 1. Moscow, 2019. P. 361–379; *Sviridov A. N., Iazikov S. V., Toporivskaia M. A., Frolov V. V.* Raskopki poseleniia Gorodishche 11 km v 2017 gody // Ibid. P. 187–203.

[13] *Smekalova T. N.*: 1) Pamiatniki epokhi bronzy i rannego zhelznogo veka na poluostrove Tarkhankut: Katalog. Materialy k arkheologicheskoi karte Kryma II. Simferopol, 2010; 2) Izuchenie poselenii epokhi pozdnei bronzy v Severo-Zapadnom Krymu s pomoshchiu distantsionnykh i geofizicheskikh metodov // Istoriia i arkheologiia Kryma. 2018. No. VII. P. 45–51, 194–204.

[14] *Smekalova T. N., Kutaisov V. A.* Arkheologicheskii atlas Severo-Zapadnogo Kryma. Pozdnii bronzovyi vek. Rannii zheleznyi vek. St. Petersburg, 2017. P. 55 ff., 93–134.

[15] Sporadic data of archaeological explorations of multi-layer settlements Iaryrchagskoe and Iorat with materials of Catacomb-grave and Babyno cultures of the Middle Bronze Age in the North-West Crime are quire verification or at least conducting excavations (see: *Kushtan D. P.* Razvedki na poseleniiakh epokhi bronzy v Zapadnom i Severo-Zapadnom Krymu (Chernomorskii i Sakskii raiony) // Istoriia i arkheologiia Kryma. 2014. No. I. P. 24–27, fig. 1: 2, 4, 5; 3: 1–3; *Smekalova T. N., Kutaisov V. A.* Arkheologicheskii atlas Severo-Zapadnogo Kryma. P. 107; *Kopeva T. A.* Katakombnaia kultura na territorii Kryma (istoriia izucheniia i issledovanii). P. 4, fig. 1. Vodopoinoe and Suvorovskoe settlements are in similar situations. The location of the latter settlement marked on the map of V. A. Kolotukhin is approximate (*Kolotukhin V. A.* Pozdnii bronzovyi vek Kryma. Fig. 1: 21).

remote, geophysical, geochemical and traditional archaeological methods[16]. During the initial stage, satellite images suggested locations (from web-service Google Earth Pro) are analysed. Bronze Age settlements are identified on the satellite images by spots of intense vegetation. They take special landscape positions: on capes of converging dry creeks/riverbeds (geological) or on their banks. Next scientists receive GPS coordinates and map routes, and conduct reconnaissance by car and on foot. The existence of Bronze Age settlements is confirmed by magnetic and electromagnetic surveys[17]. Bronze Age "houses" are seen on magnetic maps as positive anomalies of more or less rectangular form (magnet filling of half dugouts) with negative framing (non-magnet limestone walls). Positive magnetic anomalies are dark, and negative anomalies are white on maps of magnetic field. There are positive anomalies above half dugouts on maps of electric conductivity made using electromagnetic measuring device. Their filling conducts electric current better than background medium[18].

Due to large-scale investigations of wide areas which were carried out by means of magnetic survey, dozens of new Bronze Age settlements were revealed at Tarkhankut (Fig. 1). Scientists determined their spatial organization. The settlements take up special environmental niche. They are located on capes between two converging dry creeks or on their banks which enables to make the most of a flat relief (shelter against wind, aquifer at the bottom of deep dry creeks). Previously unknown oval constructions with diameter up to 50 m[19] were found using non-destructive methods in more than twenty settlements. Most of them consist of a big ungeometrical oval in which a smaller circle is inscribed (double). Few isolated constructions have been discovered. They create negative anomalies on magnetic maps (light areas on the maps). By ethnographic parallels, such constructions are named "livestock corrals" with stone wall bases (see below). This hypothesis is confirmed by chemical soil test of examples of a ground of a cultural layer from "corrals" conducted by A. V. Borisov (Institute of Physiochemical and Biological Problems in Soil Science of RAS). It has shown that soil became "ashy" not because of burning but due to microbiological mineralization of vegetative matter (manure) and its heating because of exothermic reaction in the process of decomposition[20]. Different rectangular, square and oval buildings that form "cellular" positive anomalies of different configuration on magnetic maps have been found in some settlements 100–200 m from "corrals".

Exploratory excavations

The Crimean archaeological and geophysical expedition of the V. I. Vernadskii Crimean Federal University led by T. N. Smekalova started excavations of the settlements with the "livestock corrals" with stone wall bases. Interesting sections for targeted exca-

[16] *Smekalova T. N., Kutaisov V. A.* Arkheologicheskii atlas Severo-Zapadnogo Kryma. P. 94–95.

[17] They were made using Overhauser Four-Channel system based on Canadian magnetometer GSM-19WG made by GemSystems and Canadian electromagnetometer EM38 made by Geonix.

[18] *Smekalova T. N., Yatsishina E. B., Garipov A. S., Pasumanskii A. E., Ketsko R. S. Chudin A. V.* Natural science methods in field archaeology, with the case study of Crimea // Crystallography Reports. 2016. Vol. 61. P. 533–542.

[19] *Smekalova T. N., Kutaisov V. A.* Arkheologicheskii atlas Severo-Zapadnogo Kryma. P. 109–131.

[20] *Smekalova T., Bevan B., Kashuba M., Lisetskii F., Borisov A., Kashirskaya N.* Magnetic surveys locate Late Bronze Age corrals // Archaeological Prospection. 2021. Vol. 28 (1). P. 3–16. https://doi.org/10.1002/arp.1789

vations on limited areas in the settlements were selected based on geophysical maps and interpretative plans that emerged as a result of magnetic and electromagnetic surveys and precision geodetic survey. Until now the exploratory excavations have been conducted in four settlements. Archaeological materials have been excavated. The first radiocarbon dates (see: Table) have been obtained. Samples (soil, pottery) for conducting investigations using natural-scientific methods have been selected.

The first radiocarbon dates for the Middle and Late Bronze Age settlements of Tarkhankut (based on authors' data)

Item number	Laboratory number	Place, context	Sample	Date 14C (BP)	Date years cal BC OxCal 4.3
1	SPb_3043	T-H2, test pit 2 ("corral"), depth 0.40–0.6 m; filed inventory T-H8_H2_30-1,2; 32-1,2*	Bones and tooth of cattle (collagen)	3093±40	1σ (68.2 %) 1415–1298 2σ (95.4 %) 1440–1234
2	SPb_3044	T-H8, test pit 3. Depth 0.40–0.45 m (North corner of the "room"); field inventory T-H8_H2_20-1-3	Bones and tooth of cattle (collagen)	2858±40	1σ (68.2 %) 1107–943 2σ (95.4 %) 1189–914
3	SPb_3042	T-H8, test pit 3, depth 0.45 m (North corner of the "room")	Soil	2874±45	1σ (68.2 %) 1120–980 2σ (95.4 %) 1207–923
4	SPb_3041	T-H8, test pit 4 ("corral"), depth 0.35–0.45 m; field inventory T-H8_H2_11-1-5	Animal bones (collagen)	2895±45	1σ (68.2 %) 1188–1008 2σ (95.4 %) 1217–936
5	SPb_3150	T-18, test pit 1 ("corral"), depth 0.30 m; field inventory T-18_III1_158–165; 14C-sample no. 2**	Bones and two animal teeth (collagen)	3685±50	1σ (68.2 %) 2140–1980 2σ (95.4 %) 2205–1930
6	SPb_3106	T-18, test pit 1 ("corral"), depth 0.40–0.45 m; field inventory T-18_III1_216, 276–283; 14C-sample no. 3	Animal bones (collagen)	3670±55	1σ (68.2 %) 2136–1976 2σ (95.4 %) 2201–1908
7	SPb_3107	T-18, test pit 1 ("corral"), depth 0.40 m; field inventory T-18-365, 314–318; 14C-sample no. 4	Animal bones (collagen)	2939±35	1σ (68.2 %) 1213–1087 2σ (95.4 %) 1258–1025
8	SPb_3109	T-18, test pit 2, Depth 0.40 m; field inventory T-18_III2_385–393, 394; 14C-sample no. 5	Bones and animal tooth (collagen)	3645±50	1σ (68.2 %) 2034–1916 2σ (95.4 %) 2135–1883
9	SPb_3108	T-18, test pit 2, depth 0.30 m; field inventory T-18_III1_158–96; 14C-sample no. 6	Animal bones (collagen)	3620±45	1σ (68.2 %) 2128–1943 2σ (95.4 %) 2190–1891

The End of the Table

Item number	Laboratory number	Place, context	Sample	Date 14C (BP)	Date years cal BC OxCal 4.3
10	SPb_3103	T-22a, test pit 1, depth 0.25–0.3 m; field inventory T-22a_III1_76–83; 14C-sample no. 1	Animal bones (collagen)	3630±50	1σ (68.2 %) 2119–1922 2σ (95.4 %) 2141–1882
11	SPb_3105	T-22a, test pit 1, depth 0.40–0.50 m; field inventory T-22a_III1_158–164, 179; 14C-sample no. 2	Animal bones (collagen)	3667±55	1σ (68.2 %) 2135–1972 2σ (95.4 %) 2200–1902
12	SPb_3151	T-22a, test pit 2, depth 0.4–0.45 m (cleansing of the floor of the "room"); field inventory T-22a_III2_20, 21, 42, 43, 45; 14C-sample no. 3	Bones and two animal teeth (collagen)	3078±55	1σ (68.2 %) 1412–1278 2σ (95.4 %) 1492–1134

Notes. * In a name of archaeological site abbreviation "T" means "Tarkhankut", numbers of samples reflect numbers of field inventory records.

