

TABLE OF CONTENTS

Table of contents.....	i
Preface	xiii
Session 1. Terminology and Methodology in Non-Flint Raw Material Studies	
Introduction.....	3
<i>Lotte Eigeland</i>	
The Scar Identification of Lithic Quartz Industries	5
<i>Arturo de Lombera Hermida</i>	
Reflections on Prismatic Blades – The Terminology of Blades and Classification of Lithic Artefacts in Central Sweden.....	13
<i>Per Falkenström</i>	
Approche comportementale du Magdalénien d’après l’étude techno-fonctionnelle de l’outillage lithique hors silex. La grotte de Bourrouilla (Arancou, Pyrénées-Atlantiques, France)	21
<i>Loïc Daulny & Morgane Dachary</i>	
Petrographical composition and provenance of Neolithic Black stone artefacts in the collection of the Museum der Kulturen in Basel and in archaeological excavations near the shoreline of Lake Neuchâtel Switzerland	29
<i>Inge Diethelm</i>	
Instrumental Methods of Obsidian Characterization and Prehistoric Obsidian Provenance Studies: the current status	35
<i>Gérard Poupeau, François -X. Le Bourdonnec, Sarah Delerue, Stephan Dubernet, Rosa B. Scorzelli & Mathieu Duttine</i>	
Functional analysis of macro-lithic artefacts: a focus on working surfaces.....	43
<i>Jenny Adams, Selina Delgado, Laure Dubreuil, Caroline Hamon, Hugues Plisson & Roberto Risch</i>	
The rock that rocks the rock – An experimental study with hammerstones	67
<i>Elin Hansen & Lotte Eigeland</i>	
Session 2. Non-Flint Raw Materials in Experimental Archaeology and Use Wear Studies	
Introduction – With old departures to new destinations	79
<i>Farina Sternke</i>	

Lithic Raw Material Variability and Use-wear Accrual on Short-term Use Implements: An Example from Northwestern New Mexico.....	81
<i>Harry Lerner</i>	
Formation of use-wear traces in non-flint rocks: the case of quartzite and rhyolite – Differences and similarities.....	93
<i>Ignacio Clemente Conte & Juan F. Gibaja Bao</i>	
A functional comparison of Bečov quartzite and flint tools: preliminary results.....	99
<i>Petra Priorová, Linda Hroníková & Andrea Šajnerová-Dušková</i>	
Approche fonctionnelle des tessons à bords abrasés du site néolithique ancien de Kovačevo (6200-5500 avant J.-C., Bulgarie)	103
<i>Julien Vieugué</i>	
Quinzano and Rivoli – two Middle Neolithic sites in the Adige Valley (Verona, North-eastern Italy): lithic choices and functional aspects of the non-flint stone implements.....	111
<i>Anna Lunardi</i>	
Les râpes Baniwa et Wai Wai, derniers instruments de pierre taillé indigènes d’Amérique du Sud	123
<i>André Prous, Jorge Manuel Costa e Souza, Filipe Amorelli, Marcio Alonso, Ana Carolina Rodriguez Cunha & Angelo Pessoa Lima</i>	
Matières premières “alternatives” dans le Brésil central: quartz, quartzite, agate et hématite.....	133
<i>André Prous, Andrei Isnardis, Ângelo Pessoa Lima, Marcio Alonso, Henrique Pilo & Maria Clara Migliacio</i>	
Pitted and grinding stones from Middle Palaeolithic settlements in Bohemia: a functional study	145
<i>Andrea Šajnerová-Dušková, Jan Fridrich & Ivana Sýkorová</i>	
Le site magdalénien Final d’Etigny le Brassot (Yonne, France): Un exemple d’utilisation des roches non taillées pour le Tardiglaciaire du bassin Parisien.....	153
<i>Gaëlle Dumarçay</i>	
 Session 3. The Socio-Economic Implications of Non-Flint Raw Material Use	
Introduction: From descriptions of prehistoric objects to an understanding of social and economic behaviour	165
<i>Laurent-Jacques Costa</i>	
The use of non-flint raw materials by Paleoindians in Eastern South America: A Brazilian perspective	169
<i>Astolfo Gomes de Mello Araujo & Francisco Pugliese</i>	
Lithic industries and raw material in Southern Italy Mousterian: an example from the Grotta dei Giganti (Salento, Apulia).....	177
<i>Enza Spinapolice</i>	
The First Obsidian Workshop at the Polish Lowland – a Technological and Microwear Study.....	187
<i>Małgorzata Winiarska-Kabacińska & Jacek Kabaciński</i>	
Mesolithic quartz quarrying in Eastern Middle Sweden – In the light of a quarry excavated at Stjärneberg, Linköping.....	193
<i>Fredrik Molin, Magnus Rolöf & Roger Wikell</i>	

Obsidian Economy in the Rio Saboccu Open-Air Early Neolithic Site (Sardinia, Italy)	203
<i>Carlo Lugliè, François-Xavier Le Bourdonnec, Gérard Poupeau, Consuelo Congia, Thomas Calligaro, Ignazio Sanna & Stéphan Dubernet</i>	
The use of quartzite as a chrono-cultural marker in the Mesolithic of the Low Countries.....	217
<i>Yves Perdaen, Philippe Crombé & Joris Sergant</i>	
Quartz and other knapped raw materials of the South Indian Neolithic: A comparison of surface assemblages from three Indian ashmound sites	225
<i>Ulla Rajala, Marco Madella & Ravi Korisettar</i>	
What shall we leave behind? From the mechanical analysis of rocks to stylistic variability in the Mesolithic of Brittany.....	233
<i>Grégor Marchand & Rodrigue Tsobgou Ahoupe</i>	
Irreplaceable? Or just not indispensable... Substitution and complementarity in lithic raw material management in the Maya lowland	241
<i>Chloé Andrieu</i>	

LIST OF FIGURES

Fig. 1.1. A) Vein quartz formation and morphostructural groups; B). The Hertzian model as observed in quartz. A: Radial fissures; B: Concentric fissures; C: Subsurface and parallel fissures	6
Fig. 1.2. Percussion marks. A: Radial fissures; B: Step; C and D: Transverse fissures; E and F: Striking platform fissures; G: Splintering; H: Scales; J: Edge battering. Figures D and G show material from the archaeological site of La Juería; H and J from <i>Locus</i> I de As Gándaras de Budiño. Figures H and J scale = 5 mm	8
Fig. 1.3. Morphostructural groups and percussion marks on quartz from the archaeological site of <i>Locus</i> I de As Gándaras de Budiño, N= 380	9
Fig. 1.4. The relationship of fracture mechanics and quartz morphostructure with percussion marks.....	10
Fig. 2.1. The blade production region in Central Sweden.....	13
Fig. 2.2. The Power of Imagination	14
Fig. 2.3. Main attributes for the blade classification.....	15
Fig. 2.4. Distribution of blade raw materials	16
Fig. 2.5. A revised classification scheme.....	17
Fig. 2.6. Proximal blade fragment of silicified ash tuff (left) and complete blade of porphyry (right) from Los parish in the province of Dalarna.....	17
Fig. 2.7. Diagram showing the platform types in the blade population	18
Fig. 2.8. Platform core of porphyry tuff from Älvdalen parish in the province of Dalarna.....	19
Fig. 3.1. ARA 03 – Ens. B – K24.2158, quartzite, percuteur de fracturation aménagé. Exemple de production de support (outil sur éclat), de façonnage de la morphologie du support (A: négatifs d'éclat) et de façonnage du front actif (B: aménagement bifacial par une série d'enlèvements d'éclat). B: front actif linéaire; C: front actif punctiforme	24
Fig. 3.2. ARA 01 – Ens. A – L24.836, grès, polissoir à main passif aménagé Exemple de façonnage du front actif (B: aménagement des deux encoches par une série d'enlèvements d'éclat; encoches avec abrasion fonctionnelle, l. 0,9 cm env.) et de retouche d'accommodation (A: un négatif aménagé la zone de préhension pour le pouce)	24
Fig. 3.3. ARA 05 – Ens. B – L17.547, grès, fragment de préparateur de taille. Vue de profil de la face latérale de galet utilisée pour l'abrasion. Stigmates de percussion: négatif d'esquille (à droite) et arrachements de matière.....	25

