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Assemblage biographies of edge-ground celts

This chapter contains the results, presented as the analysis of all biographical possibilities that occur within the assemblages, highlighting the general patterns and commenting on significant deviations wherever these occur. The data obtained from each individual artefact is organised in Appendix 3, ordered according to the biographical phase to which it pertains. Comments on the analysis of specific objects are also made available there.

The numbers provided in each subsection are reduced from the totality of the assemblage to the number of specimens relevant to that subsection. By way of example, butt fragments are not accounted in percentages on edge use-wear (they are inherently empty records) and are also discussed separately from medial fragments with respect to the traces of hafting (it is often not clear whether fragments would have been in the position to contact a potential haft to begin with). Accordingly, the numbers cited therein are not initially relatable to each other.

7.1 Pearls

The analysed selection from Pearls includes 21 specimens. Most of these are intact artefacts and thus provide data on the complete biography. Hence the Pearls assemblage offers a comparatively deep understanding of the different biographical possibilities, even if the sampling strategy precludes assemblage representativity to the results. The picture on procurement and early reduction strategies is less illustrative, however, as few materials in the assemblage could provide good information on these stages. Similarly, analysis of the depositional processes is comparatively hampered by the lack of contextual data. All materials were studied in the field.

7.1.1 Materials and procurement strategies

An overview of the raw materials in the selection is presented in (Figure 21). The group is diverse and exotic rock types are overrepresented in comparison to the total assemblage.

High-pressure rocks predominate, and harbour a degree of variation within their group. The majority are jadeitites (>95% jadeite mineral content) but this group is varied: some are slightly foliated or banded, one stood out for the observation of mica and another for its omphacite content (Davies, pers. comm. 2015). Two more are jadeite-bearing high-pressure rocks but their mineral content is potentially more heterogeneous. P 001 appears to be rich in omphacite. All are heavy and dense, and barring one all have a fine-grained, sugary texture exposed in fresh fractures. The RSJC is the nearest known source of jadeitite at >1200km direct distance. However, only the MFZ is known to have been exploited at times contemporaneous to the ECA, and is at >3000km direct distance. The provenance of these materials is under geochemical investigation (Knaf *et al.* in prep.). Until then, it remains possible that they originated from multiple sources or from as of yet undiscovered localities as well. It is also unknown whether the potential routes were archipelagic, coastal, or inland. However, there is some evidence indicating that at least part of the materials entered Grenada as unmodified blanks collected from secondary contexts. A petal-shaped water-rolled pale jadeitite pebble measuring ca. 75 mm forms a medium-sized blank. The pebble was never worked and this is possibly due to a vein crosscutting the material. Furthermore, Falci *et al.* (in prep.) found two unmodified jadeitite blanks and a core associated with lapidary production. The colouring of the jadeitites is diverse. Most are pale translucent, ranging from very pale green towards light green and mottled variants. Two are of a deeper olive green and few contain darker minerals.

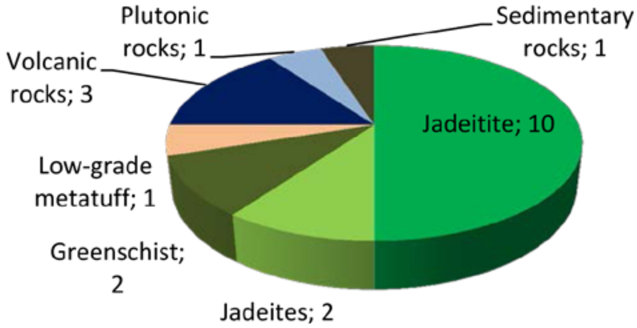

Figure 21: Overview of raw materials from the Pearls sample.

At least five finished specimens (42%) exhibit internal defects that were exposed during reduction and could not be erased by further shaping (Figure 22). They consist of crack lines and vugs, some of which quite severe, that do not follow initiation/termination outlines characteristic of (technological)

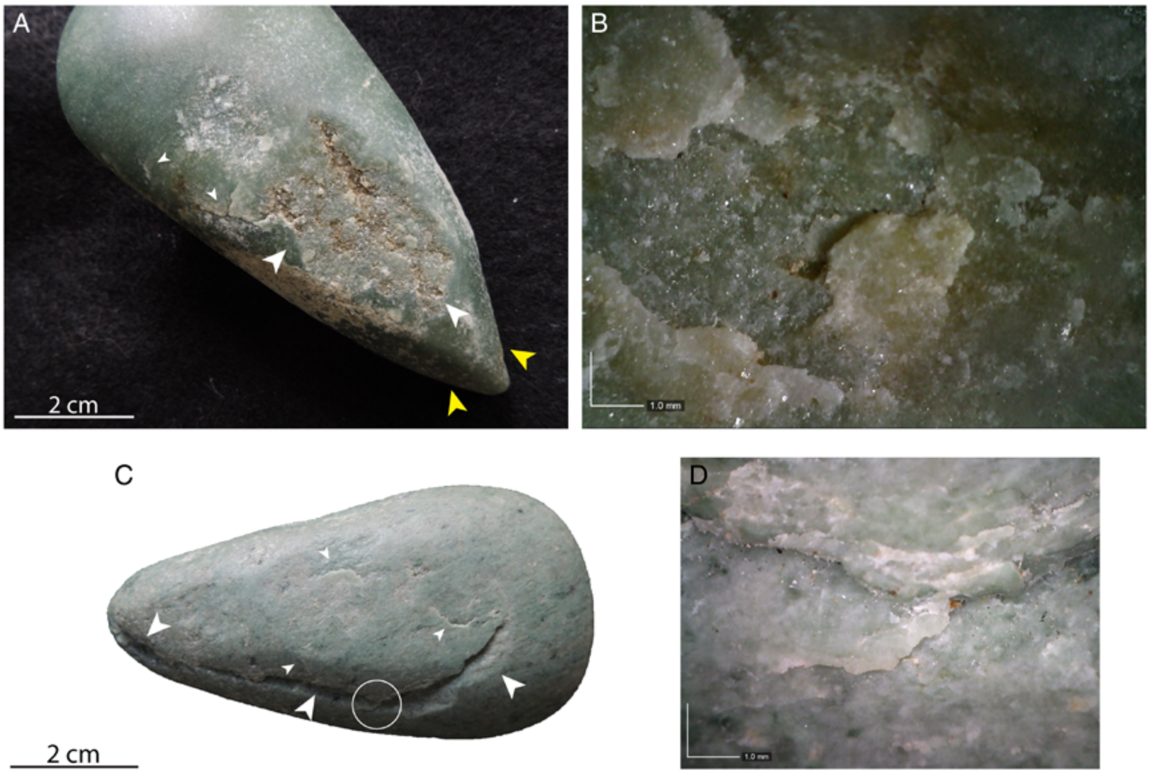

Figure 22: Stigma in jadeitite celts from Pearls. A) Vug in P 009 exposed during manufacture (large arrows) and smaller crack lines (small arrows). Note also bilateral 'burin facets' (yellow arrows). B) Well-formed, fresh crystals exposed on P 018. C) Deep crack on P 003 running lengthwise (large arrows), paralleled by minor sub-surface crack lines (small arrows). D) Close-up of white circled area.

impact scarring. The boundaries of these features are abrasively smoothened over and were thus formed prior to manufacture. It is possible that they are natural features of poor quality raw material, in which case the question rises why they were retained. Perhaps the flaws were not initially noticeable if the rocks arrived at Pearls in unworked form. Alternatively, they may be technological stigma from heat contact, proposing the possibility of mining from primary context through fire-setting. The same features are observed in experimental, ethnographic, and archaeological contexts of high-pressure rock celt procurement (Lozano *et al.* 2017; Pétrequin *et al.* 2008; 2012a), but other associated stigma such as rubefaction and curved flake profiles were not. The issue is further discussed in Chapter 8.

The other metamorphic rocks in the sample include a very fine-grained low-grade metatuff and two fragments of fine-grained greenschist. All have massive fabrics, with the metatuff having mottled grey-brown colours and the greenschists being typically green. Neither rock is local to Grenada. Both lithologies could derive from mainland South America, for instance from the Guiana shield through the stone axe production networks in that area (Boomert and Kroonenberg 1977). Low-grade metamorphic rocks including metatuff and greenschist are also known from the geology and archaeology of Tobago (Boomert and Rogers 2005). They similarly occur both in the geological and archaeological assemblages of the Dominican Republic (Section 7.2 and 7.3), making the Greater Antilles a third possible point of origin. There are no indications of possible procurement strategies. The final greenstone is not metamorphic but a volcanoclastic sediment, which has thin bands in lighter and darker greens radiating over the surface. It is fine-grained and relatively heavy, and the only specimen within the collection to display this pattern. Its provenance or procurement are unknown.

The three volcanic rocks include an olivine-bearing ultramafic semi-lunar axe, an ultramafic volcanic lava, and a large trachyte/phonolite roughout. The fourth igneous rock is a fine to medium-grained plutonic with a dark, near-black appearance mottled by light coloured minerals. The ultramafics are dark, almost black in colour whereas the trachyte/phonolite is blue-greyish in appearance. The olivine content points towards the South American mainland as the most likely source for the semi-lunar ultramafic (Davies, pers. comm. 2015), which is in accordance with the typology of the specimen. For the other ultramafic and the plutonic rock no specific origin can be given. Trachyte and phonolite potentially occur throughout the volcanic arch. This specimen was collected from a secondary context and transported to Pearls as a raw material blank, given that it still exhibits some water-worn cortex.

7.1.2 Early reduction

The reduction trajectory is clear only for the trachyte/phonolite roughout. The original boulder approximated the current dimensions, given that the butt was left unmodified and patches of cortical surface also remain on the edge. Two well-placed blows thinned the bifacial outline, with one slight bulb of percussion on the blade evidencing direct percussion. This was followed by impacts on the bilateral sides, which are variably defined by heavy step/hinge terminations and major crushing overlapping earlier scars. Both stigma indicate that the dominant technique of bilateral shaping was bipolar percussion. Still, the continued use of direct percussion is implied by several less invasive conchoidal scars on the edge. Some crushing is also attributable to a roughing up of scar ridges. Manufacture of this specimen appears to have been discontinued due to a series of large, heavy hinge terminated scars located proximolaterally to the edge, which severely weakened the mass of the blade (Figure 23, a).

Figure 23: Manufacturing traces in Pearls. A) Invasive flake reduction on trachyte/phonolite P 014. B) Bifacial thinning scars on jadeitite P 009. C) Pecking traces on jadeitite P 010. D) Scars from impacts and counterblow (small arrows) on P 014.

The jadeite bearing rocks display enough evidence to presuppose that a flaking phase was widely applied, but not enough to reconstruct to what degree that operational sequence was shared. Some retain evidence related to the shaping of the sides and the blade, seen in vestigial scars and the asymmetry of the resulting edge. Flake negatives on the butt remain present on two other jadeitites and on the sedimentary rock. Bifacial thinning is observed in three jadeitites where shallow flaking concavities are retained in spite of subsequent abrasive manufacture. In a fourth the technique has left deep scars terminated only by flaws in the rock (Figure 23, b). The bilateral plane of this specimen is characterised by two large scars along the parallel axis, which approximate burin facets (Figure 22, a). These scars appear to be stigma from the burin blow technique (Inizan *et al.* 1999, 84-85), rather than a preparation perpendicular to the faces as is common to bilateral aspects. They run from the butt upwards for about one quarter of the total length, and visibly interrupt the intended petal-shaped outline. In this particular specimen (P 009), the reduction programme is poorly executed in comparison to other materials. The invasiveness of the flake scars indicates a lack of technical know-how in shaping jadeitite, perhaps in the form of misapplied force or inappropriate hammerstone materials. The damage is too extensive to fully erase by later smoothening, though in most other cases attempts were made. In comparison with the other materials, such flaws appear comparatively more often on jadeitite and to larger degrees.

Little can be said for the early reduction sequence of the other raw materials. Small vestigial flake scars were found on the edge and tang of the ultramafic semi-lunar axe, which were not completely erased by later treatment. These remain from the knapping of the outline, indicating a previous phase where the morphology was shaped through numerous small and well-placed facets. The metatuff, plutonic, and greenschists bear no compelling evidence of a potential flaking stage.

A similar conclusion is reached for the pecking of preforms. Seven celts display some form of pecking, six being jadeitite and one greenschist. Pecking traces take the shape of regularly spaced surface pitting in most specimens, the pits being interstitial remnants of the pecked topography that were not completely erased. Such traces will disappear upon better levelling, or can be mistaken from intrinsic porosity: this is why the ultramafic celt lacks confidence for this technique. Two jadeitite specimens are incompletely ground, and here the pecked topography is retained in full towards the sides and back of the object (Figure 23, c). In both the roughness remains low and craters small, indicating careful finishing of the impacts with fine precision favoured over rough crushing of the topography (Section 4.1.3). Coarse pecking is seen only in the repurposed jadeitite in which these pecked areas are superimposed on the polished surface.

7.1.3 Abrasive manufacturing

All celts were subjected to an abrasive treatment, with the exception of the roughout (Table 5). Many exhibit multiple applications of both grinding and polishing. Twelve specimens display well-developed bright lustres, ranging from a deep greasy gloss to a vitreous shimmer. Prior abrasive reduction techniques could not be recognised in six of those, but are inferred to still have taken place for those polished with soft materials. As most were incompletely polished evidence of reductive grinding was often retained. One sign pertains to the retention of coarse grinding grooves on the sides in cases where they are clearly not associated with the later abrasive technique. Multiple abrasive techniques were observed on nine jadeitites (75%), and further on a greenschist, ultramafic, and sedimentary rock. Though these percentages again reflect the sampling strategy, there is a higher tendency for green-coloured rocks within the assemblage to bear stronger lustres. In 73% the abrasive action occurred all over the surface, though not reaching deeper production scars and often superimposed by pecking marks on the sides. The remaining five specimens were abraded mainly on the bevels and faces.

Table 5: Trace signatures of abrasive manufacture categories in Pearls.

***n*=19**	**Dull**			**Bright**				**Multiple**	**Other**
	Dry ground	Intermediate	Sand-ground	Wet ground	Mirror	Wood	Soft		
Igneous rocks	1	1		2				2	2
Low-grade rocks		1	1		1			1	1
High-grade rocks	1		3	2	2	2	3	9	1
Sedimentary rocks			1		1			1	
Total	2	2	5	4	4	2	3	13	4

*Dull lustres (*n*=11)*

A jadeitite and plutonic rock both display a well levelled microtopography characterised only by a dull, flat scintillation that strongly resembles the ‘dry grinding’ signature obtained experimentally (Section 5.1.2). The plutonic rock also displayed the coarse grinding grooves discussed above, indicating the use of a less fine-grained rock than the experimental platform; the jadeitite did not and most closely resembles the result of exp. 2510 (greenschist blank on quartz arenite). Stereoscopic striations are otherwise rare amongst the sample, and the technique(s) associated with the coarse grinding grooves on the sides could not be interpreted due to complete overlay by other wear patterns.

Nine additional specimens display microtopographies that remain characterised by a dull and rough scintillation of the higher areas, but show varying invasiveness into the upper and lower slopes (Figure 24, a-c). The signatures corresponds to asperities crushed and further rounded by abrasion and fatigue stress, and match well with the experimental 'sand-ground' results. These traces are found across a range of rocks, including four jadeitites, one greenschist, the sediment, olivine-bearing ultramafic, and metatuff. Variation in the wear trace signature persists within this group, however. The contrast between the modified highs and unmodified lows is lower in some specimens, on which 'stone scratches' (see Table 2) are also present. These two fall in between the 'dry ground' and 'sand-ground' signatures (Table 5). Others developed a stronger, brighter topographical contrast and small isolated rough polish structures. The microtopographies of a greenschist (P 015) and jadeitite (P 011) show a distinct wear characteristic. They display the general rough, invasive scintillation and rounding of a 'sand-ground' signature, but the space between the rough textured points (which are not erased through abrasion) has been smeared out into extensively distributed dull polish (Figure 24, d). There are hints of this occurrence in the manufacture of experiment 2550 (Appendix 1), but not to the extensive distribution seen here.

It is difficult to estimate to what degree this range reflects one or more technological variations, since there will be some interference from the rocks themselves differentially responding to the

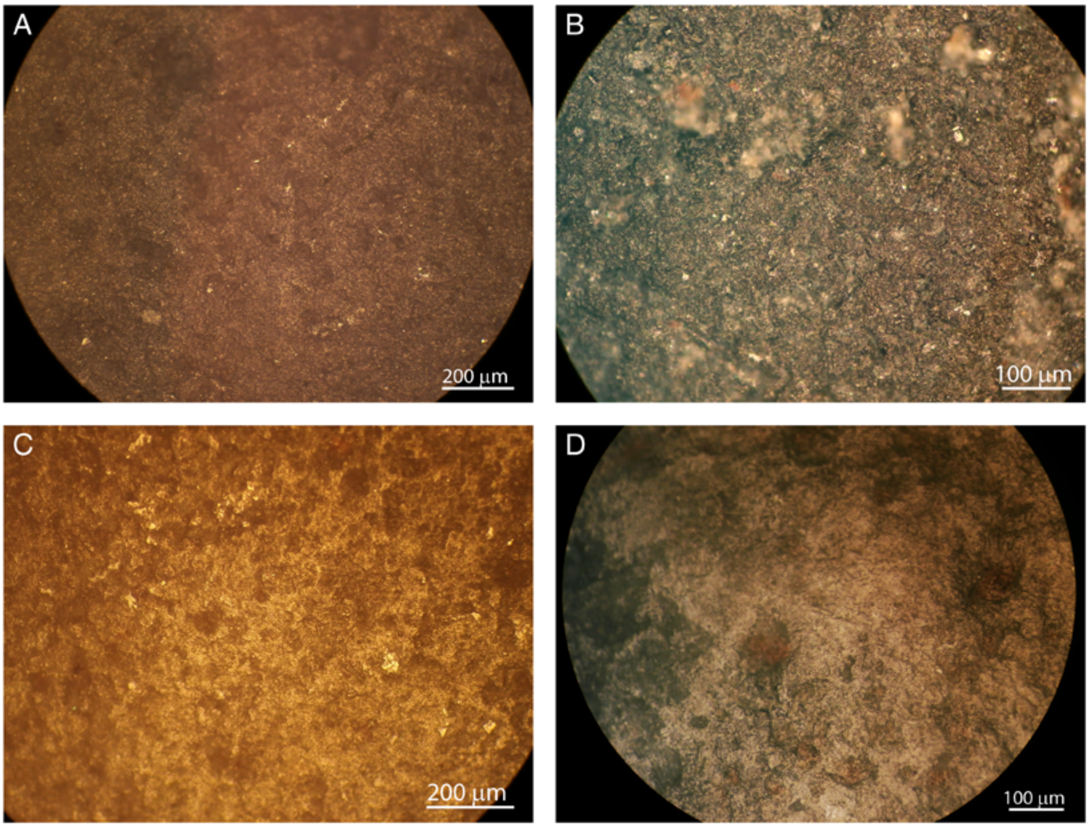

Figure 24: Wear traces from abrasive grinding in the Pearls assemblage. A & B) Dull and rough scintillation from 'dry grinding' on olivine-ultramafic P 006. C) Brighter and rough scintillation from 'sand-ground' techniques on volcanoclastic sediment P 005. D) Rough micro-asperities amongst smeared dull polish on greenschist P 015.

interaction. Further overlay by later wear trace patterns may also play a role in the brighter and more rounded appearance of certain micro-topographies. Still, the use of either loose sand abrasives or sandstones of similar granularity and cohesion as experimental platform exp. SWH seems evident. Perhaps both were in use for different artefacts, depending on the context in which they were abraded (at Pearls, or before) and where the community obtained its grinding platforms from.

Finally, a successive finer grinding technique was applied to two igneous specimens, which show thin striations located parallel to the edge. These indicate contacting rocks of finer granularity than the grinding slabs or abrasives, likely applied to sharpen the edge after grinding. Since igneous rock blanks were more susceptible to retain striations during the experiments, the absence of such whetting on the metamorphic rocks in the sample is not regarded as indicating differential treatment.

*Bright lustres (*n=*13)*

Six other manufacturing wear signatures are heuristically distinguished as polishing techniques, since they resulted in the visible surface lustres. They pertain to stone grinding polish, mineral derived polish, wood derived polish, and indications of the use of soft materials. The distribution of these lustres is usually at the most intense on the proximal and medial face. Fluid transitions with the bevels suggest that in many cases these areas were originally polished towards a similar intensity, which is now covered by wear from subsequent use. Towards the backside most lustres fade out independently of the distribution of hafting friction, suggesting that this cut-off reflects the extent of the focus on polishing.

Three specimens display traces interpreted as the result of polishing with different variants of soft materials. The surfaces of two are characterised by a greasy lustre with the naked eye, mirrored by a microtopography covered in a dense blanket of polish. Its texture is rough and dull and it is evenly spread throughout the microtopography in a highly invasive, connected/covering distribution. Any angularity in the asperities is rounded and most areas evidence a lack of relief reduction (Figure 25, a), which distinguishes this modification from the scintillative categories of hard stone grinding traces that evidence abrasion and/or fatigue wear (Section 5.1). Adhesion shear is probably the dominant mode of wear, and a soft contact material is strongly implicated. The microtopography of the third celt shows a higher contrast between small, rough, and bright polish structures on the higher points, a widely distributed dull and rough blanket over the intermediate relief of the slopes, and the unmodified deep interstices (Figure 25, b). The asperities appear more strongly smoothened, but the relief is otherwise largely unmodified from what is inferred as a preceding abrasive technique. The two wear trace patterns potentially indicate different types of soft contact materials, such as hide, prehension, or non-siliceous plants versus more abrasive silica-rich vegetal materials (e.g. palm leaves, bamboo stems). Experimental work is needed to understand the interaction of various potential candidates with a jadeitite matrix.

