# TRANSLATION

**By Richard Bland**
Museum of Natural and Cultural History, University of Oregon, Eugene, Oregon 97401; rbland@uoregon.edu

## A NOTE ON THE PIGMENTS IN THE MOTIFS OF ENGRAVED IVORY TOOLS FROM THE EKVEN BURIAL SITE (CHUKOTKA, RUSSIA)

**A. S. Pakhunov**
Institute of Archaeology of the Russian Academy of Sciences, Moscow, Russia
**Kirill A. Dneprovsky**
State Museum of Oriental Art, Moscow, Russia
**Elena S. Sukhorukova**
State Museum of Oriental Art, Moscow, Russia
**E. G. Devlet**
Institute of Archaeology of the Russian Academy of Sciences, Moscow, Russia

### ABSTRACT

Using methods of micro X-ray fluorescence analysis and scanning electron microscopy, research was conducted on 15 objects from the collections of the State Museum of Oriental Art. All these objects were made of walrus ivory and include harpoon heads and zoomorphic objects, fragments of ferrous ore of different hues (with and without traces of abrasive rubbing), and two stones with remnants of paint on the surface. The ivory artifacts are decorated both by engraving and with paint rubbed into the engraved lines. Analyses establish that the set of micro-admixtures in the pigments differ in composition, which likely indicate different raw material sources. The hematite pigments from the engraved artifacts and from the stones in Burial 302 indicated that pigment from a slab of limestone was used to color the zoomorphic artifact, where pigment from the harpoon head did not evidence any limestone.

#### ORIGINALLY PUBLISHED AS

пахунов, А.С., К.А. Днепровский, Е.С. Сухорукова, and Е.Г. Дэвлет (2017). О пигментах в декоре костяных гравированных изделий могильника Эквен (Чукотка). *Теория и практика археологических исследований* 4(20):82–90. [Pahunov, A.S., K.A. Dneprovsky, E.S. Sukhorukova, and E.G. Devlet (2017). On the Pigments in the Decor of Bone Engraved Objects of the Ekven Burial Ground (Chukotka). *Theory and Practice of Archaeological Research* 4(20):82–90.]

At the beginning of the first millennium AD, the coasts and islands of the Bering Strait were densely occupied by settled tribes of sea mammal hunters—the ancient Eskimos (Bronshtein and Dneprovsky 2016; Rudenko 1961). In the history of the Bering Sea, several archaeological cultures are distinguished. One of them—Old Bering Sea—was distributed along the coasts of Chukotka and the islands of the northern part of the Bering Sea, St. Lawrence Island, and the Diomedes. Its bearers—hunters of whales, walruses, and seals—were settled in favorable places for sea mammal hunting: on the shore of the sea, sometimes at a substantial elevation, such as the Ekven site on Bering Strait (Fig. 1). Lacking knowledge of metallurgy, people used ivory, bone, and stone to fabricate hunting equipment and the objects of daily life and religion. Round or rectangular dwellings were built on the surface, often on slopes, with a floor of stone or wood, atop a stone foundation, with large whale bones as a frame for the walls. The walls were formed of sod blocks or stone. A corridor entrance up to 6 m long was oriented as a rule downslope toward the sea. The roofs were made of sea mammal skins stretched over a wooden frame. The dwellings were heated by oil lamps.

Interments were excavated into the ground on high places. The burial enclosures, with strengthening walls around the burial pit, were constructed of whale bone or wood, while the bottom of the grave was often lined with a whale scapula or stones. The deceased was generally placed in an extended position on the back, though sometimes on the side with the legs bent. Graves had, as a rule, an indefinite cardinal orientation and often contained a rich burial inventory.

The objects examined for this research resulted from a series of research campaigns over the last 50 years. The expedition of S. A. Arutyunov and D. A. Sergeev investigated the Ekven cemetery between 1961 and 1970 (Arutyunov and Sergeev 1975). From 1987 to 1995, work at the cemetery was conducted by the Chukotka Archaeological Expedition of the State Museum of Oriental Art. From 1995 to 2001, House N-18 at the Ekven settlement was completely excavated and analysed (Bronshtein and Dneprovsky 2001).

The question of the origin of the Old Bering Sea culture remains unresolved. The known artifacts attest to the existence of an already formed tradition, dated to the first half of the first millennium AD (Bronshtein and Dneprovsky 2016). The period is one with a remarkable efflorescence of representational art of the early Eskimos, especially in the art of carving bone. The primary raw material was the durable and malleable walrus tusk and, more rarely, the walrus baculum and caribou antler. The decoration of most artifacts reflects the plastic and formal configuration of the ivory surface. The finishing component—special kinds of engraved ornamental compositions—has long attracted researchers (Bronshtein 1986; Collins 1937). While many authors, in formal published descriptions, describe red or black pigment in the engraved lines, only recently has special attention turned to examining this essential part of the final finishing of the artifacts in early Eskimo, and in particular Old Bering Sea, art (Meunier 1992:42–43; Sukhorukova 2012).

> Within the overall stylistic commonality of ancient Eskimo art, additional features in the artistic traditions of each of the ancient Eskimo cultures are most clearly expressed by the distinctive decorative compositions (Arutyunov and Bronshtein 1993; Bronshtein 1986; Dneprovsky 2006). Three basic types of design are distinguished in Old Bering Sea art, corresponding to three chronological stages: early (OBS-I), middle (OBS-II), and late (OBS-III) Old Bering Sea. Each is distinguished by particular linear combinations of the primary motifs or components (Fig. 2).

The *abstract* linear compositions of OBS-I combine finely drawn dual and single lines and a series of very small triangles arrayed in a certain order. The *curvilinear* design of OBS-II includes arc-shaped, zigzag-shaped, and oval elements; lines of different thickness are characteristic, although not as fine and definite as in the design of OBS-I, and should be termed intermittent. The OBS-II lines are drawn with different pressure. By contrast, the compositions of OBS-III are no longer abstract designs but are stylistic zoomorphic decorated images, marked with broad stripes of solid and dotted lines.