Fig. 3.4. ARA 05 – Ens. B – L17.455, grès quartzite, percuteur de fracturation. En encadré, vue de profil. A: front actif saillant, martèlement et écrasement marqué de la ligne de fracture. B: front actif linéaire, arête de fracture émoussée et esquillée	25
Fig. 3.5. ARA 05 – Ens. B – L17.1171, grès quartzite, fragment de percuteur de fracturation	25
Fig. 3.6. ARA 03 – Ens. B – L24.2230, grès, polissoir à main passif. L'utilisation a provoqué un arrondissement régulier de la surface de cassure (A). Toute la surface arrondie est régulière et peu rugueuse au toucher. Une usure identique affecte également la gouttière (B)	26
Fig. 3.7. ARA 05 – Ens. B – L17.599b, grès quartzite, polissoir à main passif. Abrasion nette des aspérités de la cassure associée à des stries longitudinales, fines et parallèles. Les stries ont toutes la même orientation, celle du plus grand allongement de la gouttière. L'usure est principalement disposée sur une bande rectiligne, offrant la plus grande longueur de contact dans la gouttière	26
Fig. 3.8. la Butte des Queyrans, quartzite, plurifonctionnel : percuteur de fracturation et percuteur sur pièces intermédiaires	27
Fig. 4.1. Geological map of the north-western part and the western lake region of Switzerland showing the study area and the geological sources of the raw materials, as well as the location of the ground stone axes. Two ground stone axes are examples from an old collection housed in the <i>Museum der Kulturen</i> in Basel	30
Fig. 4.2. Raw material: Tongestein, shale, pélites-quartz. Note the clear patina which is typical for the artefacts	31
Fig. 4.3. Raw material: Knotenschiefer, spotted shale, schistes noduleux. Note the granular surface which is typical for the artefacts and the complex mineral composition of Black Stone. Thin sections were photographed through a microscope with polarized light. The extent of the slide is 720 micron	31
Fig. 4.4. Tongestein = shale or pelite = pélites-quartz. Grains of quartz, mica, ore, clay and small quantities of other minerals. All are fine-grained, embedded in dark pigments and show parallel structures	32
Fig. 4.5. Flecken- or Knotenschiefer = knotted schist/spotted shale = schiste noduleux. The same minerals can be seen in the shale. They undergo a structural change if they come into contact with lava at a low to medium temperature. Newly formed cordierite fixes the pigmentation and gives it a new, round structure.....	32
Fig. 4.6. Diagram of powder X-ray diffraction in the Debye-Scherrer system; Abscissa: x-ray diffraction, Ordinate: Intensity. Qz: quartz; Fsp: feldspars; Chl: chlorite; Gl: mica. ID 3526, shale; ID 6770, knotted schist. The diagram confirms the microscopic results.....	32
Fig. 6.1. Analytical steps for a functional interpretation of macro-lithic artefacts.....	44
Fig. 6.2. Different levels of observation of a stone artefact's surface.....	48
Fig. 6.3. Variation of the topography and the microtopography of a macro-lithic artefact including the profile and regularity of the surface	49
Fig. 6.4. Schematic representation of the wear traces observed on individual grains or minerals.....	49
Fig. 6.5. Graphic representation of the correlation between distribution and density of traces	50
Fig. 6.6. Examples of wear traces visible on different grinding implements used to process cereal.....	51
Fig. 6.7. Examples of wear traces visible on different grinding implements used to process cereal.....	54

Fig. 7.1. Typical hammerstone which fits well into the hand	68
Fig. 7.2 a. Hammerstones of different shapes and sizes belonging to the knapper Harm Paulsen	68
Fig. 7.2 b. Unknown number of hammerstones in the toolkit of the knapper Esben Kannegård	68
Fig. 7.3. Typical knapping toolkit.....	68
Fig. 7.4. Hammerstones used in the experiment, sorted according to size and shape.....	69
Fig. 7.5. Fractured granite hammerstone	71
Fig. 7.6. “Classic” hammerstone of fine-grained quartzite	71
Fig. 7.7. Hammerstone made of gabbro. Left: Use-wear as a result of knapping flint for 2 hours. Right: Use-wear as a result of working basalt for 5 minutes	71
Fig. 7.8. The largest hammerstone used in the experiment.....	72
Fig. 7.9. The smallest hammerstone used in the experiment	72
Fig. 7.10. Map of archaeological sites mentioned in the text.....	73
Fig. 7.11. Medium hard hammerstones from Trosterud 1	74
Fig. 7.12. Ornamented hammerstone from Svinesund, Vestegaard 6.....	75
Fig. 8.1. Map of the Elena Gallegos study area and the location of FA2-13	82
Fig. 8.2. Some examples of YSW (a – e) and SJF (f – j) short-term use tools from FA2-13	83
Fig. 8.3. Overall Invasiveness of wear.....	84
Fig. 8.4. Overall Invasiveness of for experimental flake tools	85
Fig. 8.5. Line graph of pixel gray values after 10 minutes of use.....	86
Fig. 8.6. Line graph of pixel gray values after 30 minutes of use.....	86
Fig. 8.7. Line graph of pixel gray values after 60 minutes of use.....	86
Fig. 8.8. Line graph of pixel gray values for two flake tools from FA2-13	87
Fig. 8.9. Mean coefficients of variation for experimental flake tools	87
Fig. 8.10. Mean coefficients of variation for flake tools from FA2-13.....	87
Fig. 8.11. Raw material surface hardness by indent location.....	88
Fig. 8.12. Variance in raw material surface hardness by indent location.....	88
Fig. 8.13. Average raw material sample surface roughness.....	89
Fig. 9.1. Description examples of experimental use-wear traces produced when working on wood, skin and non-woody plants	95
Fig. 9.2. Different types of micropolish on the experimental quartzite tools: 1) meat cutting, 2) hide scraping, 3) bone scraping, 4) antler scraping, 5) shell scraping, 6) wood scraping, 7) incisions on sandstone and 8) ocre scraping	97
Fig. 10.1. Localities of the main types of quartzite in the north-west Bohemia: 1 – Staré Sedlo, 2 – Tušimice, 3 – Kamenná Voda, 4 – Bečov, 5 – Skršín, 6 – Žitenice (after Popelka 1999).....	100
Fig. 10.2. The macro structure of the Bečov quartzite.....	100
Fig. 10.3. The micro structure of the Bečov quartzite (100x).....	101

Fig. 11.1. Carte de répartition des sites du Néolithique ancien en Bulgarie du Sud-ouest et en Grèce du Nord	104
Fig. 11.2. Principales catégories d'outils en terre cuite	105
Fig. 11.3. Schématisation des différentes formes de la partie active des outils (en encadré, les plus récurrentes)	105
Fig. 11.4. Schématisation des différentes sections de la partie active des outils (en encadré, les plus récurrentes) et reconstitution de l'inclinaison de l'outil par rapport à la matière travaillée.....	106
Fig. 11.5. Diversité des surfaces émoussées et des dégraissants usés.....	106
Fig. 11.6. Stries indiquant la cinématique des bords actifs des outils.....	107
Fig. 11.7. Répartition stratigraphique des tessons à bords abrasés et leur datation relative.....	108
Fig. 12.1. Location of Quinzano and Rivoli	112
Fig. 12.2. Quinzano and Rivoli: Raw material composition of assemblages.....	113
Fig. 12.3. Examples of stone tools analysed: 1. Quern (Rivoli); 2. Handstone (Rivoli); 3. Abrader (Rivoli); 4. Polisher (Rivoli); 5. Pounder (Rivoli); 6. Pecking stone (Quinzano); 7. Pounder/polisher (Quinzano); 8. Axe (Rivoli); 9. Axe (Quinzano); 10. Chisel (Quinzano); 11. Pounder/polisher (Rivoli); a. <i>Percussion posée</i> ; b. <i>Percussion lancée</i>	115
Fig. 12.4. Relationship between raw material choice and tool-type function	119
Fig. 13.1. Régions de production des planches à manioc	124
Fig. 13.2. Grande case Waiwai	125
Fig. 13.3. Jeune femme waiwai râpant le manioc	125
Fig. 13.4. Utilisation d'une râpe Baniwa	126
Fig. 13.5. Racines de manioc	126
Fig. 13.6. Râpe a manioc baniwa	127
Fig. 13.7. Petite râpe à fruits waiwai	127
Fig. 13.8. Râpe biniwa, vue de profil.....	127
Fig. 13.9. Position de taille	127
Fig. 13.10. Grande éclats de diabase waiwai	128
Fig. 13.11. Grand éclat de diabase expérimental	128
Fig. 13.12. Retouche des dents	129
Fig. 13.13. Fixation des dents; on voit l'enclume à droite	129
Fig. 13.14. Râpe à manioc Waiwai	130
Fig. 13.15. Dents waiwai (celle du haut présente une face polie).....	130
Fig. 13.16. Traces d'utilisation sur l'enduit d'une dent de la râpe moderne.....	131
Fig. 13.17. Manioc archéologique avec les stries laissées par la râpe	131
Fig. 13.18. Manioc râpé sur l'instrument Waiwai	131
Fig. 14.1. Grand dépôt de déchets de quartz.....	134
Fig. 14.2. Tailleur moderne en action	134
Fig. 14.3. Eclat moderne, produit des <i>garimpeiros</i>	134
Fig. 14.4. a & b. Racloir en quartz.....	135