Two celts displayed traces of wood friction, homogeneously distributed over a well levelled surface. The consistent association with abraded surface areas evidences that these traces relate to a polishing technique, rather than to use wear or hafting friction. P 003 has use traces distinct from the polishing and displays more plant-like hafting wear, whereas P 009 appears unused lacking both use traces and haft friction. Their macroscopic lustre is also greasy, but much brighter than that of the surfaces just described. Microscopically, the polish is domed, pitted, and bright on the asperities, and rough and dull on the upper slopes (Figure 25, c-d). The characteristics are divergent otherwise:

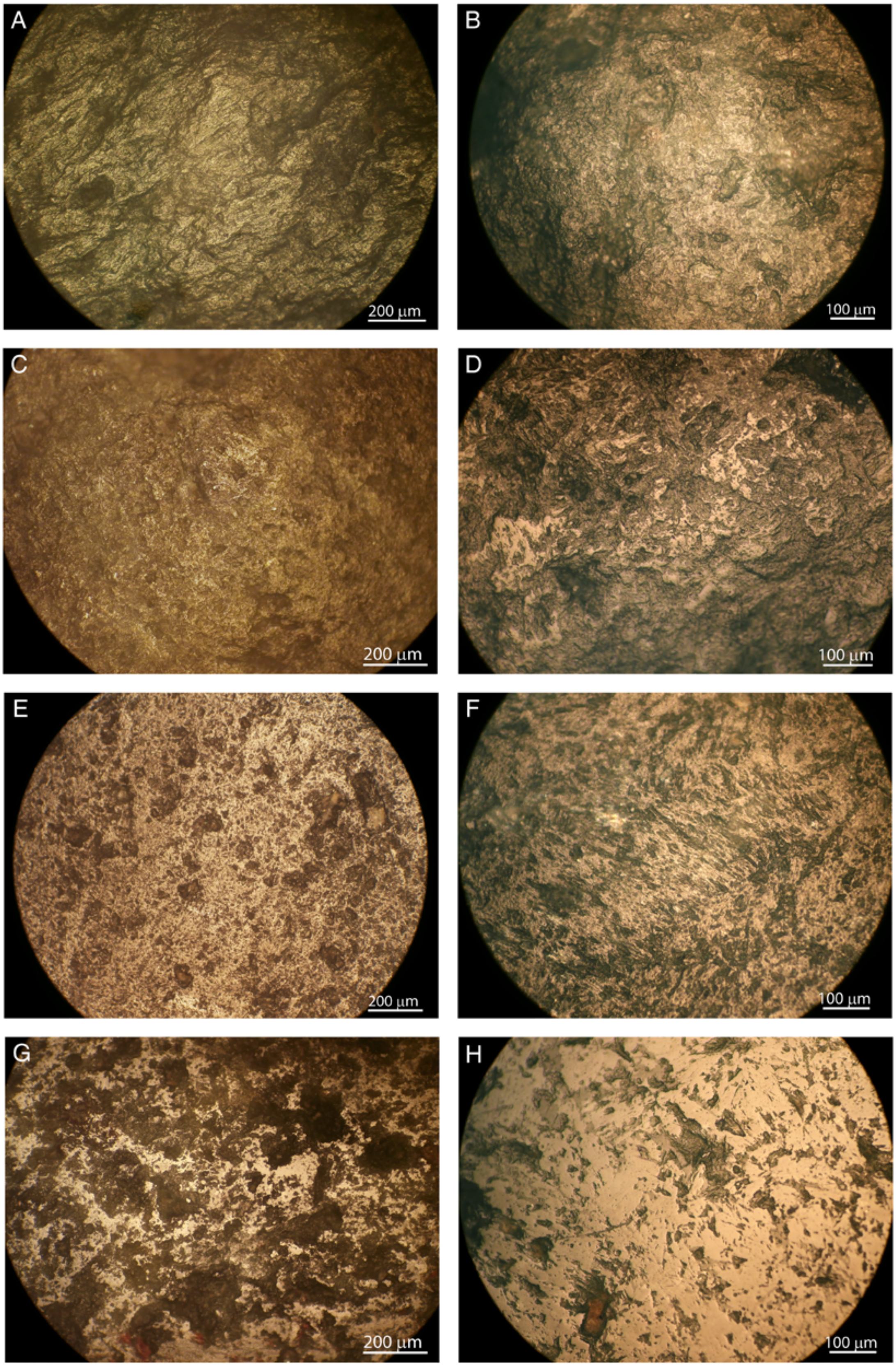

Figure 25: Wear traces from various polishing techniques in Pearls. A) topography from polishing with soft material A on jadeitite P 001. B) topography from polishing with soft material B on jadeite-bearing P 013. C) traces from friction with wood on jadeitite P 003. D) traces from friction with wood on jadeitite P 009. E) wet grinding traces on a quartz arenite type of platform on jadeitite P 021. F) wet grinding traces on a hard lithic platform on ultramafic P 019. G) 'bright mineral mirror polish' on greenschist P 016. H) 'bright mineral mirror polish' on jadeitite P 011.

on P 003 the domes have a rough and slightly greasy texture and remain mostly isolated, whereas on P 009 the polish developed more extensively. It is smooth to almost flat and topographical doming abates, with a connected/loose distribution and striations in multiple directions. The rough polish is bright immediately afterwards and dissipates at lower elevations, indicating mild pliability in the contact materials. The former wear trace pattern of P 003 closely resembles the outcome of the friction experiment against seasoned dense hardwood (Appendix 2, exp. 2552), and was likely subjected to polishing with such a material for no longer than intermediate duration. The latter signature seen on P 003 indicates hard wood in which more moisture was present, either from fresh preparation or (more likely) added as lubricant.

Four celts displayed traces resulting from extended abrasive contact with a hard and cohesive lithic platform under wet conditions. Two of these exhibit the same characteristic as the abrading experiments using quartz arenite under wet conditions (Figure 25, e). The microtopographies display very bright, flat, and rough polish in covered/connecting distribution, that exceed the experiments in developed intensity. The surfaces are also slightly striated under low magnification, and the abrading platform is therefore inferred to have been a rock of similar properties as exp. 2497 (Section 5.1.1). Evidence indicating a previous abrasive technique was observed on both. The other two celts exhibit similar traces of abrasion, but the overall topography is more directional and retains more evidence of crushed and abraded peaks in its relief (Figure 25, f). The polish is also less bright and in covered/closed distribution, failing to connect over the higher ratio of interstitial space. The overall appearance is very similar, but the granularity or mineralogy of the abrading platform probably differed somewhat, i.e. less angularity, more matrix content, or mineralogical heterogeneity. The macroscopic lustres were of (sub)metallic intensity.

The final polishing technique observed in this assemblage, which results in a bright metallic to vitreous lustre, was applied to four specimens. The topography is extremely levelled, and microscopically corresponds to a very bright and extremely flat polish restricted to the asperities that reach the upper topographical level (Figure 25, g-h). The polish occasionally displays small pits (probably from particle ejection under fatigue stress) or extremely fine multidirectional striations, and is sharply bounded from the interstitial space. The interstitial space may be very shallow and is usually not modified, but sometimes carries modification from previous abrasive episodes such as a 'sand-ground' pattern. The wear signature is quite typical, and is henceforth referenced to as 'bright mineral mirror polish'. It has not been experimentally reproduced thus far; the interpretation is further discussed in section 10.2.3.

7.1.4 Composition of the hafts

The indications for hafting is well preserved within this assemblage, and various ways of dealing with the handling system could be distinguished. The exclusion of the blank, roughout, and edge fragment leaves 18 artefacts potentially bearing traces of wear, resulting in a complete reconstruction of the hafting arrangement for twelve specimens (including un-hafted wedges). The main hafting arrangements that result from the analysis are represented in Figure 26.

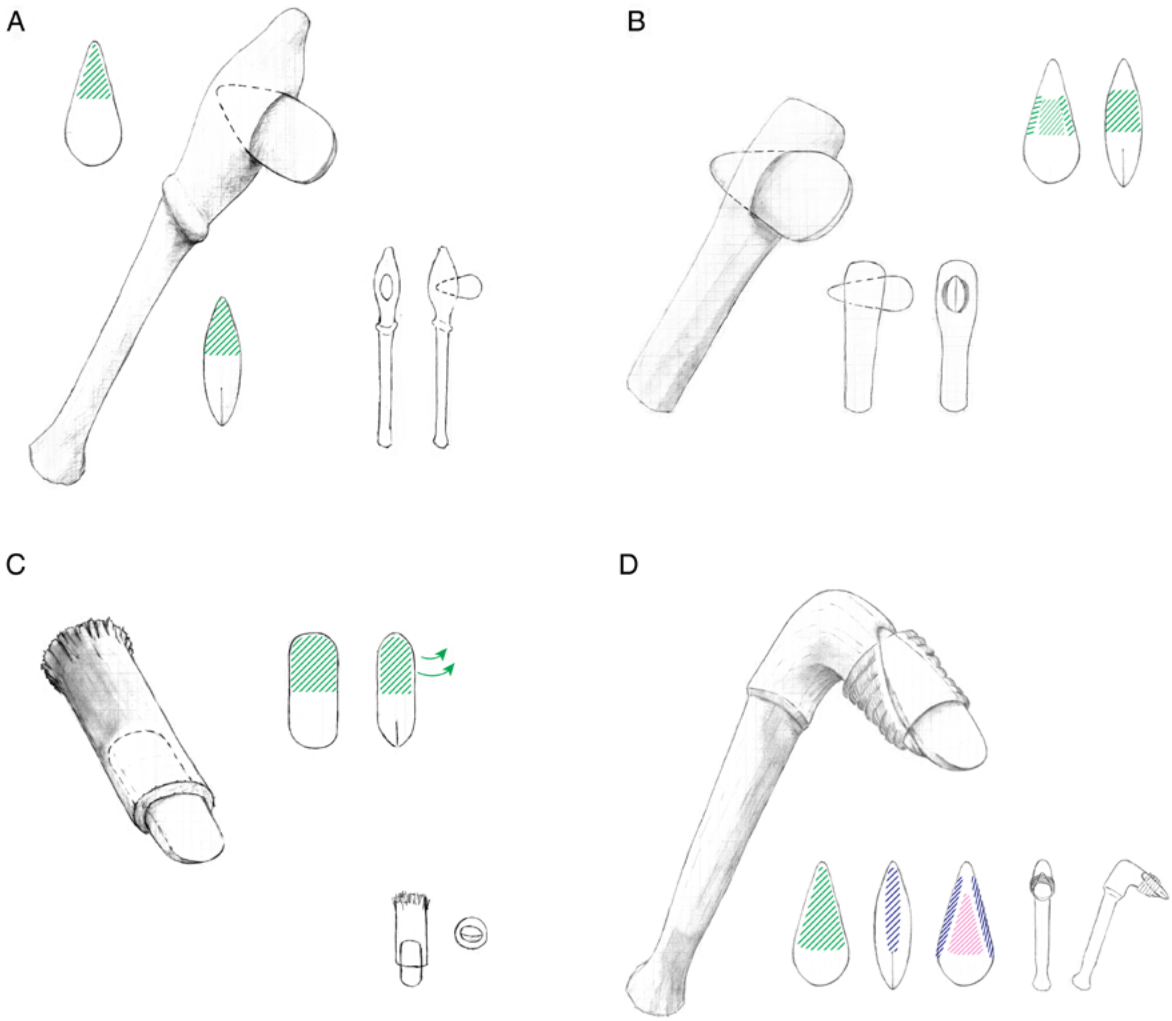

Figure 26: Identified spatial zones correlated to basic hafting types for edge-ground macro-lithic tools. A) male embedded axe, P 002. B) male split axe, P 021. C) male embedded chisel, P 001. D) juxtaposed adze, P 013. Green hatching indicates friction against the material of the handle, blue hatching indicates friction from binding materials, transparent hatching indicates areas of non-obligatory contact. The designs of A, B, and D are inspired by published photographs of recent finds from Los Buschillones (Jardines Macías *et al.* 2013; 2015), and the thickened distal pads follow a handle from north Caicos (Mason 1876, 373).[28] Drawings by Finn van der Leden.

*Axe-style hafts (*n=*5)*

Three specimens display traces consistent with lateral-transversal direct parallel-male fitting (see Figure 4), corresponding to basic axe handles (Figure 26, a). The traces consist of a slightly domed topography with smooth but uneven polish, restricted to the asperities and little interlinkage. The topography approximates that of the experimental chopping of desiccated seagrape (exp. 2550 phase 4, Appendix 2.2), and is in general characteristic of well developed wood contact wear. These traces evenly cover a clearly defined zone on the butt, evidencing a single contact material on all sides, beyond which they disappear abruptly to give way to the manufacturing wear present underneath (Figure 26, a, green

28 Note that most known long handles actually have male split attachment slots, and that P 021 from image B is a very large-sized celt that in reality was hafted in a large handle. An embedded design would be more suitable for medium or short handles, but no such handles are archaeologically known to me.

hatching). Two of these contained residue deposits in association with the hafted zones, which based on morphological grounds could be a type of processed, non-pristine resin (following Langejans and Lombard 2015, 206). It corresponds to a category of residues that is documented under laboratory conditions for the assemblage of El Flaco, and will be detailed exhaustively in section 7.2.4. The smaller celts were embedded for ca. 1.5-2.5 cm and the larger one up to 5 cm in its haft. All had symmetrical distributions of use wear traces, suggesting the orientation was parallel and not perpendicular (i.e., they were not male-hafted adzes).

A similar attachment system but one in which the slot fully perforates the handle (male split) is indicated for two fragmented, (very) large-sized specimens. One displays a polish similar to exp. 2552 (seasoned wood friction): this is developed very densely on the curvatures that lead towards the lateral sides, but fully absent in the centre of the face. It is consistent with the faces left floating in the socket to prevent pressure on the thin walls from potentially breaking the handle. The other displays well developed polish indicating contact with wood on all distal aspects, terminating evenly after 5.5 cm counted distal to medial, and with a slightly brighter and smoother texture on one lateral side. The fact that its butt is missing and estimated to have added between five and ten centimetres of length strongly suggests the axe protruded from a split slot (Figure 26, b). Neither carried micro-residue deposits.

*Chisel-style haft (*n*=1)*

A terminal-axial positioning is inferred for P 001, otherwise hafted as perpendicular-male and embedded (Figure 26, c). Polish from friction with wood is well developed on the distal areas and extends into fracture negatives, suggesting de- and re-hafting episodes next to an extensive use life. The texture somewhat resembles the non-corrugated areas on exp. 2553 (soaked wood friction), which may simply indicate a different wood. Crucially, the polish spread is directional, perpendicular to the long axis of the chisel, and contains striations of the same orientation (Figure 27, a). This seems to correspond to a twisting gesture along the long axis of the celt, which therefore must be hafted axially. Considering also the small-sized rectangular morphology, the specimen is interpreted as a chisel suited for intricate design-work.

*Adze-style hafts (*n*=4)*

Two specimens display a wear trace pattern fully consistent with latero-distal transversal direct perpendicular-juxtaposed fittings (see Figure 4), corresponding to adze handles hafted with bindings (Figure 26, d). Both celts display wear trace patterns indicating dissimilar contacts on the dorsal and ventral faces, supported by associated residues on three sides. The ventral faces contain mostly domed microtopographies with polish characteristic of contact with wood (Figure 27, c). The dorsal faces show contrasting wear, which variably extends to the lateral sides. On the smaller P 007 the levelled microtopography contains densely packed, invasive polish with a rough and greasy texture. It has the appearance of modified material filling up the space between the roughness of micro-asperite points, though the deeper interstices remain unaffected (Figure 27, b). It indicates a softer contact material with adhesive redistribution of material as the main mode of wear, and is therefore most probably attributable to flexible ligatures (Section 5.2 describes some potential materials). These traces spatially extend for ca. 3 cm covering the distal half of the three non-ventral aspects, and are interlaced with residue deposits.

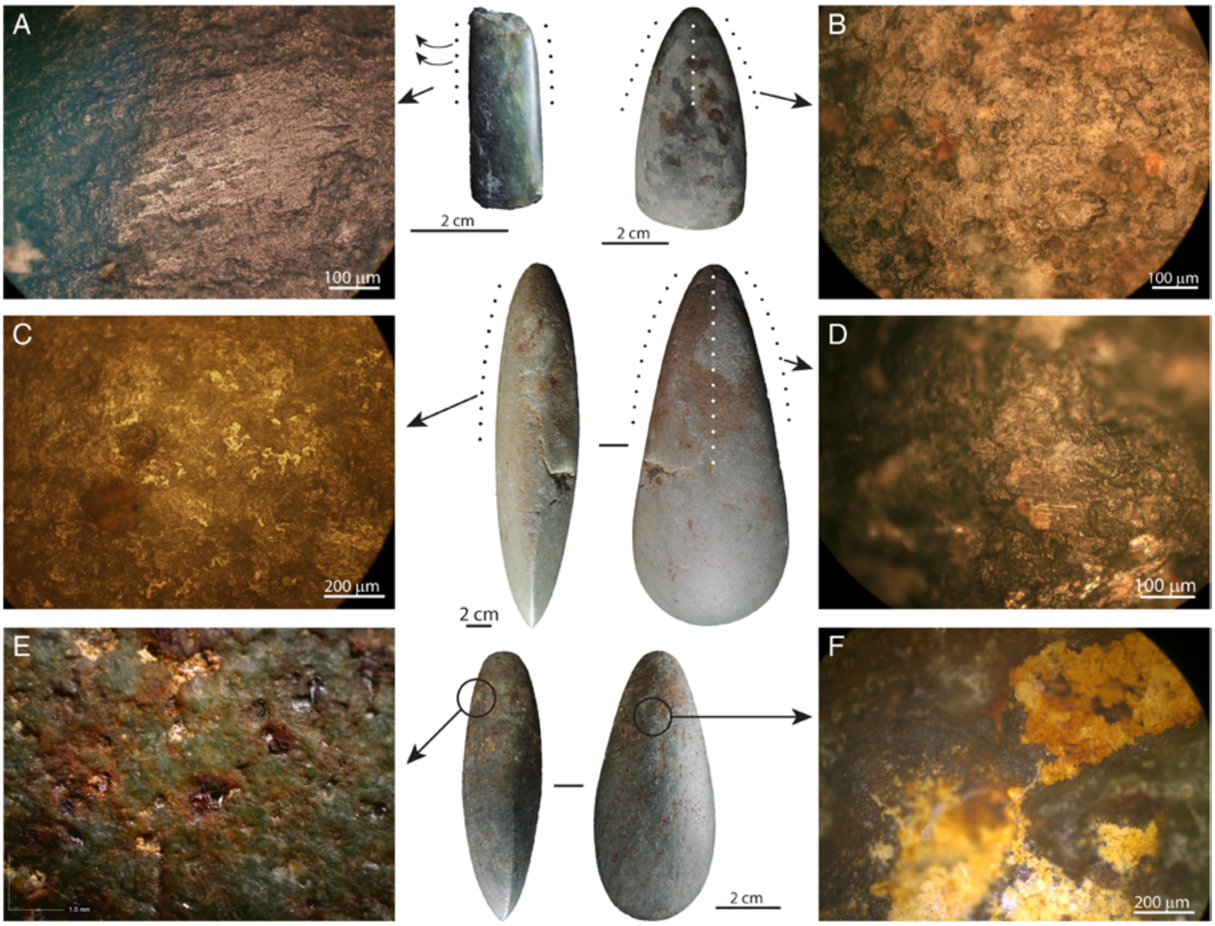

Figure 27: Wear traces associated with hafting in Pearls. A) Directionality on jadeite-bearing P 001 overlaying wear from polishing. B) Topography associated with soft material binding on metatuff P 007. C) Polish characteristic of contact with wood on jadeitite P 022. D) Rough peaks with developed striations and some interaction with the upper topography on jadeitite P 022. E & F) deposits of residue on jadeitite P 013.

On the larger P 022 the pecked microtopography contains matt polish with mild abrasive and invasive characteristics (Figure 27, d), that somewhat resembles the more developed experimental traces of contact with bark bindings (exp. 2554, Appendix 2.2). It similarly suggests contact with a flexible material tightened around a wooden rest, though of a different type than was used for P 007. The polish occurs in association with sharply defined residue deposits, that may have served as adhesives to keep the bindings in place. For both adzes these deposits strongly resemble or match the resinuous residue deposits also observed for axe-style hafts before, that are described in detail in section 7.2.4. Two additional celts were probably hafted in this fashion as they display the same asymmetric distribution of wood friction traces and residues, but traces of binding were not observed to have developed. The residues on these specimens appears to contain anorganic components of granular red-to-yellow morphology (Figure 27, e-f).

P 022 displays well developed bright and smooth polish located ca. 4-5 cm to 0.5 cm from the distal end of the lateral sides, indicating extensive contact with wood. These traces are not congruent with the mildly developed friction polish of the ventral face, and can suggest two things. Either, fresh wooden inserts were in place underneath loose bindings to better secure the haft, or, the biography contains multiple hafting episodes including a male split attachment in which the faces were left floating (Figure 26, b). At this point neither option is favoured, nor are they mutually exclusive.

Other indicators

An oft-seen adaptation to potential hafting is roughening of the medial-distal zone of the lateral sides, which improves the grip of the system of attachment. In four specimens these areas were simply not thoroughly abraded during manufacture, while in four others they were purposefully enlarged after polishing. This was done by fine pecking, resulting in a surface lower in elevation than the levelled faces, with which they share a sharp boundary. No correlations appear with the type of fitting, haft material, or use of residue.

The remainder of the assemblage showed poorly developed, unclear, or an absence of traces regarding potential hafting systems. One specimen displayed asymmetrically distributed friction on the distal aspect and use wear, but the traces were not interpretable. Three others also displayed uninterpretable types of wear on the posterior surface microtopography, including the semi-lunar axe, due to unknown contact materials or probable re-polishing. P 010 contained a spot of residue corresponding to the aforementioned morphologically resinous category, but lacked traces. Traces of wear from a haft were also absent from P 009 and P 019, which is consistent with other aspects of their biographies.

7.1.5 Use-wear

Wear traces associated with the working of various woods were observed on 12 out of 16 celt edges (75%), sometimes as multiple signatures. Three others displayed unidentified pliable and hard material contact, and one edge contained no traces of use (Table 6).

Table 6: Trace signatures of use categories in Pearls.