Pigment rubbed into engravings is recorded on many Old Bering Sea artifacts from collections in the vault of Archaeology of Chukotka at the State Museum of Oriental Art in Moscow—both on objects in the inventory of the burials of the Ekven cemetery and among materials found in dwelling structures of the Ekven and Paipel'gak sites. Preliminary visual observations first determined the specific color applications of the design during the different stages of development of Old Bering Sea art, and inferred the techniques of engraving and staining. In particular, in the engraving of artifacts of middle Old Bering Sea, both red and black pigments were discovered—deeper lines designating the basic elements of the composition are

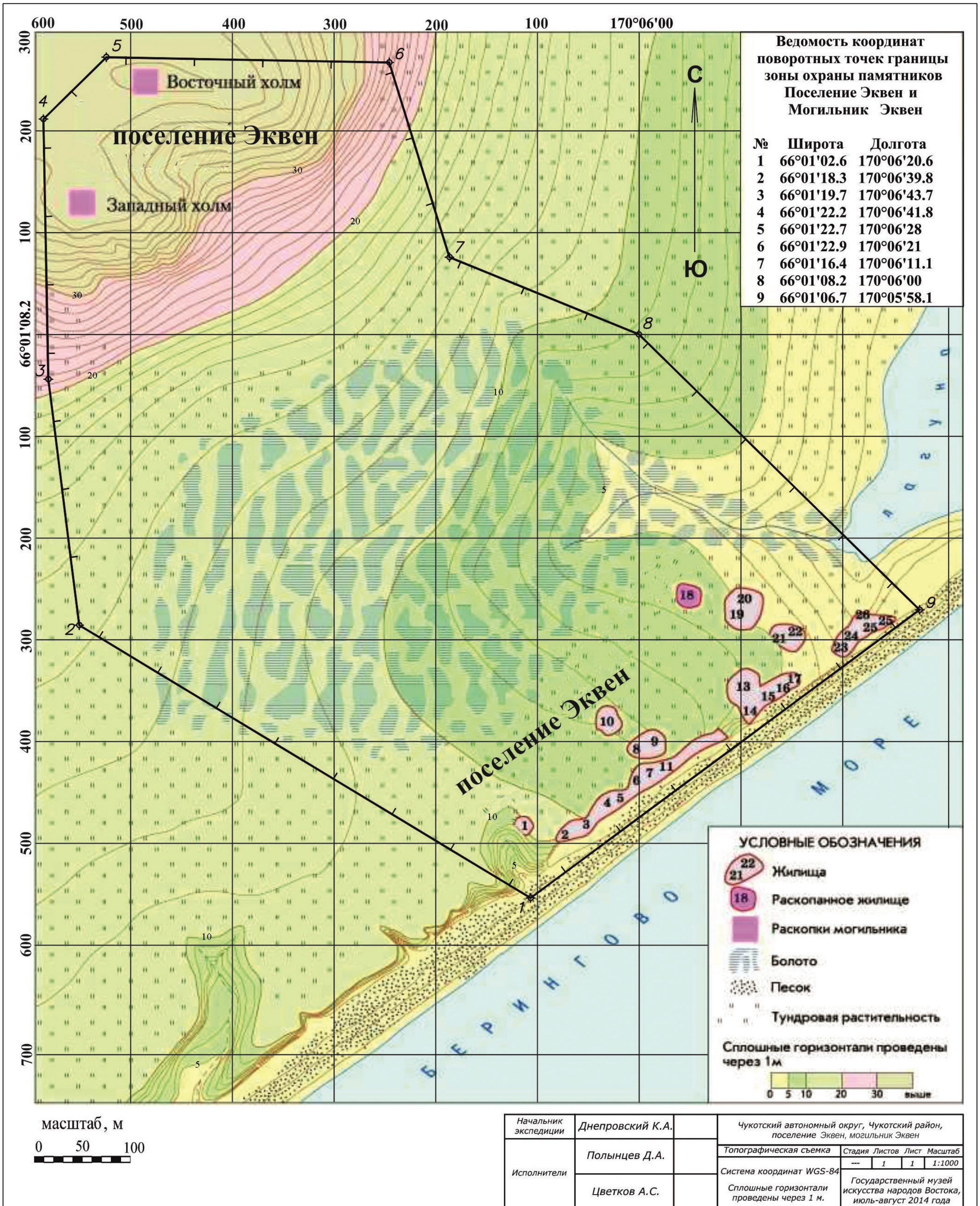


*Figure 1. A fragment of the map with the designation of the settlement and the burial ground of Ekven, Chukotka. (In the photo Burial no. 327 of the Ekven burial ground.)*