Fig. 14.5. a & b. Point de projectile en quartz.....	136
Fig. 14.6. a, b, c & d. Lames de hache et préformes en hématite.....	137
Fig. 14.7. Taille expérimentale de l'hématite	138
Fig. 14.8. Face interne d'un éclat de façonnage.....	138
Fig. 14.9. Préforme expérimentale de lame polie en hématite	139
Fig. 14.10. Débitage préhistorique sur enclume de l'agate	140
Fig. 14.11. & 14.12. Perçoirs d'agate	141
Fig. 14.13. Micro-vestige d'utilisation sur un perçoir d'agate préhistorique	141
Fig. 14.14. Racloirs sur les plaquettes de quartzite.....	141
Fig. 14.15. a & b. Pièce plan-convexe en quartzite.....	142
Fig. 15.1. Palm sized palette (Bečov I).....	146
Fig. 15.2. Tablet/anvil (Bečov IV – Upper Acheulian).....	146
Fig. 15.3. Bečov I (Most district). Part of profile A and a schematic drawing of the same section	147
Fig. 15.4. Bečov I (Most district). Attempted reconstruction of the settlement feature. Drawing of the settlement feature	148
Fig. 15.5. Pieces of porcellanite found in the Bečov I dwelling	149
Fig. 15.6. Experimental rubbing of weathered porcellanite	149
Fig. 15.7. Experimental grinding of weathered porcellanite.....	150
Fig. 15.8. Pitted anvil (Bečov – a new Middle Palaeolithic site – Upper Acheulian).....	150
Fig. 16.1. Localisation du site d'Etigny-le-Brassot (Yonne)	154
Fig. 16.2. Lames minces de granite, microgranite et tonalite métamorphisée	155
Fig. 16.3. Exemple de fiche d'étude des thermoaltérations des roches.....	156
Fig. 16.4. a) Remontage de grès présentant une fragmentation de surface; b) Remontage de granite présentant une fragmentation de masse.....	157
Fig. 16.5. Corpus expérimental de grès chauffé en four	158
Fig. 16.6. Matière organique d'origine animale vue au microscope électronique à balayage.....	158
Fig. 16.7. Percuteur E24-B	160
Fig. 16.8. Pourcentages atomiques moyens des éléments récurrents au sein des échantillons, par échantillon	160
Fig. 17.1. Location of Archaeological Sites and Regions (numbers) cited in the text. 1= RS-C-43 and RS-S-327; 2= PR-FI-124; 3= PR-FI-138; 4= Capelinha; 5= BA-RC-28; 6= Serranopolis region; 7= Lajeado region; 8= Lagoa Santa region; 9= Lapa do Dragao; 10 = Abrigo do Pilao; 11= Lapa do Boquete	170
Fig. 18.1. The geographic position of the Salento region	178
Fig. 18.2. The most important Mousterian sites of the region; on the Adriatic coast: Grotta Romanelli and Grotta Zinzulusa; on the Ionian coast: the caves from Uluzzo Bay (as Grotta del Cavallo) and on the extreme part of the peninsula near Capo Santa Maria di Leuca: Grotta Titti and Grotta dei Giganti.....	178
Fig. 18.3. Cross section of Giganti Cave (A. Segre sketch, archives ISIPU, Rome): A-B-C-D, marine levels; st1, 2, 3: stalagmites; d1, 2, 3, detritus facies; f1, 2,	

3: fireplace levels; Sa: red sand. Probable chronology: d1, f1 Wurm I; d2, f2, f3 Wurm I-II; f3 (?), Sa Wurm III.....	179
Fig. 18.4. External view of Giganti Cave	180
Fig. 18.5. Classification of the assemblage into the different stages of the <i>chaîne opératoire</i> : 0-1: Procurement and preparation; 2: blank production; 3-4: utilization and maintenance; 5: discard.....	180
Fig. 18.6. Levallois Debitage: UND: unidirectional; CNT centripetal; BID: bidirectional; CON: convergent; IND: indeterminable	181
Fig. 18.7. The degree of predetermination in flint and non flint blanks.....	181
Fig. 18.8. Typology of the artefacts	181
Fig. 18.9. Limestone Levallois blanks	182
Fig. 18.10. A: limestone core; B: retouched predetermined limestone blanks.....	182
Fig. 18.11. Formal flint tools	182
Fig. 18.12. Detail of the retouch on <i>Callista chione</i>	182
Fig. 18.13. Percussion pit from the internal part of the shell	182
Fig. 18.14. Area surveyed in 2006.....	183
Fig. 18.15. Dolomitic lamination in Melissano limestone, Capo S. Maria di Leuca	184
Fig. 18.16. Bioclastic Castro limestone, Marina di Castro	184
Fig. 19.1. Location of the site Cichmiana 2 (black circle)	188
Fig. 19.2. Cichmiana, site 2. Concentration 4. Obsidian artefacts from the workshop.....	189
Fig. 19.3. Cichmiana, site 2. Concentration 4. Structure of the obsidian workshop inventory	190
Fig. 19.4. Cichmiana, site 2, Concentration 4. Examples of microwear traces on the obsidian artefacts.....	191
Fig. 20.1. Location of research area in Sweden. Graphics: Lars Östlin.....	194
Fig. 20.2. Palaeogeographical map of Östergötland showing the Littorina Sea and the shoreline at 50 m O.D. Note that the shorelines in the northern and southern parts are not synchronous. The location of Mesolithic site at Stjärneberg is indicated by a dot. Map by Dag Hammar and Lars Östlin	195
Fig. 20.3. The quartz quarry at Stjärneberg surrounded by red feldspar.....	196
Fig. 20.4. An example of the find distribution at the quarry site at Stjärneberg. (chunks by weight and bipolar flakes with remaining feldspar by quantity).....	198
Fig. 21.1. Schematic maps of the Western Mediterranean showing the obsidian source-islands Lipari, Palmarola, Pantelleria and Sardinia	204
Fig. 21.2. Location of the Rio Saboccu S1-S2 site and of the Monte Arci volcanic complex in Sardinia. The secondary obsidian sources are shown as light grey areas and the primary sources, all located inside the Monte Arci massif, are indicated (in these areas) in black	205
Fig. 21.3. Binary diagram comparing the Rb and Zr contents in obsidians of the Rio Saboccu S1-S2 structures and from the western Mediterranean source-islands. The Sardinian obsidians are separated into two groups with the SC and SA+SB sample types respectively (SB = obsidians of the SB1+SB2 types). Data on obsidian from sources, this work (Table 21.3).....	208
Fig. 21.4. Ternary diagram comparing the Zn, Sr and Zr contents in obsidians from the Rio Saboccu S1-S2 structures and from the Monte Arci. Data on obsidian from sources, same as in Figure 21.3.....	209

Fig. 21.5. Obsidian cores with poli-orthogonal rotation during the reduction sequence.....	211
Fig. 21.6. Formal obsidian tools. <i>Enchoches</i> (SAB99, 553), side scrapers (SAB136, 83), truncations (SAB556, 1033), side abrupt piece (SAB459), backed pieces (SAB707, 992), side burin (SAB632), notched piece (SAB278) and geometrics (SAB104, 708).....	212
Fig. 21.7. Refitting of a geometric tool in SA obsidian type to the proximal part of a truncated flake	213
Fig. 22.1. Distribution of Wommersom and Tienen quartzite	218
Fig. 23.1. A typical ashmound at Wandalli, Raichur district.....	226
Fig. 23.2. Palavoy, Tadbidi and Gaudur in Deccan Plateau.....	227
Fig. 23.3. Different raw materials from the Palavoy surface survey.....	228
Fig. 23.4. Quartz implements from Palavoy	229
Fig. 23.5. Different raw materials from the Tadbidi surface survey	230
Fig. 23.6. Different raw materials from the Gaudur surface survey	231
Fig. 24.1. The most important Armorican rocks and diffusion areas during the Mesolithic period	234
Fig. 24.2. A and B: Different aspects of the local raw material acquisition in Finistère (distribution, diffusion rates and technological adaptation). The sites used for B1 are: Cobalan, L'Ormeau, Moulin Penguilly, Kerliézoc, Kerdunvel, La Presqu'île, Pont-Glas, Glaharé and Penity-Saint-Laurent.....	236
Fig. 25.1. Geological Map of the Mayan Area	242
Fig. 25.2. 1: Specialized Production Biface; 2: Domestic Production Biface.....	244
Fig. 25.3. Raw material composition of the lithic collections of a few Mayan sites.....	246

LIST OF TABLES

Tab. 3.1. Matières premières présentes suivant les différents ensembles archéologiques	23
Tab. 5.1. Instrumental methods of obsidian characterization in provenance studies	38
Tab. 6.1. Characterization of rock textures represented in the three main rock families.....	46
Tab. 6.2. Hypothesis of relationship between tribological mechanisms and observed wear traces	46
Tab. 6.3. Main criteria for description of the different traces on macro-lithic artefacts	53
Tab. 7.1. Size and Shape Categories.....	69
Tab. 7.2. Description of the Experiment.....	70
Tab. 10.1. An overview of the duration over which the different materials were worked with the experimental flint and quartzite tools	101
Tab. 12.1. Quinzano and Rivoli: Classification of the stone tools according to their function.....	116
Tab. 12.2. Sample of the experimental data. The table shows the length of time for which the tools were used and their wear traces. Wear traces have been examined macroscopically and microscopically (low magnification). The long working times for certain experiments were aimed at the study of long-term trends with regard to the morphological modifications of the working surfaces	118
Tab. 14.1. restes de la préparation d'un ensemble de cristaux – village de Cuiaba.....	137
Tab. 14.2. Comparaison entre les attributs des éclats de quartz préhistoriques et modernes	138
Tab. 14.3. Variété; poids initial, après taille et/ou piquetage; temps et perte de poids polissage	141
Tab. 17.1. Counts and frequencies of raw materials for some Paleoindian sites from Southern Brazil (after Chmyz 1978, 1979,1980; Dias, 1994; Lima 2005). S.S. = Silicified sandstone; F = Flint; Qz = Quartz; Volc = Volcanic; Qt = Quartzite. Numbers in parenthesis are related to Figure 1	172
Tab. 17.2. Counts and frequencies of raw materials form some Paleoindian sites from Central Brazil (after Bueno 2005; Prous <i>et al.</i> 1997; Schmitz <i>et al.</i> 1996; Schmitz <i>et al.</i> 2004). S.S. = Silicified sandstone; F = Flint; Qz = Quartz; Volc = volcanic; Qt = Quartzite. Numbers in parenthesis are related to Figure 1.....	172