***n*=17**	**Woodworking traces**			**Other use traces**		**Miscellaneous**			
	Typical/ unspecified	Experimental range	Exceeding	Hard material	Pliable-soft material	Reworked pounder	Heavy edge wear	Resharpening	No wear
Igneous rocks	1	1		1			2		
Low-grade rocks					1* (see text)			1* (see text)	
High-grade rocks	3	3	5	1		1	4		1
Sedimentary rocks		1							
Total	4	5	5	2	1	1	6	-	1

Woodworking

The traces from woodworking at Pearls include various distinguishable subcategories of wear. Commensurable with the inferential division of section 5.2.2, there are five specimens displaying wear matching the experimental results in its characteristics. Two (P 003, 019) appear as a mixture between the uneven, semi-rough texture and domed topography of mahogany and the somewhat reticulated spread and spatial distribution of the galba experiment (Figure 28, a; compare Figure 11), though the archaeological wear is much more densely developed. P 005 and one side of P 020 also display an abundantly domed topography with semi-rough polish, pitted and with scintillation from contact extending to the upper slopes, but with little inter-linkage. The signature is quite similar to

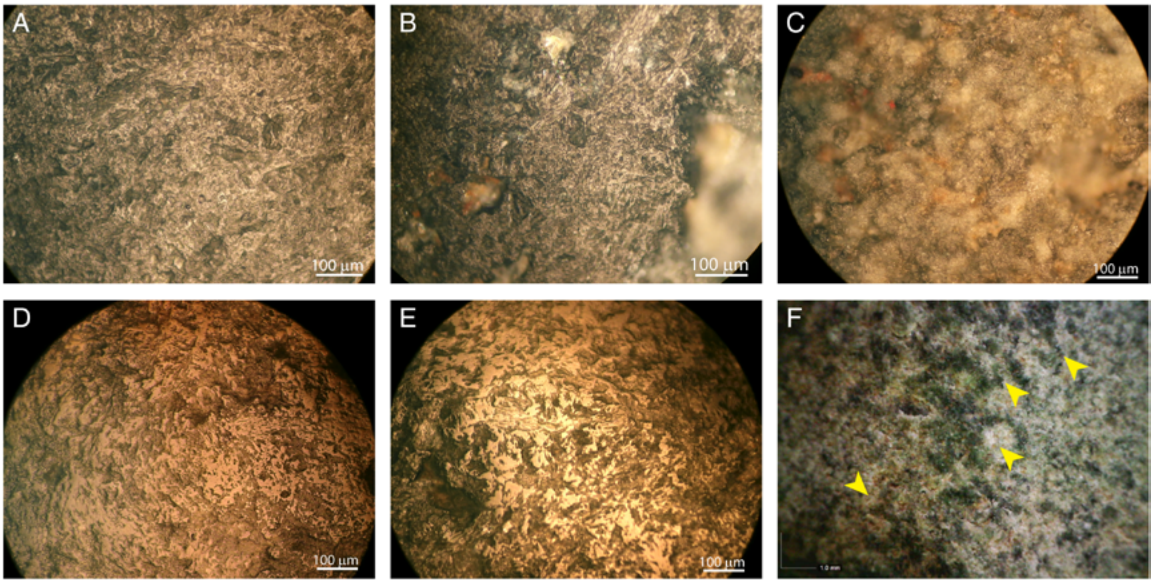

Figure 28: Woodworking wear traces in Pearls.

Typical wear trace signatures on A) ultramafic P 019 and B) jadeitite P 021. C) Wear from use contact with a pliable-soft material on metatuff P 007. Hard material wood-associated wear traces on D) jadeitite P 002 and E) jadeitite P 004. F) Rounding of grains on the central (vertical) ridge of jadeite (arrows) P 011.

the experimental results from chopping waterwood, dry seagrape, and bleary cedar, though it does not resemble all variables for each individual result. More clustering of polish is seen on P 010, otherwise comparable in characteristics.

Four celts (P 017, 018, 021, 022) display rougher, sometimes pitted polish with moderate invasiveness on the microtopography, though individual structures are not very domed and remain quite small in size. In some the polish is abundantly distributed and well reticulating, indicating an extensive stage of development (Figure 28, b). Such traces are more comparable to general expectations for wood chopping wear (Section 5.2), and may thus represent contacts against woods of lower specific density than the experimental range (cf. Section 5.2.2). The state of wear is not as developed in others, which are best regarded as contact against wood with unspecified detail. In any case, these trace patterns illustrate on-going shifts in wood categories at the site, perhaps also involving different states of working.

The two morphological wedges, previously seen to lack indications of hafting, are set apart by unusual trace distributions. P 010 exhibited extensive longitudinal striations, and P 019 invasive use wear up until deep into the medial zone of the faces, where it is thickest. Both are heavily rounded and have partially worn over microretouch, whereas the other celts were rounded variably but, mostly within the range of usability (cf. Mills 1993), with little to no retouch. These patterns are highly suggestive of the celts being wedged into a resisting woody mass, gradually splitting it apart through pressure from the thickest areas.

Five celts displayed traces from woodworking that are provisionally interpreted as representing contacts against woods of higher specific density than the experimental range (cf. Section 5.2.2). The micro-topography on these specimens retains only slight doming, best visible when partially out of focus (Figure 28, d-e). The polish distribution is closed on the asperities and fully connected through a rough and dull scintillation more generally (see Figure 6), concentrated over the entire bevel. However, the size of individual structures and degree of reticulation follows primarily the (minimised) microtopographical relief. Polish texture is smooth to flat (Table 4), bright, and sometimes glistening, whereas pitting is minor and corrugations are occasionally seen. Such patterns developed to a very high intensity on P 002 and P 004, but less so on the others. Rounding, chipping, and morphological distribution varies. Both polish characteristics and the level of modification of the topographical slopes indicate a hard contact material, but more pliable than unyielding bone/antler or minerals. Nevertheless, the polish is smoother and less invasive, domed, and pitted than wear trace patterns resulting from contact wood commonly are. There is a textural resemblance with some experiments, particularly galba and desiccated seagrape (Figure 11, b, e), but on the whole denser and/or differently worked materials remain implied.

Other use activities

Three celts displayed dissimilar traces of wear from use. The small rectilinear chisel (P 001) and semi-lunar axe (P 006) displayed polish from contact with a hard material, being rough and confined to the microtopographical peaks with little modification of the slopes. Because of poor development and interference of traces from manufacture, no further interpretation can be given. Traces on P 006 were clustered on the central part of the bevel, however, indicating that semi-lunar axes operate in functionally similar ways to biconvex celts. Force traverses only the central edge and tang, and though the wings add weight they do not impart significant percussive contact on their own.

One celt (P 007) displayed a wear trace signature characterised by dull, moderately invasive polish with a rough and greasy texture (Figure 28, c). Smoother, glistening polish was observed only occasionally on isolated domed structures. While thus retaining some variables characteristic of wood, the traces appear more indicative of a softer pliable material than at least the experimental woods. However, it is unclear if the overall signature is not partially related to potential 'sand-ground' resharpening activities. The micro-topography is comparable to those traces, while the edge is currently sharp and free of damage, contrasting extensively developed traces of hafting. The distinction remains ultimately unclear.

The last remaining celt (009) displayed no traces from use whatsoever. Otherwise, a butt fragment (011) was reworked into a pounder, whose broken aspect showed shaping and repecking scars with the intermittent ridges displaying rounding and polish indicative of a softer contact material (Figure 28, f).

7.1.6 Depositional context

The depositional context of these materials is unknown. Still, some assessments can be drawn from the apparent integrity of the celts. The roughout and the fragments all appear to have been discarded following catastrophic failure. Re-use, which could be either repurposing or recycling (Section 3.1.3.3), took place only for fragment originally large enough to maintain enough grip for handheld use afterwards. The other fragments would not have permitted this, nor were any sharp edges utilised.

For the complete celts no single explanation is easily favoured. Though intact specimens are not common, explanations that invoke ceremonial depositions are not possible given the contextual issues with the site. Such inferences tend to regard unblemished specimens as unused and therefore specially produced (Section 3.1.1), an assumption disproven by the extensive development of wear from use. Nevertheless, the selection contains little exhaustion. Apart from fragmentation the best indication therefore would be widespread and heavy dulling (Mills 1993), but extensive rounding is only seen in a few celts. Even then, the duller edges are not scarred or otherwise rendered incapable of simple renewal through quick resharpening. One celt indeed showed corresponding traces, and the practice could have affected several others given that the edge morphologies are often slanted, dent, or otherwise deviate from an ideal straight profile.[29] Without context, it may well be the case that specimens were habitually left lying around when not needed (*sensu* Siegel and Roe 1986), and that the intact celts were never retrieved but lost over time. The deposition of these celts thus remains unresolved, and warrants further research into depositional practices at Pearls.

7.2 El Flaco

The analysed assemblage from El Flaco numbers 106 in total, of which 80 are macro-lithic artefacts. Some of these are mostly intact and provided information on wear traces for the full biography, but most are fractured artefacts and flakes from manufacture or catastrophic breakage. The remaining 26 are flakes that may relate to the (meta)volcanic flaking industry rather than celt production debitage, but this could not always be distinguished (Section 6.1.2). These artefacts are considered in the section on procurement strategies due to their overlap in raw materials. However, they do not constitute (hypothetical) bifacial thinning waste, since most flakes easily reach or exceed the maximum dimensions of the largest celts found on the site.

The assemblage was studied partially in the laboratory (fnrs 20-1258, 2317, and 9999, except 718) and partially in the field (all others). Several artefacts originating from a surface context were not submitted to high magnification analysis in the interest of time.

7.2.1 Materials and procurement strategies

The raw material identifications and their distribution through the assemblage are depicted in Figure 29. Fine-grained volcanic rocks, low-grade metamorphic greenschists with basaltic protoliths, and incompletely altered volcanics (with metamorphic overprint) comprise the vast majority of both celts and lithic flakes, in broadly similar proportions. These can derive from either mountain range (Sections 2.1 and 6.1.2) and indicate a strong reliance upon materials which are accessible from alluvial contexts both within the Cibao valley and north of the Paso de los Hidalgos.

With few exceptions, the volcanic rocks can all be characterised as massive and fine-grained with dark grey/blackish colouring. A bluish tinge is brought out on some specimens with comparatively higher degrees of polishing. Some could be identified as basalts using the plagioclase feldspar/quartz/k-feldspar triangle, but most were too fine-grained to make a distinction (Knaf, pers. comm. 2015). Brecciation is present in a few specimens. Concerning the phaneritic igneous and plutonic rocks, two are distinguished as rich in plagioclase and orthoclase (towards gabbro or diorite) whose minerals form a white/dark mottled pattern. These rocks do not co-occur as flaked materials.

Rocks which are incompletely altered (overprinted) by low-grade metamorphism comprise the second group. Basaltic protoliths dominate, though a few other volcanic rocks were also included, and are mostly characterised by low to medium degrees of overprinting.[30] They are somewhat tougher

29 Lacking further evidence, these indications are principally associated with edge scarring as a result of flaking during the early reduction phase. Resharpening has not been discussed for Caribbean materials in the context of eventually altering celt morphologies before, though abraders are occasionally called sharpening stones. However, in early colonial times the Kalinago were described to frequently sharpen their metal axes (Moreau 1990).

30 The exact percentages may be subject to revision, since the boundary with more completely

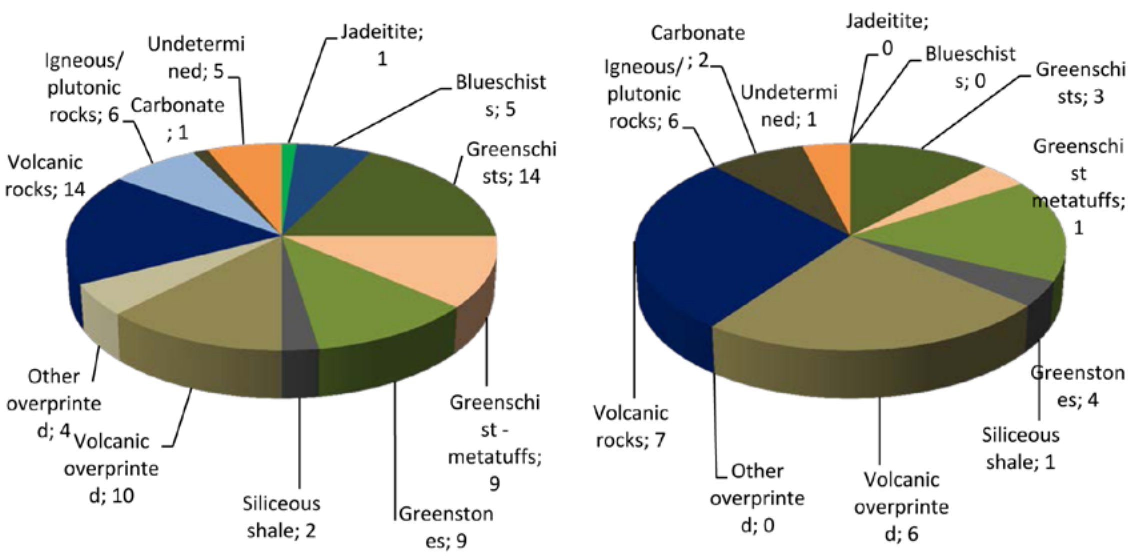

Figure 29: Overview of raw materials amongst the macro-lithic (left) and flaked stone assemblage (right) of El Flaco.

and denser than the unaltered equivalents and incline towards grey-greenish to dark-bluish colours. Most flaked materials and the expedient celts displayed water-worn surfaces, indicating they were procured from alluvial beds. Several other flaked materials have weathered natural surfaces and are of undisclosed origin.

Greenschists comprise the group of low-grade metamorphic rocks. Many have (basaltic) volcanic protoliths, remain fine-grained and with generally massive fabrics, exhibiting a variety of paler and darker green hues. A notable subgroup comprises nine specimens with tuff (or potentially siltstone) protoliths, most of which have even paler green colours and very fine granularity. Foliated layering and garnets are occasionally present, indicating further variation in the lithological origin. Such layering will weaken the rock by enabling fracture planes under the stress of percussive activities, and is likely to have been actively selected against. Most unspecified greenstones are expected to have been altered under greenschist facies conditions as well, but the variety in colouration, texture, and fabric is somewhat larger. Two of the low-grade metamorphic rocks are siliceous shales, which occur in the same lithological beds and were obtained from alluvial contexts. Certain varieties are potentially traceable to more distinct origins, such as metatuff outcrops in the El Yujo subcomplex near Jarabacoa, La Vega province (Lewis and Jiménez G. 1991). On the whole, however, they were likely transported by the El Yaque del Norte and detailed mineralogical study is needed to establish such provenances.

Other types of rocks are rare. High-pressure metamorphics include at least one blue-pale green mottled jadeitite fragment which resembles the materials worked at Playa Grande. Five others are probable blueschists, two having a striking white-interrupted foliation that results from subsequent alteration and one with partial omphacite recrystallization.[31] Few others additionally exhibit characteristics of these rock types, but were not true members (following specialist examination) or ultimately considered as undetermined in the field. Potential high-pressure rock types do not form

metamorphosed rocks is fuzzy. Rocks described to me as metabasalts could fall in either group, depending on whether the specialist identified alteration in a basalt, or the protolith of a largely metamorphosed rock.

31 The assemblage from 2016 includes few additional omphacitic and jadeitic celts, but these are not considered here.

part of the flaked stone assemblage. The closest nearby high-pressure zone is the Puerto Plata area north of the central Cordillera Septentrional, followed by the RSJC to the east.

7.2.2 Early reduction

Traces from the initial and intermediate steps of reduction are somewhat frequent in this assemblage (Table 7), but data on the sequences is lacking. Most specimens recovered from El Flaco are ground surface fragments, resulting in lower rates of observation on previous manufacturing steps. Nevertheless, both flaking and pecking were probably common. Roughly a third of specimens displayed traces of pecking in the forms of unground surfaces or minor pitting within ground areas, celts primarily on the finer scale. Evidence of initial flaking activities was identified in various forms as well. In the cases that technological characteristics are evident, they indicate direct percussion. Bipolar percussion is not evidenced within the assemblage. Four discarded roughout fragments and two mostly expedient, informally made celts provide additional resolution into reduction strategies at the site.

Table 7: Observed reduction techniques and manufacturing steps at El Flaco. See section 7.3.2 and Table 10 for explanations of collating and the sub-categories.

Technique	Times observed	Prevalence and comments
<u>Flaking total</u>	<u>22</u>	Probably medium to high
Cortex removal	*0*	-
Bifacial thinning	*6*	*Unclear*
Lateral intrusive flaking	*7*	*Unclear*
Direct percussion	*6*	*High (observations counted on celts only)*
Bipolar percussion	*0*	*Absent*
Hammering – heavy, transverse	2	Low
<u>Pecking total</u>	<u>28</u>	Probably very high
Coarse pecking	*5*	*Low. Most observations pertain to non-celt artefacts or reworking*
Fine pecking	*7*	*Medium to high*
Unclear/no evidence	40	-
Roughout/preform fragments	4	Very low to low
Expedient use	2	Very low

The intact roughout displays evidence of bifacial thinning in the form of large, well-placed conchoidal scars (Figure 30, a). Shallow flake negatives and ripples, more invasive than could be corrected with subsequent methods, were seen to indicate this technique in several other fragments (Figure 30, c). Subsequent 'lateral intrusive flaking' (*sensu* Rodríguez Ramos 2010a) on the bilateral aspects enacted more precision in shaping the final morphology of sides and edge. The outcome is a series of small scars usually with flat to gradual profiles and step terminations. The latest flaking impacts sometimes grade into pecking marks, indicating a transition in gesture, tool, or force of impact to reduce fracture propagation into the localised crushing of mineral grains. The primary intent of pecking was to prepare the preform for grinding, by removing flake ridges and other asperities. It is evident mostly from incomplete abrading due to elevation or remnant pitting and discolouration underneath ground surfaces, only rarely were the lateral sides left rougher for attachment of a haft. The fact that this procedure is not without risk is evidenced by a mishap flake which displays a mostly pecked dorsal surface, equalising a flake negative surface, that fractured the roughout by misdirected force or a

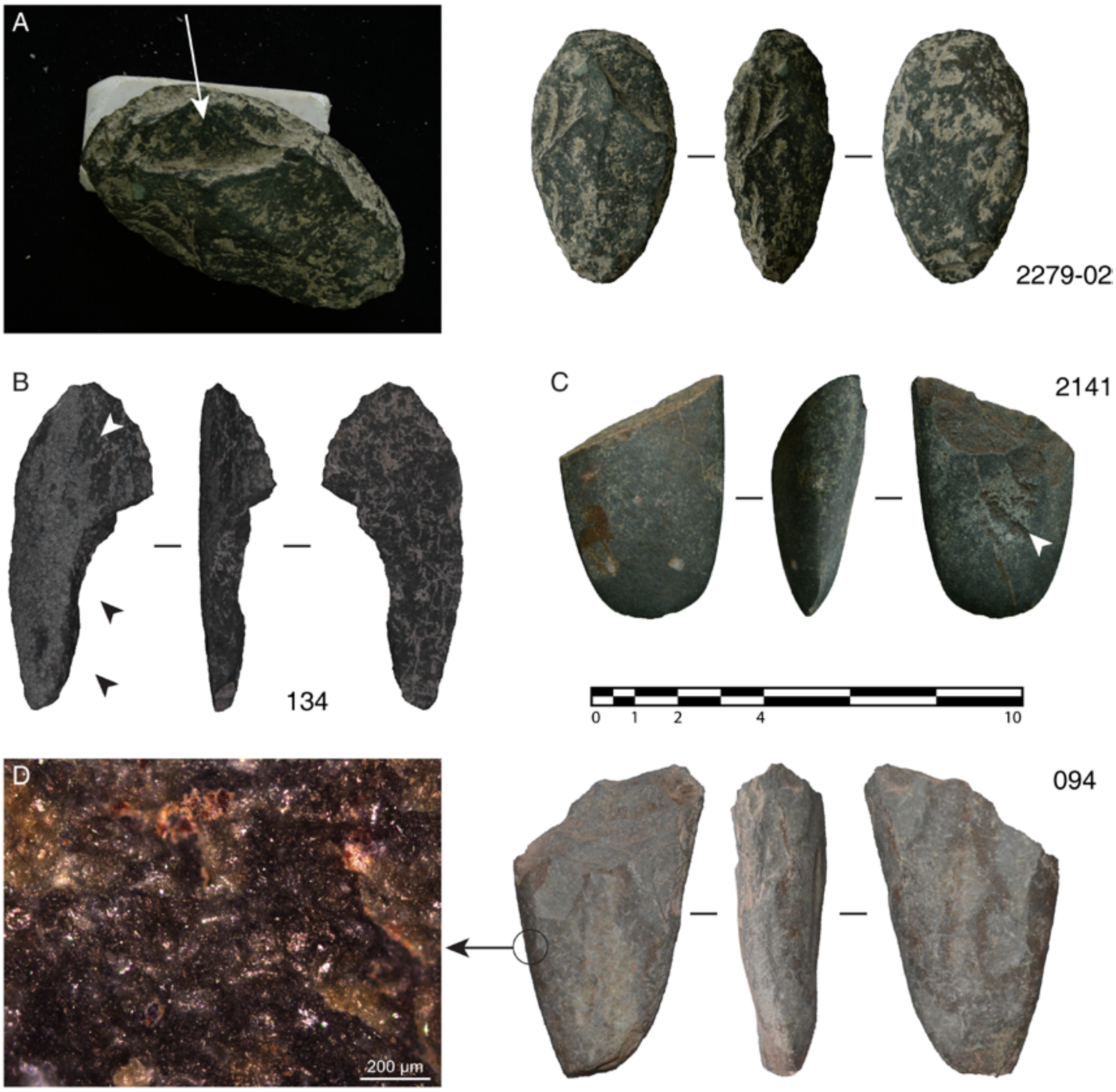

Figure 30: Early reduction of macro-lithics at El Flaco. A) Flaking roughout with critical removal on overprinted volcanic FL 2279-02. B) Pecking traces (arrow) overlaying mishap removal on low-grade metamorphic FL 134. C) Scar from bifacial thinning, partially covered in pecking marks (arrow), persisting on ground facial surface of volcanic FL 2141.D) Micrograph of natural (unmodified) surface on expedient metamorphic FL 094.

weakness in the rock (Figure 30, b, c).

This operational sequence appears fairly uniform, insofar that nearly all materials represent fragments of finished artefacts. Two expediently made pieces clearly deviate from it, by retaining most natural surfaces and form in combination with evidence from hafting and use. Medial-distal fragment 094 was originally a water-rolled pebble of which the natural shape approximates the morphology of a petaloid. Both faces are water-worn: these surfaces are relatively smooth but show an indistinct bright scintillation, irregular elevations, and rounding (Figure 30, d; and Section 7.2.4 for analysis of the overlying wear). The regularity and evening characteristic of abraded topographies is absent. Only some unwanted rugosities on a lateral side were corrected by incipient pecking and grinding. Similarly, edge-medial fragment 2318 is a wedge-shaped water-rolled pebble on which an edge was created by a few hard lateral percussion impacts on one face, followed up by a tranchet blow on the other. The surface is otherwise unmodified, while limited but interpretable wear traces confirm it was used in this state. The remaining preforms display water-worn or weathered surfaces as well, indicating that dimensions fitting the intended result formed a criteria in some raw material selections.

