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John W. Olsen[1,2]✉, Arina M. Khatsenovich[1,2], Evgeny P. Rybin[1], Dashzeveg Bazargur[3], Tserendagva Yadmaa[3], Alexei M. Klementiev[1,4], Daria V. Marchenko[1], Byambaa Gunchinsuren[3], Anatoly P. Derevianko[1]

[1]Institute of Archaeology and Ethnography, Russian Academy of Sciences, Siberian Branch, Russian Federation
[2]School of Anthropology, University of Arizona, USA
[3]Institute of Archaeology, Mongolian Academy of Sciences, Ulaanbaatar, Mongolia
[4]Institute of the Earth's Crust, Russian Academy of Sciences, Siberian Branch, Russian Federation

The significance of Tsagaan Agui in Mongolian Paleolithic Archaeology

Abstract: Tsagaan Agui (White Cave; Цагаан Агуй), located in the Gobi Altai Mountains of southern Mongolia, represents one of the few stratified and well-dated Pleistocene archaeological sites now known in the Gobi Desert. Archaeological studies undertaken at Tsagaan Agui since 1995 have revealed that the cave's sediments contain cultural remains ranging from the Middle and, possibly, Lower Paleolithic, to the later historic period. Analyses of these deposits suggest environmental conditions favorable for intermittent human occupation existed throughout most of the Pleistocene and early to middle Holocene, the latter likely during periods of larger-scale climatic and environmental degradation.

Keywords: *Tsagaan Agui, Paleolithic, Gobi Desert, Gobi Altai Mountains, Mongolia*

Email: olsenj@arizona.edu, https://orcid.org/0000-0001-5295-7451

Introduction

Mongolia occupies a crucial geographical position in the center of the Asian land mass. Bordering Kazakhstan to the west, China on the west, south, and east, and Russian Siberia to the north, Mongolia's geographical setting has helped define the region as a crossroads of prehistoric peoples and their cultures beginning in the Paleolithic.

Although the scientific investigation of ancient sites in Mongolia began in 1889 with an expedition from the East Siberian Branch of the Geographical Association of Russia, led by N.M. Yadrintsev, this expedition's work was focused on a survey of the Mongol Period capital city of Karakorum (Qara Qorum) and thus contributed very little to the prehistoric archaeology of Mongolia (Gunchinsuren 2017). Soon thereafter, the Academy of Sciences of the Russian Czar, Alexander III dispatched another research team to the Orkhon and Tuul (Tola) river valleys under the direction of V.V. Radlov (F.W. Radloff). Although the impressive results of this expedition were published in four volumes from 1892 to 1899 (Radloff 1892-1899), again, the Stone Age is conspicuously absent from the discussion.

In the early twentieth century, two American vertebrate paleontologists, William Diller Matthew and Henry Fairfield Osborn, proposed Central Asia as the focus of mammalian evolution, including that of humans and other primates (Beard 2004; Corbey and Roebroeks 2001); an idea which immediately generated enthusiasm for initiating both paleontological and prehistoric archaeological field investigations in Mongolia and adjacent territories, especially North China. In his influential summary publication, Mathew opined: "All authorities are today agreed in placing the center of dispersal of the human race in Asia. Its exact location may be differently interpreted, but the consensus of modern opinion would place it probably in or about the great plateau of central Asia…it seems fair to conclude that the center of dispersal of mankind in prehistoric times was central Asia north of the great Himalayan ranges" (1915: 209, 212). A decade after Mathews' seminal publication, Osborn amplified and extended his ideas in a series of equally impactful publications (1924, 1926, 1927). Presciently, Mathew and Osborn drew specific and persuasive links between climate change and human evolution, even if their focus on arid Central Asia was quickly superseded by both archaeological and hominin paleontological discoveries made by Louis and Mary Leakey and others in Africa beginning in the 1950s.

The ideas of Matthew and Osborn not only aroused heated discussion in scientific circles, but were also responsible, both directly and indirectly, for the commencement of field archaeological studies in north China, Inner Mongolia, and Mongolia proper (known in those days as Outer Mongolia) directed toward the discovery of the remains of ancient humans and their cultures. In the 1910s and 1920s, this region was traversed by several large multidisciplinary expeditions, including those of the Japanese (headed by Torii Ryūzō), the Swedish (directed by Sven Anders Hedin), and the British (led by Sir Marc Aurel Stein), among others (Bannikov 1954; Gunchinsuren 2017; Larichev 1969).

JMRAAE, The Joint Mongolian-Russian-American Archaeological Expedition

Due to the dramatic changes that characterized the USSR's political and economic circumstances in the late 1980s, field investigations conducted by Russian researchers in Mongolia ceased in 1989. Negotiations aimed at forming a joint trilateral archaeological expedition constituted to study Mongolia's Stone Age prehistory were initiated in 1994 by Academician A.P. Derevianko on the Russian side, J.W. Olsen on the American side, and with Academician D. Tseveendorj representing the Mongolian archaeological community. Their initiative was supported by the President of the Mongolian Academy of Sciences, Academician D. Baatar and the Director of the MAS Institute of History, Professor A. Ochir. On 15 June 1995, an agreement creating the Joint Mongolian-Russian-American Archaeological Expedition (JMRAAE; Монгол-Орос-Америкийн Археологийн Хамтарсан Экспедици; Российско-Монгольско-Американская Совместная Археологическая Экспедиция) was signed in Ulaanbaatar by representatives of the Mongolian Academy of Sciences, the Siberian Branch of the Russian Academy of Sciences, and the University of Arizona.

Tsagaan Agui

One of JMRAAE's first tasks was to undertake comprehensive, interdisciplinary examinations of Tsagaan Agui (White Cave; Цагаан Агуй) that was discovered and first investigated in the 1970s by the founding figure of Mongolian Paleolithic archaeology, D. Dorj. In fact, Professor Dorj's essential role in the history of archaeological studies at Tsagaan Agui has only recently come to light through the discovery of a box of characteristic brown flint artifacts from that site labelled in Mongolian "Dorj. 1972. Bayankhongor. Tsagaan Agui" in storage at the Russian Academy of Sciences, Siberian Branch's Institute of Archaeology and Ethnography in Novosibirsk. As early as 1987, when Tsagaan Agui was first systematically investigated by a joint Mongolian-Russian expedition, it became clear that the cave is one of the most significant and remarkable Paleolithic sites yet found in Mongolia (Derevianko et al. 1990). Tsagaan Agui retains that status today.

Tsagaan Agui, located in the Gobi Altai Mountains in Bayanlig *sum*, Bayankhongor *aimag* (44°42’53.3″ N, 101°10′13.4″ E; 2000 m asl), was first the subject of coordinated archaeological research in 1987-1989 and subsequently investigated during six field seasons from 1995-2000 (Derevianko et al. 2000a) (Figure 1).

Its Main Chamber was found to comprise 14 archaeological layers divisible into at least five discrete units: Late Upper Paleolithic (Layer 2), Initial Upper Palaeolithic (Layer 3), Late Mousterian Middle Palaeolithic (Layers 4-5), Mousterian Middle Palaeolithic (Layers 6-11), and an industry in Layers 12 and 13 described then as Acheulean-like (Derevianko et al. 2000b; Khatsenovich et al. 2022). Nonetheless, the chronology of the cave’s stratigraphy prior to ca. 45,000 cal BP, its faunal composition, and the patterns of climatic and environmental changes in and around the cave, remained unclear. Middle and Upper Paleolithic human migrations and dispersals throughout Central Asia are usually associated with lower altitudes and relatively temperate steppe and forest-steppe environments (Khatsenovich et al. 2019, 2022; Kolobova et al. 2020). For unknown reasons, however, Tsagaan Agui, situated in an extremely arid environment at the time and at 2000 m asl, was occupied during the Middle Paleolithic.

Tsagaan Agui has been studied during three research campaigns: in 1987-1989 by a Mongolian-Russian expedition, and in 1995-2000 and 2021-present by the Joint Mongolian-Russian-American Archaeological Expedition (Derevianko and Petrin 1995; Derevianko et al. 1995; Derevianko et al. 1996; Khatsenovich et al. 2022). Most deposits have been studied throughout the cave’s complex layout, including the Entrance Terrace and Entrance Grotto, the Main Chamber, and the Inner Grotto, the latter accessible only by means of a ten-meter crawlway.

