Supplementary Information I: Experts panel results

Development and calibration of a spatial model for the analysis of Paleolithic archaeological potential in the Duero basin of the Iberian Peninsula

Amanda Merino-Pelaz[1,2], María de Andrés-Herrero[3], Andrés Díez-Herrero[4], David Álvarez-Alonso[3], Luis Miguel Tanarro[5]

1 Institut Català de Paleoecologia Humana i Evolució Social (IPHES-CERCA), Zona Educacional 4, Campus Sescelades URV (Edifici W3), 43007 Tarragona, Spain.

2 Universitat Rovira i Virgili, Departament d'Història i Història de l'Art, Avinguda de Catalunya 35, 43002 Tarragona, Spain

3 Department of Prehistory, Ancient History & Archaeology, Complutense University of Madrid, C/ Profesor Aranguren s/n, Ciudad Universitaria, E-28040 Madrid, Spain

4 Department of Geological Risk and Climate Change, Geological and Mining Institute of Spain (IGME, CSIC), C/Ríos Rosas 23, E-28003 Madrid, Spain

5 Department of Regional Geographic Analysis and Physical Geography, Complutense University of Madrid, C/ Profesor Aranguren s/n, Ciudad Universitaria, E-28040 Madrid, Spain

Corresponding author: Amanda Merino-Pelaz (amerino@iphes.cat)

FIRST ROUND OF THE EXPERT PANEL SURVEY

The survey was distributed among more than 60 experts, with a one-month deadline for responses. The survey consisted of closed-ended questions to be rated on a scale from 1 to 5, indicating whether a variable is of lesser or greater importance for the presence or discovery of Paleolithic archaeological sites. A total of 34 experts responded, with different backgrounds (archaeologists = 28, geologists =4, geographers = 1).

Group 1 variables

For the variables in Group 1, experts were asked to rate how important each one is in influencing human presence in a territory. The questions were divided into six distinct categories: relief, lithology and mineral resources, lithological geodiversity, active geomorphological dynamics, shelters and overhangs, and water resources.

Block 1.1: Relief

Table 1: total scores of relief variables, scored from 1-5.

Variables	1	2	3	4	5
1.Slope and slope variation	2	3	5	16	8
2. Hillside orientation (insolation)	7	9	11	4	3
3. Mountain passes (passes, cols, valleys)	0	0	4	11	19
4. Fluvial corridors	0	1	2	15	16
5. Fords in rivers and streams	0	0	6	9	19
6. Regional corridors or routes	1	0	9	9	15
7. Insolation rate	8	9	12	4	1
8. Viewshed	4	8	13	4	5

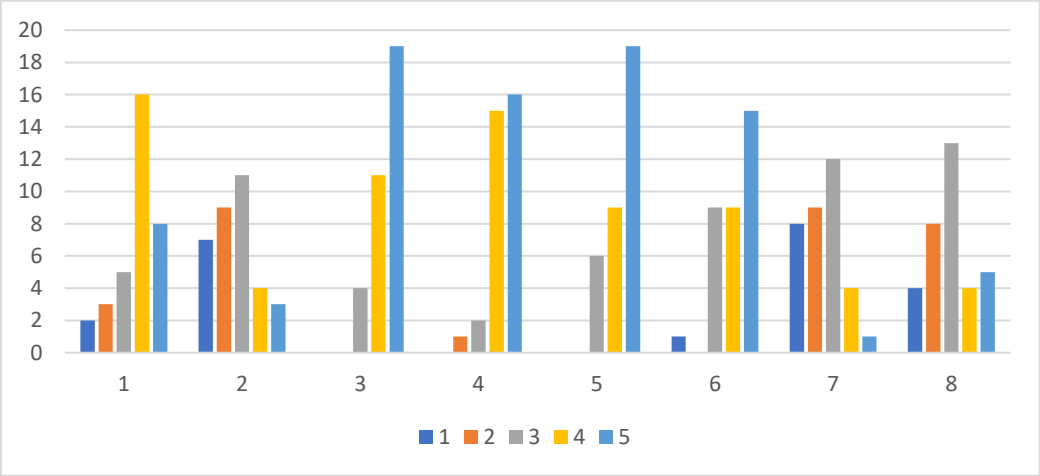

Fig. 1: total scores of relief variables, scored from 1-5.

In the first block of questions, there is strong consensus among experts in assigning high importance (scores between 4 and 5) to variables related to potential barriers and passageways in the landscape that facilitate or hinder human movement (mountain passes, fluvial corridors, and fords in rivers and streams, 3–5). Opinions vary more regarding slope: although most respondents considered it fairly important (n=24), 10 out of 34 experts rated its importance as medium to low. Hillside orientation and insolation rate—two related variables—received similar scores and were the lowest rated among all variables assessed by the panel. Finally, the visual

basin extent was generally considered of medium importance, though responses were divided: 12 experts rated it between 1 and 2, while 9 rated it between 4 and 5.

Block 1.2: Lithology and Mineral Resources

This block assesses the importance of the presence of raw material sources for lithic production. In general, experts assigned higher importance to the presence of silica-bearing formations. In contrast, other lithologies received more varied opinions: most experts rated them as moderately important, nine considered them of low importance, and seven of high importance.

Table 2: total scores of lithology and mineral resources variables, scored from 1-5.

Variables	**1**	**2**	**3**	**4**	**5**
Formations with potential to contain silica varieties (quartz, flint, jasper, chalcedony)	0	3	6	8	17
Other lithological elements of interest for tool use (igneous and metamorphic rocks such as hammerstones, etc.)	2	7	18	6	1

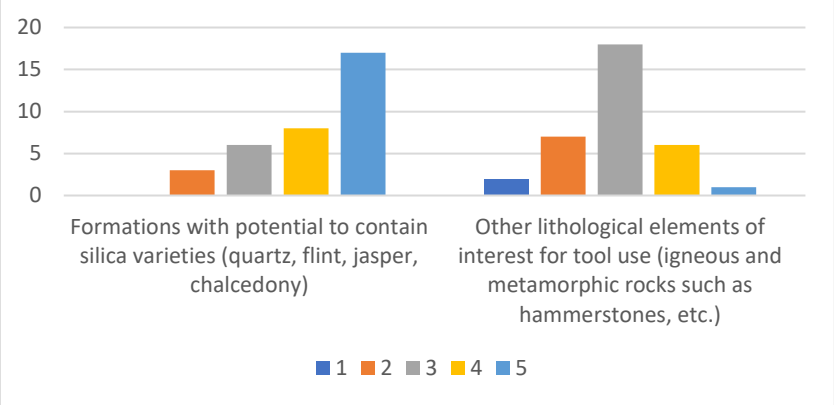

Fig. 2: total scores of lithology and mineral resources variables, scored from 1-5.

Block 1.3: Lithological Geodiversity

This block refers to sources of biodiversity and food resources (flora and fauna) and how these may have favored the settlement of human groups. Experts generally consider the presence of lithological nuclei and geodiversity corridors to be of medium to high importance. Opinions vary more for the second variable, where most still assign it medium importance, but there is greater diversity of views regarding whether it may be of high or low importance.

Table 3: total scores of lithological geodiversity variables, scored from 1-5.

