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Skill in Stone Knapping: an Ecological Approach

Manek Kolhatkar[1]

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Abstract
Skill has allowed lithic analyses to expand their scope beyond the limits set by a representational understanding of practices and sociocultural dynamics. It remains excluded from coarse archaeological contexts in favour of higher resolution ones however. Such coarse contexts are ubiquitous and must be included to broaden description, interpretation and theorization into broader and more heterogeneous narrative landscapes. This paper argues that skill is key to including lithic practices from coarser archaeological palimpsests, provided it is reframed as a process immanent to any cultural practice that conjoins with other processes to shape contexts of various scales. Second, skill must be anchored with a set of core concepts—technical difficulty, accidents and execution quality—that each knapping event and every lithic assemblage actualizes, regardless of scale. Third, methodologies must be built using this set of core concepts and adapted to a site's specifics. Using such a methodology, I describe learning patterns, skilled reduction sequences and spatial patterning in the plowed fields of La Martre (Quebec, Canada), where millennia of continuous occupation and hundreds of thousands of lithic remains have been mixed up in a dense and homogeneous layer. I show that understanding skill as a trans-scalar process can help free lithic analyses from prior, bounded and familiar units of analysis. It can and should be used first to draw broader patterns that connect contextually specific lithic expressions. It affords for scalable analyses that can help expand the scope of the depositional contexts archaeologists routinely work with.

Keywords Skill · Ecology · Lithic analysis · Palimpsests · Scales

"[…] In scientific research you start from *two* beginnings, each of which has its own kind of authority: the observations cannot be denied, and the fundamentals must be fitted. You must achieve a sort of pincers maneuver." (Bateson, 1972:xxiii)

✉ Manek Kolhatkar
manek.kolhatkar@umontreal.ca

1 Département d'anthropologie, Université de Montréal, Montreal, Quebec, Canada

Introduction

Skill has become a prominent concept in archaeology and lithic analysis since its detailed analysis at the French Upper Paleolithic sites of Étiolles and Pincevent in the eighties (Audouze & Karlin, 2017; Bodu *et al.,* 1990; Olive, 1988; Pelegrin, 1985, 1990; Pigeot, 1987, 1990; Ploux & Karlin, 1994). Much essential work conducted over the past 40 years in lithic technology and in European, African, Asian and American contexts have shown its potential for better describing and understanding past socio-cultural dynamics, cognition development, assemblage variability and spatial patterning. Furthermore, skill has initiated a departure from an essentialist understanding of past practices that a normative construction of culture entertained to encompass more variability (*e.g.* Assaf *et al.,* 2015; Bamforth & Hicks, 2008; Bril *et al.,* 2005; Eren *et al.,* 2011a, 2011b; Goldstein, 2019; Grimm, 2000; Karlin & Julien, 2019; Klaric, 2018a; Lohse, 2011; Milne, 2005, 2011, 2013; Roux & David, 2005; Roux *et al.,* 1995; Stout, 2002; Takakura, 2013). Yet, skill is a process both immanent to any human practice and that conjoins with other, non-human, processes of growth to shape all kinds of forms and contexts (Ingold, 2000, 2011, 2013). It could also provide lithic analysis with a framework to encompass a broader range of taphonomic contexts that must be often dealt with by archaeologists (Bailey, 2007, 2008; Murray, 1997, 1999, 2013; Perreault, 2019; Rezek *et al.,* 2020; Shott, 1998, 2010).

Such a framework would be much needed at sites such as La Martre (northern Gaspe Peninsula, Quebec, Canada), where hundreds of thousands of lithic remains were produced over hundreds to thousands of years in the homogeneous and good quality material of the three nearby Cap-chat chert quarries (Burke, 2002, 2010; Chalifoux, 1999b, 2000). Owing to the slow sedimentation of the upper marine terraces where La Martre and many other sites in the region have been discovered (Benmouyal, 1987; Lothrop *et al.,* 2016), these lithic remains occupied the soil's top forty centimetres. Twentieth century's plowing activities then mixed up the soil, its lithic remains and probable occupation episodes in a homogeneous and dense layer where clear contextual differentiation prior to lithic analysis was very difficult to near impossible (Chalifoux, 1999b; Chalifoux & Tremblay, 1998; Dumais, 2000). Moreover, Late Paleoindian Sainte-Anne/Varney projectile points dated between 10 800 and 8000 cal. BP (Bradley *et al.,* 2008; Chapdelaine, 1994, 1996, 2020; Lothrop *et al.,* 2011, 2016; Petersen *et al.,* 2000) attest to an ancient baseline for the site and the region's human occupation. Together with the affordable environment provided by the nearby Goldthwait sea, Saint-Lawrence and La Martre River shorelines, residual ice caps, chert outcrops, sandy and flat marine terraces, and occupation of these terraces as they emerged over the millennia, prolonged occupation means that plowing activities may simply have aggravated the mixing of La Martre's hundreds of thousands of lithic remains.

La Martre is an archaeological palimpsest (Bailey, 2007; Lucas, 2005) whose open-ended assemblage, or aggregate (Bennett, 2010; Rezek *et al.,* 2020) asks lithic analysists the following: how should lithic remains be knitted together and to others outside La Martre so that differences may be perceived, patterns uncovered, interpretive structures constructed, and narratives expanded? What scale(s) would be appropriate for lithic narratives at La Martre? Current methodological and theoretical lithic frameworks rest upon materialistic and idealistic assumptions: the world is given to us as fragments that must be reconnected using mental schemes for it to make any sense (*e.g.* Bateson, 1972; Bergson, 1987; Debaise, 2015; Ingold, 2000; Montebello, 2015). Indeed, chronological time needs to be divided along spatial boundaries (either horizontal or vertical) to create units, or contexts, prior to any lithic analysis. Contexts allow for structured comparisons both within smaller sets and in relation to the larger whole that a historical cultural framework provides (Hodder, 1982; Sackett, 1973; Thomas, 2004; Trigger, 2006). This whole will tie these contexts into a landscape for investigating specific lifeways such as Late Paleoindian cultural norms or technological organization (*e.g.* Nelson, 1991; Pelegrin, 1995; Perlès, 1991; Ploux *et al.,* 1991; Rajala & Mills, 2017; Shott, 2018). Yet, this basic contextual requirement is not met in La Martre's dense and mixed layer of lithic remains. Lithic analysis should be enacted before contextual units are created, but it needs another framework to afford for differences to be perceived and tied to a meaningful whole.

In this paper, I suggest that skill is key to building such a framework, and a necessary condition to drawing scales of understanding at La Martre. To that end, however, our understanding of skill must shift from being encapsulated within the particulars of specific contexts and scales, to being a process in effect each time people knap stone, regardless of time and place. Contexts grow along the process of skill, not the other way around. An ecological epistemology that foregrounds relations over relata (Bateson, 1972) can help with that shift. It provides with an alternative to our underlying materialistic and idealistic assumptions about lithic practices, skill, archaeological materials and the world's ontology more generally (see also Holdaway & Davies, 2019; Holdaway & Wandsnider, 2008; Ingold, 2000, 2011, 2013; Murray, 1997, 1999, 2002, 2013; Rezek *et al.,* 2020; Shott, 1998, 2010; Webmoor & Witmore, 2008). The plowed fields of La Martre provide with a backdrop from which to follow this epistemological shift and work through the problems that both plowed fields and an ecological approach to skill poses to lithic analyses.

After a brief overview of La Martre and previous research on skill, I show how an ecological approach to skill provides with a baseline for understanding lithic practices that holds up in poorly preserved contexts while assuming varying shapes that must be explored accordingly. Furthermore, I suggest that three core concepts—technical difficulty, accidents, execution quality—may be used to build methodologies for exploring skill in lithic analysis. I then present one such methodology, devised according to these core concepts and to some of the constraints of La Martre's plowed fields. I show that learning patterns, skilled reduction sequences, and spatial patterning could be described in spite of plowing. I conclude that the purpose of an ecological approach to skill is not to answer all questions we may have about past lifeways. Indeed, the patterns that I paint with a broad brush at La Martre may only open up a whole set of questions regarding the locality's relations with a northeastern North American or Late Paleoindian landscape and that cannot be answered at this point. Rather, it is about creating the conditions affording for such questioning. Previously excluded narratives drawn from poorly preserved archaeological contexts can be tied to better preserved sites and, in the process create broader, more heterogeneous lithic landscapes and enrich archaeological narratives and investigations. In sum, skill must be understood as a scalable, dynamic process that can be used in contexts and scales where it is usually not considered to be of use, as opposed to a concept already scaled to specific and familiar contextual scales.

The La Martre Site: an Overview

The La Martre site (Fig. 1) is located on the northern coast of the Gaspe Peninsula (Quebec, Canada), along the Saint-Lawrence river estuary, one kilometre upstream from the mouth of the La Martre River (Chalifoux, 1999c; Chalifoux & Tremblay, 1998; Dumais, 2000; Ethnoscop, 1997; S.A.P.Q., 1970). It is a constellation of fifteen "stations" situated on elevated terraces along the steep eastern and western flanks of the La Martre Valley (Fig. 2). The word "station" was used by the original investigators to differentiate between the different marine terraces that emerged after the Goldthwait Sea had begun receding starting around 12 000 cal. BP (Dalton *et al.,* 2020; Dyke, 2005; Richard, 2020; Tremblay, 2004).

La Martre is one of the oldest known sites from Quebec and northeastern North America, as is asserted by its Plano projectile points, and more specifically, its Sainte-Anne/Varney points (Fig. 3). While the time of entry and peopling of the American continent has been pushed back to several millennia from its prior Clovis paradigm (Amick, 2016; Bourgeon *et al.,* 2017; Waters & Stafford, 2014), data in northeastern North America remains scarce until its Early Paleoindian phase, from 13 000 cal. BP to 12 200 cal. BP (Lothrop *et al.,* 2011, 2016). As the ice front slowly retreats northward, Quebec becomes hospitable and allows for a Middle Paleoindian occupation of its southern region, between 12 000 and 11 600 cal. BP (Chapdelaine, 2007, 2020; Chapdelaine & Richard, 2017). Among the various cultural features used to recognize either phase, projectile points remain their most important stylistic markers (Bamforth, 2009). Shapes vary, but the fluting of their proximal end remains constant until the Late Paleoindian phase (11 600–10 000 cal. BP), characterized by fine, all-over parallel pressure retouch devoid of any fluting (Fig. 4). Sainte-Anne/Varney points (Fig. 4, G and H) have been found at La Martre on four stations (3, 12, 15 and 16) (Chalifoux, 1999a, 1999b, 1999c, 2000; Chalifoux & Tremblay, 1998; Dumais, 2000). These

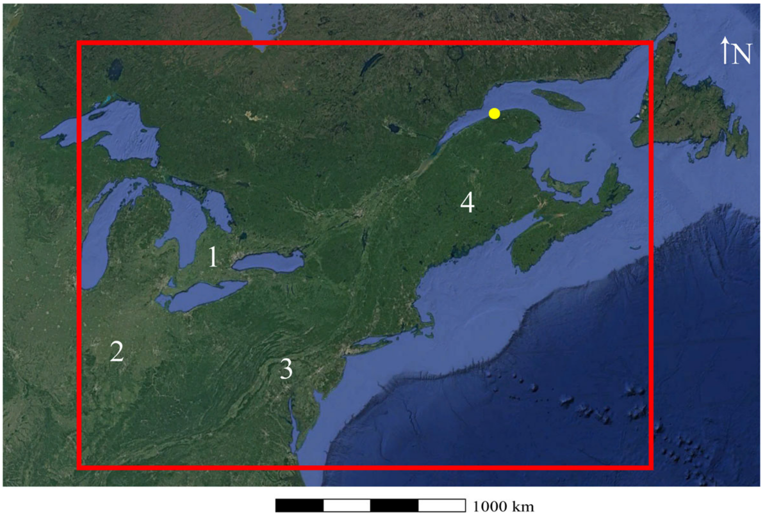


Fig. 1 Northeastern North America (1: Eastern Great Lakes; 2: Ohio Valley; 3: Mid-Atlantic; 4: New England Maritimes). The yellow dot shows the location of the La Martre site (Quebec, Canada). Base map: Google Earth, october 2019. (from Kolhatkar, 2020, fig. I-2)

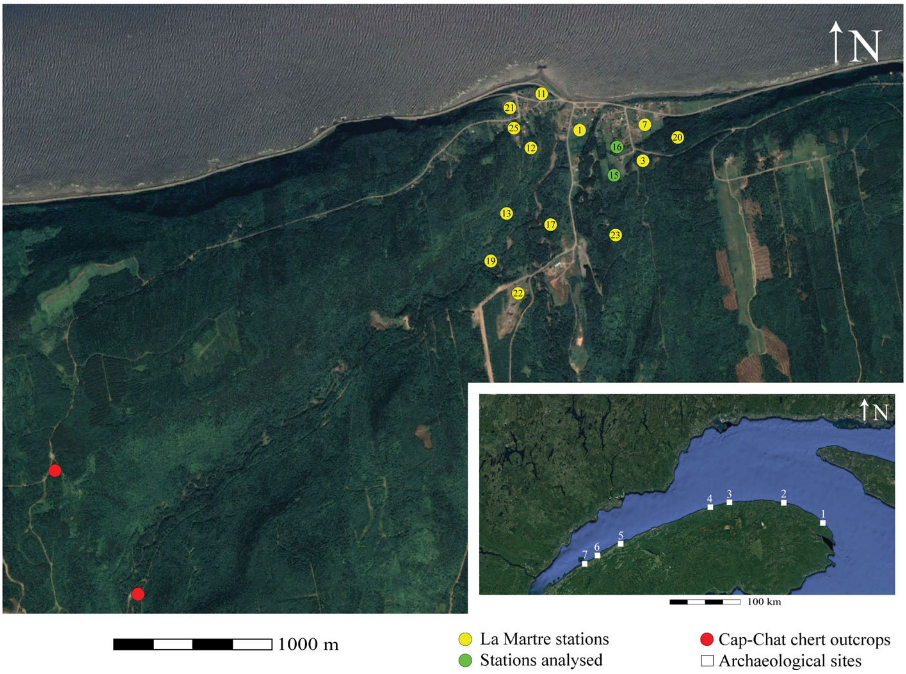


Fig. 2 The La Martre site, with stations and nearby Cap-Chat chert outcrops, and with neighbouring sites (1: Plourde; 2: Ayotte; 3: Cap-au-Renard and La Martre; 4: Sainte-Anne-des-Monts, Petite-Tourelle and Saint-Joachim; 5: Mitis; 6: Rimouski; 7: Bic). Base map: Google Earth, October 2019. (from Kolhatkar, 2020)

points have been dated elsewhere between 10 800 and 8000 cal. BP (Bradley *et al.,* 2008; Chapdelaine, 1994, 2020; Lothrop *et al.,* 2016). While these dates exceed the standard but poorly controlled Late Paleoindian lower chronological limits, they are compatible with the terraces' known date of emergence. Except for its shoreline, the Gaspe Peninsula remains covered in ice until at least 10 000 cal. BP (Dyke, 2005). At La Martre, marine terraces located between 25 and 35 m emerged around 12 000 and 10 000 cal. BP, around which time the La Martre River Valley was a vast bay that penetrated inland. By 9000 cal. BP, terraces located at 15 metres were exposed (Chalifoux & Tremblay, 1998, Dumais, 2000). Furthermore, palynological research points to the region's habitability starting around 12 000 cal. BP, as the periglacial desert made way to a shrub tundra with dwarf birch and willow. No vegetal macrofossil older than 12 000 cal. BP has been found in the region (Asnong & Richard, 2003; Hétu & Gray, 2002; Marcoux & Richard, 1995; Richard *et al.,* 1997).