During initial excavations of apparently re-deposited Pliocene material in the Lower Grotto in 1989, an unsophisticated single-platform pebble core was uncovered. This nucleus, exhibiting four flake scars and a simple cortex platform, was found enclosed in sediments overlain by lower Pleistocene reddish sands. Thus, it is possible this core represents an extremely ancient (“pre-Acheulean”) complex and

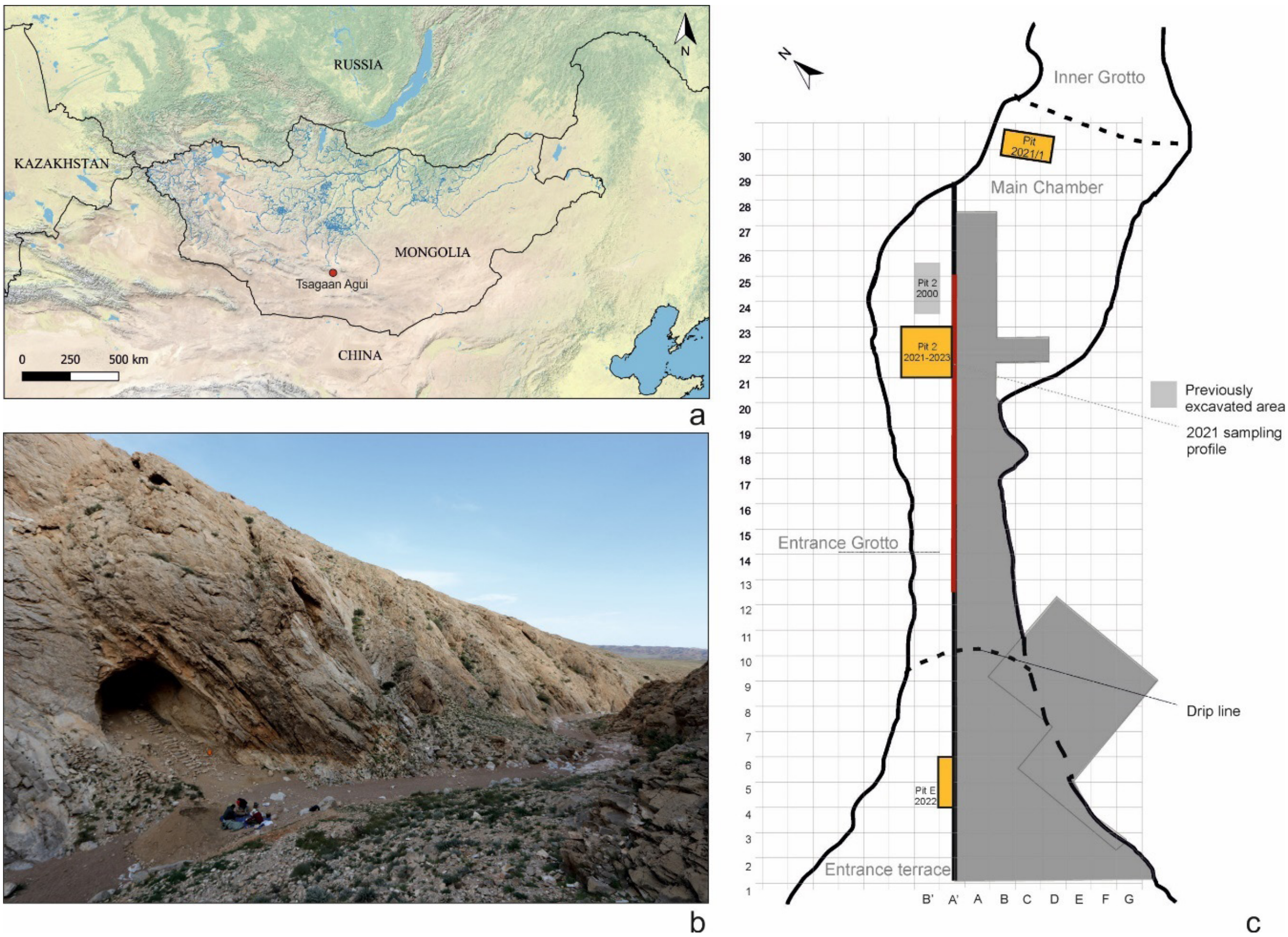

Figure 1. a – Location of Tsagaan Agui Cave; b – overall view; c – plan view of Tsagaan Agui Cave.

may be the material signature of the cave's earliest occupants (Derevianko and Petrin 1995).

Chert occurs as nodules in the massive Devonian limestone bedrock surrounding the cave, but its poor quality makes knapping difficult and yields rather unsophisticated end products (Derevianko et al. 2004).

A series of chronometric dates has established the chronology of human occupation in the Middle and Late Pleistocene Gobi Altai Region. Archaeological analysis has revealed several occupational events by people bearing different material cultural complexes. Tsagaan Agui's chambers contain varying technological and typological assemblages: Layers 5-7 in the cave's Entrance Terrace yielded more centripetal and convergent Levallois products while most of the blade industry, interpreted as Initial Upper Paleolithic, was obtained from the Inner Grotto. Cumulatively, this evidence indicates high cultural diversity, albeit in problematic and as yet poorly understood stratigraphic context in the case of the earliest archaeological material. Tsagaan Agui was the first Pleistocene site in Mongolia to yield rich a faunal assemblage in archaeological context. These materials need to be further systematized, classified, and integrated within the known evolution of Pleistocene fauna associated with Paleolithic remains throughout Eurasia.

Expedition focus and achievements, 1995-2000

Paleolithic localities in the arid zones of Central Eurasia frequently consist of mixed surface aggregates; palimpsests of human behavior often representing many millennia. From JMRAAE's inception, it was recognized that the thorough investigation of buried sites in clearly stratified contexts was required to establish the dynamics and chronology of Stone Age industries in this complex region (see Fairservis 1993).

Thus, five primary goals of the Joint Mongolian-Russian-American Archaeological Expeditions were implemented in 1995 and guided the expedition's work during the first campaign of research undertaken at Tsagaan Agui and the greater southern Gobi Desert:

1. Elaboration and clarification of the Mongolian Paleolithic chronostratigraphic sequence based on the excavation of stratified open-air and cave sites.

2. Systematic analysis of the large number of artifacts discovered during previous expeditions at more than 1,000 Stone Age localities in Mongolia by means of standardized techno-typological classification of industries derived from buried contexts.

3. Investigation of localities varying in type and depositional history in order to identify recurring techno-typological patterns in Early, Middle and Late Paleolithic industries and to trace the development of primary flaking strategies and types of stone tools over long periods in Mongolia.

4. Initiation of an interdisciplinary approach combining the efforts of experts from many social, natural, and physical sciences to reconstruct the paleoenvironmental conditions and paleoeconomies of Pleistocene Mongolia.

5. Tracing the main routes of migration of prehistoric populations through Central Asia and contiguous regions, focusing on the role of Mongolia as a nexus of human interaction encompassing, minimally, the eastern Central Asian, Siberian, and North Chinese realms.

Coincident with JMRAAE's inception in 1995, it was recognized that the exploration, let alone resolution, of these problems would, of course, require collaborative research extending over many years, if not decades, and would entail commensurate strategic financial and logistical commitments to support both fieldwork and subsequent laboratory analyses and publications. Despite the massive geopolitical and global financial shifts that have taken place since 1995, JMRAAE has nonetheless been remarkably successful in managing to weather, if not navigate through, such complexities.

From the outset, Tsagaan Agui provided a test bed for exploring each of these five challenges in a coordinated and strategic way. The 1995-2000 trilateral investigations of the cave and its environs demonstrated the efficacy of applying a multinational interdisciplinary approach to the resolution of complex, diachronic human behavioral questions at a moment in the developmental trajectory of paleoanthropology and the intertwined histories of Mongolia, Russia, and the USA when such coordination and funding were fraught with problems ranging from logistical to economic. Success has been due in no small measure to the stability and openness of Mongolia itself.

Expedition focus and achievements, 2021-present

In 2021, JMRAAE resumed investigations of Tsagaan Agui Cave to study cross-sections preserved from the 1990s excavations and open a new unit to obtain more faunal remains, lithic artifacts, and samples for dating and paleoenvironmental analysis. Pit 2 in the Main Chamber has been studied during field seasons in 2021-2023 and excavations there are still ongoing. We tested a small gallery joining the cave's Main Chamber and Inner Grotto, in 2021. In 2022, we also excavated Pit E in the Entrance Terrace to better understand the position of Levallois artifacts found there in 1987-1989 and described as having originated in Layers 5-7. Below, we provide descriptions of stratigraphy and principal finds from all units excavated in 2021-2023.

