Re-evaluation of Scrapers Reduction Model Using Geometric Index of Reduction (Mar-Tarik Middle Paleolithic Assemblages)

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Paleolithic lithic assemblages are traditionally described on the bases of presence of a variety of tool types (typology) and of different knapping technologies. In this study we tried to investigate whether the presence of different groups of scrapers in the Mar-Tarik site assigned to the Middle Paleolithic represent specific function or just different stages of the reduction process and constant changes as the result of accessibility to the raw materials. In this research Dibble's scrapers reduction model which was proposed for the first time based on Bisitun rock shelter Middle Paleolithic assemblages, was tested using the Geometric Index of Reduction method for the unifacial scrapers. The results indicate that similarities in the dimensions of the different types of scrapers in Mar-Tarik and Bisitun might be a result of using small size raw materials. Meantime different functional aspects of these two sites might have been responsible for differences in the intensity of retouch on their artifacts.

Keywords: *Middle Paleolithic, Bisitun Mountain, Scraper Reduction Model, Geometric Index of Reduction*

Introduction

Curation, rejuvenation, and resharpening are among the most important procedures relating to the extent of stone artifacts use-life. Resharpening could be considered one of the most important actions to increase the useful longevity of tools. This method could be seen as an economical tactic in order to produce sharp edges while minimizing the cost of transporting of multiple tools or bulky raw materials (Kuhn 1995: 18-24). Due to the fact that resharpening dull edges is considered a reduction process, it affects the final shape of artifacts drastically.

Lithic assemblages discovered from the Middle Paleolithic sites of Bisitun Mountain in the Zagros Mountains have been studied repeatedly since the 1950s. During the course of these analyses, it became clear that it might be possible to lump various Mousterian scraper categories into simpler groups. The scraper reduction model (SRM) was developed to find out whether different kinds of scrapers represent specific functions or as claimed by Dibble, they are merely reflections of different stages of the reduction process (Dibble 1984a,b, 1995).

Since the time that the SRM was first proposed by Dibble (1984a), there have been several critiques concerning its applicability to all Middle Paleolithic assemblages around the world. Mellars suggests that the high amount of retouch on the scraper edges of those assemblages that are located in relatively close to the raw material sources, cannot be interpreted by the SRM (Mellars 1996: 335-341). On the other hand, recent studies on the Lower Paleolithic assemblages of High Lodge in England indicate that no indication of preconceived forms is applicable for the knappers of this collection and that the different kinds of scrapers represent different stages of reduction process (Brumma and McLarenb 2010).

Geometric Index of Reduction (GIR), which was originally developed by Kuhn (1990), is a quantitative method that could be used to measure the intensity of retouch on unifacial scrapers' edge, consequently could predict the degree of access to the raw materials. Like SRM, the GIR method has undergone several changes and modifications since the time it was proposed. Some studies support the notion of correlation between the mass getting lost during the retouching process and the intensity of retouch (Hiscock and Clarkson 2005; 2008). However, other studies suggest that although the GIR could be used as a reliable indicator of the

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intensity of retouch in most cases, when it comes to assemblages with high amounts of retouch on their edges, no such correlation exists (Eren and Sampson 2009).

Generally speaking aside from some arguments about the methodological aspects of the GIR, most scientists unanimously agree that the GIR is the best way to investigate the degree of reduction. In this research we have combined SRM with GIR to re-evaluate Dibble's hypothesis based on the new data derived from the recent excavation at the Middle Paleolithic site of Mar-Tarik in Bisitun.

History of Paleolithic Researches in Bisitun Mountain

Bisitun Mountain is a huge rocky mountain 1300 m in height, located in Chamchamal Plateau 48 km east of the city of Kermanshah in Kermanshah province in Iran's central Zagros (fig.1).

With multiple Paleolithic caves and rock shelters in Bisitun Mountain (Table 1), most of which show evidence of human occupation (scattered lithic artifacts on the surface), it sounds pale to assume that this area has been in use for groups of hunter-gatherers since Pleistocene. Its location of Bisitun near an important ancient route was the reason for attention even in historical times. In the 6th century B.C., Darius the Great, the Achaemenian king, carved his famous inscription on Bisitun rock (Trinkaus and Biglari 2006).