La Martre's terraces are covered with thousands of lithic remains, suggesting that the locality is occupied continuously for the next millennia. It expands northward north-eastern North America's already well defined social landscape of lithic materials, information exchange networks and general land use (*e.g.* Anderson, 1990, 1995; Chapdelaine, 2012; Chapdelaine & Richard, 2017; Ellis & Deller, 2000; Ellis & Lothrop, 1989; Jackson & Hinshelwood, 2004; Julig, 1994; Kitchel, 2018; Lothrop *et al.,* 2016; Meltzer, 1988; Spiess *et al.,* 1998; Storck, 1997). Indeed, Sainte-Anne/Varney points can be found all over northeastern North America, and such points still provide with the most secure footing for tying La Martre to the region's social

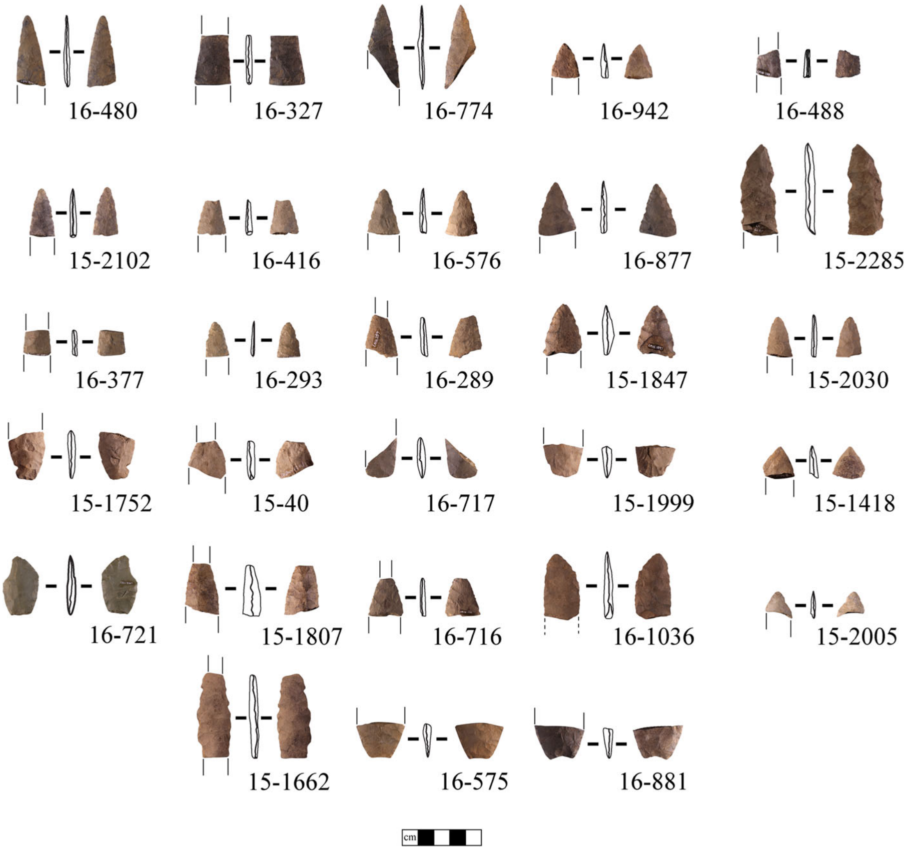


Fig. 3 Plano projectile points found at La Martre, stations 15 and 16. All points are Sainte-Anne/Varney, except 16-575 and 16-881, which are pseudo-Agate Basin points. Photograph by Manek Kolhatkar (from Kolhatkar, 2020)

landscape (Bradley *et al.,* 2008; Chapdelaine, 1996; Dumais, 2000; Lothrop *et al.,* 2011, 2016; Petersen *et al.,* 2000). La Martre is also part of a nexus of sites found all over the northern Gaspe peninsula shoreline (Benmouyal, 1987; Lothrop *et al.,* 2016) (Fig. 2). The region might have been all the more significant due to its environmental setting and the continuous occupation it would have afforded: (i) various Cap-Chat chert outcrops, three of which have been found close to La Martre, 100 to 300 metres high, and clearly associated with quarrying activities (Benmouyal, 1987; Burke, 2002, 2010; Chalifoux, 1999b, 2000; Chalifoux & Tremblay, 1998); (ii) the proximity of the Goldthwait Sea before it became the Saint-Lawrence River, and of a nearby residual ice cap (Dyke, 2005; Lothrop *et al.,* 2016; Richard, 2007, 2020) allowing for both lithic and high quality animal protein resources to be plentiful and easy to access (Pelletier & Robinson, 2005; Robinson *et al.,* 2009); (iii) extensive, sandy and flat terraces affording for good occupation surfaces. No site, however, has shown the same amount of knapped lithic remains (Benmouyal, 1987; Chapdelaine, 1994).

Yet, in spite of the importance that the northern Gaspe Peninsula seems to have had for its oldest inhabitants, little research has been conducted in the region: its most thorough analysis dates back to the eighties (Benmouyal, 1987), after which sporadic

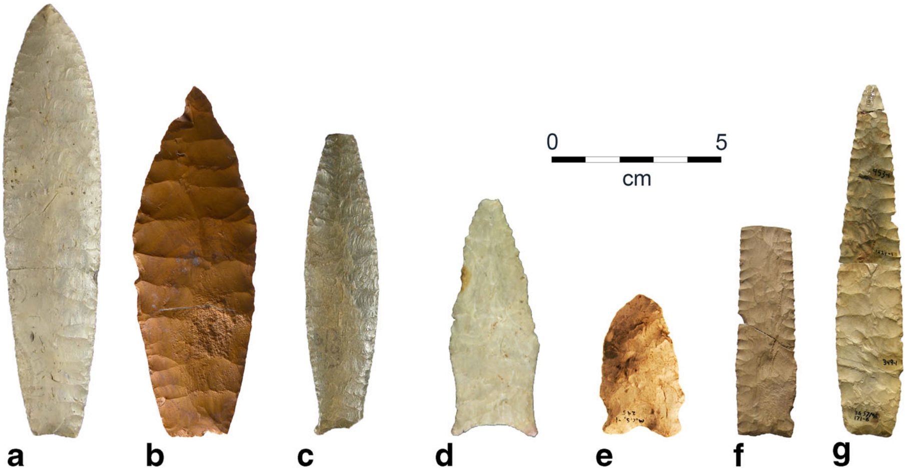


Fig. 4 Late Paleoindian biface forms, northeastern North America. A: Agate Basin-like point, southern OH; B: Agate Basin-like point, central NY; C: Beaver Lake point, OH; D: Dalton point, OH; E: Hi-Lo point, Stewart site, Ontario; F & G: Ste. Anne-Varney points, Varney Farm site, ME (Image credits: A, C, D-Ohio History Connection; B-NY State Museum; F and G-Maine State Museum). Reproduced from Figure 11, Lothrop *et al.,* 2016, with kind permission of *PaleoAmerica* Journal editor Ted Goebel

research was conducted (Chalifoux, 1999b; Chalifoux & Tremblay, 1998; Chapdelaine, 1994; Dumais, 2000; Pintal, 2006). This is in line with a general lack of research on the northeastern North American Late Paleoindian timeframe in general, due in part to research efforts focused on Early Paleoindian and the first peopling of the region (Chapdelaine, 2020; Lothrop *et al.,* 2016). La Martre, however, poses additional challenges to its inclusion in broader archaeological narratives, due to its size, depositional disturbance, and density of lithic remains. Indeed, visual inspections, surface collection, test pits and more extensive excavations have shown that (i) La Martre's lithic remains are located very close to the ground surface, owing to slow sedimentation; (ii) the region's acidic soils seldom if ever allow for organic residue preservation, meaning that only lithic remains or carbonized organic residues may be uncovered (Chapdelaine, 1994; Hétu & Gray, 2002).

In addition, fieldwork also showed that the stations' pedological contexts have been transformed in various ways. Stations 15 and 16, terraces 40 to 35 m high on which this research is focused due to their proximity (Fig. 5), were spared the destructive housing development and extensive sandpit operations affecting the other stations. If a sandpit was nonetheless excavated through these stations, it is relatively small compared with stations 15 and 16's respective 30 000 and 12 000 m^2. In addition to solifluxion, tree falls and animal burrowing, plowing has affected each station with almost no exceptions, creating a thirty to 40-cm-thick layer of brown and homogeneous soil (Fig. 6), destroying its stratigraphic structure, dispersing its lithic remains horizontally to a degree that is difficult to estimate, and dismantling any structure such as hearth pits that could have been preserved on the terraces. When compared with housing and sand pits however, plowing did not destroy lithic tools and debris: it merely moved them to unknown degrees. Indeed, research on plowing contexts has shown that plowing

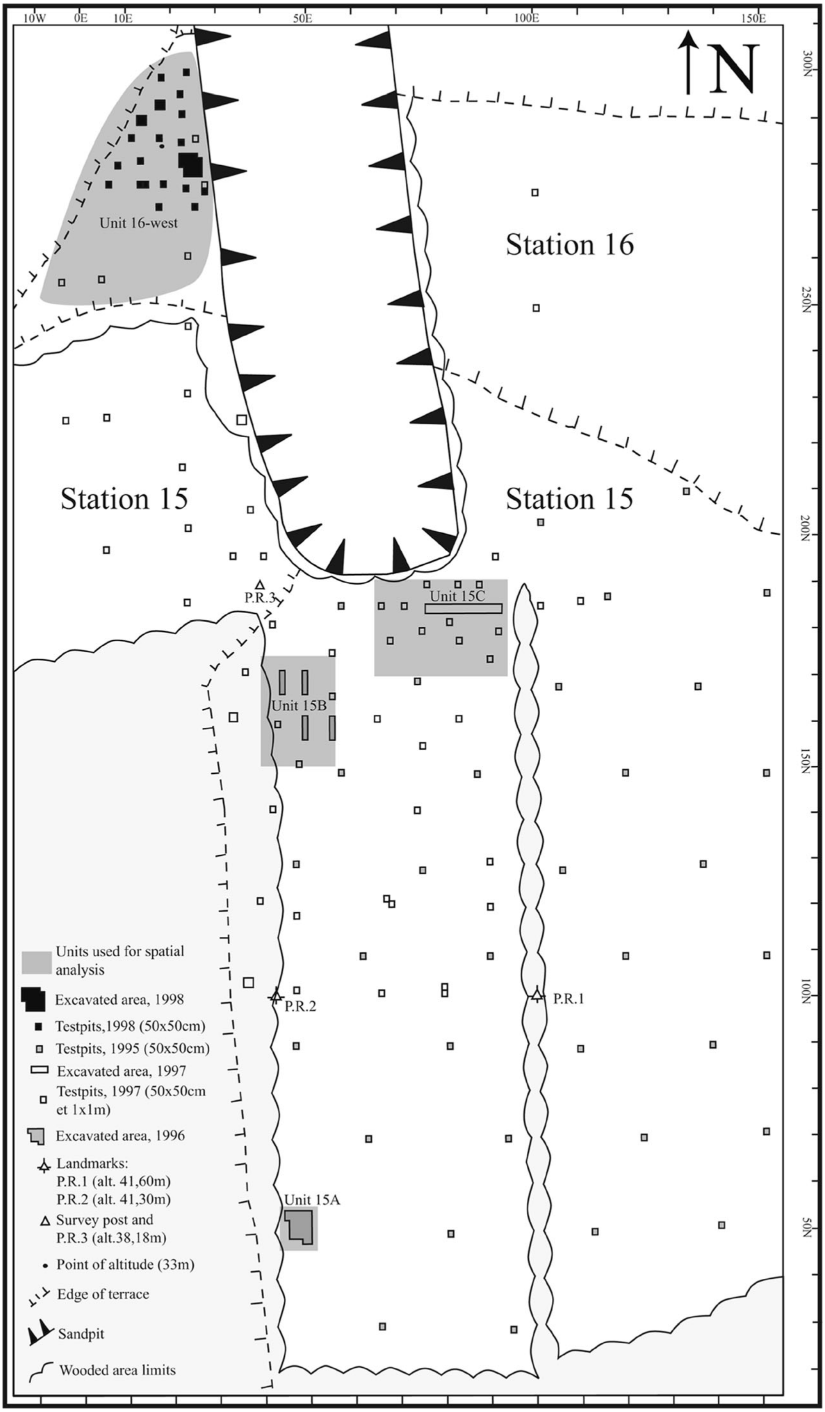


Fig. 5 Stations 15 and 16 at La Martre (from Kolhatkar, 2020, adapted from Chalifoux, 1999a, 1999b, 2000, Chalifoux & Tremblay, 1998)

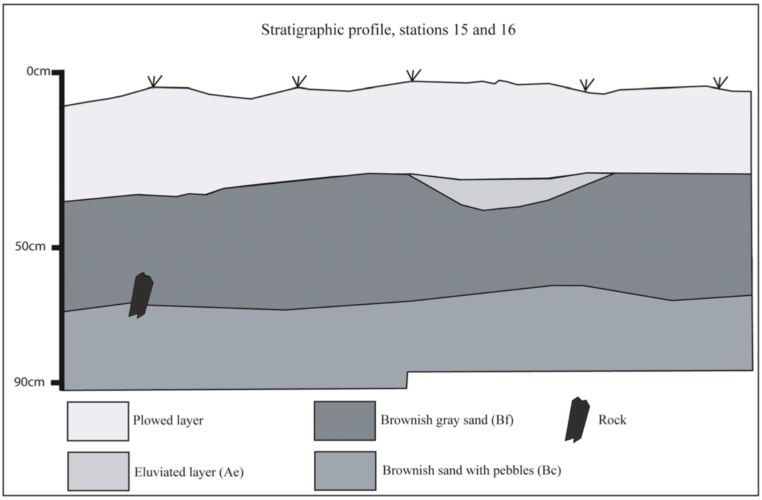


Fig. 6 Stratigraphic profile, stations 15 and 16 (from Kolhatkar, 2020, adapted from Chalifoux & Tremblay, 1998)

activities do not completely destroy an archaeological context (*e.g.* Ammerman, 1985; Ammerman & Feldman, 1978; De Alba, 2003; Dunnell & Simek, 1995; Frink, 1984; Leach, 1998; Lewarch & O'Brien, 1981; Navazo & Diez, 2008; Odell & Cowan, 1987; Roper, 1976; Shott, 1995; Steinberg, 1996; Yorston *et al.,* 1990). Such studies, however, are mainly preoccupied with contextual deposition before plowing activities took place, which has been the subject of a controversy regarding behavioural archaeology's essentialist assumptions about culture and systemic contexts (Barrett, 1988; Binford, 1981; Murray, 1999; Schiffer, 1972, 1985). Plowing activities at La Martre may simply have exacerbated centuries or millennia of lithic mixing, owing to poor chronological control of the Late Paleoindian phase and slow sedimentation of the upper terraces.

On-site sampling procedures of stations 15 and 16, from 1995 to 1998, combined visual inspections and 0.50 × 0.50m test pits, spaced fifteen metres apart. Following this first evaluation, excavation areas were opened during later fieldwork owing to: a high concentration of bifacial and unifacial tools (15a and 16-west), quartz flakes (15b), and an arbitrary exploration of distributional patterns (15c). These were coupled with intensified visual inspections and test pits around those sectors of stations 15 and 16. Test pits and excavation areas coverage amount to approximately 135 m^2, or 0,3% of both stations' 42 000m^2 total surface. 924 bifaces, 289 unifacial tools and 142 439 flakes were uncovered (Table 1). The count includes both small fragments (that could belong to the same object), complete objects, and pieces broken to various degrees. Even when accounting for mostly ambiguous unifacial tools due to the site's high energy context (Dumais, 2000) and for bifacial fragments that might multiply the tool count, the tool-to-flake ratio remains very low (0.008). This points to workshop activities on both stations, in line with quarrying activities close by, and dedicated to bifacial reduction on good quality Cap-Chat chert that accounts for 99.9% of the assemblage's (local) raw material. No points other than Plano were found.

