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RESEARCH ARTICLE

The Northern Central Desert of Iran during the Pleistocene: From Foundations Laid to Paths Uncharted

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Abstract

The northern margin of the Iranian Central Desert (NICD), situated between the southern foothills of the Alborz Mountains and the expanding interior deserts, represents a geographically narrow yet ecologically dynamic zone that has long been hypothesized as both a dispersal corridor and a habitable landscape during the Pleistocene. Despite its strategic position within broader Afro-Eurasian population networks, Paleolithic research in this region has remained fragmentary and uneven, with most interpretations historically dominated by data from the Zagros Mountains. This study addresses this imbalance by providing a critical synthesis of Paleolithic research conducted in the NICD up to 2025, with particular emphasis on Middle Paleolithic occupations and their techno-typological, and settlement implications. The primary objectives are to evaluate whether NICD lithic assemblages constitute a coherent intra-regional technological entity, and to examine the extent to which the NICD functioned as a lived-in landscape rather than merely a transient corridor. To this end, the study draws on published data from a range of site types—including stratified open-air sites (e.g., Mirak), caves and rockshelters (e.g., Sorheh), and extensive surface scatters (e.g., Chah-e Jam, Zaviyeh, Eyvanekey landscapes)—and employs a descriptive–analytical, library-based method integrating lithic techno-typology, geomorphological context, and chronometric evidence where available. Preliminary observations indicate that Middle Paleolithic assemblages across the NICD share recurrent traits, notably an emphasis on Levallois reduction, generally light to moderate retouch intensity, and limited evidence for the heavily curated tool forms typical of classic Zagros Mousterian assemblages. At the same time, marked intra-regional variability is evident, reflecting differences in landforms, raw-material availability, adaptations, site function, and degrees of mobility across highland, intermediate, and lowland zones. Stratified sequences at Mirak and Sorheh further demonstrate repeated occupations during MIS 3 and adjacent periods, supporting the interpretation of the NICD as a region of sustained hominin presence across multiple phases rather than episodic use alone. Taken together, these findings suggest that the NICD hosted adaptable hominin populations capable of exploiting arid to semi-arid plains, pediments, and mountain-edge ecotones, with lithic traditions that are neither simple extensions of the Zagros Mousterian nor direct replicas of Levantine entities. Future research should prioritize targeted excavations, improved chronological control, systematic raw-material sourcing, and high-resolution analytical approaches—including refitting, use-wear, and quantitative morphometrics—to refine regional models of technological organization and population dynamics within this underexplored sector of the Iranian Plateau.

Keywords: Iranian Plateau, The NICD, Paleolithic Sites, Hominin Arid-Zone Adaptation, Lithic Techno-Typology.

Introduction

Historically, Iranian Plateau has functioned as a pivotal point for cultural exchanges and the movement of hominins, a trend that was the case from the Pleistocene epoch. Iran's varied geography and strategic positioning have facilitated the movement of hominins and fostered cultural exchanges. A recent investigation underscores the region's significance, suggesting that the Iranian Plateau functioned as a central hub for *Homo sapiens* during their primary exodus out of Africa, approximately between 70,000 to 45,000 years ago (Vallini et al. 2024). Thus, this region is essential for a thorough understanding of the Paleolithic era; however, the limited scope of research has resulted in notable gaps in our knowledge regarding this lengthy period in Iran, complicating our grasp of the cultural developments that took place. While certain areas, such as the Central Zagros, have been the subject of relatively extensive Paleolithic research (see e.g., Abolfathi 2018; Matthews & Fazeli 2022; Shoaee et al. 2021, Vahdati Nasab 2010 for reviews), others, including the Iranian Central Plateau, have not received adequate scholarly focus within the context of the Paleolithic sphere. This limited scope of comprehensive studies has resulted in considerable gaps in our understanding of this period in Iran, complicating our grasp of the cultural advancements that occurred.

The alignment of the Alborz Mountains to the north and the Central Desert to the south has given rise to a slender, elongated biozone that stretches in an east-west direction across the northern part of the Iranian Central Desert (NICD) (Fig. 1). This area, as a component of the Iranian Central block has hosted various Paleolithic landscapes, as detailed below. Based on these accounts, it is proposed that during the Pleistocene, the strip of the NICD was a habitat for various hominin populations and most probably, one of the dispersal corridors (formally proposed in Vahdati Nasab et al. 2013; later discussed in: Hashemi et al. 2024a, b; Shoaee et al. 2021, 2023; Vahdati Nasab et al. 2019; Vahdati Nasab & Hashemi 2016 among others) linking Africa and West Asia to the Central and Inner Asia to the east and maybe the Caucasus to the west. The width of this corridor was variable and depended on climatic fluctuation and its impacts, specifically, the expansion and contraction of the Central Desert (Hashemi et al. 2017; Vahdati Nasab et al. 2013).

The importance of the NICD lies in its potential to illuminate the nature of hominin adaptations in arid to semiarid and ecologically fluctuating environments. Paleoclimatic reconstructions, as detailed in Hashemi (2018), Hashemi et al. (2017), Shoaee et al. (2023), and Vahdati Nasab et al. (2019) roughly suggest that the NICD was intermittently hospitable during warmer episodes of Marine Isotope Stage (MIS) 5 and even during MIS 3. Such environmental windows likely facilitated both short-term occupations and longer-term regional population persistence. Moreover, geomorphological evidence from sites like Chah-e Jam, with expanses of over an 8.5-kilometer of lithic scatters (Vahdati Nasab & Hashemi 2016), indicates that paleolakes and associated playas, if not saline, provided critical resources that attracted hominin populations. These observations are consistent with broader patterns seen in other arid regions, where water availability and vegetated patches (oases, *sensu lato*) often serve as magnets for repeated human occupations (see e.g., Kelly 2013: 90; Mischke et al. 2021; Petraglia et al. eds. 2015; Sun et al. 2023).

While the NICD holds considerable relevance for Paleolithic studies in Iran, it is overlooked by several notable research limitations. Key among them is the lack of a cohesive synthesis of previous findings, a dearth of absolute dating and stratified sites, the temporal mixing of lithic surface scatters, and a scarcity of paleoenvironmental data. These factors create a significant void in our understanding of the adaptive strategies employed by hominin populations inhabiting the area during the Pleistocene. Additionally, the absence of a detailed history of research impedes the ability to effectively tackle these challenges, highlighting the necessity for a library synthesis to assess ongoing research in the NICD and to delineate future research directions.

In this investigation, a descriptive-analytical framework will be utilized to conduct a detailed but summarized examination of the current literature pertaining to Paleolithic research in the NICD, up to 2025. The data collection relies on library (documentary) research method. The citations under review span a broad spectrum of topics, including comprehensive manuscripts resulting from previous pedestrian field surveys and archaeological excavations, and studies focused solely on the attribute-based analysis of lithic artifacts. After outlining the findings of earlier research, each citation will be meticulously analysed to evaluate its strengths and weaknesses. The study will conclude with discussions that highlight critical gaps of understanding and provide recommendations for future research endeavours in the NICD, considering both short-term and long-term strategies.

History of Research

Archaeological research activities in the NICD can be divided into two primary categories. The first category includes studies that are exclusively conducted within the area of interest. The second pertains to field research that is executed in adjacent areas, specifically to the east, west, and south of the Iranian Central Desert, which is commonly and collectively referred to as the Iranian Central Plateau (ICP). This paper does not consider research in the latter or the broader ICP or in the northern Alborz, owing to page limitations.

The formal research within the NICD is including, in a west to east direction (Figure 1): Ghasidian et al. 2024; Hariryan et al. 2021 at Sorheh Rockshelter complex, Heydari-Guran et al. 2014 at Zaviyeh surface scatters, Nateqi et al. 2020 at Showr-e Qazi and Sar Darreh surface scatters, Hashemi et al. 2024a, b at Eyvanekey surface scatters, Berillon et al. 2007a, b at Moghanak and Otchunak surface scatters, Vahdati Nasab & Feiz 2014 at Soufi Abad surface scatters and open-air site(?), Vahdati Nasab et al. 2019 at Mirak open-air site, Vahdati Nasab & Clark 2014 at Delazian open-air site, and Vahdati Nasab & Hashemi 2016 at Chah-e Jam surface scatters.

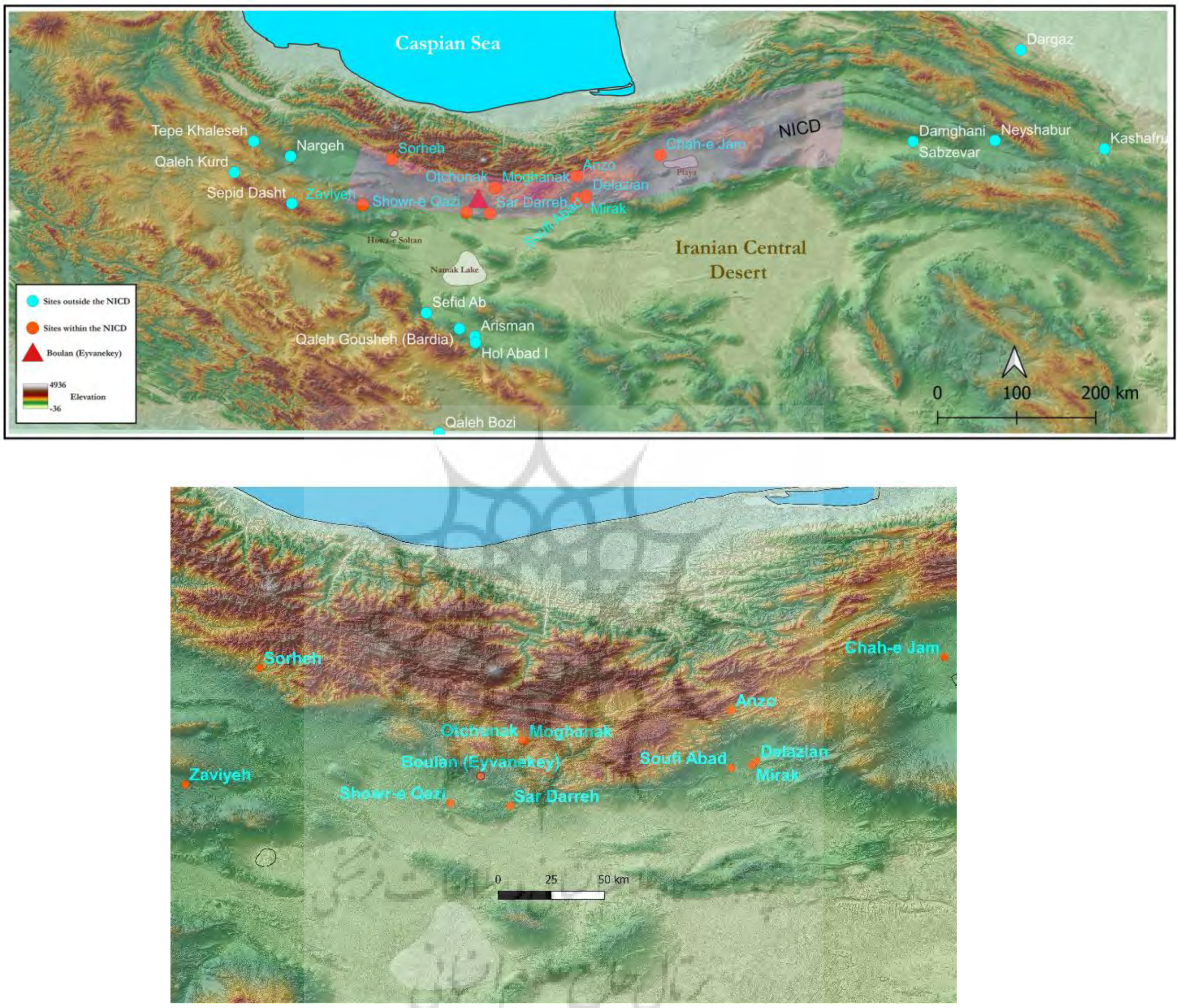

Figure 1. The physical map of the NICD and the selected Middle and Upper Paleolithic sites mentioned in the text; Above: the general picture and below: zoom in the NICD (Hashemi et al. 2024b: fig. 1).