Variables	**1**	**2**	**3**	**4**	**5**
Geodiversity corridors	1	2	14	11	6
Main areas with lithological and ecological monotony	2	6	16	7	3

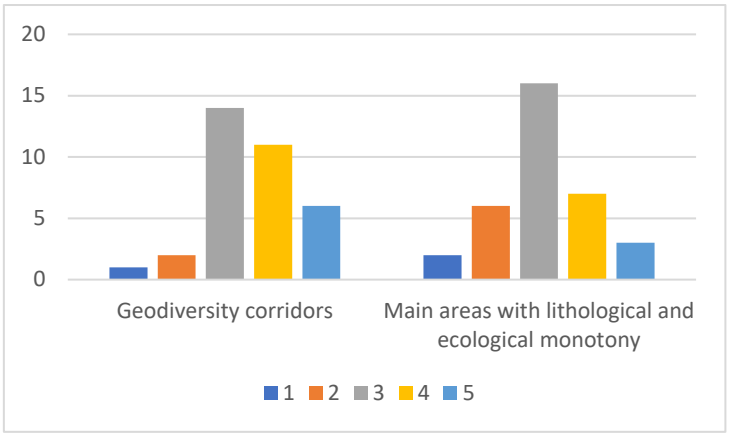

Fig. 3: total scores of lithological geodiversity variables, scored from 1-5.

Block 1.4: Active Geomorphological Dynamics

This block evaluated possible limiting variables affecting the stability or temporality of sites. Most experts considered these variables important, although there is somewhat more disagreement regarding wind action.

Table 4: total scores of active geomorphological dynamics variables, scored from 1-5.

Variables	**1**	**2**	**3**	**4**	**5**
Paleofloods (settlements on riverbanks)	2	4	4	13	11
Periglacial and glacial processes (settlements in mountain areas)	4	4	7	12	7
Pleistocene wind action (settlements on plains)	5	4	12	10	3

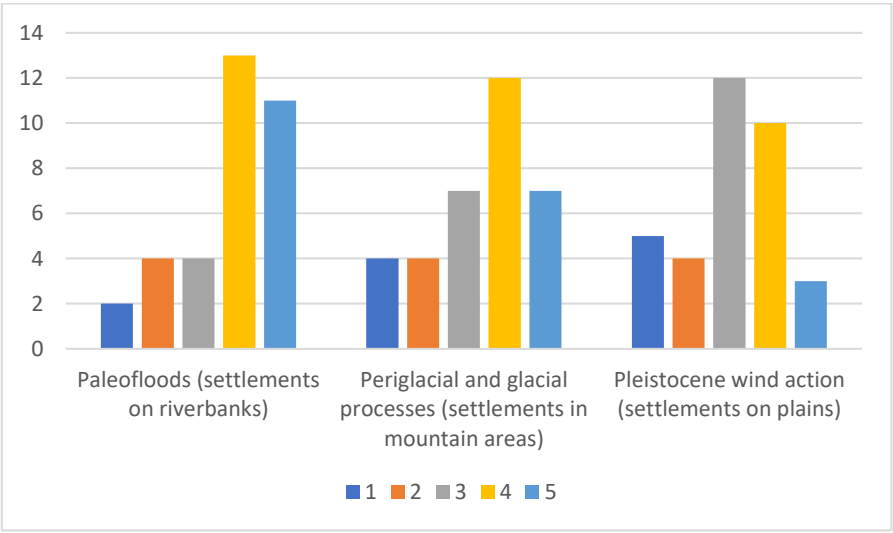

Fig. 4: total scores of active geomorphological dynamics variables, scored from 1-5.

Block 1.5: Shelters

There is greater consensus among experts on the variable identifying karst formations. There also seems to be agreement on assigning medium-high importance to formations on slopes and escarpments, with only five researchers rating it as low. However, opinions are more divided

regarding the lithologies that could form cavities and shelters, with some considering them unimportant while others assign medium or higher importance.

Table 5: total scores of shelter variables, scored from 1-5.

Variables	1	2	3	4	5
Karstifiable carbonate and evaporite lithologies	0	3	4	7	20
Granite rocks with formation of boulder fields containing cavities and overhangs between the blocks	3	9	12	7	3
Conglomerate formations (forming cavities, shelters, and overhangs at the base of towers)	1	12	6	13	2
Slopes and escarpments of valleys and canyons with rock shelters, overhangs, and ledges	0	5	12	13	4

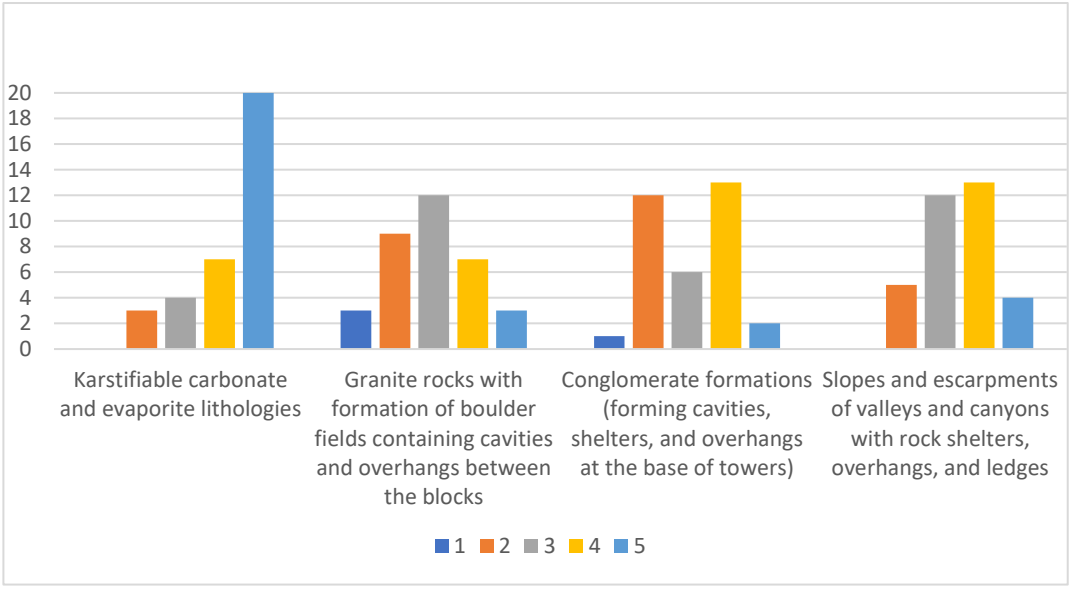

Fig. 5: total scores of shelter variables, scored from 1-5.

Block 1.6: Water Resources

There is some consensus that these variables have medium to high importance, with a few exceptions (four experts scored them as 2). However, opinions are more divided regarding groundwater, with thirteen scoring it a 3 and the rest split evenly between medium-high and medium-low.

Table 6: total scores of water resources variables, scored from 1-5.

Variables	1	2	3	4	5
Distance to river flows according to their permanence (perennial or temporary)	0	0	3	11	20
Distance to ponds and lagoons	0	3	9	11	11
Distance to natural springs and fountains	0	1	5	10	18
Presence of groundwater with water table close to the surface	3	8	13	5	5

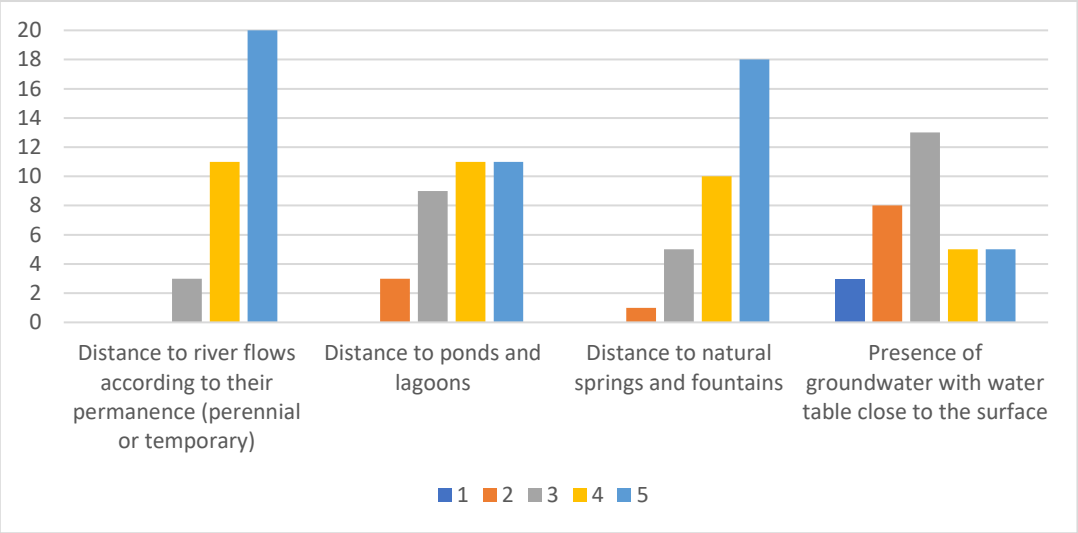

Fig. 6: total scores of water resources variables, scored from 1-5.