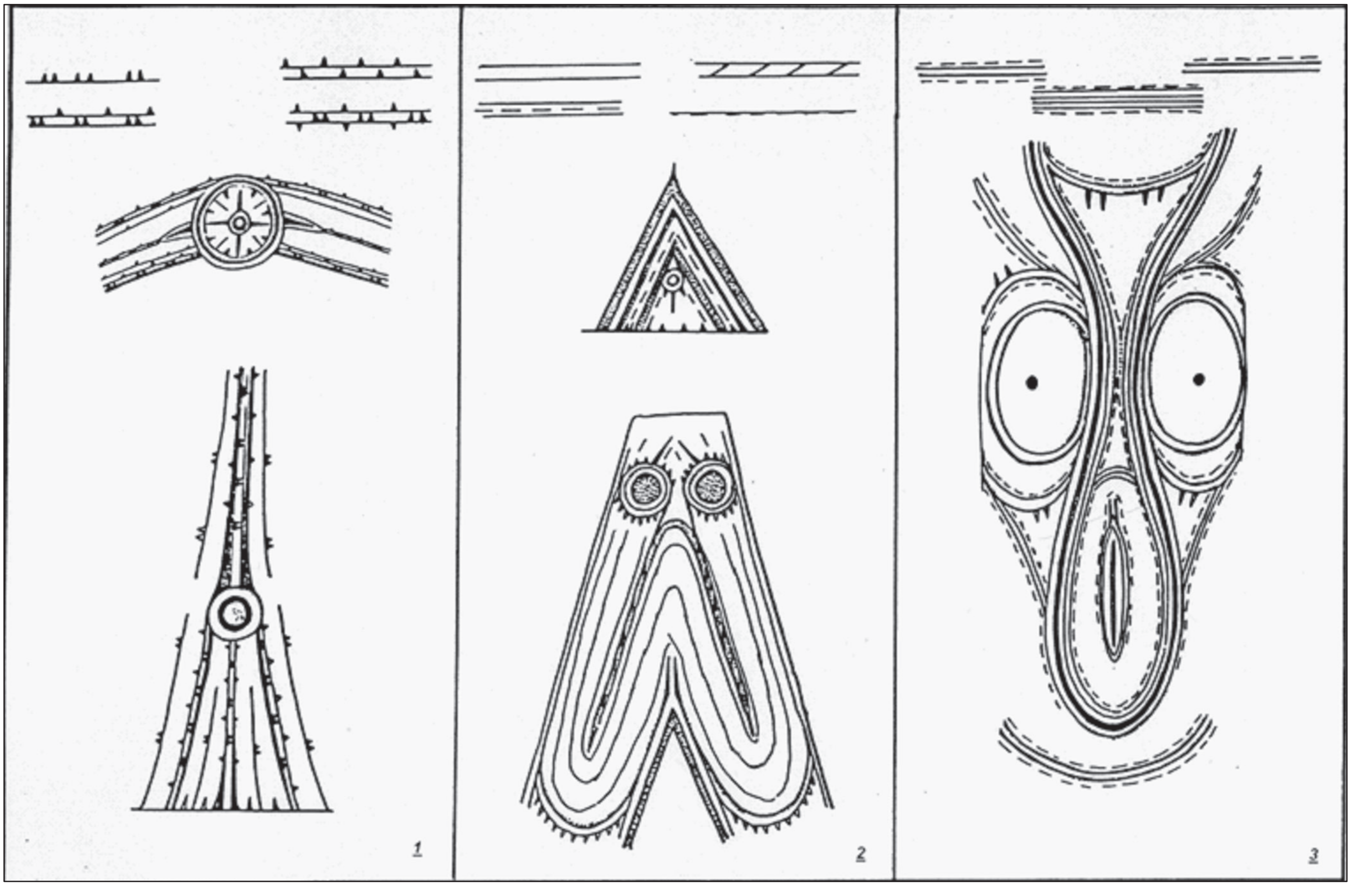

*Figure 2. Types of ancient Bering Sea ornamental engraving: (1) OBS-I; (2) OBS-II; (3) OBS-III (according to Arutyunov and Bronstein 1993). Drawing by N. S. Survillo.*

emphasized in red, and the thin auxiliary lines are black (Sukhorukova 2012: Fig. 3).

Decorated artifacts with traces of pigment in engraved lines were selected for investigation from Burials 222, 302, and 327 of the Ekven cemetery, as well as small fragments of iron-bearing rocks found in the same burials (Table 1, Figs. 3–7). Some of the lithic objects are faceted on several sides, evidence of a grinding surface that allowed the production of a powdery pigment by abrasive rubbing. Choosing burials containing both the objects decorated with the pigments and the possible raw material used to produce the pigment allowed for chemical analysis and comparison of these two groups. All three burials fall, in general, within the OBS-II style, but while the decorated artifacts from Burials 222 and 327 represent the "classic" variant of the OBS-II artistic tradition, the ornamentation

*Figure 3. Distribution of red and black pigments in the decor of a zoomorphic artifact from Burial no. 222, Ekven burial grounds. Reconstruction by E. S. Sukhorukova.*

*Table 1. List of investigated specimens.*

| Object # | Burial | Registration # | Brief Description |
|---|---|---|---|
| 1 | 222 | GMV KP 53185/58 | Iron-bearing stone |
| 2 | 222 | GMV KP 53185/59 | Iron-bearing stone |
| 3 | 222 | GMV KP 53185/61 | Paint on stone |
| 4 | 222 | GMV 111 Dr-IV | Zoomorphic artifact |
| 5 | 302 | GMV KP 53185/794 | Harpoon head |
| 6 | 302 | GMV 397 Dr-IV | Zoomorphic artifact |
| 7 | 302 | GMV KP 53185/887 | Iron-bearing stone |
| 8 | 302 | GMV KP 53185/889 | Iron-bearing stone |
| 9 | 302 | GMV KP 53185/890 | Iron-bearing stone |
| 10 | 302 | GMV KP 53185/891 | Iron-bearing stone |
| 11 | 302 | GMV KP 53185/894 | Iron-bearing stone |
| 12 | 302 | GMV KP 53185/895 | Iron-bearing stone |
| 13 | 302 | GMV KP 53185/893 | Paint on stone |
| 14 | 327 | GMV KP 53185/1644 | Harpoon head |
| 15 | 327 | GMV KP 53185/1678 | Iron-bearing stone |

and harpoon morphology of Burial 302 objects are characteristic of a transition from OBS-II to OBS-III.

From Burial 222 we analyzed an engraved zoomorphic artifact of unknown purpose (no. 4), which had the best preserved pigments (Figs. 3, 4). The other analyzed artifacts include a harpoon head (no. 5) and another zoomorphic artifact (no. 6) from Burial 302 (Fig. 5), as well as a harpoon head (no. 14) from the Burial 327 complex (Fig. 6).