Pit 1 /2021, Gallery in the Main Chamber

Pit 1 is located in a small gallery that joins the Main Chamber and Inner Grotto in Tsagaan Agui Cave. Our initial intent was to test the thickness and degree of disturbance of deposits in this location. We uncovered a 2 m^2 unit in Pit 1, revealing three layers with lenses and sub-layers and significant disturbance resulting from human activity during the Medieval period as well as bioturbation (Figure 2).

Layer 1 is an aeolian dusty, sandy loam mixed with small fragments of limestone *éboulis* detached from the cave ceiling and modern animal biowaste.

Layer 2, separated from Layer 1 by a gravel sublayer, itself includes several sublayers and lenses. Sublayer 1 is a brownish-grey cemented dusty-sandy loam with small gravel inclusions. Lenses 4 and 5 in Square G29 are clayey loam with calcareous drip spots generated by water percolating through the cave ceiling. Lense 5 is associated with ash and charcoal filling the pit in Square D29. Sublayer 6 is developmentally associated with Lense 5: it is greyish-blue clayey loam with gravel inclusions. Beneath this lense, a krotovina was noted next to a large boulder. Sublayer 8 is the main body of Layer 2; a brownish-grey sandy loam with gravel and charcoal inclusions. Sublayer 9 is situated beneath the pit in Square D29 unit and represents mixed sediments from Lense 5 and the ashy soot filling of the pit. Lense 10 lies conformably on bedrock. It is comprised of greyish-blue wet clay sediments with ferrous spots associated with tubular stalactite (“soda straw”) speleothems dripping from the ceiling.

Layer 3 is thought to be of Pleistocene age. It is a brownish-grey sandy loam, barely covering the bedrock. A small pit discovered in Square D29 contained mostly ash, soot and charcoal, plant scapes and thatch, but also asynchronous artifacts, including lithics.

Pit 2 / 2021-2023, Main Chamber

Four square-meter Pit 2 reached a depth of 3 m by the end of our 2023 field season, but excavations are still ongoing (Figure 3).

The stratigraphic profile includes eight major layers:

Layer 1 originally included three horizons (Derevianko et al. 2000a), but due to damage inflicted by tourists and treasure hunters, Horizon 1 was destroyed. Horizon 2 is a thin, 5 cm lense of ashy sediments, that includes burned scat and plant remains. Horizon 3 is comprised of sooty humic sediments 10-15 cm thick. Most likely it represents the Medieval-early modern period of the cave’s use if not human occupation.

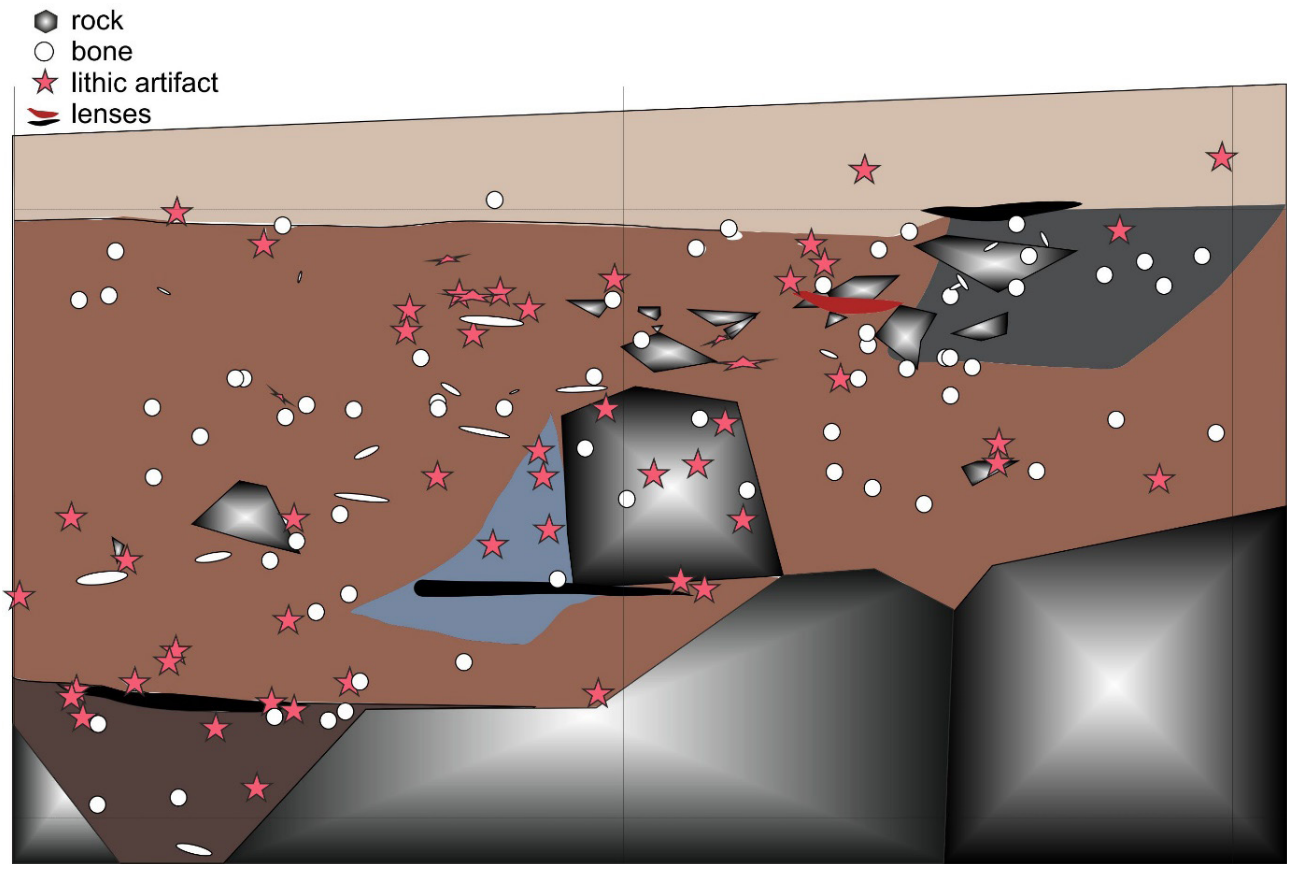

Figure 2. Stratigraphic profile of Pit 1 in the Small Gallery of the Main Chamber in 2021. East wall.