GROUP 2 VARIABLES

In Group 2 variables, experts were asked to rate the importance of each in influencing the preservation or destruction of sites. The questions assessed variables related to active geomorphological processes during the Pleistocene and Holocene, and geomorphologically stable areas or zones of preferential deposition.

Block 2.1: Active Geomorphological Processes (Pleistocene/Holocene)

The expert panel agrees on assigning high importance to fluvial processes in site preservation. For karstic processes, opinions split between medium and high importance. Views are more varied for other variables, such as gravitational processes (high or medium importance, some low) and wind processes (most rate medium-low importance, few rate high). Scores for glacial and periglacial processes are evenly distributed: twelve experts rate them low or very low, fifteen high or very high, and seven medium importance.

Table 7: total scores of active geomorphological processes variables, scored from 1-5.

Variables	**1**	**2**	**3**	**4**	**5**
Fluvial processes	0	1	5	10	18
Gravitational processes (slope movements, subsidence, and collapse)	0	4	11	12	7
Glacial and periglacial processes	6	6	7	10	5
Aeolian processes	5	6	15	6	2
Karstic processes	2	2	10	7	13

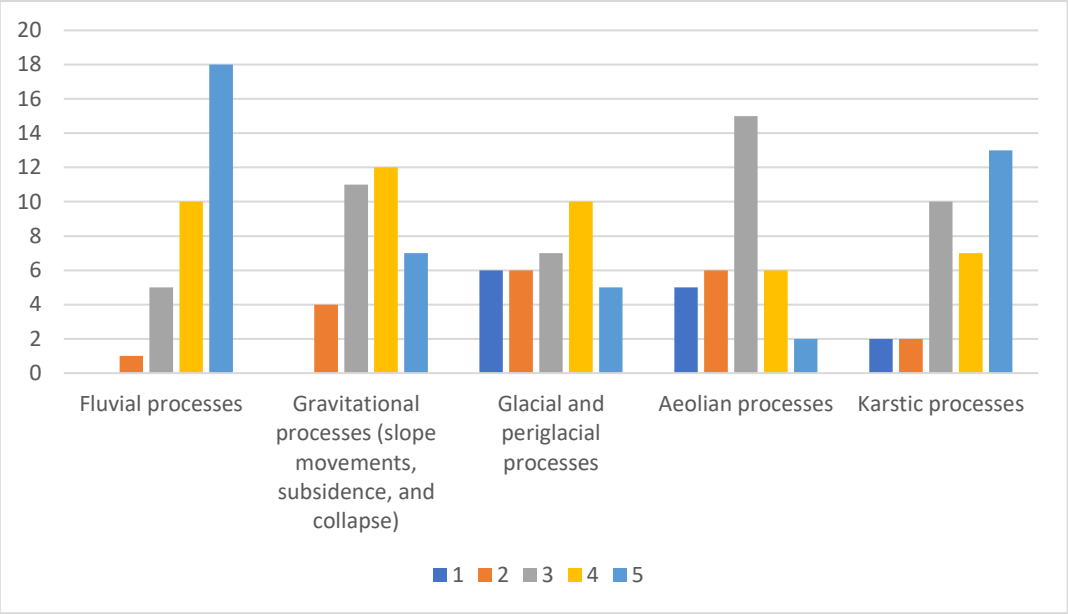

Fig. 7: total scores of active geomorphological processes variables, scored from 1-5.

Block 2.2: Stable Areas or Zones of Preferential Deposition

Regarding zones of preferential deposition, their existence is generally considered important for site preservation, with opinions ranging from medium to very high importance. Only three experts rated them as of little or no importance.

Table 8: total scores of stable areas or zones of preferential deposition variables, scored from 1-5.

Variables	**1**	**2**	**3**	**4**	**5**
Stable zones (summit surfaces, endorheic areas, interfluves)	2	1	10	14	7
Deposition zones (alluvial plains, eolian mantles, caves and karstic deposits, lacustrine and palustrine areas)	0	1	5	11	17

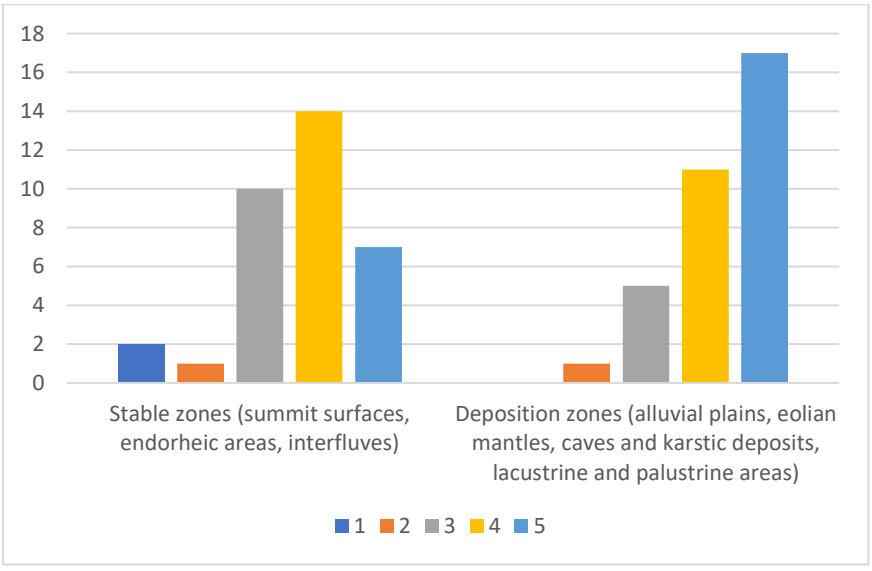

Fig. 8: total scores of stable areas or zones of preferential deposition variables, scored from 1-5.

GROUP 3 VARIABLES

In Group 3 variables, experts were asked to rate the importance of each in facilitating the discovery of archaeological sites. The questions evaluated factors such as the degree of anthropization of a territory, the presence of prior research studies in the area, and the potential for site destruction due to human activity.

Block 3.1: Degree of Anthropization of a Territory

Although opinions vary, most experts assign considerable importance to these variables as factors influencing the discovery of archaeological sites. However, about four experts tend to rate them as having little or no importance.

Table 9: total scores of degree of anthropization variables, scored from 1-5.