7.2.3 Abrasive manufacturing

Abrasive reduction techniques were identified on 61 fragments, with 5 abraded artefacts not interpretable by microscopic analysis and the remaining 14 comprising roughouts and expedient celts. Most celts were fully abraded, but when discontinuous or with fluctuating intensity it are the faces and bevels that were consistently favoured. Manufacturing striations were erased from these areas, but sometimes retained on the curvatures of the lateral sides. Their directionality nearly always follows the long axis (maximum divergence of 45°), indicating back-and-forth gestures. The majority of surfaces display dull lustres and corresponding abrasive techniques, often joined by striations in the periphery. Indeed, the assemblage is distinguished by the significant variation observed for such techniques, which is assumed to indicate a larger variety of platforms than can be interpreted on the basis of the experiments. A minority of specimens display brighter lustres and abrasive techniques corresponding to wet contact with hard stone surfaces, though field limitations often inhibited more precise characterisations. Secondary polishing techniques are present, but rare.

Table 8: Trace signatures of abrasive manufacture categories in El Flaco.

***n*=61**	**Dull**					**Bright**					**Multiple**
	Dry ground	Intermediate	Sand-ground	Specified different	Unspecified	Wet ground specified	Wet ground unspecified	Wood	Mirror	Other/ Unclear	
Igneous rocks	1		4	1	2	3	2			1	2
Overprinted rocks	2		3	1	1	1	1	2			2
Low-grade rocks	5	10	9	1	2	4	2				4
High-grade rocks			2	1	1		1		1	1	1
Other rocks	2				2						
Total	10	10	18	4	8	8	6	2	1	2	9

*Dull lustres (*n*=50)*

The majority of surface microtopographies with dull macroscopic lustres range from 'dry grinding' to 'sand-ground' trace signatures, though some display other types of contact or could not be further interpreted. A type of 'dry grinding' is inferred for ten specimens. Seven of these display well levelled microtopographies that lack polish development, of which the non-greenschists display elongated fine striations under stereoscopic view (Figure 31, a). Three additional green metamorphics possess a higher micro-relief and are densely striated. Such patterns could have been obtained through grinding on cohesive quartz-rich sandstones, which probably occur in the Yaque del Norte river basin. However, further experimentation with other types of potential grinding platforms is needed to test whether this result is significant to the platform composition, absence of water, or the specific combination (Section 5.1.2.3).

Four celts were considered in the field as probably corresponding to 'dry grinding', but could also resemble a flatter and duller type of 'sand-ground' topography. This is the pattern wherein grain crushing has led to slight or medium scintillation (Figure 31, b), and similar to the assemblage of Pearls, most dull surfaces exhibit some kind of correspondence. Six more are positively assessed to fall in between 'dry grinding' to a slight 'sand-ground' signature. Subsumed under the 'sand-ground' column in Table 8 are three additional specimens corresponding to a duller, lower roughness 'sand-ground' modification. Three display strongly correlating wear trace signatures, and five more topographies wherein the peaks are brighter, surface relief is higher, and minor polish typical from contact with lithic materials occur. The final seven were recorded under field limitations and here considered as having unspecified 'sand-ground' correspondences due to lack of details. These do vary in the presence and density of stereoscopic striations.

Altogether, 61.6% of the assemblage display traces of abrasive wear that strongly resemble specific experimental results (Section 5.1.2.3) or form a clear but varied gradation between. Importantly, that variation is spread quite evenly and is not clearly correlated with specific lithological groups, otherwise a factor at this level of inference. Instead the possibility exists that an unrecognised repertoire of grinding platforms of slightly different characteristics was chosen, since alternative choices (such as immature sandstones) are yet to be experimentally investigated. The pattern is not intrinsically suggestive of different technological choices. For one, these grinding platforms are potentially interchangeable in reductive efficiency and speed, and second, differences in the resulting surface appearances are not distinctive to the untrained (but attentive) eye.

Finally, four celts displayed dull lustred topographies with wear contrary to the experimental results, indicating unknown techniques. Eight others are unclear and not further interpreted, together accounting for another 20% of surfaces. These results are at least partially attributable to mineralogical differences (Table 8) since not all rock types were experimentally covered. Confusion over water-worn topographies was generally ruled out via high magnification comparison with local water-rolled pebbles.

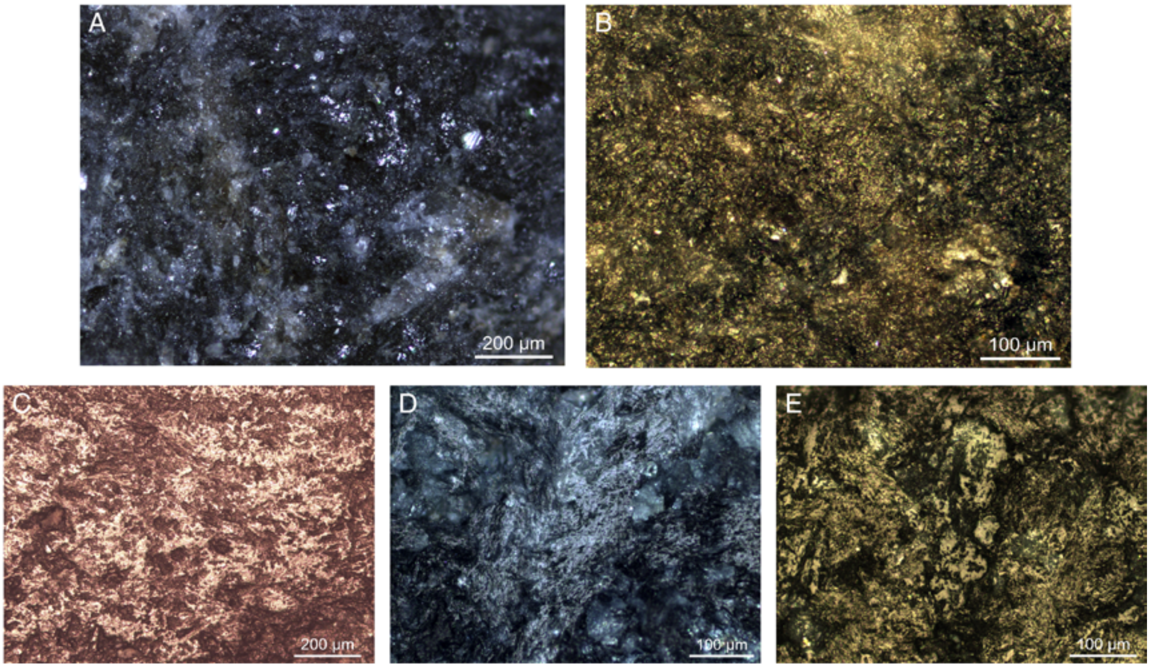

Figure 31: Wear from abrasive manufacturing in El Flaco. A) 'dry ground' surface on volcanic 1218. B) brighter 'sand-ground' trace signature on volcanic 1250. C) wet stone variant 1a on gabbro 179. D) wet stone variant 2 on volcanic 1002. E) partially wood contact-derived polish with very fine striations on overprinted volcanic 945.

*Bright lustres (*n*=19)*

A minority of surfaces was treated with a technique producing a bright lustred appearance, subdivided into mineral-based techniques (25%) and wood-based techniques (3.3-6.6%).[32] Surfaces in the former group display lustre up to sub-metallic intensity, and exhibit dense polish typical of wet contact with a stone on the microtopography. Specific correspondences to the experimental surfaces were not observed, but several archaeological specimens could be characterised as distinctive (field limitations inhibited this level of resolution for others). Levels of roughness, surface distributions, and striation patterns all varied.

Three share a rough and flat polish on the high microtopographical points, which is bright to very bright, non-invasive and of high contrast with the slopes, and interconnects in a covering distribution (Figure 31, c). The texture is rougher than the experimental polish from wet abrading on quartz arenite (exps 2511 and 2513) and the lacks the dense striations seen in wet abrading against cohesive sandstones (exps 2782, 2515-A). It is therefore considered a distinct modification, referenced as 'wet stone variant 1a' in Appendix 3. A fourth displays mostly equivalent wear except with the polish structures smaller in size and less densely distributed, and probably represents a shorter-term interaction with this technique (described as 'wet stone variant 1b'). It was observed on artefacts of different kinds of rocks.

By similar logic, 'wet stone variant 2' pertains to a wear trace signature exhibited on two igneous specimens. The surface is stereoscopically striated, and microtopography displays gouges and a well developed, non-invasive polish. It has a rough and highly pitted texture, and is distributed in loose/connected across a dull scintillating topography with the texture and micro-relief characteristic of fatigue crushing (Figure 31, d). The closest experimental correspondence for a platform is the fine-grained, cohesive sandstone (used in exp 2782), but the match is not strong and a different platform is more probable. 'Wet stone variant 3' is a provisional category for two celts on which the polish consisted of bright, rough plateaus with little to no invasiveness, that were heavily striated and interlinked in a reticulating type of pattern (partially as a result of microtopographical differences). Finally, a single blueschist of unspecified typo-morphology displayed spots of 'bright mineral mirror polish', but it is not certain if and how these traces relate to celt biographies.

The wood-based polishing techniques were evident on two celts, differentiated by a bright and greasy lustre as well as deeper colouration. The micro-topographies are well levelled and the asperities display characteristically interlinking domed polish, densely interlinked with a smooth, glistening texture and very fine micro-striations (Figure 31, e). Most of their surface areas are characterised by duller and rough polish reaching the upper slopes, however. This seems to indicate preceding abrasive contact against a lithic platform, but overlain by traces from contact with the more pliable wood. Given the presence of fine striations, the technique probably involved a fine-grained abrasive or particularly siliceous materials. Two additional specimens were probably also polished with (seasoned) wood, but the inference is not certain since the traces are not well developed, and one has a dissimilar mineralogical composition.

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32 The total percentages add up to 113.2% as a result of multiple techniques being distinguished on several pieces.

7.2.4 Composition of the hafts

Indicators of hafting activities are observed on 31 specimens, almost all of which belong to the group of 62 abraded celt fragments (65 minus three unspecified macro-lithics). Wear from friction with wood is most common, followed by residues interpreted as adhesives and wear from contact with softer materials. For 17 artefacts a distinction between the parallel male (axe) and perpendicular juxtaposed (adze) hafting archetypes could be made (Figure 32, a), with some variation in the slotting and combination of bindings. Figure 26 (Section 7.1.4) remains a useful guide for the representation thereof. 16 others remain of unspecified fitting due to underdeveloped traces or the absence of spatial patterns. However, the wear trace patterns or residue accumulations on these remain associable to hafting activities and are wholly consistent with what is seen on fully interpreted specimens. An additional 16 fragmented pieces returned no traces associable to a hafting arrangement, four of which

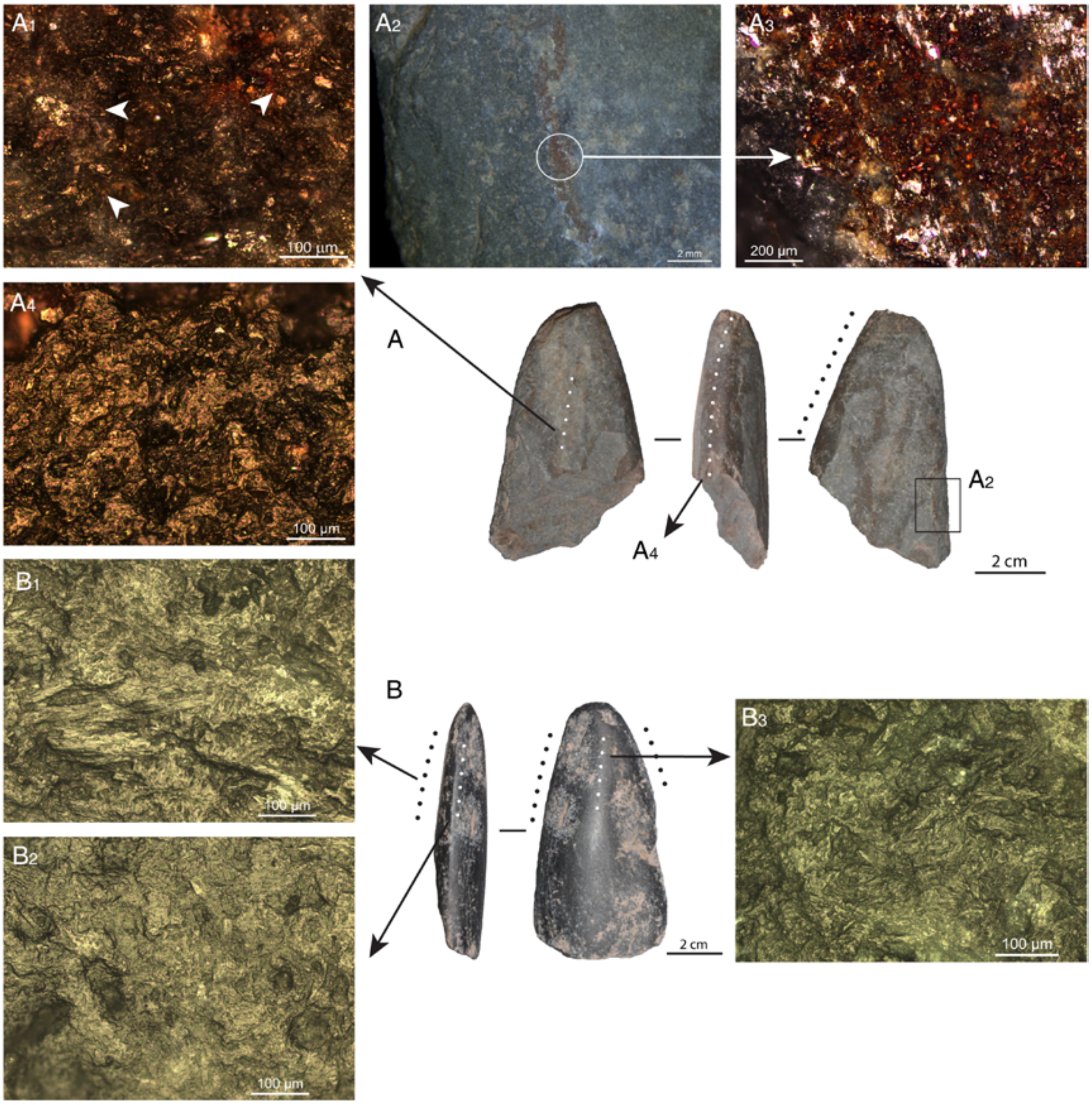

Figure 32: Reconstructed hafting compositions in El Flaco. A) juxtaposed hafted low-grade metamorphic 094. A_1) dispersed traces of contact with wood. A_2 and A_3) adhesive residues. A_4) very well developed band of traces from contact with a pliable-soft plant-like material on the lateral side. B) male probably-split hafted gabbro 179-01. B_1 and B_2) well developed traces of friction contact with wood on the distal zones of both faces. B_3) somewhat distinct development of friction contact on the lateral side.

were relatively intact and are discussed further below. Otherwise, these results are not distinguishable from preservation bias acting upon the spatial sensitivity of traces from a hafting arrangement (Section 4.1.3). Six small edge fragments are further excluded on these grounds, and 13 objects were considered indeterminate.

*Male hafts (*n*=10)*

Male embedded attachments (Figure 4) are inferred for eight specimens. The presence of hafting traces is always unmistakable in these, for both the consistent wear pattern (dry wood friction/residues) and the contrast with manufacturing traces. Four celts were hafted with an orientation parallel to the long axis, and thus functioned as typical axe-heads (cf. Figure 26, a). This follows from wear traces indicating friction with a pliable to hard material being consistently distributed from the butt to medial surface areas, notably developed on the faces. These specimens lack pronounced asymmetry in morphology or use wear patterns and must have been hafted with the blade parallel to the axis of the haft. For the remaining four this orientation was unclear since these had somewhat asymmetric outlines and/or were fragmented in the haft and use zones. For some of these the embedded slotting is extrapolated on the basis of observed penetration depth in wear versus a probable depth given the original dimensions. One specimen in particular (FL 179-01) displayed a stronger development of wood friction polish on its bilateral sides. Possible alternative reconstructions for this celt include a split slot, or an ill-fitting perpendicular embedded slot in a large handle (which would render it an adze).

Otherwise, only one other specimen was potentially hafted as an axe in a male split socket (cf. Figure 26, b). The bilateral sides displayed a stronger development of wear from friction than the faces, though (necessary) evidence for the distal interruption could not be observed due to fragmentation. A tenth celt (210) displayed friction wear on all mediodistal aspects (the butt is missing), as well as repecked bilateral sides carrying in the medial zone a smooth undulating friction polish on their boundary with the polished faces (Figure 33, a). The most congruent interpretation is a male axe fitting with additional supporting ligatures, similar to some ethnographic examples (Section 5.2). The type of attachment fitting is not certain, however, only that it was exceeded by the extent of the bindings. Of note is that male embedded fittings with an axial orientation to the shaft were not confidently inferred. Several 'chisel-like' small, elongated celts are present in the assemblage, but each of these ultimately proved to be indeterminate or not interpretable.

*Juxtaposed hafts (*n*=7)*

Juxtaposed attachment systems are inferred with high confidence for three specimens and with moderate confidence for four more. All display obvious asymmetries in the distribution of wear, the former more clearly from multiple trace signatures and residue deposits than the latter. Traces indicative of friction contact with wood are always present on the downwards (ventral) face, indicating the element that rested on a wooden surface. Contrasting wear is observed on the bilateral sides and upwards (dorsal) face. The three specimens of high confidence all exhibited a microtopography with strongly developed polish, most consistent with a resistant plantish material (Figure 32, a; Figure 33, b). The polish is usually well spread and invasive, having a rough and greasy texture on the peaks for some artefacts and a matt and duller texture for others. Further abrasive and/or adhesive wear of the peaks also differs per artefact, in the form of progressive rounding of asperities and filling in of the interstitial topography (some comparable to observations for Pearls, Section 7.1.4). There were probably different preferences for binding materials, but all share the spatial emphasis on the most protruding locaitons of the morphology. The bindings resist the transmitted force of use blows better in these zones than in any other place, thus heightening friction and subsequent formation of wear. The poor attachment of FL 798 resulted in a higher intensity of wear on the distal zones and bright spot formation from counterblow flaking of the butt (Figure 33, c).

The four specimens of reasonable confidence lacked well developed wear from bindings, but share the characteristically asymmetric distribution of residues with potential adhesive properties on all surfaces but the ventral face.[33] These include the category of potential treated resins (Figure 32, a3), described below. Together, they range from smaller sized celts to fairly substantial specimens, providing a potentially broad range of applications towards various woodworking and fashioning tasks.

Other indications

One celt (FL 2294) displayed wear traces convincing of a perpendicular or adze-like orientation, but its direct attachment system (juxtaposed versus male) proved to not be fully interpretable. Furthermore, 16 specimens are classified as hafted in an unspecified manner. These celts were conceivably all hafted according to the archetypes described above, but issues of surface preservation and inconsistencies in the wear prevented a complete inference. The wear generally consisted of the same type of contact traces previously described and the residues addressed below. Four mostly intact specimens were defined by the absence of traces from a haft. One of these is interpreted as a wedge, further supported by morphological indicators and use wear (below). Another had been heavily polished against a wooden surface, which renders any recognition of hafting in wood strenuous. This specimen was reworked in a hammer/pestle and it must be considered that the heavy polishing took place as part of the reworking process thus obscuring the original biography. The other two are characterised by pecked surfaces which suffer from PDSM/encrustations and are difficult to interpret on those accounts. Similarly, one is blunt and the other may be a potential wedge on account of hammer-blows on its butt.

These are distinguished from the 16 on which no traces were observed, but have fragmented or damaged medial and distal areas. Nevertheless, some do contain technological modifications in the forms of leaving the bilateral sides unpolished, or more rarely repecking them. The active reworking is usually characterised by simple hammering crushing the surface (similar to the prior shaping technique) whereas regularised fine pecking is seen in only few specimens (Figure 33, d).

*Residues (*n=*15)*

Residues are relatively common on medial-distal areas in the assemblage. The residue group of potential heat-treated resins already referenced at Pearls (Section 7.1.4) is present on seven specimens. This residue consists of black deposits with an oily, granular to viscose texture and clear boundaries lacking cracking. Around these deposits it becomes smeared out as thin yellow-reddish droplets constituting a transparent film or stain with a fatty, viscose texture (Figure 33, e-f; cf. Figure 32, a3). It is not

33 It would appear that ligatures often do not develop clear patterns of wear. There may be several reasons for this, such as tight fixations (inhibiting friction), intermediate residue deposits (prevent modification of the underlying lithic surface), or poorer interpretability for particular contact materials (cf. Rots 2010, 135). Conversely, the wooden rest probably bears the brunt of the friction as wear is always well expressed on this aspect. Less clearly defined spatial distributions remained at the level of inference of being hafted through indeterminate means.