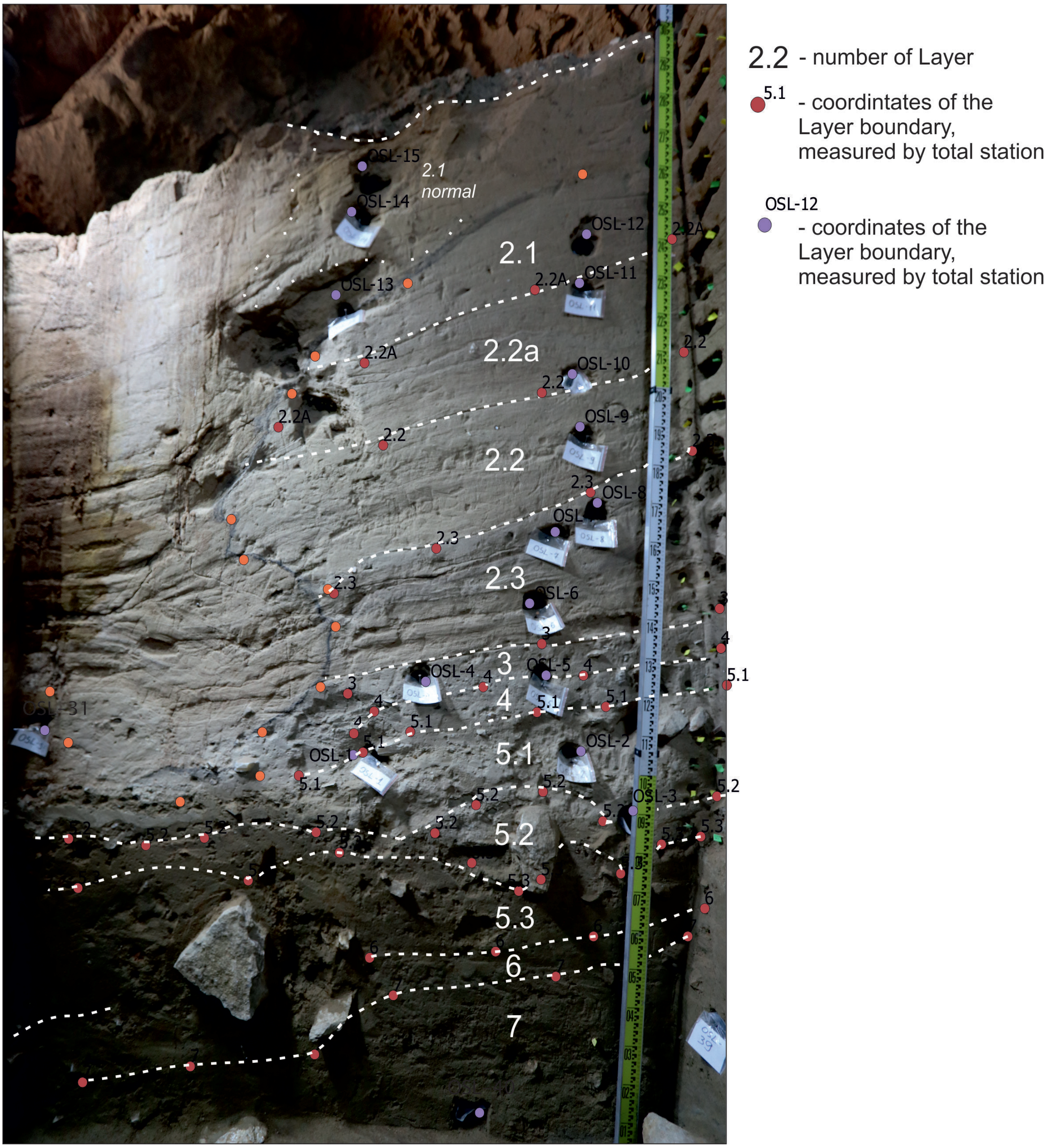

Figure 3. Stratigraphic profile of Pit 2 in the Main Chamber in 2023. North wall.

Layer 2 was identified in all pits excavated in the cave, but it changes across the longitudinal cross-section significantly, including the genesis, color, texture, and structure of the sediments. In Pit 2 in the cave's Main Chamber, Layer 2 is subdivided into three distinct and, as we know from new radiocarbon dates, asynchronic layers. We have, however, retained the sequence's original enumeration to avoid confusion with previously studied pits.

Stratification of Layer 2.1 is heterogenous due to the presence of a chimney in the cave ceiling open to the sky, located immediately above Unit B'18 in Pit 2. Layer 2.1 is about 65 cm thick and consists of sandy interlayers and lenses of dense cemented sand, brownish-orange in color, formed from deposits sourced in the cave ceiling (Figure 4. *a, b*).

These layers are cross-bedded and dip toward the northwest corner of the excavation unit. Unit B'19 contained a lens of undisturbed Layer 2, described for 1996-1997 Spit 2 in the Main Chamber. Un-reworked and not colored with terra rossa weathered bedrock transported through the chimney by water, these sediments are comprised of greyish-brown fine-grained polymictic carbonate sand (Derevianko et al. 2000a), with small carbonate and manganese inclusions and ferrous patches (Figure 4. *c*). In Unit A'18, Layer 2.1 consists of lenses of well-washed greyish-yellow coarse sand and unrounded grains of aeolian sand. These sands are associated with water from the chimney; they are cemented by white carbonate sublayers and dip toward the southwest corner of the unit (i.e., the cave entrance) following the cavern's inclination. Hydrodynamic scour replaced the original stratigraphic sequence of Layers 2-4 in Units A'18 and B'18. The boundary of this scour is clearly visible, demarcated by a manganese (Mn) lens (Figure 4. *d*).

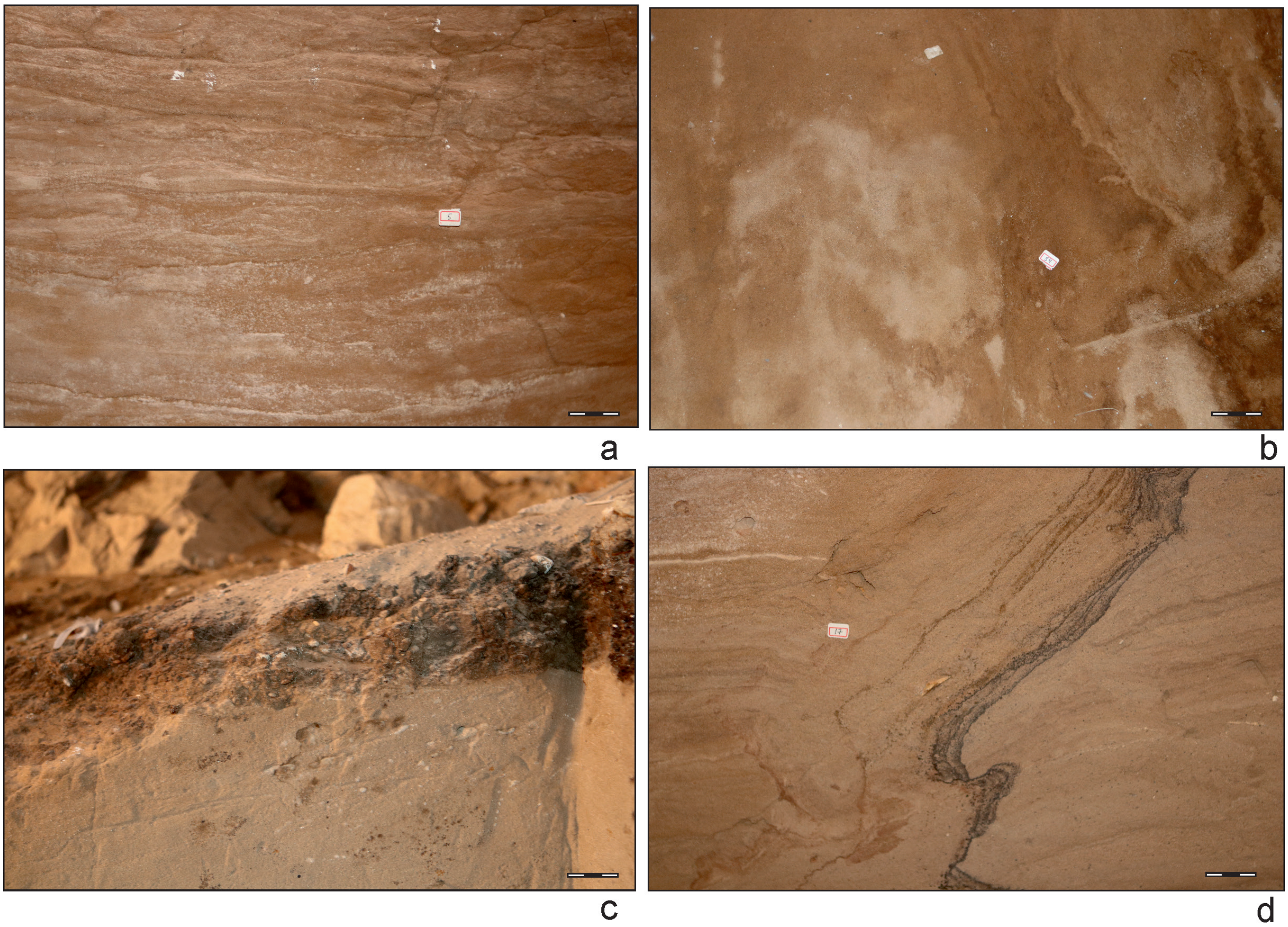

Figure 4. a, b - Orange-brown sands cemented by white carbonate sublayers associated with water from the chimney (West wall and excavated surface); c – un-reworked greyish-brown fine-grained polymictic carbonate sand in Layer 2.1 (North wall); d – Manganese (Mn) lens demarcating the boundary of the hydrodynamic scour (North wall).