** At T-18 settlement 14C-sample no. 1 (SPb_3104, T-18, test pit 1, depth 0.30 m; no. 114, 132 — the teeth of cattle) didn't succeed due to low amount of collagen.

Tarkhankut-H2 settlement (Fig. 1: 7) is located on a cape between two deep dry creeks/riverbeds (Fig. 2: 1)[21]. A double "corral" was found on the cape. It consists of a stone circle with the diameter of 28 m and an adjacent oval with the length of about 48 m. Two test pits were made at different structures of the settlement. An oval hole (bell-shaped in sectional view) *Test pit 1* (2×2 m) was examined. In the part near the bottom, a construction of five big and medium limestones was found. Four fragments of Bronze Age pottery, a burnt nucleus on a small flint pebble, and a small square stone with a sharpened wide working edge were unearthed in a filling. *Test pit 2* (4×2 m) was dug across a stone base of an internal wall of the double "corral". Main artefacts are animal bones. There are also 18 fragments of Bronze Age pottery found there (Fig. 2: 2–6)[22] and a fragment of a round stone with marks of processing. The observed height of the stone base was 0.4–0.5 m, width of breakdown — 2–2.15 m. The wall is built on a dead soil (ancient daylight surface of a steppe?). A peculiarity of the building technique of the wall lies in its stonework: internal border formed by large flat stones placed edgewise which are externally reinforced by middle-sized and small stones.

A date of remains of bones 3093±40 BP (SPb_3043) was obtained by means of radiocarbon dating. Its calibrated date is 1440–1234 BCE (see: Table) which allows us to attribute archaeological materials found in the test pit 2 to the Late Bronze Age. The materials from the test pit 1 can be cautiously dated to the same time. The obtained dates cover the period of existence of Sabatinovka culture. The pottery is similar to ware of a neighbouring Sabatinovka settlement Burun-Eli[23]. For example, herringbone carvings at shoul-

[21] The area of the site extends to neighbouring capes where an Early Iron Age settlement was found (*Smekalova T. N., Kutaisov V. A.* Arkheologicheskii atlas Severo-Zapadnogo Kryma. P. 111–112).

[22] Worthy of note is a high level of a fragmentation of pottery.

[23] *Kolotukhin V. A.* Pozdnii bronzovyi vek Kryma. P. 42.

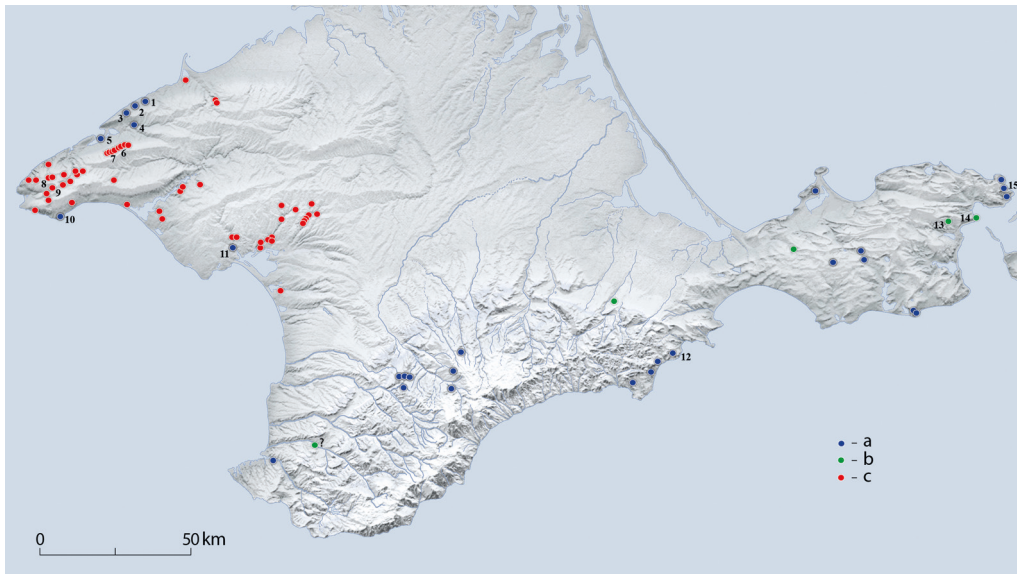

Fig. 1. Crimea. Settlements of the end of the Middle — the Late Bronze Age*:* a) known in the 20th century from excavations and explorations (with test pits drilling); b) multilayer discovered in the 21st century during building of the "Tauria" highway; c) discovered in the 21st century using non-invasive methods (including settlements where exploratory excavations have been conducted). *Mentioned settlements:* 1 — Burun-Eli, 2 — Bai-Kiiat, 3 — Skalistoe-2, 4 — Vodopoinoe, 5 — Iarylgach; 6 — Tarkhankut-H8; 7 — Tarkhankut-H2; 8 — Tarkhankut-22a; 9 — Tarkhankut-18; 10 — Oirat; 11 — Suvorovskoye; 12 — Planerskoe I; 13 — Gorodishche 11 km; 14 — Gospital II; 15 — Kamenka. The maps are constructed by authors

ders of pottery of Belozerka settlement Bai-Kiiat which, according to V. A. Kolotukhin, emerged "at the end of the Sabatinovka phase" are attributed by him to "archaic" elements of ornament (Fig. 2: 5)[24]. Other archaic signs of Middle Bronze Age pottery should be noted here as well: there are corded pattern and scratches on walls (Fig. 2: 3, 6).

Tarkhankut-H8 settlement (Fig. 1: 6) is located on a cape between two converging dry creeks/riverbeds where a double "corral" was found. It consists of a stone circle with the diameter of about 28 m and adjacent oval with length of about 45 m. There are rectangular buildings ("residential quarter"?) on a magnetic map. They are approximately 20–50 m apart from each other. V. F. Stolba and S. B. Lantsov excavated two 2×2 m test pits at a place of an exterior wall of a double "fence" (test pit 1) and a wall of a room at the "residential quarter" (test pit 2) in 2008. In these two pits, stone wall bases of the circle of the "corral" and the "room", fragmented Late Bronze Age pottery, fragment of a stone axe, few flint artefacts, and animal bones were found[25]. Two test pits were made at other different structures of the settlement. Their numbering was continued.

There is a western wall and a northern/northern-western part of a rectangular "room" (internal dimensions approximately 2.5–2.7 m) with solid walls at a *test pit 3* (6×2 m). Its long side is oriented to the South-North. The long western wall was probably external due

[24] Ibid. P. 42–44, fig. 52: 4.

[25] *Smekalova T. N., Kutaisov V. A.* Arkheologicheskii atlas Severo-Zapadnogo Kryma. P. 114–118, fig. VI. 3: 42–48.