There are accounts of other Paleolithic localities in the other parts of Iranian Central Plateau, including Qaleh Kurd Cave (Soleymani & Alibeigi 2018; Vahdati Nasab et al. 2021, 2024), Nargeh (Biglari 2003b), and Tepe Khaleseh (Alibeigi & Khosravi 2009), all of which are positioned just to the west of the ICP. In addition, there are records of Paleolithic surface scatters located to the east, particularly in Sabzevar (Sadraei et al. 2017), Neyshabour (Sadraei et al. 2021), and at Kashafroud terrace (Ariai & Thibault 1975). Moreover, several sites in the southern Iranian Central Desert, such as Sefid Ab (Biglari 2003a), Qaleh Gousheh, Holabad, and Arisman (Conard et al. 2009; Heydari-Guran & Ghasidian 2011), are encompassed within the larger Kashan region. More south, there is Qaleh Bozi complex of rock shelters and cave, at some 25km to the southwest of Isfahan (Biglari 2014; Biglari et al. 2009, 2015; Jaubert et al. 2010). As mentioned above, these latter archaeological sites are not subject to focus here.

Regrettably, archaeological excavations within the NICD have been limited to Mirak open-air site and Sorheh Rockshelter complex. In addition, outside the NICD, excavations have been only taken place at Qaleh Kurd Cave and the Qaleh Bozi Paleolithic complex. The remaining locations have tentatively been analysed based on comparative grounds via lithic techno-typological studies. This limitation is not just attributable to a lack of interest, logistical difficulties, or financial constraints; instead, it is primarily due to the absence of *in-situ* anthropogenic Pleistocene deposits, which constitutes the main obstacle faced in the ICP. The following section presents a detailed analysis of the formal publications on Paleolithic sites within the NICD, followed by a brief discussion of possible courses of action in light of the current situation.

The Pleistocene Period in the NICD

The initial lithic discoveries within the NICD were documented by Hubert Rieben in 1955, when he identified two lithic artifacts located in the Quaternary deposits of the Tehran Plain. Rieben suggested that these artifacts were reminiscent of the Mousterian tradition and estimated their age to be around 50,000 years (Rieben 1955 in Biglari 2012: 10). A subsequent brief report concerning a lithic artifact found in southern Alborz is credited to Claudio Vita-Finzi. While conducting geomorphological surveys in the vicinity of Eyvanekey, he recovered one lithic artifact, which he classified as belonging to the Upper Paleolithic Period (Vita-Finzi 1968 in Biglari 2012). In 1971, Sadeq Kouros reported the existence of a rock shelter in the Abyek region of Qazvin that contained lithic artifacts. Following this, another nearby rock shelter was discovered, which he linked to the Late Pleistocene or Upper Paleolithic Period? (Biglari 2012: 25). Later sporadic accounts include the report of Malek Shahmirzadi of a scraper find in Masileh, at the east side of Namak [playa] Lake (Malek Shahmirzadi 1994) and the discovery of lithic surface scatters during the survey around Qomroud by Kabuli (1999) which he attributed to Epipaleolithic Period.

After a long hiatus in surveys of the NICD and southern Alborz, a report was presented by Mehryar and Kabiri in 1984 concerning the discovery of lithic artifacts, this time in southern Semnan (Mehryar & Kabiri 1986: 6). Their survey introduced the open-air sites of Delazian and Mirak. Then, Enayatollah Amirlou (1990) conducted an excavation at Qaleh Asgar in Damavand, Tehran Province. The findings from this mission were attributed to the Epipaleolithic Period; yet there are accounts against this proposition (see Biglari 2012). Following, H. Rezvani, in his master's thesis, provided an overview and general assessment of several archaeological sites in the current Semnan Province, among them were Delazian and Mirak (Rezvani 2001). We will come back to Mirak later.

Moghanak and Otchunak (interchangeably, Ochunak or Owchunak) are two Paleolithic surface scatters located approximately 22 km southeast of Damavand (Figure 1), situated between the villages of Sorkheh Deh to the northeast and Otchunak to the southwest. The stone artifacts attributed to these two landscapes have been scattered over Quaternary deposits with an average elevation of approximately 1850 m asl for Moghanak and 2050 m asl for Otchunak. The sites are located on the dissected fluvial terraces of the Quaternary period along both sides of the Doab River. The two landscapes have four kilometers to each other. A total of 680 stone artifacts has been recorded from two seasons of surface survey in 2005 and 2006, of which only 23 are associated with Otchunak. The lithic materials obtained from the 2006 field surveys at Moghanak, which amounted to 566 specimens, were the subject of a master's thesis (Sadeqi Nejad 2015). Most of the raw materials identified in the recovered artifacts are composed of tuff (80%), chert (10.5%), and basalt (6%), with the remaining fraction attributed to other materials such as limestone and sandstone. Regardless of being of igneous or sedimentary origins, raw materials are locally sourced. In the absence of databale stratified context, several characteristics of the Middle Paleolithic assemblage—including the implementation of the Levallois method, the predominance of flake blanks made using hard-hammer technique, certain type-lists associated with the Mousterian tradition, and the frequent occurrence of side scrapers and denticulates/notches on flakes—suggest that Moghanak is likely to date back to the Middle Paleolithic Period. Other characteristics of lithics from Moghanak include the low degree of retouching, with most products (nuclei and flakes) originating from relatively unsophisticated knapping concepts. The considerable size of several simple flakes and core blocks, which exhibit minimal preparation (Berillon et al. 2007a, b; Chevrier et al. 2010; Sadeqi Nejad 2015), renders the assemblage closely comparable to Eyvanekey (Hashemi et al. 2024a, b; see below). Additionally, the practice of retouching naturally frost-shattered trihedral thick pieces and utilizing them as opportunistic tools (Chevrier et al. 2006: fig. 8.3) is another notable observation at Moghanak that evokes the Eyvanekey landscape to the south.

One of the most evident strengths of the publications concerning Moghanak and Otchunak is the inclusion of geologists and geomorphologists within the pedestrian survey team. This involvement ensures that the publication, while brief, is rich in geomorphological and geological contextual information. Additionally, it provides crucial information about the types of raw materials (diversity) and their procurement locations, which are essential for discussions on hominin land use strategies. Nonetheless, the lack of datable deposits and the mixing issue restrict the authors' ability to explore chronological themes and synchronic large-scale comparisons or make it impossible to state with confidence how many occupational phases the valley experienced. It is regrettable that the MA thesis by Sadeqi Nejad (2015) was never published as an article.

The **Delazian** mounds occupy a desert setting on the NICD (Figure 2). The site lies c. 8 km south-east of Semnan and c. 500 m south of a pronounced meander of the Gīnāb River. The river skirts the mounds from the north-west within an incised channel c. 15 m deep before bending away to the south-east. Opposite the river (to the south-southeast) a series of dissected, rolling hills forms a degraded, badland-like landscape. Approximately 3–4 km to the south to southeast more substantial uplands rise, constituting the northernmost heights of the *Dasht-e Kavir*. Several abandoned qanat courses and linear sequences of qanat shafts are also evident to the north of the site as very low linear relief features (Mehryar & Kabiri 1986; Vahdati Nasab et al., 2007: 11).

Mehryar and Kabiri first investigated the mounds in 1984 following reports of extensive damage to local architectural ruins at the area. Their initial report (Mehryar & Kabiri 1986) briefly recorded “lithic artifacts” but did not discuss the potential Palaeolithic significance in any depth. Delazian’s archaeological importance, together with the Mirak locality, was later emphasised by field surveys undertaken by Rezvani Moqaddam in the late 1980s and early 1990s (Rezvani 1999, 2001 in Vahdati Nasab et al., 2007: 11). In 2007 Vahdati Nasab, Roustaei and Rezvani conducted a systematic surface survey of Delazian; their results were presented at the Sixth Conference on Near Eastern Archaeology at Sapienza, Rome, and offered preliminary interpretations (Vahdati Nasab et al., 2010).

Then, due to the importance of the site, another systematic survey was conducted at the site (Vahdati Nasab 2009) and the items documented became the subject of a MA thesis (Khaksar 2009). Again, alas, the results of the thesis, which apparently is a high quality one for MA degree, remained unpublished. Based on the archives of Tarbiat Modares University, several points in the study remain ambiguous. One unclear issue is the attribution of a small number of formal tools — and, as the author puts it, “tools associated with resource exploitation and preparation (?), such as projectile points” — to the site’s functional interpretation. Khaksar interprets the site as a short-term base camp, but the author’s rationale is not made explicit, and it is unclear why the occupation should be considered short-term rather than long-term. The argument appears to rest on an assumed strong correlation between retouched tool types and specific tool-use behaviors. Current research, however, demonstrates that this assumption is untenable: both ethnographic (see e.g., Shott & Sillitoe 2005; Sillitoe & Hardy 2003) and archaeological (see e.g., Claud et al. 2019; Dibble & McPherron 2006; Fuentes et al. 2019) evidence show widespread use of unretouched flakes and other unretouched blanks (debitage and primary removals) as expedient tools.

Figure 2. The general look of one Delazian mound and the sampling locus A (Vahdati Nasab & Clark 2014: fig. 3).

Later in the thesis (Khaksar 2009), light retouch is treated as an indicator of short-term site use. Again, contemporary understanding indicates that light retouch is not a simple proxy for occupation duration: it may reflect particular style or relevant to the ready availability of high-quality lithic raw material on the local scale rather than brief occupation (see e.g., Parry & Kelly 1987; Kuhn 1995; Bicho & Cascalheira 2020). Observations further show that, as the proportion of blades and bladelets in an assemblage increase, overall retouch intensity tends to decrease (see implications but not exact sentences for these assertions e.g., Eren et al., 2008). Although the magnitude of the evenness index (Chatters 1987; Pielou 1966) reported later in the thesis plausibly points to a base camp — and is therefore a sensible line of reasoning — including retouch intensity among the primary justificatory factors for as an indicator of a short-term base camp is problematic.

Finally, the multivariate tests presented in the thesis support the claim that, at Delazian, lithic raw materials were exploited at a local scale; this hypothesis appears well founded in the absence of geomorphological evidence of the locales for raw material procurement. Likewise, assigning the assemblage to the Upper Palaeolithic Period, based on the available surface-distribution data also seems plausible (Khaksar, 2009).

Afterwards, the results of the Delazian lithic analysis were published by Vahdati Nasab and Clark (2014) in the *Journal AMIT*. What follows is a summary of their paper. Quantitatively, the assemblage was reported to be dominated by flakes (≈56%), followed by blades (~16%) and bladelets (~25%), while cores were described as scarce, with a blank-to-core ratio of approximately 36.5:1. On the basis of low cortex incidence and the scarcity of cores, it was inferred by Vahdati Nasab and Clark (2014) that primary decortication and early core reduction had most likely been carried out off-site, and that only semi-prepared blanks were brought into the loci. Retouched pieces were described as relatively uncommon, and where present, retouch was characterised as light to moderate and not invasive (over 70% light–moderate). From these observations, limited curation and minimal evidence of intensive reworking were inferred interpretations that were considered consistent with the local availability of raw material and repeated short-term occupations. However, as in Khaksar's (2009) work, the reasoning behind interpreting the site as a short-term camp remains unclear.

Raw material analysis was reported to show the dominance of chalcedony and chert, with tuff and jasper also present. According to the authors (Vahdati Nasab & Clark 2014), platform width-to-thickness ratios and the generally low degree of platform preparation were taken to indicate knapping strategies consistent with the ready availability of high-quality local raw material. Statistical tests were applied in support of these inferences. In the absence of absolute dates, Delazian was assigned by the authors to the Upper Palaeolithic Period, primarily on typological and technological grounds—namely, the frequency of blades and bladelets (Figure 3), the absence of classic Mousterian Levallois elements, the presence of endscrapers and laminar traits, and the dominance of unidirectional dorsal scar patterns. Possible regional affiliations were discussed, including comparisons with the Baradostian, Zagros Aurignacian, and Rostamian traditions, as well as later Zarzian assemblages, though the tentative nature of this cultural attribution was explicitly acknowledged.