Tab. 17.3. Ratio between formal and generalised artefacts in Paleoindian lithic industries	173
Tab. 18.1. Assemblage composition	179
Tab. 18.2. Degree of alteration of the assemblage	180
Tab. 18.3. Raw material proportions at Giganti Cave.....	180
Tab. 18.4. Morphology of the raw material	180
Tab. 18.5. Proportion of the raw materials used on some sites of the region: GG: Grotta dei Giganti; TT: Grotta Titti; ROM.G: Grotta Romanelli level G; ZNZ, Grotta Zinzulusa; ULZC: Grotta di Uluzzo C; ALTO: Grotta Torre dell'Alto; CAV: Grotta del Cavallo; BERN: Grotta M. Bernardini	185
Tab. 18.6. Raw material proportion on some Ionian sites: ALTO: Grotta Torre dell'Alto, layers B, C, D, E; CAV: Grotta del Cavallo, layers I and F; BERN: Grotta M. Bernardini, layers A and B	185
Tab. 21.1: Absolute and relative distribution of raw materials at Rio Saboccu S1-S2.....	206
Tab. 21.2: PIXE chemical compositions of Monte Arci obsidians	207
Tab. 21.3: PIXE chemical compositions of obsidians from the Rio Saboccu S1-S2 structures.....	208
Tab. 21.4: Absolute and relative distribution of technological categories at Rio Saboccu S1-S2.....	209
Tab. 21.5: Distribution of butt typologies among different technological categories at Rio Saboccu S1-S2.....	209
Tab. 21.6: Distribution of upper face patterns among debitage and retouched pieces at Rio Saboccu S1-S2.....	210
Tab. 21.7: Absolute and relative distribution of platform core typologies at Rio Saboccu S1-S2.....	210
Tab. 21.8: Absolute and relative distribution of obsidian core morphologies at Rio Saboccu S1-S2.....	210
Tab. 21.9: Distribution of the method of debitage among Rio Saboccu S1-S2 obsidian cores.....	211
Tab. 22.1: Scatters from VD1 attributed to a specific assemblage type.....	222
Tab. 22.2. Microliths from VD1 made from quartzite	222
Tab. 24.1. Classification of Armorican rocks using various criteria.....	237
Tab. 24.2. Production methods related to various raw material types	238

PRÉFACE

As a result of a small workshop on lithic technology held at the Department of Archaeology, University College Cork in 2002 organised by Professor Peter Woodman, we realised that we were working on projects at the time that involved the lithic analysis of a wide range of lithic raw materials (Laurent J. Costa had just completed his PhD on Tyrrhennian Mesolithic assemblages; Lotte Eigeland and Sven Erik Grydeland were carrying out research on Norwegian Mesolithic assemblages and Farina Sternke was working on the German Quartzite Palaeolithic). While these assemblages are spatially and chronologically separated, we encountered similar problems during their analysis, in particular with regards to the technological and typological descriptions of the respective lithic raw materials which happened to be almost exclusively non-flint raw materials. It is widely accepted that the known technologies and typologies based on flint cannot be directly projected onto non-flint assemblages. Unfortunately, previous research on specific non-flint raw materials was scarce, particularly in Europe (with a few exceptions in the UK, the Iberian Peninsula and Northern Scandinavia), while the African, Asian and Australian assemblages offered little comparison in terms of their technological and typological descriptions. As a result of this, each one of us adopted his/her own Do-it-yourself approach which included experimental replication to recognise and describe the different technological traits of the raw materials. As will be seen from the many similar approaches in this volume, experimental archaeology in its various forms has firmly taken centre stage in non-flint raw material research.

Upon the conclusion of our respective research projects, we decided that it would be of benefit to organise a meeting of like-minded researchers to assess and reflect upon the current progress of non-flint raw material research worldwide and to facilitate the exchange of information among those involved. Ultimately, the aim of this colloquium was to promote research into non-flint raw materials through the rejection of old prejudices and a propagation of new directions.

The 25 papers (63 authors from 4 continents and 16 countries) collated in this volume include most of the papers and posters presented at the colloquium C77 *The Use of Non-Flint Raw Materials in Prehistory – Old Prejudices and New Directions* at the XV. Congress of the International Union of Pre- and Protohistoric Sciences in Lisbon, Portugal, on 4th and 9th September 2006. The colloquium was divided into three different sessions, *Terminology and Methodology in Non-Flint Raw Material Studies*, *Non-Flint Raw Materials in Experimental Archaeology and Use Wear Studies* and *The Socio-Economic Implications of Non-Flint Raw Material Use*, which reflected the different interests of the organisers and discussed different sets of problems. Given the diversity of approaches to the study of non-flint raw materials, it is not surprising that some elements of the sessions overlap. This is also reflected in the individual contributions.

The different papers reflect various stages of research in their respective fields of investigation and archaeological periods in several regions of the world. Unsurprisingly,

European contributions are the most numerous within this volume. Nevertheless, we believe that this volume can be regarded as an accurate reflection of current non-flint raw material studies.

Regarding the geographical distribution of non-flint raw material research, the contributions from North and South America as well as India are not entirely unexpected, since flint is absent or rather scarce in these regions. In Europe, non-flint raw material studies are more abundant in Northern Scandinavia and the Mediterranean region for similar reasons. With regards to the latter, we also accepted contributions which focused on obsidian, as we felt that research into this raw material, while having received more attention than other non-flint raw materials, will contribute to the overall field of non-flint raw material research.

It is clearly noticeable that archaeological research in Central and Western European countries, whose prehistoric records are commonly associated with the use of flint, increasingly focuses on non-flint raw materials, e.g. quartzites in Belgium, Germany and the Czech Republic, quartzite and other coarse-grained materials in France, rhyolites, Green Stones and Black Stones in Ireland and Green Stones and Black Stones Switzerland and obsidians in Poland. However, research areas commonly associated with the distribution of Baltic flint, such as Southern Sweden, Northern Germany, the Netherlands and Denmark (with the exception of Greenland), remain under-represented. This is despite the fact that non-flint raw materials were used throughout their respective prehistoric periods, in particular for the production and use of axes and other macro tools.

Regarding their chronological distribution, the articles present assemblages from the Middle Palaeolithic through to the Classical Mayan period and in two cases (Prous *et al.* and Prous *et al.*), even to the present.

The raw materials discussed include obsidian, rhyolite, sandstone, gabbro, quartzite, Yellow Silicified Wood, Black Stone, quartz, chert and many more.

The articles in this volume are grouped into three separate sections in accordance with the themed sessions of the colloquium. We accepted contributions in both, English and French. The articles are preceded by a short introduction by their respective session chairs.

It is important to remember that the contents of this volume reflect the current research progress within each individual country which can differ significantly depending on the research histories as well as the different technological and typological traditions followed.

We would like to thank the U.I.S.P.P. and the organisers of the Congress in Lisbon, who provided a venue for the colloquium and facilitated the publication of this volume. Finally, we thank all the participants and authors for their contributions and support.