Variables	1	2	3	4	5
Urban settlements	1	3	6	12	12
Infrastructure	2	2	5	9	16
Mining activity, forestry, and agricultural operations	2	0	7	7	18

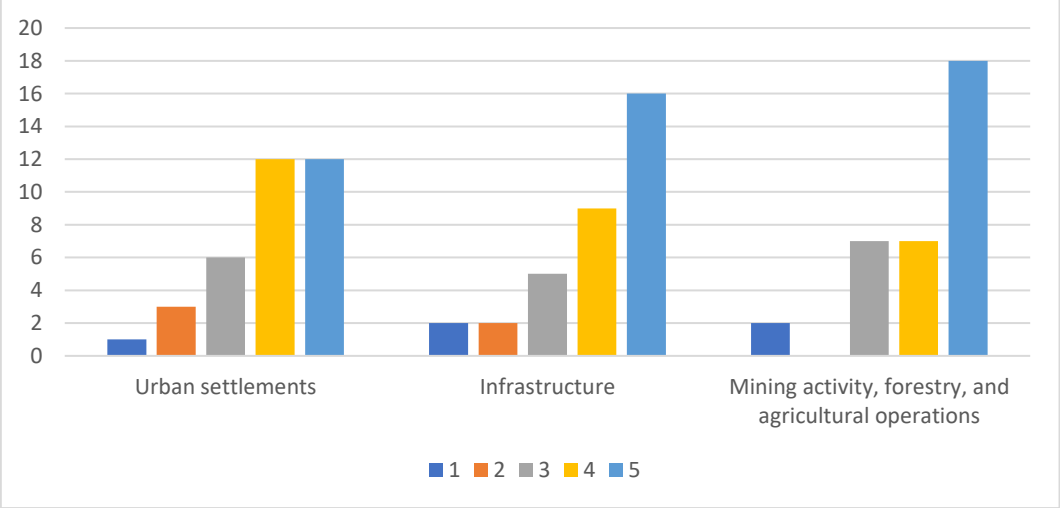

Fig. 9: total scores of degree of anthropization variables, scored from 1-5.

Boock 3.2: Previous Research

Cataloging, inventory, or archaeological research studies are considered important factors that may have influenced the discovery of archaeological sites. The archaeological map generates the greatest consensus.

Table 10: total scores of previous research variables, scored from 1-5.

Variables	1	2	3	4	5
Archaeological inventory	0	0	5	17	12
Regional or local catalogs or inventories	1	0	11	14	8
Theses, master's or bachelor's dissertations, or similar works	1	2	11	8	12

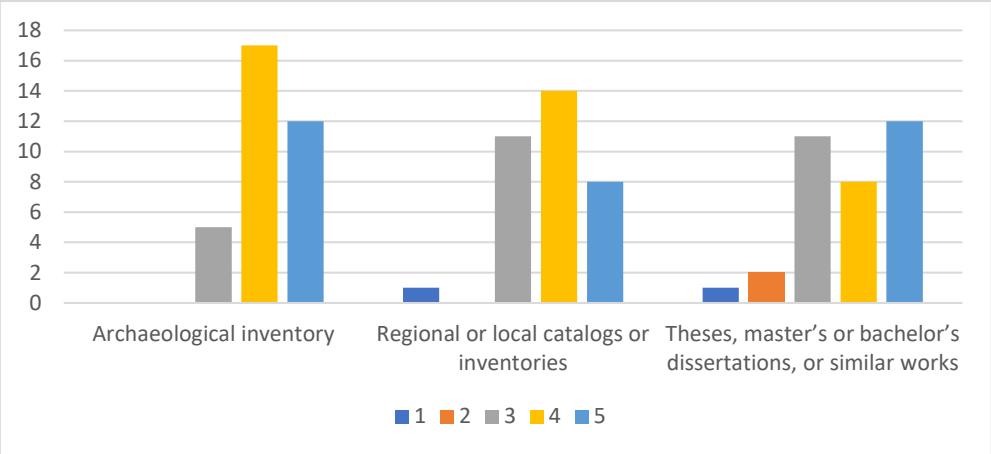

Fig. 10: total scores of previous research variables, scored from 1-5.

Block 3.3: Possibility of Destruction or Deterioration by Human Activities

Regarding variables influencing current site destruction, there is consensus on assigning medium to very high importance to agricultural, mining, or urban development activities. Opinions are more divided on forestry or agricultural interventions, with some experts rating their importance as low.

Table 11: total scores of possibilities of destruction or deterioration by human activity variables, scored from 1-5.

Variables	1	2	3	4	5
Agricultural tillage	0	3	5	15	11
Forestry interventions	0	5	13	11	5
Mining activity	0	2	6	9	17
Historical urbanization	0	2	6	9	17

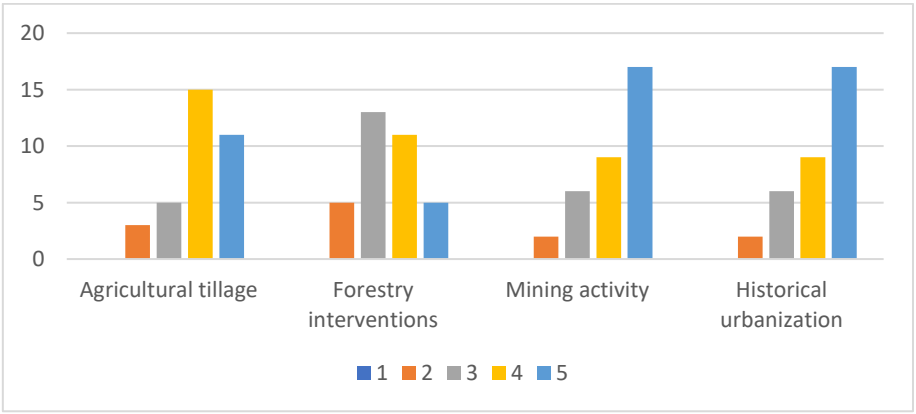

Fig. 11: total scores of possibilities of destruction or deterioration by human activity variables, scored from 1-5.

WEIGHTING VARIABLES

The maximum score for a variable is 170 points. Variables scoring below 90 points are highlighted in yellow (only two related to insolation and orientation), and those scoring above 140 points are highlighted in green. The highest-rated variables include three related to relief and how it influences human mobility in the landscape (mountain passes, river fords, and fluvial

corridors); lithologies linked to karst formations, a common shelter during the Paleolithic; distance to rivers, springs, and fountains; alluvial processes affecting site destruction; zones of preferential deposition; mining, forestry, and agricultural activities, as well as urbanization, as factors limiting site destruction or discovery; and archaeological maps as factors enhancing the discovery of archaeological sites.

Table 12: List of variables with the scores assigned by experts and their weight. The final weight is obtained by dividing each variable's score by the sum of the scores of all variables.