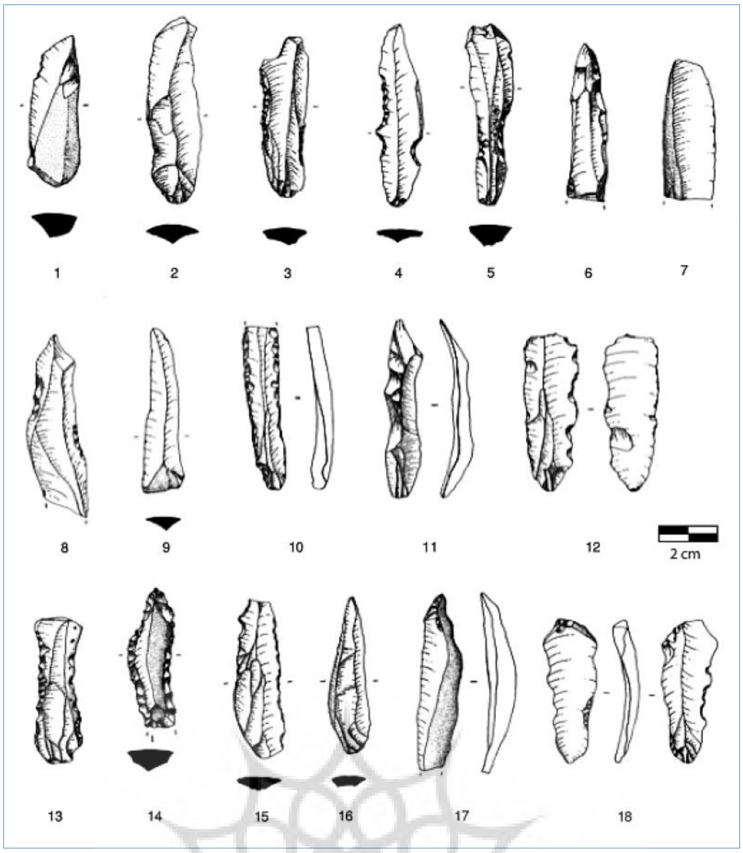

Figure 3. Delazian blades (Vahdati Nasab & Clark 2014: fig. 4).

The study was presented as relatively robust in terms of statistics, incorporating 100% sampling of transects, multi-metric measurement of lithics (length, width, thickness, platform attributes), and the use of statistical tests such as ANOVA and t-tests to compare various loci. This quantitative approach was argued to lend empirical strength to the technological and typological interpretations. Delazian was also situated by the authors (Ibid.) within the broader context of Upper Paleolithic research in the Zagros and Central Plateau, with comparisons to sites such as Warwasi and Ghar-e Boof. This regional framing was viewed as enhancing the interpretative scope of the paper.

In research method, multiple lines of lithic evidence were integrated—debitage composition, core frequency, retouch intensity, platform types, dorsal scar orientation, and cortex ratios—so that behavioral interpretations regarding procurement, on-site versus off-site reduction, and occupation duration were based on converging indicators rather than on single traits. The authors (ibid.) were notably cautious in interpretation, acknowledging palimpsest formation, the limitations of surface assemblages, and the absence of stratified deposits. They refrained from making definitive cultural attributions without chronological control, a transparency that constitutes a methodological strength.

A principal limitation arises from the sampling design, which consisted of two linear transects measuring 4 × 40 m (320 m² in total; ibid.). This design could have been improved through a combination of stratified random and adaptive sampling, thereby increasing the likelihood of recovering evidence related to cores and primary knapping activities. Although a supplementary 30 ha grab sample yielded valuable quantitative data, it may not adequately represent the full variability of the site complex. The criteria for artifact recovery from the surface were not explicitly stated in this 30 ha grab strategy. Consequently, it remains uncertain whether the low frequency of cores reflects genuine behavioral patterns or, alternatively, results from sampling bias due to the omission of primary reduction areas. While this possibility was acknowledged by the authors, a more extensive, grid-based sampling strategy would have provided stronger control over spatial variability.

Although the assemblage was noted to be in relatively fresh condition (ibid.), refitting analyses were not conducted. Such work could have significantly strengthened arguments concerning on-site activities versus secondary deposition. In addition, certain interpretive steps were seen to risk overgeneralisation. The inference of short-term occupation and abundant raw material from low retouch intensity and blank-to-core ratios, while plausible, may overlook alternative explanations such as functional selectivity, tool-maintenance behavior, or differential discard patterns.

The **Zaviyeh** site complex, situated approximately 12 km west of Parandak near its namesake town in Markazi Province, central Iran, occupies a mean elevation of 1,270 m asl (Figure 4). Located at the north-western margin of the Central Iranian Plateau and associated with an ancient shallow playa system, systematic surveys have identified at least 27 discrete lithic artifact concentrations spanning the Late Pleistocene to Holocene. Middle Paleolithic artifacts predominantly occur in lower-lying areas and erosional gullies, composed mainly of chert, siltstone, and radiolarite, with extensive Levallois technology. While no primary raw-material sources were documented, geological context suggests local silicified tuff and chert, whereas nonlocal exotic sandstone artifacts—combined with broad spatial distribution and low densities—indicate a dynamic raw-material economy and high mobility among Middle Paleolithic groups (Heydari-Guran et al. 2014). This interpretation, however, relies on indirect geological inferences rather than direct source identification.

Figure 4. A view of landscape at Zaviyeh (Heydari-Guran et al. 2014: fig. 4).

Due to limited access to curated artifacts in Iran, precise quantitative data on Middle Paleolithic artifacts per locality were unavailable. Seventeen localities yielded material in low-to-medium concentrations, with assemblages generally lacking cores and exhibiting disproportionately high retouched tool frequencies and large blanks (Ibid.). Levallois technology was well-represented across flakes, blades, and tools, with many flakes and blades displaying *chapeau de gendarme* or finely facetted striking platforms. Non-Levallois debitage was described as rare, though metric data were not provided. The proportion of thin, broad Levallois flakes at Zaviyeh was low—comparable to other Kashan-area sites—while the assemblage favored elongated, triangular forms with sharp points. Retouched artifacts, including scrapers, were reported as frequent, though unsupported by detailed quantitative analysis. Zaviyeh tools were generally larger than Zagros Mousterian equivalents, with the highest retouched point percentage among the studied sites (Zaviyeh, Holabad, Qaleh Gusheh), exhibiting stronger typological affinities with Zagros point assemblages. Blades formed a smaller component at Zaviyeh than at the other sites (Ibid.).

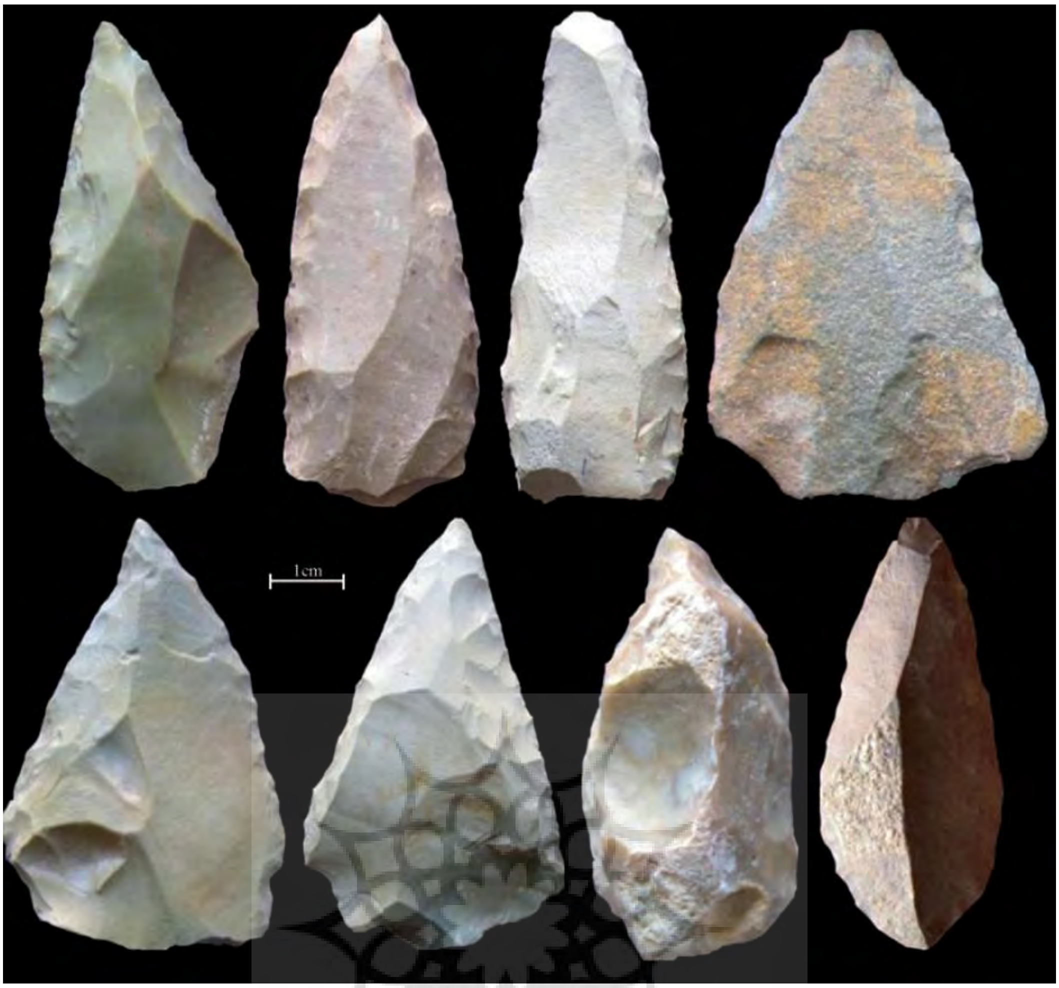

Figure 5. Points from Zaviyeh (Heydari-Guran et al. 2014: fig. 6).

Zaviyeh's technological profile contrasts with Khorramabad and Kermanshah Mousterian assemblages, where Levallois technology was less prevalent. This pattern aligns with sites in the western Northern Iranian Central Desert (NICD) or adjacent regions (e.g., Qaleh Kurd Cave: Vahdati Nasab et al. 2024; Mirak: Vahdati Nasab et al. 2019), and with Levantine Middle Paleolithic traditions. Levallois technology was also documented at Qaleh Gusheh and Central Plateau travertine sites (Heydari-Guran et al. 2009; Conard et al. 2009). Zaviyeh assemblages differed from classic Zagros Mousterian industries in lower retouch intensity and greater Levallois emphasis. Compared to Bisitun, Warwasi, Kunji, and Hulailan, Zaviyeh exhibited less retouch, with scrapers not conforming to Dibble's (1984) reduction model—suggesting shorter use lives and less intensive curation. Metric comparisons revealed scraper dimensions broadly similar to Bisitun, interpreted as evidence that Zaviyeh scrapers retained volume due to limited resharpening, unlike Bisitun's large-blank selection (Heydari-Guran et al. 2014). Points were predominantly Levallois-based with light retouch, contrasting with Zagros Mousterian points that were often heavily retouched and non-Levallois.

The authors positioned Zaviyeh within a broader challenge to the Zagros Mousterian's historical dominance in Iranian Middle Paleolithic interpretations. They argued that Central Plateau sites (Zaviyeh, Holabad, Qaleh Gusheh, Mirak) demonstrate diverse entities distinct from the Zagros Mousterian, with extensive Levallois use contrasting the limited, sporadic occurrence in West Central Zagros Mousterian (see Hashemi et al. 2021 for bolstering such a claim again after the discovery of some other Paleolithic sites in Semnan Province: e.g., Chah-e Jam). Central Plateau assemblages further differed through lower retouch intensity, fewer heavily resharpened tools, and reduced evidence for long-term curation. Scrapers retained platform integrity with limited reduction, while points were commonly Levallois-based with light retouch—reflecting technological patterns distinct from Zagros cave/rockshelter sites.

Qaleh Bozi, the only excavated Central Plateau Middle Paleolithic site, complicated this model by yielding abundant bifacial tools with minimal Levallois evidence (Biglari 2014)—a stark contrast to surface assemblages like Zaviyeh (Heydari-Guran et al. 2014). The authors acknowledged this discrepancy but treated Qaleh Bozi as an exception rather than integrating it into their framework. Comparatively, Central Plateau assemblages showed partial similarities to Levantine Mousterian (Levallois emphasis, scarce heavily retouched scrapers) but key differences, such as the absence of truncated-facetted cores (Ibid.). These mixed signals prompted caution against straightforward cultural affiliations.

Throughout, the authors emphasized the preliminary nature of their interpretations, noting that the absence of stratified, well-dated open-air sequences severely limited chronological resolution and interregional comparison. Consequently, they argued against strong claims for cultural transmission, instead favoring a null hypothesis of largely independent technological evolution within the Central Plateau (Ibid.). They further proposed that Middle Paleolithic settlements—including Zaviyeh—were structured around permanent water sources in an arid landscape, drawing analogies to better-documented regions like the Syrian Desert. However, they explicitly noted these comparisons remained tentative due to the Central Plateau dataset's limited size, low site density, and lack of faunal or paleoenvironmental evidence. This environmental model aligns with regional analogies (e.g., green Arabia issue of *Quaternary International* in 2015: Petraglia et al., eds., 2015) yet remains speculative without direct evidence from Zaviyeh itself.