Layer 2.2 is represented by cross-bedded medium-grained yellowish and greyish sands containing cobbles up to 5-7 cm in diameter, which are associated with neotectonic processes and fragmentation of the cave's roof; gypsum ($CaSO_4 \cdot 2H_2O$) crystals were identified here. At the contact of Layers 2.1 and 2.2 there is a manganese (Mn) layer 3-5 cm thick, which then continues as a thick lens of black-grey, loose, non-silty sand impregnated with manganese. Coprolites also mark the boundary between these two layers (simply described as "debris" in previously excavated spits in the Main Chamber). At the contact of Layers 2.2 and 3, stratigraphic disturbances were recorded in the form of depressions containing darker deposits and small bones. Paleontological and planigraphic analyses of remains found during screening of sediments from Layer 2.2 and lower Layer 2.1 indicate that at that time the cave was inhabited by hyaenas (62 coprolites and 89 bones from hyaenid gastrointestinal tracts).

Layer 2.3 – cross-bedded dusty-sandy loam – absent in the 1990s excavation pits, appearing first in Pit 2 Units A'19/1 and B'18.

The thickness of Layer 3 in excavations conducted between 1997-2000 was 1-3 cm. It can be traced along the longitudinal section of the cave as a thin, grey, loamy, carbonaceous stratum. In the 2021-2022 excavation profile, its thickness reaches 15 cm, and falls sharply towards the northwestern corner of the pit. Although the contact between Layers 2.2 and 3 is heavily disturbed by hyaena dens, the top of Layer 3 is clearly marked by a combustion feature. Small boulders are associated with this feature, one of which was completely covered in a layer of charcoal, but it cannot be confidently concluded that these boulders once formed the outline of an anthropogenic firepit. Non-human bones and stone artifacts were also found on the surface of the combustion feature and in its fill.

Layer 4, a sandy loam, is also about 15 cm thick and dips obliquely towards the northwest corner of Pit 2. It contains small and medium calcite ($CaCO_{3}$) crystals. Coarse-grained sands occur here in distinct lenses.

Layer 5 is represented by grey-blue and yellow-grey loamy lenses. The genesis of some of these lenses is associated with large stones and calcite crystals in the layer; sediments from the cave ceiling were concentrated around them, and the wet loam became compacted as sediment accumulated. In 2022, it became clear that lenses forming separate layers allowed dividing Layer 5 into three distinct units (Layers 5.1, 5.2, and 5.3), and these units are much older than the upper part of the stratigraphic profile. The boundary between Layers 4 and 5 remains problematical: radiocarbon dates from the top of Layer 5 are contemporaneous with dates from Layer 4, while OSL determinations from Layer 5.1 are much older. Identification of this boundary is a task for subsequent excavations.

Layer 5.1 – greyish-blue clay loam, dusty when dry, containing small rocky debris and calcite crystals. Accumulation of this layer coincided with rockfall, including large calcareous crystals, from the cave ceiling; manganese lenses are associated.

Layer 5.2 – clayey loam cemented by limestone drips, with inclusions of rounded limestone fragments and sandy filling, probably associated with the most humid period of the cave's history. Here, lenses of round, coarse sand are associated with large limestone blocks, accompanied by thin horizontal cemented manganese lenses that we interpret as evidence of intermittent low-energy water flows and standing puddles in the cave.

Layer 5.3 – wet ductile blueish-green clayey loam with ferruginous red sublayers, dusty when dry. This layer is relatively thick and includes limestone blocks and large calcareous crystals and rock debris.

Layer 6 – yellowish-brown round coarse sand with rock debris and rounded pebbles. Most likely the source of this sand was outside of the cave.

Layer 7 – blueish clayey loam with yellowish-orange ferruginous inclusions, sandy sublayers and rock debris. Sand is rounded and coarse. This layer is not homogenous: sand and clayey loam were patchily deposited.

Layer 8 – greyish-blue wet silty clay loam, rolls up while digging. The thickness of this layer is unknown, since excavations are ongoing.

Layers 5.1 – 8 are associated with humid conditions and were formed by alluvial processes. Archaeological and faunal material has been found in all layers, but their quantities vary inversely: the number of artifacts grows from the upper to the lower layers, while the number of faunal remains decreases in the lower deposits.

Figure 5. Stratigraphic profile of Pit E in the Entrance Terrace in 2022. North wall.

Pit E / 2022, Entrance Terrace

Pit E was excavated on the Tsagaan Agui Cave Entrance Terrace in 2022 (Figure 5).

The stratigraphic sequence in Pit E contained layers 1, 4-9, and 11-13, identified on the Entrance Terrace in 1987 – 1988 (Derevianko, Petrin, 1995). The changes in stratigraphy uncovered along Line A' mostly relate to the upper part of the profile – lenses 1 – 3, associated with large blocks on the surface of the terrace – and additional subdivisions of the lower layers. Lens 1 – whitish–grey marly loam with red and dark spots. Lens 1.1 – grey light loam, compressed under a large limestone block with calcite crystals and artifacts. Lens 2 – bluish-grey light loam under the limestone block. Lens 3 - bluish-grey light loam with a more porous structure; includes plant roots. Sublayer 3.1 – rust-colored loam that divides lenses 2 and 3. Layer 4 – solid red sandy clay with light medium-grain agent. Sediments are inhomogeneous due to the density of carbonates. This layer is the thickest in the cross-section and, probably due to its solidity, protected underlying layers from destruction. Unfortunately, this layer is almost absent in 2022 Units A'4 – A'5. Sublayer 4.1 – a yellowish stratum of the same texture and structure as Layer 4, situated in the upper part of Layer 4 and may have undergone color change due to chemical reactions. Layer 5 – brownish-grey sandy clay; the upper part of the layer contains gravel, while the lower portion is more plastic. In the 2022 Excavation Pit this layer was not covered with a solid Layer 5 deposit and was significantly bioturbated by rodents – marmots, ground squirrels, pikas – and hyaenas. Layer 6 – greyish-brown sandy clay with fine-grained debris. Layer 7 – debris with a sandy clay agent; probably associated with colluvial processes. Layer 8 – red, round, coarse sand. Layer 9, first excavated in 1988, is now subdivided into two separate strata (Layers 9 and 10) where upper is a sandy medium fine gravel with a laminar structure, and the lower is grey heavily-cemented sandy clay 1-2 cm thick appearing in separate sections of the profile. Layer 11 consists of red, round, coarse sand. Layer 12 includes two subdivisions: 12.1 is composed of dusty sand with fine debris; 12.2 – loessic sandy clay. Layer 13 - red heavy clay (labeled Layer 10 on the 1980s profile), lying conformably on the bedrock of the terrace. The stratigraphic layers of the Entrance Terrace sequence are thin and dip significantly from northwest to southeast in the direction of the 1988 Excavation Pit because of bedrock relief.

Preliminary chronology

Most of the samples taken for OSL and AMS ^{14}C dating are currently being processed, but we have dates in-hand for each layer in Pit 2, allowing us to create a preliminary chronological column. Here, in Table 1, we provide radiocarbon dates for Pit 2 in the cave's Main Chamber, the Entrance Terrace and Entrance Grotto, which are interesting in part because of the ability to reconstruct the chronology of hyaena activity and the presence of particular vertebrate species in the Gobi Altai region. Samples were processed in the Golden Valley Laboratory of Novosibirsk State University (Table 1).

Table 1. New radiocarbon dates for Tsagaan Agui Cave.

Pit, Year	*Lab. Code*	*Sample Type*	*Taxon*	*Layer*	*Specifics*	*Radiocarbon Age*	*Cal. BP, 95%*
Pit 2, Main Chamber, 2021	GV- 4380	bone	Indeterminate	2.2	Digested by hyaena	29,970±219	32945-32075
	GV- 4379	bone	Indeterminate	3	From combustion feature; not burned; digested by hyaena	33,636±617	38107-34897
Entrance Grotto, 1989	GV- 3623	coprolite	*Crocuta ultima*	fill in crack of large redeposited rock in contact with terra rossa deposits		21,743±76	26259-25846
	GV-3621	bone	Large ungulate	Layer 5 (?) cleaning of fallen wall	split by human agency; hyaena gnawed	41,593±983	46174-42910
	GV-3619	bone	*Coelodonta antiquitatis*	lowermost Layer 5, A14		51,565±2293	Out of range
Entrance Terrace, 1988	GV-3620	bone	*Camelus knoblochi*	Layer 5, A5, depth 325 cm		39,784±538	44139-42525

We do not provide dates for Layers 2.1 and 4 here yet, but the first may be preliminarily assigned to the Last Glacial Maximum (ca. 26,000-20,000 years ago), and the dates for the second are in accord with Layer 4's already presumed age of slightly older than 40,000 years ago. The strata underlying Layer 4 cannot yet be dated by radiocarbon means. Additional radiocarbon and OSL dates are currently in progress at the University of Vienna, Austria and the Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences in Beijing.