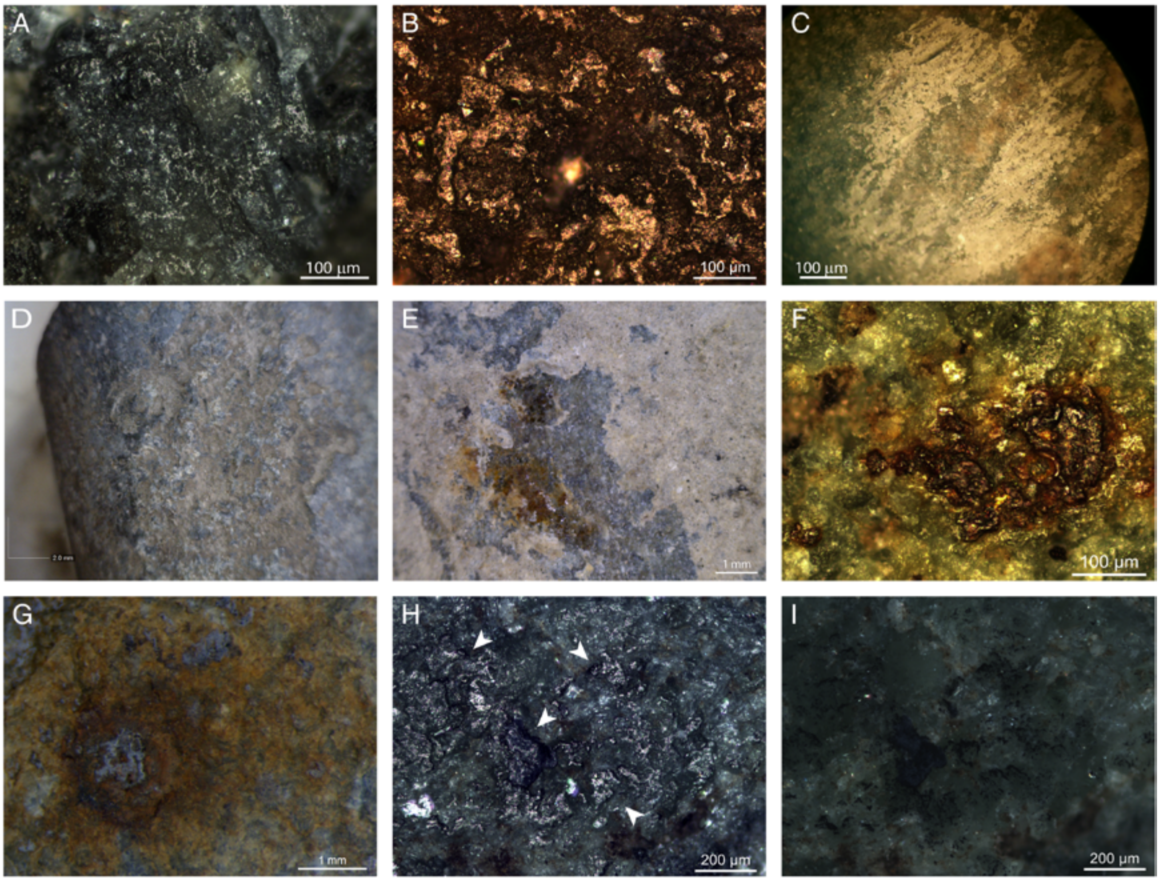

Figure 33: Traces of wear from hafting in El Flaco. A) Smooth reticulating friction polish on the boundary between ground and repecked surface on plutonic 210. B) rough and greasy polish from soft material friction on low-grade metamorphic 94. C) Troughed bright spots on metatuff 798. D) Roughening of a ground side through hammer blows on metatuff 798. E & F) Black viscose clumps with reddish film residue on greenschist 2171 (overlain by sediment encrustations) and metamorphic 544. G) Grainy red with black residue on greenschist 1244. H & I) Black tarry residue under normal and polarising light on blueschist 2317 (arrows indicate deposits under normal light).

clear whether this film corresponds to a thinner or diluted deposit of the same kind, or an exuded component thereof. This residue is morphologically interpreted as a (heat-)processed, non-pristine resin (following Langejans and Lombard 2015, 206). However, morphological variation occurs in colouring, viscosity, and density throughout the assemblages. This variation could be associated to taphonomic degradation, different preparation methods, or the presence of resins from different plants or compounds within the group. Elementary characterisation is required to further investigate what components there are and how it develops through time and space.

This group of residues is usually associated with the distal areas of artefacts, or medial and asymmetrically if a juxtaposed system is implied via wear, and is often correlated with the ligatures. This points towards an anthropogenic function, presumably as adhesive, over alternative possibilities such as natural extracts from the wood of the handle (*guayacan* excretes heartwood oils, for instance). The concentrated black deposits appear mainly on rougher topographies such as pecked sides, whereas most levelled surfaces contain only remnants of the film fading into a stain/discolouration.

Three other residues occurred in association with medial and distal areas. First, a granular red-and-black residue was found on two specimens, for one of which the archaeological attribution is suspect.[34] It is a dense mixture of fine red grains and blackish clumps which is equally distributed over peaks and valleys (Figure 33, g; cf. P 007, Figure 27, e-f). The origin and relation to the treated resin class of residues is unclear, but one possibility is that it represents a mixture of such resin with anorganic material. Second is the appearance of a somewhat transparent and fluid, amber-coloured residue on two pieces, including the jadeite fragment. This is morphologically closer to a pristine resin (Langejans and Lombard 2015, 206). Third, five specimens carry residue consisting of viscose black strands or droplets with an oily texture and clear boundaries. Compared to the non-pristine resin, it lacks the yellow-reddish coloured film and concentration of larger clumps (Figure 33, h-i). Though its appearance is evocative of a tarry substance, the factual nature is not clear. Most of the fragments on which it is encountered actually lack mechanical wear that could link it unequivocally to hafting activities, though these deposits obscure most of the microtopography. Otherwise, when the wear trace evidence indicates a specific type of slotting for any type of residue, the deposits are associated primarily with ligatured attachments (7, versus 2 in embedded slottings).

7.2.5 Use-wear

A total of 26 edges are present in the analysed assemblage from El Flaco, all of which carry traces of wear. This count includes implements where the factual rim had been destroyed or reworked into a blunt surface, as long as remnant traces of use were detected along the proximal margins. Five of the largest celts could not be subjected to a full high magnification analysis due to working distance limitations in the field. Two preforms were confirmed to lack traces and four objects were unclear due to PDSM or the inability to link microscopic traces to macroscopic edge wear (Table 9). Two specimens also provided indicators of use wear on the butt, and are discussed at the end of the section. Residues in association with traces of use wear were not encountered.

Table 9: Trace signatures of use categories in El Flaco.

n=26	**Woodworking traces**					**Other use traces**			**Miscellaneous**			
	Incipient	Unspecified	Experimental range	Exceeding	Distinct	Hard material	Soft material	Indistinct	Reworked pounder	Heavy edge wear	Resharpeing	No wear
Igneous rocks	2		1	2			1	2		5		
Overprinted rocks				1	1			1	1	1	1	
Low-grade rocks	2	1	6	1	1			1	2	5	4	
High-grade rocks				1	1					1		
Other rocks												
Total	4	1	7	5	3	-	1	4	3	12	5	-

34 This specimen was sawn for petrography and residue was found on the sawmark as well as other distal areas. It is possible that residue deposits were translocated during the procedure by the water stream, but contamination is not ruled out.

Woodworking

Woodworking traces dominate the assemblage, various forms of which were encountered throughout. FL 2294 displayed two separate wear trace signatures, separated by a resharpening event. As before, some of these patterns can be further divided based upon their correspondence with the experimental results.

Seven celts display traces of wear of which textural, topographic, and spatial characteristics is in reasonable to strong correspondence to the experiments with galba, bleary cedar, waterwood, and fresh seagrape. These were likely used to work a similar suite of woods, being the fresh sapwoods of tropical hardwood species with specific densities between 0.6 and 0.9 g/cm^3. The archaeological microtopographies are domed, sometimes extensively, and the texture and degree of pitting in the polish fluctuates within the experimental variation (Figure 34, a). Interlinkage consists of reticulation between the nearest structures, and invasiveness is little (dull and rough) to absent (both variables become more pronounced with higher relief). The size and concentration of polish is larger, however, but is probably attributable to differences in working time and intensity. A few specimens display isolated clusters of reticulating domed polish, with a well developed near-smooth and pitted texture, sometimes surrounded by early stage rough and dull polish. These signatures match the experimental results from working mahogany very well, with a near perfect correspondence by FL 253 (Figure 34, b; compare Figure A8, d). Though specific wood species remain far beyond the current inferential limits, the archaeological traces are nevertheless noteworthy.

Five specimens display traces which far exceed in intensity and distribution the textural and topographical characteristics obtained from the experiments. They display bright, smooth, and non-invasive polish with intense doming, decreasing in volume (see Table 4), with variation (Figure 34, c-d). Polish structures on FL 179-01 are nearly flat and heavily pitted, with occasional directionality. Doming is visible only towards the boundaries of the polish structure, the lower topography being

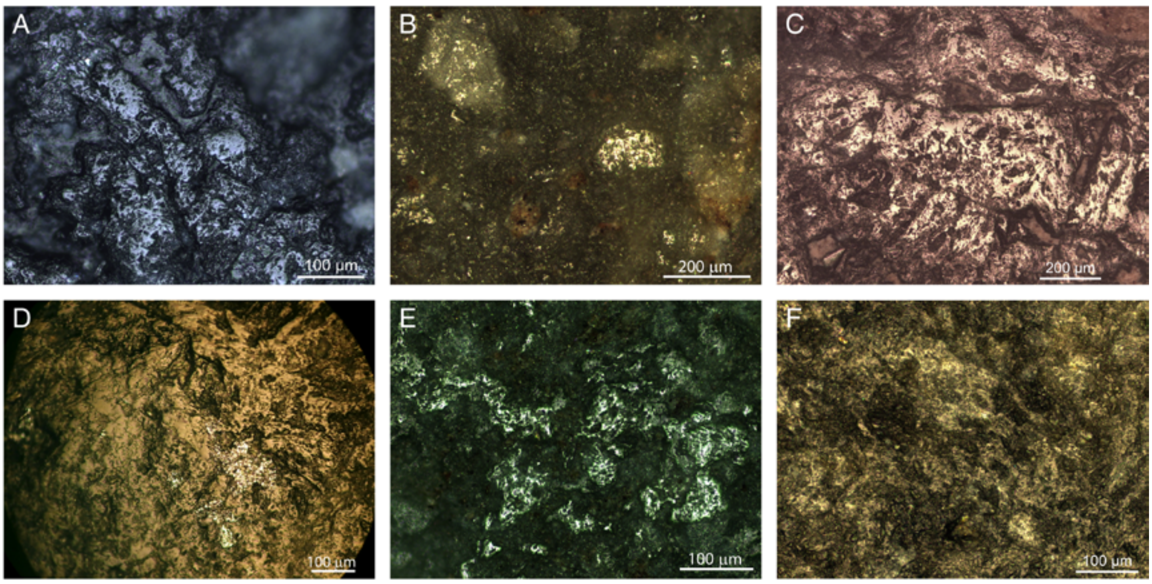

Figure 34: Use wear traces in El Flaco. A) Woodworking traces approximating experimental characteristics on volcanic 1002. B) Woodworking wear strongly resembling the experimental contacts with mahogany on greenschist 253. C) Exceeding woodworking on gabbro 179-01. D) Exceeding woodworking on possible blueschist 2279-06 at 100×. E) Distinct traces of woodworking on tuff greenschist 819. F) Use wear from a softer contact material on volcanic 1250.

directly modified through a dull and rough texture instead. The spatial distribution and interlinkage on this specimen resemble that of chopping desiccated seagrape (exp. 2550, phase 8; Figure 11, e), but harder and drier woods are thought to be implied in the formation of this wear. Conversely, FL 2279-06 displays polish with the corrugation and linkage characteristics of the experiment with galba, but is far smoother to flat in texture and almost devoid of pitting. This is consistent with expectations for a steady continuation of polish build-up and erasure of relief under stable conditions, the implication thus being a long use duration.

Four specimens display incipient traces of wear from woodworking, since the textural and topographic characteristics appear less well developed. These consist of extended patches of rough, dull, reticulating polish draped over flatter topographical areas, with the incidental presence of a dome. Though there is some resemblance with the experimental result from friction with dry cambrón (exp. 2552), they more likely represent early stages of development. Asymmetric distribution of the development as a result of visible resharpening favours this interpretation.

Finally, three specimens displayed well developed traces of contact with wood, but distinct from the experimental range of characteristics. Their microtopographies are extensively domed, containing smooth, bright, greasy textured polish restricted to the asperities in a somewhat irregular spatial distribution (Figure 34, e). There is little to no modification of the upper slopes. Possibly, the contact materials consisted of softer or greener wood varieties, or species with different extract or silica contents, than those cut during the experimental programme.

Other

FL 1250, a smaller celt, displayed wear indicative of a non-woody contact material on its bevel. The traces consist of a blanket of rough polish, non-abrasive and invasive up to the deeper valleys of the microtopography, but brighter on the peaks (Figure 34, f). This pattern is consistent with a soft material, and resembles contact with meaty tissue more so than plant materials. The edge carries fairly invasive impact retouch inconsistent with such a material, however. This indicates either a multi-use palimpsest with harder contact materials, or the working of materials with both soft and hard components, such as animal carcasses or hard-shelled meaty fruits.

Both resharpening and reworking activities are observed within the assemblage. Two different modes of resharpening are present at El Flaco: one operated by carefully flaking a new edge, and the other by honing a dull edge through abrasion (Figure 35). The former is evidenced in two specimens with a series of feather terminated flakes remodelling an exhausted edge, one of which ran into an unexpected direction and broke the edge of the depicted celt in half. Presumably, newly produced scar ridges would be ground anew to reproduce a smooth edge. Traces from abrasive resharpening were observed on three edges, but not necessarily in relation to hypothetical retouch flaking. In one specimen the wear resembles that of grinding using an ineffective coarse-grained sandstone (compare Figure 34, h with exp. 2515-A), resulting in ploughed polish interspaced with early stage weak wood traces. This invariably alters the morphology of the bevel by shaving of a few millimetres, and erases previous traces of wear.

Three analysed specimens were reworked. Edge damage had probably become too substantial to allow resharpening, which led to the repair of suitable fragments by removal of the original blade followed up by the pecking of blunt facets. This results in conical hammers/pounders/pestles characterised by a flat, generally multi-faceted frontal aspect (Figure 35). Subsequent use wear

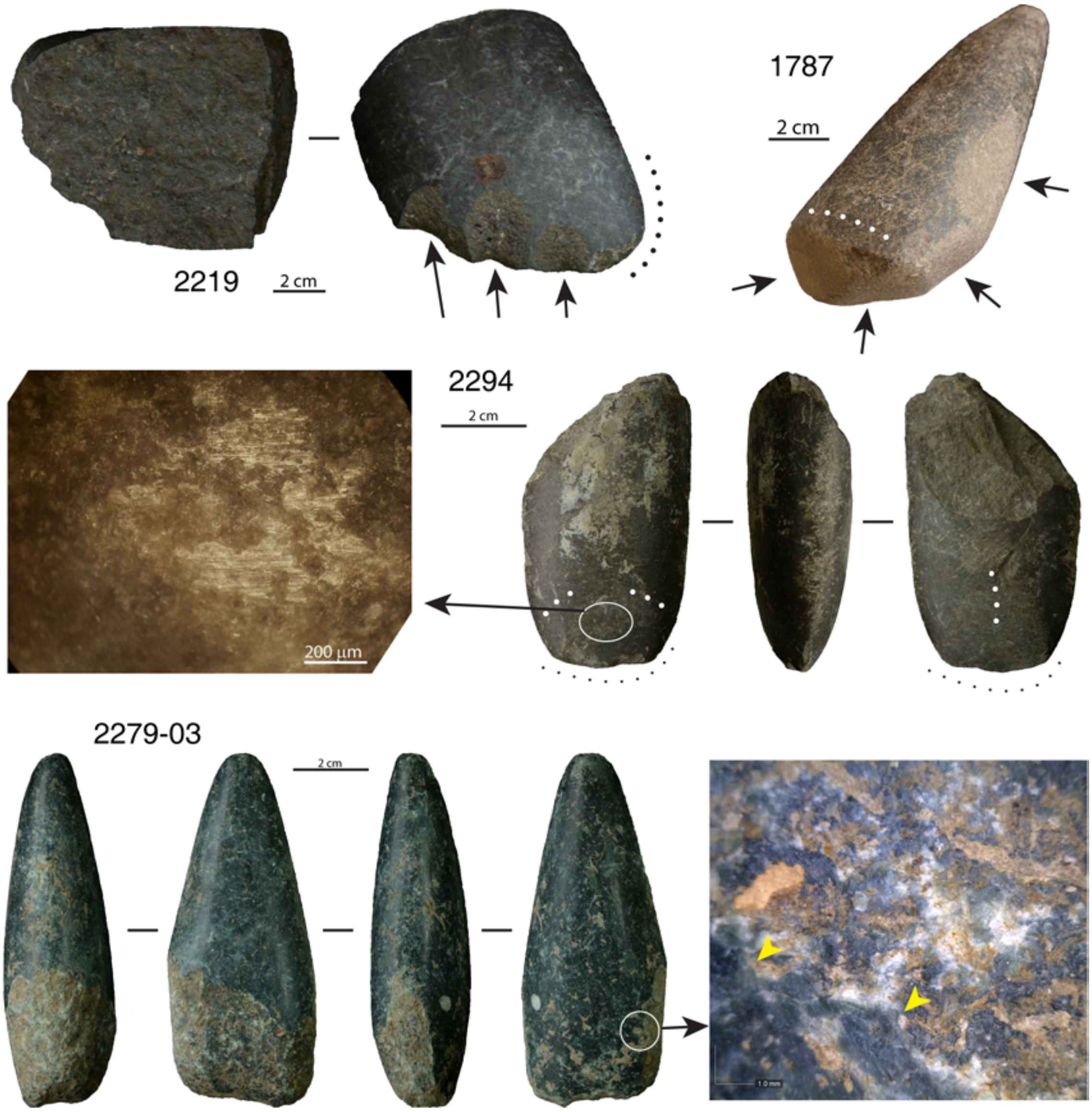

Figure 35: Resharpening activities in El Flaco through flaking on greenschist 2219 and abrasion on greenschist 2294, and reworking of metamorphic 1787 and overprinted 2279-03. Dots indicate relation to hold-over and newer use wear, and yellow arrows where the ground surface is interrupted by reworking scars.

from pounding consists of rounding of the asperities, but working distance limitations in the field unfortunately inhibited high magnification analysis. Two out of three, where the technique resulted in a fine pecked topography, also retained use wear on the proximal face and side aspects from prior use as celts. In 2279-03 this was not evident.

7.2.6 Depositional context

The spatial context of the materials from the 2013-2015 collections indicates that they entered the archaeological record as sweeping refuse. Upon abandonment in the domestic space, they were at a later point removed during the cleaning of the house and swept into the site formation context (Section 6.1.2). This pattern appears fairly widespread in Late Ceramic Age habitation in the Greater Antilles (Samson 2010; Siegel 1992), and occurs indiscriminately of the type of material culture (cf. Section 9.1). What has yet to be established is through what process these celts were abandoned prior to having been swept out of the house.

The primary insight is not only that the assemblage is significantly fragmented, but moreover that the useful edges are almost completely exhausted. Of the 21 blades that could be examined for stereoscopic wear, five were completely destroyed (no bevel remained) and twelve more strongly dulled with heavy use retouch or the complete mangling of the edge (no edge remained). Only four edges were sharp, two of which were themselves flakes detached from the edge upon impact (unintentional or as rejuvenation) and the other whole-body breaks that equally rendered the fragments useless. Nearly all of the unusable edges also contain this type of breakage, where a sideway impact splits the medial area. The majority of fragments would appear to demand extensive repair, if not simply beyond salvaging, in addition to the common use-related breakage around the area of the haft (whether closer to the proximal or to the distal aspect).

There is good evidence for repair and reworking in the assemblage, indicating that simple breakage during use did not necessarily entail direct discarding. Small unifacial edge flakes with a percussion bulb on the edge may result from unintentional breakage during use, or may represent rejuvenation flakes. Either option is possible. Both sharp-edged and dull-edged flakes were present, but the former may have originated with an active edge deformed by retouch and so do not provide a means of distinguishing the two. The two specimens that were discarded during a resharpening episode had accidentally broken the bevel in it, which lends further credence to this idea.

Those two specimens also carry near-straight fractures across the transverse plane in the medial zone, as do many others in the assemblage. These breaks are most commonly bending-initiated or compressive fractures with straight or characteristic slightly curvaceous profiles. Fairly even microtopographies evidence fluid trajectories of the forces, sometimes with sideways rippling. In schistose specimens the fracture often results in more irregular patterns. Such transverse medial

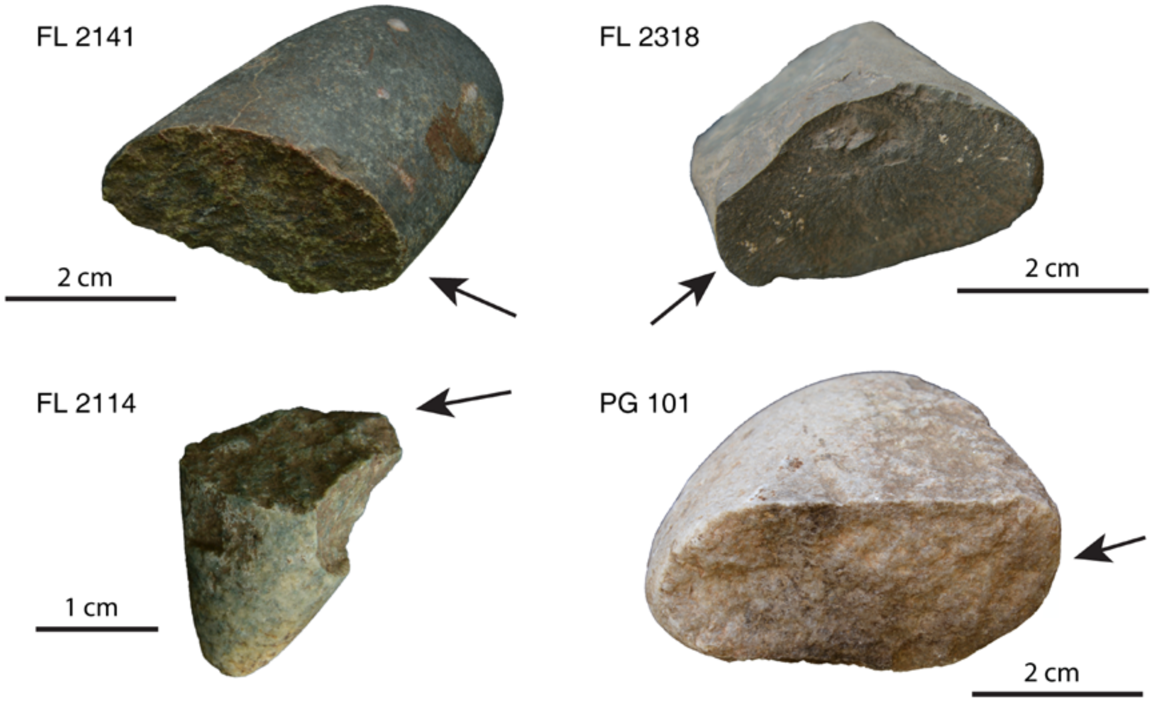

Figure 36: Fractures across the transverse plane between the proximal-medial and medial-distal zones on butt fragment FL 2114, edge-medial fragments FL 2241 and 2318, as well as blade fragment PG 101 from Playa Grande.

fractures are associated with the isotropic breakage of the artefact on or near the articulation with the hafting arrangement during active use (e.g. Olausson 1982/1983; Rostain 1994, 366). They are seen on the majority of specimens from El Flaco, including large medial fragments with both the butt and the edge missing (Figure 36). Furthermore, some specimens bear possible impact scars (crushed grains) located on the bilateral sides, and others indicate a transversal direction of force through smooth initiations and terminations (cf. Figure 36, d). These traces suggest another cause of transversal breakage, supported by the occurrence of such fractures on celts with completely exhausted edges or medial fragments with two breakage planes. Since these celts were already rendered inoperable the transverse fractures are unlikely to be related to natural use/haft fracturing. An alternative is the practice of intentional destruction, which will be more fully discussed in Chapter 8.