Name	Type	Area (sq.meter)	Elevation from sea level (m)	Opening direction	Archaeological remains
Hunters (Bisitun)	Rock shelter	35	1300	S/E	Middle-Upper Paleolithic
Ghar-e khar	Cave	---	1400	S	Middle-Upper and, Epipaleolithic
Mar-Tarik	Cave	80	1540	S-S/E	Middle Paleolithic
Mar-Aftab	Cave	190	1565	N/E	Middle Paleolithic
Mar-Dodar	Cave	170	1585	S- S/W-S/E	Middle-Upper and, Epipaleolithic

***Table.1**: Specifications of Bisitun's Paleolithic Locations (After: Biglari, 2000).*

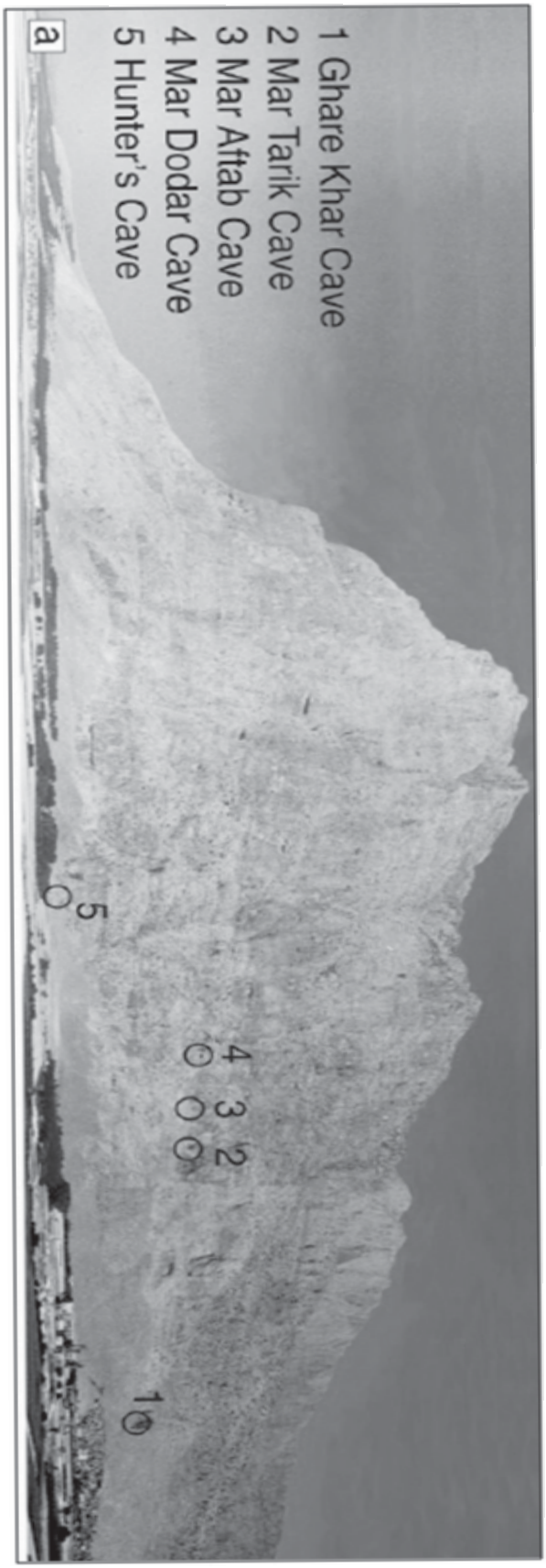


***Fig.1**: Location of Paleolithic Sites in Bisitun Mountain (After: Heydari, 2007).*

The first researcher who pointed out the Paleolithic remains in Bisitun was Carleton Stanley Coon from the University of Pennsylvania Museum. He started his excavation at Bisitun rock shelter (also known as Hunter rock shelter) in 1949. The results from this excavation proved the presence of Middle and Upper Paleolithic industries at this site (Coon 1951; 1952). Years after Coon's expedition, Philip Smith conducted a small excavation at one of the Bisitun's sites, Ghar-e Khar (Khar Cave), and reported Middle, Upper, and Epipaleolithic industries (Young and Smith 1966; Smith 1986). A few decades after Smith's archaeological activities, Iranian researchers resurveyed Bisitun Mountain, which resulted the discovery of three new sites, Mar-Tarik, Mar-Aftab, and Mar-Dodar, dating from the Middle to Epipaleolithic periods (Biglari 2000).