Faunal remains

The archaeofauna of Tsagaan Agui has been primarily studied through classic paleontological analysis of identifiable remains. Another source of potential information is sedimentary ancient DNA (sedaDNA) that will be provided by Yale University. All unidentifiable bones have been sent to Vienna University for ZooMS analysis. Both studies are currently ongoing.

The zoogeographical aspect of Pleistocene mammalian evolution Mongolia is an empty void. It is a territory that includes an invisible border between forest-steppe and dry steppe to semi-desert faunal complexes, where the first is best represented in Transbaikalia and northern Mongolia and the second by the Gobi Desert in southern Mongolia and North China. Mammalian bones identified at Tsagaan Agui are characteristic of Pleistocene steppe and desert biotic communities in both Mongolia and China. Table 2 provides a taxonomic list of animals identified in each layer of Pit 2.

Table 2. List of fauna identified in Pit 2 in the Main Chamber.

Common Name, Taxon	*Stratigraphic Layer*										
	1	2.1	2.2	3	4	5 top	5.1	5.2	5.3	6	7
Hedgehog, *Erinaceus* sp.	+										
Bat, Chiroptera	+					+					
Hare, *Lepus tolai*	+	+	+	+	+	+	+	+	+	+	+
Pika, *Ochotona* sp.	+	+	+	+	+	+	+	+	+	+	+
Rodent, Rodentia	+	+	+	+	+	+	+	+	+	+	+
Jerboa, Dipodidae	+	+	+	+	+	+	+	+	+	+	+
Hamster, Cricetidae				+	+	+	+	+	+		
Ground squirrel, *Spermophilus* sp.	+			+	+	+				+	
Marmot, *Marmota* sp.					+	+					
Wolf, *Canis lupus*						+					
Cave hyaena, *Crocuta ultima*				+	+	+					+
Indeterminate carnivore	+		+	+	+	+		+	+	+	
Red fox, *Vulpes vulpes*	+	+	+					+	+	+	+
Corsac fox, *Vulpes corsac*					+	+				+	
Pallas's cat, *Otocolobus (Felis) manul*					+	+		+	+		
Mountain weasel, *Mustela altaica*									+		
Steppe polecat, *Mustela eversmanii*									+		
Wild horse, *Equus ferus*	+			+	+	+					
Mongolian wild ass, *Equus h. hemionus*	+		+	+	+	+					
Horse, *Equidae*	+	+	+	+	+	+			+		
Woolly rhinoceros, *Coelodonta antiquitatis*		+									
Argali or mountain sheep, *Ovis ammon*		+	+	+	+	+					
Siberian ibex, *Capra sibirica*			+		+						
Caprine, Caprinae	+		+	+		+					
Bovine, Bovinae				+							
Tibetan antelope, *Pantholops hodgsonii*	+			+		+					
Goitered gazelle, *Gazella subgutturosa*	+	+	+		+	+					
Knobloch's camel, *Camelus knoblochi*					+						
Small ungulate	+	+									
Medium ungulate	+	+	+	+	+	+					
Large ungulate	+	+	+	+	+	+			+		
Bird, Aves	+	+	+	+	+	+	+	+	+	+	+
Amphibian, Amphibia	+					+					
Reptile, Reptilia	+				+				+		
Coprolites		+	+	+	+	+					

No crucial changes in faunal composition were noted but remains from Layer 5.3 indicate more humid conditions, supporting the presence of typical steppe inhabitants such as mountain weasel (*Mustela altaica*) and steppe polecat (*M. eversmanii*). Remains of frogs (Family Ranidae) were also recovered here. A proximal left ulna fragment of a beaver (*Castor fiber*) was also recovered from Layer 2 in Pit 2022/1 (Klementiev et al. 2022), suggesting a perennially wet environment very different from the conditions surrounding Tsagaan Agui today.

Based on preliminary pollen analysis we hypothesize that there was an active trophic water reservoir in the vicinity of Tsagaan Agui. Small mammal remains (Marchenko et al., in press) do not indicate substantial climate changes occurred during the human occupation of Tsagaan Agui. A mandible belonging to the Middle Pleistocene yellow steppe lemming (*Eolagurus* cf. *simplicidens*) was found in Layer 5.3, while other, later, species of *Eolagurus* were found in Layers 4, 5.1 – 5.3. The principal area of *Eolagurus*'s modern distribution is in Xinjiang. This animal is very sensitive to climate changes and its reproduction depends directly on annual temperature and precipitation regimes. In the twentieth century, *Eolagurus* became extinct in Kazakhstan and the Pre-Caspian Basin (Gromov and Erbaeva 1995; An et al. 2023). The full taxonomic list of small mammals and amphibians from Tsagaan Agui can be found in Marchenko et al., in press.

We have studied the modern fauna of the Gobi Altai region to better understand climatic changes through the Pleistocene and Holocene up to modern times, in part through the collection of samples of modern Gobi inhabitants for comparative purposes. Naturally occurring skeletal remains were collected within a 150-200 km radius of Tsagaan Agui. The most numerous such remnants are those of domesticated *Camelus bactrianus*. The Tsagaan Agui comparative osteological collection now also includes domesticated horses, cattle, and yak from the Arts Bogd Uul range and skeletons of goats, sheep (including the baidrag breed, Байдраг үүлдрийн хонь), and Mongolian shepherd dog (bankhar, банхар). Skeletal remains of wild animals collected include *Otocolobus* (*Felis*) *manul*, *Lepus tolai*, *Vulpes vulpes*, and *Capra sibirica* from the Khalbaganat Uul range, as well as *Gazella subgutturosa*.

During the 2023 field season, specimens of *Meriones meridianus* (1 individual), *Allactaga bullata* (5 individuals), and *Cricetulus migratorius* (2 individuals) were collected and skeletal preparations made. Fecal pellets (42 samples) were collected from rocky niches, rockshelters, and nests of raptorial birds and owls, also containing all skeletal elements of lagomorphs and rodents identifiable to species (127 individuals; MNI calculated on the basis of left and right cheek teeth). We have monitored the modern fauna that inhabits or visits Tsagaan Agui Cave using a Bushnell Trophy Cam HD Aggressor Low-Glow game camera that recorded multiple animal visits from October 2022 to June 2023: mouse-size rodents, hare, Pallas's sandgrouse (*Syrrhaptes paradoxus*), wild pigeons, kestrel, bats, a migrating steppe polecat (*Mustela eversmanii*), and domesticated sheep, goats, and cattle. At least one red fox (*Vulpes vulpes*) uses the cave as its permanent residence even during the mating season, suggesting that at least some of the *Lepus* remains in archaeological horizons in the cave may be the result of foxes' predatory and denning behavior.

The Holocene archaeological record

Most Holocene cultural remains at Tsagaan Agui, representing various historical periods from the Bronze Age through the introduction of Buddhism in the region, originate from Layers 1 and 2 in Pit 1 and Layer 1 in Pit 2. The long-term use of Tsagaan Agui as a Buddhist pilgrimage spot is attested to by the discovery of a bronze incense or medicine spoon (that may also have functioned as a *thokcha* amulet) and a small copper or bronze offering cup. Paste beads found in the cave may date to the late Bronze Age: such beads are characteristic of the Andronovo (ca. 2000-1150 BCE) and Karasuk (ca. 1500-800 BCE) cultures in southern Siberia and the Glazkovskaya culture (ca. 2200-1200 BCE) in Cis-Baikalia, Mongolia, and the Ordos Region in China (Okladnikov, 1957; Novgorodova, 1970) (Figure 6. *3, 4*). Carnelian beads became widespread in Central Asia beginning in the Bronze Age and the one found in Tsagaan Agui could represent any time up to the Medieval Period (Figure 6. *5*).

Among the most interesting historic period finds are two birch bark fragments bearing inscriptions in Old Mongolian (Figure 6. *1, 2*). One text was legible and has been translated by Zh. Gerelbarakh:

a.01. kilinčes . . . (хилэнцэс . . .) (evil…)
a.02. öber-e arilg

The inscribed judicial birch bark fragment discovered in Tsagaan Agui Cave falls within the earlier corpus, associated with the post-imperial period of the Northern Yuan (Их Юань, 1368-1635 CE), before a new wave of Buddhism arrived in Mongolia.