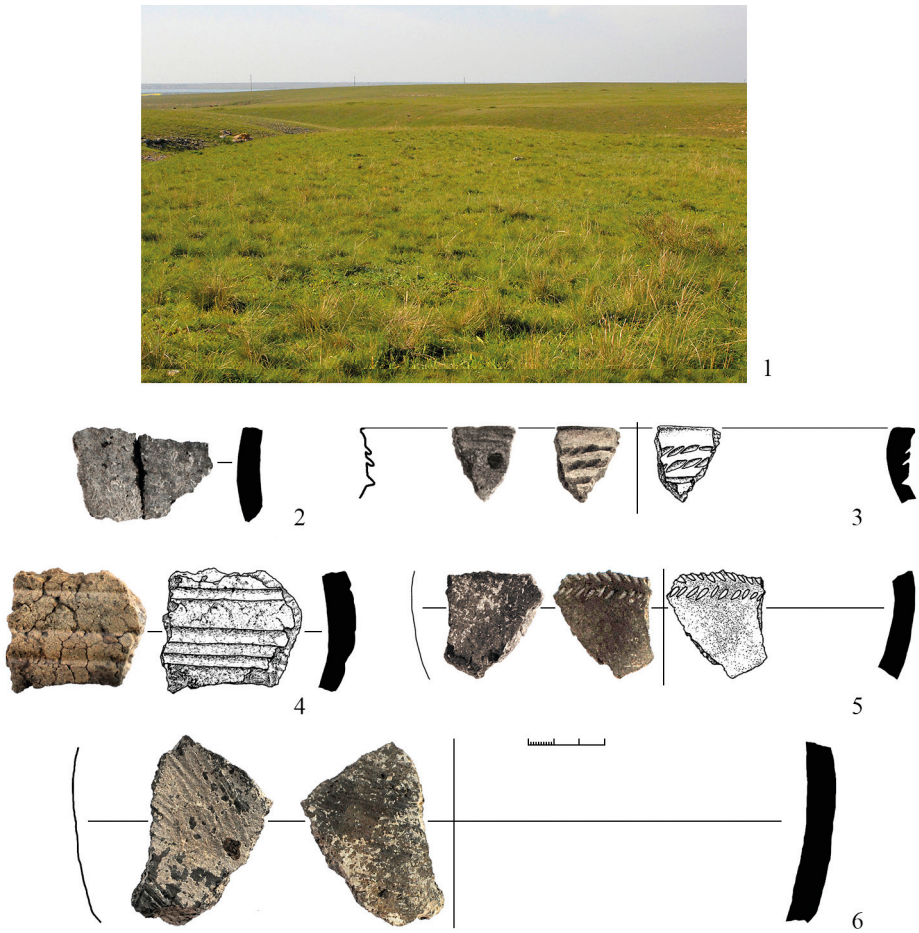

Fig. 2. Tarkhankut-H2 settlement: 1 — southern view; 2–6 — pottery from test pit 2 (based on authors' data)

to its double masonry with stone facing and a greater width (1.4–1.45 m) in comparison to northern (1.2–1.3 m) and southern (1.1 m) walls. They could have been either partitions between rooms or compartments of one big building (by the way, northern wall was built using five-row "orthostatic" masonry). 20 fragments of Late Bronze Age pottery were found here (Fig. 3: 1–3, 5, 7–9) as well as a fragment of a grindstone (?) with traces of processing, and a fragment of a shell of a sea bivalve and animal bones. Prevalence of animal bones among finds can mean that the found building was non-residential. *Test pit 4* (4×2 m) cuts across a stone base of an internal wall of the double "corral". Main artefacts are animal bones. There are also 11 fragments of pottery found there (Fig. 3: 4, 6, 10); three stones with traces of processing (two are round and flat with hollows on both sides, and one is elongated, pyramid-shaped); three chips or fragments of bone tools. The observed height of the stone base was up to 0.35 m, width of breakdown — 1.2–2.2 m. The wall was built on dead soil (ancient daylight surface of a steppe?). The wall was made using masonry with stone facing with two rows of large flat stones placed on the edge. The space between them was filled with small and medium limestones.

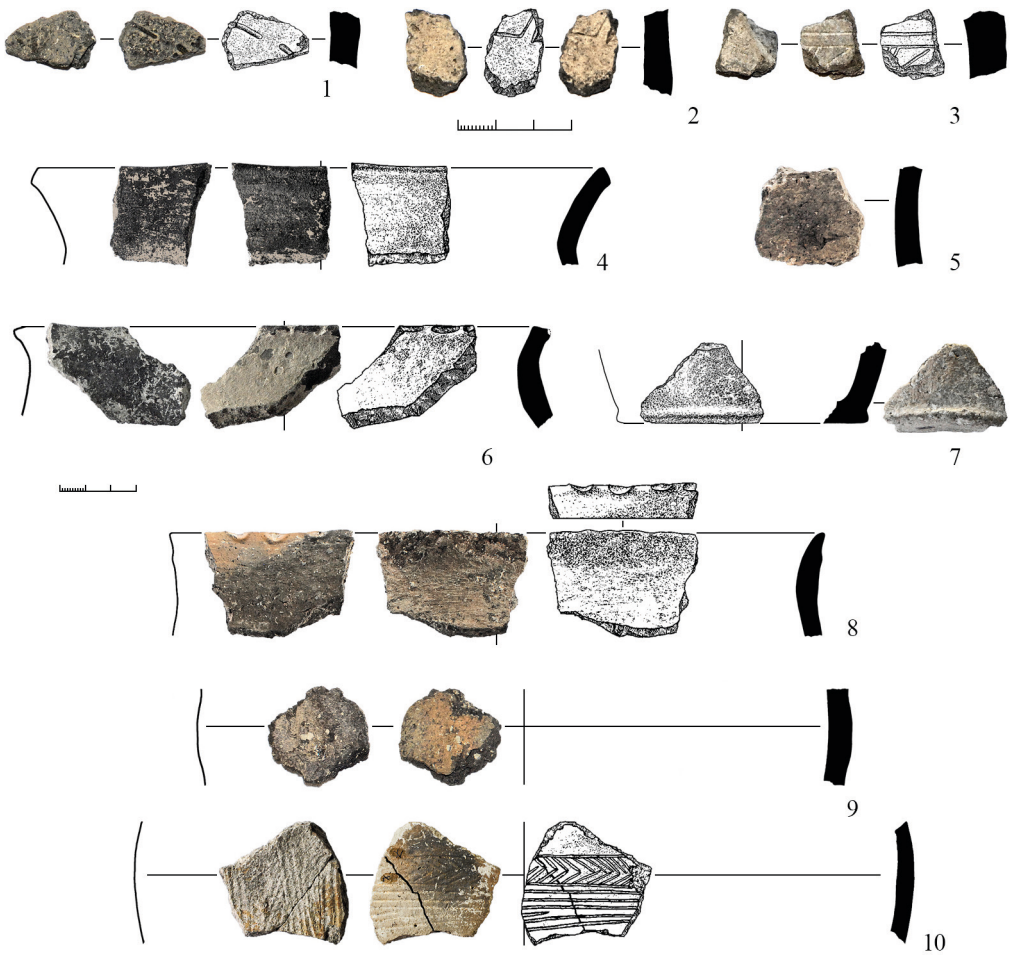

Fig. 3. Tarkhankut-H8 settlement: 1–3, 5, 7–9 — pottery from test pit 3; 4, 6, 10 — pottery from test pit 4 (based on authors' data)

Radiocarbon dates of the bone remains were received from test pits 3 and 4 (one was received by soil). Dates were calibrated using OxCal 4.3 program[26] — 2858±40 BP (SPb_3044), 1189–914 BC; 2874±45 BP (SPb_3042), 1207–923 BC; 2895±45 BP (SPb_3041), 1217–936 BC (see: Table). Combined date from three dates is 2874±25 BP, 1125–941 BC. It allows us to attribute archaeological materials found in test pits 3 and 4 to the concluding stage of the Late Bronze Age, to the Belozerka culture. The found pottery generally shares characteristics of ware of the Belozerka culture: a bent downward rim with finger dents, walls with carved pattern, thin-walled vessels made of puddle clay with chamotte and sand (Fig. 3). It is also similar to ware from neighbouring settlements Bai-Kiiat and Skalistoe-2 of the Belozerka culture[27]. However, the stone architecture found here displays archaic traits of the preceding Sabatinovka culture.

[26] *Bronk Ramsey C.* Bayesian analysis of radiocarbon dates // Radiocarbon. 2009. Vol. 51 (1). P. 337–360.

[27] *Kolotukhin V. A.* Pozdnii bronzovyi vek Kryma. P. 42–44, fig. 52–55.

Tarkhankut-18 settlement (Fig. 1: 9) is located on the northern shore of a shallow extensive dry creek/riverbed. Its territory is regularly ploughed. Double "corral" was found in the settlement. This "corral" consists of two ovals of almost the same size. Their long side is oriented in North-West-South-East direction. There are also few local positive anomalies. They can be remains of "rooms" destroyed by ploughing. There are two test pits at these presumably different structures of the settlement. *Test pit 1* (6×2 m) was dug across a stone base of an external wall of the double "corral". Among finds there were 3.5 times as many animal bones as fragments of pottery (132) (Fig. 4: 3–5, 10, 13, 15). 11 flint artefacts were also discovered (few flakes with utilization retouch, chips, a fragment of nucleus, an end-scraper, a shard with a chisel-shaped blade), and a fragment of a stone with marks of processing. The width of a stone wall base is 2.20–2.40 m. The wall was built using two-layer masonry with a stone facing with large and medium stones along the edges. The space between them was filled with small stones. It is found that the stone wall was built on a cultural layer of the settlement — at a level of 0.3–0.35 m below the present-dayground surface. *Test pit 2* (4×2 m) is made at a place of a dark rectangular blot which probably was the inner part of a "room". In the northern part of the test pit (at a level of 0.3 m below the present-daygroundsurface) few medium flat limestones were found. They lie flat but randomly. They can be the remains of walls of a construction (?) damaged during annual ploughing of the settlement's area. Among finds the number of fragments of pottery (297) (Fig. 4: 1, 2, 6–9, 11, 12, 14, 16–18) is almost equal to the number of animal bones. There are also five flint artefacts (a few flakes, a fragment of a pebble joint, a nucleus-shaped fragment of a secondary nucleus, an end-scraper on a laminar chip), two fragments of stone artefacts (grindstones) and a flat bone tool with two triangular ditches at its ends.

