KITES ON THE MARGINS.
THE ARAGATS KITES IN ARMENIA

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Abstract: Many desert kites have recently (2010) been discovered on the basaltic slopes of Mount Aragats in Armenia. The implementation of various complementary techniques (geomatics, statistical analyses, geoarchaeology, malacology, radiocarbon analysis) has enabled definition of their specificities. Isolated from the classic Syro-Jordanian zone, they are characterised by a certain simplicity, great morphological homogeneity, strongly related locations to the morphological characteristics of the mountain massif, and dated between the Bronze Age and beginning of the Common Era.


Keywords: Kites; Stone-built structures; Hunting; Animal management; Protohistory; Armenia.
Mots-clés : Kites ; Constructions en pierre ; Chasse ; Gestion des animaux ; Protohistoire ; Arménie.

INTRODUCTION
Since their discovery in the 1920s by aviators flying over the Jordanian and Syrian deserts, ‘desert kites’, or simply ‘kites’, have been the subject of several studies. The works of Helms and Betts (1987), Échallier and Braemer (1995), Fowden (1999) and Morandi Bonacossi and Iamoni (2012), to which we refer the reader, are a good introduction to the archaeological, chronological and functional problems posed by these odd constructions.

Although many decades have passed since their discovery, and in spite of an important investment in field work, questions as basic as those which touch on chronology or use do not yet have fully satisfactory answers. The age of these constructions, whether relative or absolute, remains very difficult to establish in contexts in which archaeological material is either absent or rare and without any clear stratigraphic relation with the construction. From the few reliable data that are today available in the Near Eastern region, the kites would appear to date to the Chalcolithic and the Bronze Age periods (Échallier et Braemer 1995; Nadel et al. 2010 and 2013). For some researchers, however, the oldest constructions probably predate the Pre-Pottery Neolithic (Helms and Betts 1987; Betts 1998), a view supported by some archaeozoological studies (Legge and Rowley-Conwy 1987; Gourichon 2004) which show that the gazelle remains found on some archaeological sites come from seasonal non-selective hunting. In other terms, the mortality profiles observed are compatible with those that would be observed at the end of a seasonal collective hunt of a herd in migration, with beaters, using a ‘demi-piège’ of kite type (Testart 1984) as a hunting aid. They are also compatible with any other type of non-selective hunting, and thus do not necessarily imply the use of kites.

The wide spread hypothesis of a unique use of the kites as ‘demi-pièges’ for collective hunting of gregarious animals—

1. For true traps, the presence of the hunter is not necessary for the game to be captured and possibly killed. “Demi-pièges” are hunting aids which require the active presence of the hunter to function (Testart 1984).
gazelles or oryx in the Near East, reindeer in Scandinavia, bison or pronghorn in North America, saiga antelope or urial in the Aralo-Caspian region—rests mainly on late historical accounts which there is no reason to doubt.2 The accounts of travellers who crossed the steppes and deserts of the Near East between the end of the 16th and the beginning of the 20th century are relatively few (Burckhardt 1835; Barker 1876; Mitford 1884; Wright 1895; Sinclair and Ferguson 1902; Musil 1928a and b; Aharoni 1946). Except perhaps the oldest account, that of Pedro Teixeira (Sinclair and Ferguson 1902), which mentions no enclosure and describes branches or antennae made of posts topped with cloths flapping in the wind, all the accounts describe collective gazelle hunts using long continuous lines of blocks that cause the convergence of one or more herds of gazelles frightened by the beaters into enclosures, the local Syrian Arabic name for which is masyada (Burckhardt 1835; Fowden 1999). The kites of the archaeologists can be recognized in these descriptions. However, at closer inspection, all these accounts describe frightened animals which rush by means of gaps in the walls into pits dug on the exterior of the enclosure. Of the thousands of kites discovered in the Near East, none seems to present this characteristic, and it should be asked whether these particularly recent constructions can be considered to be a universal functional model. This leads us to distinguish two families of kites (fig. 1): enclosure-kites (E kites), and pit-kites (P kites) which are divided into two variants, the pit-kites stricto sensu (PEa kites) and the pit-kites with enclosure (PEm kites). Absent from the Aragats sample, the E kites family has been isolated to take into account the “game drive enclosures” described in North America (e.g., Raymond 1982; Lubinski 1999) and their occasional presence elsewhere. The very small PEa kites, confined to the Negev and Sinai (Meszel 1974; Holzer et al. 2010; Nadel et al. 2010 and 2013), are by far the rarest. They are clearly “demi-pièges”, in Testart’s meaning (1984), intended for hunting.3 At this stage of our knowledge, PE kites should be divided into two variants: PEa kites (m for modern) which we know only through the texts and PEa kites (a for archaeological), the kites studied elsewhere. The very small Pss kites, confined to the Negev and Sinai (Meshel 1974; Holzer et al. 2010; Nadel et al. 2010 and 2013), are by far the rarest. They are clearly “demi-pièges”, in Testart’s meaning (1984), intended for hunting.3 At this stage of our knowledge, PE kites should be divided into two variants: PEa kites (m for modern) which we know only through the texts and PEa kites (a for archaeological), the kites studied by archaeologists. The possibility that PEa and PEm kites are identical remains to be demonstrated. The use of PEa kites, the family to which the Armenian kites belong, cannot be so simply determined by their morphology.

The discovery of many kites in 2010 during geological work on the volcanic range of Mount Aragats by one of us4 led to this study. The various complementary specialities of the different participants—geology, geomatics, prehistoric archaeology and geoarchaeology—have enabled us to analyse and to compare many observations from the start of the exploration phase and to establish protocols of acquisition and analysis of new data never before used in the study of kites5 (Barge et al. 2013). Thus, the aims of this first detailed study of Aragats kites is more to present a new corpus and to test the new methodologies adopted in the ongoing Globalkites6 project, to pinpoint poorly documented issues that hamper comparisons and more comprehensive studies, than to solve the most difficult problems that remain unanswered: how were they used, for which animals? At this point of our field and laboratory work, any answers to these questions would not be anything else than opinions.

2. In aquatic environments, similar “demi-pièges” are used for capturing ducks at the moment of mouling (Payne-Gallwey 1886: 5). These devices are quite different in the way they function from the ‘hadra’ of Bahrain, which are true traps despite their similar shape.
3. They are quite different from the pits with antennae described by Barth (1903), which are true traps intended for the capture of reindeer.

5. O. Barge and J. É. Brochier, “Visible from space, understood during the fieldwork: the example of ‘desert kites’ in Armenia”. 16th International Conference on Cultural Heritage and New Technologies, Urban Archaeology and Prospection, Vienna, 201.
6. Globalkites is a research program financed by the ANR (CNRS) and directed by B. Crassard (CNRS, Archeorient, Lyon).
GENERAL INFORMATION

The use of Google Earth satellite images was decisive for managing the survey and enabled the gathering of much data. However, confirmation of the presence of kites was possible only through inspection on the ground.

Many long walls were located on the satellite images at the foot of the southern slopes of Mount Aragats. The first investigations on the ground enabled confirmation that these are indeed kites, very similar to those found in the Near East. The elements that compose them were observed in the field before their recognition on the satellite images. On these images, new kites were observed and these new discoveries led to the investigations that followed, which in turn led to new observations. Thus the daily back-and-forth between consultation of satellite images and inspection in the field efficiently enabled establishment of both an understanding of the kites and of their distribution (see below fig. 2). During the two field campaigns carried out in spring 2011 and autumn 2012 within the framework of the LIA France-Armenia, seven kites formed the subject of thorough study (including excavation, sampling and plans) and 24 were visited out of 173 kites identified and analysed on the satellite images.

The plans were made with the aid of a DGPS and the data acquired were structured in a spatial database exploited using a GIS. This includes geolocated and oriented photographs, the location and context of the samples, the width, the height and the manner and quality of construction of the kites (and other structures intersecting them when present) by homogenous sections. This database also functions on the scale of the region: the plans were used to manage the survey and enabled the gathering of much data. The GIS thus enables an exploratory data analysis to be carried out on the scale of each kite studied in the field as well as the drawing of its plan. It also enables analyses to be carried out on the scale of all the kites discovered in Armenia.

LOCATION

The Armenian kites are located in Western Armenia, not far from the Turkish border, over a zone that is some 50 km in longitude and 40 km in latitude (fig. 2). They occupy the south and south-west slopes of Mount Aragats at altitudes between 900 and 1500 m asl, which represent low altitudes in the regional context. They are not found anywhere else in Armenia, and are also absent, beyond the border, in the plain of Kars and on the slopes of Mount Ararat.