Mar-Tarik Cave

Mar-Tarik is a relatively deep karstic cave located between the footstep and high wall of Bisitun Mountain and it has an overview over a natural platform (fig.1). During the excavation by the joint Iranian-French members, 286 pieces of stone artifacts were recovered in this site, which mostly were made of chert of various colors and chalcedony (Jaubert et al. 2009; Jaubert and Biglari 2004). According to the geological studies, natural outcrops of the chert used in this assemblage are located about 15 km southeast of the site. The Mar-Tarik assemblage represents a variable in case of its tool typology, and retouched scrapers contain a relatively high percentage of this collection. The scraper groups found include side, double and convergent scrapers. A few transverse and end scrapers have also been reported. Primary studies of typology and technology assign the artifacts to the Middle Paleolithic period (fig. 2); (Jaubert et al. 2009; Jaubert and Biglari 2004).

Research Objectives

Two decades after Dibble originally proposed the SRM model, and with the long history of debates in mind, the Mar-Tarik site, located a few hundred meters away from Bisitun rock shelter in Bisitun Mountain, was excavated. This was a suitable opportunity to once more test Dibble's model with new materials that probably came from the same sources as Bisitun. For this reason, the questions of this study were designed as:

- Did the primary blanks used for making scrapers in Mar-Tarik cave come from the same population?
- Do the results achieved from applying GIR to the unifacial scrapers of Mar-Tarik support Dibble's Reduction Model?
- Do morphological changes in the three groups of scrapers in Mar-Tarik site show that they reflect special functions or stylistic differences?

Materials and Methods

The side, double and convergent scrapers from the Middle Paleolithic layers of Mar-Tarik cave, which are presently kept in Iran's National Museum, were the materials of this research. Consider the fact that there are some differences in technical views in categorizing scrapers, in this study all blanks that had constant retouch (even though weak) on one or more edges, have been incorporated into the scraper group. Fifty-seven scrapers, including 33 side scrapers, 8 double scrapers, and 15 convergent scrapers, were chosen for further analysis.

In order to re-evaluate the SRM model, two different approaches were employed. First, we calculated all the necessary measurements using digital calipers similar to what Dibble did on the Bisitun collections (Dibble 1984b). Maximum length was measured (from the point of percussion to the most distal end of the blank). Maximum width was measured at the point perpendicular to the morphological axis at the point that the highest number would register. Maximum thickness was measured at the point of intersection of length and width for all the three groups of scrapers. Then, means and standard deviations of length, width and thickness were calculated. The second method involved assessing the amount of retouch on the edges using GIR technique originally proposed by Kuhn (Kuhn 1990; 1992) and later revised by Hiscock and Clarkson (2005; 2008).

As it was described by Kuhn and illustrated in figure 3, by increasing the degree of retouch, the vertical thickness of flake at the termination of the line of retouch scars (t) gets closer to the unified maximum thickness of flake (T). Therefore, the