The Editors

THE SCAR IDENTIFICATION OF LITHIC QUARTZ INDUSTRIES

Arturo de LOMBERA HERMIDA

Àrea de Prehistoria, Universitat Rovira i Virgili, Tarragona, Spain, E-mail: alombera@prehistoria.urv.cat

Abstract: *Quartz is one of the main raw materials used by prehistoric communities from the Lower Palaeolithic to the Holocene. There have been difficulties in developing a proper technological analysis on this material proved difficult due to low morphological standardisation of the products, predominantly caused by the application of analytical criteria commonly used for flint (i.e. ringcracks, ripple marks and bulbs). Furthermore in classical typological studies, quartz is usually considered as a secondary lithic source and linked to opportunistic and simplistic knapping strategies. An experimental approach and archaeological comparison facilitates the identification of several types of knapping scars on quartz blanks. These can identify the impact points of the hammerstones and removal direction, allowing a correct technical analysis. In addition, the scars (radial fissures and fractures) are closely related to the petrological characteristics of quartz, its formation processes, morphostructural varieties and flaking mechanics. The technological analysis of quartz along these criteria has permitted the identification of different reduction strategies, showing a greater variability and complexity in the management of this type of lithic raw material.*

Keywords: *Quartz, technical analysis, scars, raw materials*

Résumé: *Le quartz est l'une des principales matières premières utilisées par les communautés préhistoriques depuis le Paléolithique Inférieur jusqu'à l'Holocène. Toutefois, les difficultés inhérentes à la perception des stigmates de taille sur les produits détachés de cette roche ont empêché l'étude approfondie de ces industries. L'application des critères de lecture du silex (identification de cônes, d'ondes de percussion, de bulbes, etc.) et les études typologiques ont fait que les industries du quartz sont traditionnellement considérées comme un recours lithique secondaire, preuve de stratégies opportunistes et peu élaborées. Par le biais d'une approche expérimentale et par la comparaison de matériaux archéologiques, nous avons pu identifier plusieurs stigmates de taille sur des supports en quartz. Ces stigmates permettent de discerner les points d'impact du percuteur et le sens du débitage des éclats et assurent une lecture technique correcte. Ces stigmates (fissures radiales, écrasement, etc.) sont directement liés aux caractéristiques pétrologiques, aux processus de formation, aux variétés morpho-structurelles ainsi qu'à la mécanique de fracturation du quartz. La lecture technique des quartz par l'identification de ces stigmates a permis de mettre en évidence différentes stratégies d'exploitation de ce matériau, démontrant ainsi une plus grande variabilité et une complexité dans leur gestion.*

Mots clés: *Quartz, analyse technique, traces de percussion, matières premières*

INTRODUCTION

Quartz is traditionally considered to be a secondary raw material resource, because of its inferior knapping quality. Due to its high resistance to weathering, it is one of the most ubiquitous raw materials. This explains its high frequency on many Palaeolithic sites, but it is usually linked to expedient knapping strategies. In spite of its abundance, few technological and experimental studies on quartz have been carried out to-date. The petrological characteristics of quartz and the low standardisation of its products do not permit an easy technological reading. This situation is caused by the extrapolation of the technological criteria associated with other raw materials (e.g. quartz, basalt and quartzite) and the use of exclusively typological and morphological approaches to the classification of lithic industries. The low standardisation of quartz products prevents archaeologists from classifying and even recognising them as man-made tools in the typological sense.

Hence, few extensive and systematic studies have been carried out on quartz industries. Experimental and technological approaches are critical for an understanding of its behaviour and knapping characteristics. Subsequently, these data can then be compared to the archaeological record (Mourre 1996; Villar 1991a). The first step is to develop a correct technological reading of objects made on quartz to understand the technological

and economic behaviour of the prehistoric communities who used them.

PETROLOGICAL CHARACTERISATION

Quartz is a mineral of the tectosilicate group (SiO₂). It is one of Earth's most frequent minerals and a component of sedimentary, metamorphic and intrusive rocks (e.g. sandstone, quartzite, granite). Its crystallisation can occur during all stages of magmatic cooling and metamorphic processes (Luedtke 1992).

Quartz is traditionally considered to be a homogeneous raw material, classified following its external aspect, colour and opacity. Two main types can be observed: hyaline and milky quartz (or vein quartz). This classification does not take the petrological characteristics into account; neither does it distinguish the different knapping qualities of the raw material. Thus, some white *sacaroid* or grainy quartz can be placed in the same category as the macrocrystalline type, whose mechanical behaviour is quite different. Due to this homogeneity, technological selection criteria and economic implications cannot be applied (de Lombera 2005; Llana 1991). For that reason, other authors prefer to adapt the geological and petrological classifications based on the formation processes of quartz (Mourre 1996). Two types of quartz are defined:

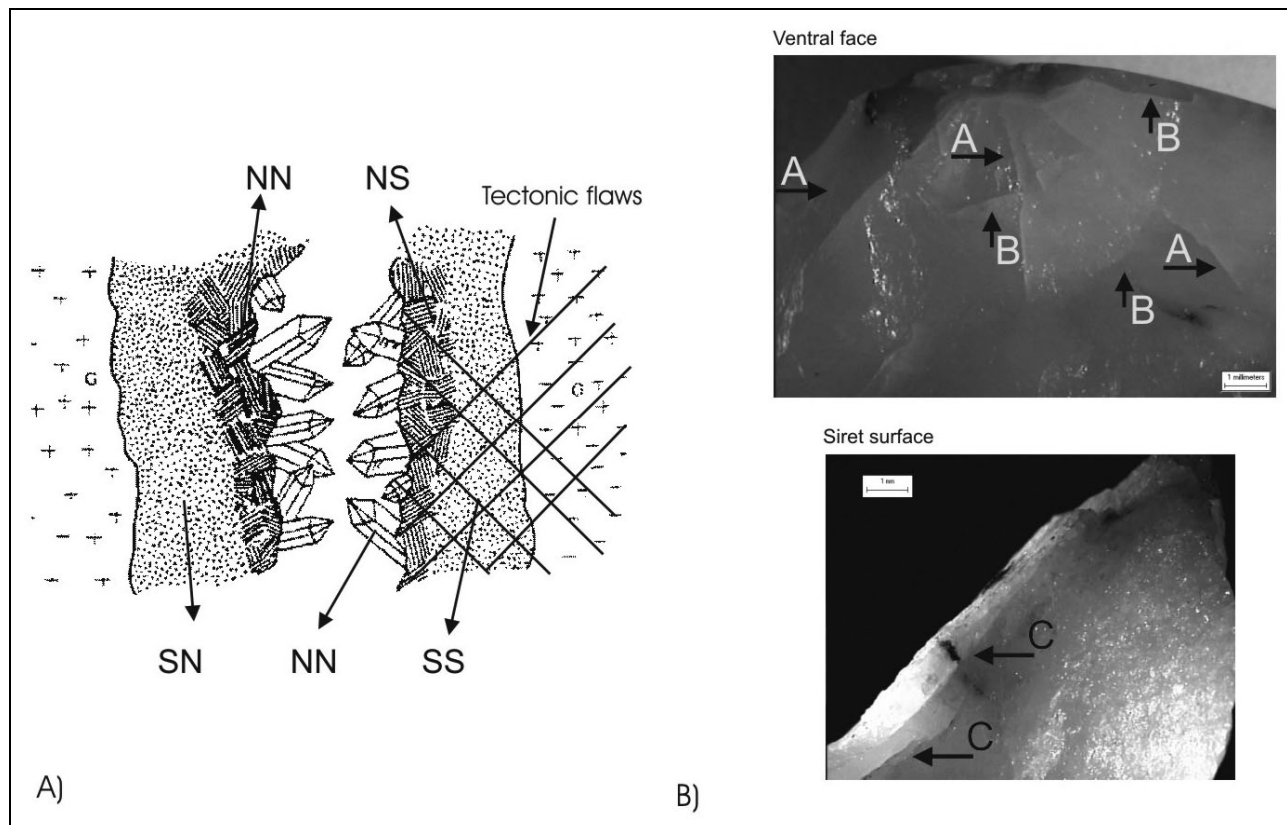


Fig. 1.1. A) Vein quartz formation and morphostructural groups (Collina-Girard 1997); B). The Hertzian model as observed in quartz. A: Radial fissures; B: Concentric fissures; C: Subsurface and parallel fissures

Automorphic quartz – when quartz displays its crystal structure, crystal faces can be identified. This is traditionally called *hyaline* or *translucent* quartz. It occurs in specific geological contexts such as hydrothermal and magmatic contexts. The different types of hyaline quartz (e.g. smoky) are produced by internal gas and liquid inclusions. The presence of crystallization cores, constant environmental conditions, a great span of time and space are required for its formation (Luedtke 1992).

Xenomorphic quartz – formed through the aggregation of several microcrystals, but macroscopically, has a solid structure. It presents an important polymorphy due to the crystal dimensions. This difference in crystal size is due to divergences in temperature, space, growing rates and core density during its formation (Luedtke 1992).

Differences in cooling rates, temperature and core density can occur in the same primary vein formation, therefore, different kinds of quartz textures can be observed. Usually in the outer part of a quartz vein, many small and microcrystals are produced at low temperatures (350°-400° C), with higher cooling rates and a higher presence of cores (rock impurities), thereby, creating a grainy texture. Conversely in the inner part of the vein, where the cooling rates are slower, larger crystals are produced

(macrocrystalline texture or hyaline crystals). Therefore, a number of textures can be observed in the same quartz vein, or even in cobbles, and their mechanical properties differ considerably (Collina-Girard 1997). At the same time during formation, the tectonic forces can produce many internal flaws along with accidental breakages. Some authors (Martínez and Llana 1996) distinguish four morphostructural groups of quartz based on the presence/absence of these morphostructural variables (texture and internal flaws) (Fig. 1.1a):

Grain (G) – distinguishes grainy quartz (xenomorphic) from macrocrystalline quartz (automorphic). The first group can be subdivided into fine-grain or coarse-grain quartz.

Plane (P) – is applied to quartz with internal flaws or crystalline surfaces.

Following from this, quartz artefacts are placed into four morphostructural groups: NN (no grain, no plane), NS (No grain, plane), SN (grainy, no plane) and SS (grainy, plane). This morphostructural classification related to its formation and mechanical properties permits the recognition of the applied technological or economic criteria on the selection of quartz artefacts in accordance with the prevalent social needs of prehistoric communities (de Lombera 2005; Llana 1991; Seong 2004).