The study thus establishes Zaviyeh as a key site demonstrating the Central Plateau's distinct Middle Paleolithic trajectory, characterized by consistent Levallois technology, reduced retouch intensity, and settlement patterns tied to water resources. It challenges the historical assumption of Zagros Mousterian dominance in Iran and underscores the need for further research to resolve the relationship between Central Plateau assemblages and broader regional traditions.

The extensive **Soufiabad** locality comprises a series of small and large mounds situated 12 km southwest of the city of Semnan and 1.5 km south of the village of Soufiabad near the town of Sorkheh. The approximate center of the site lies at an elevation of c. 1,030 m asl., and the concentration of cultural materials covers roughly 25 hectares. Soufiabad consists of some fifty small mounds dispersed across a broad landscape between the village of Soufiabad to the north and Biabank to the south. The site was investigated in a survey carried out in 2012. The assemblage exhibits the presence of the Levallois operational concept, a prevalence of retouched implements in flakes, and an abundance of blades and bladelets along with their parent cores. The toolkit also includes a variety of scrapers (including thumbnail, convergent, side and end scrapers), denticulates/notched pieces, as well as carinated blanks and burins. Taken together, these attributes strongly suggest that Soufiabad most probably contains material attributable to at least two Palaeolithic phases — the Middle and the Upper Palaeolithic periods (Vahdati Nasab & Feiz 2014: 465–468).

Feiz (2012) defended an MA thesis on the Soufiabad surface scatters; like the study of Moghanak, this thesis remains unpublished. The following summary presents the principal observations and interpretations drawn from the Feiz's work. She reports that the Soufiabad surface assemblage exhibits clear signs of temporal mixing. Although thumbnail scrapers — tools often regarded as diagnostic of the Epipalaeolithic — are present, the assemblage lacks geometric microliths and other typical Epipalaeolithic markers; on this basis Feiz considers an Epipalaeolithic attribution for the industry at Soufiabad to be unlikely.

Regarding raw-material procurement and the reduction sequence, Feiz (ibid.) notes an abundance of cortical flakes, debrises, and large quantities of unmodified raw material within the scatters, indicating that many stages of the reduction sequence were carried out on-site. At the same time, the low frequency of early-stage core shaping on raw nodules suggests that initial core preparation probably occurred close to raw-material sources, outside the main surface-scatter loci. She therefore infers that cores arrived at Soufiabad in a semi-prepared condition, having been transported from nearby localities. The principal raw materials identified in the assemblage are chert and tuff, which Feiz treats as locally sourced.

The technological observations in the thesis (ibid.) further indicate that most artifacts are unretouched flakes, implying a high proportion of unused blanks. The scarcity of substantial retouch, together with the prevalence of unused blanks, is interpreted as evidence that high-quality raw material was readily available within the landscape and that inhabitants were cognisant of this abundance.

Metric analysis carried out shows that flakes are generally small, a pattern that may reflect either the limited dimensions of the available raw nodules or a deliberate technological strategy favouring small removals. Retouched implements, however, tend to be larger than the unmodified blanks. Based on tool-type diversity, raw-material usage and technological characteristics, the researcher interprets Soufiabad as functioning principally as a residential (base) camp rather than a specialised task site. This interpretation is supported quantitatively, as well by the Evenness Index (Chatters 1987; Pielou 1966) of 0.63, which Feiz argues denotes a relatively balanced representation of diverse tool categories consistent with base-camp activities. Aligning the results with Andrefsky's model (1994), she observes that assemblages from areas with ample, high-quality raw material tend to display an approximately equal ratio of formal to informal tools; Soufiabad conforms to this pattern, containing formal and informal tools with comparable ratios (52% vs. 48%, respectively; Feiz 2012).

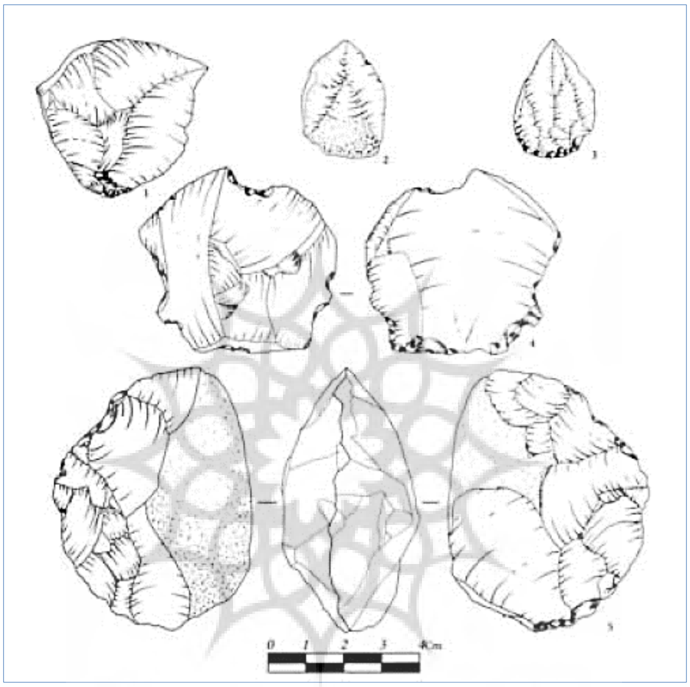

Figure 6. Some lithic artifacts from Soufi Abad (Vahdati Nasab & Feiz 2014: fig. 4).

It should be noted that no geologist or geomorphologist accompanied the field team, which limits the understanding of raw material provenance and site formation processes. Moreover, as in many surface scatters, the mixing of artifacts from different periods and the absence of stratified, datable deposits complicate chronological interpretations.

The approximate center of the extensive surface scatter of **Chah-e Jam** is situated roughly 9 km south of the city of Damghan in Semnan Province in a land with general gentle 1° southward slope, characterized by a transition from pediment zone to saline lowlands (playas). The site derives its name from the Chah-e Jam Desert (the *Haji Aligholi* Desert), a region that historically encompassed a vast playa or paleolake. This locality was first identified by Vahdati

Nasab and Hashemi during the inaugural season of a five-year systematic survey along the northern margins of the *Dasht-e Kavir* (Vahdati Nasab & Hashemi 2016).

In contrast to the open-air site of Mirak, which is characterized by a significant density of lithic artifacts across the landscape, Chah-e Jam exhibits a relatively low total artifact count and sparse spatial distribution (Figure 7). Nevertheless, surface finds are scattered across a broad expanse stretching nearly 9 km. It appears that both natural (taphonomic) and anthropogenic processes have played a significant role in the post-depositional dispersion of artifacts over such a vast area. Preliminary assessments suggest that the site's occupation spans the Middle and Upper Paleolithic periods (Vahdati Nasab & Hashemi 2016, 2018).

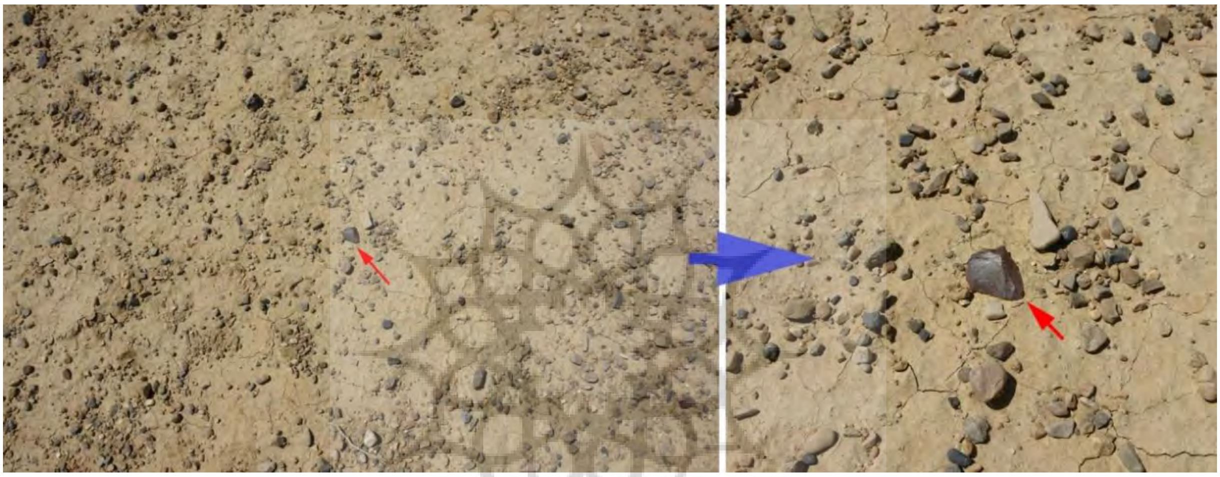

Figure 7. The deflated pavement surface at Chah-e Jam (Vahdati Nasab & Hashemi 2018).

The modern environment is dominated by sparse halophytic vegetation (e.g., *Haloxylon*, *Astragalus*, and *Tamarix*) and anthropogenic features such as qanat systems and agricultural plots. The Paleolithic record at Chah-e Jam consists of an extensive but low-density lithic scatter covering approximately 18 km^2 (roughly 9 km in length and 2 km in width). Unlike the high-density concentrations found at Mirak, the sparse distribution at Chah-e Jam suggests a combination of high-mobility land use as an adaptation to living in the deserts during periods of high climatic fluctuations and intense post-depositional processes, whether natural or anthropogenic. The original archaeological context has been further compromised by modern industrial and agricultural activities. Key anthropogenic impacts include the construction of the Tehran-Mashhad railway, the development of a major steel plant within the site boundaries, and ongoing livestock grazing and mechanized ploughing (Vahdati Nasab & Hashemi 2018).

The authors characterised the raw material spectrum quantitatively: volcanic raw materials (tuff ≈25.5%, igneous ≈27.8%), with chert, sandstone, and siltstone comprising the remainder. The absence of local chert/tuff outcrops suggests river cobbles and pebbles as primary sources. Blank analysis reveals flakes (≈82%), blades (≈9.9%), and bladelets (≈8.1%), with mean lengths clustering at ~35 mm (flakes) and ~43 mm (blades). While basic metrics were reported, deeper analytical frameworks (e.g., length/width distributions by raw material) were absent, limiting functional inferences (Vahdati Nasab & Hashemi 2016).

The authors emphasised the technological dominance of Levallois reduction: 284 items (≈64% of analysed pieces) derived from Levallois method, and over half of the flake cores they could identify were Levallois cores. Most Levallois cores were described as recurrent bidirectional, with a minority centripetal component; blade/bladelet cores were numerous but showed no clear evidence for pressure flaking. This strong Levallois signal formed the principal basis for assigning a Middle Paleolithic attribution to much of the material (Ibid.).

They classified tool types and found tools comprised ≈42% of the assemblage; scrapers were the dominant tool class (≈57% of tools), with convergent scrapers particularly abundant (≈58% of scrapers). Notches/denticulates and a suite of retouched pieces were also present, while bifaces and classic choppers were negligible. The assemblage thus showed a scraper-and-point emphasis rather than a bifacial or heavy-reduction signature. Retouched points were present (Figure 8) but occurred in relatively low numbers and were predominantly manufactured on Levallois blanks. The overall tool spectrum was therefore interpreted as emphasizing scraper and point production within a Levallois-based technological framework rather than intensive bifacial shaping or heavy core-tool traditions. However, the dominance of scrapers and the relatively low frequency of diagnostic point types, combined with generally low retouch intensity, limited the resolution of typological comparisons and made functional or cultural interpretations necessarily tentative, particularly given the surface context of the assemblage (Ibid.).

Figure 8. Some pointed or convergent tools from Chah-e Jam (Vahdati Nasab & Hashemi 2016: fig. 6).

Platform analysis indicates plain, prepared, and linear platforms predominated, with retouched items showing higher prepared-platform frequencies than unretouched debitage—suggesting deliberate blank selection. Using Clarkson's invasiveness index (Clarkson 2002), ≈74% of pieces exhibited low–medium retouch intensity versus ≈26% heavy retouch. Over 73% of pieces lacked dorsal cortex, interpreted as evidence of off-site decortication (Ibid.).