The kites run along the downhill fringe of the lava flows, their antennae (guide-walls) generally turned uphill; the map shows their linear distribution very clearly. At low altitude, they are all found not far from the plains, cultivated today, which they overlook. In this regard, it cannot be excluded that the kites also occupied these plains, but that crop cultivation has erased their traces. In any case, this topographical configuration (frontal part of the lava flows, low altitude, proximity of the plain), on the regional scale, is characteristic of the area of distribution of the kites.

GEOLOGICAL CONTEXT

Most of the kites are situated on ancient lava flows (0.85 – 0.75 Ma) which are covered on the surface with later tuffs (0.6 – 0.5 Ma). By levelling the irregularities of the flows, this cover created sub-horizontal surfaces and built up a sub-stratum favourable to soil formation, which could define the particular environmental conditions that were sought by the builders of the kites.

MORPHOLOGY

The shape of the enclosure and its arrangement in relation to the antennae have often been used to construct a typology (Helms and Betts 1987; Échallier et Braemer 1995). In the case of the kites of Mount Aragats, this solution proves to be less pertinent, as about half the corpus could not be placed with certainty in an existing category. However, fieldwork as well as examination of satellite images enabled designation of a series...
of recurrent characteristics (antennae, presence and shape of cells, shape of the entrance...), which will be examined separately at first, then more generally through factorial analysis.

We have differentiated the kites (in the strict sense) having one or two antennae from other constructions that are more or less similar, that is, 'kites' without antennae, even without an entrance, but which present other common attributes.

The first sub-group assembles the largest number of constructions, 86% of the total. These all consist of an enclosed space with an entrance which has characteristics that orient the construction so that it may assemble and confine animals. The second sub-group (14% of the total) includes those constructions that possess only one or some of the specific characteristics of the Aragats kites: they present at least one cell and a surface area comparable to a kite enclosure. They are similar to kite enclosures but lack an entrance as well as antennae.

CHARACTERISTIC FEATURES

Entrances

The slope break at the entrance to the enclosure, often mentioned in the literature, is frequently found in the Aragats kites (fig. 3a); this serves to mask the presence of the enclosure for the animals driven between the antennae before they actually
Fig. 3 – Some architectural examples: a) kite 10, the entrance and the convergence of the antennae. On the right, the antenna is interrupted by a rocky protuberance, b) and c) kite 7, the wall of the enclosure, d) example of double-faced wall, e) a circular cell of kite 7 (note on the right the fine-grained sedimentary prism against the enclosure wall), f) a quadrangular cell of kite 4, g) the wall of the kite 14 enclosure closely surrounds a rocky protuberance, h) oblique photograph of a cell at the end of a pointed appendage.
enter it. The break could also be related to the fact that the antennae frame spaces that are generally flat and sub-horizontal up to their edge, the enclosure located necessarily on the slope. This characteristic called a ‘slope break’ is present in 81% of the cases.

The entrance to the enclosure is often defined on each side by two low walls that converge towards the interior, without their being necessarily in the alignment of the antennae or presenting exactly the same orientation. The kites that have this characteristic, which is called an ‘entrée en entonnoir’ or funnel entrance, are frequent (55%) and all of them also present a slope break.

The width of the entrance, when it can be measured, is between 10 and 54 m, the average being 27 m. Some kites (4) present a low wall that closes the entrance.

Enclosures

The walls of the enclosure are regularly and clearly higher and wider than the walls of the antennae: they measure on average 76 cm in height and 77 cm in width. They can sometimes reach 2 m in height and 1.20 m in width (fig. 3b and c). These walls are mainly constructed with a single facing, but double facing has been observed locally (fig. 3d). The size of the enclosures may be considerable: in our sample, the median area value is 2.1 hectares, the inter-quartile range is comprised between 1.5 and 2.9 ha; only three enclosures are smaller than one hectare; the maximum area observed reach 9.4 ha (fig. 4).

They are sometimes partitioned. This infrequent feature is observed in a third of the cases. Among these, the partitions are most often (74%) situated in a proximal position.

Cells

The presence of cells is a constant; all the enclosures have at least one, with a maximum of eight for an average of 3.1 cells. In the field, we were able to observe that two principal forms existed:9

– circular or sub-circular cells (fig. 3e) with a diameter measuring between 3.5 m and 5.6 m (average: 4.6 m);
– quadrangular cells whose angles are generally truncated (fig. 3f). Their average length reaches 6.7 m (4.4 m to 9.6 m), their width 4.6 m (3.5 m to 5.6 m).

The average area of the circular cells (16 m²) is less by half than the quadrangular cells (31 m²). The walls of the cells are always double-sided and preserved in several courses; their height can reach more than 2 m (1.5 m on average), their width is often considerable and can reach 1.70 m. These walls always present in their upper part (when the height preserved enables this to be observed) a continuous peripheral corbelling that forms a slight overhang towards the interior. Of all the cells that were observed, it was never possible to distinguish an opening. It appears that these constructions were completely closed, as much towards the exterior as towards the interior of the enclosure.

A digging out of the rocky substratum at the place of the cells was usually observed. Although today partially filled with sediment, their surfaces are always lower than those of the enclosures, the difference often measuring several decimetres. The cells present other recurring characteristics:

– they can be in a proximal position, in which case they are positioned in the angles of the enclosure closest to the entrance. This arrangement is found in most of the kites (85%), most often in the two opposite proximal angles (70%).
– 69% of the cells, called ‘logettes en pointe’, occupy the end of an external pointed appendage of the enclosure (fig. 3b). The kites have on average 2.1 cells of this type, three of them presenting up to five, while only five kites do not have them. This feature is found in the complex enclosures and constructions, one of the reasons for their integration into the corpus. Some of these cells located at the end of pointed appendages are closed off by a wall (‘pointe barrée’), for example in the case of K59.9

9 The shape and size of the cells are not always seen clearly on the satellite images. For this reason, precise description is not presented for the 78 kites. The observations and dimensions mentioned correspond only to the cells visited on the ground.
10 Measurements were taken between the midpoints of opposite walls thickness.
Antennae

The antennae of the Aragats kites consist of continuous low walls of one course with simple facing. Their width is on average about 50 cm and their height hardly exceeds a few decimetres. The absence or low volume of scree suggests that these low walls were not much higher when the kites were in use. The fact that the walls of the enclosures, and even more so those of the cells, have been preserved to a considerable height shows that the low height of the walls of the antennae is not due to poor preservation.

The antennae are long, 350 m on average (1592 m to 12 m), some well over a kilometre. In 50% of cases (inter-quartile range), their length lies between 180 and 550 m.

They are usually highly asymmetrical; if a ratio of 1.3 between the longest and shortest antennae characterises the asymmetrical antennae, only a little more than a quarter (26.8%) of the antennae are symmetrical. It is possible that the lengths of the antennae (or their absence) are related to topographic configurations, as rocky protrusions could have played the same role as the antennae. We have observed several cases in which the antennae structure includes a rocky protrusion, such as kite10, for example (fig. 3a).

Orientation

The Aragats kites present an opening angle (angle formed by the two antennae) of between 0° (sub-parallel antennae) and 94° which follows a Gaussian distribution (Shapiro-Wilk, W: p = 0.853; average 46.9°; standard deviation 20.6°).

The analysis of the direction in which the kites are oriented1 reveals interesting features. The (circular) correlation (Fisher 1993; Hammer and Harper 2006) between the orientation of the kites and the local mean orientation of the slope,12 which is strong and highly significant (r = 0.737; p = 4.093.10-7), shows that the orientation of the Aragats kites copies the orientation of the slopes on which they are constructed. We have illustrated this relationship by constructing the distribution of the angular differences between the direction in which the kites are oriented and the local mean orientation of the slopes (fig. 5). There are some rare cases of inverse orientation (orientation opposite to that of the slope).

Most of the kites are oriented west/north-east (fig. 6). They appear to be oriented according to the slope, the antennae uphill and the enclosure downhill, and this being the case, the

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1. The direction in which the kites are oriented was calculated as the circular average of the orientation of each of the antennae, it being understood that the direction is defined from the interior to the exterior. For the kites that do not present two antennae, the direction is that by which one leaves the enclosure. For the clarity of the statistical work and of the Figure 5 a reverse orientation of kites (from exterior to interior) has been used.

12. A calculation of slope direction through GIS based on MNT SRTM enables acquisition of a mean value of the orientation of the local relief in a buffer zone of 400 m in diameter centred on the entrance to each kite.
west/north-east orientation may reflect, simply, the general orientation of the relief of the region.