7.3 Playa Grande

The analysed assemblage from Playa Grande counts 160 specimens. It consists of a mixture of discarded production cores (primarily roughouts) and fragments exhausted after use, with few pieces of debitage, indeterminate objects, and intact celts present. For high-pressure rocks the entire biography is represented in the assemblage, whereas for other rock types this is generally not the case. As a result, and especially concerning the stage of early reduction, the data for high-pressure rock materials take centre-stage. This helps in addressing the dynamics of the production process, in which usually linear sequences are sometimes reversed (abrasion preceding shaping) and certain other processes flow into one another (various degrees of hammering and pecking).

The majority of materials (nrs 009-154) were analysed in the field and are subject to the relevant limitations (Section 4.1). As a result, the associated documentation for microwear from manufacturing and use activities restrains the average inferential resolution of these biographical phases.

7.3.1 Materials and procurement strategies

The general division of rock types between the analysed sample is provided in Figure 37. High-pressure metamorphic rocks comprise nearly two-thirds of the assemblage, including identified jadeitite and blueschist. A sizeable number of rocks with high-pressure characteristics were not definitely assigned to these groups. Furthermore, the assemblage contains lower numbers of typical greenschist rocks, metamorphic rocks with low-grade characteristics, as well as a few rocks of other types or uncertain lithology. Apart from most of the jadeitite celts, which had been petrologically sorted from the assemblage before, systematic examinations were lacking. The basic division in the present groups was therefore obtained in reference to petrologically examined rocks from other archaeological contexts.

High-pressure rocks

Jadeitite and jadeite-bearing rocks comprise 29% of the analysed assemblage (*n*=46), slightly below the number of 36% for the complete inventory (Knippenberg 2012). Speich and Hertwig (in Hertwig 2014, 143-147) describe six specimens as mainly granoblastic with coarse to fine graininess and usually subhedral to anhedral minerals, but sometimes displaying fibrous mineral forms or weak foliation. The present assemblage also contains this textural variation. Regarding their colours, about half have pale green to slightly yellowish variations. The remaining pieces incorporate some bluish colours therein, ranging from a tinge to a mottle. Macroscopically distinct accessories are

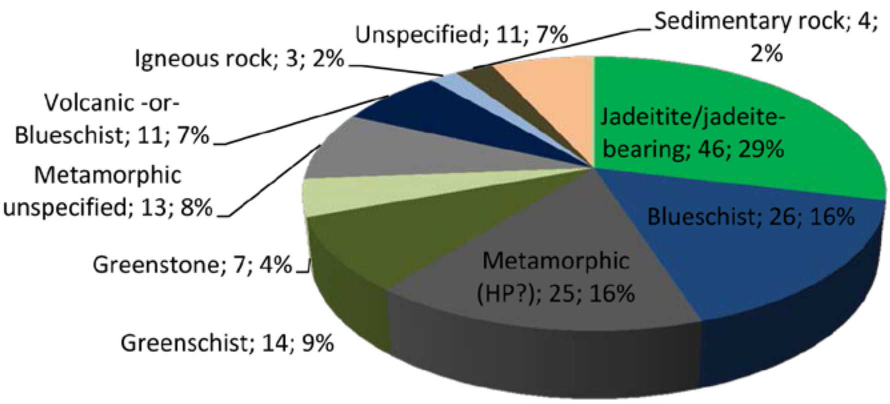

Figure 37: Overview of raw materials from Playa Grande.

sometimes present and include micaceous minerals, large blue minerals (glaucophane), and darker green minerals (omphacite). One jadeite-bearing specimen (PG 118) stood out as a visually distinct darker green and may perhaps be more omphacitic in nature. Published petrographic, mineralogical, and geochemical characterisations of specimens from Playa Grande indicate consistency with the Río San Juan Complex (RSJC) as a source area on all accounts, and a selection preference for the quartz-free suite (Hertwig 2014, 53; Schertl *et al.* 2018).

Identified blueschists comprise 16% of the assemblage (*n*=26), but the percentage of non-identifeid blueschists is probably larger than for other rock types given my initial unfamiliarity with the rock. Most have clearly foliated fabrics composed of glaucophane with partially to fully formed crystal habits, and varying grain sizes. The colours are correspondingly dark blue, with a green mottle in a few specimens (indicating accessory omphacite, jadeite, or epidote). A sub-group of 12 blueschists include white-coloured minerals in veins or mottles intersecting the dark blue glaucophane matrix. Some of these are barely affected, but other specimens contain up to 50% of such alteration. This sub-group is not as clearly involved in local manufacturing operations. Blueschist is readily available from the serpentinite mélanges in the RSJC, and further occurs in the various high-pressure terranes in the Greater Antilles (Section 2.1). There are currently no easy criteria for distinguishing the various outcrops, however (cf. Schertl *et al.* 2018).

The third group consists of metamorphic rocks with high-pressure characteristics that were not further specified (*n*=25). Most share characteristics in fabric, texture, and recognised minerals with the blueschist and jadeitite groups, but lacked confidence for a more precise classification. A few members were dominated by pale green minerals, and are potentially also jadeite-bearing rocks. Most contain a mixture of (often acicular) dark blue crystals, and (usually granular) green minerals in various shades. These rocks likely belong to the blueschist facies, but it was not clear how they should be classified further. The remainder consists of blue to nearly black metamorphic rocks with 'block-like' foliation structures, some of which contained micas and another pale grey mottling. These will probably classify as blueschists as well, but the accessories indicated by these colourations indicates uncertainty.

Macroscopically comparable rocks with little foliation were grouped separately as unspecified 'volcanic or blueschist' rocks (*n*=11). Most are similar to the rock groups now classified as blueschists, but were assumed to be a type of volcanic rock in the field given their dark colour and my unfamiliarity with blueschist variation. The biographical data often indicates more affinity with the blueschist and high-pressure rocks than with the low numbers of volcanic rock celts, but the necessary mineralogical details were not recorded at the time.

Low-grade metamorphic, igneous, sedimentary, and unspecified rocks

The greenschists (*n*=14) consist of fine-grained green to dark green rocks with massive to slightly foliated fabrics. Some contain garnets, and closely resemble in their appearance some of the greenschists found both at El Flaco (Section 7.2.1) and El Cabo (Breukel 2015). Seven other greenstones exhibited stronger foliation and green-greyish colours, and are also low-pressure metamorphic rocks probably belonging to the greenschist facies. However, they were less typical of the rocks found at the other sites and thus separated; it is possible one or two are shales instead.

The unspecified metamorphic rocks are diverse in appearance (*n*=13). Colouration ranges from uniformly brown to nearly black in some, while others are lighter or possess blue or darker mottling. Most are massive, rather than foliated, but they differ from the aforementioned rock types in some ways. The group probably contains high-pressure rocks such as omphacitite (PG 070) and low-grade metamorphic rocks with tuff or sedimentary protoliths.

Three igneous rocks have been identified (*n*=3), all fine-grained grey-black mafic rocks. These numbers will probably grow upon better characterisation of the unspecified rocks, but remain percentually very low. The low number of sedimentary rocks present (*n*=4) is more in line with other sites. These are (pale) brown carbonate rocks with varying graininess. The group of unidentified rocks (*n*=11) contains primarily appearances in a mixture of lighter grey, brown, and greenish hues. These were incomparable to the main rock types or not clearly distinguishable from other possible identifications.

Procurement activities

Signs indicating procurement from secondary context are found on pale green jadeitite rocks (*n*=15), jadeite-bearing varieties (7), probable blueschists (*n*=4) and unspecified metamorphic rocks (*n*=3). For the most part these are water-worn surfaces, and alluvial micro-topographies thus characterise roughly half of the jadeite-bearing group. If indeed from the Río San Juan area, as seems likely, the materials could derive from the bed load of the river itself, some of its supplying tributaries, as well as the arroyo Sabana (Knippenberg 2012; Schertl *et al.* 2012). The pebbles in the assemblage are all in the range of 05 to 20 centimetres and have ovoid to elongated shapes insofar as is estimable, though irregularities are common. Based upon the survey findings supplied by Knippenberg (2012), this would indicate procurement from the lower beds where the river-rolled pebbles meet these dimensions.

Natural topographies were distinguished from technologically altered surfaces on the following grounds (Section 4.1.3): since reduction reduces relief, equivalent micro-topographies between the various inclinations of macroscopic undulations indicate a natural origin. High relief in a micro-topography can rule out abrasive manufacturing, while irregular behaviour of the gradient, size, and penetration of the interstices contends with the consistency expected from repeated percussion. Similarly, erosion of the peaks and of randomly exposed mineral cleavage indicates succeeding in situ weathering (Figure 38). Surfaces with recent percussion tend to have fresh and spatially abundant cleavage planes instead, though overlaying wear from later friction (e.g. hafting) complicates the inference.

A notable occurrence amongst these water-worn materials, and a few partially flaked specimens, is that the areas near the (intended) edge were subjected to limited abrasion.[35] These traces show no relation to the grinding and (future) use of such specimens: the ground facets are diminutive, not always mirrored, and lack developed wear from manufacture (Figure 38), while seen as 'edges' they are unfinished and lack wear from use. Most of these artefacts were discarded for the appearance of terminal flaws during early reduction. This phenomenon is interpreted as resulting from short-term abrasive actions intending to manipulate the stone into showing its internal colouration. That way, the colours are consistently brought to attention and textural details obscured by the pale cortical exterior could be made visible. It indicates the appearance of the rock with further grinding and polishing, in order to affirm that the selection criteria inciting its collection were correctly anticipated.

7.3.2 Early reduction

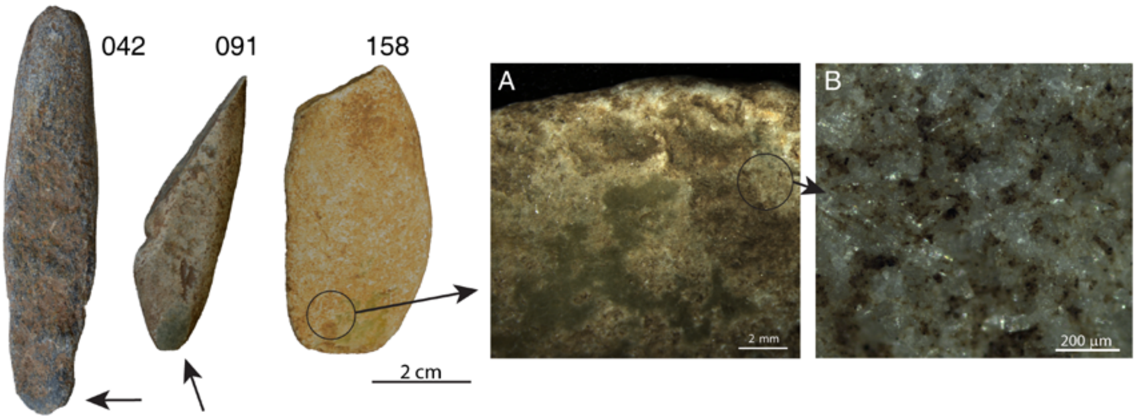

Figure 38: Procurement-related abrasion facets on the intended edges of high-pressure rock blanks. A) close-up of the edge on jadeitite 158. B) naturally worn micro-topography on the same specimen.

Many of the high-pressure rock materials are blanks, roughouts, or preforms, and return detailed information regarding the sequence of operations that led to their current form. A number of different techniques were used in their shaping, some of which are specific to particular raw materials. The situation is different for the other celt materials, in particular low-grade metamorphic rocks, all of which represent completed and exhausted fragments. Such specimens do contribute data, but at a different resolution due to the erasure of traces from previous steps. The results are collated in Table 10 per observation (not per artefact). What shape each technical operation takes and how they interrelate in the operational sequences is detailed below.

High-pressure rocks – flaking activities

The first thing to note is that the sequence of applications for the various flaking and hammering actions shows little standardisation. Different actions and techniques are applied interchangeably, synchronously, or are refrained from. Certain artefacts present a meshwork of motions: limited abrasive manipulation of the edge precedes all other actions, and is first followed by light pecking of

35 This concerns most, but not all, of the specimens considered as thereby finished by (Knippenberg 2012) in his preliminary study. He interpreted these materials as heavily used celts that were only minimally ground as a working compromise against the extreme hardness of the jadeitite, but this argument is not consistent with the microscopic data.

Table 10: Observed reduction techniques and manufacturing steps at Playa Grande. Individual observations only score certain points and therefore consistently underscore the actual prevalence in several categories. The prevalence therefore estimates the consistency with which such techniques would have been observed in an ideal situation (all celts finished and no traces erased, the whole biography laid bare). The totals do not count single artefacts multiple times (e.g., a preform with both coarse and fine pecking traces counts as 1 to the total).

Technique	High-pressure rock materials (97)		Other celt materials (63)	
	Times observed	Prevalence and comments	Times observed	Prevalence and comments
Flaking total	43	Very high	22	High
Cortex removal	*~11*	*Unclear, but probably high*	*3*	*Unassessable*
Bifacial thinning	*Up to 23*	*Medium*	*13*	*High*
Foliation plane splitting	*~11/15*	*Medium (without/with debitage)*	*1*	*Absent (pertains to an unspecified rock)*
Lateral intrusive flaking	-	*Not collated*	-	*Not collated*
Direct percussion	*8*	*Medium-high*	*2*	*Unassessable*
Bipolar percussion	*6*	*Medium-high*	*1*	*Unassessable*
Flaking skipped in the production sequence	*3*	*Very low*	-	*Unassessable*
Hammering – heavy, transverse	40	Very high	17	High
Pecking total	47	High	25	Very high
Coarse pecking	*18*	*Medium to possibly high*	*10*	*Medium*
Fine pecking	*21*	*Medium*	*9*	*Medium*
Unclear/no evidence	17	-	24	Especially for greenschists
Pre-reduction abrasion of the edge	12	Medium-high	1	Absent (pertains to an unspecified rock)
Pecking preceding flaking	10	Low	2	Low
Residue deposits	At least 7*	Unclear	-	-
Debitage	4		1	

*This includes two unspecified metamorphics (both green-coloured production fragments) and excludes residues spatially associated with possible hafting features. It is deemed possible that smaller deposits were originally dismissed during the analysis as 'probable contamination', before this became a consistent observation.

a surface, to shape the outline of primarily the edge area. These activities are only then overlain by flake scars from bifacial thinning and shaping of the sides through hammering. The order in which manufacturing processes appear for individual artefacts is preserved in Appendix 3. This section illustrates the innate dynamics constituted by individual decisions in and negotiations with working the materials.

Starting from the selection of pebbles approximating the intended length and elongation, the first procedure on average will be bifacial shaping through direct flaking. This procurement strategy largely precludes the need for significant initial flaking (*sensu* Inizan *et al.* 1999, 151), and reduction of the bifacial thickness is partially accomplished by simple cortex removal flaking. The evidence usually consists of shallow, non-overlapping flakes oriented along the long axis, often showing feather terminations and sometimes conchoidal outlines. Most edges are also worked in this way, and otherwise not subjected to percussion, though overlap with the next technique occurs.

The majority of flaking evidence pertains to bifacial thinning. Here, large step fracture scars in bilateral direction remove substantial volume, and in smaller specimens may cover the entire face with a single blow (Figure 39, 011, 124). Compared to the smaller cortex removals, the size and step termination of the scars indicate a switch to larger hammerstones and higher application of force. Both bipolar and direct percussion appear to have been used, in rare cases concurrently (Figure 39, 140). The necessary indicators for identification usually lack, however. Bipolar percussion is evidenced more often, through flake scars with step or irregular terminations opposed by another scar, frequently accompanied by localised impact crushing from the counterblow of the anvil. Alternation between percussion techniques was possibly more common, and dependent upon what was felt to be the best next step to work the material. Six specimens were rejected at this stage, after deep thinning flakes removed critical mass from (for instance) the edge.

The bifacial equilibrium plane of blueschist rocks was often aligned with the foliation plane of the rock, to take advantage of its fissile behaviour. Accordingly, when using direct or bipolar percussion (probably more so the latter) the rock splits along this plane producing an even, uninterrupted scar negative that extends over the full face of either surface (Figure 39, 004). At least twelve specimens show fairly good indications that this was how they were shaped, the scars being large, flat, uninterrupted, and aligned with the foliation in the rock. This technique has been described for blueschists in Alpine axe production context (Pétrequin *et al.* 2008; 2012a), though it has not been experimentally verified with RSJC blueschist yet. Several more glaucophane rocks displayed rectilinear sections parallel to the face with even, uninterrupted scars, but were not considered as split since these rocks lacked clear foliation.[36] The tools and technological environment for this strategy likely remain the same as for regular flake reduction. Nevertheless, it indicates a measure of skill and experience in working schistose rocks, knowing how to adapt the motions and gestures to rocks with different behaviours which lead to advantageous technical outcomes.

The assemblage contains barely any debitage from these activities. Knippenberg (2012) concluded therefore that the celts were initially manufactured without a flaking stage, also since conchoidal ripples and bulbs of percussion are infrequent in the scars discussed. I encountered only three large blueschist foliation split fragments, a smaller fourth of unclear lithology, and a large fragment possibly intended as cortex removal flake. It is unclear what this absence reflects. One small rectilinear adze (PG 084) was made from a thinning flake, but reworking cannot explain away the smaller debitage (all other celts were core tools). Some celts were immediately rejected upon manufacturing flaws, indicating that not all flaking occurred off-site. It is possible that concentrated activity areas were poorly sampled, but the issue, and with it the location of the initial reduction process, remains ultimately unresolved.

High-pressure rocks – hammering and pecking

The bifacial outline is shaped through repeated blows with a heavy and/or large hammerstone applied laterally to the bilateral sides, inducing fatigue crushing and the transversal transmission of force. The gesture results in a heavily impacted side morphology with crushed mineral clusters, frequent coarse cratering, and occasional minor cracking (Figure 39, 011, 072). Small to medium hinge terminationss grade into small flake scars on the faces, which are probably analogous to the 'lateral intrusive flaking'

36 This includes rocks in the 'blueschist or volcanic' category, which are otherwise discussed with the other rocks.

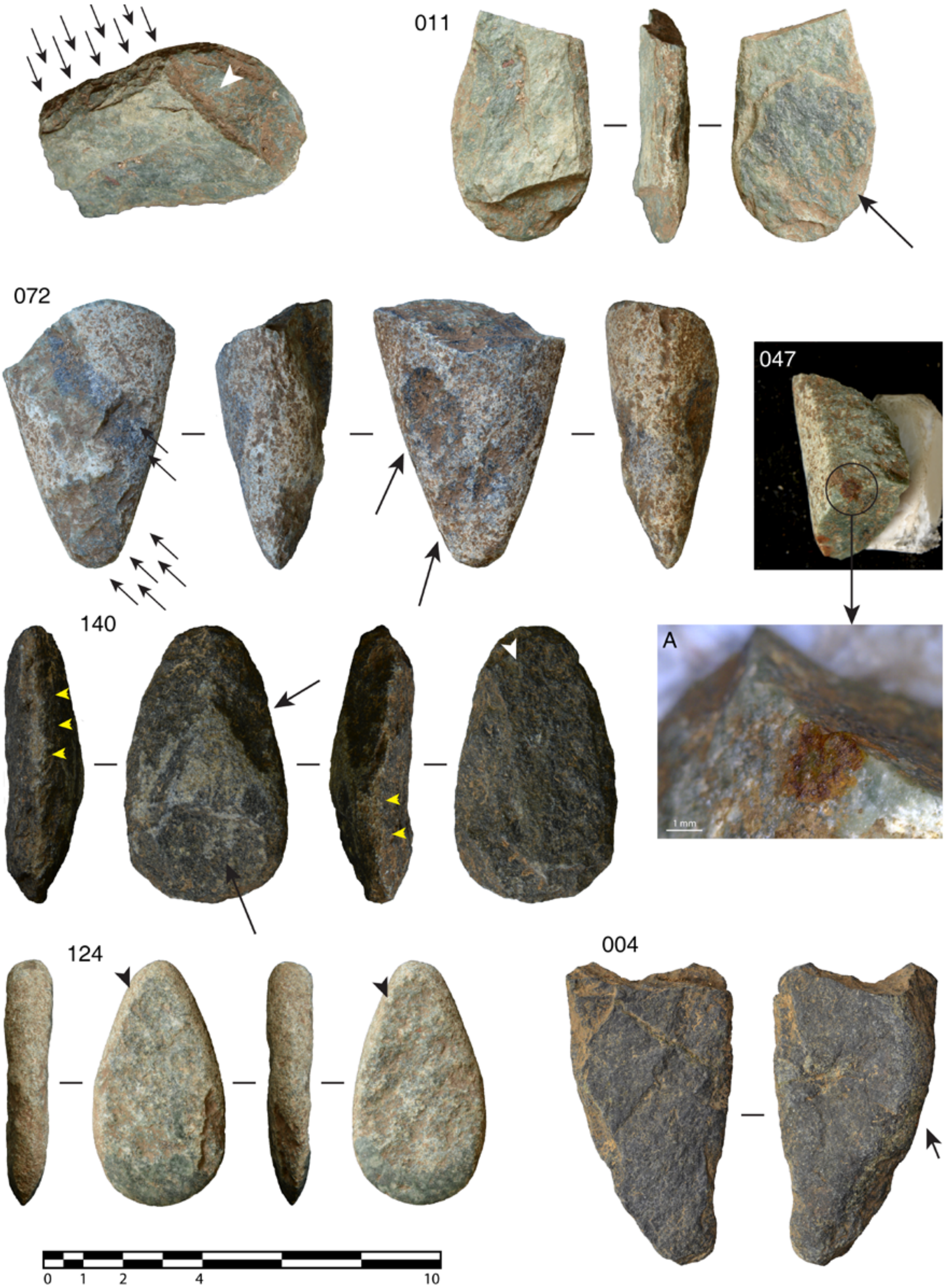

Figure 39: Manufacturing traces in Playa Grande. Jadeite-bearing PG 011 displays hammering hinges on the sides (arrow row) interrupted by an edge thinning mistake (white arrowhead). Single negative scar surfaces from bifacial thinning are visible on it (black arrow) and high-pressure PG 124 (arrowheads). Blueschist PG 140 shows evidence of shaping through feather terminated thinning scars (black arrows) removing a previously pecked surface and counterblow stigma (yellow arrowheads) opposing a debilitating bipolar initiation from the lateral angle. The dorsal face also consists of a single flat scar negative (white arrow) and may be split from a foliation plane. Glaucophane-veined jadeitite PG 072 displays a

coarse pecked topography amidst invasive hinges from hammering on the sides (arrow rows) and thinning scars from percussion (black arrows). Blueschist PG 004 is a flat foliation split plane with slight irregularities on blueschist, note also platform preparation through pecking (arrow). Jadeitite PG 047 carries treated resinuous residue, with a stereophotographic close-up in A.

of Rodríguez Ramos (2010a). This percussive activity is presently distinguished as 'hammering of the sides'. Its traces are most pronounced where the body is thickest, and taper off sharply near to the edge so as to avoid damaging its shape. Nevertheless, the majority of production flaws are associated with this phase, primarily as a result of force travelling across weaknesses in the rock resulting in more invasive hinges that damage the shape or edge. The resulting stigma are rarely erased by subsequent percussive and abrasive work, which contributes to the high observed prevalence of this hammering activity in the assemblage. This also indicates that the majority of celts flowing out of Playa Grande retain their smooth curved side morphology at that point, and are not related to the circulation of specimens with more angular shapes.