The authors (Ibid.) also acknowledged that the assemblage contained a limited questionable Upper/Epipalaeolithic signal (soft-hammer made blades, bladelet cores) and that the distribution of different technological elements overlapped across the surveyed area; they therefore cautioned that the scatter likely represented palimpsest assemblages formed by repeated use and post-depositional dispersal rather than a single, spatially segregated activity area.

The authors (Ibid.) argued that the high frequency of Levallois debitage, presence of Levallois cores and Levallois points, together with abundant convergent scrapers and notches, supported a Middle Paleolithic assignment for most of the material. this attribution depended principally on surface techno-typology rather than stratified contexts or direct dating, limiting chronological precision.

Vahdati Nasab & Hashemi (2016) reiterated that the NICD open-air sites (e.g., Chah-e Jam, Mirak) displayed relatively high frequencies of Levallois technology and a different retouch signature (more light/medium retouch, less heavy curation) compared with classic Zagros Mousterian assemblages. They proposed that this supported a meaningful technological distinction between the Central Plateau and the West-Central Zagros. Yet, they recognised the uneven publication record and excavation methods in comparative Zagros material and therefore treated this regional contrast cautiously.

Environmentally, the authors proposed that paleolake margins (playas) functioned as hominin activity magnets in the arid Late Pleistocene landscape, facilitating NICD as a dispersal corridor. While plausible, this interpretation remained inferential due to the absence of local palaeoenvironmental or faunal data from Chah-e Jam (Ibid.).

They compared Chah-e Jam with Mirak (close match) and with Qaleh Bozi (striking difference — Qaleh Bozi yielded many bifacial tools and relatively few Levallois items). Given such internal variability in the Iranian Central Plateau and the lack of absolute dates, they recommended treating claims of interregional cultural linkage cautiously and favoured, provisionally, a null model of largely independent technological trajectories until clearer technological links were demonstrated. In addition, they (Ibid.) recommended targeted excavation (to secure stratified sequences), palaeoenvironmental and sedimentological studies, improved raw material sourcing, systematic sampling for dating and faunal/botanical remains, and landscape modelling to move beyond surface-collection limitations. They noted that ongoing excavation at Mirak (at that time, 2015-16) aimed to address some of these gaps.

The authors (Ibid.) presented a clear and competently executed surface survey that produced a substantial lithic sample dominated by Levallois reduction and scraper/point toolkits; these data supported the presence of Middle Paleolithic occupations at Chah-e Jam and reinforced parallels with other NICD open-air sites such as Mirak. However, their principal claims were constrained by reliance on surface collections, by sparse stratigraphic control, and by the absence of direct dating and faunal/palaeoenvironmental evidence: as a result, many of the broader behavioural and regional inferences (mobility/chronology/cultural connection to neighbouring regions) remained plausible but provisional.

The open-air Paleolithic site of **Mirak** is situated approximately 10 km south of the city of Semnan, along the northern fringe of the Iranian Central Desert (*Dasht-e Kavir*), at an elevation of c. 1030–1035 m asl (Figure 9). The site occupies an arid plain characterized by alluvial fans, pediments, and aeolian dune-like hummocks that form part of an elongated Quaternary drainage system extending from the southern slopes of the Alborz Mountains toward the desert interior (Vahdati Nasab et al. 2019). The identification of dense surface lithic scatters during a reconnaissance survey across eight natural mounds, particularly at Mirak 8, prompted targeted excavation aimed at assessing stratigraphic integrity and chronological depth.

Excavations at Mirak 8 (Figure 9) exposed a well-preserved pedo-sedimentary sequence approximately nine meters thick, consisting of alternating alluvial and aeolian deposits. Three principal archaeological layers were identified within the lower alluvial sequence, sealed by later wind-blown sediments (Akhavan et al. 2022; Jamet et al. 2018). Luminescence dating (OSL and post-IR IRSL) provided a coherent chronological framework situating these occupations within Marine Isotope Stage 3, with ages spanning roughly 55–43 ka for the lowest layer, 47–38/33 ka for the intermediate deposits, and 28–21 ka for the uppermost levels (Heydari et al. 2020), although the latest levels are heavily affected by erosion and deflation. The stratigraphic integrity of the lower and middle layers was interpreted as strong, with rapid burial by flood events contributing to the preservation of in-situ lithic concentrations (Vahdati Nasab et al. 2019).

Figure 9. Mound no. 8 of Mirak before excavations (personal archive).

The Mirak lithic assemblages are dominated by flake-based reduction systems, with a strong emphasis on Levallois and Mousterian technologies in the lower layer (Figure 10). Diagnostic elements include Levallois flakes and points, Mousterian points, déjeté points, side scrapers, denticulates, and centripetal or recurrent Levallois cores. Elongated flakes and occasional blades occur, but laminar production remains secondary in the earlier phases. The intermediate layer presents a technologically mixed assemblage, combining persistent Middle Paleolithic traditions with emerging Upper Paleolithic elements such as prismatic blade and bladelet production. Despite this, the majority of retouched tools in this layer continue to be manufactured on flakes rather than blades. Retouch intensity is generally light, and heavily invasive retouch is rare across all layers. Raw materials consist predominantly of locally available high-quality chert, suggesting short-distance procurement strategies (Ibid.).

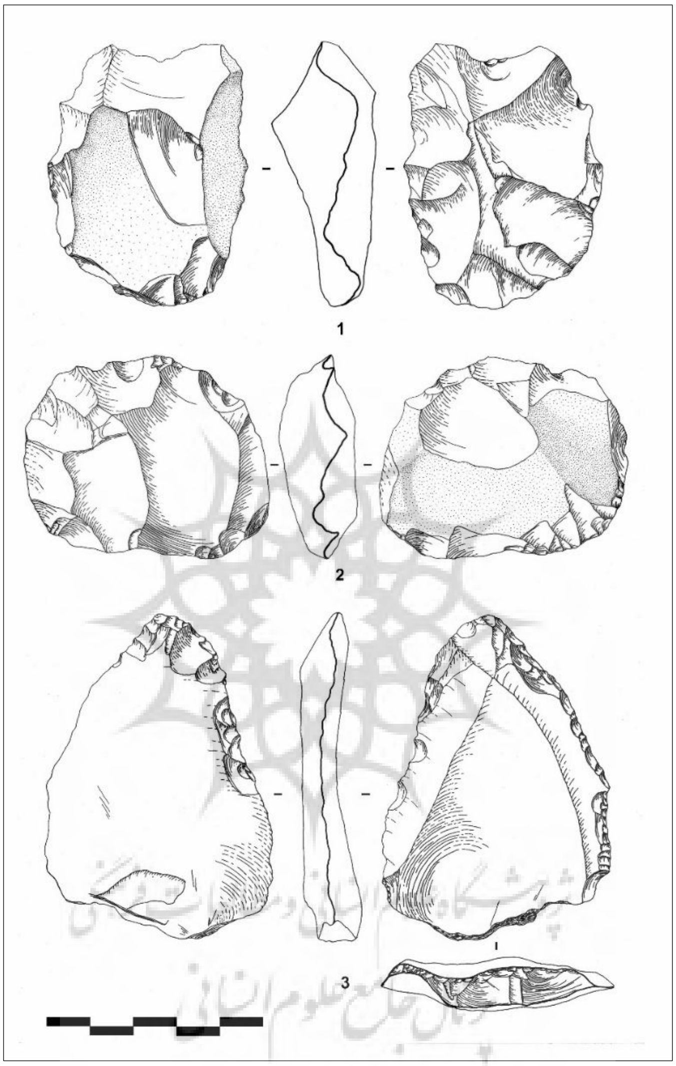

Figure 10. Few lithic representatives of Mirak L3 and 2 (Vahdati Nasab et al. 2019: figs. 7&8 with modifications).

The study by Hashemi et al. (2021) represents a methodological extension of the Mirak research program through the application of 3D landmark-based geometric morphometrics to flake tools from the Middle and intermediate layers (Levels 3 and 2). By statistically comparing tool morphology across layers dated to ca. 55–43 ka and ca. 33–26 ka, the authors demonstrated that no significant diachronic morphological differentiation could be detected in flake-based tools (Figure 11). This morphological stability was interpreted as evidence for enduring technological traditions, potentially maintained through cultural transmission within interconnected population networks (metapopulations) across the Iranian Central Plateau during MIS 3. The study is notable for introducing high-resolution quantitative shape analysis into Iranian Paleolithic research, thereby complementing traditional techno-typological approaches.

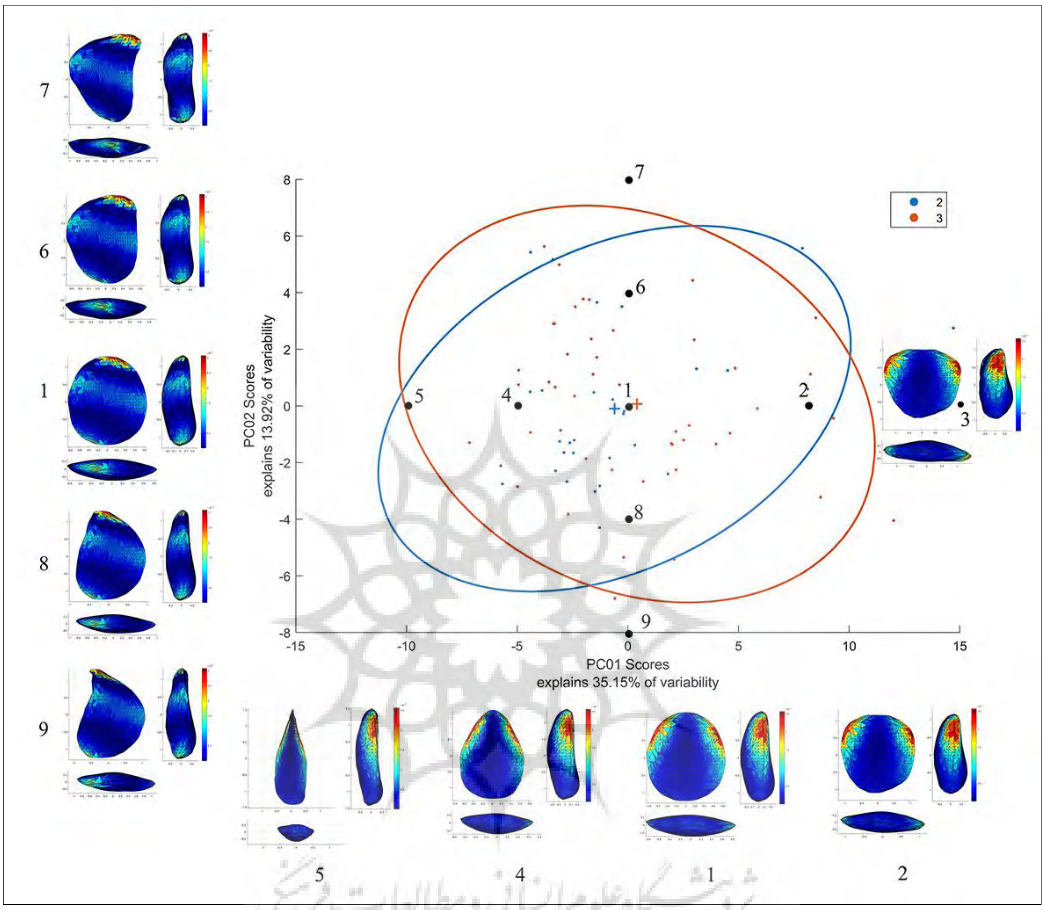

Figure 11. The centroid's similarity between the flake debitages of Mirak L3 and L2 (Hashemi et al. 2021: fig. 6).

Together, Mirak is one of the most important open-air Paleolithic sequences currently known from arid interior Iran. The evidence for repeated occupations during MIS 3 supports the interpretation of the northern margin of the Central Desert as a persistent corridor for human dispersal and settlement, rather than a marginal or intermittently used landscape (Hashemi et al. 2017). The coexistence of Middle Paleolithic traditions with early Upper Paleolithic traits in the intermediate layer contributes to broader debates concerning the nature and tempo of the Middle-to-Upper Paleolithic transition outside the Zagros Mountains. Importantly, the persistence of Levallois-based technologies into relatively late phases challenges overly linear models of cultural replacement and suggests regional variability in adaptive strategies.