The chained arrangement of kites is frequently mentioned in the literature (Helms and Betts 1987; Yagodin 1998; Échallier et Braemer 1995; Morandi Bonacossi and Iamoni 2012; Kempe and al-Malabeh 2013). This arrangement exists here, but it is not the rule as 76% of the kites are independent.

ONE TYPE, SEVERAL TYPES?

ATTRIBUTE ANALYSIS.

At the end of the work in the field and on the satellite images, each of the 78 constructions was characterised by 24 descriptors. Some of these, such as the distinctive characteristics of construction, were not retained in the analysis (it was one of the results expected from the analysis); others, such as the orientation of the left and right antennae, were combined in a more synthesized variable (the average angle of the two orientations). Two unclosed constructions that have only a few of the characteristics usually observed in the kites—a cell at the end of a pointed appendage, for example—have been excluded from the table. Thus, we have finally a sample of 76 constructions described by 17 qualitative or quantitative variables.

The question is of course to determine whether some of the characteristics observed are associated within this sample in a statistically significant way, that is, whether it is possible to reveal original combinations that are recurrent. It is clear that reading such a complex table will not enable resolution of the problem, and that an aid, in this case multiple correspondence analysis (MCA), must be used. This requires the variables (qualitative, quantitative discrete or continuous) to be homogenised using descriptor level coding. This also requires determination beforehand as to whether all the variables are active, and if not, which variables are ‘supplementary’. For the problem that concerns us here, the solution is relatively obvious: any variable that describes the construction is active, any variable that describes its position in the landscape (altitude, opening onto a slope break or conformity with the slope) is supplementary.

The analysis was carried out in two stages, successively presented (fig. 7).

![Fig. 7 – a) Multiple correspondence analysis (MCA) of the two antennae kite sub-sample (n=43). Active variables: CE, cell number; CPx, proximate cell number; A, enclosure surface area; PER, enclosure perimeter; LAN, length of the two antennae; AST, antenna asymmetry; OPE, antennae divergence angle; ENT, presence of a funnel-shaped entrance; PIC, number of cells at the end of a pointed appendage; PDB, number of pointed appendages cut off by a low wall; EPE, presence of proximal division of the enclosure. Supplementary variables (grey letters): ALT, altitude; CON, conformity between kite and local relief slope; RP, kite opening on a slope break. Descriptor levels with large contributions to factorial axes are printed in large letters. Descriptor levels, which take high contributions when non-discriminant variables are removed, are encircled by an ellipse.](image1)

![Fig. 7 – b) Multiple correspondence analysis of all constructions (n=76) which have at least one kite characteristic. Added active variable: E, presence of an entrance. Supplementary variables (grey letters): ALT, altitude; RP, kite opening on a slope break.](image2)

The kites with two antennae

This sub-group is the one that poses the fewest problems; all the individual entities are definitely kites, all the descriptors can be used. Examination of the first factorial scatter plot (fig. 7a) reveals three significant conjunctions of descriptor levels: 1) many cells (CE3) at the end of pointed appendages (PIL3) are particularly frequent in proximal position (CPx3); this combi-
nation is not related to the surface of the enclosures; 2) small enclosures (A1 and PER1) with a medium number of cells (CE2) and quite short antennae (LAN1 and 2); and 3) large enclosures (A3, PER2) with long antennae (LAN3) and very few cells (CE1) that are neither in proximal position (CPx1) nor at the end of pointed appendages (P(CT)). It is interesting to observe that it is in this conjunction that the low altitude level (ALT1) of the supplementary altitude variable is placed. These very large simple kites would thus be specific to the lower zones. A return to the primary continuous quantitative data enables clarification of this relation. The circle of correlations of the principal component analysis (PCA) on the ranks (Spearman) shows us that the surface of the enclosures and the length of the antennae are strongly correlated positively to the first axis, while altitude is just as strongly negatively correlated to the same axis (fig. 8). Altitude thus appears to be a determining factor in the morphometry of the kites: “the higher on the slopes of Mount Aragats, the smaller the enclosures and the shorter their antennae”. The morphology of the slopes of the Aragats at higher altitude, at least up to 2000 m asl, does not appear different from the lower ones where the kites are found. No reliable explanation of this fact can be proposed up to now. The opening angle of the two antennae, as could already be seen in the first factorial scatter plot of the MCA, is not correlated to these three variables.

Constructions with antennae and without antennae

We have included and described in the database not only the kites that strictly fit the definition, but also ancient constructions (i.e., whose stone blocks carry lichens that are mostly slightly nitrophilous, see below) without antennae that have one or some features regularly observed in the kites (cell at the end of a pointed appendage, cell in proximal position or funnel entrance, for example). The second analysis thus takes into account all 76 constructions, described by fifteen active and two supplementary variables (fig. 7b).

We find most of the important information present in the preceding diagram: the second axis takes on the meaning of an axis indicative of size on which the small kites and the large kites at lower altitude with long antennae are simply opposed. On this axis, no characteristic that describes the morphology of the constructions is significantly associated with a particular conjunction. But there is something new on the first axis. The constructions without antennae (AN0, LAN1) are naturally opposed to all the others (those having one, two or three antennae) on the positive side of the first axis: the levels ‘very few cells’ (CE1), ‘no proximal cells’ (CPx1) and ‘presence of a low wall barring the entrance’ (E2) participate in the conjunction and define enclosures that are simple and closed. The position of level RP1 (no slope break) of the supplementary variable RP in this conjunction shows that the construction of these enclosures does not obey the same rules as those of the constructions with one or more antennae. Observation of the levels contingency table ‘antennae / no antennae’ and ‘slope break / no slope break’ in Burt’s table removes all doubt in this respect (exact Fisher test, $p = 0.0003$). Finally, we observe that these constructions are excluded from the lowest altitudes.

To sum up, the search for strong associations of the descriptor levels demonstrates the low level of discrimination of the descriptors used; most of the levels do not enter into the rare strong conjunctions. Moreover, these probably have little morpho-typological pertinence: this is the case when a group of small kites is highlighted or when it is observed that the existence of very many cells is associated with many cells in proximal position. It would appear that the kites of the Aragats combine a quantity of morphological characteristics in a random manner and that this family of constructions possesses a certain morphological homogeneity.

However, these analyses clearly reveal two strong tendencies which could not be perceived by reading the table: 1) the...
tendency that the kites with two antennae have towards being smaller and having shorter antennae the higher the altitude; 2) the tendency that the ‘kites’ without antennae have towards being closed, without cells and without an association with a slope break.

Based on the information gathered in the field, no well-argued interpretation can be proposed today for the first tendency. The second takes us back to the definition of kites. It is clear that the constructions concerned cannot be classified in this category even if they share certain characteristics with it; on the other hand we observe that the size of these enclosures without antennae, very large in comparison to classic pastoral enclosures, cannot be considered to be different from that of kites in a strict sense: Log(A), F; p = 0.308; t: p = 0.695; modes: 1.51 ha for AN0, 1.73 ha for AN1 and 2. The several architectural features common to these two groups of constructions place them in the same technical tradition, and probably also chronologically close to each other; however, the installation of these ‘kites’ without antennae in the landscape and their original morphological characteristics clearly differentiate them from true kites. In all likelihood there is no reason to think that they had identical uses.

CASES STUDY. KITES 4, 7, 10 AND 59

The kites being studied are representative of the whole. They combine the different characteristics that have been presented, as well as exhibiting some peculiarities (fig. 9, 10, 11, 12). All share the same type of topographical situation, typi-
The lava flows are usually cut into by canyons, or at least by steep-sided thalwegs. The kites occupy the interfl uve between the thalwegs and are oriented according to the slope; the antennae are oriented uphill and frame spaces of lesser slope situated on the interfl uves, while the enclosures are located on the slope (fig. 11).

All have a funnel entrance, except for kite 10 in which two walls shorten the space between the ends of the antennae. The shape of the enclosures of these four kites reflects the diversity found regionally: to a circular or ovoid base are added one or several pointed constructions that tend to make the shape develop towards that of a star (kite 4 case). While kites 10 and 4 present enclosed surface areas of the most common size (2.1 ha and 1.4 ha respectively), kite 7 is among the smallest (0.8 ha), while kite 59 is large (4.2 ha). The walls of kite 59 are lower (some 50 cm on average) than those of the other kites (the average height is between 70 and 80 cm). These kites contain a large number of cells (K7, which has only three, is an exception). They always associate circular cells and quadrangular cells; those in proximal position are present in all cases, both sides. Also, each of these kites has at least one cell at the end of a pointed appendage. Some are closed-off by...
a wall (kite 7 case) and this is the case for all those of kite 59. The function of these closed-off points remains difficult to understand. It is possible that they constitute partitions of the enclosure; Kite 59, besides its closed-off points, presents another partition of the enclosure in its south-west part. It is also the case for kite 10: in the north-west angle of the enclosure, there is a complex layout that associates four cells and two partitions.