Though the flake negatives produced during the hammering of the sides do not form a real continuum with the scars from bifacial thinning, it is sometimes difficult to interpret which result was intended. The difference may rest primarily in alternating gestures and force directions. The techniques appear to have been interchangeable in practice for correcting earlier mistakes and preparing further stages of reduction.

Once hinges disappear and macro-topographical cratering lessens the impact traces are designated as (rougher) pecking, signifying a decrease in hammering intensity. The intent is clearly towards more precision in grain crushing to achieve a more homogeneous topography (Figure 39, 072), likely accompanied by a switch from large to medium-sized hammerstones to inhibit most of the chipping and cracking. Subsequent fine pecking is the principal final step, presumably using still lighter or softer hammers to smoothly even topographies by the crushing of individual grains to level. Out of 31 instances in Table 10, it is evidenced 22 times through holdover traces on mediodistal side aspects. However, traces of pecking form a continuous spectrum in the assemblage of Playa Grande. There is a fair degree of variation in the size and frequency of the cratering, indicating individual variance in the intensity of percussion and probably tool selection as well. Coarse pecking marks are often directly overlain by abrasive modification, and there are many instances in which (medium) pecking marks clearly averaged in between the ends of the spectrum. A regular observation is remnant pitting from pecking within ground surfaces, indicating they were well prepared in advance. These traces may even indicate a chain of repecking and regrinding to speed up the abrasive process on tougher rocks, drawing also abrasive processes within the dynamics of reduction seen here. It is unclear at this point how to distinguish the two alternatives, though.

Other

A recurrent observation in Playa Grande concerns the presence of treated resinuous compounds (see Section 7.2.4) on artefacts discarded during the early reduction process (Table 10). These are located at random, sometimes close to breaks, and are not in association with hafting zones or any further biographical progression (Figure 39, 047). Out of the several options that may account for this occurrence, the most likely candidates are interactions with resin processing at the site and/or fastening for stability during manufacture.[37] However, neither taphonomy nor contamination can be ruled out.

37 The options range from taphonomy to deviant biographical possibilities. It may turn out to be present

This underlines the urgency for identifying the exact nature of these residues, and if consistent with an anthropogenic origin, for further investigation of cultural activities at Playa Grande.

Low-grade metamorphic, igneous, sedimentary, and unspecified rocks

As stated, the evidence for reduction sequences in other types of rocks is meagre, and there are no roughouts or preforms present in identified materials. Though the sets of traces originate with the same types of production activities, there is no evidence that these rock types were manufactured into celts by the Playa Grande community. Over one-third failed to return clear indications of early reduction processes, most of which are greenschists and greenstones. These rock types otherwise carry few leftover thinning scars (n=3), scars from hammering of the sides (n=1), and holdover pecking marks (n=5). The situation is similar for the igneous, sedimentary, and unspecified groups, all of which are finished specimens. Some members from the unspecified metamorphic rock group and the 'blueschist or volcanic' group are roughouts, however, and therefore possibly mistaken high-pressure rock types. Discounting those, all of the finished celts display remnants of bifacial thinning, hammering of the sides, and pecking, with a bit more variation in the flaking procedures, spread of pecking intensity, and successive refinement than was the case previously.

7.3.3 Abrasive manufacturing

Abrasive manufacturing techniques are identified on 90 specimens, little over half the assemblage at 56%, and remained unclear on two additional surfaces. The variation is substantial, even within broader categories (Table 11), and is inferentially problematic due to the increased diversity of rock types. There are only few hafted or used specimens lacking abrasive modification (except for PG 089 presumably due to fragmentation). Counted separately are 13 specimens with brief abrasion on the intended edge to give an appraisal of the texture of the resulting surface. The spatial distribution is similar as before: the focus is towards abrading bevels and faces up to the medial zone, with the sides and distal areas periodically ignored. Though the frequency of previous pecking was scored as high (Table 10), the abrading of especially foliation splitting scars was often not preceded by such preparations. In such cases, the topographical lows remain unaffected as only the higher ridges are flattened.

*Dull lustres (*n*=41, 44.1%)*

Seven surfaces resemble the well levelled and weakly scintillating experimental topographies obtained by dry grinding on quartz arenite, or brighter scintillating in the case of jadeitite. Not all artefacts

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from natural excretion, in which case it may be an occurrence local to Playa Grande's environment (1a) or one that is more widely spread (1b). In this case the range of its natural occurrence will determine whether or not the observations can be relied upon as cultural, rather than taphonomic, though it does not exclude the compound from having been utilised for adhesives regardless.
If it is a culturally produced compound, its association with the objects could still be unrelated to their biography as celts. Corresponding explanations may entail accidental spillage during the production of the compound (2a), facilitated by the spread of the celt materials across domestic floor layers at the site, or the expedient re-use of debitage fragments during resin processing (2b). Such possibilities are difficult to address further from the celt materials alone.
Thirdly, the residues may be objectively associated with the celt biographies, in which case it is moot whether the compound is pristine or has undergone processing. This leaves as prospects the fastening of blanks to an anvil for stability during manufacture (3a), or the adhesion of other materials to roughouts either before or after surface treatment for purposes not related to technofunctional considerations (3b).

Table 11: Trace signatures of abrasive manufacture categories in Playa Grande.

***n*=93**	**Dull**					**Intermediate**			**Bright**			**Unsp.**	**Absent**	**Multiple**
	Dry ground	Intermediate	Sand-ground	Specified different	Unspecified	Cf. 2782	Specified different	unspecified	Wet ground specified	Wet ground unspecified	Mirror	Unspecified	(edge optional)	
Igneous rocks							1					1		
Other/unspecified rocks	1	4			1	1			1	3		6		
Low-grade/unspecified metamorphic rocks	2	6	5	1	2		3		4	5		1		
Other high-grade rocks			2	2	3	3	2	1	4	7		5	3	1
Jadeite-bearing rocks	4	1	3	2	2	2			2	1	1		2	1
Total	7	11	10	5	8	6	6	1	11	16	1	13	5	2

match entirely the even relief or fine striation patterns from these experiments. However, on the whole they do fall within the 'traceless' signature of dry grinding against a lithic platform.

The range of trace patterns encompassed by the 'sand-ground' signature is found on ten, half of which are greenschists (Table 11). These all possess a moderately level topography with persisting micro-relief, which is rounded and characterised by a rough, medium-bright scintillation with little to no polish formation. Nevertheless, there is quite some variation in the brightness of the scintillation, the retention of said relief, and the configuration of the striations. For instance, the micro-topography of jadeitites is brighter (Figure 40, a), but best included here (below). This probably results from minor differences in fabric properties of the grinding platforms inasmuch as the characteristics of the celts in question. However, the general interaction of intermediate grains under load appears to define even acicular matrices equally.

There is a group of eleven surfaces with wear trace patterns deemed intermediate to dry grinding and 'sand-ground' characteristics. Essentially, these microtopographies display more relief and stronger scintillation than the dry grinding experimental results, but are duller and less rounded than the experiments with intermediate particles. Striations continue to vary, but are on average denser as well. The data are strongly biased towards low-grade metamorphic rocks, and lack verified high-pressure rock materials (Table 11). Presumably, this reflects inferential imitations in the characterisation of wear trace patterns on high-pressure rock surfaces by reference to experimental surfaces from other raw materials. Since the dry grinding experiment with jadeitite resulted in a much brighter scintillation (exp. 3797), it is conceivable that jadeite surface topographies are somewhat misrepresented at present, and that equifinal wear trace signatures do not necessarily represent equivalent initial techniques for different rock materials. Further experiments are needed to assess how this differentiation plays out and to what degree unforeseen technological possibilities take part in them.

Five artefacts display dull lustred surfaces adhering to the baseline of scintillation with micro-relief, which are distinguished due to incipient development of polish. Scattered and sparse, these structures are generally small, rough, bright, and weakly linked (Figure 40, b). Striations are mostly absent, except for stereoscopic gouges on sides and on the blueschists. Some specimens may reflect a particularly efficient grinding platform in dry conditions, similar to exp. 2512 (basalt on quartz

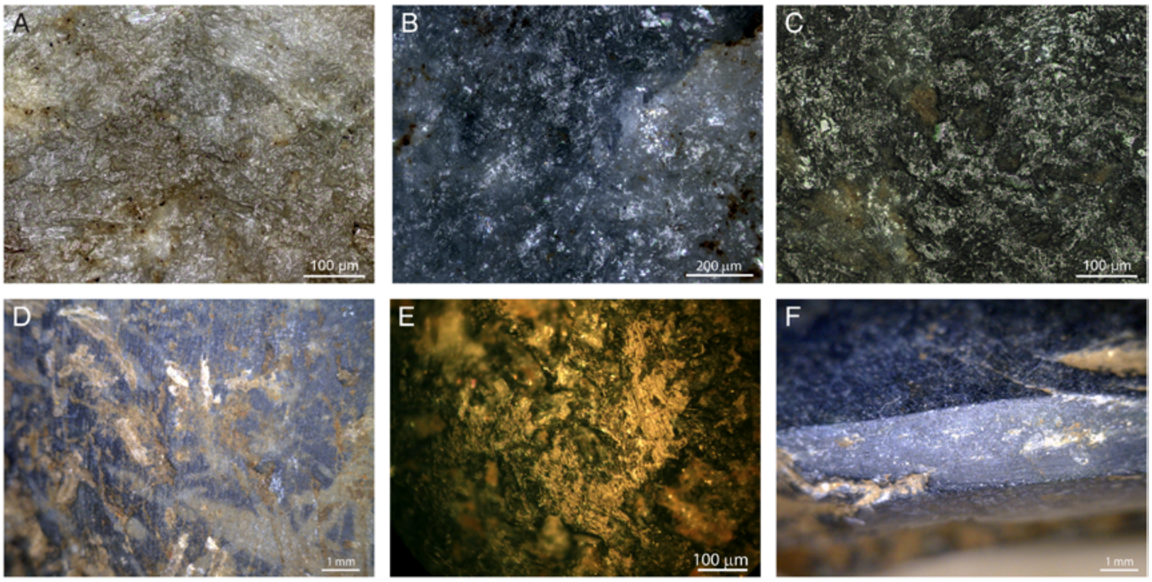

Figure 40: Wear from abrasive manufacturing in Playa Grande. A) 'sand-ground' polish on jadeitite PG 006. B) scintillating surface with best possible extent of scattered stone polish on jadeitite PG 001. C) dull, flat, rough, and striated polish on blueschist PG 161 with light overlay of wood friction traces. D) deeper gouges from intermediate grinding on greenschist PG 019. E) unspecified wet grinding trace polish on blueschist-like PG 105. F) blunting of the edge on 'volcanic or blueschist' PG 147.

arenite), though greenschist was already seen to interact differently under that set-up. The artefacts are overall well levelled, connoting efficient abrasive interactions, but in light of mineralogical differences inferences to the resolution of specific techniques are premature.

The remaining artefacts ground using a dull lustre-inducing technique remain unspecified. Additional variation in wear patterns is noted for some, such as deeply gouged topographies or bands of striations, but they were not well comparable to the aforementioned groups. Others lack such descriptions, partially lacking distinct traces and partially the result of field limitations. While differences in the utilised platforms are likely, the aforementioned inferential caution stands.

*Intermediate lustres (*n=*13, 14%)*

A number of specimens displayed matt or diffuse lustres, corresponding to the development of micro-polish. These are best categorised as intermediate to the heuristic categories of dull and bright lustres. The main group herein consists of fairly well levelled, scintillating topographies that developed concentrations of dull, flat, rough, and striated polish (Figure 40, c). The size and interlinkage of polish structures may fluctuate somewhat, as does the degree of scratching, but the results nevertheless match well with the experimental topographies of 2782 and 2513 (Section 5.2). The traces appear on six celts, all blade fragments made from high-pressure rock types. Following the experimental comparison, these were likely ground using hard, fine-grained, cohesive sandstones of comparable mechanical properties. Such tool materials are present at the site, and suggest the artefacts in question were fully made at Playa Grande. Additionally, the traces seen on a few blueschists with brighter lustres can also be characterised as such, but these are ultimately regarded as unspecified due to inferential limitations with acicular matrices.

Otherwise, there are several other specimens that, despite well developed polish on the micro-topography, nevertheless fail to reach a characteristic macroscopic brightness. Two greenschist celts displayed well developed, rough polish characteristic of contact with lithic materials superimposed over a brightly scintillating topography. Striations are dense on the sides of the corresponding artefacts (Figure 40, d). Another signature corresponds to the heavily gouged topography of exp. 2515-A, with corresponding ploughing of the bright polish (see Appendix 1). These wear trace signatures are distinguishable as different from each other and appear to correspond to technical variations, whether in the properties of the lithic platform, additives, or other variables. They are seen to occur independently from the types of celt materials, though that is by itself no evidence that the initial conditions were otherwise equival. However, it must be noted that the high amount of striations and poor levelling implies that some of these wear trace signatures reflect rather inefficient platforms for the task at hand (cf. Section 5.2).

*Bright lustres (*n*=28, 30.1%)*

Section 7.2.3 defined several unreplicated abrasive techniques resulting in bright lustres on the basis of observed characteristics and patterns of wear. These descriptions remain useful here, in order to separate out distinct technical environments from ground and polished surfaces. Four specimens displayed dense developments of bright to very bright, well connected, rough and flat polish on a level microtopography, lacking striations altogether (wet stone variant 1a and 1b). Wet stone variants 2 and 3 characterise one high-pressure specimen each (cf. Section 7.2.3). Since the rock types are different, it is probable that also the techniques used are not equival to those of the specimens from El Flaco. Nevertheless, the separation of each 'variant' in Playa Grande reflects the application of distinct techniques in the assemblage, and implies further complexity into indigenous choices of grinding and polishing platforms.

An additional five specimens display metallic lustres that microscopically match the experimental topographies of wet grinding on quartz arenite. Some of these exceed the experimental intensity, and further variation rests in striations on the sides or in the polish structures. Additionally, three blueschists match the wear trace signature from in particular the experiment with basalt (2513), but are classified as 'unspecified' for inferential limitations at this level of resolution. Several of the other 'unspecified' materials can be reasonably well described (Figure 40, e), but the wear trace patterns do not stand out as distinct or comparable against the other archaeological and experimental data. There are differences between the intensity and nature of the lustres of each, and probably variation in the properties of both tool rocks and celt materials that account for the observed differences. All, however, are broadly consistent with wet grinding on a competent lithic platform lacking added intermediate abrasives for combined surface material removal and production of gloss.

One jadeite-bearing celt of rectilinear morphology displayed a metallic lustre, corresponding to 'bright mineral mirror polish' on the bevel. The polish was exceptionally well developed, being very bright, perfectly flat, and lacking pitting except where this pertains to interstitial space. Certain accessory minerals retained a rougher texture and some striations, however. The specimen lacked traces indicating other abrasive or use activities.

Other

The remaining specimens are classified as indeterminate, largely due to lithological disparities (carbonaceous rocks or acicular blueschists) or complete overlay by later wear. While abrasive contact was evident, it was not possible to establish the relation of these activities with the techniques described above.

Other abrasive contacts in the biography consist of the aforementioned manipulation of bevel areas during procurement. The observed wear trace patterns are highly variable, but understood as representing only a brief moment of contact and therefore not developed enough to be indicative of particular techniques. It is probable that these actions took place during procurement, and that nearby rocks in the river bed were simply utilised with little regard for reductive efficiency or end-lustres.

These observations clearly differ for the four specimens that were abraded only on their bevel and used in that state. The prevalence of this activity may be higher than indicated, since only artefacts with intact bevels and medial zones displaying both use wear and hafting traces were included in this count. It is not the dominant operational sequence for high-pressure celts, as Knippenberg (2012) argued, but nevertheless does characterise a handful of materials. Similarly, his observation that celts were reworked into grinder-pounder tools by abrading the edge to a blunt facet (Figure 40, f) is reassessed. Certain specimens (a.o. PG 127) do indicate previous episodes of use, but the majority of artefacts lack interpretable use wear, which suggests they are preforms and invites alternative explanations. One possibility is that it represents an adaptation during manufacture to preserve the integrity of the edge while the bevel is ground, as it minimises the occurrence and impact of 'edge' grains dislocating from the matrix under abrasion.

Finally, there are several instances of whetting of the bevel through a secondary abrasion episode, erasing previous use traces and contrasting the manufacturing signature. This is not very prevalent, but such treatments are no longer distinguishable once the bevel becomes overlain by new wear from use. Whetting activities form the only instances in which multiple abrasive techniques were detected on the analysed specimens. Otherwise, the celts from Playa Grande were abraded using a single technique only, whether dull or brightly lustred. Soft material polishing traces are absent from the assemblage.

7.3.4 Composition of the hafts

There are 72 artefacts with the potential for hafting traces, excluding unfinished materials and adjusted for non-abraded specimens with a biographical life. Of these, 38 returned traces of wear associable with hafting. The resolution of the inferences is rather low, considering the rate of fragmentation. Typical axe and adze arrangements could be distinguished on 14 celts, and three others displayed traces of a different nature. 22 bear traces associable to hafting which could not support a full reconstruction, and 15 more bear traces of uncertain association. The standard wear trace patterns permitting the different inferential levels encompassed here have all been discussed previously and will not be repeated. Additionally, seven celts carried residue in association with a potential hafting zone.

*Axe-style hafts (*n=*6)*

Direct embedded male hafting systems with probable lateral transverse parallel orientation were identified on three (probable) blueschists. As before, these are characterised by the symmetric presence of well developed wood friction on all circumferential aspects, often comparable to the seasoned wood friction experiment. When analysable, use wear traces are also distributed symmetrically between either bevel. One blueschist showed intense development of wood friction previously discussed as 'exceeding' the experimental range on the surviving lateral side, suggesting the insertion of a wooden prop to better fasten the piece.

A direct male split system is indicated on one greenschist by the clearly bounded spatial distribution of the traces. Assuming a few centimetres of butt protrusion, the sheer size of this specimen nevertheless indicates the original hafting system was rather large. Two final specimens displayed increasing intensity of traces from wood friction on the sides compared to the faces, and fall in between the probability patterns for each type of slotting. Both displayed symmetric wear of the edge, indicating lateral transverse parallel orientation.

Adze-style hafts (n=*8)*

Latero-distal, transversal, perpendicular, juxtaposed hafting systems are inferred with certainty for two specimens. Consistent with previous observations, the traces are spatially asymmetric: one face displays clear polish from friction with wood, with the other three aspects showing traces indicative of bindings from softer materials. Such traces appear as well developed, matt to bright, invasive, rough polish that rounds the asperities but does not abrade them (best represented in Figure 41, a-b). One specimen (a non-ground blueschist) was clearly deeply bound into its haft and likely rested against a wooden ridge with its distal end. The second, green-blue metamorphic rock bore exceptionally well developed traces of hafting on the few ground zones, and was supported by adhesive residues on the

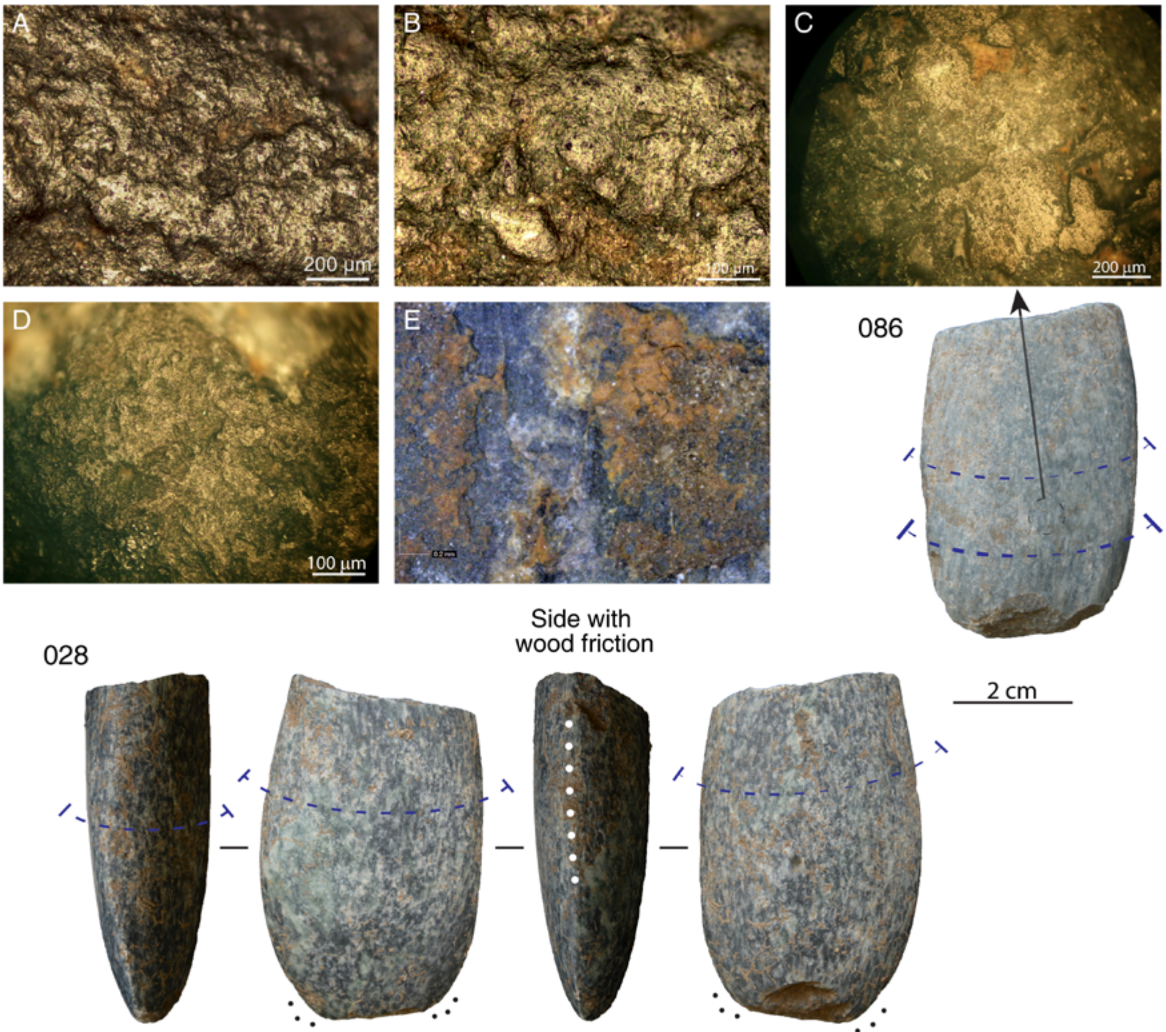

Figure 41: Hafting wear in Playa Grande. A-B) micrographs of wear from contact with plant bindings on greenschist C 1645 equivalent to a.o. PG 025. C) matt rough plantish traces on jadeite-bearing rock PG 086. D) strong developed rough and invasive traces on 'volcanic or blueschist' PG 097. E) Potential pristine resin on greenschist PG 019.

side in contact with the wooden slotting. A third specimen displayed traces of binding that are better described as a matt, greasy polish draped over the topographical relief and abrading it.