VARIABLE	Variable score (max. 170)	Final weight
1.1. RELIEF [Slope and its variation]	127	**0,02527866**
1.1. RELIEF [Slope orientation (insolation)]	89	**0,01771497**
1.1. RELIEF [Passage areas on mountains (ports, hills, valleys)]	151	**0,03005573**
1.1. RELIEF [River corridors]	148	**0,0294586**
1.1. RELIEF [Fords in rivers and streams]	149	**0,02965764**
1.1. RELIEF [Landscape corridors]	139	**0,0276672**
1.1. RELIEF [Insolation rate]	83	**0,0165207**
1.1. RELIEF [Viewshed]	100	**0,01990446**
1.2. LITHOLOGY AND MINERAL RESOURCES [Formations with the potential to contain varieties of silica (quartz, flint, jasper, chalcedony)]	132	**0,02627389**
1.2. LITHOLOGY AND MINERAL RESOURCES [Other lithological elements of interest as tools (igneous and metamorphic rocks as hammers, etc.)]	99	**0,01970541**
1.3. LITHOLOGIC GEODIVERSITY [Lithological cores and geodiversity corridors]	121	**0,02272727**
1.3. LITHOLOGIC GEODIVERSITY [Main areas with lithological and ecological monotony]	105	**0,01972201**
1.4. ACTIVE GEOMORPHOLOGICAL DYNAMICS [Paleoinundations (riverbank settlements)]	129	**0,0242299**
1.4. ACTIVE GEOMORPHOLOGICAL DYNAMICS [Periglacialism and glacialism (settlements in mountain areas)]	116	**0,02178813**
1.4. ACTIVE GEOMORPHOLOGICAL DYNAMICS [Pleistocene wind action (settlements in plains)]	104	**0,01953418**
1.5. CAVES AND SHELTERS [Karstifiable carbonatic and evaporitic lithologies]	146	**0,02742299**
1.5. CAVES AND SHELTERS [Granitic rocks with crags formation with holes]	100	**0,01878287**
1.5. CAVES AND SHELTERS [Conglomeratic formations (they form hollows, shelters, etc.)]	105	**0,01972201**
1.5. CAVES AND SHELTERS [Slopes and escarpments of valleys and canyons]	118	**0,02216379**
1.6. WATER RESOURCES [Distance to river flows according to their degree of permanence]	153	**0,02873779**
1.6. WATER RESOURCES [Distance to ponds and lagoons.]	132	**0,02479339**
1.6. WATER RESOURCES [Distance to springs]	147	**0,02761082**
1.6. WATER RESOURCES [Presence of groundwater with phreatic level close to the surface]	103	**0,01934636**
2.1. ACTIVE GEOMORPHOLOGICAL PROCESSES (PLEISTOCENE/HOLOCENE) [Processes of fluvial erosion]	147	**0,02761082**
2.1. ACTIVE GEOMORPHOLOGICAL PROCESSES (PLEISTOCENE/HOLOCENE) [Gravitational processes (slope movements, subsidence and collapse)]	124	**0,02329076**
2.1. ACTIVE GEOMORPHOLOGICAL PROCESSES (PLEISTOCENE/HOLOCENE) [Glacial and periglacial processes]	104	**0,01953418**
2.1. ACTIVE GEOMORPHOLOGICAL PROCESSES (PLEISTOCENE/HOLOCENE) [Wind processes]	96	**0,01803156**
2.1. ACTIVE GEOMORPHOLOGICAL PROCESSES (PLEISTOCENE/HOLOCENE) [Karst processes]	129	**0,0242299**
2.2. GEOMORPHOLOGICALLY STABLE OR DEPOSIT AREAS [Stable areas (culminating surfaces, endorheic zones, interfluviums)]	125	**0,02347859**
2.2. GEOMORPHOLOGICALLY STABLE OR DEPOSIT AREAS [Deposit areas (alluvial plains, eolian mantles, caves and karst depositions, lacustrine and palustrine areas)]	146	**0,02742299**
3.1. DEGREE OF ANTHROPIZATION OF A TERRITORY [Current settlements]	133	**0,02498122**
3.1. DEGREE OF ANTHROPIZATION OF A TERRITORY [Infrastructures]	137	**0,02573253**
3.1. DEGREE OF ANTHROPIZATION OF A TERRITORY [Mining activity, forestry and agriculture]	141	**0,02648385**
3.2. PREVIOUS STUDIES [Archaeological Inventory]	143	**0,0268595**

3.2. PREVIOUS STUDIES [Regional or local catalogues or inventories]	130	**0,02441773**
3.2. PREVIOUS STUDIES [Thesis, master's degree thesis, degree thesis or similar]	130	**0,02441773**
3.3. POSIBILITY OF DESTRUCTION OR DETERIORATION DUE TO ANTHROPIC ACTIVITIES [Agricultural clearing]	136	**0,0255447**
3.3. POSIBILITY OF DESTRUCTION OR DETERIORATION DUE TO ANTHROPIC ACTIVITIES [Forestry]	118	**0,02216379**
3.3. POSIBILITY OF DESTRUCTION OR DETERIORATION DUE TO ANTHROPIC ACTIVITIES [Mining]	143	**0,0268595**
3.3. POSIBILITY OF DESTRUCTION OR DETERIORATION DUE TO ANTHROPIC ACTIVITIES [Historic urbanism]	146	**0,02742299**
TOTALES	**5024/6800**	**1**

PROPOSALS FOR THE SECOND ROUND

The frequency histogram analysis considered three classes: low or no importance (scores 1 and 2), medium importance (score 3), and high or very high importance (scores 4 and 5). For the second round, it is proposed to consult only the following variables, as their frequency distribution among the three classes shows less significant differences compared to other evaluated variables.

Table 13: List of variables proposed for the second round and their relative importance according to experts.

Variable	***Low or null importance***	***Medium importance***	***High importance***
Viewshed	12	13	9
Granite rocks with boulder fields containing cavities and overhangs between blocks	12	12	10
Conglomerate formations (forming cavities, shelters, and overhangs at the base of towers)	13	6	15
Presence of groundwater with water table close to the surface	11	13	10
Glacial and periglacial processes	12	7	15

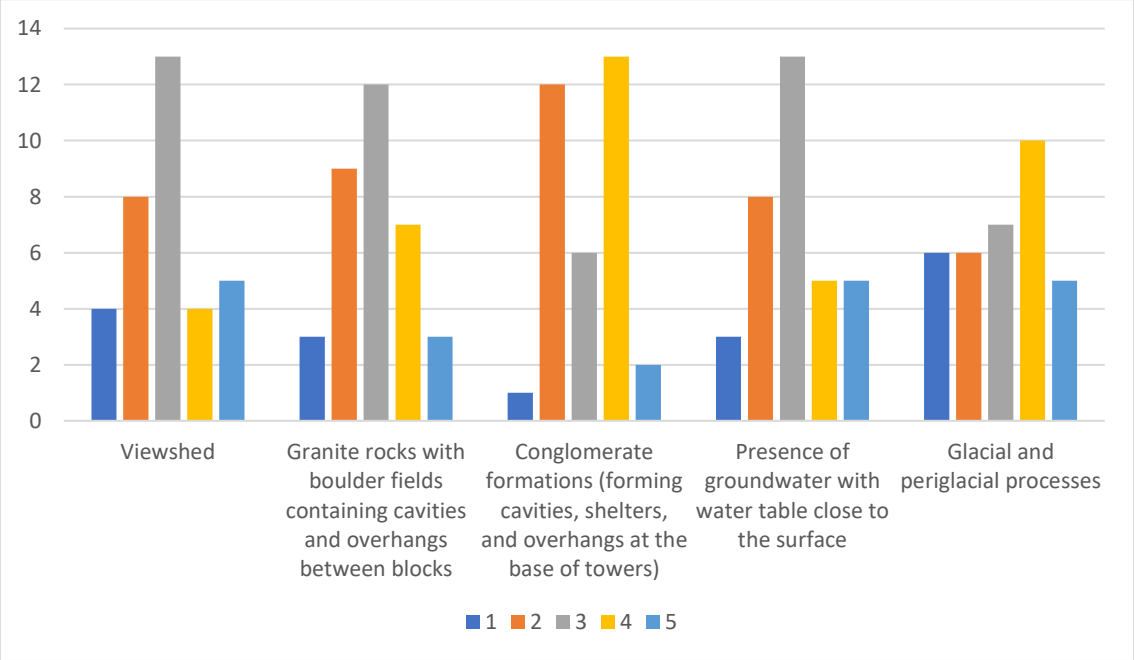

Fig. 12: List of variables proposed for the second round and their scores from 1-5.

SECOND ROUND OF THE EXPERT PANEL SURVEY

19 experts participated in the second round of the survey, most of them offering detailed answers about the scores given. Scores were updated to the previous results in round 1 for final weights.