The antennae of these kites present lengths and forms that are representative of the whole group. Kites 10 and 59 are examples in which there are interruptions in the antennae where a rocky protuberance appears. This is the case for the western antenna of kite 10 which presents no connection with the enclosure. This particularity does not exist for the enclosure walls; on the contrary, the walls of the enclosures preserve their continuity and their height, at the price sometimes of including impressively large blocks when they cross a rocky area (kite 59 case). In the case of kite 7, rocky bits are intentionally included in the surface of the enclosure (fig. 16), and in that of kite 4, as in many other cases (fig. 3g), the wall goes closely around an uneven rocky area, whereas it would have been easier to have included it in the layout.

Kites 4 and 59 present secondary antennae. Except for the western antenna of kite 4, it is difficult to understand the function of these constructions, as they are in an external position and the main antenna is uninterrupted. Hypothetically, these antennae may correspond to an initial state of the kite; in the final state, they would have been replaced by the main antennae. Kite 4, with kites 5 and 6 situated immediately to the east, are part of a group arranged in a chain. In the same way, kites 8 and 9 form a chain with kite 7, in a western position.

Fig. 11 – Map of Kite 10.
SEDIMENTARY HISTORY AND CHRONOLOGICAL EVIDENCE

Constructed directly on the basalt rock, kites are not, at first sight, constructions that appear likely to easily produce evidence of their history and use for the archaeologist. The implementation of adapted sampling procedures has, however, shown us that in this case, as for the pastoral enclosures of the Syrian steppe (Castel et al. 2008), there remains information, although fragmentary, in superficial deposits that have long been subject to erosion, alteration and bioturbation.

In the four cases analysed in detail, sub-surface samples (4 to 5 cm beneath the ground surface) were taken in the enclosure, in the cells and outside the enclosures. The enclosure and the nearby exterior areas are surfaces subject to erosion, thus not favourable to the accumulation of dust particles over the long term; sediments accumulate, however, in the hollowed-out areas that are the cells or against the low downhill walls of the enclosures (fig. 3e, 10). This simple observation immediately eliminates any recent use.

Added to these sub-surface samples are those from the stratigraphy of the cells, taken in section when trenches were dug or with a pedologic hand auger.

A DEPOSITIONAL MODEL

At all these points, possible evidence for ancient occupation is associated with evidence of pastoral use of the slopes of the Aragats in late periods. The problem is thus simply to disentangle the two types of evidence. The strong development of bioturbations, mainly due to harvester ants (of the genus *Messor* cf. *structor*) whose nests are very numerous (fig. 10) and large enough to be seen on Google Earth images is an advantage as ancient dust particles are regularly brought to the surface of the ground by these insects, in the same way that later dust particles are buried and protected.

Before entering into a detailed explanation of the evolution of dust spectra that provide us with evidence of past activities (Brochier 2002), based on the study of the four short stratigraphies obtained in cells, enclosures and outer surface areas. Uncertainties on the mean are shown as $t$ (Student)$^*$standard error. One of the four K4 samples from the exterior has been excluded after a preliminary Dixon test.

Represented in Figure 13 for each of the four kites 4, 7, 10 and 59 are the relative proportions of the two types of siliceous algae in the sub-surface horizons of the cells, in those of the enclosures and in those situated outside the enclosures. We observe that the samples from the sub-surface produce mostly statospores of Chrysophytes in the cells and that these become considerably less frequent in the enclosures and sometimes even less so outside them (the case of kite 7). The cells and some enclosures thus retain the trace of the presence of herbivores, domestic or wild, that dispersed algae that are very different from those brought by herds pastured in these places today or in recent historical periods.

LAST CENTURIES DUST EVOLUTION

It is possible to go farther and to roughly reconstruct, in the environs of kite 7, the evolution of algae equilibria over the last centuries (fig. 14). We have, in fact, four groups of samples which can be placed in chronological order. The first group consists of samples from the sub-surface taken from the zones frequented today by herds of sheep and cattle on the exterior of the kite. The signal is naturally composite, but is necessarily dominated, because of the erosion, by the most recent coprogenic dust particles. The following two groups come from nearby pastoral enclosures that are non-functional. The spectra that come from these are evidence for the trophic state of the humid zones used by domestic animals in the recent past.
past. These enclosures are included today in the pasturelands crossed by the herds; the high accumulation of excrement that was produced in the past pushes the present-day algae supply to a secondary place. The last group consists of two samples from the sub-surface of a cell of kite 7.

The analysis of the lichens, which colonise the surface of the basalt blocks that make up the low walls of the two pastoral enclosures, shows that these two walls differ in age. The chronological succession of lichens on the surface of the blocks is as follows:

- bare blocks in the present-day enclosures in use (the necessary alteration of the basalt by bacteria and cyanobacteria is still insufficient for colonisation to be possible, the dust particles and the nitrates are too abundant for the first thalli to take hold);
- blocks covered by orange-coloured lichens in the enclosures recently abandoned (the superficial alteration of the basalt is sufficient, the dust particles and the nitrates in excess have been washed away and the first thalli of nitrophilous lichens implant themselves: the genera *Caloplaca* and *Xanthoria*, orange-coloured, are dominant);
- finally, blocks carrying various lichens that lend from a distance a greyish colour to the enclosures and the kites (these form an association of not very nitrophilous lichens,—*Rhizocarpon*, *Aspicilia*, *Lecanora* and *Acarospora*—and heminitrophilous lichens that are rare and dispersed —*Caloplaca*, *Xanthoria* and *Candelariella*).

The time necessary for the development of adult thalli, after abandonment of the constructions, is about a century for the nitrophilous lichens and probably a millennium for the less nitrophilous lichens. Just from the point of view of the lichen flora, nothing differentiates the ‘old’ pastoral enclosures from the kites.

The signals preserved in the sub-surface samples are thus progressively older when one passes from present herding zones to the enclosures covered in rust-coloured lichens and then to the enclosures with grey lichens. The samples from the cells provide a signal at least as old as those from the enclosures with grey lichens. We consider them to be the oldest, which will be verified later.

Organised according to this chronology, the spectra produced by the four groups of samples from the sub-surface provided evidence for a very clear evolution of the trophic state of the watering places (fig. 14): oligotrophic environments, favourable to the development of Chrysophytes, on the surface of the fill of the cells, then more and more eutrophic environments favourable to the proliferation of Diatoms, as the present period is approached.

To sum up, these initial observations show us that the enclosures, and more clearly the cells, have preserved the trace of ancient herbivore (domestic or wild) excrements. The equilibrium between the two types of siliceous algae shows us clearly that these constructions were in use before the eutrophication in historical times of the humid zones. Their use could not have occurred therefore as recently as that related in the accounts of travellers who crossed the steppes and deserts of the Middle East during the last centuries (Wright 1895; Sinclair and Ferguson 1902; Burckhardt 1835). At this stage of the research, the Classical, protohistoric, and earlier periods are equally probable.

**CELL DUST COMPOSITION AND EVOLUTION**

The cells, often encumbered with collapsed blocks, have provided us the most often, by means of the pedologic hand auger, with undeveloped stratigraphies no deeper than some 15 cm. We will examine here only the deepest, obtained from cells 7 of kite 10 and 11 of kite 59, knowing that the observations made on the short sequences are not different from those obtained in the upper parts of the deeper sequences. These sequences will be complemented by the analysis of samples taken in the sections of the excavations in cells 3 of kite 10 and 1 of kite 59.