Table 1 Artefact type, by station, stations 15 and 16 (translated and adapted from Kolhatkar, 2020, Tab. IV-1 and IV-2)

Artefacts	Station 15				Station 16			Total
	Test pits	Area A	Area B	Area C	16-west - Test pits	16-west - Area 1	16-east - surface and test pits	
Projectile points	10	7	10	3	6	12	4	**52**
Drills	3	2	5	1	1	2	2	**16**
Bifaces	73	45	28	91	26	91	197	**551**
Preforms	34	28	42	12	1	5	12	**134**
Roughouts	42	25	51	20	3	5	6	**152**
Unidentified bifacial tools	1	0	0	0	5	7	5	**18**
Chopping tools	0	1	0	0	0	0	0	**1**
Biface total	**163**	**108**	**136**	**127**	**42**	**122**	**226**	**924**
Scrapers	5	1	4	12	3	4	1	**30**
end scraper	0	3	0	2	0	0	3	**8**
Scrapers/end scraper	0	0	0	1	0	0	0	**1**
Gravers	0	0	0	0	1	0	0	**1**
Used flakes	27	4	0	79	13	27	13	**163**
Retouched flakes	42	4	1	11	3	9	16	**86**
Unifacial tools total	**74**	**12**	**5**	**105**	**20**	**40**	**33**	**289**
Pièces esquillées/bipolar cores	1	2	0	2	0	3	1	**9**
Percussors	2	1	0	2	2	13	4	**24**
Polishing tools	5	1	0	11	2	7	0	**26**
Grindstones	0	7	7	3	1	0	11	**29**
Crushers	0	0	0	0	0	1	0	**1**
Polished tools	0	0	0	1	0	0	0	**1**
Pyrite	1	0	0	5	0	0	0	**6**

Table 1 (continued)

Artefacts	Station 15				Station 16			Total
	Test pits	Area A	Area B	Area C	16-west - Test pits	16-west - Area 1	16-east - surface and test pits	
Transforming tools total	**9**	**11**	**7**	**24**	**5**	**24**	**16**	**96**
Flakes	27260	18793	23788	37732	4603	25650	4613	**142439**
Tabular blanks (chert)	4	0	0	4	1	1	0	**10**
Pebbles	3	0	0	17	3	5	1	**29**
Cores	9	2	0	5	2	7	1	**26**
Bones (carbonized and fresh)	6	0	0	0	1	5	1	**13**
Recent	3	0	0	0	0	0	0	**3**
TOTAL	**27531**	**18926**	**23936**	**38014**	**4677**	**25854**	**4891**	**143829**
Excavated surface (m2)	24	29	20	32	8.25	21.75	0.5	**135.5**
Tool/flake ratio (excluding transforming tools)	0,008	0,006	0,005	0,006	0,01	0,006	0,05	**0,008**

In sum, given the lack of datable materials at La Martre, geomorphological, palynological research and typochronological affiliations provide the most secure baseline for understanding the region's chronology, and above which a lack of contextual control mixes up its lithic practices to various and unknown degrees. The units of analysis at our disposal are the stone flake, the biface, the excavation unit, the "station" (or marine terrace), and the La Martre site. Following their connections to understand their significance requires a framework that skill can help to build.

Previous Research on Skill in Stone Knapping

Much important work has been conducted in lithic technology and skill for the past forty years to inquire about apprenticeship (Bodu *et al.,* 1990; Finlay, 2008; Pigeot, 1987, 1990, 2004; Stout, 2002; Takakura, 2013), skilled reduction sequences (Lohse, 2011; Pigeot, 1987, 1990, 2004), raw material constraints on stone knapping (Finlay, 2011; Leroyer, 2018; Sternke, 2011), children and women in past communities (Grimm, 2000; Hildebrand, 2012; Weedman, 2010), landscape use (Milne, 2005, 2011, 2013), spatial organization (Bodu *et al.,* 1990; Karlin & Julien, 2019; Olive, 1988; Pigeot, 1987, 1990, 2004), intermediate skill levels (Karlin & Julien, 2019; Leroyer, 2018; Pigeot, 1987, 1990, 2004; Ploux & Karlin, 2014; Takakura, 2013), technical prowess (Aubry *et al.,* 2003, 2008; Karlin & Julien, 2019; Olausson, 2017; Pelegrin, 2019a, 2019b; Pigeot, 1987, 1990, 2004; Sinclair & McNabb, 2005), cognition (Roux, 1991; Delagnes & Roche, 2005; Stout, 2011) (see also Klaric, 2018b for further references).

Three domains of analysis are usually used to investigate skill related hypothesis: general conditions, assemblages, and individual objects. Conditions affording for skill development frame lithic practices in a broader unit of understanding to better ground skill-based arguments and interpretations (*e.g.* Apel, 2000, 2008; Bamforth & Hicks, 2008; Bar-Yosef, 2013; d'Errico & Banks, 2015; Ferguson, 2003; Goldstein, 2019; Grimm, 2000; Hiscock, 2014; Milne, 2005, 2011; Olausson, 2008; Pétrequin & Pétrequin, 2002; Pigeot, 1987, 1990; Sinclair & McNabb, 2005; Stout, 2002, 2005). These conditions may be environmental (*e.g.* quarries afford for youngsters to learn without endangering the survival of the rest of the group [Milne, 2005]), sociocultural (*e.g.* reaching a high-level skill of stone knapping is a specialized activity that requires time and other people to provide a craftsman with food and to value such an investment [Hiscock, 2014]) or technical (*e.g.* a level of skill required to allow for specific stone knapping techniques such as Folsom bifacial fluting or levallois debitage [Ahler & Geib, 2000, Bar-Yosef, 2013, Lassen & Williams, 2015]). Second, the level of standardization of shapes and techniques in an assemblage has allowed some to infer skill levels, since it cannot be simply taken for granted but must be acquired through practice (*e.g.* Bamforth & Hicks, 2008; Eerkens, 2000; Eerkens & Bettinger, 2001; Goldstein, 2019). Deviations from such standards may also be used to show both greater (Sinclair & McNabb, 2005) or lesser (Goldstein, 2019) skill levels. Third, the recording of variables and their attributes on bifaces, cores, flakes and various tools, along with their shaping, or *chaîne opératoire*, provide valuable data about skill, whether it be an object's general properties (symmetry, ratios, regularity, proportions), accidents encountered during knapping, or a knapper's gestures and strength thanks to kinetic analysis (*e.g.* Apel, 2008; Bamforth & Hicks, 2008; Bril *et al.,* 2005; Callahan, 1979; Darmark, 2010; Goldstein, 2019; Milne, 2005; Bril *et al.,* 2005; Roux & David, 2005; Pigeot, 1987, 1990; Shelley, 1990; Stout, 2002; Takakura, 2013).

Research on skill may be ordered along these three domains because plowing activities have broken up their connections, thus revealing the conditions that, elsewhere, allow for their seamless integration in stone knapping narratives. At La Martre, individual objects have been aggregated into an assemblage through multiple occupation episodes extending over centuries or millennia that cannot be neatly uncoupled to explore inner standardization. The sociocultural conditions used for comparing various objects, for structuring an assemblage's skilled practices, or for justifying some degree of standardization or deviation from a norm require some contextual control that plowed fields do not provide from the onset. The assemblage composition points to workshop activities dedicated to bifacial reduction, but used for an unknown duration, considering that bifaces were produced during all of Quebec's history (*e.g.* Taché, 2011, on the later Meadowood period). Environmental conditions may be more stable but they frame practices and sociocultural dynamics that cannot be clearly uncoupled in La Martre's homogeneous and plentiful lithic matrix.

Working in plowed fields thus forces us to be explicit about the way we create these connections when we compare objects and assemblages and mesh them into broader landscapes of lithic practices. As it has already been pointed out elsewhere (*e.g.* Bailey, 2007; Murray, 1997, 1999; Perreault, 2019; Rezek *et al.,* 2020), the problem posed by plowing and archaeological palimpsests more generally is epistemological before being theoretical, methodological, or even depositional: that is, it is about the kinds of concepts we use to inquire about the world and the ontology of archaeological materials (Bateson, 1972; Murray, 2013) so that we may devise theoretical and methodological frameworks with concepts that are adapted to the scale of understanding one must work with.

Towards an Ecological Approach to Skill

Opening up our understanding (and use) of skill calls for an epistemological shift that can be borrowed from the works of Gregory Bateson (1972, 1979) in ecology (see also Bennett, 2010; Bergson, 1987, 2012; de Certeau, 1990; Debaise, 2015; Deleuze & Guattari, 1980; Haraway, 2016; Ingold, 2000, 2011; Kohn, 2013; Latour, 2006; Montebello, 2007, 2015; Olsen *et al.,* 2012; Rancière, 1987, 2000, 2011, 2014, 2018; Strathern, 2004; Thomas, 2015; Tsing, 2015; Viveiros de Castro, 2009; Webmoor & Witmore, 2008; Whitehead, 2006). An ecological epistemology emphasizes the importance of meaningful relations over relata when inquiring about the world. Indeed, in order to find some meaning to the world, one must find their way through it by following its relations, navigating its fluxes and wrestling with its forces and materials. In so doing, they conjoin (Ingold, 2011) with the world's life process of uninterrupted growth they become with and shape the world along. This ecological approach may be contrasted with a Kantian (Montebello, 2015), spatial (Bergson, 2012), optic (Deleuze & Guattari, 1980), dormitive (Bateson, 1972) or bifurcated (Debaise, 2015; Whitehead, 2006) approach that stipulates a rupture between the mind and the world, allowing for the former to ascribe meaning to the latter from a safe distance, undisturbed by its many fluxes. This separation of mind and matter leads to idealist (or subjectivist) and materialist (or objectivist) baselines for framing knowledge. In the former, the world is perceived through one's pre-existing mental framework while in the latter, one's perception is the result of input from the world (see also Varela, 2017; Varela *et al.,* 1993). Both start and lead back to the world's fragmentation (Bergson, 2012), whether it be within isolated minds that must be reconnected with added social and cultural representations, or against objects that our perception individualizes to reach conclusions about the nature of the world. According to an ecological approach, the distance between mind and matter is not fixed but arbitrary, and always played along relations that allow for the world to disturb our minds, breach our expectations, and force us to reassess that which our minds alone could not have created (Bergson, 1987; Montebello, 2015). Knowledge is thus grown from the inside (Ingold, 2011), rather than being defined from some abstract outer limits. Concepts for inquiring become paramount here, for they can as much impede as they can allow one's ability to know along the world's manifold relations (see also Deleuze & Guattari, 1991; Montebello, 2015; Rancière, 2000, 2011, 2014, 2018).

Following such an ecological approach, Tim Ingold (2000:352–354) has defined skill as follows. First, it is one's engagement with their tools and materials in an environment. Second, it is contextual, meaning that it cannot be understood by isolating one from their tools, materials, and the environment they put their skills at use with. Third, putting one's skills to use requires care, attention, judgment and dexterity. Fourth, skill must be practised to be embodied. Fifth, skill is a creative practice rather than the mere execution of a projected intentionality on a passive piece of raw material. More broadly, skill must be understood as a process along which one participates in a meshwork of interwoven lifeforms making up a lifeworld that multiple scales of complexity can grow from (see also Bateson, 1972; Deacon, 2011; Kohn, 2013; Varela, 2017).

This definition of skill allows for meshing lithic remains at La Martre. First, we can include the site's scale, which mixes up high and low resolution events of up to 11 000 years and tens of thousands of lithic remains in size. An event ranges here from a flake's removal, stone-knapping's elementary unit of action (Bril *et al.,* 2005), to flake removals shaping short use-life bifaces that are discarded when broken, to various knapping learning situations, social aggregation episodes, and so on up to the conflation of these episodes and their lithic remains in plowed depositional units (Shott, 1998; Stern, 1993, 1994, 2008). Fine-grained knapping events are still enclosed within each object's borders. Thousands of events were mixed up in an open assemblage, or aggregate (Bennett, 2010; Rezek *et al.,* 2020) spanning an unknown number of years, owing to (i) slow sedimentation rates that leave lithic remains close to the surface, easily accessible to succeeding knappers as libraries of stone (Dibble *et al.,* 2017; Hiscock, 2014); (ii) quarries that are still accessible and plentiful today, and that could have allowed for millennia of exploitation; and (iii) the Saint-Lawrence river shoreline and its sandy, flat and expansive terraces.

No points other than Plano have been found (or recognized) at La Martre. Yet, rather than arguing for the abandonment of upper terraces as the shoreline retreated in order to reduce the size of a station's scale, it might be safer to work with a worst-case scenario, where terraces might be mixing up to 11,000 years of lithic practices with little to no prior chronological control over them within this bracket. We must then work at creating a baseline that can both include this scale and others, and allow for the comparison of lithic remains. An ecological epistemology shows us that the world must first be understood along relations rather than as a fragmented reality we would then have to reconnect. In assessing La Martre's lithic remains, we can recognize that each one is the result of a skilled practice, whatever its level, the knapper's original intent, and other constraints and causes that might have had a part in their shaping. Where historical cultural frameworks require (chronological) time and space specifics (Sackett, 1973; Trigger, 2006), skill does not. While (some) projectile points may be affiliated to such specifics, most lithic shapes cannot if they have not been first associated with chronocultural markers within controlled contexts. And while we could envision La Martre's history as a succession of historical cultural periods and phases, or any other bounded events, plowing activities have rendered this specific grasp on archaeological materials almost useless. Yet, it is the knappers' skilled practice that enacted these episodes, its lithic remains as much as the various patterns they created with these remains. Without skill there would not be anything (at least, anything pertaining to stone knapping) for us to perceive at La Martre (Kolhatkar, 2016). In other words, skill does not rest upon archaeological contexts to be enacted, for it is thanks to the former that the latter are.

This reversal of our understanding of skill is key to working in La Martre's plowed fields. Skill provides lithic analysis with a larger framework, or meshwork, that has no boundaries, for it is made of relations (Ingold, 2011) that provide the material for drawing fluid and moving boundaries along the various units of analysis that we must work with at La Martre. This means that skill endures and provides us with a point of entry for further exploring La Martre's scales and various cultural expressions along its lithic practices. Indeed, given that the differences we perceive can be infinite, skill provides us with a smaller set of relations that help to structure a baseline for comparing and drawing broad patterns.

Three core concepts for skill in stone knapping: technical difficulty, accidents, and execution quality

The fluidity and expansion of such a process, however, requires concepts to better grasp it and start narrowing it down (Bateson, 1972; Bergson, 1987; Montebello, 2015). We can begin to scale that process to stone knapping. I will now outline a set of three core concepts that must structure our baseline of comparison and the methodologies we use for comparing: technical difficulty, accidents, and execution quality. Bifacial knapping, as found at La Martre, is used here to flesh out these concepts. The word "biface" encompasses all steps and stages of its reduction process, from blanks to preforms and projectile points, that stem from bifacial manufacture. It can also encompass any other end product, as bifacial reduction refers to a blank made of two faces that conjoin along a secant plane (Boëda, 2001; Callahan, 1979; Inizan *et al.,* 1995; Roche & Texier, 1991; Shott, 2017). Reduction means that the knapping process is extended in time: knappers must work with the situation at hand and the technical problems it poses, even as they must orient their short-term decisions towards a longer-term objective (Bril *et al.,* 2005; Keller & Keller, 1996; Pelegrin, 1985). In the process, unforeseen events will happen, whether accidents, or any tasks needed for never-ending calibrations. This process can be framed as a cycle whose multiple iterations provide with repetitions without repetition (sensu Bernstein, 1996). Each iteration alternates a calibration and stabilization event. Materials are removed after some evaluation of the situation at hand to allow for the blank to change towards its discarded shape. With each iteration, shapes slowly change, as do knappers, who gain better knowledge of their abilities and the possibilities that a situation at hand affords for.

Yet, this knowledge does not grow in a linear fashion, but by steps. Bifacial knappers need to learn how to control various properties while shaping a biface (Apel, 2008; Callahan, 1979; Geribàs *et al.,* 2010; Pargeter *et al.,* 2019; Rein *et al.,* 2013; Waldorf, 1993; Whittaker, 1994): width-to-thickness (W/T) ratio, platform, surface, centre plane on the blank's end; along with percussor type, movement, dexterity and finger positioning on the knapper's end. Foremost is the biface's general W/T ratio, and the way width changes relative to thickness. During the earlier stages, for example (*e.g.* edging), a biface will be narrowed faster than it is thinned. This pace cannot be kept for too long however, as the blank may become too narrow for any thinning to occur (Callahan, 1979:37–38). This pace can be changed thanks to an appropriate platform preparation and positioning relative to the median plan, along with soft percussor knapping (see, however, Young & Bonnichsen, 1984). This platform allows knappers to change the way they interact with their biface's volume so as to detach more covering flakes, to the point where a flake may cover a whole surface. Working on each surface to thin their biface's volume, knappers also create a ridge network that must be used either to better control a percussion wave or, later on during pressure retouch, to allow such waves to travel further and more regularly. All the while reducing the size of their biface, knappers must work towards a broad long-term objective that orients (but does not determine) their craft even as they must control the flow of knapping by adapting to and improvising with short-term problems that each situation renewed with every flake removal presents before them (Bril *et al.,* 2005; Kolhatkar, 2020; Pelegrin, 1985).

Controlling these properties has to be learned, theoretically (knowledge) as much as practically (know-how) (Apel, 2008; Pelegrin, 1985). Experimental research on bifacial stone knapping has shown that some problems are much more difficult to address than others (see especially Apel, 2000, 2008, Bril *et al.,* 2005, Roux & David, 2005, Callahan, 1979, Stout, 2002, Waldorf, 1993, Whittaker, 1994). Consequently, some technical situations will allow knappers to show and use their expertise, while other operations they must go through will not (Callahan, 1979:37-38). Indeed, edging a tabular blank to provide one with an operating platform is a relatively straightforward task. It is one of the first tasks novice knappers must learn how to do, along with the *ad hoc* retouch of a flake's edge to create a scraper (see also Waldorf, 1993; Whittaker, 1994), and it is also a requirement for expert knappers to further shape their bifaces. This task, however, will not allow for the distinction of novices from experts. In fact, the latter may even ask the former to edge a biface in order for them to intervene where and when their expertise makes a difference (see also Hiscock, 2014; Pétrequin & Pétrequin, 2002). Harder tasks can then be executed, such as various kinds of thinning or retouch, which knappers must learn through endless practice, trials and errors, thus improving their ability to anticipate, judge and correctly achieve what they may have in mind. In a word, to improve their ability to control their knapping.