MECHANICAL PROPERTIES

Formation processes and the petrological nature of quartz determine its mechanical properties. Firstly, quartz is not a homogeneous raw material due to the presence of internal flaws and crystalline surfaces which cause unintentional breakage. Only the upper part of large quartz crystals (apices) can be regarded as homogenous. Quartz possesses conchoidal as well as uneven fracture characteristics and its strength is identical to flint (7 in Mohs scale). Hence, the resistance of quartz cutting edges is similar to flint, but its low elasticity leads to premature edge breakage and rounding, although this implies an unintentional small degree of resharpening of the cutting edges which actually prolong its efficiency (Bracco and Morel 1998). Quartz anisotropy depends on the crystalline structure and its orientation, as was suggested by Novikov and Radililovsky (1990):

Cleavage: Due to the crystalline structure debilities, oblique directions are the preferential breaking planes on quartz crystals. They are observable in some laminar hyaline cores on Upper Palaeolithic and Mesolithic sites (Villar 1997) and as a result of breakage during natural fires (Ramil and Ramil, 1996).

Diaclases: Internal flaws are caused, for example, by internal impurities, gas-liquid inclusions and tectonic forces. This factor is related to the material homogeneity rather than anisotropy *sensu stricto*.

The cleavage planes in quartz are not as developed as in schist and do not affect the knapping methods to a great extent, although they induce a preferential breaking direction (as seen in laminar reduction) and interfere with the Hertzian fracture mode (Novikov and Radililovsky 1990). Therefore, internal flaws and homogeneity are the dominant limiting factors in quartz knapping. Even the reduction of hyaline crystals is restricted to the apex part, thereby, avoiding the flawed and impure roots. On macrocrystalline quartz (NN and NS), cleavage may be due to the absence of typical Hertzian scars (bulbs, ripple marks), but on grainy quartz (SN and SS), the anisotropy cannot be explained in such a way. Firstly in grainy quartz (as in sandstone), the breakage plane does not pass through the crystals, but follows its surfaces, consequently, crystal anisotropic characteristics do not affect the breakage plane (Andrefsky 1998). Following from this, grainy quartz may develop some typical characteristics of Hertzian fracture such as bulbs (*isotropie de compensation*) (Mourre 1996). Secondly, the grainy texture can absorb the strength of the percussion force more efficiently, increasing its elasticity. In that sense, internal flaws or diaclases can be avoided, producing less broken flakes and fragments and providing a better reduction control during knapping sequences. Hence besides homogeneity and the presence of internal flaws (Plane), morphostructural characteristics (Grain) must be taken into account. Thus, the morphostructural groups are seen as a reliable method to classify different quartz varieties.

PERCUSSION MARKS: A TECHNOLOGICAL SIGNATURE ON QUARTZ

The absence of a correct technological reading of quartz blanks prevents good technological studies of archaeological assemblages, since reduction and configuration strategies cannot be identified in a reliable way. An experimental study was carried out to determine and identify percussion marks on quartz blanks. For this experimentation program, fifteen vein quartz cores were reduced by hard hammer percussion and 308 flakes were analysed. The observed criteria were applied in an analysis of the quartz lithic assemblage of two Iberian Middle Pleistocene sites, Locus I from As Gándaras de Budiño, Galicia (n=380) (Vidal 1982) and La Juería, Catalunya (n=339) (Gómez *et al.* 2006), to confirm them and to measure their reliability against the archaeological record. Impact points were identified on 80 and 85 percent of archaeological quartz implements, respectively (de Lombera 2005). The statistical data from Locus I appear to be more representative in this study due to its greater variability of quartz morphostructural groups.

The technological criteria, such as bulbs, ripple marks, bulb scars and Hertzian cones, used in archaeological research are based on the conchoidal fracture of flint, allowing for the identification of impact points, ventral faces, retouch, the direction of removals and diachrony, so that diacritic schemata can be described (Cotterell and Kamminga 1987). The first distinction is made between detached pieces (positive bases) and flaked pieces (negative bases). Due to the petrology of quartz, the application of these flint criteria for scar identification can be misleading (Mourre 1996; Villar 1991a). Commonly, straight and smooth faces are considered to be the ventral sides on quartz implements. In the case of two smooth faces, the presence of cortex is used to identify the dorsal face. Finally, the thickest part of the implement is considered to be the striking platform and the thinnest the distal end (Villar 1991b). However, these criteria are not reliable, because they can change the technological orientation and interpretation and some knapping techniques cannot be identified (such as bipolar reduction). The technological reading of cores is based on the presence of cortex or cleaner surfaces and negative scars. The removal direction is more problematic, as no ripple marks and ridges are marked, therefore, diacritic schemes are difficult to describe. Only when removals are deep and step or hinge terminations occur, the removal direction can be easily identified. During the experimentation on quartz, impact points were observed on negative and positive knapping surfaces. Some of these were already identified in previously, but were generally disregarded (e.g. Mourre 1996; Villar 1991a).

Quartz mechanical breakage follows the Hertzian model, although it is not as pronounced as in flint. Similar to siliceous rocks, the percussion force spreads three-dimensionally through the object. Contrary to flint however, a distinct Hertzian cone is not created, but the

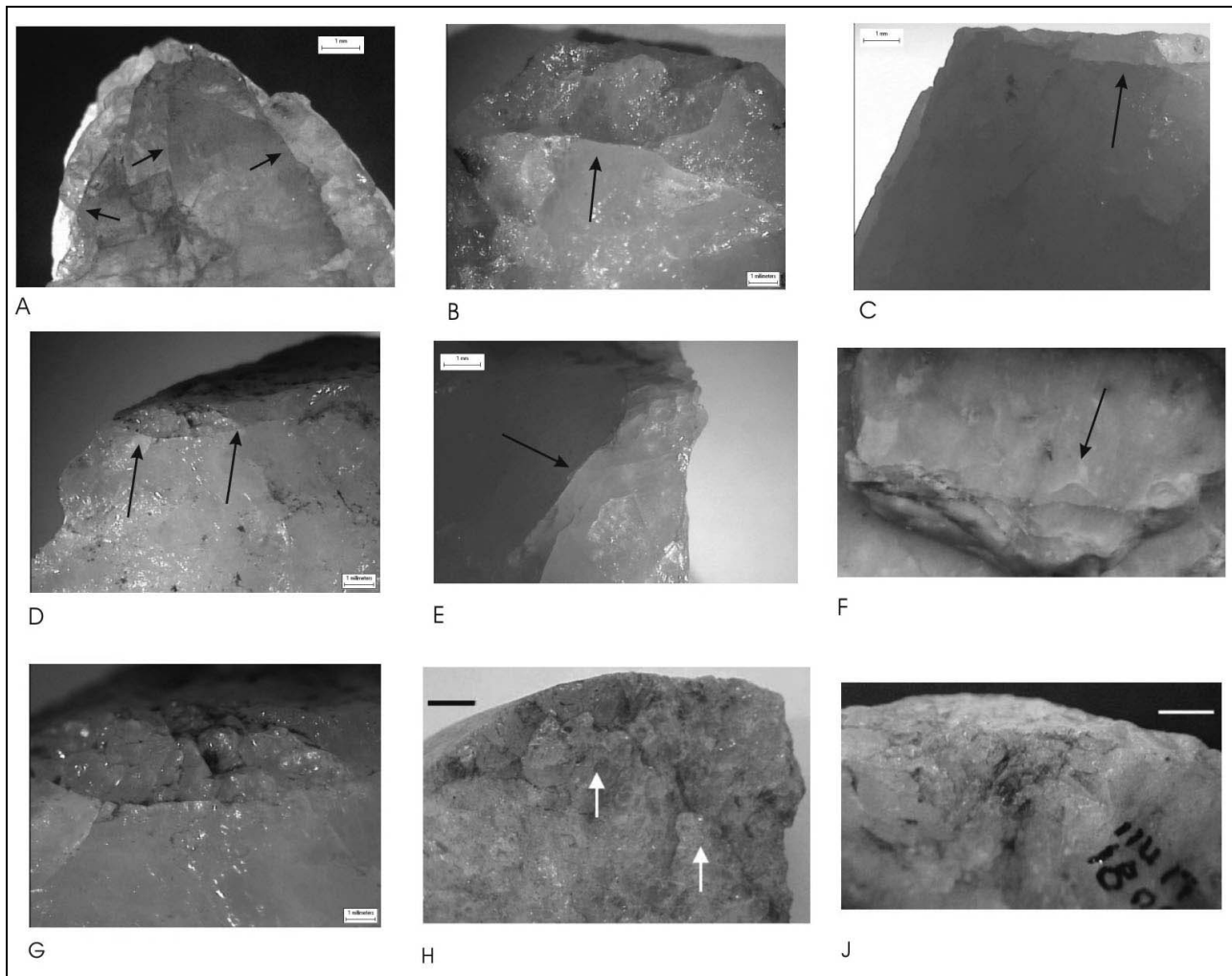


Fig. 1.2. Percussion marks. A: Radial fissures; B: Step; C and D: Transverse fissures; E and F: Striking platform fissures; G: Splintering; H: Scales; J: Edge battering. Figures D and G show material from the archaeological site of La Juería; H and J from *Locus I* de As Gándaras de Budiño (de Lombera 2005). Figures H and J scale = 5 mm

force manifests itself in three-dimensional internal flaws in the tangential and perpendicular planes (Fig. 1.1b). This is the cause of frequent *siret* fractures. The internal flaws can determine posterior removals, which can cause new breakage paths and knapping mistakes (*notion de précontrainte*) (Mourre 1996). However, the observed three-dimensional flaw planes are also present on percussion marks. As a consequence of this propagation force model, several isolated or related scars or percussion marks can be recognised on the negative and ventral faces (Fig. 1.2):