Viewshed

- Expert 1. Score: 3
- Expert 2. Score: 3. “At first glance, it seems to be an important concept, since hunter-gatherer groups have significant control over the movement of possible animal herds, especially when dealing with gregarious species. However, it is true that hunting parties do not necessarily target large herds, and tactics such as stalking may involve very small hunting groups, so it may not be necessary to have exhaustive control of the visual basin from an occupation site. In addition, the functionality of the sites themselves must be considered. The visual basin may be important in a short- or long-term base camp, but if the sites are related to resource extraction locations, such as raw material “mines” or butchering sites, this variable loses importance. Honestly, I believe the variables should be assessed taking into account the functionality of the site, since for a camp it might be rated 4 or 5, while for a butchering site it would be given a 1 regarding the visual basin variable.”
- Expert 3. Score: 3. “The extent of the visual basin is an important variable, but not necessarily a “must-have” for many of the Paleolithic sites I know.”
- Expert 4. Score: 4. “In some cases, such as sites with a strategic role (hunting grounds, control of passage zones, etc.) or places of special symbolic or social significance (like "aggregation sites," sensu Conkey), this variable may have notably influenced the choice of certain locations.”
- Expert 5. Score: 3
- Expert 6. Score: 3. “The extent and visibility have undoubtedly always been important factors, but territorial knowledge was very high, and under those conditions, the importance of visibility would diminish.”
- Expert 7. Score: 2. “In the northern area [of Spain], there are very narrow valleys with prehistoric caves that have very limited visibility of the basin.”
- Expert 8. Score: 2. “Although this variable may influence human presence during the Paleolithic, it does not at all affect the preservation capacity of sites, which ultimately is the only way to infer that human presence.”
- Expert 9. Score: 2.
- Expert 10. Score: 4. “Because it allows better control of hunting resources.”
- Expert 11. Score: 2. “I think its impact is limited, as this variable has more perceptual significance for humans than economic implications.”
- Expert 12. Score: 4. “The observation of game resources, as well as the visual inspection of different forest/vegetation areas (e.g., oak forest versus holm oak woodland), has a strategic value that is important to control visually. It is also important to consider that not all human groups would have had good relations with each other during some periods of the Paleolithic.”
- Expert 13. Score: 4. “A wide view of the territory allows better control of it, both to prevent threats and to detect the presence of herds or other important resources.”
- Expert 14. Score: 4. “The extent and visual control of a territory by humans would help avoid certain dangers and facilitate the location of animal herds that could be potential prey.”
- Expert 15. Score: 3. “It is necessary to differentiate between wandering, occasional activities, or "base camps" involving stays longer than one day. In the first two cases, the importance of the visual basin would be lower, and in the last case, greater due to increased security.”

- Expert 16. Score. 4. “A greater visual basin extent improves living conditions for human communities, both by providing access to herds of huntable animals and by allowing early protection against possible attacks from other predators.”
- Expert 17. Score: 4.
- Expert 18. Score: 4. “Perception of the location”
- Expert 19. Score: 4. “Visibility does not always have to play an important role in the settlement of groups.”

Granite rocks with boulder fields containing cavities and overhangs between blocks:

- Expert 1. Score: 1
- Expert 2. Score: 3. "Here an important dichotomy arises. Rock shelters, whatever their type, were probably used without any problem by human groups. In this sense, they could have completely conditioned human presence (it should be given a 5 in the test). But the problem is that this type of environment does not facilitate the genesis of archaeological sites, and therefore we would have no evidence of such human presence (which would mean that if we value the presence of sites and not the presence of human activity, it would end up being scored as 1). To give an example: The Nasera site, from the MSA, is a shelter under a granitic structure, preserved by the peculiar wind-blown sedimentation of the area. Is this possible in the Iberian Peninsula? Probably not. If this were the case throughout the Extremadura region (including Portuguese Extremadura and Salamanca), we should have a large number of sites in granitic shelters... but the problem is that there is no sediment under these shelters, so even if there was activity, we would never be able to know. In my opinion, the problem with this variable lies in how the question about "activity" was formulated, and not about the "preservation of activity"
- Expert 3. Score: 3. "The presence of the mentioned morphologies could have moderately conditioned human presence in a territory during the Paleolithic."
- Expert 4. Score: 1. "This variable depends on the lithology of the study area. More than a variable in the decision-making process of Paleolithic societies, this factor will condition the available options."
- Expert 5. Score: 3
- Expert 6. Score: 2. "Possibly, but I lack an objective criterion to answer with reference to the period I work on (Lower Paleolithic)."
- Expert 7. Score: 3. "I’m not sure, but I understand they did not always need a more sheltered place."
- Expert 8. Score: 4. "Granite or gneiss rocks with formations of hollows and overhangs would act as perfect shelters for humans. In these contexts, depositional processes would favor the preservation of fossil associations. There are many sites in these contexts."
- Expert 9. Score: 1
- Expert 10. Score: 4. "They can be shelter areas that facilitate occupation of outcrops even if they leave no trace in the fossil record."
- Expert 11. Score: 3. "Based on their potential use as frequented/habitat spaces, they could have conditioned presence, but not too much since more evidence should have been found, although it could be a hypothesis for targeted prospection."
- Expert 12. Score: 3. "It is difficult to evaluate the importance of this aspect: the archaeological record in these landscapes is very limited (if not nonexistent). This implies that occupation is more than plausible, but as far as I know, it is not demonstrable."
- Expert 13. Score: 2. "Hollows and overhangs can provide protection, especially useful for short-term occupations, such as hunting stations, etc. But, as far as I know, sites are not usually found in these environments."
- Expert 14. Score: 2. "These possible shelters formed in granitic rocks would probably be small and more suitable for temporary uses, where due to the nature of granite, few bone remains would have been preserved."

- Expert 15. Score: 3. "It would be necessary to differentiate between movement, occasional activities, or 'base camps' involving stays longer than a day. In the first two cases, the importance would be less, and in the last greater."
- Expert 16. Score: 4. "In the absence of other karstifiable formations, such as limestones, dolomites, or gypsum, shelters and hollows in granitic formations of boulders and slabs can be an occupational alternative for human communities."
- Expert 17. Score: 5. "This type of rock is associated with Paleolithic sites in shelters in territories without limestone caves, with an important relationship to Paleolithic art, whether engravings or paintings."
- Expert 18. Score: 3. "Possibility and potential for carrying out certain activities."
- Expert 19. Score: 4. "Their existence may have served as an attraction due to the possibility of obtaining sheltered spaces."