It follows that when analyzing skill, possibilities for action afforded by a task must be distinguished from the abilities for action that a knapper has developed, because various tasks pose various technical difficulties. In other words, expert knappers must edge their bifaces but this task does not point at their skill's limitations. To the contrary, a very difficult task makes it possible for knappers to demonstrate their high level of ability, even if they end up breaking their thin and wide biface. *Technical difficulty* allows for this distinction, by providing a lithic analysis with a skill baseline and a skill ceiling knappers work within. Various baselines and ceilings, or levels of technical difficulty can be formalized thanks to experimental research on bifacial knapping (see below).

Practice provokes mistakes, that leave *accidents* on the blank: step fractures, breaks, edge crushing, overshots, thick edges, platform destruction and so on (*e.g.* Bril *et al.,* 2005; Callahan, 1979; Shelley, 1990). Such accidents attest to how one masters a given situation's varying levels of control. Some of these accidents can attest to a knapper's general level of skill (*e.g.* skilled knappers will absolutely avoid crushing their platform or stacking up steps). Here again, such accidents cannot be directly compared, for they vary with the technical difficulty of the situation at hand: a well-controlled edged blank is different, level of expertise-wise, from a well-controlled advanced preform. Accidents reveal another gap between a knapper's intention and achievement, or knowledge and know-how. They must be understood in relation to a situation's technical difficulty (see also Pigeot, 1987), and, likewise, a similar situation may show various levels of mastery or know-how. Relating technical difficulty and accidents allows for assessing the *execution quality* of a product and a knapper's skill. That is, one's control of a technical situation as intention and achievement may diverge (or not), along with one's ability to even intend a task, as afforded by their capacity to push through a difficulty ceiling and open up a new set of choices for them to make. In turn, this allows a lithic analyst to move away from a simple novice/expert dichotomy so that learning can be considered as a process, and so that experts are allowed to make mistakes as well (Torres & Preysler, 2020).

Skill, then, must be addressed by holding together technical difficulty, accidents and execution quality. They form a set of core concepts in that they are enacted in the individual blank as much as in the assemblage domains, and at any point during a knapping process as much as during the whole process; and they are trans-scalar, meaning here that they help capture the (equally trans-scalar) process of skill, although they have been narrowed down here to stone knapping and bifacial reduction.

Methodology

The methodology I used at La Martre is a further attempt at narrowing the process of skill on the locality's specifics. It may be one of many that could be used for exploring coarse contexts, provided they actualize the set of core concepts defined above.

Units of Analysis

The Biface as a Shaped Blank

Stone knapping can be understood as a cycle extended in time, where transformation events (removing a flake, trimming an edge) alternates with stabilized states (evaluation without transformation). This cycle unfolds towards a blank's discard. Discard freezes a set of properties and protects them within the blank while plowing activities mix up La Martre's aggregated assemblage(s). The stabilization phase is as important to knapping stone as it is for its analysis. First, it provides with a unit of analysis that is less changing than the various gestures (and their scars) that enact such change precisely because such gestures were intended to stabilize a shape. Second, it allows description and stone knapping to meet on a common ground, that of evaluation of a situation at hand, whether by a knapper or by a lithic analyst. Third, it allows for reducing the number of variables and attributes that one can use to compare bifaces, and to hierarchize differences and similarities. For example, scar direction and sequencing become less important than the general state they stabilize, because it is the centre plane position, the ridge network and the cross-section shape that knappers will evaluate for the knapping to proceed. The former is not negated and can very well be relied upon nonetheless when assessing trickier cases (such as bifaces between two types) or to further differentiate between knapping procedures. The biface must then be understood in the following analysis as a "shaped blank", as opposed to a "blank in the process of being shaped".

The Biface as a Discarded Blank

Intentionality, as a cause for understanding choices and shapes, may be difficult to identify in plowed fields. Asserting, for example, that knappers wanted to produce a Sainte-Anne/Varney projectile point requires contexts to frame a biface into a larger (Late Paleoindian) whole. However, focusing on intentionality may be more of an epistemological (idealistic) problem than a depositional one, because it is knappers, not their intentionality, who shape materials (Ingold, 2000, 2011, 2013; Smitsman *et al.,* 2005). Whether because of knapping accidents or other post-depositional events, broken shapes were certainly not those that knappers set out to create. This holds up for unbroken bifaces as well: as a process extended in time, stone knapping allows for various unforeseen events to happen, down to the calibration events that attest to a knapper's expertise. A complete shape may also be left behind as a preform that can be turned to when in need, enriching La Martre's library of stone (Dibble *et al.,* 2017; Hiscock, 2014), and opening up a discarded biface's continued shaping by different knappers, oblivious to their predecessors' original intentions (see also Bar-Yosef & Van Peer, 2009, Bleed, 2001, 2011 for discussions about the limits of foregrounding intentionality in lithic analysis).

It follows that analysis must be separated from the intentionality of past knappers. Why a knapper should venture into producing difficult shapes is another matter. Why groups of knappers would reproduce such shapes is another matter yet. It is from these similarities and differences that intentionality might eventually emerge in our interpretation. This holds for various other causes, either (i) starting from a blank with various properties (size and shape) as are plentiful at La Martre's nearby quarries; or (ii) answering other environmental, cultural and personal constraints some of which may be beyond archaeologists' grasp. In all cases, one must deal with higher or lesser levels of difficulty that seem remarkably constant across the literature: the larger, thinner, and more regular the biface, the more difficult it is to produce. From there on, sets of criteria may be formulated to explain how bifaces are shaped, and to analyze mixed assemblages. In fact, skill may be the only cause we can control from the onset, because a biface, from its shape, its raw material, or the cultural norms it reproduces, is the result of a skilled practice. Skill is not so much an alternate hypothesis as the baseline allowing for various other causes to be knitted together. Likewise, its analysis must draw broad patterns that can contextualize other causes for variability.

The Biface's Width-by-Thickness Ratio as a Golden Rule

A biface allows for its width-by-thickness ratio to be computed. Experimentation has shown this value to be of paramount importance. It is equally important in the following analysis because it provides with a baseline that is easy to measure, compute, and reproduce, and against which further, more subjective variables, may be assessed. Finally, it provides with a general technical context for assessing technical difficulty and accident gravity levels variables (see below). However, most bifaces that were recovered at La Martre were broken, either during manufacture or during some ulterior taphonomic processes. They cannot simply be discarded because they are fully part of the skill process: breakage indeed occurs often and repeatedly (Callahan, 1979) and is part of the learning and improvement process. Furthermore, fresh breaks, probably caused by plowing, do not remove valuable data from bifaces and need to be included in the sample. Including broken bifaces means that traditional linear measurement axes cannot be used (*e.g.* Bordes, 1988). Rather, a grid made of one longitudinal axis crossed by multiple lateral axes interspaced every three centimetres is used (Fig. 7), allowing for width and thickness measurements. Width and thickness mean values are then computed to provide each biface with a mean width, a mean thickness, and a mean W/T ratio. Length is not considered here, given the assemblage's fragmentary nature and the emphasis on width and thickness found in the literature. This grids treats various shapes (complete oval bifaces, triangular proximal or distal sections, rectangular median sections) as equivalent. Rectangular sections will have higher W/T ratios than triangular sections, even if both shapes' maximum width and minimum thickness would be similar. A coarser resolution of analysis allows this range of variation to have little impact on an assemblage's general reading. By simplifying an assemblage variability, these metric measurements remove differences that could make a difference (sensu Bateson, 1972) to facilitate a first stage of observation and to extend maximum comparability on a common denominator. As for *chaînes opératoires*, further layers of differences are not permanently negated, and they can be added to an analysis afterwards. W/T ratios can (and must) then be coupled with qualitative variables to further an analysis (see below). Finally, biface orientation does not distinguish between proximal or distal ends, since it is the width and thickness mean values that are used. For illustration purposes, the break was oriented downwards, except for projectile points proximal ends.

Skill Evaluation

Skill evaluation proceeds through two typologies: technical difficulty and accidents. Typologies were preferred here as a way of holding together, both deductively (skill process, core concepts and general knapping principles) and inductively (as afforded by a context's scale, what can be observed, and provide for a more widely shared baseline for comparison), sets of relations between variables and their attributes to create order

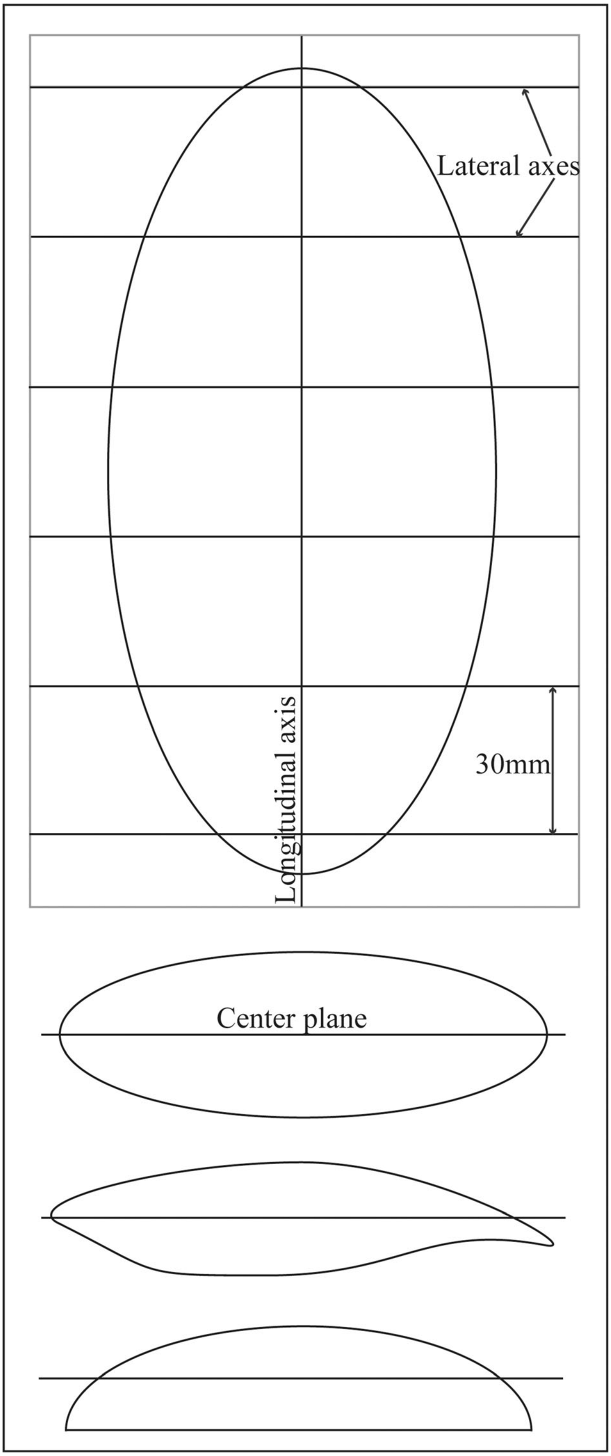


Fig. 7 Measurement grid (translated from Kolhatkar, 2020 fig. IV-5)

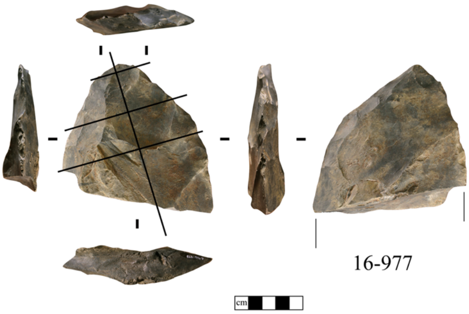


Fig. 8 Analytical procedure exemplified with bifaces 16-977 and 16-831

(see also Ellen, 2006; Hill & Evans, 1972). These typologies must then be held together to describe execution quality (see Figs. 8 and 9 for examples).

Technical Difficulty

Four technical difficulty levels were created using data found in the experimental and ethnoarchaeological bifacial stone knapping literature (Apel, 2008; Bradley, 1993; Bril *et al.*, 2005; Callahan, 1979; Chauchat & Pelegrin, 2005; Stout, 2002; Waldorf, 1993; Whittaker, 1994). Tasks are usually described according to W/T ratio, cross-section,

1, 2: The biface's (15-1659) mean W/T ratio is 2.42, which points to easy or slightly difficult levels.

3, 4: Qualitative variables point at a slightly difficult level: invasive flakes, continuous scalar retouch, and a lenticular cross-section. The biface is alloted to a slightly difficult level.

5: The biface was broken, and it shows various slight accidents as well: steps, a crushed edge and a convexity close to its left edge.

1, 2: The biface's (15-1609) mean W/T ratio is 2.44, which points to easy or slightly difficult levels.

3, 4: Qualitative variables point at a slightly difficult level: invasive flakes, continuous scalar retouch, and a lenticular cross-section.

5: The biface was slightly broken, it shows various slight steps, and a convexity close to its left edge.

1, 2: The biface's (15-2102) mean W/T ratio is 3.71 which points to a difficult level.

3: Qualitative variables to not confirm this: fine, continuous and parallel retouch, and a lenticular cross-section point to a very difficult level.

4: The biface is moved to the upper technical difficulty level.

5: The biface (the tip of a projectile point) was broken, and shows slight steps.

Fig. 9 Analytical procedure exemplified with bifaces 15-1659, 15-1609 and 15-2102

thinning and retouch procedures, which I have compiled and reduced here to their more common observable results on bifaces at La Martre (tab.2; additional information in supplementary materials 1 for thinning operations by level of technical difficulty, supplementary materials 2 for retouch operations by level of technical difficulty, supplementary materials 3 for morphology and morphometry by level of technical difficulty [all translated and adapted from Kolhatkar, 2020, tab. V-2, V-3 and V-4]). Since edges are used as platforms, they are highly variable during knapping as they pass through regular and irregular stages all the way down to finishing stages. Thus, they do not make up for adequate difficulty level evaluation. Likewise, retouch must be used sparsely because it is, by definition, close to the edge and may be removed easily by further biface transformation. In addition, facial symmetry was not considered, because it is an ambiguous variable when assessing broken fragments, and asymmetry could be considered a specific knapping method before overall symmetry is completed at the end of the reduction process.

Technical difficulty levels presented here have a very close similarity with reduction stages described by others (Callahan, 1979; Whittaker, 1994). In other words, canonical (sensu Hill & Evans, 1972) reduction stages were converted from ideal blank reduction to ideal difficulty levels knappers may or may not be able to attain (see also Apel, 2008). The translation was not straightforward however. The number of levels was chosen to (i) order the various observations drawn from the literature; (ii) to make room for skill development and exploration by knappers that two levels (*e.g.* novice/expert) would not afford for; (iii) to provide with a gradual progression from easier to more advanced difficulty levels; (iv) to provide with common horizons of achievement (sensu Ingold, 2000) that require various levels of practice; (v) and to reduce classification arbitrariness (Ellen, 2006). Thus, even though regular covering bifacial thinning flakes may be more difficult to achieve than regular pressure retouch when considering both on a continuum (Apel, 2008), both can still be considered as very difficult general horizons to reach. Inversely, two bifaces may have similarly high W/T ratios for various reasons, one being a tabular blank or a large flake marginally thinned, the other being a carefully thinned blank with alternate covering flakes. It follows that morphometry alone is an insufficient measurement and it must be coupled with qualitative variables to account for such distinctions. The two lower difficulty levels were assigned similar W/T ratio to better uncouple blank natural properties from beginners who attempt more invasive thinning while keeping close to a blank's natural properties. Slightly difficult tasks combine easy (morphometry) and difficult (thinning) tasks. Callahan (1979:30–31 Table 10) does not uncouple W/T ratios higher than 4 so higher difficulty levels were not refined here as well, keeping the number of levels as small as possible. Proportion and regularity are essential to technical difficulty assessment. For example, increased regularity distinguishes the mere removing of a covering flake from a regular set of covering scars, the more so as the cross-section becomes more regular (flattened lenticular or slightly planoconvex). Likewise, pressure retouch flakes may be easily removed, but their regularity makes all the difference, the more so as it requires a high level of preparation of a biface's surface, edge and cross-section (Waldorf, 1993, Whittaker, 1994). Finally, W/T ratio is not sensitive to size, thus allowing for thin and large blanks to coexist with delicate projectile points in the same difficulty level. This does not mean that they are absolutely and identically difficult to achieve: Apel (2008) has shown on knowledge and know-how continua that they are not, as informed from his experimentation with Callahan. Again, they nonetheless attest to some common horizon of achievement that must be thoroughly practised first.