The majority of flint artefacts found at Tarkhankut-18 settlement are flakes[28]. All artefacts are made of flint. Its color ranges from greyish-straw to yellowish-grey. There are various inclusions and caverns in flint. The quality raw material varies from very poor to high. Small rolled flint pebbles probably of alluvial origin were used. If this collection can be considered representative of characteristics of manufacturing in Tarkhankut-18 settlement, we should acknowledge that primary flaking and making of tool shapes here could be situation-specific. This could indicate both a low level of development of stone processing technologies of this population and peculiarities of archaeological sites themselves that are not directly connected to making of working tools.

We received five radiocarbon dates from test pits on bone remains: three from test pit 1 — 3685±50 BP (SPb_3150), 2205–1930 BC; 3670±55 BP (SPb_3106), 2101–1908 BC; 2939±35 BP (SPb_3107), 1258–1025 BC; two from test pit 2 — 3545±50 BP (SPb_3109), 2190–1891 BC; 3620±45 BP (SPb_3108), 2135–1883 BC (see: Table). Combined date from four dates is 2133–1945 BC.

The obtained dates cover the Post Catacomb-grave period and early stage of the Babino culture. The materials obtained are quite expressive. Among Crimean pottery of the Middle Bronze Age, there are similar finds, including straight rims with a precisely cut edge and strips of dented lines or finger dents by the edge, moderately thin-walled vessels

[28] The authors express their gratitude to A. K. Ocherednoi, PhD (History), who analysed the flint artefacts.

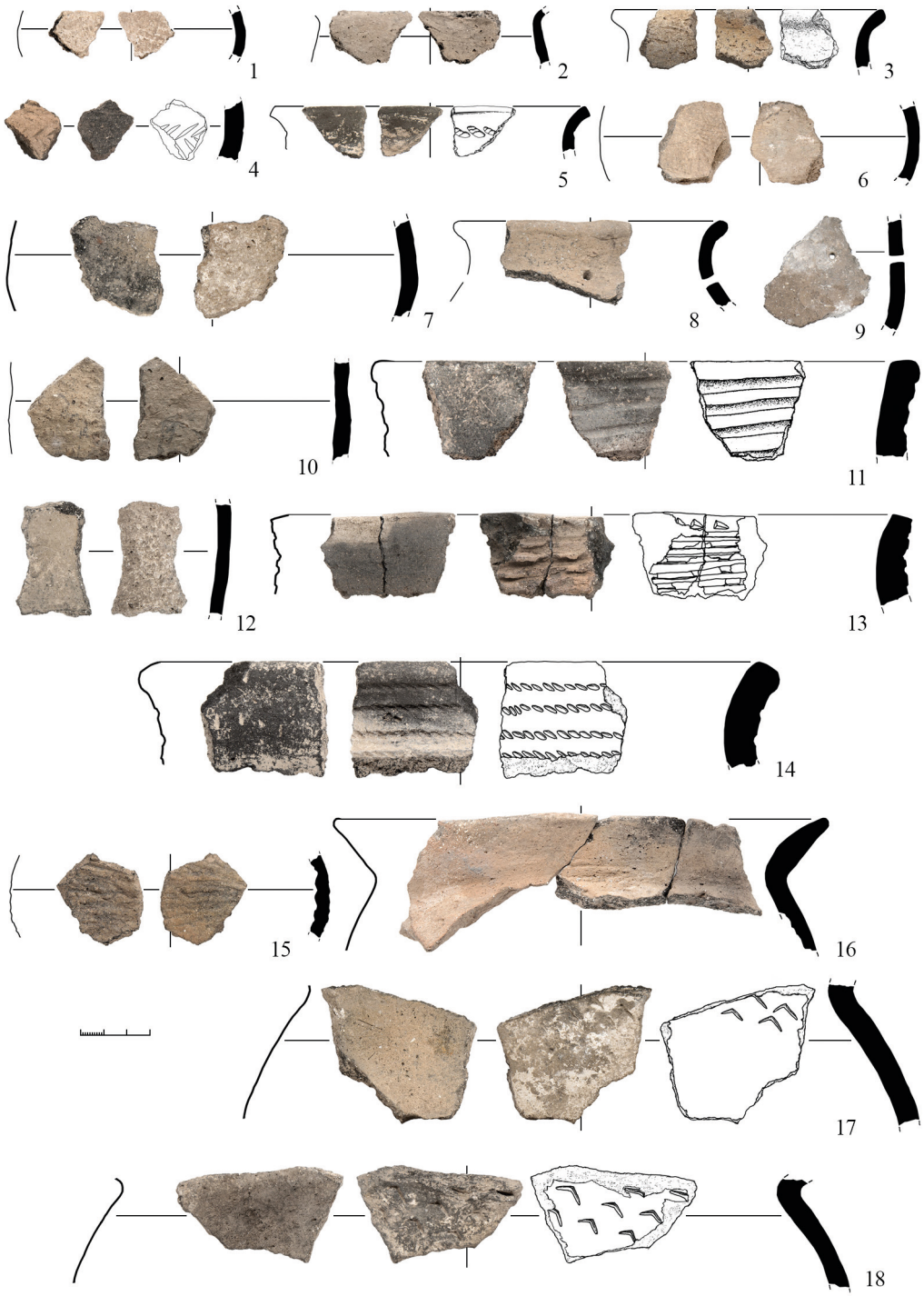

Fig. 4. Tarkhankut-18 settlement: 1, 2, 6–9, 11, 12, 14, 16–18 — pottery from test pit 2; 3–5, 10, 13, 15 — pottery from test pit 1 (based on authors' data)

with bent downward rim and roundish body (Fig. 4: 1–6, 11, 13)[29]. Corded pattern, cuts and straight cut rims (Fig. 4: 4, 5, 14) are evidence of Middle Bronze Age ornamentation. They are common features of pottery of the preceding Catacomb-grave culture. Vessels with wide bent downward corolla (bell mouthed?) rim (Fig. 4: 16) have close analogies among pottery of settlement Babino III[30]. In the meantime, a considerable number of forms and elements of pattern that don't have analogies in the known materials of the Crimean Bronze Age were found. Vessels with rough coating of the external surface with slurry (Fig. 4: 7, 10, 12) have analogies in settlements of the Middle and the beginning of the Late Bronze Age of the North-East of the Caucasus[31]. For example, such treatment of the surface of vessels in settlements of Kaiakent-Kharachoevsk culture emerges from preceding cultures of the Middle Bronze Age[32]. Vessels with wide bent downward rim and roundish body, the upper part of which is covered with the pattern with horizontal angles, are of interest (Fig. 4: 17, 18). One such vessel was broken in the ancient times. Its fragments are scattered within few meters at the depth of the 2nd and the 3rd layers of the cultural layer in test pit 2. It is important to mention finds of fragments of few vessels-strainers (Fig. 4: 8, 9).

According to stratigraphical observations, a stone wall of a "livestock corral" and a utility "room" were built at the same level (0.3–0.35 m below the present-day ground surface) but judging by a character of materials found they could have had different purposes. To check this observation, a geochemical analysis of soil samples was conducted. The samples were taken from the base of the 2nd layer of a cultural layer at test pit 1 ("corral" — see below). From the other side, materials found at test pits 1 and 2 confirm simultaneity of discovered structures, which again proves the data of radiocarbon dating. Other four samples, except for 14C sample no. 4 (of samples from a cultural layer outside of the "livestock corral" (see: Table)) show similar dates. It enables to attribute the discovered archaeological materials to the final period of the Middle Bronze Age, which is generally in line withboth the dates of the early Babino culture in other regions (23rd–20th centuries BC) and with the dates of post Catacomb-grave Eastern Europe cultural block (22nd–18th centuries BC)[33].

Tarkhankut-22a settlement (Fig. 1: 8) is situated on a cape between two dry creeks/riverbeds where two double "corrals" with additional, adjacent to each other, structures inside were found. They consisted of ovals and adjacent to them from the North-North-West big rough ovals with the length of about 50 m. Magnetic survey shows additional structures inside the ovals. Another rectangular structure with two compartments (?) was discovered to the East-South-East of the "corrals". Magnetic survey also reveals traces of ploughing, and "long fields" on a neighbouring cape[34]. Two test pits were made at different

[29] *Toshchev G. N.* Krym v epokhu bronzy. P. 94–171; *Kislyi A. E.* Naselenie i pamiatniki kamenskoi kultury Vostochnogo Kryma. P. 93–126.

[30] *Bratchenko S. N.* Leventsovskaia krepost. Pamiatnik kultury bronzovogo veka. Fig. 105: 1–8, 11.

[31] *Markovin V. I.* Severo-Vostochyi Kavkaz v epochu bronzy // Arkheologiia. Epocha bronzy Kavkaza i Srednei Azii. Ranniaia i sredniaia bronza Kavkaza. Moscow, 1994. P. 306 ff.

[32] *Markovin V. I.* Kaiakentsko-kharachoevskaia kultura // Ibid. P. 334–355.