Conservation and cleaning of the objects was variable. For example, the zoomorphic artifact (no. 4) from Burial 222 received only a superficial conservation treatment, while the zoomorphic artifact (no. 6) from Burial 302 had its surface washed with a water-alcohol solution and was partially strengthened with a 1.25% solution of benzyl methyl ketone (BMK-5). The harpoon head (no. 5) from Burial 302 was washed with dimethylacetamide (DMA) and a water-alcohol solution (70% alcohol and 30% water), after which the porous areas were impregnated with the copolymer BMK-5 at a concentration of 1.25%–2.5%. Harpoon head no. 14 was not conserved.

## METHODS

### X-RAY FLUORESCENCE SPECTROSCOPY

Element composition analysis was conducted with the Bruker M4 Tornado micro-X-ray-fluorescence analyzer with a rhodium tube (voltage 50 kV, 800 mA). The large camera allowed analysis without extracting individual samples. For some objects, two-dimensional maps of the elements were produced, which was achieved with a moving sample table and a high-speed silicon drift detector. The study was conducted after the evacuation of air at a vacuum of 20 millibars, which permitted increasing the precision of determination of the light elements. The scope of analysis was about 25 µm.

Measurement of the composition was carried out at a minimum of five points on each object, which permitted establishing the inverse proportion of calcium, strontium, and phosphorus in the composition of the bone and the components of the pigment. The thickness of the pigment layer influenced the content of the calcium in the results—as the layer increased in thickness, calcium content diminished.

### SCANNING ELECTRON MICROSCOPY

Study of the morphology of the particles of the pigments was carried out on a Vega Tescan microscope in a regime of low vacuum after coating with a layer of gold.

## RESULTS AND DISCUSSION

Two principal components are necessary to introduce color into the engraving: powder pigments and a bonding agent, producing a paint. The pigment provides the color while the bonding agent holds the pigment particles together, as a result of which a plastic mass is formed that can be applied to the surface of objects. Depending on the type and amount of the binder and the properties of the pigment, the consistency of the paint can be changed from thin to thick. One of the methods of obtaining powder of a pigment is rubbing fragments of iron-containing stones. Variability in the intensity of the paint can be attained in different ways: by selecting a source rock of different shades, by applying additives, or by thermal modification (Huntley et al. 2015; Román et al. 2015; Salomon et al. 2012, 2015). As a result of rubbing, the pieces of abrading stones acquire a characteristic multifaceted form and sharp edges, with the striations on the flat surfaces that reflect the direction of abrading motion (Barham 2002; Dayet et al. 2013, 2014; Rifkin 2012; Rosso et al. 2014). Abraders are reduced in size with use and assume a pyramidal shape, a consequence of a three-fingered hand hold.

Elemental markers of the geological source of the ocher are regional-specific impurities (calcite, dolomite, gypsum, anhydride), as well as the quantity of quartz and kaolinite (Elias et al. 2006; Froment et al. 2008). Also, micro-admixtures of metals and profiles of the concentration of rare-earth metals can indicate different sources of raw material (Eiselt et al. 2011; Iriarte et al. 2009; Popelka-Filcoff et al. 2007; Zipkin et al. 2014). In the present work, the comparison of pigments was conducted using data on the element composition of the samples, as well as consideration of the morphology of the pigment particles. The nature of the binding agent was not examined.

## BURIAL 222

In the collection from Burial 222 were two fragments of iron-containing stone with traces of abrasion (samples no. 1 and no. 2), as well as a stone covered unevenly with a layer of paint (no. 3). The color of the fragments varies—sample no. 1 is a deep dark-red, whereas sample no. 2 is an uneven yellow-red. The color of the applied paint on stone no. 3 is uniform and also lies within the yellow-red range, evidence that the pigment and binder was mixed, producing a uniform color.

Characteristic for samples no. 1 and no. 2 is a high iron content—90% and 80% by mass, respectively. Differences in composition and color allow us to theorize that the yellowish sample no. 2 contains, in addition to a small quantity of hematite, the iron hydroxides—goethite or lepidocrocite—which produce this characteristic color. Also of interest is a combination of micro-admixtures in these two samples and in the pigment of sample no. 3. This combination contains small quantities of zinc, arsenic, and lead, a set of micro-admixtures found only in this assemblage.

Also in the burial was the zoomorphic object no. 4, on which fine lines were filled with black pigment, while the wider grooves were highlighted in red. To infer the technique of decorating the object, a nondestructive analysis was conducted to determine the distribution of elements on the surface. For this, a 4 x 6 mm fragment was selected