Classification procedures go as follows. First, bifaces are ordered according to their W/T ratio alone. Second, this preliminary ordering is refined using a thinning, retouch and cross-section variables and attributes reduced list (Table 2). If the biface is trickier, meaning here that it would fit in two adjacent difficult levels, more complete tables (see supplementary materials 1, 2 and 3) may be referred to, along with finer *chaînes opératoires* analysis (sensu Klaric, 2018c, Leroyer, 2018, Pelegrin, 2019a), but within the limits of the predefined set of qualitative variables to ensure maximum comparability. The aim is to crosscheck these qualitative variables against the biface's W/T ratio

Table 2 Variables and attributes used for evaluating level of technical difficulty (translated and adapted from Kolhatkar, 2020) (see also supplementary materials 1, 2 and 3 for more details)

Technical difficulty	W/T ratio	Cross-section	Thinning	Retouch
Easy	Less than 3	Irregular	Marginal (hard percussor)	No retouch, or marginal, irregular retouch, either broad (percussion) or elongated (pressure)
Quite difficult	Less than 3	Irregular to diamond shaped	Marginal to invasive (soft percussor)	No retouch, or marginal, irregular retouch, either broad (percussion) or elongated (pressure)
Difficult	Between 3 and 4	Lenticular, flat to slightly convex surfaces	Invasive to covering (soft percussor) on flat surface	No retouch, or regular and elongated retouch (pressure)
Very difficult	Higher than 4	Lenticular, flat to slightly convex surfaces	Invasive to covering (soft percussor), on flat surface, scar sequence regularity, very large surface	No retouch, or highly regular and invasive retouch (pressure, on a prepared blank)

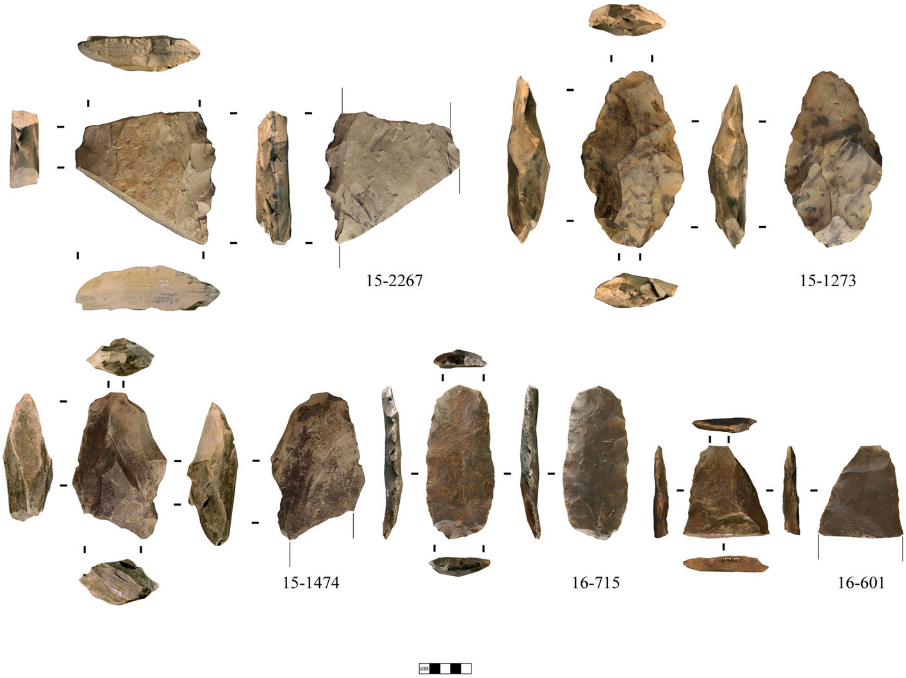


Fig. 10 Bifaces from stations 15 and 16 (photographs by Manek Kolhatkar)

and see whether or not they all point at the same difficulty level. An uneven number of qualitative variables is used to avoid a tie. A biface needs two qualitative variables to remain in the difficulty level its W/T ratio allotted it to. If one variable cannot be assessed (such as retouch), this requirement holds nonetheless. If the qualitative variables invalidate the preliminary W/T ratio-based assessment, the biface's difficulty level is upgraded or downgraded by 1. An exception here, however, concerns slight retouch or marginal edging on high W/T ratio that can be found on tabular blanks or big flakes as only biface transformation rather than selection was included in difficulty evaluation. They were deemed easy to produce, that is, easy to start with (Fig. 10 – 15–2267). In other words, analysis proceeds through increasingly finer resolutions of analysis when needed.

Accidents

Accidents were evaluated according to three levels of increased gravity (Table 3). Serious accidents would need a change of knapping strategy to continue knapping, owing to an abrupt change in blank morphology such as a break. Important accidents do not require such a change, but they must be resolved quickly lest they become serious later on. Slight accidents do not alter the general knapping strategy. Owing to the fact that breaks are ubiquitous, only accident types were counted, meaning for example that multiple slight steps amount to one recorded "accident", unless they stack up to create convexities. As for technical difficulty levels, accident gravity levels were

Table 3 Mistake type and gravity

Mistake gravity	Mistake type
Serious	Perverse or lateral fractures at the middle of a blank
	A 3mm step or convexity on a blank with a W/T ratio higher than 4
	A 3mm step or convexity on a blank with a W/T ratio between 3 and 4
	A 5mm step or convexity on a blank with a W/T ratio lower than 3
	A 2mm step or convexity on Plano projectile point
	Thick edge on a blank with a W/T ratio higher than 4
	Crushed edge on a blank with a W/T ratio higher than 4
	Thick or crushed continuous on both edges on a blank with a W/T ratio between 3 and 4
Important	Breaks at the distal end of the blank
	Thick or crushed sections of an edge on a blank with a W/T ratio between 3 and 4
	Overshot
	Platform collapse
Slight	A step or convexity less than 3mm thick on a blank with a W/T ratio higher than 4
	A step or convexity less than 4mm thick on a blank with a W/T ratio between 3 and 4
	A step or convexity less than 5mm thick on a blank with a W/T ratio lower than 3
	A step or convexity less than 1mm thick is slight on a projectile point.
	Thick or crushed sections of an edge on a blank with a W/T ratio lower than 3

uncoupled to make room for a broader range of practice, to minimize arbitrariness and to maximize operationalization (*e.g.* when measuring the size of a step).

Here again, a biface's mean W/T ratio provided with a baseline for assessing gravity levels (with the exception, here again, of barely knapped bifaces). Callahan describes this relation in reference to step size (1979:84, 106, 147), which I further extended to classify other kinds of accidents. For example, the size of a step has various implications for the knapper and the remainder of the reduction process: edging on a tabular blank will necessarily produce small steps that have no to very little consequence for subsequent thinning (Fig. 10 – 15–1273). However, a big step from the start should be an urgent concern for the knapper (Fig. 10 – 15–1474). Inversely, even slight steps on advanced wide and thin bifacial preforms may hinder further thinning or retouch by creating a stack, or more broadly, imperfections that make overall knapping control less predictable (Fig. 10 – 16–601). Steps may not be less bad than complete blank breakage as it may be impossible to work around them. Steps that stack up from multiple directions create a convexity that is computed as another, additional accident. Platform collapse, due to inadequate preparation or robustness, result in C-shaped bifaces (ibid., 87). Although there is still a dispute whether overshots are mistakes or controlled master blows (Aubry *et al.,* 2003, 2008, Bradley, 1993, Bradley & Stanford, 2004; see, however, Eren *et al.,* 2013), I have considered them as mistakes because they are part of the state the biface was discarded at, and would have become invisible, had they been part of a controlled general knapping strategy. Break types were borrowed from the literature (*e.g.* Callahan, 1979; Cheshier & Kelly, 2006; Coppe & Rots, 2017;

Crabtree, 1972; Johnson, 1979; O'Farrell, 2004; Soressi, 2002; Titmus & Woods, 1986), to confirm whether or not breaks happened during manufacture or use of potential tools. Only the former are counted as accidents. Unidentified breaks were counted as accidents as well provided their weathering was similar to the rest of the biface, assuming this showed homogeneous temporality with other tasks on a biface, and in line with workshop and bifacial reduction oriented activities at the stations. Finally, this suggested panel of accidents is not exhaustive, but constrained by what can be observed and provide with more encompassing (and, admittedly, coarser) baseline for comparison. For example, careful (or lack of) preparation of platform cannot be assessed systematically since it is, by definition, prepared to be removed. However, it can be recorded punctually (Kolhatkar, 2020).

Execution Quality

Technical difficulty levels provide with a first layer to broadly evaluate skill floors and ceilings that knappers worked within. We can go further with execution quality, that is, the difference between knapping intent and achievement, within a set of choices afforded by the difficulty level one has reached. It is designed to leave some room for knappers to work their material: it can account for experts that still make accidents, or for intermediate to novice knappers who have reached a high level of control of less difficult tasks, while not attempting to push to a new set of problems. Execution quality emerges from the relation between technical difficulty and accidents. This link initiates a way out of the idealizations that both typologies entail. Indeed, by virtue of being broad and few in number, the types used here hold a latent, or virtual, heterogeneity that can be actualized further. In fact, as we have seen, these typologies are much needed baselines for comparing and expanding differentiation, provided that the name is distinguished from the thing being named (Bateson, 1972). Execution quality could be described in various ways. For example, one could follow a biface's *chaîne opératoire*, knapping accidents, recalibration of the blank, and so on, using diacritical schemes (*e.g.* Klaric, 2018c; Kolhatkar, 2020; Leroyer, 2018; Pelegrin, 2019a; Pigeot, 1987, 2004) against its difficulty level general assessment as a backdrop. Precise quantification procedures of the way technical difficulty and accidents transform a biface's morphology could (and probably should) be devised as well, borrowing for example from geometric morphometrics (Okumura & Araujo, 2019; Shott, 2014). In the following, I use simple counts of accidents by technical difficulty levels to allow for a first layer of organization at La Martre, and to broadly outline the significance and possible uses of the execution quality concept to explore learning and knapping dynamics.

Other Classifications

Standard classifications were also used to provide data for raw materials and end products. They have been described in greater detail elsewhere and are common in the literature (Table 4). I will simply add that these typologies are not mutually exclusive, and do not justify, for example, removing a "bifacial core" from the sample analyzed. Again, producing a bifacial core requires skill that can be assessed as for any

Table 4 End product type, by level of technical difficulty, stations 15 and 16 (translated and adapted from Kolhatkar, 2020, tab. VI-7)

End product type	Technical difficulty level				Total	Variables used for identification	Reference
	Easy	Slightly difficult	Difficult	Very difficult			
Sainte-Anne/Varney projectile point	0	0	6	20	**26**	Parallel and pressure overall retouch, lanceolate, lenticular cross-section, straight to slightly concave base, parallel-sided shape, unfluted.	Bradley *et al.*, 2008
Pseudo-Agate Basin projectile point	0	0	0	2	**2**	Parallel and pressure overall retouch, lanceolate, biconvex cross-section, straight to slightly concave base, divergent edges, widest at mid-section, unfluted.	Bradley *et al.*, 2008
Bifacial core	0	0	1	8	**9**	Bifacial reduction, wide scars, irregular edges, platforms are not on center plane, asymmetrical cross-section, somewhat thick, large enough to produce usable flakes.	Bamforth and Becker, 2002
Bipolar core	0	2	0	0	**2**	Thick, invasive to covering flake scars, knapped on an anvil, crushed on both ends, opposed flake scars, no bulb, visible percussion waves.	de la Pena, 2016; Guyodo & Marchand, 2005; Shott & Tostevin, 2015
Scrapper	1	0	0	0	**1**	/	Brézillon, 1968
Drill	3	0	3	0	**6**	/	Brézillon, 1968
N/A	42	82	137	138	**399**	/	/
Total	**46**	**84**	**147**	**168**	**445**	/	/

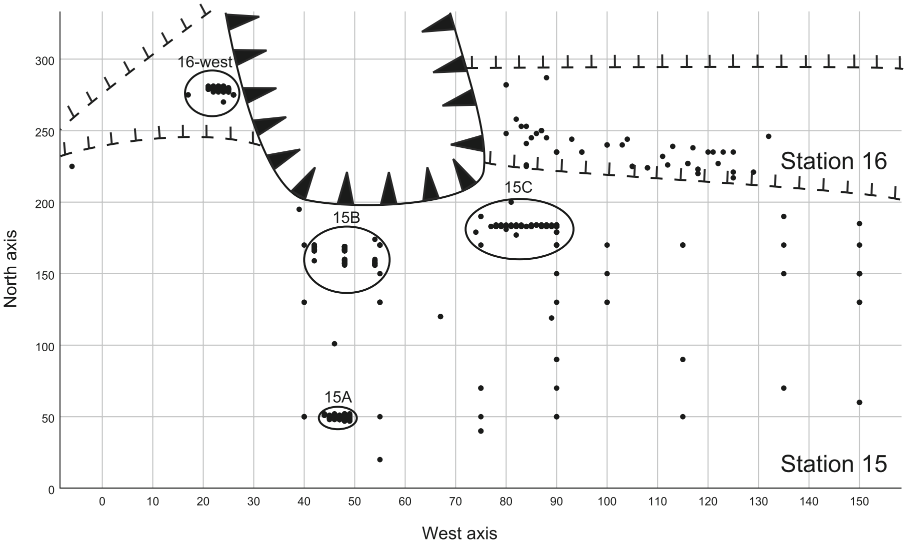


Fig. 11 Simplified overview of stations 15 and 16, with biface localisation (black dots)

other bifacial reduction. In addition, a core might also be a preform on its way to becoming a projectile point, providing with flake blanks in the process (see also Kuhn, 2007).

Sampling in the Collected Assemblage

On-site sampling procedures at stations 15 and 16 have been described above. I have worked from the catalog that the original investigators produced for both stations, focusing solely on bifaces and the common baseline they afford. Indeed, in the absence of lithic refitting, bifaces retain more knapping information than flakes. Unifacial tools were excluded as well to focus on bifacial reduction, in addition to being often very ambiguous (Dumais, 2000). Of the 924 bifaces and bifacial fragments, 445 were sampled from all over stations 15 and 16 (Fig. 11). Objects originally described as cores were checked for bifacial reduction characteristics. Sampling criteria were twofold. First, bifaces had to be complete enough, meaning (i) that both edges and faces were needed for width and thickness to be measured, and (ii) that a minimum length of 5mm is required to record at least two sets of width and thickness measurements. Bifaces broken by (probable) plowing activities were included in the sample because they still retain valuable stone knapping data. Second, bifaces had to be complex enough, by showing clear traces of human knapping (at least three flake scars) and focus on anthropic stone knapping. This meant excluding from analysis raw blanks that cannot be included in human practices owing to lack of finer depositional contexts. Finally, when considering excavated areas for a preliminary spatial analysis, I slightly extended my sample to include test pits and surface finds adjacent to the open excavation area (Fig. 5). Sixty-four bifaces were found in area 15a, 79 in area 15b, 80 in area 15c and 93 in area 16-west, which amounts to a total of 316 bifaces.