[33] *Mimokhod R. A.*: 1) Stratifitsirovannye kurgany bronzovogo veka na pravoberezhe Severskogo Dontsa. Materialy spasatelnych arkheologicheskikh issledovanii. Moscow, 2018. P. 112–114; 2) Blok postkatakombnykh kulturnykh obrazovanii v Vostochnoi Evrope: struktura i soderzhanie // Izuchenie i sokhranenie arkheologicheskogo naslediia narodov Kavkaza. XXIX Krupnovskie chteniia. Groznyi, 2016. P. 45–47.

[34] *Smekalova T. N., Kutaisov V. A.* Arkheologicheskii atlas Severo-Zapadnogo Kryma. P. 121, fig. VI. 3.57; VI. 3.58.

structures of the settlement. *Test pit 1* (5×2 m) was dug across a stone base of an internal wall of the northern double "corral". Stratigraphic data indicates Bronze Age complexes and materials in the discovered remains from the northern and central parts of the test pit (the wall of the "corral". Southern part has complexes and materials of the Early Iron Age (2–3-rowed self-faced stonework made of square and rectangular compacted stones at level up to 0.35 m below the present-day ground surface). Animal bones prevail among objects that can be attributed to the Bronze Age. About 30 fragments of pottery and a nucleus-shaped fragment of high-quality flint were also found. The width of the remains of the stone wall base of the "corral" is 1.8–2.75 m. The wall was built at rock outcrops (?). The wall was made of double stone (?) masonry with two rows of large stones. The space between them was filled with small and medium limestones. *Test pit 2* (5×2 m) was made across the northern-eastern "wall" of a rectangular structure covering both external and internal sides of it. Double row of large and medium stones at the level of 0.3 m below the present-day ground surface (remains of a wall?) was found in the eastern part of the test pit. The external row consisted of large and medium flat stones lying flat. The internal row consisted of smaller stones placed on the edge and reinforced with small stones. The distance between the rows is 1.0–1.1 m. There are very few finds; most of them were unearthed in an "internal part" of the building (from a level of "cleaning of the floor"): 17 fragments of unspectacular pottery; an amulet made of stone with natural holes; three artifacts made of high-quality flint (small flake and two chips); a fragment of a stone burnisher; few bone tools (chips?); a seashell; and few animal bones. About 10 fragments of small rough clay coating, found in the "inner part" and darting cleansing of the "floor" of the building are noteworthy.

Three radiocarbon dates of the bone remains were obtained from the test pits: two dates from test pit 1 — 3630±50 BP (SPb_3103), 2141–1882 BC; 3667±55 BP (SPb_3105), 2200–1902 BC; one date from test pit 2 — 3078±55 BP (SPb_3151), 1492–1134 BC (see: Table). Combined date from two dates is between 2136–1923 BC. Obtained dates cover the early stage of the Babyno culture. Although the materials from the test pit are not very spectacular, some pottery can be compared with materials from settlement Tarkhankut-18 (rim with precisely cut edge and short bent downward neck, scratches of surface). The third obtained date covers the period of existence of the Sabatinovka culture. There is a good chance that the building itself should also be attributed to the Late Bronze Age because the sample taken from animal bones found during cleaning of the floor of the "room" and the remains of the wall are similar to the house-building technique from a nearby Sabatinovka settlement Burun-Eli and a Belozerka settlement Bai-Kiiat[35].

Geochemical survey — reconstruction of functional zone at Tarkhankut-18 settlement, test pit 1

Currently, there are more and more works devoted to the use of geochemistry for the reconstruction of anthropogenic activity in places of ancient settlements. Along with the already developed methodology, including the determination of phosphorus[36], which is a

[35] *Kolotukhin V. A.* Pozdnii bronzovyi vek Kryma. P. 28–39, fig. 36–39, 43–46.

[36] *Jenkins D. A.* Trace element geochemistry in archaeological sites // Environmental Geochemistry and Health. 1989. Vol. 11 (2). P. 57–62; *Welleste L.* Analiz fosfatnykh soedinenii pochvy dlia ustanovleniia

marker of the activity of ancient people, other chemical elements are becoming increasingly important. Groups of chemical elements that characterize certain functional zones associated with human activity are distinguished[37]: burials are characterized by anomalous values of elements such as P (phosphorus), Cu (copper), Mn (manganese), Ca (calcium)[38]; well zones — by P (phosphorus), K (potassium), Mg (magnesium), Zn (zinc), Rb (rubidium)[39]; garbage heaps — by P (phosphorus), K (potassium)[40]; farm plots, internal building plots — P (phosphorus), Ca (calcium), Mg (magnesium), Fe (iron), K (potassium), Th (thorium), Rb (rubidium), Cs (caesium), Pb (lead), Zn (zinc), Sr (strontium), Ba (barium)[41]; paint of buildings — by heavy metals[42]; ore mining, metal production and metal smelting sites — by Cu (copper), Pb (lead), Mn (manganese)[43]; the location of archaeological sites — by B (boron), Cu (copper), Mg (magnesium), Mn (manganese), Ni (nickel), P (phosphorus), Se (selenium), Zn (zinc), K (potassium), Ba (barium), Ca (calcium), Na (sodium)[44].

The evaluation of distribution of anomaly manifestations of certain elements or groups of elements on the archaeological site showed that interpretation of obtained data is not always simple and depends upon a number of factors. An important problem of interpretation of geochemical data is geochemical proof that accumulation of a certain

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mest drevnich poselenii // Kratkie soobshcheniia Instituta istorii materialnoi kultury. 1952. No. 42. P. 135–140.

[37] *Oonk S., Slomp C. P., Huisman J. D.* Geochemistry as an aid in archaeological prospection and site interpretation: current issues and research directions // Archaeological Prospection. 2009. Vol. 16 (1). P. 35–51.

[38] *Cook S. F., Heizer R. F.* Studies on the Chemical Analysis of Archaeological Sites. Berkeley; Los Angeles, 1965; *Bethell P. H., Smith J. U.* Trace element analysis of an inhumation from Sutton Hoo, using inductively coupled plasma emission spectrometry: an evaluation of the techniques applied to analysis of organic residues // Journal of Archaeological Science. 1989. Vol. 16 (1). P. 47–55.

[39] *Knudsen D., Peterson G. A., Pratt P. F.* Lithium, sodium and potassium // Methods of soil analysis. Part 2. Madison, 1982. P. 225–246.

[40] *Wells E. C., Terry R. E., Parnell J. J., Hardin P. J., Jackson M. W., Houston S. D.* Chemical analyses of ancient anthrosols in residential areas at Pieda Negras, Guatemala // Journal of Archaeological Science. 2000. Vol. 27. P. 449–462; *Parnell J. J., Terry R. E., Golden C.* Using in-field phosphate testing to rapidly identify middens at Piedras Negras, Guatemala // Geoarchaeology. 2001. Vol. 16. P. 855–873.

[41] *Zimmermann W. H.* Die Siedlungen des 1. bis 6. Jahrhunderts nach Christus von Flögeln-Eekhöltjen, Niedersachsen: Die Bauformen und ihre Funktionen. Wilhelmshaven, 1992; *Entwistle J. A., Abrahams P. W., Dodgshon R. A.* The geoarchaeological significance and spatial variability of a range of physical and chemical soil properties from a former habitation site, Isle of Skye // Journal of Archaeological Science. 2000. Vol. 27. P. 287–303; *Parnell J. J., Terry R. E., Golden C.* Using in-field phosphate testing to rapidly identify middens at Piedras Negras, Guatemala. P. 855–873; *Wilson C. A., Davidson D. A., Cresser M. S.* An evaluation of multi element analysis of historic soil contamination to differentiate space use and former function in and around abandoned farms // The Holocene. 2005. Vol. 15. P. 1094–1099; *Wilson C. A., Cresser M. S., Davidson D. A.* Sequential element extraction of soils from abandoned farms: an investigation of the partitioning of anthropogenic element inputs from historic land use // Journal of Environmental Monitoring. 2006. Vol. 8. P. 439–444.

[42] *Wells E. C., Terry R. E., Parnell J. J., Hardin P. J., Jackson M. W., Houston S. D.* Chemical analyses of ancient anthrosols in residential areas at Pieda Negras, Guatemala. P. 449–462.

[43] *Jenkins D. A.* Trace element geochemistry in archaeological sites. P. 57–62; *Monna F., Galop D., Carozza L., Tual M., Beyrie A., Marembert F., Chateau C., Dominik J., Grousset F. E.* Environmental impact of early Basquemining and smelting recorded in a high ashminerogenic peat deposit // Science of the Total Environment. 2004. Vol. 327(1–3). P. 197–214.