1. Radial Fissures (FIS): These are the result of the radial propagation of the impact force. Their length can be measured in millimetres or even centimetres depending on the percussion angle, strength and quartz morphostructure. They can also be recorded on the lateral surfaces of *siret* fractures which create lateral hinges.
2. Proximal Fissures (Fpr): These are transverse and subsurface fractures which occur close to the impact point. They are the result of the fracture mechanics and low elasticity of quartz and cause proximal step fractures.
3. Striking Platform Fissures (Fct): These are concentric and radial fissures which are located beside the percussion point and are caused by partial Hertzian cone cracks created during hard hammer percussion. They appear on the striking platforms of the flakes and core cornices. On core cornices, they can relate to small concavities on the edge (negative Hertzian cones), also called the overhang.
4. Steps (ESC): These are caused by the low elasticity and breakage propagation model of quartz. The impact point leading to a small removal will leave a small scar behind.
5. Splintering (AST): This is the result of several radial and proximal fissures and which are usually shorter than 2 mm. Splintering is observed in macrocrystalline quartz (NN, NS) and is the result of hammerstone impacts.

6. Edge battering (MCH): On grainy quartz (SN and SS morphostructural groups), percussion points result in a whitish area which is caused by microstriae, quartz dust and partial Hertzian cones formed during the percussion and hammerstone impact. These partial Hertzian cones can be distinct or more diffuse based on the quartz morphostructure, therefore, edge battering is only shown as a whitish area in some varieties of grainy quartz. However, postdepositional effects and weathering can lead to the creation and possible misidentification of edge battering.
7. Scales (ESC): These are micro-flakes which form on ventral and scar surfaces. Breakage surfaces on quartz are not homogeneous, especially on grainy pieces, and internal flaws, gas or liquid inclusions and even crystal shapes create small secondary flaking paths parallel to the main fracture. When these are developed, they can create bulb scars or secondary micro-flaking, if incipient, they form scales which point to the percussion point. Ventral and negative scar surfaces can display many natural microfractures which can also be created by previous removals and are mixed with genuine scales. Hence, scales cannot be used as reliable diagnostic criteria, although they may be regarded as indicative of knapped surfaces.

DISCUSSION

A clear relationship exists between the aforementioned percussion marks and the morphostructure of quartz. Although these scars are present in all quartz types, the inherent morphostructure determines the appearance and association of some of them. As was shown previously, vein formation processes affect the characteristics of quartz, for example, the degree of grain compactness, internal flaws and thermal impact. As a result of this, a certain degree of variability in the scar formation in different varieties of vein quartz can be observed, but these varieties also share the same traits.

The main association occurs between edge battering and SS, as well as SN morphostructural groups, while splintering is related to NN and NS groups (Figure 1.3). Contrary to NN and SN ones, the presence of internal flaws acts as a cumulative factor that increases edge battering on NS and SS groups. The inverse relationship between splintering and edge battering suggests that they are different examples of the same phenomenon which is closely related to morphostructural characteristics. As shown previously, edge battering is produced by percussion impacts of the hammer on the surface of the

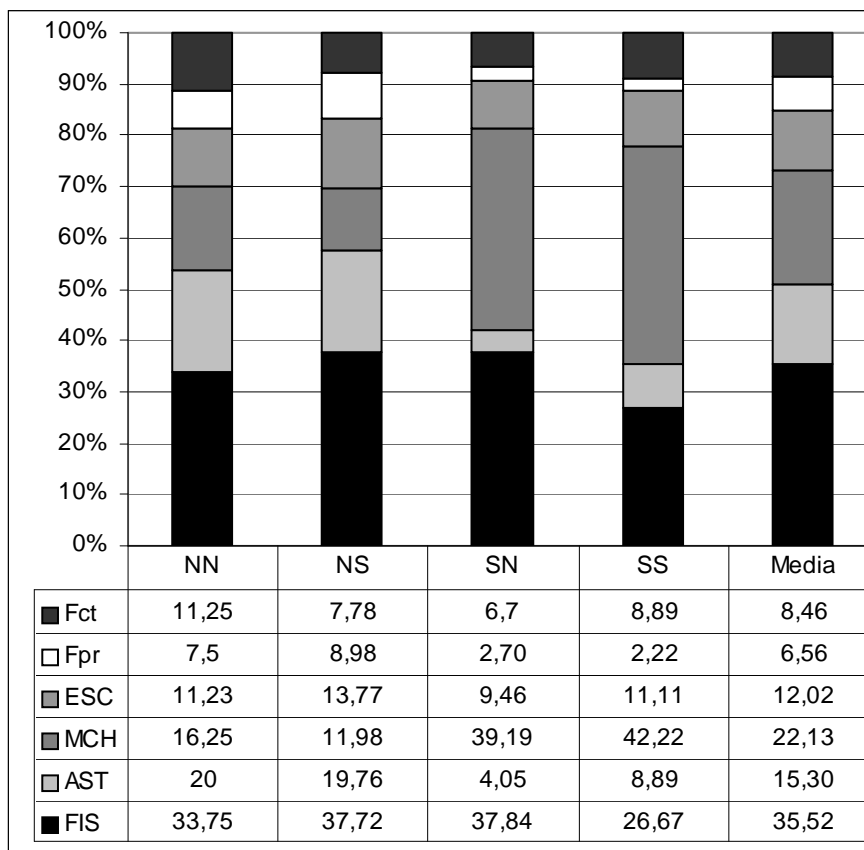


Fig. 1.3. Morphostructural groups and percussion marks on quartz from the archaeological site of Locus I de As Gándaras de Budiño, N= 380 (de Lombera 2005)

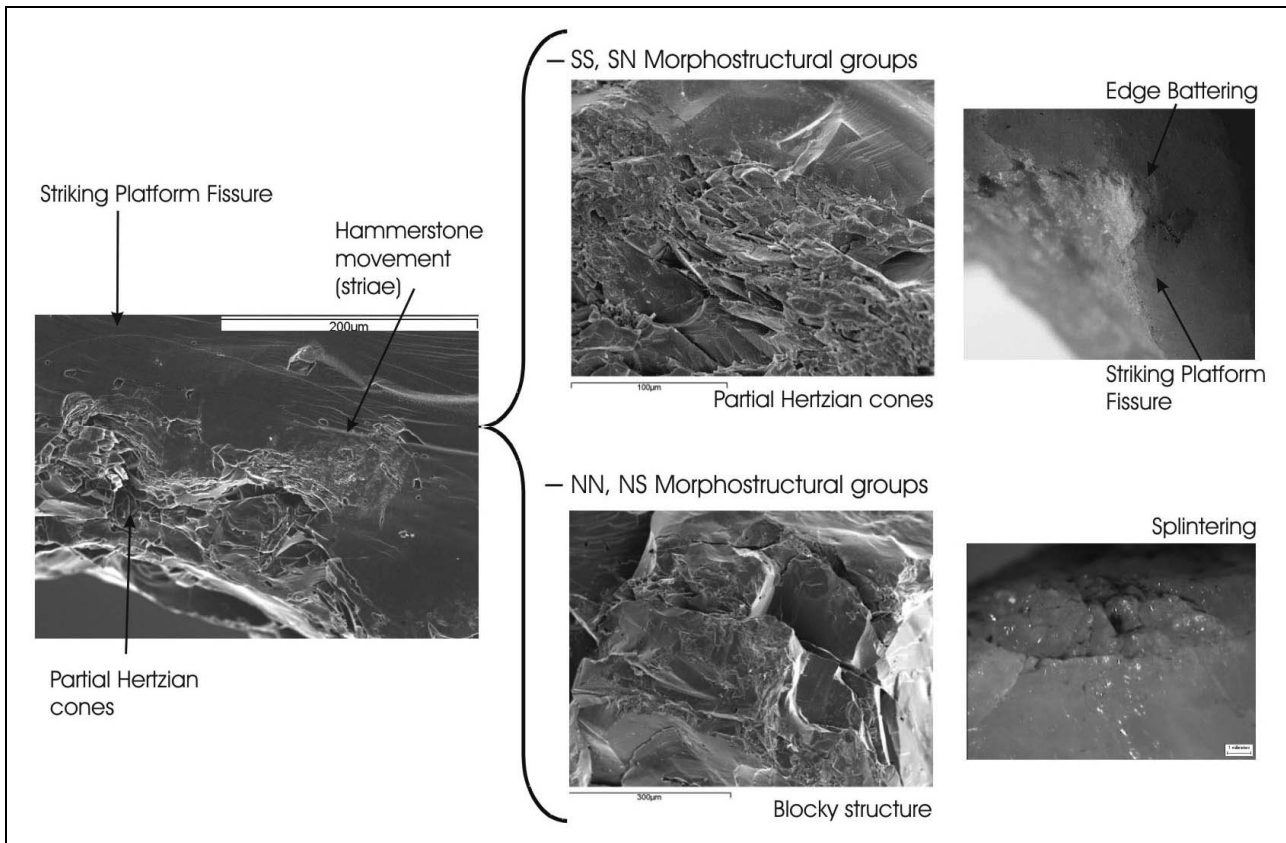


Fig. 1.4. The relationship of fracture mechanics and quartz morphostructure with percussion marks