Table 5 Biface integrity by levels of technical difficulty, stations 15 and 16 (translated and adapted from Kolhatkar, 2020, tab. V-7)

Technical difficulty level	Biface integrity					Total	%
	Broken during manufacture		Fresh break	Complete biface	Broken during manufacture and fresh break		
	One end missing	Both ends missing	One end missing		Both ends missing		
Easy	21	1	3	21	0	**46**	**10,3**
Slightly difficult	61	7	4	12	0	**84**	**18,9**
Difficult	120	11	8	7	1	**147**	**33**
Very difficult	131	25	6	3	3	**168**	**37,8**
Total	**333**	**44**	**21**	**43**	**4**	**445**	**100**

Results

Broad lithic and spatial patterns could be described. Results are described in greater detail elsewhere (Kolhatkar, 2020; see also this reference, annex A and E, for higher

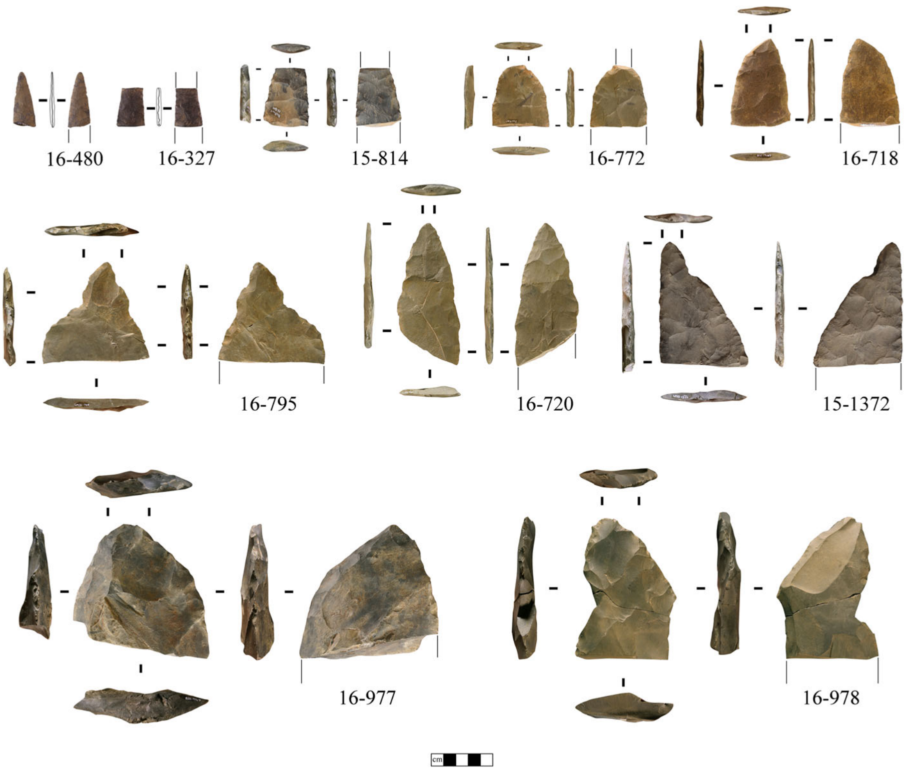


Fig. 12 Very difficult bifaces, stations 15 and 16 (photographs by Manek Kolhatkar)

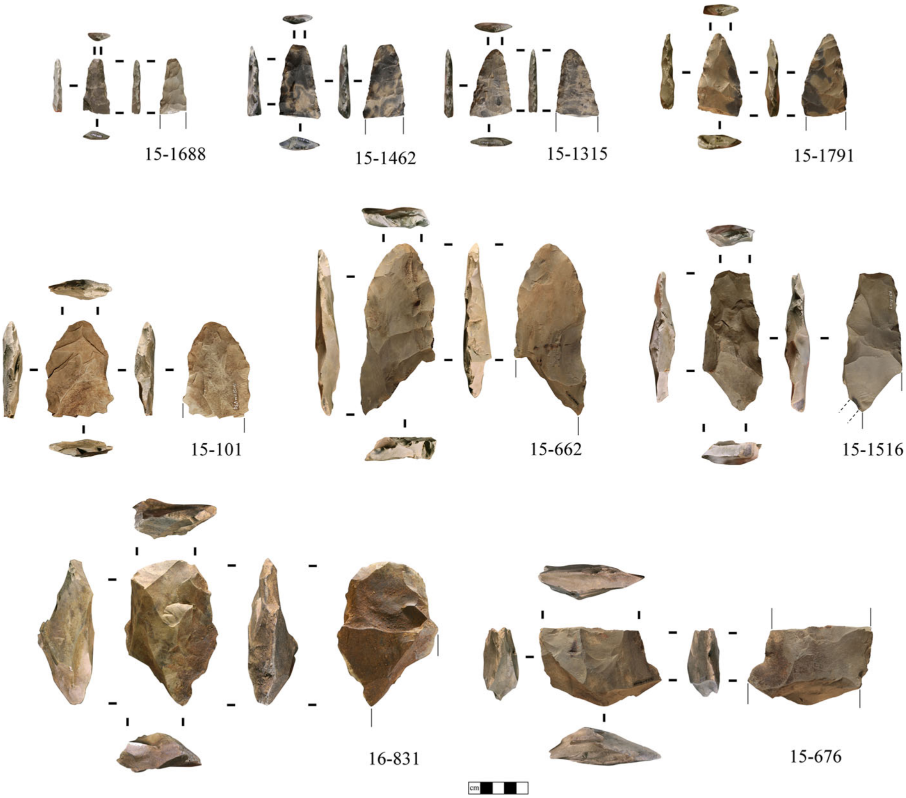


Fig. 13 Difficult bifaces, stations 15 and 16 (photographs by Manek Kolhatkar)

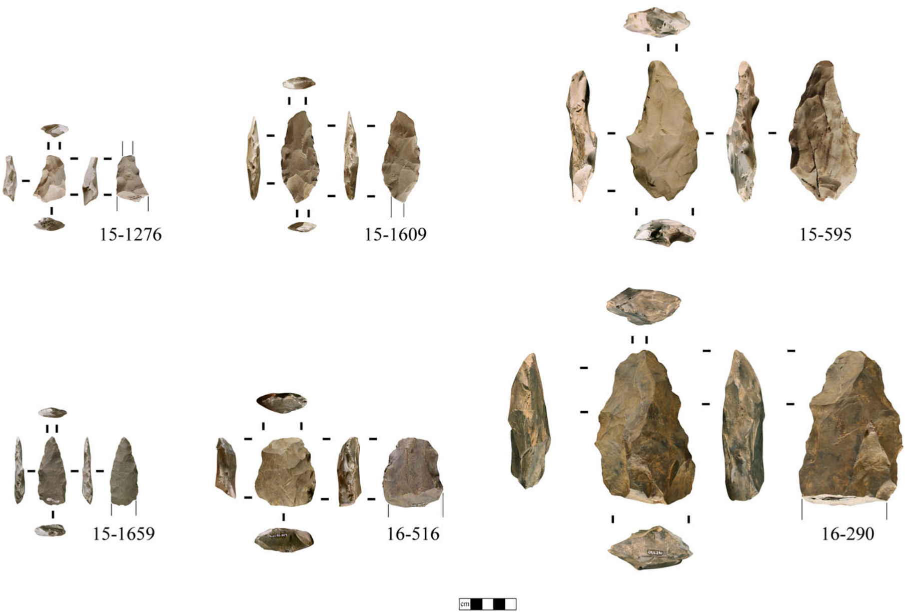


Fig. 14 Slightly difficult bifaces, stations 15 and 16 (photographs by Manek Kolhatkar)

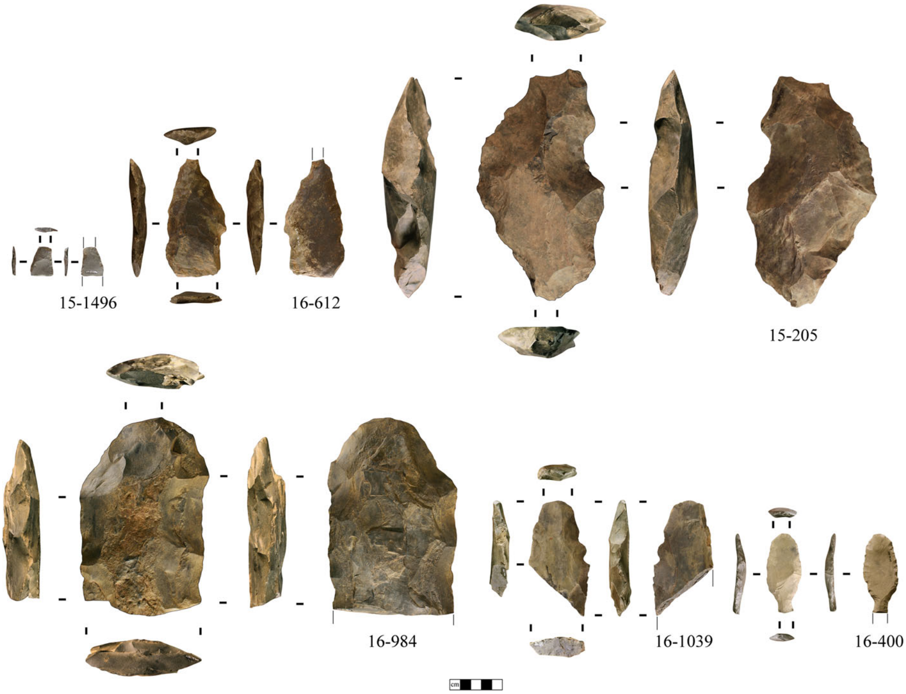


Fig. 15 Easy bifaces, stations 15 and 16 (photographs by Manek Kolhatkar)

resolution photographs). Here, I will focus on a general overview of the assemblage, followed by learning patterns, skilled reduction sequences, and spatial organization.

Overview

Most sampled bifaces are very difficult to knap (Table 5), owing to high W/T ratios and either very regular thinning or alternate bifacial covering flake scars (Fig. 12). Difficult bifaces are thicker and narrower, while still showing covering flake scars (Fig. 13). Slightly difficult and easy bifaces account for the remaining sample (Figs. 14 and 15). There were 1341 accidents recorded on this sample (Table 6). Unsurprisingly, most of them are breaks and steps, followed by convexities and thick edges. A few overshot scars could be recorded as well. No breaks due to use could be clearly identified on projectile points, which seems compatible with a general workshop use of stations 15 and 16 (Table 6). Most are lateral snaps, followed by unidentified break types, and perverse fractures. Most bifaces show homogeneous weathering. Finally, out of 445 bifaces, technical difficulty level preliminary assessment with W/T ratio had to be corrected on 88 bifaces with qualitative variables (Kolhatkar, 2020, Tab. V-8).

Raw material cannot account for skill variability, as it is virtually the same on nearly all sampled bifaces, with the exception of five pink quartzite choppers. The remainder was knapped in good quality Cap-Chat chert (Burke, 2002, 2010), starting from various blank types such as tabular blanks, flakes of various sizes, pebbles and thicker chert blocks bounded by sedimentary layers. Blank type could be identified on 64 bifaces only (14,3%). Blank types are dispersed in the lower difficulty level, since better

Table 6 Accident type count and accident total-by-difficulty total ratios, by level of technical difficulty and level of accident gravity, stations 15 and 16 (translated and adapted from Kolhatkar, 2020, tab. V-9)

Mistakes		Technical difficulty				Total
Mistake gravity	Mistake type	Easy	Slightly difficult	Difficult	Very difficult	
Serious	break	24	70	130	157	381
	step	27	59	69	52	207
	convexity	5	28	34	14	81
	thick edge	2	8	6	14	30
	crushed edge	0	2	1	0	3
	Sub-total	58	167	240	237	702
	Mistake count-by-biface count ratio	1.26	1.98	1.63	1.41	1.57
Important	break	0	1	5	0	6
	thick edge	7	14	22	6	49
	crushed edge	1	8	6	0	15
	overshot	1	3	7	2	13
	platform collapse (C-shaped)	0	0	3	0	3
	Sub-total	9	26	43	8	86
	Mistake count-by-biface count ratio	0.19	0.3	0.29	0.04	0.19
Slight	step	46	84	147	168	445
	convexity	2	14	24	12	52
	thick edge	15	14	22	0	51
	crushed edge	0	3	2	0	5
	Sub-total	63	115	195	180	553
	Mistake count-by-biface count ratio	1.36	1.36	1.32	1.07	1.24
Total		**130**	**308**	**478**	**425**	**1341**
Total mistake count-by-total biface count ratio		**2.82**	**3.66**	**3.25**	**2.52**	**3.01**
Total number of bifaces		**46**	**84**	**147**	**168**	**445**

knappers either choose their starting blank more wisely, or do not make serious mistakes at such an early start, except along incipient fracture lines invisible from the outside. Six types of end products could be found at La Martre (Table 4). Identifiable end-products account for only 10.52% (*N*=47) of the analyzed sample. They can be found at all difficulty levels, provided that a knapper is able to produce them. Some of these very difficult bifaces can be recognized as Plano points, either Sainte-Anne/Varney or pseudo-Agate Basin points (Fig. 3).

Learning Patterns

Technical difficulty frequency and mistake counts show various patterns. While a simple count value shows 474 mistakes for difficult bifaces, and 424 mistakes for very difficult ones, and so on, it may be more significant to compute the number of accidents for each technical difficulty level by the total number of bifaces for each difficulty level (Table 6). Slightly difficult bifaces have the highest index (3,6), followed by difficult

Table 7 Number of accidents per biface, by gravity level and all gravity levels combined, by level of technical difficulty, stations 15 and 16

Gravity of accident	Number of accidents per biface	Technical difficulty level							
		Easy		Slightly difficult		Difficult		Very difficult	
		N	%	*N*	%	*N*	%	*N*	%
Serious	0	6	13.04	2	2.38	9	6.12	7	4.17
	1	22	47.83	27	32.1	70	47.6	105	62.5
	2	18	39.13	26	31	36	24.5	37	22
	3	0	0	28	33.3	30	20.4	18	10.7
	4	0	0	1	1.19	2	1.36	1	0.6
Important	0	39	84.78	61	72.6	116	78.9	160	95.2
	1	5	10.87	20	23.8	21	14.3	8	4.76
	2	2	4.348	3	3.57	8	5.44	0	0
	3	0	0	0	0	2	1.36	0	0
Slight	0	0	0	0	0	0	0	0	0
	1	30	65.22	56	66.7	105	71.4	156	92.9
	2	15	32.61	25	29.8	36	24.5	12	7.14
	3	1	2.174	3	3.57	6	4.08	0	0
All accident gravity levels combined	0	0	0	0	0	0	0	0	0
	1	4	8.696	1	1.19	6	4.08	5	2.98
	2	12	26.09	10	11.9	34	23.1	97	57.7
	3	21	45.65	22	26.2	47	32	42	25
	4	7	15.22	36	42.9	40	27.2	20	11.9
	5	1	2.174	13	15.5	17	11.6	4	2.38
	6	1	2.174	2	2.38	3	2.04	0	0
Total number of bifaces		**46**	**100**	**84**	**100**	**147**	**100**	**168**	**100**

(3,2), easy (2,8) and very difficult (2,5) bifaces. This pattern generally holds when considering mistake gravity level for each technical difficulty level ratios as well (Table 6). When considering the number of mistakes for each biface (Table 7 and Fig. 16), most very difficult bifaces show two mistakes: most of them are near flawless shapes broken at some point during manufacture. The other difficulty levels have more evenly distributed mistake counts per biface. Even then, difficult bifaces tend to pull towards fewer mistakes than slightly difficult ones. Distribution shapes slowly change as difficulty levels are followed down to the easiest one. Inversely, these patterns also mean that mishaps during very difficult knapping coexist with well executed difficult knapping.

These patterns are of interest for three reasons. First, as was already suggested above, technical difficulty level and mistake frequency growth are not linear, for the latter changes according to the former's internal structuring principles in line with what experimentation and ethnoarchaeological research have already shown (see above): judgment and dexterity are improved with practice, chance is not relied upon, platform

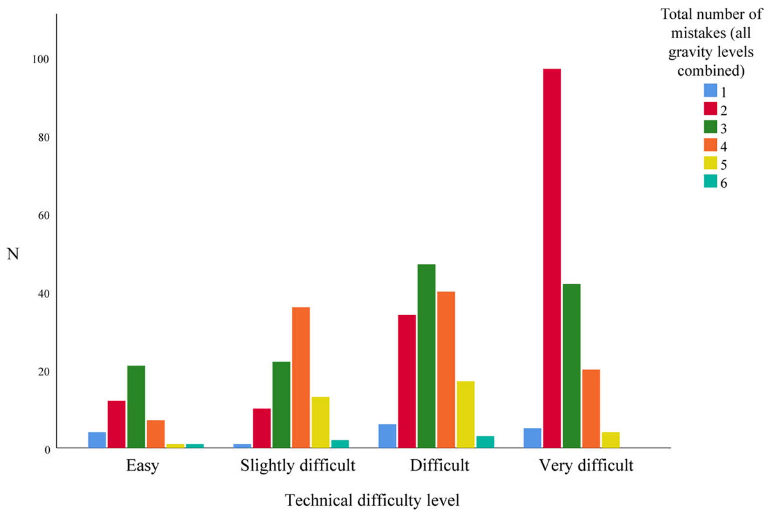


Fig. 16 Total number of mistakes (all gravity levels combined), by level of technical difficulty, stations 15 and 16

preparation is key, principles that afford for pushing through difficulty levels ceilings. It follows that when knappers are able to push through the very difficult baseline, they have already learned to master these principles. In other words, the higher the difficult level, the fewer the accidents. A non-parametric independent sample Kruskal-Wallis H test, run with SPSS Statistics 25 (N=445, df=3, p=.000, CI=95%), confirms this trend by showing that the mistake frequency per biface (per gravity level and for all gravity levels combined) is statistically different for each difficult level. Thus, although we could expect accident occurrence to grow with an increasing level of difficulty, and in addition to there being more very difficult bifaces than difficult ones, this is not what happens. Expert knappers are able to steer away from this linear assumption. But there are also more "very difficult" bifaces in the assemblage, meaning that expert knappers seem to have abandoned their biface more often than other knappers did: even though they made far fewer mistakes, when they made one, it was also a more critical one. This should not be surprising, as shaping wide and thin blanks puts a lot of constraints on a knapper's skill and materials.