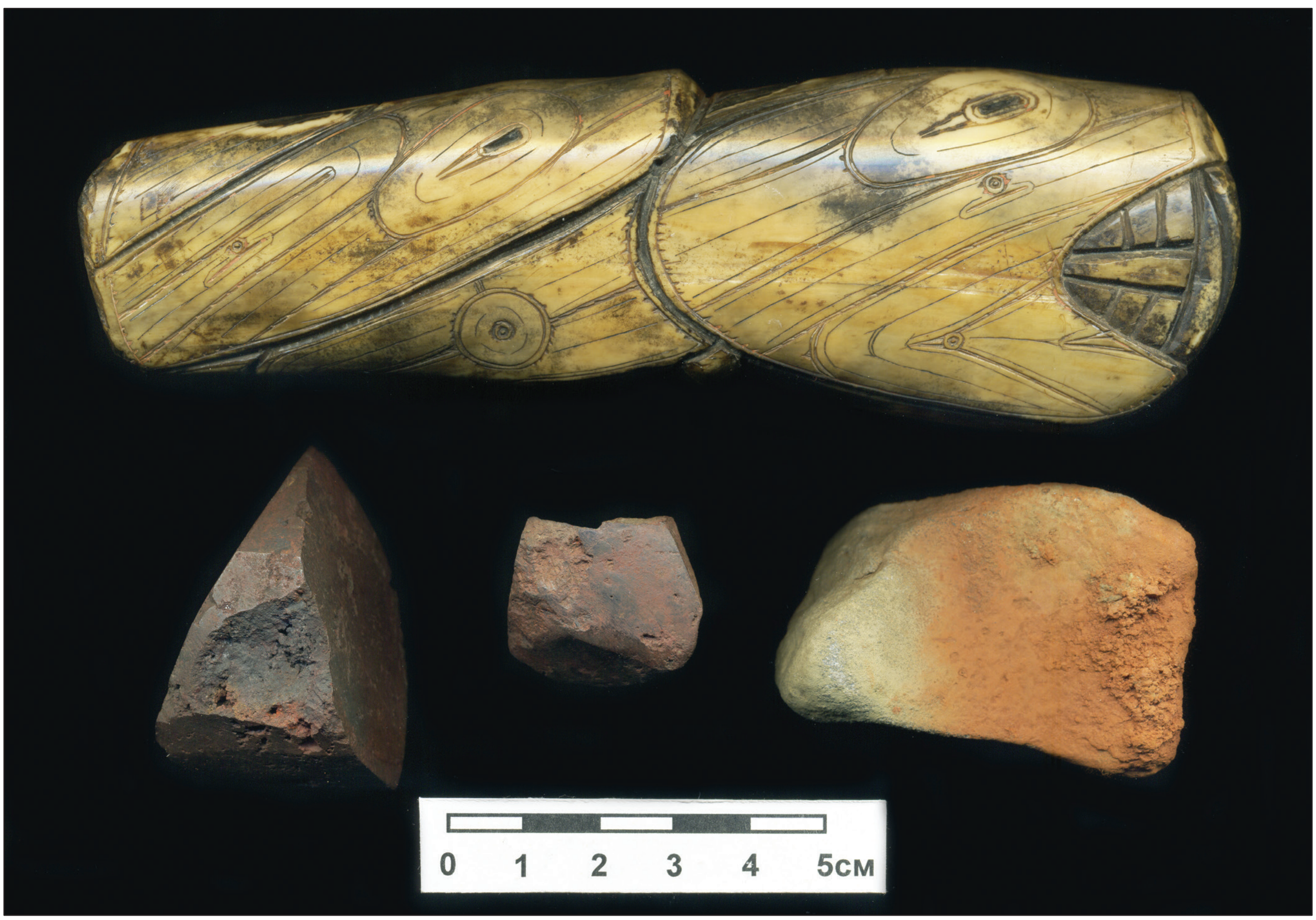


*Figure 4. Objects from burial 222. The burial ground is destroyed. At the top is zoomorphic item no. 4. Bottom row: samples of iron-bearing rock no. 1 and no. 2; stone with traces of paint no. 3.*

that included red and black lines, and a two-dimensional map was produced. The analysis showed that the elements characteristic for the pigment (aluminum, silicon, iron, manganese) were found only in the grooves. The red pigment was ocher with a large amount of hematite. The distribution of iron and manganese was inverse: manganese was found in the grooves where red pigment was absent and in the line of its imprints. This indicates that the red pigment was applied over the black pigment. The black color was obtained through the use of soot mixed with clay minerals.

The composition of stones no. 1 and no. 2 differ from stone no. 3 as well as the pigments from the zoomorphic artifact no. 4. In the raw pigments, potassium was absent, whereas in the applied pigment its content amounts to 16% by weight; probably this is connected with the addition of potassium-containing material, for example, feldspar, which could happen at the stage of preparation of the applied pigment from the rubbed pigment.

## BURIAL 302

Harpoon head no. 5 and zoomorphic artifact no. 6 were selected for analysis, as well as six samples of iron-containing stones (nos. 7 to 12) and one stone with traces of red pigment on the surface (no. 13). Element analysis of the samples indicated high iron content in all the stone fragments. However, traces of abrasion were found on only three—nos. 8, 9, and 10. These samples as well as sample no. 7 are nearly pure hematite, with an iron content of more than