Five other specimens are characterised by asymmetrically distributed traces from friction with wood and residues. These were likely also hafted in perpendicular juxtaposed systems, but uncommon alternatives such as poorly fitting male hafts with bindings, or perpendicular indirect fastening, cannot be ruled out entirely. Traces from potential bindings were not seen or deemed interpretable on these, partially due to fragmentation. A high-pressure metamorphic rock displayed well developed traces of binding in combination with residue, but the surface presumed in contact with the wood was heavily damaged; another jadeite-bearing rock carried residue in association with friction traces on the ventral face, but lacked traces of bindings.

Other indications

Two high-pressure rock petaloids, of near identical morphology both originally and as fragments, may have been covered in wrappings while placed in the haft (Figure 41, 028, 086). Both displayed large, invasive polish structures with a matt and greasy to rough texture on both faces and one of the bilateral sides. The rougher variant compares somewhat favourably to the experimental traces obtained through friction with bark (Figure 41, c). The remaining lateral side aspect displays traces indicating wood friction, combined with residue on PG 086. Such patterns could form in a parallel male attachment if originally four-sided wrappings (or an embedded slot crammed with soft material) had worn through. Alternatively, wooden inserts could have been placed to increase the tension of the wrap. None of the ethnohistoric or ethnographic scenarios would produce such patterns (Section 2.3), but the butts are unfortunately missing, preventing a definitive assessment.

PG 097, a petaloid fragment with rectangular cross-section and shallow side notches in the 'volcanic or blueschist' group, was also hafted in a distinct manner. Both faces are characterised by traces from friction with wood and both sides by traces from an abrasive soft material (Figure 41, d), strongly suggesting bindings in combination with the side notches. The butt facet displays removal scars from impact or counterblow. Possibly, the celt was attached in a terminal axial male split arrangement, wedged between wooden spalls around which bindings would hold it in place. Another scenario is rehafting from an embedded male axe into a juxtaposed adze system, in which new wear from bindings would not overlay older wear from the wooden slot (less likely). Ultimately, the arrangement is so forth unique and not well interpretable.

Amongst the remainder of the assemblage, traces of wear indicative of hafting include polish from friction with wood, patination and rounding, and traces indicative of contact with soft-medium plantish materials. Traces leading to an unclear assessment (Appendix 3) include isolated bright spots, inferentially problematic topographies, adaptations such as side notches lacking traces, and distinct but uninterpreted wear in potential hafting zones. Repecking of the sides and other activities manipulating the zone of hafting are rare in the assemblage, but it is common that hafting zones were not abraded in high-pressure materials. Signs such as asymmetric distributions or isolated indications of ligatures are common, they are not accepted as evidence for perpendicular juxtaposition unless co-occurring on preserved morphologies (Section 4.1.3). Indeed, fragmentation is the main reason for the relatively low number of accepted reconstructions at Playa Grande. There are no cases in which the absence of wear from hafting could be convincingly argued to reflect the absence of a hafting arrangement.

*Residues (*n*=12)*

Residues with adhesive connotations in combination with patterns of hafting are rare at Playa Grande, and morphologically varied. They occur commonly on the sides, in which the topographical relief more easily traps and preserves the compounds. In a few cases they occur on face zones, in association with friction from wood.

The heat-treated resinuous compound defined in section 7.2.4 was encountered twice in good spatial association with wear from hafting. However, a correlation remains suspect considering that this residue group occurred frequently for other reasons (not counted here, Section 7.3.2). Instead, three specimens displayed a residue which appears morphologically consistent with a plantish origin and interpreted as a resin, potentially pristine (Langejans and Lombard 2015, 206). The deposits consist of medium to small-sized strands of a light yellow sharp bounded residue with a rust-brownish tinge, viscose texture, and sharp craqueler in one (Figure 41, e). Sediments overlay these resins. A clearer interpretation cannot be given in lieu of laboratory analyses. Three others carried black tarry droplets morphologically identical to the residue described for El Flaco (Figure 32, j-k), though their associations with a haft were never entirely clear due to fragmentation. Finally, one specimens displayed a black, micro-granular residue with sharp boundaries and three others uncharacterised residues.

7.3.5 Use-wear

There are 68 specimens retaining (parts of) the bevel, many of which display traces of use. These patterns could be inferred with some resolution on 41 specimens (Table 12). The division between high-pressure rocks and other rock types is roughly even, probably reflecting that use is the primary biographical phase at Playa Grande for the latter. The comparatively higher percentage of unspecified contact materials reflects interpretative caution with certain lithic materials and field conditions, as well as interference by traces from manufacture. Issues with the wear formation on high-pressure rock materials are considered as well. However, the generally good comparability on other wear trace patterns suggests that the apparent higher concentration of traces from contact with softer materials indicates real differences. There are no specimens at Playa Grande that signal a deliberate non-use as tool by means of otherwise highly developed biographical investments.

Woodworking

Two-thirds of the interpretable traces of wear from use pertain to various forms of woodworking contact, separable along similar lines as before. Five petaloid celts display wear that corresponds well to the experimental results (Section 5.2.2), and therefore indicate the working of fresh wood in the 0.6 to 0.8 g/cm^3 specific density range (probably slightly broader). The high-pressure rock types are all small to medium in size, the others large to very large. Polish structures are rough to near-smooth, bright to very bright, and occasionally greasy. They are abundant, mildly domed, and slightly to somewhat invasive, with the lower topography developing a dull scintillation where this occurs. Pitting and the degree of interconnection vary.

A few other specimens also resembled some variables from single experimental correspondences (most often mahogany), but were ultimately inferred as displaying incipient or unspecified woodworking wear. Incipient traces of woodworking are characterised by rough and dull textured modifications that interlink or reticulate, but have not yet formed connecting spots of polish.

Table 12: Trace signatures of use categories in Playa Grande.

***n*=41**	**Woodworking traces**					**Other use traces**			**Miscellaneous**			
	Incipient	Experimental range	Exceeding	Distinct	Unspecified	Hard/ hard-pliable material	Soft/soft-pliable material	Indistinct	Repurposing	Heavy edge wear	Resharpeing	No wear
Igneous rocks							1				1	
Other/unspecified rocks		1		1	1	1	1	1		5		
Low-grade/unspecified metamorphic rocks		1	1	2	3		3	3	5	3	1	
Other high-grade rocks	1	2	2	1	3	1	2	2	2	7	1	
Jadeite-bearing rocks	2	1			1		3	1	1	3	1	1
Total	3	5	3	4	8	2	10	7	8	18	4	1

Three fragments contain the highly developed traces of woodworking provisionally associated with the working of wood species with higher specific density values. Microtopographical doming is intense and decreases in volume, ranging from relatively small structures to extensive flat plateaus with smooth and very bright polish (Figure 42, a-b). Interconnection varies, invasiveness and pitting are low, and some directionality is present in the form of striations from environmental particles. Some areas display rougher and more invasive polish, which may represent a previous stage of development or palimpsest with somewhat softer wood types. Two of the specimens are blade fragments of medium-large petaloid celts.

Two medium to large-sized greenschist celts display a coherent and well developed wear trace signature which is distinct from the experimental variables, despite corresponding to the generic characteristics of wood friction wear. The polish remains isolated and forms near-smooth, highly pitted domes in spite of the generally low topographic relief (a characteristic example is Figure 42, c). Lower elevations may display a rough and bright scintillation, but it is not always present or distinguishable from wear from 'sand-ground' abrasive manufacture. A celt of undetermined lithology displays wear that falls between this distinct signature and the 'exceeding' morphology, displaying large, well developed spots of a smoother, greasy polish than described. The high-pressure entry in Table 12, woodworking (distinct) displays traces that may result from a more pliable contact, considering the large volume and invasiveness of the polish (Figure 42, d).

Traces from use on softer materials

A significant number of celts display wear traces that do not appear to result from woodworking, or grade from the lower range of wood hardness. Variation within this group ranges from inferred pliable-soft to very soft contact materials, described here though not interpreted further due to a lack of comparative experiments. Most are smaller petaloids and chisels, and there is quite some difference in the wear between them. Some artefacts display wear quite comparable to those seen from hafting ligatures, consisting of a matt, rough, and invasive polish (abrasively) affecting the underlying topographic relief (Figure 42, e). Brightness and invasiveness varies, for instance, such traces are restricted to the upper topography on PG 130, also displaying striations in the polish (Figure 42, f). Conversely, the polish is greasier and not as rough with a much higher degree of microtopographical

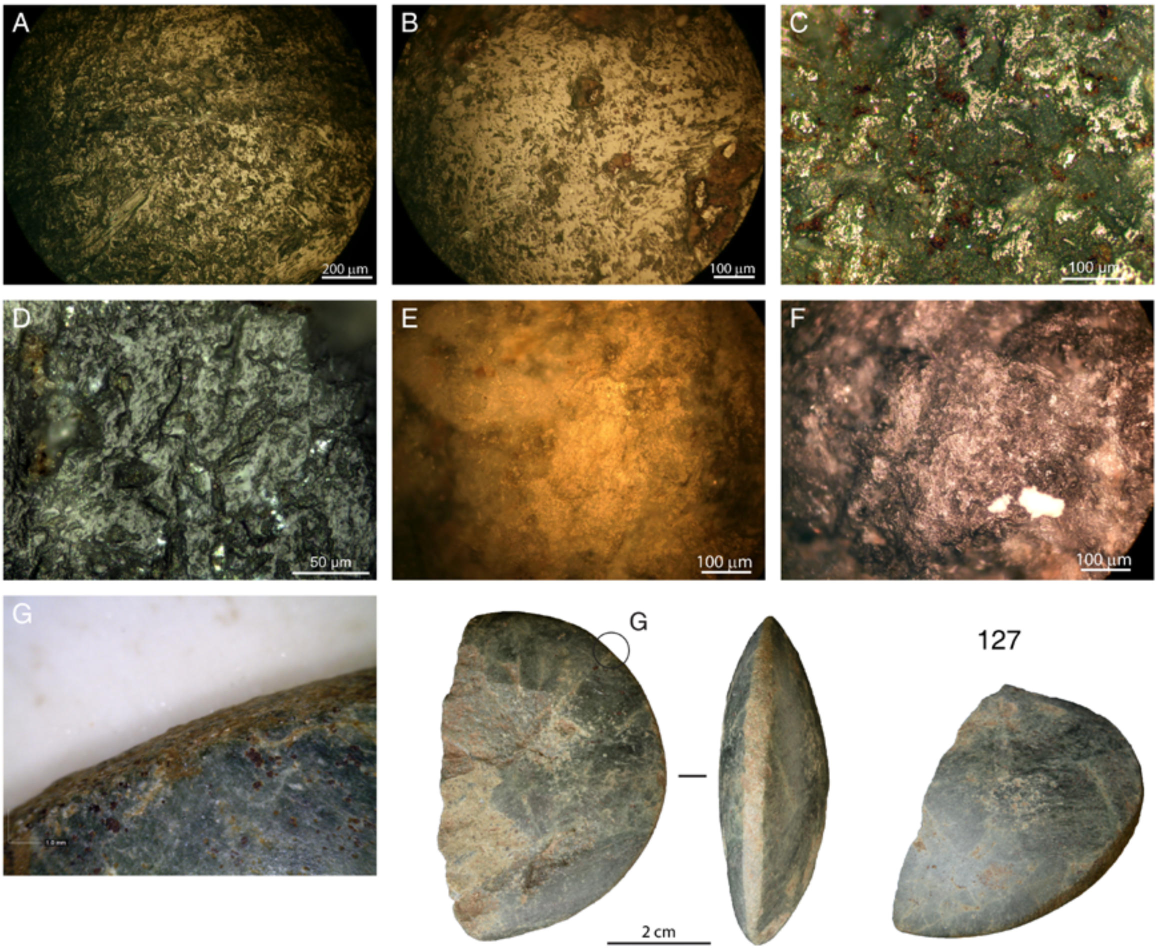

Figure 42: Use wear traces and repurposing in Playa Grande. A) woodworking of exceeding smoothness on high-pressure PG 060; B) woodworking of exceeding intensity on metamorphic PG 127; C) Woodworking, distinct equivalent to greenschist PG 018; this micrograph taken on greenschist C 1313. D) Pliable material (interpreted as woodworking) use wear polish on blueschist PG 161. E) Use wear polish (soft material, animal?) on possible sediment PG 099. F) 'soft material' polish with rough, matt, abrasive, and mildly invasive characteristics on blueschist PG 130. G) Close-up of edge of metamorphic 127 with clear evidence of percussive blunting.

rounding on PG 035. Others display the same invasive, bright, and non-invasive traces from use on soft materials as were previously described at El Flaco (Figure 34, f), combined with severe use retouch. Some of these contacts appear to involve plantish materials, particularly where the polish is more matt, smooth, and affecting the topographical volume. Still, it is impossible to satisfactorily verify such inferences, considering the wide variety of tool materials and lack of a referential basis addressing the corresponding activities.

Other activities

Resharpening is observed through both the application of abrasive techniques and by careful retouching of the edge. Abrasive resharpening is evidenced in two specimens. These display small facets right behind the edge that are characterised by wear from brief grinding, while retaining use wear traces on the bevel further back. Retouching of the edge is evidenced on three celts, all of which apparently discarded due to the procedure opening further fracture planes or inducing fissuring of the lithic mass. This is particularly clear for the greenschist and blueschist objects, which cracked across internal foliation planes. Additionally, there are four edge flakes which are potentially rejuvenation products, though the grounds for making this distinction remain uncertain. The preservation of edges is variable overall, with roughly equal presence of sharp, medium dull, unusable dulled, and completely destroyed rims.

Re-use activities can also be separated into two main groups. Several celts had been repurposed through modification of the edge, either by percussive roughening or abrasive faceting (Figure 40, f; Figure 42, g). Unlike at the other sites, the bevels retain petaloid morphologies. However, traces of wear from use from hypothetical prior edge-ground usage were not observed on most, so that the interpretation of reworked celts remains somewhat elusive. It may also connote a purpose in (re) sharpening processes instead.

The re-use of rejected high-pressure rock fragments as hammerstones may be argued for PG 010, a blank of which the edge displays crushing impacts, but was not equivocal for other specimens. Though originally considered common at the site *(*Knippenberg (2012), this probably referred to the wear patterns presently interpreted as associated with manufacture. Such re-use would make perfect sense considering the extreme suitability of hard and tenacious jadeitite pebbles for the percussion of high-pressure rock types (cf. Pétrequin *et al.* 2012a). Nevertheless, there was only a single case where re-use as hammerstone was biographically evident for a production fragment at Playa Grande.

Finally, the blade of a large-sized greenschist petaloid (PG 063) had been flaked from the distal direction and the resulting edge given semi-abrupt backing. This configuration allows the object to fit in hand easily, although no clear subsequent wear had been observed.

7.3.6 Depositional context

The depositional context of the materials is not well recorded for individual artefacts. Most seem to derive from layers comprising waste lenses or secondary landfills, overlaying earlier house floors. The stratigraphic reliability was discussed in section 6.1.3. Fragmentation is rife within the assemblage, and many specimens appear associated with a fragmentation event (Figure 43). Only eight (out of 163) remain in usable or repairable condition. Edge related fractures and mistakes in production are independent factors, both overlapping with transverse fracturing in the medial zone.

Eleven times had an edge broken in half along the longitudinal or skewed longitudinal axis and six times more one fractured in multiple places. In both events the result is irrepairable. Detachment of the flake from the edge has been observed once, and as noted, there are four edge flakes that resulted from either use fracturing or rejuvenation practices, currently considered indistinguishable. Most of these fragments are (severely) dulled or battered beyond usability. Otherwise, most edges in the assemblage are medium dull to sharp, though micro-retouch is common.

A total of 79 specimens displays transverse fractures in the medial zone. These can be either straight and fluid bending-initiated fractures (36 artefacts), or display irregular skewing and slanting of the direction, including bumps and angular horizontal ridges (43 artefacts). Such ridges or fissures are common for rocks with anisotropic fabrics (blueschists, foliated greenschists), which may splinter from the force rather than permitting a smooth oblique-transversal trajectory. Fractures of this kind are typical of in-haft breakage and account for most of the sharper edges in the assemblage, including eight specimens where the fracture intersects hafting wear and all instances where the direction is oblique to the transverse plane.

However, other biographical trajectories are observed to induce such fractures, most of which

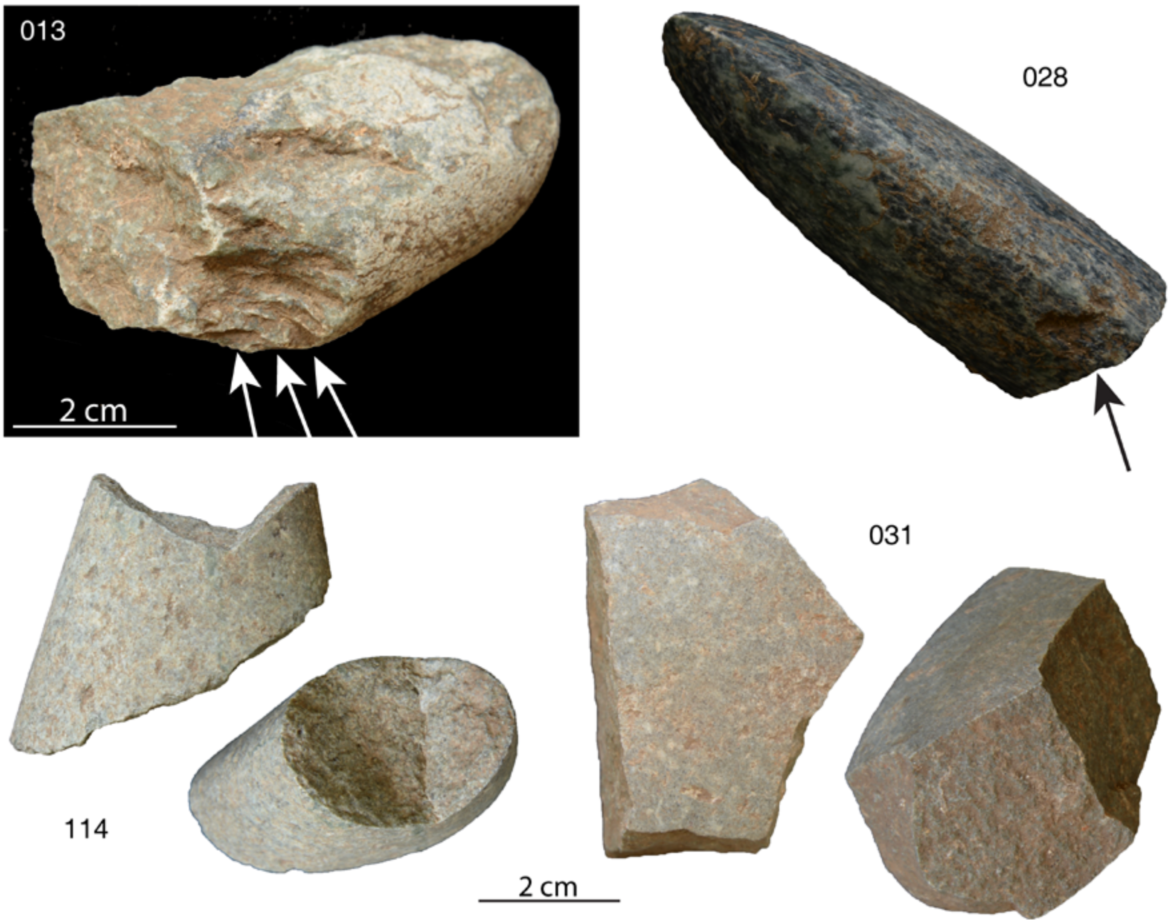

Figure 43: Fragmentation patterns in Playa Grande. Hinge fissures over a transverse medial break indicating heavy bipolar hammering to split the jadeitite now medial-distal fragment PG 013. The fully ground and biographically exhausted PG 028 shows impact craters near the break. Jadeite-bearing PG 114 and undetermined PG show geometrically concave fragmentation and blocky fragmentation respectively.

involve the intentional destruction of the artefact. Eleven specimens were exhausted by regular means, including edge fracturing or a standard transverse medial break. Twelve more are roughouts rejected for unrelated production mistakes (commonly flaking accidents).[38] This is clearly illustrated in Figure 39, 011, where a severe step fracture destroyed the ability to hold an edge. Subsequent to that a small part of the butt was removed, almost as an afterthought, that cannot be associable to the initial breakage. Further evidence for the intentionality of this act rests in the frequent presence of impact marks from bipolar percussion. These are often located near or on the spot where the break occurs, opposed by 'counterblow' impact damage, most resulting scars terminating as step or irregular fractures. One extreme case displays fissures from repeated transverse hammering on one side that reduced the mass of the roughout until the split occurred, with further impact crushing inside of this area (Figure 43, 013). The actual number of occurrences is probably much higher, but in many cases the impact points were singular or considered unclear given extensive traces from transversal hammering from production.

38 The destroyed roughouts are distributed fairly evenly between flawed and non-flawed specimens, to be expected when pieces with mistakes on one part are broken in two. Observed reasons for rejection include the destruction of the (intended) edge by flake removals interrupting the bevel, deep thinning, and overzealous hammering of the sides resulting in unintended flakes, all of which remove critically important mass.

Most remaining cases concerns fragments from the complete collapse of an object (13), unclear fragmentation patterns for which no specific origin could be found (11), and schists collapsing in a rectilinear pattern (4, not counting edges). There are a few massive rocks that fractured in blocky or geometrically concave shapes (Figure 43), but the origin of these patterns remains unclear.