The evolution is characterised in the cells by the following succession: carbonated silts with little organic content at
the base, and generally less carbonated silts, sometimes of peaty aspect, at the top (fig. 15-16). The latter, which can contain up to 16% organic matter (measured by loss on ignition on the fraction less than 0.5 mm), produce in the majority of the soil microfauna, active in the humid season. The presence of carbonated horizons, unexpected in this volcanic context, deserves some comment as it conditions the most sensitive biogenic dust particles to disappear (faecal spherulitic carbonates for POCC for example) and is related to the construction of the kites. Some artificial cuts have shown us that the top of the basalt flows, divided into large blocks, was covered with a thick calcareous soil of indeterminate age. The buried part of the blocks is covered with an undulating calcareous crust that is finely laminated, light brown to cream in colour, sometimes interrupted by sandy layers, which can be as much as 2 cm thick. The extraction of the blocks from the top of the lava flows during the construction of the kites had the effect of dispersing on the soil surface innumerable fragments of crust which we find drowned in the silts at the base of the stratigraphies, but also, in great number, at the surface of the enclosure and on the nearest external surfaces. The abrupt change in the physico-chemical properties of the superficial horizons of the soil that resulted explains the good preservation of the most fragile biogenic dust particles. The environment however remains an aggressive one with well before the late periods (fig. 16: 8). In all occurrences in 42 samples analysed), as well as relatively low frequencies of charcoal micro-fragments, which do not show any significant differences with those estimated in the enclosures (Fisher’s test, p = 0.193). The latter are thus more probably related to natural fires or to herding fires rather than to long occupation of these places. Related like the faecal spherulites to high calcareous contents of sediment, coccoliths (not to be confused with faecal spherulites) are regularly observed; they indicate either an aeolian contribution from a distance or dusts transported by the animals. The case of kite 10 was by far the least convincing of the four in regard to (chronological) differences between the algae spectra from the sub-surface of the cells and from the enclosures (fig. 13). The observation of the evolution of the relative proportions of the Diatoms and the Chrysophytes in cells L10.03 and 07 clearly shows that there was frequentation by herbivores well before the late periods (fig. 16: 8). In all cases, the use of the Lycopodium spores to determine the presence of parasites, both helminths and protozoa, produces in 42 species of parasites. The presence only confirms the major place occupied by the dust particles derived from excrement in the spectra. The samples richest in faecal spherulitic calcite or, generally speaking, in dust particles indubitably linked to excrement, were selected for the palaeo-parasitological analysis. The objective was to determine the identity of the animals, wild or domestic, that frequented these places. Nine samples taken from three cells of kites 10 and 7 were analysed following classic protocols of extraction and observation (Harter et Bouchet 2002; Le Bailly et Bouchet 2006). None produced any remains of parasites. The absence of pollen grains in the preparations, whereas the mutual occurrence of pollen and parasite eggs is regularly observed in palaeo-parasitological research, suggests that these negative results could be due to poor preservation of the organic remains.

There was a notable scarcity in all the samples of fragments of silicified epidermis (which could have signified the existence of roots), of burned phytoliths and POCC (only two occurrences in 42 samples analysed), as well as relatively low frequencies of charcoal micro-fragments, which do not show any significant differences with those estimated in the environs (Fisher’s test, p = 0.193). The latter are thus more probably related to natural fires or to herding fires rather than to long occupation of these places. Related like the faecal spherulites to high calcareous contents of sediment, coccoliths (not to be confused with faecal spherulites) are regularly observed; they indicate either an aeolian contribution from a distance or dusts transported by the animals. The case of kite 10 was by far the least convincing of the four in regard to (chronological) differences between the algae spectra from the sub-surface of the cells and from the enclosures (fig. 13). The observation of the evolution of the relative proportions of the Diatoms and the Chrysophytes in cells L10.03 and 07 clearly shows that there was frequentation by herbivores well before the late periods (fig. 16: 8). In all...
Fig. 15 – Cells L59.01 and L59.11, results of semi-quantitative dust particle analysis. Frequency classes used are: 1, present; 2, few; 3, moderately abundant; 4, abundant; 5, dominant. The frequencies are not proportional to the absolute frequencies of the different types of dust particle. 1, calcite; 2, organic matter (measured by loss on ignition at 480°C); 3, faecal calcareous spherulites; 4, siliceous phytoliths; 5, silicified epidermis; 6, burnt phytoliths; 7, Diatom frustule; 8, Chrysophytes statospore; 9, Logarithm of the frustule-statospore ratio; 10, Coccoliths; 11, Rhizopodian.

Fig. 16 – Cells L10.03 and L10.07, results of semi-quantitative dust analysis. Frequency classes used are: 1, present; 2, few; 3, moderately abundant; 4, abundant; 5, dominant. The frequencies are not proportional to the absolute frequencies of the different types of dust particle. 1, calcite; 2, organic matter (measured by loss on ignition at 480°C); 3, faecal calcareous spherulites; 4, siliceous phytoliths; 5, silicified epidermis; 6, burnt phytoliths; 7, Diatom frustule; 8, Chrysophytes statospore; 9, Logarithm of the frustule-statospore ratio; 10, Coccoliths; 11, Rhizopodian.
sufficiently deep stratigraphies we find the same evolution of relative proportions of the two types of siliceous algae (fig. 16: 9). This evolution can be divided, from bottom to top, into four stages: (a) C dominant, (b) C and D in equivalent proportions, (c) C dominant, then again C and D in equivalent proportions (d). The trajectory followed in the fourth stage only confirms the observations made based on late pastoral enclosures. From sub-surface samples taken outside the enclosures and from present-day faeces, we know that the evolution ends with eutrophic facies very largely dominated by Diatoms.

The analysis of dust particles accumulated by wind and by rainwater runoff in the cells thus presents us with a complex and probably long history. The succession observed pushes back the beginning of the fill (probably the period of construction/utilisation of the kites) to a period much earlier than the pastoral enclosures covered with grey lichens. However, the samples from the cells do not permit on their own any advance in the chronological analysis. Two samples, taken from primary archaeological deposits, will help us.

TOWARD A GEOARCHAEOLOGICAL RELATIVE CHRONOLOGY.

The first sample comes from a thick accumulation of very pure manure discovered in the large buildings built along kite 140. These buildings were dated by pottery to the medieval period (1300 – 1600 AD), the manure by radiocarbon analysis on seeds [1430 – 1620 cal. AD], terminus ante quem of the construction of the kite. This manure, very rich in Chrysophytes, is characterised by a Log(D/C) of -5.41. The second one comes from the stratigraphy of a vandalised kurgan constructed in immediate vicinity to kite 10. We do not have precise data on its period of construction, but its morphological characteristics place it in the first phase of the Early Bronze Age. The anthropic dust particles are well preserved (burned and unburned phytoliths, burned and unburned faecal spherulites, various POC, siliceous algae) and enable estimation of the Log(D/C) at -0.30. The medieval minimum of Log(D/C) was thus preceded by a protohistoric phase in which Diatoms and Chrysophytes are much more in equilibrium. These two reference points, combined with that from the samples of present-day faeces (Log(D/C) = 3.17), make it possible to construct a curve of evolution, although still very rudimentary, between the Bronze Age and the present. It is compatible with the curve we constructed based on the fill of the cells: the passage from a Chrysophyte microflora to a Diatom microflora between the medieval period and today, the medieval minimum of Diatom frequencies and the Diatoms/Chrysophytes equilibrium previously. Based on these correlations, whose validity rests in part on the homogeneity of the trophic state of the water ingested by the animals on the scale of one part of the slopes of the Aragats, the lowest points reached in the fill of cells 3 of K10, 1 and 11 of K59 appear close to the Bronze Age.

ARCHAEOLOGICAL AND RADIOCARBON EVIDENCE.

We have been able to observe, during the surveys, numerous habitation sites built on the slopes that link the volcanic mountain mass to the plain. They appear to be large circular cells that coalesce, in successive tiers on gentle slopes. Worked obsidian and pottery sherds are abundant. In Figure 17 it appears that the wall of kite 94 cuts through the cells—this has been checked on the ground—and that these cells are partly erased on the interior of the kite enclosure. This superimposition allows to define a clear terminus post quem. This does however still lack precision in the absence of excavation of these sites. A period that extends between the Chalcolithic and the Bronze Age is probable.

The excavations in cells L1.03 and L59.01, down to a depth that appears to be virgin soil, have not yielded archaeological material that allows precise dating of the constructions. A fragment of an iron needle found in the first decimetres of the fill of L1.03 shows that the beginning of the fill is earlier than the 1st millennium BCE or than the medieval period. This estimation, very broad, is not in disagreement with the result of a measurement of residual radiocarbon [340 – 5 cal. BC] carried out on some small fragments of bird eggshell from the first decimetres of the fill (table 1).

In the fill of cell L59.01, dug in the substratum (fig. 18), a median horizon situated between 45 and 60 cm below the ground surface produced a few bone splinters and half a man- dible, poorly preserved, that could be identified as the genus Capra without any more precision. This horizon also produced...
Kites on the margins. The Aragats kites in Armenia

This technique appeared in the region timidly in the Early Bronze Age (Gazanots site, Kuro-Araxes culture: Badalyan and Avestyan 2007), and became more and more commonly used (Late Bronze and Early Iron). A terminus post quem for the construction of the kites of the Aragats thus appears to be situated at the beginning of the 3rd millennium.