The principal strengths of these publications lie in their robust geoarchaeological framework, reliable luminescence chronology, and careful integration of stratigraphy with lithic analysis. The Mirak sequence is one of the few in Iran to provide securely dated, stratified open-air deposits spanning multiple phases of the Late Pleistocene. Moreover, the application of advanced analytical techniques, particularly 3D geometric morphometrics, significantly enhances the objectivity of lithic comparisons and sets a methodological benchmark for future research in the region.

Despite these strengths, several limitations remain apparent. Faunal remains are extremely sparse and poorly preserved, limiting reconstructions of subsistence practices and paleoenvironmental conditions. No hominin fossils have been recovered, rendering cultural attribution to specific human species necessarily inferential. In addition, while lithic technology is documented in detail, other aspects of site use—such as spatial organization, activity differentiation, and seasonality—remain underexplored due to the constraints inherent in open-air contexts. The uppermost Upper Paleolithic layer, although potentially significant, is heavily eroded and thus underrepresented in current analyses.

Further work at Mirak would benefit from expanded excavation of adjacent mounds to test the lateral continuity of occupations and to refine intra-site spatial patterning. More detailed raw-material sourcing, use-wear, and residue analyses could clarify functional variability and mobility strategies. Paleoenvironmental proxies, including sedimentary geochemistry and microfaunal studies, are needed to contextualize human occupations within MIS 3 climatic oscillations. Finally, Mirak provides an ideal setting for integrating technological, morphometric, and paleoecological data into broader models of Late Pleistocene population dynamics in interior Southwest Asia.

In sum, the Mirak publications constitute a substantial and methodologically rigorous contribution to Paleolithic research in Iran. The site is convincingly demonstrated to preserve a long sequence of Late Pleistocene occupations that document both technological continuity and gradual innovation along the NICD. While interpretive claims regarding population movements and cultural transmission remain necessarily cautious in the absence of human remains, the strength of the stratigraphic and chronological evidence renders Mirak a key reference point for future discussions of Middle and Upper Paleolithic variability beyond the Zagros core area. The combination of traditional lithic analysis with advanced morphometric methods is particularly commendable and signals a productive direction for future Iranian Paleolithic studies, provided that these approaches are further integrated with functional and environmental lines of evidence.

Recent pedestrian surveys in the Eyvanekey area have resulted in the discovery of some lithic surface scatters, among them are **Showr-e Qazi** and **Sardarreh** — situated on the southern distal part of alluvial fans and pediments at the NICD, in the modern lowlands downstream of the Jajrud and Eyvanekey alluvial systems. Archaeologists (Nateqi et al. 2020) located Showr-e Qazi on low, gently undulating sand/loess-mantled hummocks near the village of the same name (coordinates and restricted sectors were recorded during survey), and Sardarreh on a slightly higher, clay-and-gravel-capped terrace a short distance away (Figure 12); both loci occupied topographic positions somewhat raised above adjacent floodplain/pediment surfaces and thus had escaped complete burial by younger alluvium. Surface visibility at both sites was variable: Showr-e Qazi was expressed as low, sandy hummocks with intermittent aeolian pavement and seasonal gullies, while Sardarreh comprised a compact, gravelly surface with local desert varnish on some artifacts. Access and modern disturbance were notable at both locations: parts of Showr-e Qazi adjoined cultivated land, roads and a military range and therefore remained only partially surveyed, and Sardarreh lay close to agricultural and industrial features that had likely truncated or dispersed surface deposits.

The authors (Ibid.) described both assemblages as low-density but technologically informative surface scatters dominated by chert working and on-site knapping evidence. At Showr-e Qazi they recorded that ca. 83% of recovered pieces were on high-quality chert; the assemblage composition was dominated by debitage (flakes and elongated flakes) with blades and bladelets also present. About 61% of debitage had “elongated” morphologies (blade + bladelet + elongated flakes). Only a few items bore clear Levallois attributes (six pieces were noted). Overall, the authors recorded substantial evidence for on-site reduction: cores, core-rejuvenation scars, and cortex proportions indicating local decortication and renewal. Tools constituted a high fraction of the collected samples (because all visible pieces were picked up), and within the diagnostic tools, scrapers dominated (convergent scrapers were frequent), with retouched pieces, notches/denticulates and a few carinated/Dufour-type items also present. Platform types were mainly plain, prepared and linear, and retouch intensity was generally low–medium. Metric summaries showed mean flake lengths in the mid-30 mm range and blades around the low-40 mm range.

Figure 12. The landscape at Sardarreh (Nateqi et al. 2020: fig. 9).

Sardarreh presented a similar, though smaller, signal. The authors (Ibid.) recovered 35 artifacts there (low areal density), again dominated by chert (≈74% of pieces), and by flakes (≈83% of debitage) with a modest blade component (~17%). They documented evidence for all three reduction strands (flake, blade, bladelet) and identified a handful of Levallois flakes/rejuvenation elements (six pieces), including some with *chapeau de gendarme* platforms. Retouched items at Sardarreh were few (about 5 retouched specimens from the sample), retouch was typically marginal and short, and use-wear or functional attributions were not provided. The presence of cortex on both sites (but generally low percentages) together with core-rejuvenation pieces argued, in the authors' reading, for at least partial primary knapping on the spot.

Overall, the authors interpreted both assemblages as principally Middle Paleolithic in character (Levallois emphasis + convergent scrapers + dominance of flakes), while acknowledging the occurrence of later blade/bladelet elements that suggested some multi-period palimpsest formation. They explicitly noted that the high proportion of tools in their collected samples was a product of collection strategy (all visible artifacts were picked up) and of low surface density, and they treated typological frequencies with appropriate caution.

The authors argued that the two Eyvanekey lowland sites fitted a broader pattern on the NICD: surface scatters clustered at the margins of former playas, where water and associated vegetation would have created attractive loci for Pleistocene hunter-gatherers. On this basis they suggested that the corridor formed by the Alborz flank and the desert margin (see Vahdati Nasab et al. 2013) had intermittently supported human occupations during more humid phases of the Late Pleistocene, and that regional techno-typological coherence (e.g. Levallois emphasis at Mirak, Chah-e Jam, and these new localities) hinted at an internally consistent Central Plateau Middle Paleolithic “signal” that contrasted in some respects with the classic Zagros Mousterian (notably in higher Levallois frequency and lighter retouch intensity). They were careful to emphasise methodological and evidential limits: site formation processes were unresolved, surface contexts were affected by wind and water reworking as well as modern disturbance, sample sizes were small, and no absolute dates or faunal data were available to anchor chronology or subsistence models. Consequently, they framed their regional claims as tentative, advocated a conservative null hypothesis of largely independent technological development on the Central Plateau until clearer technological links or stratified sequences were established, and recommended targeted excavation, sedimentology/palaeoenvironmental work, raw-material sourcing and systematic sampling for dating and faunal remains as immediate priorities.

While the authors (Nateqi et al. 2020) presented useful new field observations and materially expanded the distribution of known open-air localities along the NICD, their principal inferences rested on a relatively small and inherently biased surface sample and therefore remained provisional. They collected every visible artifact (a defensible strategy given the extreme low density), but that approach inflated the apparent tool:debitage ratio and limited the interpretability of typological frequencies; the authors acknowledged this effect but nonetheless used proportions (e.g. scraper dominance, Levallois incidence) as a central axis of chronological and behavioral interpretation. Sedimentological and taphonomic controls were insufficient: assessments of post-depositional mobility, palimpsest mixing and the relative vertical integrity of the surfaces were largely qualitative, so claims about on-site reduction and activity patterning is speculative. The absence of any secure chronometric data (radiometric or OSL) and the near lack of faunal or botanical evidence meant that environmental and chronological assertions —including placement in MIS phases or arguments about occupation intensity— were necessarily conjectural. Finally, comparative statements contrasting the Central Plateau with the Zagros were plausible and interesting, but they leaned on unevenly published comparative data and on surface assemblages of variable recovery methods; as the authors themselves recommended, resolving those questions required stratified excavations, systematic raw-material sourcing, and a more rigorous quantification of reduction sequences. In short, the paper made an important and welcome contribution by documenting new localities and initial techno-typological patterns, but its larger behavioral and regional claims should be treated as hypotheses awaiting stratigraphic testing and absolute dating rather than as established conclusions.

Then, the research focused on the pediment and piedmont zones of **Eyvanekey** area ensued. This area seems to be a critical segment of the NICD. Investigations were centered approximately 62 km southeast of Tehran, covering an 891 km^2 area with 65.2 km^2 explored through systematic pedestrian surveys. The landscape consisted of piedmont plains, alluvial fans, and pediment zones characterized by saline and swollen clays at more southerly latitudes near Showr-e Qazi.

The survey identified several extensive Paleolithic surface scatters, including **Boulan**, **Hossein Abad**, **Korak**, **Sangab**, and **Chandab**. These localities varied significantly in scale; for instance, the lithic scatter at Korak spanned 2 km, while Sangab reached 8 km in length. Collectively, the project recovered more than 1000 lithic artifacts across these sites, providing the first formal expansive account of Pleistocene hominin presence in these central portions of the NICD. The recovered assemblages primarily exhibited affinities with the Middle and Upper Paleolithic periods. Techno-typological analysis of the Boulan assemblage revealed a tradition oriented toward informal and opportunistic tool production. While most artifacts were non-standardized, the presence of a Levallois core with minimal preparation and flakes with facetted platforms indicated MP technological elements. UP components were represented by a range of blades and bladelets, although these were often described as "robust" and "broad" (Hashemi et al., 2024a, b).

The authors (Ibid.) reported that the Boulan assemblage comprised a modest surface collection of 165 lithic specimens (Figure 13), dominated by two raw-material classes — high-quality chert (just over 45%) and a greenish brown to light-grey volcanic tuff (≈52%) — with only negligible quantities of siltstone and limestone. They described the assemblage as flake-oriented: unretouched debitage made up slightly less than half the sample (≈49.7% of the total by technological structure), flakes represented ≈83% of the debitage, blades ≈14.6%, and bladelets were almost absent (~1.2%). Tools accounted for just over 30% of the collection and were overwhelmingly manufactured on flakes (≈58% of tools on flake blanks; ≈20% on blades), producing an apparently high tool:debitage ratio relative to the other Paleolithic expedient unretouched assemblages. Metric data showed that flakes were generally medium–large (mean maximum length ≈46.2 mm, mean width ≈39.9 mm) and cores averaged ~55.6 mm in maximum length, yet primary cortex was uncommon (recorded on only ~11% of pieces, most with ≤30% coverage), a pattern they interpreted as evidence that decortication and initial block reduction had often occurred away from the knapping locales sampled at Boulan.

Critically, while these descriptive statistics were useful, the authors (Ibid.) relied principally on typological and basic metric summaries rather than on reduction-sequence quantification, refitting, or spatially constrained attribute analyses. The surface context and extensive desert varnish on many pieces further limited the potential for functional or microwear inference (the varnish obscured edge traces), and the authors therefore could not undertake use-wear studies; this curtailed their ability to demonstrate whether the abundant unretouched flakes functioned as expedient tools or were simply debitage, an evidential gap the study repeatedly acknowledged.

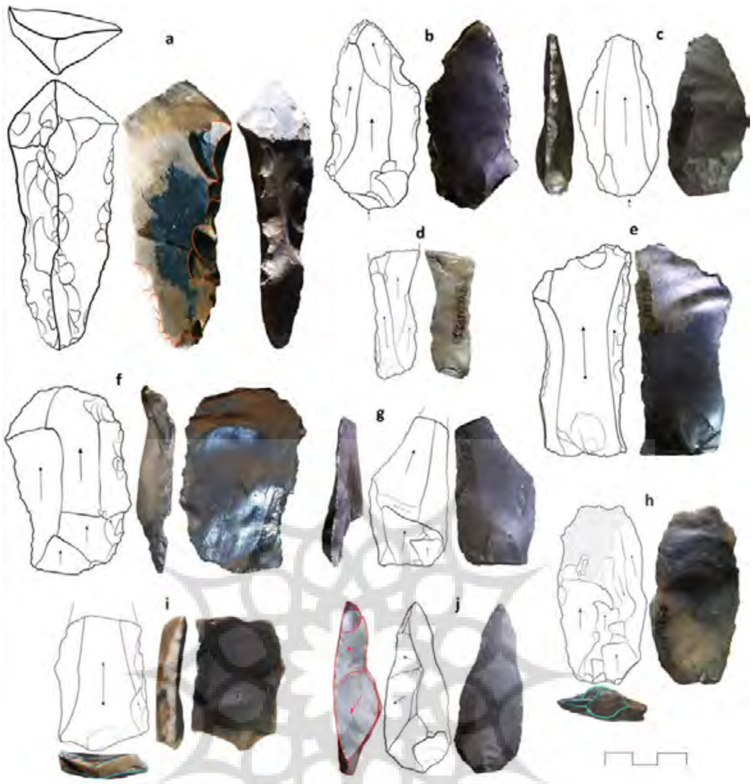

Figure 13. Some tool and non-tool debitage made on elongated blanks at Boulan (Hashemi et al. 2024b: fig. 6).