striking platform, creating partial Hertzian cones (Fig. 1.2j and 1.4). On macrocrystalline quartz (NN and NS), successive radial and transversal fissures occur (splintering) due to its low elasticity, forming a blocky structure around the impact point (Fig. 1.2g and 1.4). Both are partial Hertzian cones manifested in different ways. Regarding the other percussion marks, radial fissures are represented in high percentages in all groups (about 35 to 40 percent). Proximal fissures are related to NN and NS groups, while steps and striking platform fissures, although less constant, are closer to macrocrystalline quartz varieties, especially to those with internal flaws (NS).

Scar formation is closely linked to percussion mechanics and the petrological characteristics of quartz. Proximal and radial fissures, as well as steps are caused by an insufficient elastic response to the percussion and breakage propagation model. This group, although present in all quartz types, is related to macrocrystalline quartz, showing lower percentages in SN and SS groups. This appears to be the result of the grainy texture which absorbs the percussion force more sufficiently, increasing its elasticity and provoking fewer fissures or cracks and roughly following the conchoidal fracture model (*isotropie de compensation*) (Mourre 1996). Similar to these percussion marks, microwear traces on quartz reflect these petrological characteristics: the poor response of quartz to high pressure provokes the

formation of subsurface damage and a high degree of edge fracturing rather than abrasive processes (Derndarsky and Ocklind 2001; Knutsson 1988).

The other scar group is related to hammerstone impact during percussion. Proximal fractures and partial Hertzian cones are produced on the striking platform. One of these parallel cracks will dominate and form the flake breakage plane, while the others create secondary breakage planes leading to micro-flaking which can manifest itself as a small cascade of proximal step scars (Cotterel and Kamminga 1987: 687). On positive fractures, i.e. flakes, a small concavity on the impact point is formed instead of a bulb. This can be observed when the flake is refitted to its scar. Here, the morphostructure plays an important role. On grainy quartz, these scars are related to edge battering, while they are related to splintering and blocky structures on macrocrystalline quartz (Fig. 1.4). Scales are formed when incipient micro-flakes and secondary breakage planes are produced on ventral surfaces.

CONCLUSION

The low elasticity and resistance of quartz blanks to percussion (tenacity) create a particular group of percussion marks, i.e. proximal and radial fissures as well as steps. Morphostructure plays an important role, but some differences are also related to the texture of the

quartz. Grainy textures increase elasticity and decrease the occurrence of fissures and cracks. Conversely, these petrological characteristics cause the appearance of scars related to specific fracture mechanics that can be also observed in flint blanks, such as partial Hertzian cones and micro-flaking. However, they are closely related to the morphostructure of quartz, e.g. edge battering and splintering. All these criteria must be taken into account for the development of a reliable technological analysis of quartz implements that will facilitate an overall understanding of the economic and social selection processes at work and an exploration of their relationship to the variability of prehistoric quartz industries.

Acknowledgements

I thank to Ramón Fábregas, Xose Pedro Rodríguez and Farina Sternke for revising the most obvious shortcomings of the English translation. This work was possible thanks to a research grant from the CaixaGalicia Foundation.

References

- ANDREFSKY Jr, W. (1998). *Lithics. Macroscopic approaches to analysis.* University Press, Cambridge.
- BRACCO, J.-P.; MOREL, P. (1998). – *Outillage en quartz et boucherie au Paléolithique Supérieur: Quelques observations expérimentales* In: *Économie préhistorique: les comportements de subsistance au Paléolithique. XVIIIe Rencontres Internationales d'Archéologie et d'Histoire d'Antibes.* APDCA, p. 387-395.
- COLLINA-GIRARD, J. (1997). – *Les outillages sommaires sur supports naturels tenaces (quartz et quartzites). Technomorphologie et evolution psychique.* In: *Préhistoire Anthropologie Méditerranéennes. Première Table Ronde sur l'Exploitation du Quartz au Paléolithique*(Ed). Université de Provence. CNRS, p. 210-226.
- COTTERELL, B.; KAMMINGA, J. (1987). *The Formation of Flakes.* *American Antiquity* 52(4), p. 675-708.
- DE LOMBERA HERMIDA, A. (2005). – *La gestión del cuarzo en dos yacimientos del Pleistoceno Medio-Superior. El Locus I de As Gándaras de Budiño (Porriño, Pontevedra) y la Jueria (Girona, Catalunya).* Tesis de Licenciatura inédita, Departamento de Historia I. Universidade de Santiago de Compostela, Santiago de Compostela.
- DERNDARSKY, M.; OCKLIND, G. (2001). *Some Preliminary Observations on Subsurface Damage on Experimental and Archaeological Quartz Tools using CLSM and Dye.* *Journal of Archaeological Science* 28, p. 1149-1158.
- GÓMEZ, B.; CARRANCHO, A.; GARCÍA, S.; GARRIDO, D.; RIBA, D.; SALA, R. (2006). – *Nuevos datos de ocupación antrópica del Pleistoceno Medio final en el Noreste de la Península Ibérica: La Jueria (Sant Gregori, Girona)* In: *IV Congreso de Arqueología Peninsular. Septiembre de 2004.*(Ed). Universidade do Algarve, Faro, p. 277-238.
- KNUTSSON, K. (1988). – *Patterns of tool use. Scanning electron microscopy os experimental quartz tools.* Societas Archaeologica Upsaliensis, Upsala.
- LLANA RODRÍGUEZ, C. (1991). *Algunas consideraciones económicas del Paleolítico superior a través de los cuarzos y cuarcitas de grano grueso.* *Gallaecia* 12, p. 29-38.
- LUEDTKE, B.E. (1992). – *An Archaeologist's Guide to Chert and Flint.* University of California, Los Angeles.
- MARTÍNEZ CORTIZAS, A.; LLANA RODRÍGUEZ, C. (1996). – *Morphostructural variables and the analysis of their effect on quartz blank characteristics.* In: *Non-Flint Stone Tools and the Palaeolithic Occupation of the Iberian Peninsula.* Moloney, N.; Raposo, L.; Santonja, M. (Eds). *Tempus Reparatum*, Oxford. 649, p. 49-53.
- MOURRE, V. (1996). *Les industries en Quartz au Paléolithique. Terminologie, Methodologie et Technologie.* *Paleo* 8, p. 205-223.
- NOVIKOV, V.P.; RADILILOVSKY, V.V. (1990). – *Quartz anisotropy in Stone-Age artifacts of the Hissar* In: *Le Silex de sa genèse à l'outil. Actes du V^o Colloque international sur le Silex* (Ed) Cahiers du Quaternaire 17, p. 593-598.
- RAMIL REGO, E.; RAMIL SONEIRA, J. (1996). – *El fin de los tiempos glaciares en Galicia. Magdalenense y Epipalolítico.* In: *Os primeiros poboadores de Galicia: O Paleolítico.* Fábregas Valcarce, R. (Ed). Edicións do Castro, Sada. 73, p. 117-147.
- SEONG, C. (2004). *Quartzite and Vein Quartz as Lithic Raw Materials Reconsidered: A View from the Korean Palaeolithic.* *Asian Perspectives* 43(1), p. 73-91.
- VIDAL ENCINAS, J.M. (1982). *Las Gándaras de Budiño: Balance preliminar de dos campañas de excavaciones (1980-1981).* *El Museo de Pontevedra* XXXVI, p. 91-114.
- VILLAR QUINTEIRO, R. (1991a). *Algunas consideraciones sobre el tratamiento técnico de los cuarzos presentes en yacimientos del Paleolítico Superior de Galicia y Asturias. Características de estos soportes.* *Gallaecia* 12, p. 39-50.
- VILLAR QUINTEIRO, R. (1991b). – *Identificación y estudio de la industria lítica del nivel 1 de la Cueva de A Valiña* In: *Cova da Valiña (Castroverde, Lugo). Un xacemento do Paleolítico Superior en Galicia* (campañas de 1987 e 1988). Llana, C; Soto, M.J. (Eds). Xunta de Galicia, Santiago de Compostela. 5, p. 55-84.
- VILLAR QUINTEIRO, R. (1997): *El Paleolítico Superior y Epipaleolítico en Galicia.* *Zephyrus* 50, p 71-106.