The technical features of the walls, the search in the field for stratigraphic links between the kites and other constructions, radiocarbon analysis, analysis of the associated archaeological material and analysis of the dust particles show that the kites of the Aragats that we have been able to study in detail were constructed between the Bronze Age (at the earliest, early Bronze) and the change of era (fig. 20). However, there is nothing that enables us to extend these initial results to all the kites of the Mount Aragats area. Future excavation in the sediment traps that are the cells should improve the precision of this assessment; they should also enable us to determine whether the kite phenomenon concerns the entire protohistory of Armenia or covers only a short period.

Table 1. Radiocarbon measurements. These absolute chronological dates are, in any cases, terminus ante quem. (*): this measurement was obtained on only 0.8 mg of carbon. IntCal 09 calibration curve was used.

<table>
<thead>
<tr>
<th>Lab. Number</th>
<th>material</th>
<th>CR%</th>
<th>N%</th>
<th>C/N</th>
<th>2 sigmas calibrated range</th>
</tr>
</thead>
<tbody>
<tr>
<td>L10.03</td>
<td>eggshell</td>
<td>2100 ± 35 BP</td>
<td>–</td>
<td>–</td>
<td>1400 - 5 cal. BC</td>
</tr>
<tr>
<td>L29.01</td>
<td>bone</td>
<td>895 ± 30 BP</td>
<td>8.4</td>
<td>2.0</td>
<td>1590 - 1210 cal. AD</td>
</tr>
<tr>
<td>Poz 51370</td>
<td>eggshell</td>
<td>995 ± 30 BP</td>
<td>–</td>
<td>–</td>
<td>990 - 1150 cal. AD</td>
</tr>
<tr>
<td>Poz 52957</td>
<td>seeds</td>
<td>415 ± 30 BP</td>
<td>–</td>
<td>–</td>
<td>1430 - 1620 cal. AD</td>
</tr>
</tbody>
</table>

Fig. 17 – Superimposition of kite 94 on large coalescent circular cells. Left, aerial orthophotography; right, slope map derived from DEM.

a few fragments of bird eggshell. The two dates obtained, on bone collagen and eggshell, place this horizon between the 11th and 12th centuries (table 1). These two chronological references, from a horizon that we know to be anterior to the medieval minimum (14th–16th c.) of the Diatoms (fig. 19), are again only terminus ante quem.

We mentioned above the widespread use of the double facing technique, with or without a rubble infill, in the construction of walls (fig. 3d). This technique appeared in the region timidly in the Early Bronze Age (Gazanots site, Kuro-Araxes culture: Badalyan and Avestyan 2007), and became more and more commonly used (Late Bronze and Early Iron). A terminus post quem for the construction of the kites of the Aragats thus appears to be situated at the beginning of the 3rd millennium.

The technical features of the walls, the search in the field for stratigraphic links between the kites and other constructions, radiocarbon analysis, analysis of the associated archaeological material and analysis of the dust particles show that the kites of the Aragats that we have been able to study in detail were constructed between the Bronze Age (at the earliest, early Bronze) and the change of era (fig. 20). However, there is nothing that enables us to extend these initial results to all the kites of the Mount Aragats area. Future excavation in the sediment traps that are the cells should improve the precision of this assessment; they should also enable us to determine whether the kite phenomenon concerns the entire protohistory of Armenia or covers only a short period.

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The geoarchaeological analysis has shown that the infilling of the cells, occurring at variable speeds, was mainly due to water runoff, and more randomly, to the collapse of the walls. A component of aeolian origin is also highly probable. The infilling of the cells, from the beginning, thus appears to have taken place in a relatively open landscape.

During the excavation of cells L59.01 and L10.03, two samples were water-sieved using a 0.5 mm mesh, and produced an abundant malacofauna. The first one (L59) comes from the horizon that produced many bone splinters (fig. 18) between 40 and 55 cm beneath the ground surface; the second one comes from the base of the stratigraphy revealed in L10. These faunas naturally do not enable description of the environment at the time the kites were used, but the sedimentary homogeneity of the fills appears to demonstrate some permanence in the nature of the landscape.
Table 2. Land snail assemblages from cells L10.01 and L59.01.

<table>
<thead>
<tr>
<th>Cell</th>
<th>Species</th>
<th>Ind.</th>
</tr>
</thead>
<tbody>
<tr>
<td>L10.03</td>
<td><em>Gibbulinopsis interrupta</em> (Reinhardt in Martens, 1876)</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td><em>Improvisa pupoides</em> (Krynicki, 1833)</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td><em>Kalitinaia crenimargo</em> (L. Pfeiffer, 1848) var. <em>obtusior</em> (Mousson, 1876)</td>
<td>12</td>
</tr>
<tr>
<td>L59.01</td>
<td><em>Gibbulinopsis interrupta</em> (Reinhardt in Martens, 1876)</td>
<td>172</td>
</tr>
<tr>
<td></td>
<td><em>Pseudochondrula seductilis</em> (Rossmässler, 1837)</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td><em>Kalitinaia crenimargo</em> (L. Pfeiffer, 1848) var. <em>obtusior</em> (Mousson, 1876)</td>
<td>12</td>
</tr>
</tbody>
</table>

The malacofauna is well preserved, with no trace of alteration; the shells are slightly encrusted with carbonates. They consist of four small terrestrial species (table 2). The volume of the samples taken is modest, but this does not explain the poverty of species observed (three species per site): it only exaggerates it. The small number of species represented by many individuals is probably due to unfavourable climatic and edaphic conditions and to the lack of ecological niches available in an environment that was probably very homogeneous. The biogeographical heritage related to the climatic and anthropic history of the environment could also account for the pool of species present.

The assemblages indicate open environments, steppic or semi-desert, with poor vegetation cover of the ground or substratum. In his 1949 study of the region of Gnishik (altitude about 2000 m), N.N. Akramovskii indicated as a habitat for *Gibbulinopsis interrupta* the dry pastures of the steppic and semi-desert zones (Likhachev and Rammel’meyer 1962). According to the same author, *Kalitinaia crenimargo* lives preferentially in the Artemisia steppes and in phryganas. These two species are abundantly present in the cells of kites 10 and 59.

22. A detailed description of the preferential environmental characteristics particular to each taxon is added at the end of this article.
DISCUSSION

The initial results obtained from the study of the kites of the Aragats are essentially descriptive. We wished to present our observations, both qualitative and quantitative, in a detailed manner in order to render future comparisons more comprehensive. We hope also to have demonstrated the importance of a thorough analysis of the architectural and morphological data. However, it must be understood that the necessary data for comparisons are absent from the literature, aside from a few exceptions, in spite of intense research activity related to the ease of virtual explorations made possible by Google Earth. The situation is hardly better concerning the chronology, the problem coming from both the technical difficulties related to studying this type of construction and the very limited number of operations on the ground. However, certain questions can be clarified, although not completely resolved.

GEOGRAPHY

The kites of Armenia are contained in a relatively small region within which their density is high, comparable to that observed in Syria in the Hauran or in the region of Palmyra. This high density falls abruptly as soon as one leaves the studied region; no kite on the scale of Armenia or North-Eastern Turkey has been found outside this region, either on satellite images or on the ground. Those recently found in Turkey (Kennedy 2012), near the Syrian border, are not so numerous and don’t fill this gap. We know that all kites are not detectable on satellite images, either because of insufficient spatial resolution or because of poor preservation. Armenia and Eastern Turkey are, however, almost completely covered by high-resolution images. Moreover, because the Aragats kites present a very clear signature on the images, it is unlikely that the absence of kites observed in the lands around them is due to observational bias. The kites of the Aragats thus appear to constitute an isolated phenomenon. The number of kites recently discovered, especially thanks to the use of Google Earth (Kennedy 2012), has increased steadily, so that today there is a spatialised inventory consisting of more than 4270 kites. We do not know whether the discontinuities that appear in it reflect reality or whether they are due to observational bias. According to this inventory, the distance between the Aragats kites and their nearest neighbours reaches 500 km in the direction of Syria, and about 850 km to the south-western part of the plateau of Ustyurt. Even though the distances are sizeable, the Armenian kites tend to fill the gap between the Near East and the Aralo-Caspian zone (Kazakhstan and Uzbekistan), which can be considered as two independent regions.