The authors (Ibid.) characterised the technological schema as broadly expedient but with mixed signals pointing to both Middle and, in places, Upper Paleolithic affinities. A strong unidirectional, sub-parallel removal pattern predominated (≈77% unidirectional scars on flakes), and platform evidence was dominated by plain platforms (≈75%), with a minority of lipped platforms (≈10.6%) and simple facetted or *chapeau de gendarme* butts uncommon — the authors therefore inferred a general reliance on hard-hammer percussion with sporadic soft-hammer use.

Cores were frequently informal and varied in volumetric shape (single-platform unidirectional cores, sub-prismatic and polyhedral morphologies), and the assemblage contained scattered indicators of Levallois concepts (one clear Levallois core and a very small number of retouched Levallois points) alongside numerous pseudo-Levallois/triangular removals and sub-triangular unretouched blanks that sometimes bore basal trimming suggestive of hafting. The tool catalogue was dominated by side-retouched and "nibbled" flakes, scrapers (side more than convergent), notches/denticulates, and a few unusual items (a keilmesser-like bifacial knife and a small amygdaloid biface), but classic heavily-retouched Mousterian reduction sequences were largely absent. Their (Ibid.) interpretation — that Boulan reflected an essentially opportunistic, flake-based technological organization with limited formal preparation but occasional Levallois and laminar traits — was reasonable given the data; nonetheless it rested on a small, surface-collected sample with little stratigraphic control and minimal chronometric anchoring. Key analytical shortcomings thus remained: the reduction strategy was not presented as a sequence of quantitative stages, bladelet production was inferred indirectly from dorsal scars rather than from a robust bladelet corpus, and broader claims linking Boulan's technological profile to mobility or provisioning strategies were suggestive rather than demonstrably tested by the data.

Distinct spatial patterns in raw material processing were observed across the landscape. While Boulan lacked large cores, the nearby site of Chandab yielded massive cores and "tested" raw material nodules ranging from 15 to 30 cm in size. This suggests a strategy of initial reduction at raw material sources (like Chandab) followed by the transport of blanks to other localities, a behavior indicative of logistical mobility (Ibid.).

The authors concluded that the discovery of these vast landscapes significantly strengthens the Northern Dispersal Corridor hypothesis. The research suggested that during the Pleistocene, the NICD was not a permanent desert but a fluctuating environment that offered "windows" of milder conditions suitable for hominin occupation.

The spatial distribution of the sites—scattered and low-density rather than clustered—was interpreted as a reflection of high logistical mobility. The investigators argued that these populations were "plain dwellers" who utilized the open desert landscapes for hunting and gathering, likely employing projectile technology as evidenced by certain pointed lithic forms. This high mobility was considered an adaptive necessity for surviving in the unpredictable and heterogeneous environments of the Pleistocene Iranian Plateau (Ibid.).

While the research provided invaluable data on a previously neglected region, several methodological and taphonomic caveats must be acknowledged. First, the reliance on surface scatters presents significant challenges; the lack of stratified, *in-situ* contexts means that the "Middle" and "Upper" Paleolithic affinities are based solely on comparative techno-typology rather than absolute dating. Consequently, the temporal "mixing" of artifacts from different periods is a distinct possibility. Second, the post-depositional processes in these arid zones—such as high-energy flash floods, aeolian deflation, and the formation of desert pavements—have likely displaced artifacts horizontally, complicating the interpretation of original human behavior. Finally, modern anthropogenic impacts pose a severe threat to the site integrity. These factors necessitate caution when drawing definitive conclusions about Paleolithic settlement patterns in the Eyvanekey region.

Another Paleolithic locality recently identified in the NICD is the **Sorheh complex**, consisting of six caves and rockshelters in Savojbolagh, approximately 19 km north of Karaj, at an elevation of about 1,900 m asl (Figure 14). The principal shelter occupies a precipice above the Senj tributary, where natural brecciated tuff and faulting produced a cavity that was repeatedly infilled by fluvial sand and episodic tuff rockfall. The locality was first reported during regional survey and subsequently sampled by targeted excavations in 2019 and 2022; looter activity was noted and early trenching was required to secure intact deposits. A four-part geological succession was identified and was reported as GH1–GH4, with the main Palaeolithic horizons embedded in the upper sand and rockfall units. The depositional history was argued to be dominated by alternation of fluvial sand accumulation and short, gravity-driven rockfall events, with micromorphological blocks taken to characterise anthropogenic and natural inputs. Two archaeological horizons (AH) were recognised within the Pleistocene sequence and were separated by a rockfall episode; nevertheless, lithics continued to be present across both occupation horizons and were described as belonging to a single techno-complex. OSL and radiocarbon methods were applied: OSL ages on K-feldspar samples were reported for GH4a–4e and for GH3 with values that range broadly (e.g. GH4a ~53.6 ± 5.9 ka; GH3 samples clustering broadly in the ~36.8–32.2 ka window), while a set of calibrated 14C ages obtained on charcoal from GH3 returned results in the interval ~38.9–33.7 cal ka BP. A Bayesian model was constructed to integrate these results and to estimate the timing of the IUP occupation at Sorheh (Ghasidian et al. 2024).

Figure 14. A general look at Sorheh Complex (Hariryan et al. 2021: fig. 2).

The Sorheh lithic corpus was dominated by local green tuff, with minor chert and radiolarite employed. The assemblage was characterised by systematic Levallois reduction oriented to both elongated Levallois flakes and blades; blade-producing cores, parallel and platform core features, and highly facetted (*chapeau de gendarme*) platforms were recorded. A small but diagnostically varied tool set was reported (retouched blades, end scrapers, carinated pieces, points and denticulates); several elongated unretouched points and putative hafted implements were illustrated. On technological grounds the assemblage was aligned with the Initial Upper Palaeolithic (IUP) blade-oriented tradition as recognised in the Levant, parts of Eurasia and Central Asia, and it was argued that the Sorheh material displays the same mix of Levallois laminar reduction and UP-style tool forms that characterise IUP contexts elsewhere (Figure 15; Hariryan et al. 2021; Ghasidian et al. 2024).

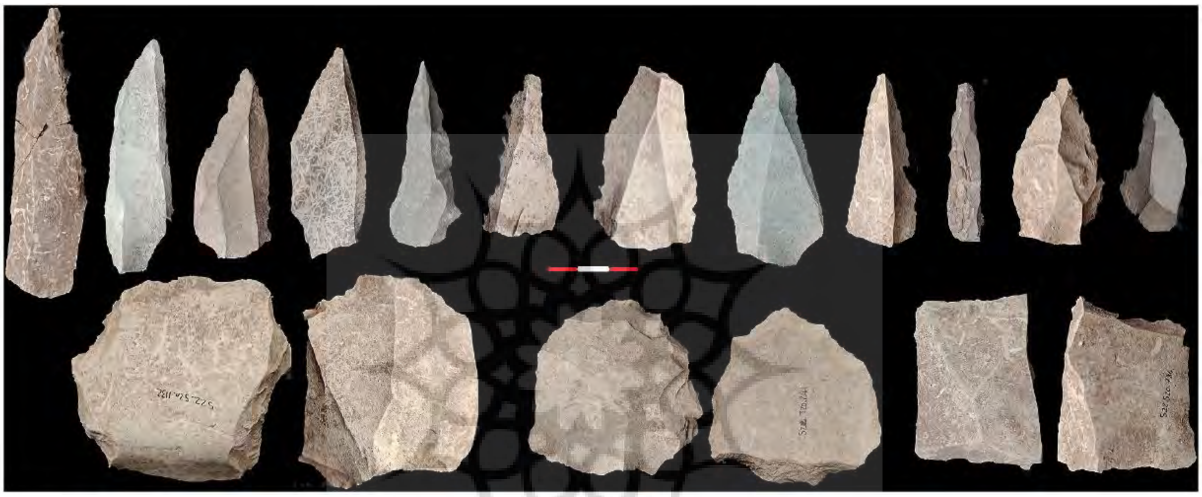

Figure 15. IUP-associated lithic artifacts from Sorheh (Ghasidian et al., 2024: fig. 4).

A faunal sample of 1,112 specimens was reported and was dominated by medium ungulates (*Capra/Ovis*), with occasional remains of larger cervids and ursids. Charcoal identification was attempted on 28 samples and several taxa (*Prunus* subgenus *Amygdalus*, cf. *Fraxinus*, *Populus*/*Salix*) were recorded, but preservation was frequently poor. The stratigraphic and palaeobotanical evidence was used to interpret Sorheh as a seasonally occupied, short-term hunter-camp located in a mountain-edge ecotone. Climatic oscillations in MIS3 were invoked to explain episodic habitation during warmer interstadials and increased rockfall during colder stadials (Ghasidian et al. 2024).

The Sorheh ensemble was framed as filling a geographic gap in the eastern-to-western distribution of the IUP on the Iranian Plateau: chronologically and technologically the assemblage was placed in the ~50–35 ka window and was compared to Levantine, Altai and eastern European IUP assemblages. From this perspective, Sorheh was presented as a plausible node in hominin dispersal and cultural transmission networks across the intersection of Afro-Arabian and Palaearctic biogeographical realms. The authors explicitly discussed the implications for models of AMH expansion and for potential interaction zones with Neanderthals, while noting that no hominin skeletal remains have been recovered to secure cultural attribution (Ibid.).

The Sorheh site on the Iranian Plateau presents a significant late Pleistocene assemblage characterized by blade-oriented, elongated Levallois technology, demonstrably comparable to recognized Initial Upper Paleolithic (IUP) complexes. Its integration of OSL and radiocarbon dating, micromorphology, and zooarchaeological analyses provides a robust regional and climatic framework, establishing Sorheh as a key site for understanding Late Pleistocene settlement dynamics. However, several critical limitations constrain the interpretive strength of the findings. Looter disturbance compromised stratigraphic integrity in parts of the site, resulting in small, surface-biased lithic samples that weaken typological frequency claims. Radiocarbon dating proved patchy, with insufficient carbon yield from many charcoal samples and limited reliable 14C ages from trench GH3, necessitating reliance on OSL for deeper chronology. Crucially, the attribution of this claimed IUP tradition to an AMH dispersal event remains inferential due to lacking biological evidence. Furthermore, the raw material sourcing beyond local tuff remains superficially addressed, leaving landscape-scale procurement strategies and mobility patterns poorly constrained. While the site's significance as a late Pleistocene IUP-equivalent is well-established, elevating Sorheh from an important discovery to a decisive paleoanthropological locus requires targeted research: denser stratigraphic sampling, expanded chronometric coverage, and high-resolution analytical techniques (including refitting, microwear, residue, and isotopic approaches) to rigorously test dispersal and interaction hypotheses.

Discussion

-A regional portrait

Initial observations by Hashemi et al. (2017, 2021) indicate that Middle Paleolithic (MP) lithic assemblages from the NICD display broad intra-regional techno-typological similarities, while differing in several respects from the classic Zagros Mousterian (ZM) tradition (Table 1). Notably, lithic industries typically classified as classic Mousterian in Europe and the Central Zagros (e.g., Bordes 1961, 1981; Dibble 1984, 1991; Baumler & Speth 1993; Jaubert et al. 2009) appear to be absent from the NICD. As has similarly been argued for the Levant (e.g., Shea 2014), the Middle Paleolithic assemblages of the NICD cannot be readily subsumed under the classic Mousterian framework, at least on current evidence (Hashemi et al. 2021). This observation raises the broader question of whether the term "Mousterian" is analytically appropriate for characterizing NICD MP industries, a debate that remains partly terminological and perspective dependent. At the same time, shared regional traits do not imply technological homogeneity across the NICD, as intra-regional variability is expected due to differences in chronology, geomorphology and altitude, raw-material availability, land-use strategies, and site formation processes. In particular, the prevalence of surface assemblages introduces the possibility of temporal mixing, which likely contributes to observed variability within the NICD lithic record. Consequently, the NICD lithic facies has been argued to be more comparable, in several respects, to Levantine Levallois-emphasised Mousterian types than to the classical Zagros cave-based Mousterian assemblages. However, intra-regional heterogeneity is also evident and must be acknowledged; similarity at the level of a collective facies does not imply technological uniformity at every locality.