Conglomerate formations (forming cavities, shelters, and overhangs at the base of towers)

- Expert 1. Score: 1
- Expert 2. Score: 3. "See previous answer, because we are in the same situation."
- Expert 3. Score: 5. "Shelters located in undercuts beneath conglomeratic strata in tertiary basins are usually good places for human settlement during the Paleolithic."
- Expert 4. Score: 1. "Same as the previous one."
- Expert 5. Score: 3
- Expert 6. Score: 2. "Possibly, but I'm still in the same situation."
- Expert 7. Score: 3. "Same as in the previous answer."
- Expert 8. Score: 2. "Similar to the previous answer, but the formation of overhangs and shelters is much less common. They would be, in any case, more ephemeral shelters, not as geologically 'stable' as granite or gneiss shelters."
- Expert 9. Score: 4
- Expert 10. Score: 4. "Same as before."
- Expert 11. Score: 3. "Based on their potential use as frequented/habitat spaces, they could have conditioned presence, but not too much since more associated evidence should have been found, although it could be a hypothesis for targeted prospection."
- Expert 12. Score: 4. "In the case of conglomerates, we do know occupations, especially in lower height ones, which could have served as refuge/shelter (La Peña de Estebanvela, El Molí del Salt...). Conglomerates forming shelters under high cliffs (20 meters or more) are not very recommendable since falling blocks make these places unsafe shelters (see example of the Romanesque monastery of San Juan de la Peña, Jaca). Still, there are some occupations under high cliffs (Roca dels Bous)."
- Expert 13. Score: 3. "It depends a lot on geological characteristics. In some places, caves and shelters of significant dimensions develop in these materials, susceptible to human occupation similar to that observed in karstic formations in limestone."
- Expert 14. Score: 2. "These shelters in conglomeratic formations would also be small and probably for temporary uses."
- Expert 15. Score: 3. "It would be necessary to differentiate between movement, occasional activities, or 'base camps' involving stays longer than a day. In the first two cases, importance would be null, and in the last considerable if they allow accommodation of the whole group."
- Expert 16. Score: 4. "In the absence of other karstifiable formations, such as limestones, dolomites, or gypsum, shelters and overhangs under conglomerate towers can be an occupational alternative for human communities."
- Expert 17. Score: 3. "This type of rock can condition the use of shelters sporadically, though not as intensely as granitic rocks, and prehistoric art does not appear on them."
- Expert 18. Score: 3. "Same as the previous."

- Expert 19. Score: 4. "Their existence may have served as an attraction due to the possibility of obtaining sheltered spaces."

Presence of groundwater with water close to the surface

- Expert 1. Score: 5
- Expert 2. Score: 4. "I think this variable is important due to the presence of springs with quality water. See, for example, interpretations around the position of the Olduvai Bed I sites near potable water points."
- Expert 3. Score: 3. "If water surfaces, it could be a good condition; if not, I don't think it conditioned human presence."
- Expert 4. Score: 2. "Access to water is a necessity for any human society, but it doesn't necessarily have to be groundwater, which is harder to access."
- Expert 5. Score: 4
- Expert 6. Score: 3. "Access to water has always been important; one should assess if it was the only way to get water. Today, primitive communities often dig wells in dry riverbeds, knowing how to exploit underground water."
- Expert 7. Score: 4. "I understand that as a necessary resource, the presence of springs, wells, rivers, etc., would have considerable importance."
- Expert 8. Score: 1. "Low probability of settlements, few depositional processes to preserve those settlements."
- Expert 9. Score: 3
- Expert 10. Score: 3. "Populations have always needed water; that is why all societies lived near rivers."
- Expert 11. Score: 3. "I don’t know, since it would require distinguishing types of urgencies (like natural springs, seepages, etc.)."
- Expert 12. Score: 5. "Springs and clean water are vital for human subsistence. Also, some animals like horses (widely hunted during the Pleistocene) only drink very clean water."
- Expert 13. Score: 4. "Central camps, or 'central places', must necessarily be near a water source."
- Expert 14. Score: 3. "The presence of groundwater emerging seasonally would be fundamental for humans in certain scarcity periods."
- Expert 15. Score: 3. "One should differentiate between movement, occasional activities, or ‘base camps’ with stays over a day. In the first two cases, it would be important if associated with more developed vegetation cover; in the last, none unless a water spring coincided with a suitable base camp site."
- Expert 16. Score: 5. "The presence of groundwater close to the surface allows permanent access to potable water, even in summer or autumn when surface streams may dry."
- Expert 17. Score: 4. "Groundwater near the surface, especially if emerging as springs, provides a water resource for humans and animals, even allowing these spaces to be used as hunting grounds."
- Expert 18. Score: 4. "A place with attraction functions."
- Expert 19. Score: 5. "Important source of fresh water outside rivers."

Glacial and periglacial processes

- Expert 1. Score: 5
- Expert 2. Score: 2. "Difficult question. In the Paleolithic record, there are few sites in high mountain areas where these processes occur. If there were many sites, many would be strongly altered. For example, in central and northern Europe, few Middle Paleolithic sites exist at high altitudes due to destruction. In southern Europe, where glacial activity was limited (e.g., Guadarrama), we might expect sites in high mountains exploiting those resources. However, the

only example is El Esquilleu, which is rocky, not high mountain. I think this variable is important only if activity existed in affected zones, but evidence shows preference for low altitudes and related fauna, so this variable loses relevance."

- Expert 3. Score: 3. "Periglacial processes occur in zones of perpetual snow at considerable altitude with mean temperatures below 5ºC. I don't believe there was stable human presence to create sites. Human presence in glacial areas was likely sporadic (e.g., hunting). Glacial maxima could have destroyed settlements. Some periglacial processes preserve human presence well (e.g., rock shelters protected by gelifraction). Others can move human remains on slopes."
- Expert 4. Score: 5. "In areas with strong glaciation, continuous human presence is impossible, so finding regular Paleolithic occupation remains is unlikely."
- Expert 5. Score: 4
- Expert 6. Score: 3. "Sometimes preserved in fluvial deposits, floodplains, but less in high latitudes with permafrost. On slopes, processes like solifluction or mudflows may occur depending on latitude and frozen soils."
- Expert 7. Score: 3. "Deglaciation causes much surface movement but is not a major factor for site preservation. Areas with highest earth movement from deglaciation were not usual settlement zones."
- Expert 8. Score: 1
- Expert 9. Score: 2
- Expert 10. Score: 2. "Some conditioning, but I don't think glaciation limited settlement on the plateau."
- Expert 11. Score: 4. "Possibly more than we think."
- Expert 12. Score: 4. "In glacial/periglacial areas, preservation is generally poor, and these are also unfavorable habitats, making conservation estimation difficult. Clear distinction needed between glacial and periglacial: glacial areas with moraines and ice have little life and strong erosion/sedimentation. Periglacial areas with loess and specialized megafauna (e.g., mammoths) offer better preservation and hunting opportunities."
- Expert 13. Score: 5. "Glacial processes totally destroy earlier sediment deposits. Interglacial occupation traces are destroyed by glaciers during glacial periods."
- Expert 14. Score: 4. "Important variable for site preservation especially in Central Europe and high latitudes where glacial and periglacial phenomena may erode all human evidence."
- Expert 15. Score: 3. "Effect of glacial or periglacial processes depends on site location (open air, shelter, cave) and sediments covering it."
- Expert 16. Score: 4. "Active glacial and periglacial processes can move and destroy Paleolithic occupation layers, making remains unrecognizable."
- Expert 17. Score: 5
- Expert 18. Score: 3
- Expert 19. Score: 5. "Very much, these processes are very aggressive on preexisting deposits."

Table 14: total scores of second round variables, scored from 1-5.