[44] *Cook S. F., Heizer R. F.* Studies on the Chemical Analysis of Archaeological Sites; *Da Costa M. L., Kern D. C.* Geochemical signatures of tropical soils with archaeological black earth in the Amazon, Brazil // Journal of Geochemical Exploration. 1999. Vol. 66. P. 369–385.

element is man-made, and that it isn't a result of mineral composition of sediments on a certain site. Indicator ratios or geochemical modules are used for some elements, for example, for potassium, calcium, strontium or phosphorus. They are used to separate mineral component from anthropogenic one because these elements can form part of both anthropogenic chemical compounds and of mineral composition of the sediments[45]. Other factors that influence the behavior of individual chemical elements are pH (acid-base), Eh (oxidation-reduction) potentials of the soil environment, organic matter content in soils etc., which also needs to be taken into account when assessing the formation of the cultural layer at a settlement. Therefore, recently for the reconstruction of various factors of the formation of cultural sediments, methods of multivariate factorial and correlation analyses have been used to identify individual groups of geochemically related elements and characterize the influence of anthropogenic or natural factors on them[46]. The use of complex research methods, such as geochemical, geophysical, and archaeological methods in the assessment of the archaeological site provides an opportunity for a detailed reconstruction of all the features of life, including human economic activity in this location. For example, the results of the spatial distribution of the anthropogenic elements (Ca, K, P and Mn) by means of the pXRF analysis carried out at Seoke (Botswana) stone walled sites showed the areas of different daily activities, including cattle corrals[47].

Samples of deposits on the ***Tarkhankut-18 settlement*** (*test pit 1*) were taken from the surface of the second horizon of the cultural layer by a grid, at every 50 cm. In addition, samples from the surface of eolian sediments (*background test pit*) were taken to define background concentrations of geochemical components. Background test pit was made outside of archaeological settlement to define the composition of geologically similar sediments that were unaffected by human interference. The background samples were taken from the same lithological horizon as the cultural layer. The altitude of this lithological layer was compared with the level of the cultural horizon.

Geochemical composition of samples was defined by wavelength dispersive x-ray fluorescence (XRF-WD). We received data using computer program Surfer Mapping System (Version 3.0) and made maps on the basis of this data. The maps contain distribution of chemical indicators connected with anthropogenic activity at the test pit 1 and distribution of certain chemical elements by area of the background test pit.

Fig. 5 displays a map of distribution of the phosphorus content P_2O_{5anthr} (%), calcium CaO_{anthr} = $CaO/(CaO+Na_2O)$ (%). To split potassium, calcium and phosphorus that are within the anthropogenic sediments of the same elements comprising rock-forming minerals the following ratios were used: $CaO/(CaO+Na_2O)$; $P_2O_5/(P_2O_5+Na_2O)$; $K_2O/(K_2O+Na_2O)$[48]. Changes in microrelief are well marked by maps of distribution of terri-

[45] *Kulkova M. A.* Metody prikladnykh paleolandshaftnykh geokhimicheskikh issledovanii. St. Petersburg, 2012.

[46] Ibid.; *Oonk S., Slomp C. P., Huisman J. D.* Geochemistry as an aid in archaeological prospection and site interpretation: current issues and research directions. P. 35–51; *Nielsen N. H., Kristiansen S. M.* Identifying ancient manuring: traditional phosphate vs. multi-element analysis of archaeological soil // Journal of Archaeological Science. 2014. Vol. 42. P. 390–398.

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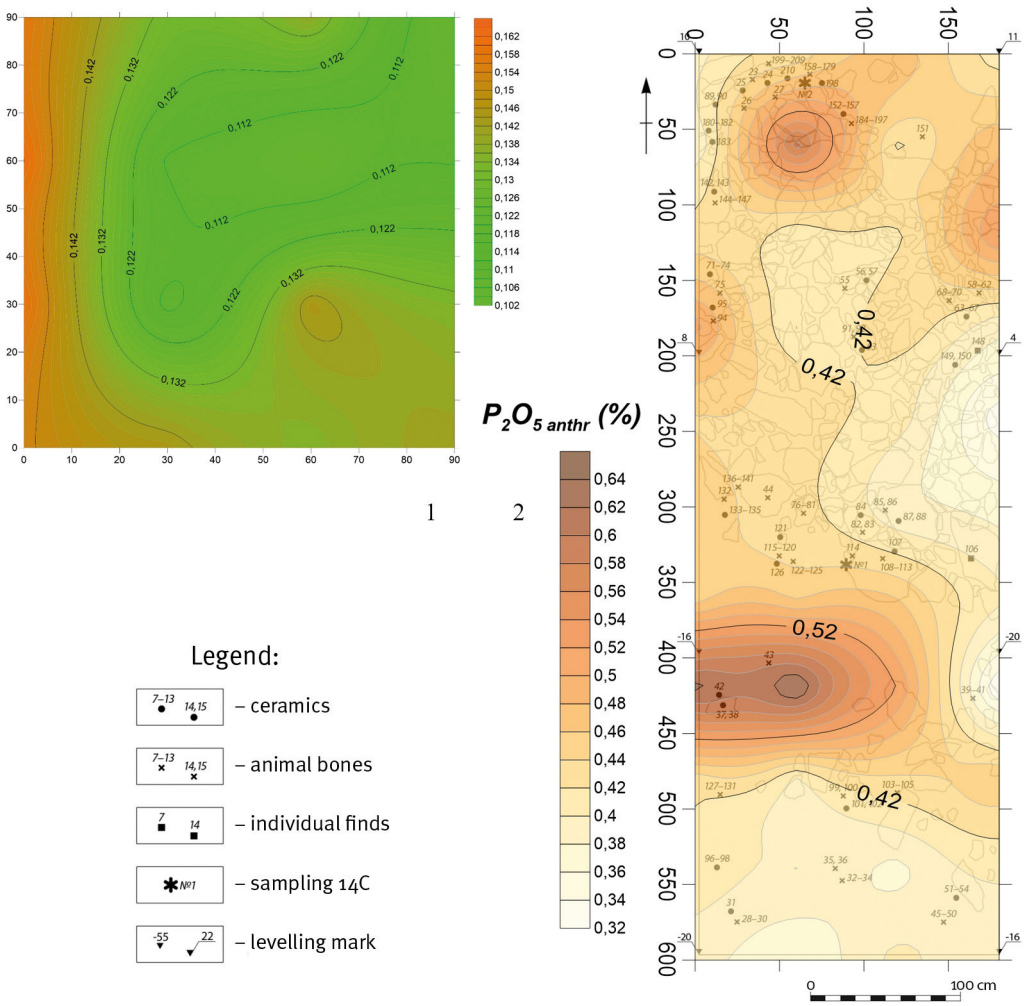

Fig. 5. Tarkhankut-18 settlement, distribution of P_2O_{5anthr} (%) in deposits: 1 — the background test pit, 2 — the excavation area. The level of 2nd cultural horizon. The maps are constructed by authors

gene sediments Al_2O_3 and SiO_2[49]. There is more alumina (Al_2O_3) in deposits enriched by clay subcomponent. Its increase can also be connected with processes of deterioration and the chemical weathering. Elevated levels of SiO_2 are in this case related to a bigger sandy disintegrated subcomponent. Analysis of SiO_2 distribution shows special aspects of microrelief. Elevated areas have elevated levels of silica and sandy subcomponent.