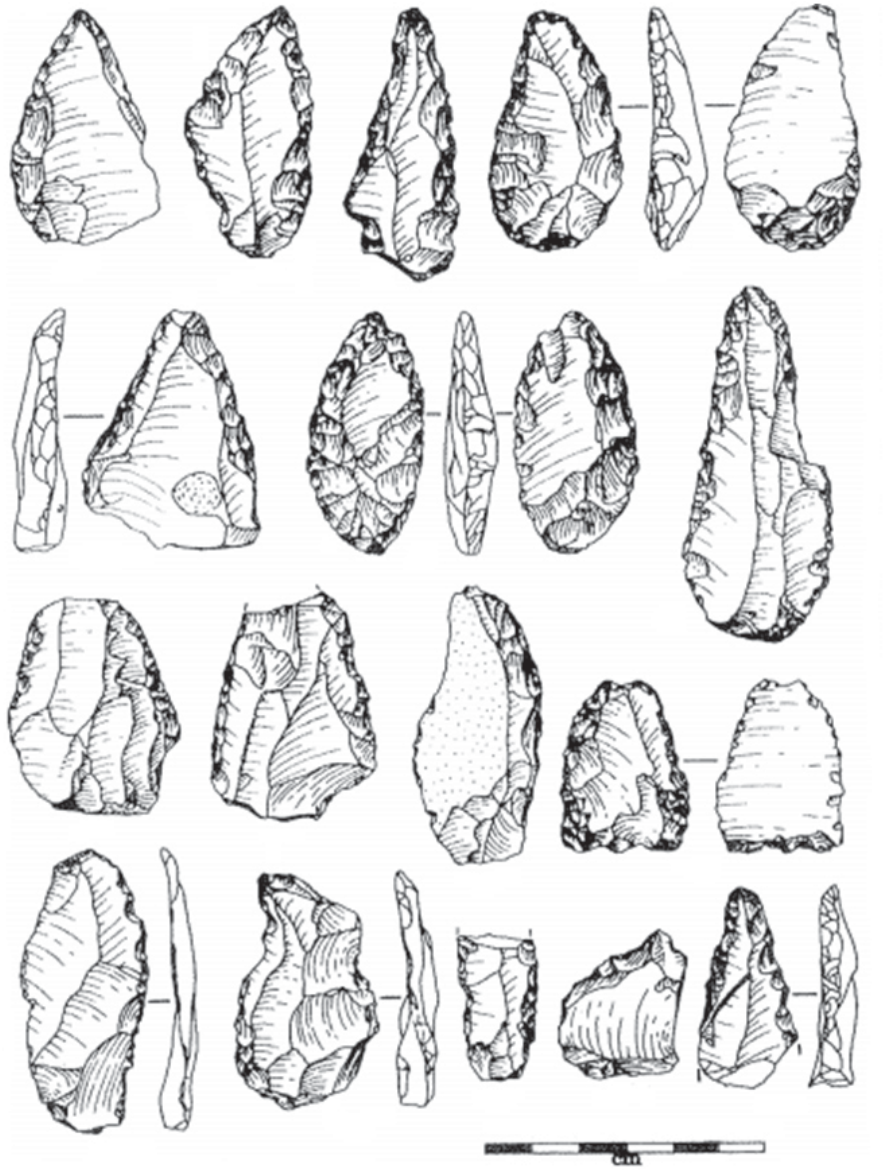


***Fig.2**: Martarik's Lithic Assemblages (After: Jaubert et al. 2009).*

higher GIR index (t/T) value indicates more intense retouch. Needless to say, the GIR index varies from 0 (no retouch) to 1 (maximum retouch), (fig. 3). Because of the functional limitations of the GIR method, only unifacial scrapers (33) were subjected to this study. Three points were measured on the surface of each piece: one point at the center of the scraper edge (A), a second point at the distal end of the piece (B), and a third point (C) at the proximal end. To calculate the sine of the retouch angle we placed a thin copper wire from dorsal to ventral (only part of retouch) scraper in such a way that the angle was made between the two surfaces. Then we put the wire on a protractor and calculated the proper angle. Ultimately, through three different indices (A, B, C), the average GIR for each scraper was calculated.

Results

1. The results for SRM on Mar-Tarik collection: As mentioned earlier, for each scraper category at the Mar-Tarik site (side, double, and convergent) three dimensions (maximum length, maximum width and maximum thickness) were registered. In Table 2, the statistical averages and standard deviations of these measurements are presented. Performing ANOVA tests on the results obtained from Table 2 indicates that no significant difference exists in average maximum length ($P = 0.072 > 0.05$), maximum width ($P = 0.202 > 0.05$), and maximum thickness ($p = 0.077$