MORPHOLOGY AND MORPHOMETRY

We have not discussed in this presentation on the shapes of the Aragats kites as they appear to be ordinary and simple. The large majority of the enclosures are more or less ovoid. They sometimes take on star shapes with the addition of cells at the end of pointed appendages with rectilinear-convex delineations; the remaining shapes are irregular shapes and some very rare triangular shapes. These kites are quite different from the stereotyped shapes of the Arabian desert (Kennedy 2011), from those of the north of the plateau of Ustyurt (Yagodin 1998; Bull and Eșipov 2013), and from the diversity seen in the Syro-Jordanian group (Helms and Betts 1987; Échalier et Braemer 1995). The computation of the isoperimetric circularity of the Aragats kite enclosures (fig. 21) demonstrates their homogeneity; since nine times out of ten, the shapes are ovoid. Metric data are unfortunately too rare in the literature to carry out comparisons on a large scale. Only the work of Kempe and al-Malabeh (2010) on the kites of the Jordan Harrat has enabled a first test (fig. 21): we observe that the enclosures of this small sample have a highly significant smaller circularity than the Aragats kites, a characteristic that appears to be related to very numerous cells at the end of concave edge pointed appendices.

In the very numerous studies devoted to kites, we find very few mentions of measurements taken in the field or based on satellite images. The work of Kempe and al-Malabeh (2010) on the star-shaped kites of Jordan in the basaltic region of the Harrat is an exception. Thus from a strictly dimensional perspective, we would expect that the star-shaped kites of the Harrat are exceptions as well.

Improvisa pupoides, abundant in cell L1.00.3, is completely replaced by Pseudochondrula seductilis in cell L5.91.01. Like the species above, these are xerophilic species of open environments—steppes and phryganas. This permutation can result from slight differences in the structure of the habitat (more or less stony, more or less favourable for cushion-shaped plants) or in the edaphic conditions (more or less carbonated milieu). Other factors that are not strictly environmental, such as the history of regional land snail communities, could also be considered.

point of view comparisons can only be limited. We will concentrate only on the two most easily accessible dimensional features: the length of the antennae and the surface area of the enclosures.

We have 88 measurements of antennae in the Jordanian sample, 33 in a sample from Central Syria, 45 in a sample from the Syrian Jezirah (Quenet et Chambrade 2014) and 103 measurements in the Armenian sample. The best parameters of position and dispersion, for these measurements distributed in a very asymmetrical way, are the median and the interquartile range (IQR). The analysis of the lengths of the antennae based on these four samples (table 3) shows that on one hand the Syrian kites analyzed and those of the Aragats have antennae of similar size,25 and that on the other hand the kites of Jordan Harrat have antennae significantly longer than those of all the other samples.


25. Length of the antennae of the samples studied: Md [IQR], Syria Al Rawda 460 m [350 m], Syria Jezirah 241 m [350 m], Aragats 349 m [374 m], Jordan Harrat 1680 m [1978 m].

26. Surface areas of the enclosures of the samples studied: Syria Al Rawda 1.48 ha [1.18 ha], Syria Jezirah 3.39 ha [3.31 ha], Aragats, 2.06 ha [1.38 ha], Jordan Harrat, 1.86 ha [1.21 ha].

Table 3. Comparison of enclosure surface areas and antennae lengths among the four samples of kites available. Non parametric ANOVA (Kruskal-Wallis, Bonferroni probabilities corrected). Bold probabilities points to significant medians differences.

<table>
<thead>
<tr>
<th>AREA</th>
<th>Syria (Barge &amp; Castel sous presse)</th>
<th>Syria (Quenet &amp; Chambrade 2013)</th>
<th>Jordan (Kempe 2010)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Armenia</td>
<td>0.296</td>
<td>0.126</td>
<td>1.000</td>
</tr>
<tr>
<td>Syria (Barge &amp; Castel sous presse)</td>
<td>0.020</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Syria (Quenet &amp; Chambrade 2013)</td>
<td>0.019</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Armenia</td>
<td>0.373</td>
<td>1.000</td>
<td>5.82E-19</td>
</tr>
<tr>
<td>Syria (Barge &amp; Castel sous presse)</td>
<td>0.046</td>
<td>1.44E-08</td>
<td>1.44E-08</td>
</tr>
<tr>
<td>Syria (Quenet &amp; Chambrade 2013)</td>
<td>2.19E-13</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It is probably not necessary to search farther for an explanation of this observation; the better visibility of traces in a desert environment and the fact that they are not destroyed by farming activity are possible causes. However, it should be stressed that unlike other Near Eastern constructions, those of Jordan for example, clusters of antennae, evidence of remaking and probably of use over the long term does not exist here.

The surface area of the enclosures is not subject to these factors. Still based on these four samples, no significant differences (table 3) between the surfaces of the enclosures of the Aragats and the others can be demonstrated.26 These two metric characteristics, often estimated on samples of small size, do not enable differentiation of the Aragats kites from the rare Syro-Jordanian kites for which we have the necessary information. The orders of size observed here are comparable to those of the North American “game drive enclosures” (e.g., Raymond 1982; Lubinski 1999), which can, however, have surface areas measuring dozens of hectares.

The multivariate analysis of the characteristics found on the satellite images has enabled us to reveal a strong association which would probably have remained little known otherwise, the strong inverse correlation between the altitude and the surface of the enclosures or the length of the antennae. However, its significance remains obscure without other examples in other contexts.
FUNCTION

Analysis of the descriptors, whether univariate or multivariate, permits to define some points related to the morphology of the constructions as well as their use. The building of antennae oriented upwards on a slight slope, with an enclosure below separated by an edge or threshold, appears to be a strong characteristic of the Aragats kites. This conformation is more logical for use as a ‘demi-piège’ than for pastoral use. The immense size of the enclosure also points in this direction.

Such conformation is not unique; the kites of the region of Al-Rawda in Syria (Barge et al. in press) present the same, but inverse cases are also known, as in the Syrian Jezirah (Quenet et Chambrade 2014).

The presence of an edge or threshold, whether natural or artificial, at the junction of the antennae and the enclosure (or pit) is very common, as much in Syria (Morandi Bonacossi and Iamoni 2012) as in Jordan (Helms and Betts 1987) as in the kites of type P_2 in the Negev (Nadel et al. 2010).

The analysis of the orientation of the entrances is more ambiguous. These are conditioned by the orientations of the local slopes and probably, on a smaller scale, by those of the volcano. The Aragats kites could thus have been constructed to intercept herds coming downhill. The fact remains that the directions towards which the kites open are clearly concentrated between the west and the north-east, which does not exclude that they also correspond to the orientation of the herds’ migrations. The absence of clear data in the literature on the orientations of the entrances, and on those of the slopes, both local and regional, makes any comparative analysis impracticable.

The use of the cells (‘logettes’) deeply dug into the substratum, often in a proximal position or at the end of an appendage, is still not understood. Their high corbelled walls possess no entrances from the enclosure. The gaps in the walls described in travellers’ accounts, through which the animals would have rushed, have never been observed here. Always present in the layout of the kite, these cells, which up to now are free of any archaeological material, are the most elaborate part of the constructions, indicating that their role must have been essential.

The layout of the enclosure remains just as obscure. Partitions are frequent, especially if the pointed appendices cut off by a wall (‘cut-off points’) are considered to be a particular form of partition. Observation of these constructions from within the enclosures shows that they were not entities constructed later on by shepherds. It appears that no effort was made to exclude from the enclosure the rocky protuberances scattered over the surface of the lava flows. Although the antennae sometimes include these protuberances, to the point of making the antenna wall sometimes unnecessary, the enclosure walls are often built around them at the cost of complex construction. Perhaps the purpose was to preserve a certain topographic complexity, to mask the walls and make the interior and exterior of the enclosure identical in appearance.

This group of elements does not allow a simple response to the question asked in the introduction concerning the identity of kites of types PE_a and PE_m, a situation very similar to that confronted by Betts and Yagodin (2000) in the study of kites of the Aralo-Caspian zone, for which there are also historical accounts. Although several indications point towards their use for hunting, there are still many gray areas in understanding the function of the Armenian kites.

Our investigations give no information about the game which was possibly hunted. Scarce data from archaeological sites in Aragats region only show that the gregarious Gazella subgutturosa, although uncommon, was present in this area from the Neolithic through the late Iron Age (B1 escu et al. 2010; Smith et al. 2004; Obermaier 2006).