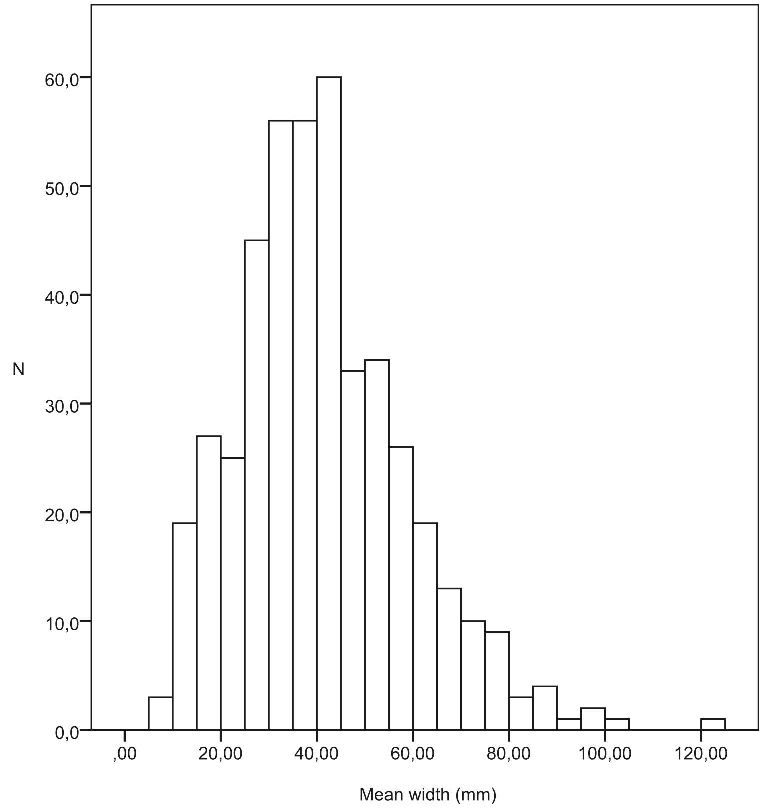
Second, higher accident frequency counts in lesser technical difficulty levels may show learning as a process. Indeed, "difficult" and "slightly difficult" levels could be understood as transitional horizons of practice, made up of knappers whose heterogeneous skill levels contrast with knappers from the "very difficult" level. Indeed, difficult knapping has shown good (few accidents) and lesser (many accidents) knappers working at the same kinds of tasks, in mostly equal proportions. Good knappers already control these tasks. Lesser skilled knappers, emerging from "slightly difficult" tasks, seem able to attempt such operations and know of them (Pelegrin's knowledge), but they do not yet have the dexterity to succeed (Pelegrin's know-how). On the other hand, the "slightly difficult" level shows more accident counts per biface compared to the "difficult" level of difficulty. Knappers from this lesser level have poor enough skill to fail while not discarding their biface, thus filling up the slightly difficult level with poorly executed knapping. Indeed, knappers who make up this category's technical difficulty level have had less time to practise and better stabilize and standardize their knapping. Even easier knapping, when failed, could also owe this to a biface's initial or "natural" properties a knapper could not overcome, and thus, to his poor initial choice. These mistake counts per technical level of difficulty freeze knappers' abilities in time and with those, skill stages in the same way a reduction sequence's stages do for bifaces.

Third, since accident count does not simply grow with every added level of difficulty or with total biface count number by level of difficulty, and is more important at intermediate levels (difficult and slightly difficult levels), simple site linear formation rates (sensu Shott, 1998, 2010) cannot explain the patterns observed above. Rather, such patterns must be explained according to anthropic processes that skill allows to paint in broad brushes, even if their finer details cannot be investigated. Sampling size, then, even though relatively small when compared to the whole of stations 15 and 16, already manages to capture skill's inner and less contextually sensitive logic. It would be interesting to further test this anthropic formation process with a bigger sample from La Martre or other archaeological palimpsests, the more so if better preserved depositional contexts allow for chronological control to monitor a site's and skill's formation rates.

Skilled Reduction Sequences

Uncoupling stage reduction levels from technical difficulty and skill levels affords for skilled reduction sequences uncoupling. Indeed, focusing on available volume for knapping, and given that knapping is a reductive process, biface reduction trajectories along various technical difficulty levels may be distinguished. To this end, a W/T scatter diagram may be understood as a broad reduction continuum read from the upper-right to the lower left as biface size decreases along various W/T rates or trajectories. Short lived bifaces that were seldom reworked after being discarded show various steps of a broader reduction process when considered as an assemblage. In contrast with stages pre-ordered in a linear fashion, this scatter diagram opens up various possible means of knapping stone, understood here as reducing a biface's width and thickness. Biface dispersion tends to decrease as well, as bifaces are either more standardized and/or provide less room for variability. As size decreases, so does flake size and, consequently, so does a flake's potential for altering the size of a biface on this scatter diagram, while biface standardization and control improves. This continuum spreads out across various (probable) occupation episodes that grew this general distribution and that plowing mixed up.

Technical difficulty levels allow for finer description in the broader dispersion opened up by the assemblage. This broad understanding of the reduction continuum must be specified. Indeed, it could be that its width and thickness inflections (Fig. 17) are simple steps knappers follow along increasing mastery of canonical reduction stage. However, plotting blank types in the reduction continuum (Fig. 18) shows that they are quite dispersed, meaning that knappers started their work from various beginnings (various blank types and sizes) complicating simple morphometric interpretation. Finer distinction is required. Since the W/T ratio that was used to assess technical difficulty levels removes width and thickness values, it may be useful to plot these levels on the W/T scattergram to see how they are distributed across the assemblage (Fig. 19). If we



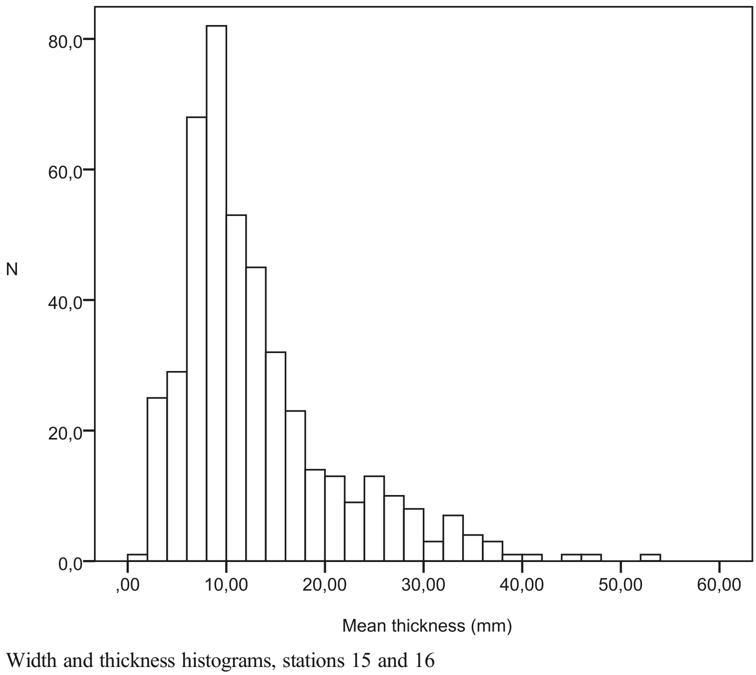


Fig. 17 Width and thickness histograms, stations 15 and 16

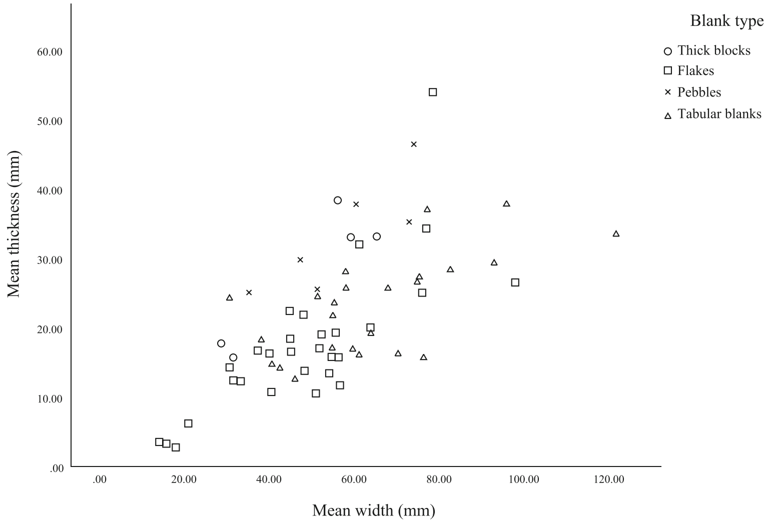


Fig. 18 Blank scatter diagram, stations 15 and 16

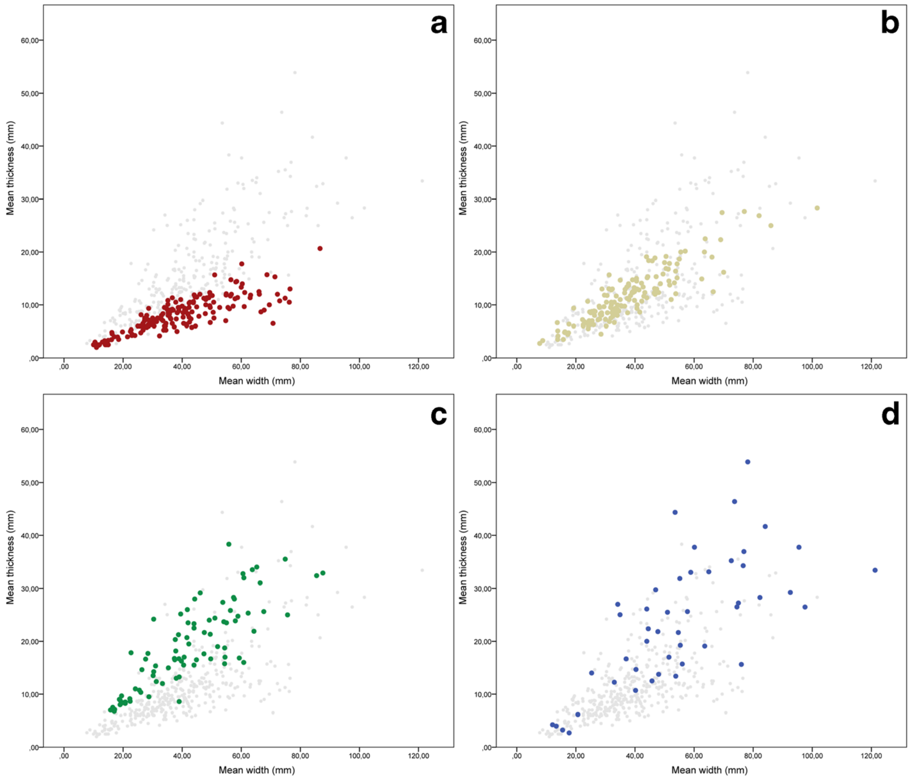


Fig. 19 Width-by-thickness scatter diagram, by level of technical difficulty, stations 15 and 16 (A: very difficult; B: difficult; C: slightly difficult; D: easy) (translated and adapted from Kolhatkar, 2020, fig. V-17)

follow a canonical use of reduction stages (Callahan, 1979), W/T ratios would be concentrated in various areas of the scattergram, as various stages leading to complete reduction. Levels of technical difficulty would indeed be reduction stages. But this is not what we see. Rather, each level expands all over the width spectrum, albeit at various thickness horizons that nonetheless overlap. Higher levels make for tighter dispersions along a central tendency than lower levels. Mistakes would have to be taken into account for a more complete view of these trajectories. However, together with broad width spread, simple technical difficulty levels already suggest various skilled reduction sequences as knappers' abilities for action allow them to explore various areas in this reduction continuum. Yet, as blank dispersion shows, this spread in the reduction continuum is not a strict and linear *chaîne opératoire* (Pelegrin, 1995) or a staged reduction sequence such as Callahan's (1979) or Smallwood's (2010, 2012), since these starting points can be found at various "places" in the reduction continuum. Rather, each biface shows a way of dealing with the W/T ratio and other technical problems, and biface spread by technical difficulty level shows aggregated ways of dealing with such concerns at various steps along bifacial volume reduction. Indeed, plowing means we must proceed with care when connecting various bifaces into an "assemblage", given that neither specific sociocultural structures nor chronological units may be assumed to underlie such spreads (see also Rezek *et al.,* 2020). Similar lithic problems must be dealt with by variously skilled practitioners, however, regardless of cultural tradition or cause for discard (*e.g.* breakage, low W/T, intolerable accidents, postponing for another visit at the workshop), resulting in "spreads-as-reduction sequences". It is within these specific reduction sequences that more traditional, sociocultural or staged reduction sequences structuring could be grown, without artificially separating such structuring according to chronological or spatial boundaries prior to their lithic binding. This in turn would keep similarities in sight in spite of chronocultural (and other) differences. Finally, in contrast with idealized reduction stages as used in the literature, novices that once fell out of such a descriptive framework and became invisible due to lack of practice can invest such a reduction continuum on their own knapping trajectories, provided they also work at bifacial reduction.

Spatial Organization of Skill

Until now, skilled practices have been described with little regard for space and soil movements. Skill patterns were emphasized to see whether or not there was some inner coherence to stations 15 and 16. Yet, plowing together with skill may in fact show an alternate way of organizing space through lithic practice. I have focused on the four excavation units opened by the original investigators along a north-south axis (Fig. 5) due to their more intensive coverage and to get a broad sense of the stations' spatial organization. Finer vertical distribution was not considered here due to plowing.