The lithic industry revealed in 2021-2022 Pit 2

Layer 2.1 was accumulated during the Last Glacial Maximum (ca. 26-20,000 years ago). Layer 2.1 contains a flake industry with occasional blades and bladelets, produced mostly on non-local raw

Figure 6. Finds from Pit 1 in the Small Gallery: 1, 2 – inscribed birch bark fragments; 3, 4 – paste beads; 5 – carnelian bead; 6 – microblade.

materials, including one made of a type of jasper characteristic of the Arts Bogd Uul area, circa 200 km from the cave (Figure 7. *1*). In Layer 2.1, we found a modified rod-like fragment of serpentinite flaked from both ends (Figure 4. *4*). The nearest known serpentinite outcrops occur some 40 km south of the cave.

Layer 2.2 contained 19 lithics, including an expedient core, end-scrapers, and a truncated-faceted piece (Figure 7. *2*). They are made on local Devonian flint and do not reflect the use of imported raw material. A truncated piece was also found in Layer 2.3 (Figure 7. *3*).

Layer 3 yielded a laminar industry and evidence of Levallois point production interpreted as Initial Upper Paleolithic (IUP) in the 1990s (Brantingham et al. 2001). We recovered an additional small assemblage of 43 lithics, including an expedient core, truncated-faceted pieces, and unretouched flakes. A small number of blades also occurred here, but no evidence of standardized IUP subprismatic bidirectional large blade production. This cannot be explained only as a result of poor quality local raw material since Levallois points made on imported high quality stone were also found. This industry is based on flakes produced by orthogonal and flat unidirectional knapping.

Terminal Middle Paleolithic Layer 4 also contained bidirectional blades and denticulated-notched tools. A total of 132 lithic artifacts were found here. The tools assemblage is represented by several types and most of them exhibit ventral secondary treatment.

Two flakes exhibit ventral trimming of the bulb of percussion, and one is a blank for a truncated-faceted piece. One symmetric point made on a subtriangular elongated flake was found.

Middle Paleolithic Layer 5.1 is represented by core management elements, quadrangular bipolar cores of two types (on-anvil and anvil-rested; Picin et al., 2022), as well as *siret*. A series of points, including oblique varieties and those with concave bases, and pick were also recovered (Figure 7. *4–6*).

Layers 5.2, 6, and 7 contained hammerstones and retouchers (2, 3, and 4 specimens, respectively). The most interesting hammerstone, from Layer 7, exhibits traces of percussion on a wide surface that can be associated with the bipolar technique (Figure 8. *9*).

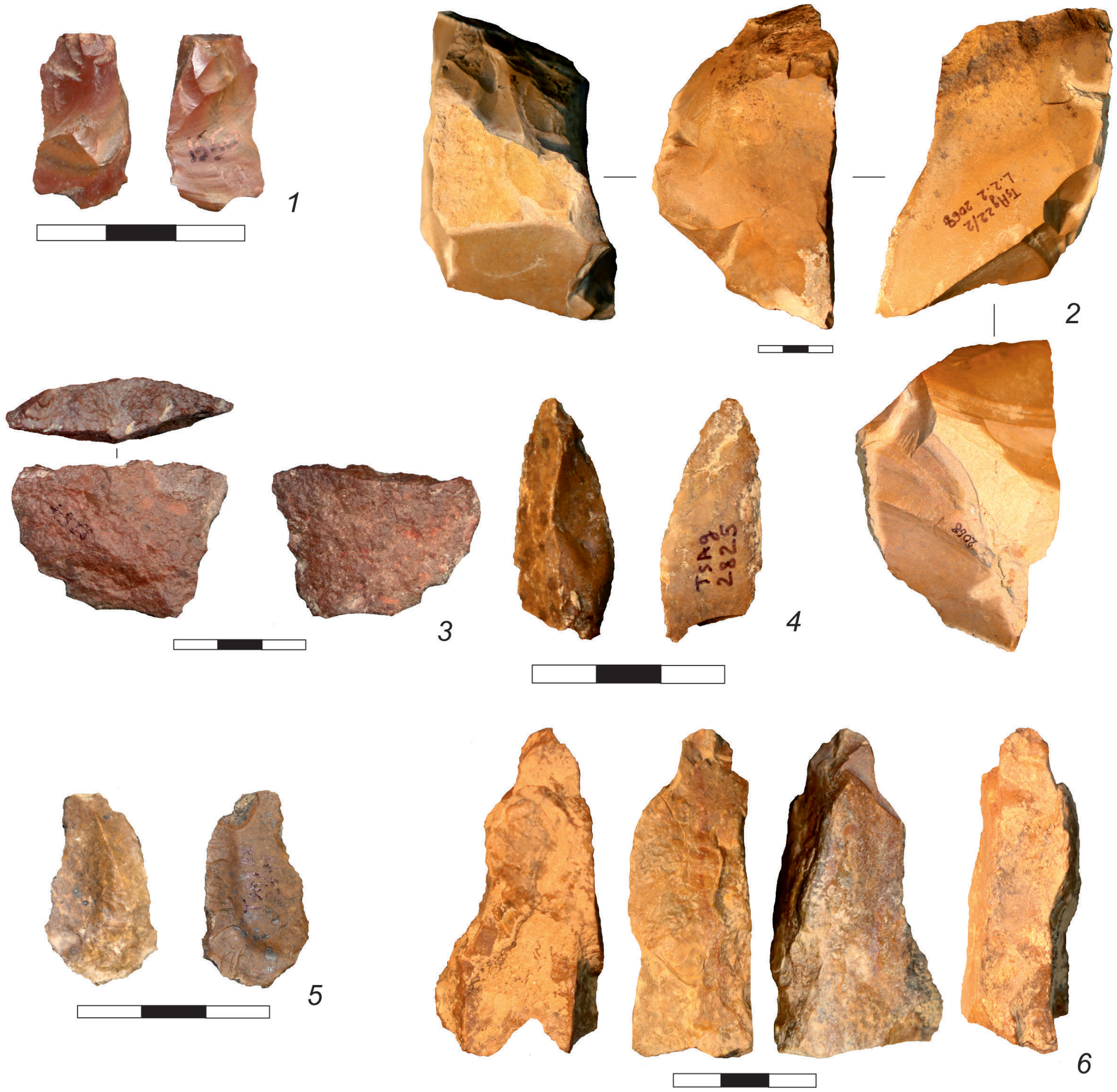

Figure 7. Finds from Pit 2 in the Main Chamber: 1 – flake (Layer 2.1); 2 – expedient core (Layer 2.2); 3 – truncated flake (Layer 2.3); 4 – asymmetric retouched point (Layer 5, top); 5 – asymmetric point (Layer 5, top); 6 – pick (Layer 5, top).