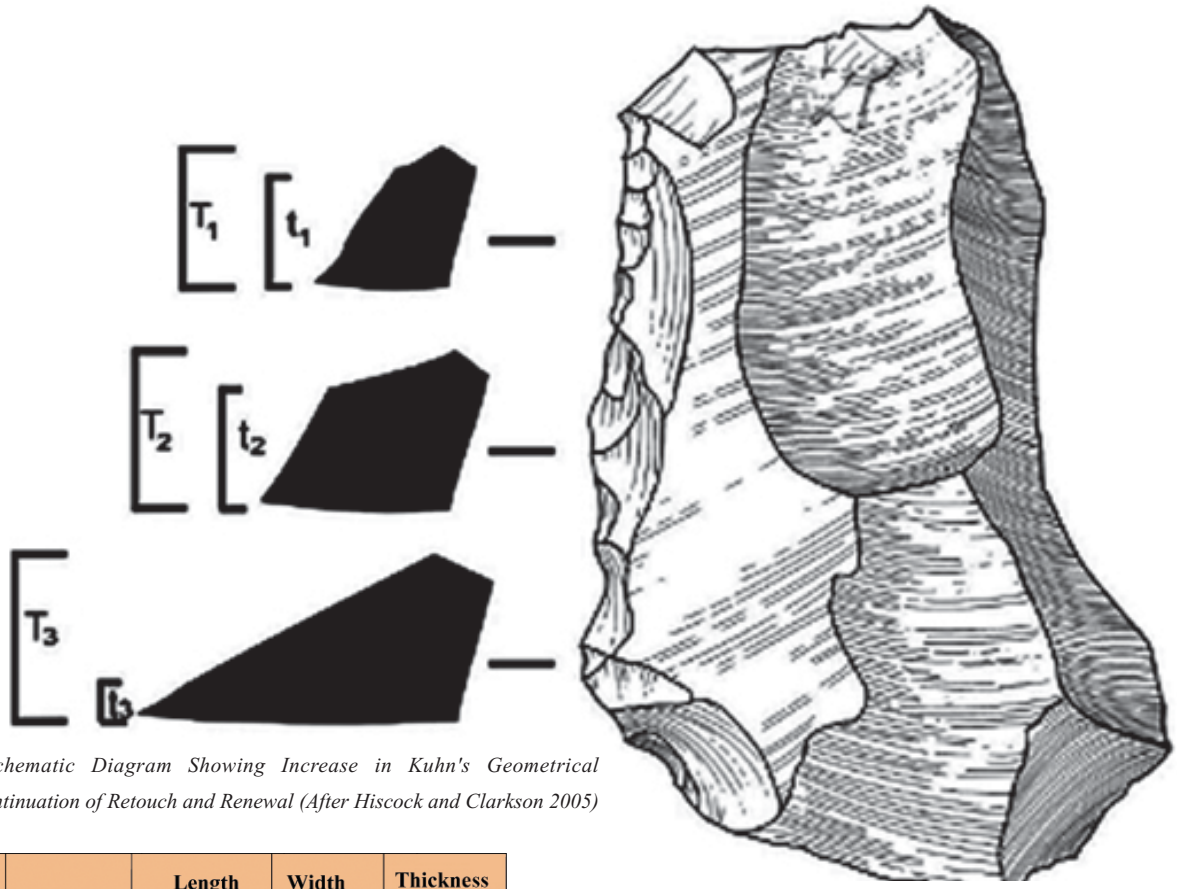


Fig.3: *Schematic Diagram Showing Increase in Kuhn's Geometrical Index Continuation of Retouch and Renewal (After Hiscock and Clarkson 2005)*

Types		Length	Width	Thickness
Side Scrapers	N	33	33	33
	Mean	43.6852	24.8215	9.5058
	Std. Deviation	10.85920	8.97022	3.82811
Double Scrapers	N	8	8	8
	Mean	54.7575	25.0100	8.9238
	Std. Deviation	19.46741	7.85078	3.14339
Convergent Scrapers	N	16	16	16
	Mean	46.9456	20.5437	7.0875
	Std. Deviation	9.66309	5.84524	2.53083
Total	**N**	**57**	**57**	**57**
	Mean	**46.1544**	**23.6472**	**8.7453**
	Std. Deviation	**12.41423**	**8.16492**	**3.52921**

Table.2*: Statistical Averages and Standard Deviations of the metric analysis*

> 0.05) among the three different groups of scrapers (Table. 3).

2. The results for GIR Test

Considering H_0 as:

The Middle Paleolithic occupants of Mar-Tarik had enough access to the raw materials; therefore, the tools produced by them did not undergo intensive retouch. In order to test such claim, the calculated GIR indices for 33 unifacial scrapers were examined using the Population Mean Test (One Sample t-test; Table.4).The results for descriptive statistics tests presented in Table 4 indicate that the Mar-Tarik average GIR index (0.34) is relatively low; however, such results must be confirmed by statistics (Confidence Interval of the Difference).