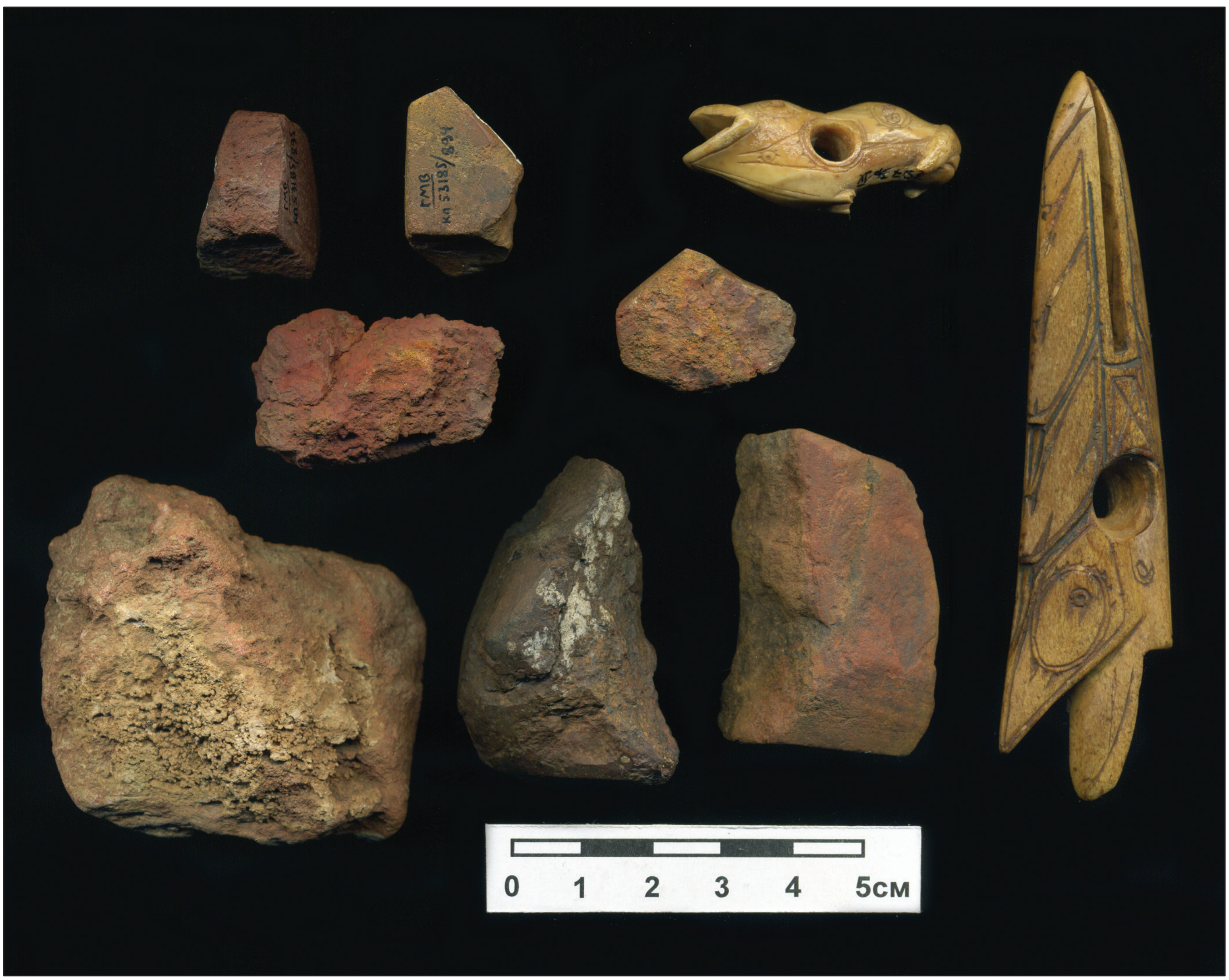


*Figure 5. Objects from Burial 302. The burial ground is destroyed. Top row: samples of iron-bearing rock no. 12 and no. 11, zoomorphic artifact no. 6. Middle row: samples of iron-bearing rock no. 9 and no. 8. Bottom row: stone with traces of red pigment no. 13, samples of iron-bearing rock no. 10 and no. 7. On the right: the tip of the harpoon no. 5.*

80%. In samples no. 11 and 12 the amount of silicon and aluminum is significantly higher, rendering them harder and less favorable for making powder for pigment. This probably also explains the absence of abrasion—with the presence of better raw materials, the use of these lesser-quality stones was unnecessary. The stone with traces of pigment (no. 13) is a slab of limestone, possibly used as a grindstone. Zinc occurred as an impurity in all samples, with barium in six of eight specimens of red pigment.

In spite of the uniformity of composition based on data of element analysis, comparative analysis of the particle morphology of the pigment samples indicated significant differences in form and size of the particles of hematite. Some samples had spherical particles of submicron size (no. 7 and no. 8), while others had ellipsoidal (spindle-shaped) particles measuring 0.5 to 1 micron (no. 9 and no. 10), and others had small intergrown crystals measuring only about 100 to 300 nanometers (nos. 11, 12, and 13).

An analysis of pigment samples from objects from the burial made it possible to establish that rocks containing hematite with different morphology of particles were used to decorate the harpoon head (no. 5) and zoomorphic item (no. 6) with red. However, the red paint from zoomorphic artifact no. 6 corresponds closely to a pigment sample from the slab of limestone (no. 13)—pigment for use other purposes was probably prepared on the slab.

## BURIAL 327

A harpoon head (no. 14) and an iron-containing stone with traces of modification (no. 15) were analyzed. Admixtures of manganese, which is characteristic for iron-containing minerals, were present in pigments from this burial, as well as a high level of titanium. However, a correspondence between the particles of hematite from the paint on the object and from the stone could not be established.