Variables	**1**	**2**	**3**	**4**	**5**
Viewshed	0	4	6	9	0
Granite rocks with boulder fields	3	3	8	4	1
Conglomerate formations	2	3	8	5	1
Presence of groundwater	1	1	7	6	4
Glacial and periglacial processes	1	3	5	5	5

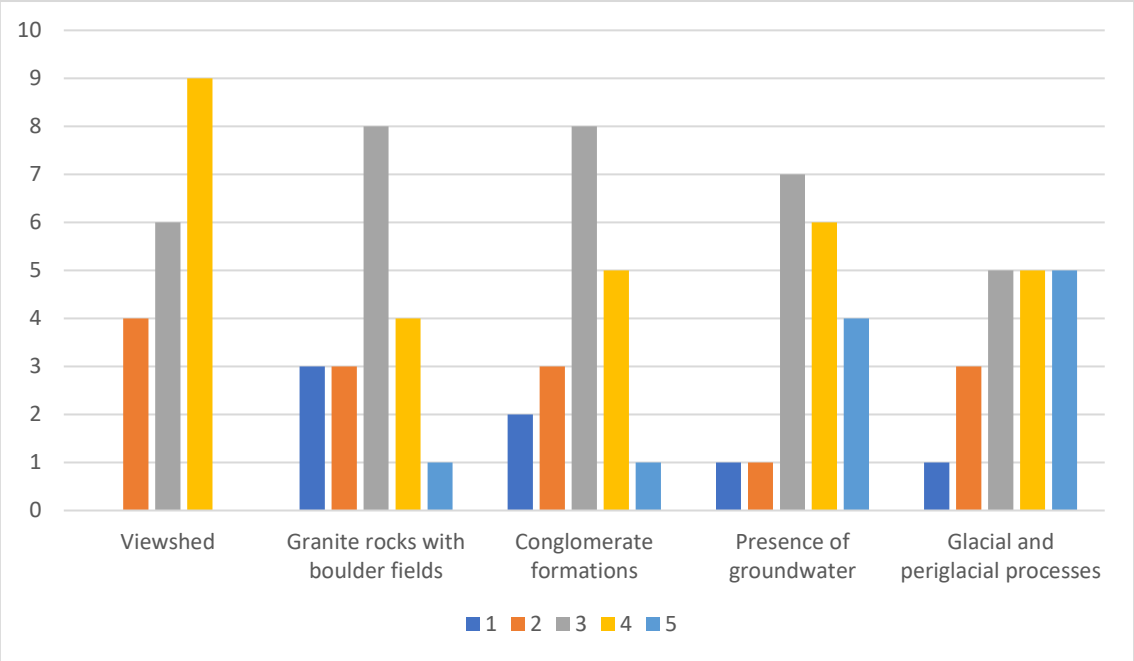

Fig. 13: total scores of second round variables, scored from 1-5.

Updated scores and weights:

Variations were minimal; however, the scores lowered in caves and shelters, while they increased in variables related to viewshed, groundwater, and glaciers. The second round was particularly interesting for discerning the reasons behind the discrepancies among experts. Below it can be found the final weight of all variables. In the main manuscript, Table 5 summarizes the final weights after combining variables to form the factors of the multicriteria analysis.

Table 15: List of variables with the scores assigned by experts and their weight after second round calibration. The final weight is obtained by dividing each variable's score by the sum of the scores of all variables.

VARIABLE	Variable score (max. 170)	Final weight
1.1. RELIEF [Slope and its variation]	127	**0.02522344**
1.1. RELIEF [Slope orientation (insolation)]	89	**0.01767627**
1.1. RELIEF [Passage areas on mountains (ports, hills, valleys)]	151	**0.02999007**
1.1. RELIEF [River corridors]	148	**0.02939424**
1.1. RELIEF [Fords in rivers and streams]	149	**0.02959285**
1.1. RELIEF [Landscape corridors]	139	**0.02760675**
1.1. RELIEF [Insolation rate]	83	**0.01648461**
1.1. RELIEF [Viewshed]	106	**0.02105263**
1.2. LITHOLOGY AND MINERAL RESOURCES [Formations with the potential to contain varieties of silica (quartz, flint, jasper, chalcedony)]	132	**0.02621648**
1.2. LITHOLOGY AND MINERAL RESOURCES [Other lithological elements of interest as tools (igneous and metamorphic rocks as hammers, etc.)]	99	**0.01966236**
1.3. LITHOLOGIC GEODIVERSITY [Lithological cores and geodiversity corridors]	121	**0.02272727**
1.3. LITHOLOGIC GEODIVERSITY [Main areas with lithological and ecological monotony]	105	**0.01972201**
1.4. ACTIVE GEOMORPHOLOGICAL DYNAMICS [Paleoinundations (riverbank settlements)]	129	**0.0242299**

1.4. ACTIVE GEOMORPHOLOGICAL DYNAMICS [Periglacialism and glacialism (settlements in mountain areas)]	116	**0.02178813**
1.4. ACTIVE GEOMORPHOLOGICAL DYNAMICS [Pleistocene wind action (settlements in plains)]	104	**0.01953418**
1.5. CAVES AND SHELTERS [Karstifiable carbonatic and evaporitic lithologies]	146	**0.02742299**
1.5. CAVES AND SHELTERS [Granitic rocks with crags formation with holes]	95	**0.01784373**
1.5. CAVES AND SHELTERS [Conglomeratic formations (they form hollows, shelters, etc.)]	98	**0.01840721**
1.5. CAVES AND SHELTERS [Slopes and escarpments of valleys and canyons]	118	**0.02216379**
1.6. WATER RESOURCES [Distance to river flows according to their degree of permanence]	153	**0.02873779**
1.6. WATER RESOURCES [Distance to ponds and lagoons.]	132	**0.02479339**
1.6. WATER RESOURCES [Distance to springs]	147	**0.02761082**
1.6. WATER RESOURCES [Presence of groundwater with phreatic level close to the surface]	112	**0.02103681**
2.1. ACTIVE GEOMORPHOLOGICAL PROCESSES (PLEISTOCENE/HOLOCENE) [Processes of fluvial erosion]	147	**0.02761082**
2.1. ACTIVE GEOMORPHOLOGICAL PROCESSES (PLEISTOCENE/HOLOCENE) [Gravitational processes (slope movements, subsidence and collapse)]	124	**0.02329076**
2.1. ACTIVE GEOMORPHOLOGICAL PROCESSES (PLEISTOCENE/HOLOCENE) [Glacial and periglacial processes]	112	**0.02103681**
2.1. ACTIVE GEOMORPHOLOGICAL PROCESSES (PLEISTOCENE/HOLOCENE) [Wind processes]	96	**0.01803156**
2.1. ACTIVE GEOMORPHOLOGICAL PROCESSES (PLEISTOCENE/HOLOCENE) [Karst processes]	129	**0.0242299**
2.2. GEOMORPHOLOGICALLY STABLE OR DEPOSIT AREAS [Stable areas (culminating surfaces, endorheic zones, interfluviums)]	125	**0.02347859**
2.2. GEOMORPHOLOGICALLY STABLE OR DEPOSIT AREAS [Deposit areas (alluvial plains, eolian mantles, caves and karst depositions, lacustrine and palustrine areas)]	146	**0.02742299**
3.1. DEGREE OF ANTHROPIZATION OF A TERRITORY [Current settlements]	133	**0.02498122**
3.1. DEGREE OF ANTHROPIZATION OF A TERRITORY [Infrastructures]	137	**0.02573253**
3.1. DEGREE OF ANTHROPIZATION OF A TERRITORY [Mining activity, forestry and agriculture]	141	**0.02648385**
3.2. PREVIOUS STUDIES [Archaeological Inventory]	143	**0.0268595**
3.2. PREVIOUS STUDIES [Regional or local catalogues or inventories]	130	**0.02441773**
3.2. PREVIOUS STUDIES [Thesis, master's degree thesis, degree thesis or similar]	130	**0.02441773**
3.3. POSIBILITY OF DESTRUCTION OR DETERIORATION DUE TO ANTHROPIC ACTIVITIES [Agricultural clearing]	136	**0.0255447**
3.3. POSIBILITY OF DESTRUCTION OR DETERIORATION DUE TO ANTHROPIC ACTIVITIES [Forestry]	118	**0.02216379**
3.3. POSIBILITY OF DESTRUCTION OR DETERIORATION DUE TO ANTHROPIC ACTIVITIES [Mining]	143	**0.0268595**
3.3. POSIBILITY OF DESTRUCTION OR DETERIORATION DUE TO ANTHROPIC ACTIVITIES [Historic urbanism]	146	**0.02742299**
Total	**5035/6800**	**1**