Ultimately combining the results from the confidence interval of the difference with the one sample t-test, and since Sig is less than 0.5, the

		Sum of Squares	df	Mean Square	F	Sig.
Thickness	Among Groups	63.311	2	31.656	2.695	.077
	Within Groups	634.185	54	11.744		
	Total	697.497	56			
Length	Among Groups	803.330	2	401.665	2.771	.072
	Within Groups	7826.999	54	144.944		
	Total	8630.330	56			
Width	Among Groups	214.468	2	107.234	1.646	.202
	Within Groups	3518.821	54	65.163		
	Total	3733.288	56			

Table.3*: Analysis of Variance of Basic Tool Dimension by Scraper Class*

	N	Mean	Std. Deviation	Std. Error Mean
Mean Index	33	.3496	.16245	.02828

Table.4*: Descriptive Statistics of One Sample t-test*

assumption H_0 is rejected and we can dismiss the equality claim of total average mean of index with 0.5 (≠μ0.5), (Table. 5).

Test Value = .5						
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Mean Index	-5.319	32	.000	-.15040	-.2080	-.0928

***Table.5**: Interpreted Statistics (Confidence Interval of the Difference)*

Discussion

Dibble`s extensive work on the Middle Paleolithic lithic assemblages of the Bisitun rock shelter led him to propose that on some occasions, the different groups of scrapers, more than 21 types in Bordes's typologies [according to the location of retouch along the perimeter of the flake blank (Bordes 1961)], neither necessarily introduce a specific typology nor describe a special style of tool making. Rather, only different stages in their use life and infrequent process of the edge resharpening, which by itself is affected by the availability of raw materials, ultimately resulting in the production of different kinds of scrapers such as side scrapers, double scrapers, convergent and transverse forms (Dibble 1984a,b; 1987; 1991; 1995).

Before discussing the results, it is necessary to review what SRM predicts in the case of important variations of the three elements of length, width and thickness of scrapers during the retouch and renewal process. As was pointed out, during the retouching process only the edges of side and double scrapers were retouched; therefore, these types of scrapers should keep their original length (size). On the other hand in convergent scrapers during the retouching process not only were lateral edges retouched but also the distal ends of these pieces were retouched. As a consequence of that the convergent scrapers are the only scraper type that lose some of their length during the retouch process (Dibble 1995: 324-25). On the other hand it sounds logical to imagine, given the presence of retouch along the edges of the flakes, that there should be a significant relationship between retouch and the width of primary flakes. In other words, as retouch continues, the reduction pattern of scrapers must also be changed from side scrapers to double and ended in convergent forms; therefore, each level of these scraper classes had to show more or less the same mean thickness. The expectation is that the third element, thickness, demonstrates the least changes.

Considering the results presented in Table 2, it is evident that changes in the mean length of three scraper classes of Mar-Tarik cave are not consistent with the prediction of SRM and are different from the reduction pattern observed in Bisitun rock shelter. As opposed to what SRM predicts, the side scrapers mean length (43.6) is less than double scrapers (54.7), and the double scrapers is less than the convergent type (46.9). Such results deviate from what was obtained from Bisitun, at which all three classes represented no significant differences in their mean length (Dibble 1984b).

On the other hand, the results concerning the mean width of three scraper classes show more consistency with the SRM (Table. 2). No significant differences between the mean width of side and double scrapers (24.82 and 25.01) is observed, and as is expected, convergent scrapers demonstrate the least width mean (20.54).

The same scenario stands for the mean of maximum thickness, and three classes of scrapers more or less represent the same mean of maximum thickness (side: 9.5, double: 8.9, and convergent: 7.0). Such consistency is not unexpected given the fact that the only dimension of blank that remains intact despite the retouching along the margins is thickness. The data of Table 2 imply that there is no significant difference among the three scraper classes in the mean of maximum thickness.

This similarity of mean length, width, and thickness among different scraper types in Bisitun was one of the factors used by Dibble to propose that the primary blanks used for all different classes of scrapers were from the same population (Dibble 1984b). Although this scenario almost repeats itself in the case of Mar-Tarik, the homogeneity among the raw material sources could be the reason for such consistency in the dimensions of the scrapers. It has been proposed by various researchers who worked on the Zagros Mousterian assemblages that river cobbles were the main sources of raw materials (Baumler and Speth 1993; Hole and Flannery 1967; Lindly 1997). Concerning the small size of raw

material sources in the studied area, it is not unexpected to observe such homogeneity in the case of the blank dimensions.