Metric variables (width, thickness, W/T ratio) and skill variables (technical difficulty only, for space purposes) were used to assess area variability (Fig. 20). Variables were tested with a non-parametric independent sample Mann-Whitney's U (CI=95%, see Table 8 for p values), on SPSS Statistics 25. 16-west stands out in most cases. 15b and 15c, close to one another, do not appear to be significantly different. 15a and 16-west, each located at either extremity of stations 15 and 16, are almost fully distinct from one

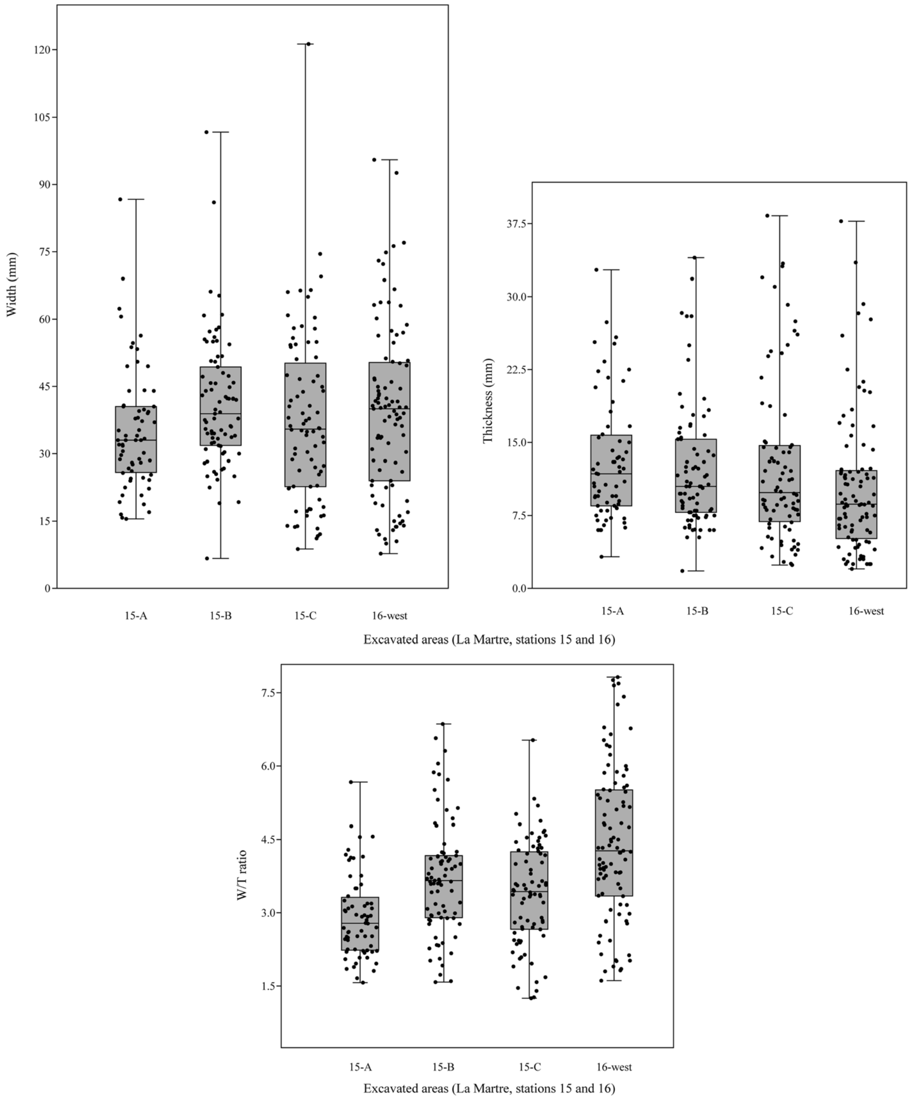


Fig. 20 Excavated areas boxplots and jitter plots, by width, thickness, and W/T ratio, stations 15 and 16

another (except for their width). While width and thickness are seldom discriminant variables, W/T ratios and technical difficulty are in most cases. Though each technical difficulty level can be found in areas 15a, b, c and 16-west (Fig. 21), inter-area comparison shows both clear variation and a northward pull towards higher W/T ratios and increased counts of higher levels of technical difficulty. Difficult operations dominate 15b and 15c with very difficult tasks not far behind. These proportions are disrupted with 16-west's huge spike of very difficulty bifaces, and lesser operations relatively more important at 15a. W/T scatter diagrams show 16-west cutting through the general dispersion on the lowest section of the diagram, 15a on its upper section, and 15b and 15c in between (Fig. 22).

Table 8 P-values from Mann-Whitney's U tests used to compare excavated areas 15a, 15b, 15c and 16-west along their mean width, mean thickness, W/T ratio, and technical difficulty (stations 15 and 16) (translated and adapted from Kolhatkar, 2020, tab. VIII-4)

Mean width (mm)			
	15a	15b	15c
15b	0.002		
15c	0.534	0.84	
16-west	0.108	0.395	0.448
Mean thickness (mm)			
	15a	15b	15c
15b	0.42		
15c	0.222	0.522	
16-west	0.001	0.005	0.57
W/T ratio			
	15a	15b	15c
15b	0		
15c	0.003	0.124	
16-west	0	0.002	0
Technical difficulty levels			
	15a	15b	15c
15b	.001		
15c	.009	.946	
16-west	.000	.005	.000

16-west stands out when considering skill and W/T ratio variables, followed by 15a, while 15b and 15c do not and show similar technical difficulty levels patterns (Fig. 21). This concords with other data for stations 15 and 16: 16-west's lesser vertical distribution homogenization (bifaces were uncovered from the plowed layer and its underlying B horizon); 16-west is located at the far north end of station 16, against its northwest corner, which could have offered better protection against plowing (Fig. 5). While

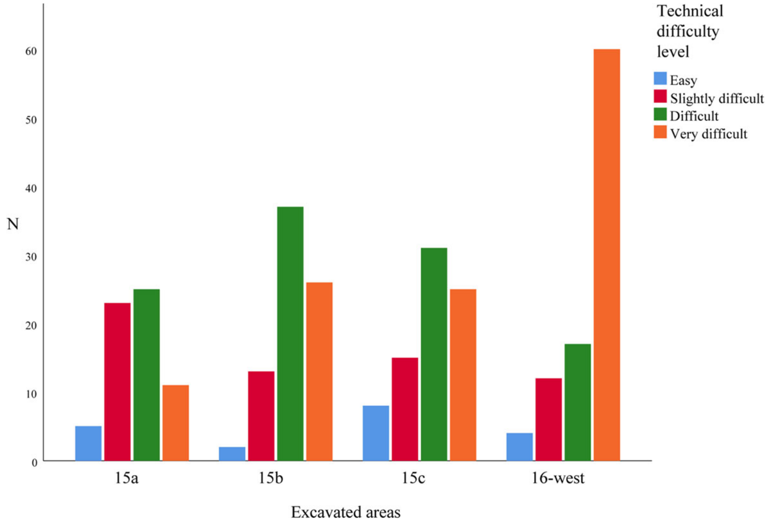


Fig. 21 Technical difficulty levels, by excavated areas, stations 15 and 16

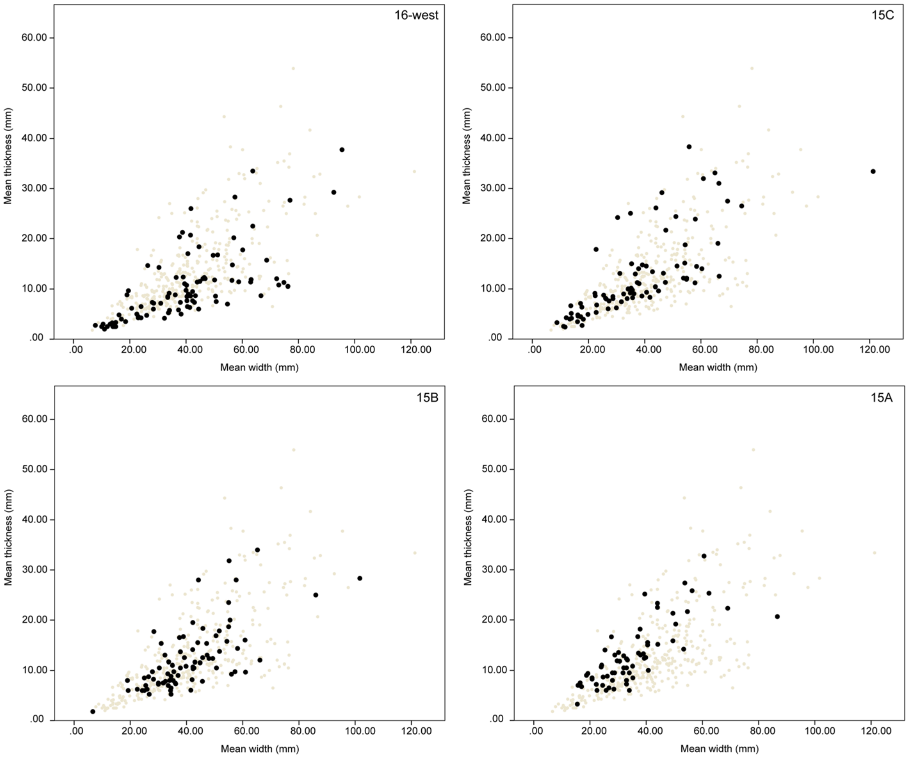


Fig. 22 Excavated areas width-by-thickness scatter diagrams, stations 15 and 16 (translated and adapted from Kolhatkar, 2020)

16-west is easier to single out and could point to a better preserved locus in the plowed fields of stations 15 and 16, the overall northward increase of the W/T ratio values and counts of higher levels of technical difficulty could suggest that the general spatial organization of the stations was preserved, regardless of mixing and of geomorphological boundaries between stations. The similarity between 15b and 15c could simply mean that they should be considered as a single interpretive unit. Area 15a, on the south end of the stations, could have been less impacted by plowing as well. Further research would be needed to see if the technical difficulty profiles from 15a and 15b/c define a specific dwelling unit, either through structured reoccupation or various occupation events.

This still leaves 16-west standing out as a locus of highly skilled knappers who explored very high W/T ratios and produced many Plano points, both Sainte-Anne/Varney and pseudo-Agate Basin, but who also coexisted with lesser knappers. In fact, as has been shown, all excavated areas show skill levels mixing, albeit in varying proportions, suggesting possible learning places together with high-level performance at a special place where visibility could have justified such practices (Carr, 1995; Quinn, 2015; Hiscock, 2014; Sinclair & McNabb, 2005). Technical difficulty spread along each locus's reduction continuum would also suggest various reduction sequences. Similar problems would have been confronted by knappers: non-discriminant width or thickness variability would in fact provide a common background for the four loci, against which discriminant variables (technical difficulty and W/T ratio) would point at various ways of resolving comparable metric problems.

It is difficult to understand how non-anthropic processes could explain this pattern. Plowing may have mixed up spatial structuring to a higher degree where 15b and 15c were excavated, making up for the need of a larger unit of analysis at the terrace's centre compared to its borders. However, it did not erase all spatial organization, the more so since skill variables were used and that contrary to size or geometry, they may be less sensitive to plowing activities. Furthermore, considering skill for lithic analysis means that plowing cannot simply be reduced to a distortion that may be removed to reveal a pristine systemic context. Plowing is part of the human transformation of stations 15 and 16 that started thousands of years ago. It coalesced with places, bodies and blanks grown along lines of skill. Space at stations 15 and 16 may have been rearranged but neither did the various lithic nor plowing activities rearrange its broad organization.

Discussion

My general goal in this paper has been to devise means of tying coarse archaeological contexts to broader lithic landscapes. As ubiquitous but often excluded contexts, they are paramount to enriching our archaeological narratives. La Martre, a major site, occupied for probable millennia and replete with lithic remains that cover its marine terraces, has indeed remained peripheral in northeastern North American research. Poor chronological control over its mixed lithic remains may certainly explain this treatment more than its remote location along the northern Gaspe Peninsula. Indeed, where should one begin their analysis in this matrix of shifting similarities and differences? I suggested that skill could provide a framework to answer the analytic problem of knitting together La Martre's various lithic remains and to tie them to a broader landscape of lithic practices, provided that it was understood as a process immanent to practise, freed from its encapsulation within historical cultural and contextual frameworks.

I reframed skill in stone knapping through four layers of descending generalization: (i) the relational understanding of the world that an ecological epistemology provides; (ii) the process of skill as a specific set of relations immanent to any human practice; (iii) core concepts (technical difficulty, accidents and execution quality) for understanding stone knapping and bifacial reduction; and (iv) a methodology adapted to La Martre's size and low resolution. The domains that archaeologists draw from in their research strategies (general conditions, assemblages and individual objects) but that La Martre's plowed fields had separated could thus be integrated once more. Skill provided with a framework for comparing 445 bifaces and describe learning patterns, reduction sequences, and spatial organization, outside of prior historical cultural definition or finer contextual control, within the setting of a workshop associated to various chert outcrops.

In other words, reduction sequences and spatial patterns could be described after skill had first been assessed, pointing to the fact that skill analysis does not start from good spatial and chronological contextual control. Framed that way, La Martre would be indeed a poor choice for conducting such an analysis. But as we have seen, needing such units prior to analysis stems more from epistemological assumptions than from taphonomic limitations. As I have shown, it is the other way around: skill is a scalable process that can be used to explore contexts of various size and resolution. Concerns such as specific intentions, end products, life histories, individual knappers, occupation episodes and historical cultural frameworks, that need contextual control, and that structure a lithic analysis (let alone skill analysis) prior to its actualization, become secondary. Or, more precisely, lithic analysis must first paint broader patterns before such concerns can be addressed. It must restore a set of relations that endures in spite of plowing, and that can be used to tie in such coarse and open contexts in broader archaeological narratives and lithic landscapes. It can do so, because skill is a process immanent to all practices along which specific contexts grow. In fact, skill is required to so, for those very reasons.

Such generalizations may bring back the spectre of excessive, behavioural universalization that archaeologists have been working hard at uprooting from their practice (Fowles, 2016; Hodder & Hutson, 2003; Murray, 1997, 1999, 2013; Robb & Pauketat, 2013; Shanks & Tilley, 1987; Trigger, 2006). Tensions between the global and the local, the universal and the particular, and how the former erases the latter for a minority's general interest disguised as that of a majority are indeed at play. However, framing the need for generalizations and the possibility of ever finding common grounds within these tensions may be another expression of the deeper, mind and matter bifurcation that an ecological epistemology departs from and that has already been addressed above and elsewhere (see also Alberti & Marshall, 2009; Debaise, 2015; Holbraad, 2009; Ingold, 2011; Kapferer, 2013; Latour, 2006; Montebello, 2015; Rancière, 1987, 1998; Rogoff, 2003; Viveiros de Castro, 2004, 2009; Whitehead, 2006). Indeed, if the trade-off is the exclusion of most sites archaeologists must deal with for lack of understanding and, consequently, the very human beings that inhabited them, we might not be on a much more secure ethical footing than we were forty years ago. Rather, the "universal" I assumed here is simply that people from various backgrounds go about the world in the same way, that is, navigating it with their skilled bodies as vehicles for knowing the world along its manifold relations. We are made of the same "stuff", sharing a common world that we go about differentiating in the particulars of our practices. This symmetry, or equality, provides us with a baseline for comparing the bifaces produced at La Martre by various people, at various moments, and for various ends because they all resulted from the same knapping principles that knappers had to deal with. Skill as a process is the act, unrealized, of dealing with those principles to reach one's objective. Skill makes us equal when confronted to a stone blank. How we put our skills to use is another matter. Why we do so in another matter yet. It is thanks to this baseline that La Martre's knappers and the differences they created can now be included into broader narrative landscapes and participate to their shaping.

This is not to say that all questions can be answered at La Martre. Scale remains a major constraint. But it does not impact our ability to draw patterns: it constrains the scales of those patterns. We may never be able to describe emic assessment of one's skill at La Martre or even at the 16-west locus (*e.g.* where a moderate knapper [relative to the framework used here] would have in fact been considered as a master by his or her peers). Again, it remains to be shown whether archaeologists should aim at emic constructions of the past (Hayden, 1984, Murray, 1999, 2006, Robb & Pauketat, 2013, Tostevin, 2011; see also Rogoff, 2003). But following my argument here, archaeologists should first wonder about the stuff that emic assessments are made of, and should not assume that skill's sole purpose is to reconstruct complex and finer past sociocultural dynamics. As I have shown, it can and in fact should be used to draw broad patterns that do not negate finer stories, but that restore the relations we need to tell such stories and others drawn from coarser contexts.

From there on, one could continue adjusting their scale of analysis from the general patterns that could be drawn in La Martre's open-ended and 10,000-year-old archaeological palimpsest. Such broader patterns are a first and necessary step to (i) further describe deviations, variations and standardization in lithic practices; (ii) identify contextual boundaries, such as 16-west, and either delve into the finer details of 16-west's reduction sequences, *chaînes opératoires*, end products, and other lithic remains that were not included in this paper; (iii) to reconnect the 16-west locus to a broader Late Paleoindian landscape and chronological timeframe. Or one could continue to devise ways of generating lithic landscapes that are not based on historical cultural frameworks or chronological landmarks, but on skill and stone knapping: landscapes as lithic canvases on which contextual, non-lithic data might be drawn (Kolhatkar, 2016, 2020). The (techno-morphological) variables that could be recorded in spite of plowing point at variables that could be used in other (higher resolution) contexts as well. Finer variables recorded in higher-resolution contexts are no longer the norm, nor do they provide with the price of entry into research on skill. They become the exception. A more extensive baseline for comparison can then be used, while leaving room for the more extensive details of higher resolution contexts that cannot be described in lower resolution ones.

My concern, then, was not with plowing as a taphonomic process, nor even with learning in various cultural settings. Rather, it was with overturning plowed fields as a backdrop for revealing the arbitrary epistemological limitations that underscore our practice, through the pragmatic, relational problems that La Martre poses. Furthermore, it was about freeing skill from such limitations and use it to build another framework for lithic analysis that is at once less sensitive to contextual transformation (*e.g.* bifacial reduction), and that can be scaled to various contexts' resolution and size (La Martre's plowed stations 15 and 16). Finally, it was about expanding our ability to include a broader range of contexts, practices, people and stories into our archaeological narratives.

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Data Availability Lithic assemblage (La Martre, DhDm-1) lent by the Réserve de Québec, and housed at the Université de Montréal, Département d'Anthropologie, C-3103.

Declarations

Conflict of Interest The authors declare that they have no conflict of interest.

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