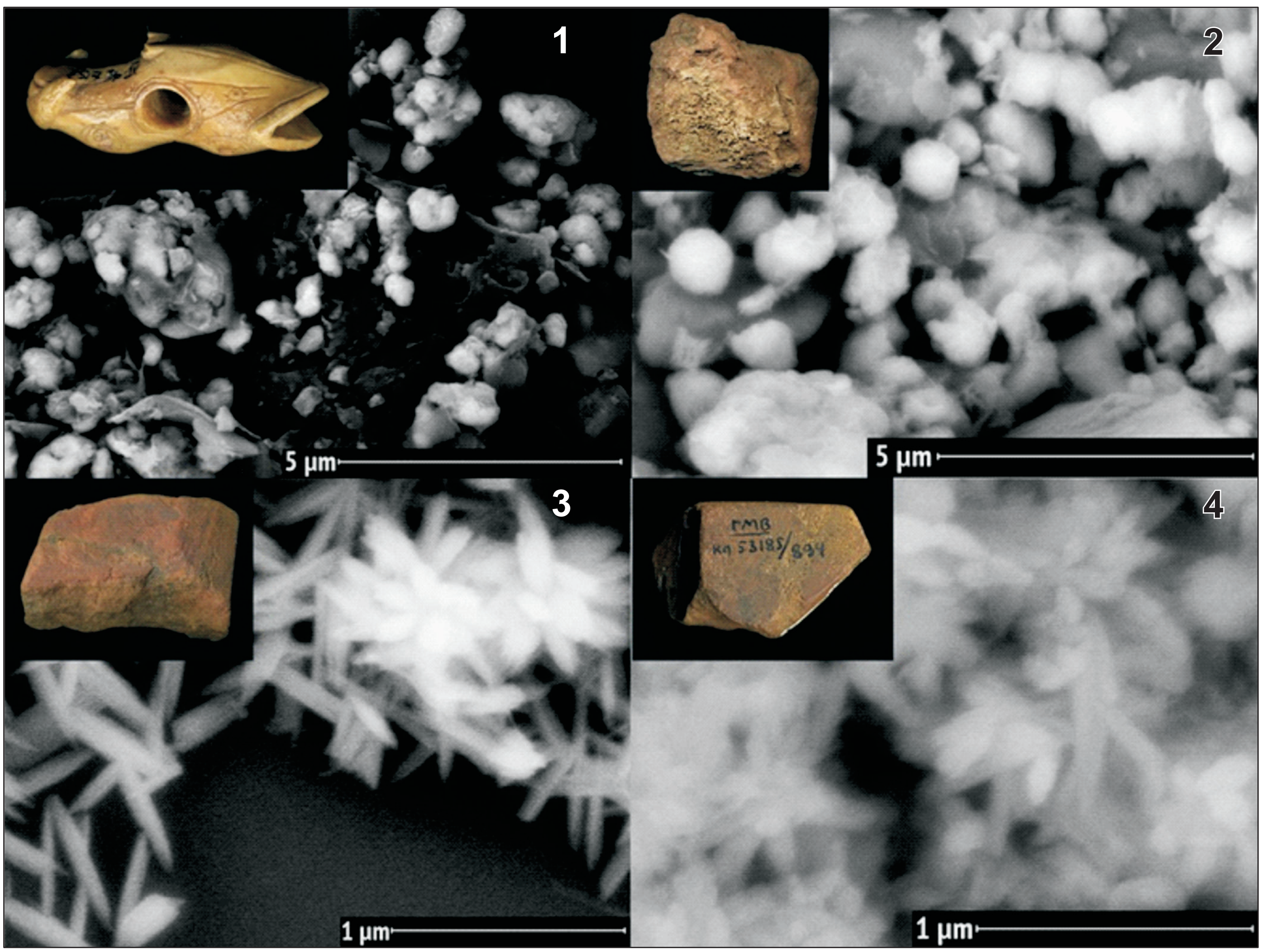


*Figure 6. Images of pigment particles obtained on a scanning electron microscope. (1) sample no. 6; (2) sample no. 13; (3) sample no. 7; (4) sample no. 11.*

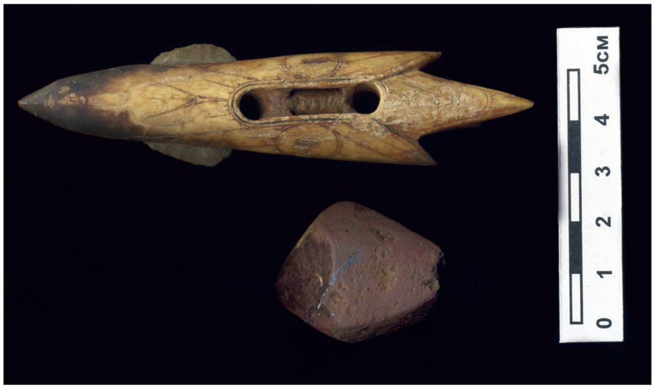


***Figure 7. Objects from Burial 327. The burial ground is destroyed. Harpoon tip no. 14 and iron-containing rock no. 15.***

## CONCLUSIONS

Differences in the composition of the micro-admixtures and form of crystals depend on the conditions of the formation of the rocks. The discovery in the different burials of specimens with a variable set of micro-admixtures may be evidence of the use of raw materials from different sources. Evidently, the hematite raw material was widespread in this region, which permitted the collection of raw material as needed for the production of pigment without the need to stockpile material or to rely on raw material from a single source.

The element analysis proved insufficient to differentiate pigments with similar compositions. However, the primary differences in the particle morphology of hematite did permit the use of this parameter in the comparative analysis of the raw material used to produce the paint. In addition, the methodology proved useful in determining the nature of the pigment used to decorate the zoomorphic object from Burial 302, although the pigment from the harpoon head did not correspond to the hematite samples in the burial. Also, as a result of this research, it proved possible to illuminate some technical aspects of the process of filling the lines of the engraving with paint: first, black pigment was rubbed in all the engraved lines, then red paint—pigment with a binder—was applied locally into broader grooves over the black paint.

## REFERENCES


Arutjunov S. A., and M. M. Bronshtein
1993 Vorwort zum Katalog [Foreword to the Catalog]. *Arktishe Waljäger vor 3000 Jahren: Unbekannte sibirische Kunst* [Arctic Whale Hunters 3,000 Years Ago: Unknown Siberian Art]. Mainz.

Arutyunov, S. A., and D. A. Sergeev
1975 Проблемы этнической истории Берингоморья. (Эквенский могильник) *[Problemy etnicheskoi istorii Beringomor'ya (Ekvenskii Mogil'nik)*/Problems of the Ethnic History of the Bering Sea (the Ekven Cemetery)]. Nauka, Moscow.

Barham, L. S.
2002 Systematic Pigment Use in the Middle Pleistocene of South-Central Africa. *Current Anthropology* 43(1):181–190.

Bronshtein, Mikhail M.
1986 Типологические варианты древнеэскимосского графического орнамента (к проблеме этнокультурной истории Берингоморья в I тыс. до н. э.–I тыс. н. э.) [Typological Variants of Old Eskimo Graphic Decoration (On the Problem of the Ethnocultural History of the Bering Sea in the 1st Millennium bc–1st Millennium ad)]. Советская этнология [Sovetskaya etnologiya/Soviet Ethnology] 6:46–59. Moscow. Translation published in 2006 in *Alaska Journal of Anthropology*.