A systematic juxtaposition makes the contrasts explicit. The ZM is commonly characterised by a mix of short and elongated flakes, higher laminar indices in some phases, frequent steep invasive retouch, robust racloir/facetting indices and a suite of tool types including heavily retouched scrapers and core-on-flake preparations; by contrast, the NICD Middle Paleolithic (MP) is marked by a predominance of thinner flakes, a higher relative frequency of Levallois reduction (recurrent rather than single-platform centripetal variants), lower rates of heavy retouch, and generally more points (both Levallois and non-Levallois) and convergent scrapers with light retouch (Table 1). These differences, support the interpretation that the NICD MP constitutes a distinct technological facies (or set of related facies) that is not fully encompassed by the canonical ZM repertoire. Nevertheless, overlap and shared attributes exist (e.g., Levallois presence), and thus arguments for a strict taxonomic separation must remain provisional pending more extensive attribute-level and refitting analyses.

Table 1. Collective characteristics of the MP industries in the NICD and the Zagros.

Assemblages/Entities?	**Collective Characteristics**	**Selected Citations**
Zagros Mousterian	Both short and elongated flake blanks are common; it is highly laminar in both early and later phases; the true blade technique (prismatic) is scarce; high ratios of relatively thin flake blanks, many of them being retouched in rather steep invasive fashion; emphasis on unidirectional preparation; the racloir and facetting indices (IR and IF) are relatively high; the Levallois indices (IL and ILty) are relatively low (Bisitun Cave is a counterexample; Dibble 1991: table 1); the	Baumler & Speth 1993 Bewley 1984 Dibble 1984, 1991 Dibble & Holdaway 1993 Lindly 2005 McBurnery 1970

	Ilam or blade index is moderate (e.g., 20–30%); within the tool list, side-, double side-, and convergent scrapers (including Mousterian points) constitute a considerable ratio; the frequency of notches and denticulates is usually insignificant; minor tool types: truncated-facetted pieces, awls, limaces, rods, thick and wide transverse scrapers with stepped retouch, demi-quina scrapers, and core-on-flakes; Upper Paleolithic-affiliated elements including endscrapers and burins are rare.	Rolland & Dibble 1990: 490 Skinner 1965 Nymark 2021
Middle Paleolithic NICD	Points (non-Levallois or Levallois) are common; an overwhelming predominance of relatively thin flakes; the presence of short, elongated, and pointed flakes with the former being dominant; moderate to low racloir (IR) index (Bordes & de Sonneville-Bordes 1970; Rolland 1981); low ratios of heavily-retouched scrapers; relatively high ratio of unmodified unretouched flakes over retouched flakes with usually non-invasive short and direct retouch; the higher frequency of side scrapers and convergent scrapers within the tool list; the decent ratios of Levallois points, the significant higher Levallois indices (ILtyp, IL) than the Zagros Mousterian; Levallois reduction scheme is mostly recurrent; no hand axe have been recorded; generally comparable to Levantine Mousterian (e.g., Shea 2014) and dissimilar to the west European Mousterian.	Hashemi et al. 2017, 2021, 2024b Vahdati Nasab et al. 2019

-Environment as technology's crucible: arid and semi-arid adaptations

These techno-typological contrasts are plausibly linked to divergent adaptive contexts. The NICD occupies a narrow latitudinal biozone bounded by the Alborz to the north and the Central Desert to the south, environments that oscillated between more hospitable intervals and pronounced aridity through late MIS 5 to MIS 2. It is therefore proposed that, whereas the ZM tradition predominantly developed within montane caves and rockshelters characterized by relatively stable resource catchments, the NICD assemblages emerged from populations adapting to a mosaic of generally lower carrying capacity environments, typified by arid to semi-arid pediments with ephemeral stream systems. In consequence, the lithic strategies observed in the NICD—light retouch, abundant unretouched flakes, recurrent Levallois schemes on locally available chert and tuff—are consistent with economies oriented to higher mobility, opportunistic raw-material use, and task-specific toolkits suited to patchy and seasonally variable resources with good availability of lithic raw material sources. In short, techno-typological differences between the NICD and the Zagros should be understood, at least in part, as ecological adaptations to distinct palaeobiomes and resource distribution patterns rather than as simple cultural ''types.''

A tripartite spatial model is proposed here whereby NICD localities are classified into three ecological–geomorphological zones: (1) highland/piedmont sites (e.g., Moghanak/Otchunak, Sorheh), (2) intermediate-zone or landscape-mosaic sites (e.g., Eyvanekey, the Zaviyeh locality), and (3) lowland downstream sites (e.g., Chah-e Jam, Soufi Abad, Mirak, Delazianm and Showr-e Qazi). This tripartite partitioning implies that Pleistocene hominin populations could occupy a vertical and latitudinal spectrum of landforms within the NICD; critically, it implies not merely dispersal through a corridor but sustained habitation of multiple ecological niches across the strip. The distribution of sites from west (Zaviyeh, Sorheh) to east (Chah-e Jam), together with multiperiod occupations at localities such as Mirak and Sorheh, supports the inference that populations persisted across the NICD long enough to exploit a broad range of landforms and resources rather than using the area exclusively as a high-speed movement corridor.

-Site types and behavioral variability

The archaeological record of the NICD includes caves and rockshelters, open-air occupations and extensive lithic surface scatters. Consequently, a spectrum of site functions and occupation intensities is represented: some localities record evidence consistent with base camps and repeated occupation (e.g., Mirak), whereas others (e.g., Showr-e Qazi) record ephemeral task-specific use or lower intensity occupations. That said, the functional interpretation of surface scatters must be cautious because palimpsest formation and surface mixing are common in this region; nevertheless, the co-occurrence of site types points to flexible settlement systems in which different landforms were exploited for complementary activities—raw-material procurement, butchery, manufacture and maintenance of tools—depending on seasonality and resource distribution.

-Within-region lithic variability: curated versus expedient traditions

Notwithstanding the broader NICD coherence, pronounced intra-regional differences in lithic technological organization are observed. For instance, Mirak, Chah-e Jam and Zaviyeh display a tendency toward more formalized and, at times, curated tool forms (including retouched points and convergent scrapers), whereas Eyvanekey and Moghanak are typically represented by larger, more expedient blanks and a higher incidence of opportunistic tool use. This patterning correlates in part with raw-material availability: where high-quality chert nodules were locally abundant, lower curation and lighter retouch predominated because replacement costs were reduced; conversely, where raw material was scarcer or transport distances greater, more curated tool kits and intensive retouch were favoured. Thus, techno-economic behavior within the NICD appears to have been modulated by immediate lithic ecology as much as by broader cultural conventions.

-Temporal depth, palimpsests and the confirmation of multi-period occupation

Although several NICD localities are affected by surface mixing (Boulan, Soufiabad, among others), absolute dating from securely stratified contexts (notably Mirak and Sorheh) confirms occupational episodes spanning MIS 3 into later periods. In consequence, two complementary observations can be made: (1) some NICD sites contain stratified, datable deposits that attest to repeated occupations across glacial–interglacial or at least glacial-interstadial fluctuations; and (2) many surface scatters are temporally mixed and therefore must be treated analytically with methods designed to detect and, where possible, separate temporally discrete components (e.g., multivariate attribute analysis, 3-D morphometrics, or artificial intelligence approaches). Together, these strands of evidence indicate that NICD occupation was episodic but recurrent during the Late Pleistocene.

-Lowland signal: points, task-specificity and mobility in downstream landscapes

A preliminary but consistent pattern is that lowland and downstream-zone assemblages are frequently enriched in points, point-like and triangular removals (e.g., Chah-e Jam, Zaviyeh), a trend that may reflect a stronger emphasis on hunting-related toolkits, task-specific kills or higher mobility strategies in those open, low-relief environments. Accordingly, these localities may represent specialized loci—ambush points near water, kill or processing stations, or transitory camps on seasonal movement routes—where highly transportable and morphologically diagnostic implements were preferred. By contrast, upland and intermediate localities retained a greater proportion of generalist flake toolkits consistent with on-site reduction strategies and multifunctional activities. This pattern is consistent with models that link landscape position, prey availability, and mobility strategies to toolkit composition. Who were the toolmakers?

-Limits and cautious inferences on hominin authorship

The question of which hominins occupied the NICD—Neanderthals, archaic *Homo sapiens*, anatomically modern *Homo sapiens*, or a shifting mix—cannot be resolved definitively in the absence of associated hominin remains within the NICD itself. Nevertheless, given the documented presence of Neanderthal skeletal remains in the Central Zagros and the temporal overlap of relevant industries, plus the existence of early and later MP occurrences across adjacent regions (Qaleh Kurd Cave and Caucasian MP assemblages), it is plausible that both Neanderthals and *H. sapiens* (or late archaic forms) were present in the broader Iranian Plateau at different times or in different subregions. Thus, while technological affinities may be suggestive, techno-typology alone must not be used to assign species identity: the current evidence allows only the cautious proposition that multiple hominin groups could have been involved in producing NICD lithic variation.

A brief comparison with the Levantine Middle Paleolithic

The NICD MP shows partial affinity with Levantine Levallois-emphasised Mousterian assemblages, notably in the recurrent use of Levallois methods and in the lighter retouch regimes observed in some Levantine contexts. However, while the Levantine record includes certain Levallois point traditions and varied blade/flake mixes, the NICD patterning remains regionally distinct in raw-material choices, proportions of point forms, and landscape-driven functional emphasis. Thus, the Levant offers useful comparative analogies, but NICD sequences should be treated as locally conditioned expressions of broader Levallois-oriented behaviors rather than as direct imports of Levantine technological systems.

Conclusion

This study highlights the NICD as a distinct and internally coherent Middle Paleolithic region whose lithic assemblages display broad techno-typological similarities while differing in systematic ways from the classic ZM tradition. The absence of classic Mousterian signatures sensu Europe and the Central Zagros, together with higher frequencies of Levallois reduction, and lighter retouch regimes suggest that the Middle Paleolithic industries of the NICD cannot be straightforwardly subsumed under the canonical Mousterian framework. Instead, the NICD assemblages appear to constitute a regionally specific Levallois-oriented facies that shows partial affinities with Levantine Middle Paleolithic traditions, while remaining technologically and environmentally distinct.

These technological patterns are best understood within their ecological and geomorphological context. The NICD represents a heterogeneous arid to semi-arid landscape composed of narrow highland zones, intermediate pediment, and lowland floodplain playa zones, each offering different resource structures and constraints. The proposed tripartite spatial model demonstrates that Pleistocene hominin groups were able to occupy and exploit this full range of landforms, indicating sustained habitation rather than mere movement through a dispersal corridor. Variability in site types, occupation intensity, and lithic curation strategies reflects flexible settlement systems adapted to patchy and seasonally variable resources, with lowland assemblages often showing signatures consistent with higher mobility and task-specific hunting strategies.

Finally, although stratified sites such as Mirak and Sorheh confirm repeated Late Pleistocene occupations of the NICD, the prevalence of surface assemblages and the absence of hominin fossils impose clear interpretive limits. While multiple hominin groups may have occupied the region at different times, species-level attribution cannot be resolved on techno-typological grounds alone. Future research in the NICD must adopt a coordinated, phased approach that addresses current methodological challenges while leveraging emerging analytical opportunities. Central to this strategy is the expansion of controlled, stratified excavations at key sites to reduce dependence on mixed surface collections and to enhance chronological precision through integrated radiometric dating. Complementary systematic investigations—including raw-material sourcing, refitting analyses, and use-wear studies—are imperative for elucidating techno-economic organization and mobility patterns across diverse NICD landscapes. Concurrently, advanced analytical techniques such as three-dimensional morphometrics and machine-learning–assisted classification should be employed judiciously alongside traditional technological analyses to avoid erroneous interpretations of complex, palimpsested assemblages. Furthermore, prioritizing paleoenvironmental reconstructions and conducting inter-regional comparisons with the Zagros and neighboring areas will be essential to contextualize NICD assemblages within broader Late Pleistocene population dynamics. Collectively, these integrated efforts are crucial for transforming the NICD from a primarily descriptive framework into a robust, testable model of Middle Paleolithic adaptation, persistence, and variability within Southwest Asian prehistory.

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