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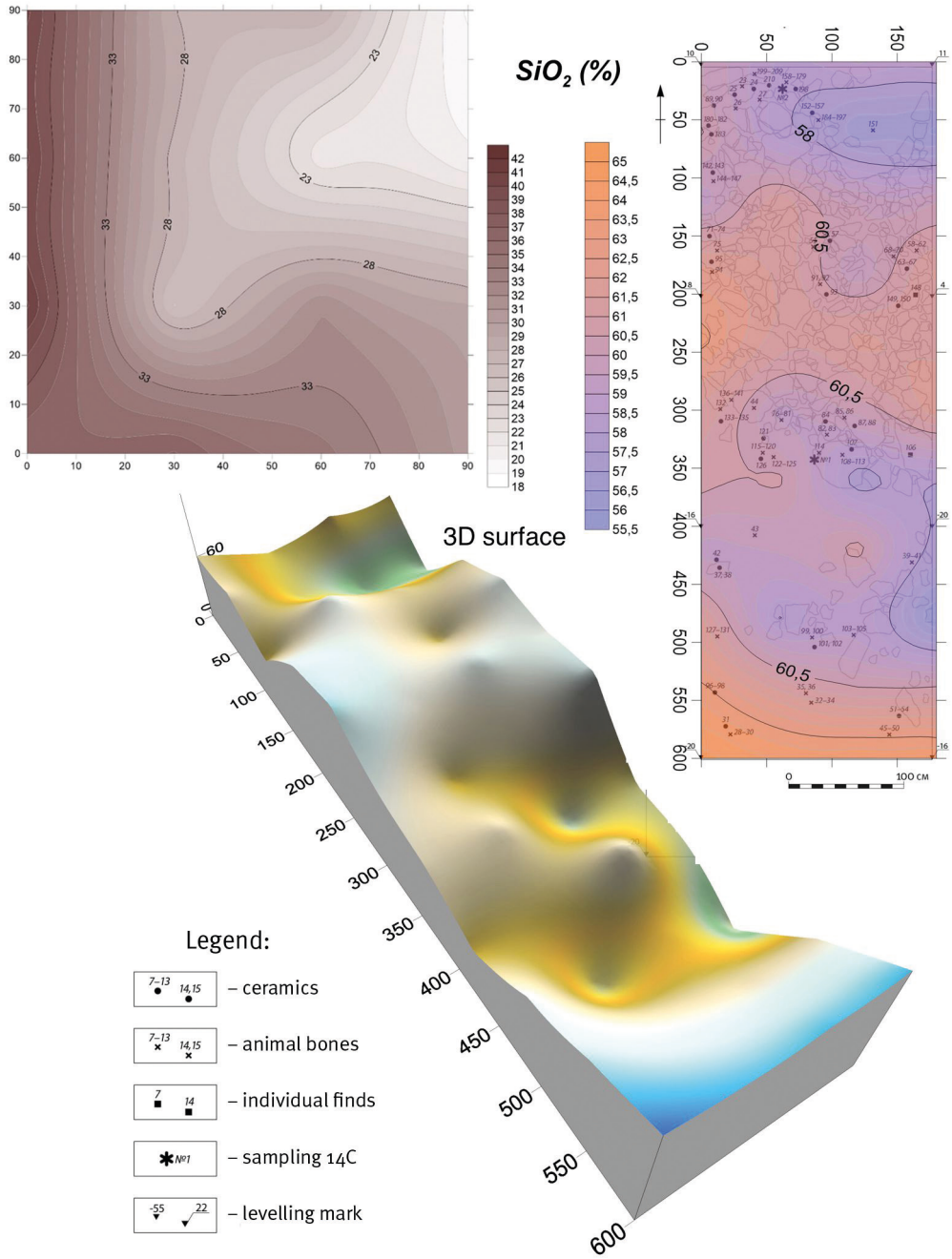

Fig. 6. Tarkhankut-18 settlement, distribution of SiO_2 (%) in deposits: 1 — the background test pit, 2 — the excavation area; 3 — 3D-distribution. The level of the 2nd cultural horizon. The maps are constructed by authors

Compared with the background concentration in the deposits of the excavation area, there are higher levels of silica. Elevated areas enriched with sandy component coincide

with elevations of the microrelief under stone composition of walls on 3D-distribution map of silica (Fig. 6) in the deposits of the excavation area (test pit 1) (probably sandy up filling was added later).

Comparison between the distribution of alumina subcomponent in deposits of the area of the background test pit and excavation area reveals higherlevel of aluminainthe dug test pit (10–12 %) than in background deposits, where the concentrations of alumina are from 4 to 10 %. It is connected with strong weathering of the deposits (trampling down) and processing of materials as a result of anthropogenic activity. This idea was supported by the calculation of the Chemical Index of Alteration (CIA)[50]. The distribution of this indicator on the surface of the cultural layer corresponds to the trampled zones inside of the corral.

The level of anthropogenic phosphorus in the excavation area is roughly threefold higher. Elevated (close to anomaly) levels were defined by the inside part of the corral where intense acitivty of humans and animals took place (Fig. 6).

Comparison of concentrations of calcium in the deposits in the settlement area (Fig. 7: 2) with background values (fig. 7: 1) shows that the background deposits have high levels of calcium (up to 40 %), while levels of calcium in the deposits from the inside part of excavation area are 4–10 %. This demonstrates the dissolution of calcium carbonates in the deposits of the excavation area as a result of aggressive chemical environment that could exist in animal stables. The map of distribution of anthropogenic calcium in the excavation area (fig. 7: 2) correlates with the map of distribution of anthropogenic phosphorus. Carbonates are the main mineral component of sediments in this area. Their dissolving in the zone of the corral occurred under the influence of ammonia g. Urea is hydrolyzed through urea's ferment in the ammonium carbonate ($(NH_4)_2CO_3$), whereas ammonia ions (NH^{4+}) give the main source of NH_3. Ammonium nitrogen (NH^{4+}–N) including components of urine acid decomposed into (NH^{4+}–N) is joint ammonium nitrogen (JAN). Ammonia forms in all cases when dung preserves in the environment: in the corral, in the places of mature storage. Such acid conditions solve carbonates, and their concentrations in the corral became much lower than in the environment.

Other components, for example, the ones that can be connected with places of accumulation of human or animal feces (Ba, LOI, K_2O_{anthr})[51], have abnormal concentrations inside the corral. Comparison of maps of distribution of anthropogenic (Fig. 8: 1) and terrigene (from mineral part of the deposits — Fig. 8: 2) potassium in deposits of excavation area clearly shows that there are high levels of anthropogenic potassium in the deposits of the eastern part of the inside of the corral. It can mean that this part was intensively used for keeping animals (accumulation of manure). Terrigene potassium distribution has no patterns.

So, the maps of distribution of terrigene sediments (like SiO_2) demonstrate features of microrelief in the excavation area. The elevated areas where stones are piled up and lowered areas where livestock was kept are seen very well. The deposits in these areas are strongly "trampled" and processed (based on Al_2O_3, CIA). High levels of anthropogen-

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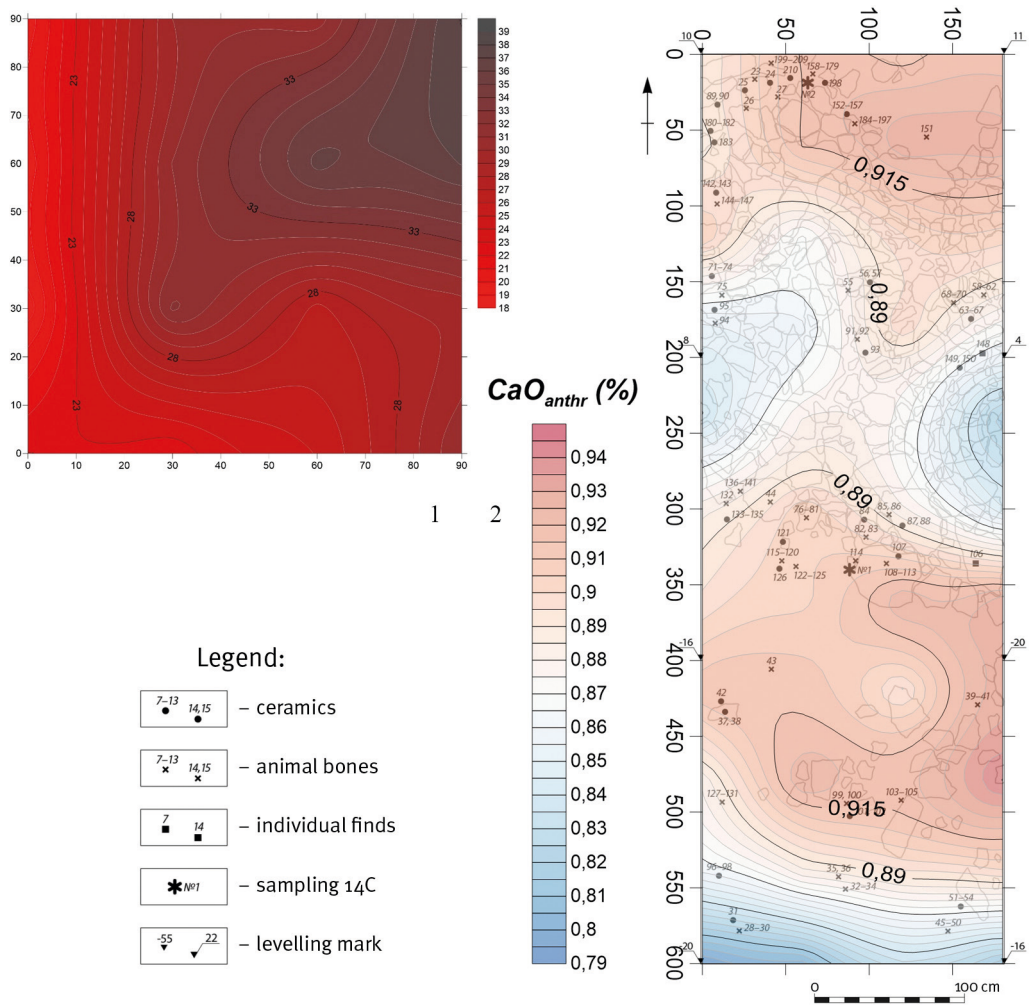

Fig. 7. Tarkhankut-18 settlement, distribution of CaO_{anthr} (%) in deposits: 1 — the background test pit, 2 — the excavation area. The level of 2nd cultural horizon. The maps are constructed by authors

ic components (K_2O_{anthr} and P_2O_{5anthr}) in the lowered areas inside the corrals indicate intensive anthropogenic activity related to animal keeping. These parts also have high geochemical background of other elements that is different from the background area — outside of anthropogenic activity. Aggressive chemical environment that changed chemical composition of deposits and led to almost complete dissolution of carbonates was formed in livestock corral environment, which is also confirmed by archaeological data It is also evidenced by anomalies of anthropogenic K_2O_{anthr} and Ba that are formed with development of humus, manure etc. Consequently, we can determine the main function of this area of the settlement based on geochemical elements data. It was the ***corral for keeping livestock.***