Without a methodical analysis of the affinities between the constructions in different geographic zones, as well as of the simplicity of these constructions, known to have been used in various places (i.e., Galton 1853 for Africa; Barth 1983 for Scandinavia; Arkush 1986 for North America) it is certainly premature to discuss the possible diffusion of this hunting technique. We will simply state that the concomitant and deliberate presence of converging antennae, of an enclosed space and of cells is encountered from the Eastern Hejaz to the vast plateau of Ustyurt, in the arid margins of Syria and in Armenia, whereas these characteristics are absent from kites in other geographic zones. Without a reliable chronological framework, this observation remains no more than a statement.

CHRONOLOGY

Kites are constructions that are difficult to date, whatever the context. Those of the Aragats are no exception. However, the situation here is relatively favourable: the traces of previous and later occupations are frequent and provide us with relative ages, anthropisation indexes justify correlation of the different sedimentary sequences in the cells dug into the substratum, at last, these sequences have preserved biological remains which can be radiocarbon dated.

Our estimate for the period of construction of the Aragats kites (3000 – 5 cal. BC, from the Early Bronze to the change of era), rests only on a few superimpositions and some radios-
carbon determinations obtained from the fill of two cells. It is very wide and naturally does not allow differentiation between a long and a short chronology. The exceptional occurrence of remodelling of the constructions, as well as the morphological homogeneity, argues for a relatively brief period of use. New radiocarbon determinations, in progress on other constructions, should enable improvement of this initial estimate.

Of the thousands of kites known in the Near East, very few have been excavated and even fewer subjected to chronological analysis. The most numerous and the most reliable data come from Pₚ kites in the Sinai and the Negev (the analyses concern 5 of the 17 known kites); the constructions were used between the end of the 4th and the 3rd millennia (Eddy and Wendorf 1998; Kobusiewicz 1999; Holzer et al. 2010; Nadel et al. 2010), but these dates provide information only on the chronology of kites that are very particular morphologically and outside the Syro-Jordanian sector, where they are both more numerous and more varied. Elsewhere, the chronological indications are rare and not very clear; they do not allow in any case estimation of whether the kites were used over millennia from the very beginning of the Neolithic (and even before) or only during one, or more, short periods. It however appears that the end of the 4th and the 3rd millennia were the main periods of use (Échallier et Braemer 1995). The great morphological diversity observed in both Jordan and Syria (Helms and Betts 1987; Échallier et Braemer 1995), the frequency of modification of plans and of course the accounts of usage in the modern period argue for utilisation over a long duration, unlike the Armenian kites.

In Armenia, the presence of archaeological objects (generally obsidian flakes) has sometimes been observed in the enclosures, nearby, or quite far away. Their dates vary, between the Middle Palaeolithic and the protohistoric periods; the absence of any stratigraphic link with the constructions excludes their use for any chronological or functional analysis. This is also true for the many petroglyphs found on the slopes of the Aragats (Ferruglio et al. 2009), whose age could be anywhere between the very Early Neolithic and the Iron Age. Not associated with the kites, they are only evidence for human presence on the Aragats (Badalyan and Avetisyan 2007). In the present state of research, these archaeological elements add nothing to the dating or to the function of the kites.

The discovery of many kites on the slopes of the Aragats has enabled us to construct a complex protocol of acquisition and exploitation of the data which has proved to be efficient. Although it has provided a detailed evaluation, in a probably very favourable context, it does not solve a number of problems. For some, such as that of the chronology, a short-term solution will be found; others, such as a detailed understanding of how these ‘demi-pièges’ functioned or which gregarious animals were hunted, will remain much more difficult to resolve. From a methodological point of view, the tools developed, whether in the phase of acquisition of the data in the field or in their treatment, appear to be transposable to other places; they should enable more reliable comparisons between different geographic zones and a better understanding of the phenomenon. This is now in progress, as part of a broader program, ‘Globalkites’.

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MALACOLOGICAL SUPPLEMENTS

Gibbulinopsis interrupta (Reinhardt in Martens 1876)
This species of alpine and subalpine meadows is found in Turkey (Schütz 2010), in the central part of the Northern Caucasus.
to here) do not enable distinction between Improvisa pupoides (Krynicki 1833), Euchondrus lamelliferus (Rossmässler 1837) and Semidenta nachicevanjensis (Hudec 1972). For Sysoev and Schileyko (2009), P. seductilis has been found in the Dobroudja where it lives on sunny hills, in the phryganas, xerophilous open forests, undergrowth of subalpine zones, mountain steppes and semi-deserts;

heaps of dried plant remains, under plants and under stones (Akramowski 1976).

The distribution area of this species includes Croatia, Bulgaria, Romania, European Turkey, Asia Minor, the territories of the western part of Armenia next to Turkey, and certain localities in Georgia (Batumi) (Akramowski 1976; Schileyko 1984; Grossu 1987). P. seductilis inhabits open spaces and is generally found in scree, under stones (Schileyko 1984). In Turkey, this snail is most often associated with limestone regions although it is not strictly rupicolous. It lives on stony ground covered by grass or shrubs. It lives under stones, in leaf litter, at the foot of rocks and is totally absent from forests (Schütt 1996 and 2010). In Romania, P. seductilis has been found in the Dobroudja where it lives on sunny hills, in the steppes, in litter, among xerophilous plants and in very dry environments (Grossu 1987).

In Armenia, this species is present in the valley of the Akhurian river from Maralik to the stream of Naryshdere in the east, between 1400 and 1860 m in the mountainous steppe zone, under stones and in alluvial terrain. A separate population has been found near the village of Gerger in the region of Azizbekov (Akramowski 1976).

Improvisa pupoides (Krynicki 1833)

The conchylological features (the only ones we have access to here) do not enable distinction between Improvisa pupoides (Krynicki 1833), Euchondrus lamelliferus (Rossmässler 1859) and Semidenta nachicevanjensis (Hudec 1972) (Hudec 1972; Sysoev and Schileyko 2009). For Sysoev and Schileyko (2009), E. lamelliferus could be present in Adjarie.

S. nachicevanjensis is restricted to its type-locality situated in the high Karabakh (near Stepanakert). Thus I. pupoides is the only one of these three Multidentulinae that lives in the region that concerns us here. Its distribution corresponds to Asia Minor, the Northern Caucasus, the eastern part of the Southern Caucasus (Batumi in Georgia, Armenia) and Northern Iran (Akramowski 1976; Sysoev and Schileyko 2009). It is also found in Syria (Likhachev and Rammel'meier 1962). I. pupoides inhabits the slopes or plateaus of open country; it is found in scree, in rock fissures and under stones, sometimes in rare shrubs, in the soil and under litter covered by thorny bushes (Schileyko 1984).

In Armenia, it is a species characteristic of the mountain steppe and phrygana zone, but these snails are also present in the dry steppe zone; they live in loose soil and in plant debris and under thorny bushes having a cushion aspect (Akramowski 1976).

Kaltitinaia crenimargo (L. Pfeiffer 1848)

This snail is found between the Black Sea and the Caspian, in Turkey (Schütt 2010), in the central (from Pyatigorsk) and eastern part of the Northern Caucasus, in Dagastan, in the eastern part of the Southern Caucasus (Georgia, Armenia, Azerbaijan) (Akramowski 1976). It lives in open steppe zones, often forming large colonies (Schileyko 1978). In Turkey, the carinated shape is characteristic for the snails living in the mountains, whereas the snails of non-carinated shape found here (var. obtusior Mousson 1876) are more frequent in plains along the banks of watercourses (Schütt 2010).

Akramowski (Akramowski 1949 and 1976) provides much information on K. crenimargo in Armenia. This species inhabits the northern regions of the country, the Lake Sevan basin and the Zangezur. It is found in semi-desert zones, in phryganas (on shallow soils where tall plants cannot develop) and in the mountain steppes, but also in dry places of the forest zone. This species is present in Northern Armenia at altitudes of up to 1300 m and in the Sevan basin up to 1950 m.

The snails having the obtusior shape are found in the Ararat plain and on the Arabats massif, in semi-desert zones, mountain steppes and phryganas. They are present up to an altitude of 1700 m; the typical habitat conditions are the semi-deserts of Armenia (up to 32 individuals per square meter have been found) and the phryganas. By following some elements of phrygana, they can penetrate into dry parts of gardens and even into forest clearings.

In winter, K. crenimargo lives in the soil, near the roots of bushes and scrub plants and under piles of stones or under big rocks. In spring and autumn during phases of activity it remains on the ground, but during periods of rest it lives under bushes and scrub plants, under stones and occasionally on the vegetation. In summer it occupies the same places, although not on the vegetation (Akramowski 1976). During the dry period of summer and during the winter Kaltitinaia crenimargo penetrates into the soil to a depth of several centimetres (Schileyko 1978).
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