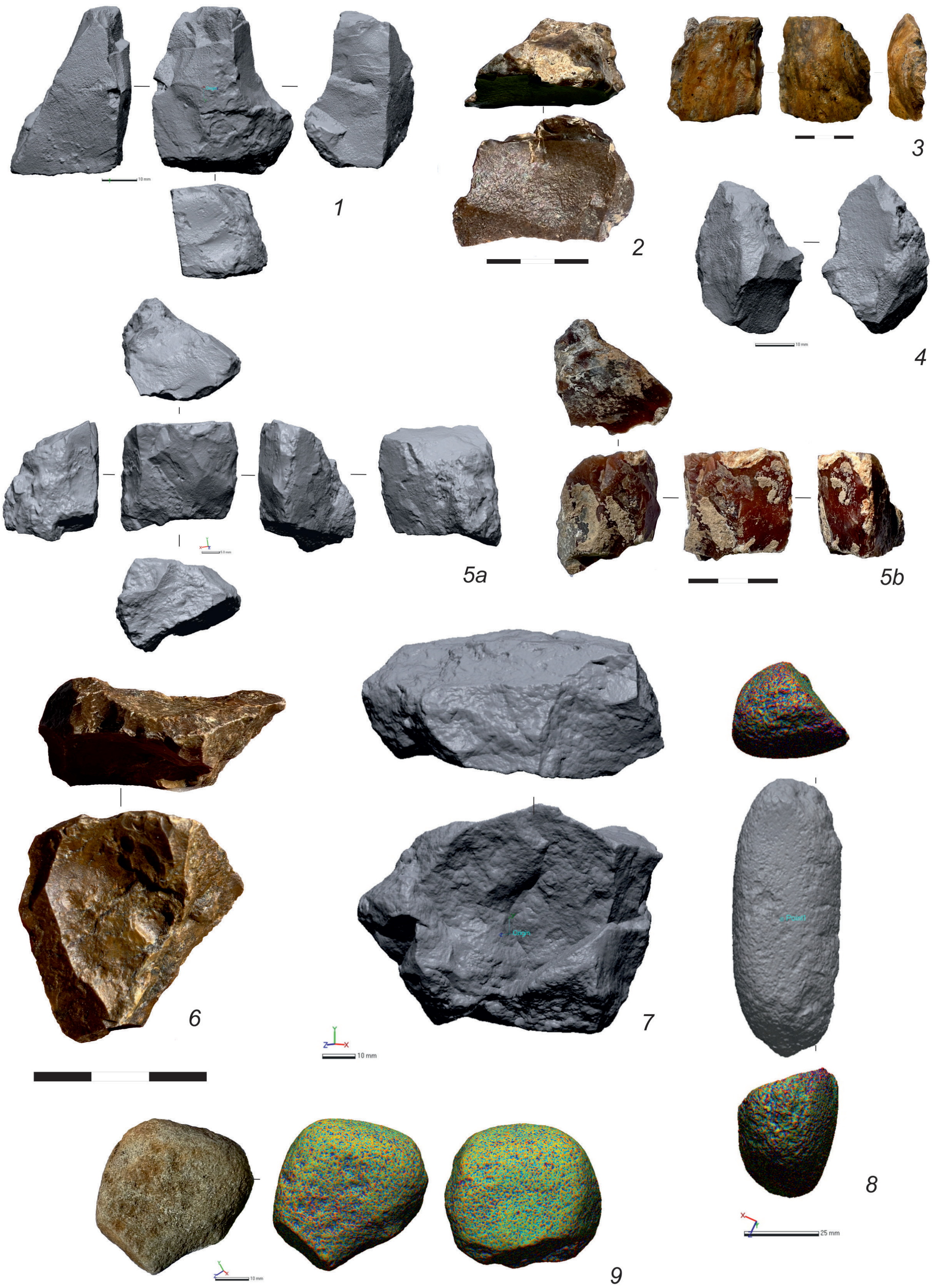

Figure 8. Finds from Pit 2 in the Main Chamber: 1, 2, 5 a,b – bipolar cores (photos and 3D models); 3 – backed ventral side-scraper; 4 – perforator; 6, 7 – Levallois cores; 8, 9 – hammerstones (Layer 7) (curvature designed in Geomagic Design X).

About one-third of the artifacts in Layer 5.3 relate to this technique: most are blanks with counterblows on the distal ends, angular shatter morphologically like *sirets*, and two cores. One of the nuclei is well-proportioned and has a flattened base that was repeatedly refreshed (Figure 8. *2*). Such precise bipolar core management is absent in the underlying layers. The second morphologically refers to expedient cores for multidirectional knapping and made is on reddish translucent flint (Figure 8. *5a, b*), whose vein was already completely exhausted by time of accumulation of Layers 5.1 – 2. Tools are represented by two perforators and a side end-scraper made on flakes (Figure 8, *3, 4*). Six bipolar cores from this layer indicate different approaches to knapping: there are both vertical and horizontal, axial and non-axial, on-anvil and anvil-rested varieties (Picin et al. 2022).

Sixty-five lithics were recovered in Layer 5.3; most are blanks and shatter. The most intriguing artifacts in this sub-assemblage are possible polyhedrons made of limestone and quartzite and a series of small points.

Layer 6 contained 58 lithics, including a backed ventral single straight side-scraper on a sub-rectangular flake and two end-scrapers, one of which has a high working edge (Figure 8. *8-9*).

The lithic collection from Layer 7 is most numerous, comprising 103 artifacts, including cores, tools, blanks, and shatter. Two Levallois or Levallois-like cores were also found here, one fashioned on a massive nodule of Devonian flint, covered with cortex (Figure 8. *7*). The striking platform is multifaceted and its right side, significantly oblique, was used to form a right core lateral through the longitudinal removal of diagonal flakes, functionally but not morphologically like *débordant* examples. One distinctive feature of this core is the presence of opposed striking platforms bearing traces of the bipolar technique. This does not allow is to categorize this nucleus as a classic Levallois core, but the apparent system of core management, predetermined flake removal from the flaking surface, and the relatively early age of the layer suggest that it is an early Levallois form made on poor-quality raw material. The second nucleus more closely resembles classic convergent unidirectional cores for point production with straight facetted striking platforms (Figure 8. 6). Rare Levallois flakes are also present in this assemblage, as well as evidence of the bipolar technique and the use of expedient cores for multidirectional knapping – this morphology remained unchanged up to the Upper Paleolithic assemblage found in Layer 2.2.

Conclusions

Analysis of animal remains indicate humid conditions prevailed at Tsagaan Agui during periods of the Pleistocene, while the core faunal composition did not change significantly until ca. 40,000 cal BP. Typical inhabitants of dry steppes and semideserts were present, similar to the fauna of arid regions in China. Humans and hyaenas occupied Tsagaan Agui simultaneously, but hyaenas were apparently permanent residents, while human presence was episodic, especially during the Upper Paleolithic.

The new phase of excavations at Tsagaan Agui has revealed the use of the bipolar technique and Levallois technology in Layers 5.2 – 7. Levallois technology had previously been revealed in Layer 3 in the cave's Main Chamber, dated to 38,000-34,000 cal. BP, and in Layers 5 – 7 in the Entrance Terrace (Derevianko and Petrin 1995). Levallois cores from the Entrance Terrace exhibit recurrent centripetal removals for flake production, while nuclei from Layer 3 are classical linear convergent cores for point production. These are later forms than those found in Layer 7 in 2023. Use of the bipolar technique was previously described based on several artifacts recovered from the Entrance Terrace [Khatsenovich et al. 2023], but the lithic industry revealed in Layers 5.2 – 7 of Pit 2 allows reconstruction of the bipolar knapping process that took place in the cave itself, since there are *sirets* and hammerstones present. The bipolar technique is one additional strategy for maximizing raw material economy revealed at Tsagaan Agui along with large blank production from every convenient arête of a nodule, cores with broad flaking surfaces on the ventral face of blanks, as well as narrow-faced cores, transverse fragmentation, Mousterian *tranchets,* and obvious recycling.

Lithic assemblages uncovered from Layers 5.2 – 7 are situated, both geographically and culturally, between the earliest complexes of the Russian Altai Mountains and China – Denisova Cave, Zhoukoudian Locality 15, Jiangjunfu 01 and, probably, some unpublished assemblages from the Tibetan Plateau, as can be seen from the technological, technical, and tool packages. The bipolar technique did not become widespread in northern Asia, unlike China, where Levallois technology was relatively late and sporadic, while the bipolar technique was very common.

Investigations of Tsagaan Agui Cave, with its deep, stratified cultural sequence, will undoubtedly continue to add data to the chronostratigraphic record of the Mongolian Paleolithic. In 1995-2000, the expedition's excavations in the main chamber proved very informative and work undertaken at Tsagaan Agui in later years has focused on delineating the stratigraphic section of the Entrance Terrace as well as excavations of the Lower Grotto and the cave's principal and lesser chambers, permitting us to resolve the circumstances of the cavern's formation and infilling as well as elucidating the record of its human habitation.

In recent years, we have focused on reconstructing human-animal interactions, changing paleoclimatic and paleoenvironmental conditions, and generating a more refined chronology for the cave interior and its surroundings. Detailed lithic analysis has revealed technologies and techniques that may highlight connections with other regions.

The significance of Tsagaan Agui Cave in Asian Paleolithic archaeology is becoming better defined. Now, more than three decades into our joint investigation of Tsagaan Agui, the cumulative results prove the effectiveness of this approach, and we look forward to many more years of collaborative trilateral research.

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Contribution authors:

Arina M. Khatsenovich - https://orcid.org/0000-0002-8093-5716

Evgeny P. Rybin - https://orcid.org/0000-0001-7434-2757

Dashzeveg Bazargur - https://orcid.org/0000-0003-2183-0591

Tserendagva Yadmaa - https://orcid.org/0000-0002-8937-6447

Alexei M. Klementiev - https://orcid.org/0000-0002-2129-7072

Daria V. Marchenko - https://orcid.org/0000-0003-3021-0749

Byambaa Gunchinsuren - https://orcid.org/0000-0001-5052-5081

Anatoly P. Derevianko - https://orcid.org/0000-0003-1156-8331

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