The results from the GIR (0.34) test imply the presence of medium to low retouch on the side scrapers. Such low GIR value with respect to Dibble's SRM that predicts among the three classes of scrapers (side, double and convergent scrapers), the side scrapers should show the least amount of retouch is seem logical. In addition, it is essential to consider other bioenvironmental factors, which could affect the characteristics of the lithic assemblages. Among such factors are settlement patterns, geomorphology of the site, access to the water resources, and duration and length of use. Results from fauna analysis of Mar-Tarik indicate that this site was a hunting station, and only selected parts of the animal bodies were transported to the site by the hunters (Jaubert and Biglari 2004). These data indicate that Mar-Tarik, in contrast to Bisitun, was not used frequently to process the animal flesh. Such information is consistent with the topography of the site and its location on a steep rack, away from the plain. The geological position, the accessibility, and the distance from the plain could all be considered key factors dictating the final shape of the lithic assemblages, and they might be responsible for differences between the Bisitun and Mar-Tarik lithic assemblages.

Another important point concerning the raw materials is the question of to what extent the human populations who occupied Mar-Tarik and Bisitun possessed the knowledge of the geographical location of raw material sources during the Middle Paleolithic period. Stringer and Gamble proposed simple categorizations concerning the degree of access to raw material resources in the Middle Paleolithic. According to them, if the raw material resources were within a 5 km radius, they are considered "local;" between 5 and 20 km, "regional;" and, between 30 and 80 km “exotic” (Stringer and Gamble 1993:174).

According to geological studies, there is a natural outcrop of chert 15 km northeast of Bisitun Mountain (Jaubert and Biglari 2004); therefore we consider local access for the residents of the Bisitun Mountain sites. As was discussed earlier, the SRM suggests that one reason for the renewal of the blank edges and the presence of high retouches was the lack of access to raw materials. The results from Dibble's test in the Bisitun and Mar-Tarik sites are different in this matter. Now the question is, although raw materials existed in a radius of less than 20 km, why were the Middle Paleolithic flint knappers of Bisitun and Mar-Tarik under different pressures? To answer this question, the functionality of the Bisitun rock shelter and the Mar-Tarik cave must be taken into account, mainly because of their different topographic locations. Meantime, it is possible to assume that both sites were in use in Middle Paleolithic as seasonal butchering stations (Lindly 1997). This could be the main reason that the inhabitants of these sites did not possess a vast knowledge concerning the exact locations of the raw material sources within close proximity.

Conclusions

This research was primary designed to re-evaluate the Dibble SRM, which was first proposed based on the Bisitun Middle Paleolithic assemblages. The results taken from statistical tests on the three different classes of scrapers compared with Dibble's model imply that in both sites, the same primary flakes were used for making lithics. However, in contrast to what Dibble has proposed in the case of Bisitun, we suggest that the homogeneity in the raw material sources, which came mainly from river cobbles, was the main reason for similarities in dimensions among different classes of scrapers.

The results from GIR indicate that the unifacial side scrapers of Mar-Tarik represent medium to light retouch. This is in contrast with what had been previously proposed for the Zagros Mousterian. As it was discussed, it seems some elements other than access to raw materials like site function, topography, geographical location and settlement patterns also had an effect on the intensity of use of lithic assemblages. Considering the morphological changes within three groups of scrapers in Mar-Tarik, unless use ware analysis is conducted on the edges of the scrapers, it seems immature to accept or reject the idea that morphological variations are the

result of access to the raw materials, or a special style of knapping.

An important point to mention here is that we should never consider the SRM as a global model in interpreting scrapers of all sites. Even Dibble who proposed this model, has repeatedly mentioned that generalizing this model to all Paleolithic sites is neither possible nor scientific (Dibble 1995). Since Dibble proposed this model, various examples the presence of heavy retouch on scrapers at sites located near raw material sources (Mellars 1996: 335-341). Therefore, creating retouch on the edges of blanks could have had different reasons such as: increase of the edge length, making a special tool, and shaping it for functional reasons.

On the other hand, it is obvious that access to the proper raw materials was a major concern for most of the Middle Paleolithic populations in the Zagros Mountains. Therefore, the degree of access to good quality raw materials could have drastically changed the overall shape of the lithic assemblages. In regions such as Zagros, the intensity of retouch was generally high due to the lack of access to the raw materials; therefore, it seems that the SRM model can be applied to track the morphological changes of lithic artifacts. Meantime it must be kept in mind that other bioenvironmental factors such as site function, geomorphology, site location and more must be taken to account in studying and interpreting lithic assemblages.

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