Bronshtein, M. M., and K. A. Dneprovsky
2001 Жилище морских зверобоев древней Чукотки [A Dwelling of Sea Mammal Hunters of Ancient Chukotka]/*Альманах «Памятники культуры. Новые открытия 2000* [Anthology Sites of Culture. New Discoveries 2000]. Moscow, pp. 587–619.

Bronshtein, M. M., K. A. Dneprovsky, and A. B. Savinetsky
2016 Ancient Eskimo Cultures of Chukotka. In *Oxford Handbook of the Prehistoric Arctic*, edited by T. Max Friesen and Owen K. Mason, pp. 469–488. Oxford University Press, Oxford.

Collins, Henry B.
1937 *Archaeology of St. Lawrence Island, Alaska*. Miscellaneous Publications, Smithsonian Institution, Washington, D.C.

Dayet, L., F. d'Errico, and R. Garcia-Moreno
2014 Searching for Consistencies in Châtelperronian Pigment Use. *Journal of Archaeological Science* 44:180–193.

Dayet, L., P. J. Texier, F. Daniel, and G. Porraz
2013 Ochre Resources from the Middle Stone Age Sequence of Diepkloof Rock Shelter, Western Cape, South Africa. *Journal of Archaeological Science* 40(9):3492–3505.

Dneprovsky, Kirill A.
2006 A Late Birnirk House at Paipelgnak in Northern Chukotka: A Preliminary Report Based on the Excavations from 2002–2004. *Alaska Journal of Anthropology* 4(1–2):34–53.

Eiselt, B., R. S. Popelka-Filcoff, J. A. Darling, and M. D. Glascock
2011 Hematite Sources and Archaeological Ochres from Hohokam and O'odham Sites in Central Arizona: An Experiment in Type Identification and Characterization. *Journal of Archaeological Science* 38(11):3019–3028.

Elias, M., C. Chartier, G. Prévot, H. Garay, and C. Vignaud
2006 The Colour of Ochres Explained by Their Composition. *Materials Science and Engineering: B* 127(1):70–80.

Froment, F., A. Tournie, and P. Colomban
2008 Raman Identification of Natural Red to Yellow Pigments: Ochre and Iron-Containing Ores. *Journal of Raman Spectroscopy* 39(5):560–568.

Huntley, J., M. Aubert, J. Ross, H. E. A. Brand, and M. J. Morwood
2015 One Colour, (at Least) Two Minerals: A Study of Mulberry Rock Art Pigment and a Mulberry Pigment 'Quarry' from the Kimberley, Northern Australia. *Archaeometry* 57(1): 77–99.

Iriarte, E., A. Foyo, M. A. Sánchez, C. Tomillo, and J. Setién
2009 The Origin and Geochemical Characterization of Red Ochres from the Tito Bustillo and Monte Castillo Caves (Northern Spain). *Archaeometry* 51(2):231–251.

Meunier, Y.
1992 Le décor du harpoon esquimau [The Decoration of the Eskimo Harpoon]. *Etudes Canadiennes* [Canadian Studies] no. 32.

Pahunov, A. S., K. A. Dneprovsky, E. S. Sukhorukova, and E. G. Devlet
2017 On the Pigments in the Decor of Bone Engraved Objects of the Ekven Burial Ground (Chukotka). *Theory and Practice of Archaeological Research* 4(20):82–90.

Popelka-Filcoff, R. S., J. D. Robertson, M. D. Glascock, and C. Descantes
2007 Trace Element Characterization of Ochre from Geological Sources. *Journal of Radioanalytical and Nuclear Chemistry* 272(1):17–27.

Rifkin, R. F.
2012 Processing Ochre in the Middle Stone Age: Testing the Inference of Prehistoric Behaviors from Actualistically Derived Experimental Data. *Journal of Anthropological Archaeology* 31(2):174–195.

Román, R. S., C. B. Bañón, and M. D. L. Ruiz
2015 Analysis of the Red Ochre of the El Mirón Burial (Ramales de la Victoria, Cantabria, Spain). *Journal of Archaeological Science* 60:84–98.

Rosso, D. E., F. d'Errico, and J. Zilhão
2014 Stratigraphic and Spatial Distribution of Ochre and Ochre Processing Tools at Porc-Epic Cave, Dire Dawa, Ethiopia. *Quaternary International* 343:85–99.

Rudenko, Sergei I.
1961 *The Ancient Culture of the Bering Sea and the Eskimo Problem*. Arctic Institute of North America, University of Toronto Press.

Salomon, H., C. Vignaud, Y. Coquinot, L. Beck, C. Stringer, D. Strivay, and F. d'Errico
2012 Selection and Heating of Colouring Materials in the Mousterian Level of Es-Skhul (c. 100,000 years BP, Mount Carmel, Israel). *Archaeometry* 54(4):698–722.

Salomon, H., C. Vignaud, S. Lahlil, and N. Menguy
2015 Solutrean and Magdalenian Ferruginous Rocks Heat-Treatment: Accidental and/or Deliberate Action? *Journal of Archaeological Science* 55:1–49.

Sukhorukova, E. S.
2012 Древнеберингоморское искусство: форма, линия, цвет [Drevneberingomorskoe iskusstvo: forma, liniya, tsvet/Old Bering Sea Art: Form, Lines, Color]. In Изобразительные и технические традиции в искусстве Северной и Центральной Азии *[Izobrazitel'nye i tekhnicheskie traditsii v iskusstve Severnoi i Tsentral'noi Azii*/ Representative and Technical Traditions in the Art of Northern and Central Asia], pp. 110–121. Kemerovo, Moscow.

Zipkin, A. M., J. M. Hanchar, A. S. Brooks, M. W. Grabowski, J. C. Thompson, and E. Gomani-Chindebvu
2014 Ochre Fingerprints: Distinguishing among Malawian Mineral Pigment Sources with Homogenized Ochre Chip LA-ICPMS. *Archaeometry* 57(2):297–317.