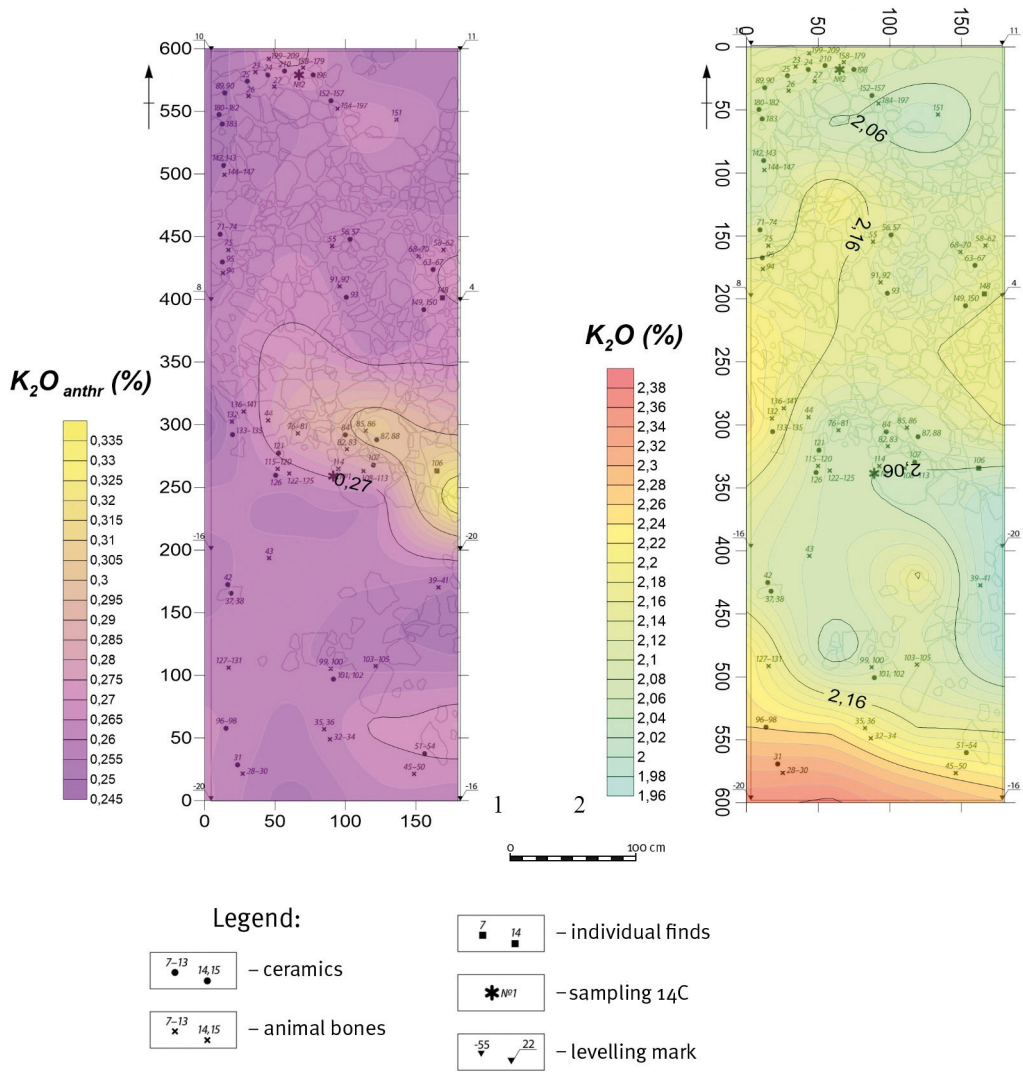

Fig. 8. Tarkhankut-18 settlement: 1 — distribution of K_2O_{anthr} (%) in deposits; 2 — distribution of $K_2O_{terrigene}$ (%) in deposits. The level of 2nd cultural horizon. The maps are constructed by authors

Discussion

Exploratory excavations of the Crimean archaeological and geophysical expedition demonstrated for the first time that different structures in the Tarkhankut settlements discovered by non-invasive methods can be either chronologically interlinked (synchronous) or belong to different historical periods. The expedition discovered the features of the Middle and Late Bronze Age building technology in the North-West of Crimea. It studied differences in wall masonry of the "rooms" and the walls of "livestock corrals". Three types of walls have been discovered: shell, double shell, and 3–5-row "orthostatic". Masonry with stone facing (the width of the remains of foundation of the wall is up to

2.0–2.2 m) is characterized by internal border formed by large stones placed edgewise filled up with small and medium stones and strengthened by vertically put medium and large stones. It was mainly used for inner walls of the "corrals". Double masonry with stone facing (the width of the remains of the foundation of the wall is from 1.4–1.45 to 2.0 m) is formed by two rows of big limestones placed edgewise. The space between them is filled with small and medium stones or with flat medium stones placed edgewise. It was mainly used for external walls of the "corrals". "Orthostatic" masonry (the width of the remains of the foundation of the wall is from 1.1–1.2 to 1.3 m) was formed by 3–5 rows of limestones of the same size put edgewise. It was mainly used for inner walls of the "rooms". The notable feature of the Tarkhankut building technique is similar to buildings of the Kamensk culture of the Middle Bronze Age of the East Crimea, for example, in the eponymous settlement Kamenka as well as in Planerskoe I etc.[52]

"Double livestock corrals" discovered by means of non-invasive investigation in the North-West of Crimea are similar to stone buildings in the settlements of eastern Crimea. These arerelatively well-preserved oval stone constructions in Hospital II settlement[53] (interpreted as "defensive grounds for livestock housing during winter"[54]) and the remains of the similar building with reconstructed diameter of about 40 m in Gorodishche 11 km settlement[55]. The authors of excavations and A. E. Kislyi[56] attribute these buildings to the Kamensk culture of the Middle Bronze Age of the East Crimea. The most recent investigations on the Taman peninsula, where dozens of sites (settlements and ground burials) of the end of Middle — the Late Bronze Age were found, are also of interest. They are attributed to Babino and Sabatinovka cultures. In Balka Lisovitskogo 4, Panagiia 1, and other settlements of the Sabatinovka culture, stone constructions of residential/living (?) and utility (?)[57] purposes were discovered. They are similar to the Crimean materials[58].

Geochemical analysis of ground taken at the base of the 2nd layer of the cultural layer conducted in the Tarkhankut-18 settlement confirmed that the corral for keeping livestock really existed in this area of the site. Using big corrals with fences made of stone and wood, and small corrals near settlements, building sheep yards for domestic sheep — are ethnographic features similar to the Pindus in northern Greece (in Greek Macedonia), where stone and wooden double and triple corrals exist even today. They serve for milking and shearing of sheep[59]. Winter pastures of Semirechye Kazakhs were set in places at hillsides protected from wind. There, near houses, livestock corrals and sheep yards for young

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[52] *Kislyi A. E.* O stenakh (spetsialnye postroiki kamenskoi kultury Vostochnogo Kryma). P. 269–288.

[53] *Beilin D. V., Kislyi A. E., Mikhailov A. M., Rogudeev V. V., Sharapa A. V., Iurochkin V. Iu.* Raskopki poseleniia epokhi bronzy Gospital II v g. Kerchi (predvaritelnoe soobshchenie). P. 11–13, fig. 2; 3.

[54] Ibid. P. 12–14.

[55] *Sviridov A. N., Iazikov S. V., Toporivskaia M. A., Frolov V. V.* Raskopki poseleniia Gorodishche 11 km v 2017 gody. P. 187, fig. 1; 2.

[56] *Kislyi A. E.* Egalitarnost i neravenstvo. P. 9–36.

[57] Only preliminary data about excavations and obtained materials was published.

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stock were built[60]. A. E. Kislyi provided interesting information regarding recent past and present. He used literature about modern livestock, consultations and focus group data of Crimean families of sheepherders[61]. Obtained data uncovers traditional and special features of economic system based on livestock. In general, the building techniques used for "livestock corrals" on the Tarkhankut are similar to stone buildingsin settlements of the end of Middle — Late Bronze Age of the Black Sea Region[62]. In this regard, the final results of 20-year studies in Kislovodsk basin in the North Caucasus are of interest. About 300 sites with unique for this region non-burial stone architecture were found and investigated there. Based on radiocarbon dates, it can be suggested that this architecture existed for more than thousand years (the beginning of the 2nd — the middle of the 1st millennium BC)[63]. It opens up new opportunities for comparative analysis of the architecture of 'moving herders' ('migrating herders') who left Bronze Age archaeological sites in the Crimea, North Caucasus, and on the whole — Circumpontic region.

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