

Stone procurement and transport at the late Early Pleistocene site of Cueva Negra del Estrecho del Río Quípar (Murcia, SE Spain)

Rohmaterialbeschaffung und -transport am späten frühpleistozänen Fundplatz von Cueva Negra del Estrecho del Río Quípar (Murcia, SO Spanien)

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ABSTRACT - The late Early Pleistocene deposit, dating from ca. 0.8-0.9 Ma, at Cueva Negra del Estrecho del Río Quípar in Murcia, Spain, contains an abundant assemblage of small flaked artifacts of chert, quartzite and limestone, and one bifacially-flaked limestone hand-axe. We have investigated several possible sources of the chert in an attempt to throw light on Palaeolithic interaction with the environment. Possible sources on the landscape were sampled at distances of up to 30 km from the site. Trace-element fingerprints were analyzed by laser-ablation inductively-coupled plasma mass-spectrometry (ICP-MS). Factor analysis was used to differentiate between sources and as a pointer to where chert analyzed from the cave may have been obtained. Our initial assumption was that most had come from less than 1 km away, namely, from a conglomerate outcrop where chert nodules could be quarried readily. Whilst trace-element evidence supports that hypothesis, it also points to a fair likelihood that some recovered chert lithics had been brought from sources up to 30 km away from the cave. Although evidence is scarce for transport of stone from a similar distance at other late Early Pleistocene sites in Europe, it nevertheless is present in the archaeological record, particularly in Spain where it may be possible to begin to consider differences in stone-procurement strategies between late Early Pleistocene technological assemblages.

ZUSAMMENFASSUNG - Die ins ausgehende Frühpleistozän (ca. 800 000-900 000 Jahre) datierenden Schichten der Fundstelle Cueva Negra del Estrecho del Río Quípar in Murcia, Spanien lieferten ein umfangreiches Inventar kleiner Abschläge aus Silex, Quarzit und Kalkstein sowie einen beidflächig bearbeiteten Faustkeil aus Kalkstein. Verschiedene mögliche Aufschlüsse des Silexrohmaterials wurden untersucht, um Hinweise auf paläolithische Landnutzungsmuster zu gewinnen. Potentielle Aufschlüsse wurden bis zu einer Entfernung von 30 km von der Fundstelle aus beprobt. Spurenelemente der Proben wurden mit Hilfe der Massenspektrometrie mit induktiv gekoppeltem Plasma (ICP-MS) untersucht. Über eine Faktorenanalyse wurde die unterschiedliche Zusammensetzung des Materials aus den geologischen Aufschlüssen untersucht und mit dem Silexrohmaterial aus der Fundstelle verglichen. Die Ausgangsüberlegung war, dass die Mehrzahl des Materials aus einer Entfernung von weniger als 1 km stammt, aus einer Zone mit Konglomeraten, in der Silexknollen leicht beschafft werden können. Die Ergebnisse der Massenspektrometrie bestätigen diese Vermutung, weisen aber mit einiger Wahrscheinlichkeit auch auf Aufschlüsse hin, die in einer Entfernung bis zu 30 km von der Fundstelle liegen. Von anderen Fundplätzen des ausgehenden Frühpleistozäns in Europa liegen kaum Hinweise auf einen Materialtransport über so große Entfernungen vor. Sie sind aber gerade in Spanien im archäologischen Kontext nachweisbar und eröffnen die Perspektive über unterschiedliche Beschaffungsstrategien von Rohmaterial im Frühpleistozän nachzudenken.

KEYWORDS - Late Early Pleistocene, ICP-MS, Factor analysis, procurement, chert
Spätes Frühpleistozän, ICP-MS, Faktorenanalyse, Rohmaterialbeschaffung, Silex

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Introduction

Provenance studies of raw material used for making stone artifacts is an integral part of the analysis of Palaeolithic sites. Such studies have been conducted from the earliest stone-tool assemblages in Africa, such as at Kada Gona, Ethiopia, ca. 2.6 Ma (de Heinzelin et al. 1999; Semaw 2000; Panger et al. 2002; Domínguez-Rodrigo et al. 2005). Tykot (2004) has listed many of the archaeological materials that have been the object of provenance studies, several of which relate to stone tools. Such studies are of particular interest to palaeoanthropologists, who often seek to infer Palaeolithic techno-economic strategies, foraging behaviours, mobility patterns, territorial size, planning, cognition, and social exchange, by reference to practices by modern hunter-gatherers documented by ethnographers (Brantingham 2006). Comparisons between different contemporaneous Palaeolithic techno-groups, made from the standpoint of their associated artifact industries, might allow plausible conjectures to be put forward about the likely behaviours of Palaeolithic communities or even perhaps about interactions between neighbouring ones. Prudence requires, nevertheless, that sceptical scientific scrutiny must be satisfied with regard to both precision and accuracy before meaningful spatiotemporal contemporaneity can ever be acknowledged such that it might be commensurable with the contemporaneous variability in the ethnographical record of recent times. The hope is that plausible conjectures may lead to proposals of limited working hypotheses for testing by future archaeological research.

On the very long time-scale of the African Palaeolithic, with regard to the Oldowan a manifest increase in technical complexity is seen both when "Acheulian" bifacial reduction of stone appeared, ca. 1.7 Ma at Kokisilelei in Kenya (Roche et al. 2003; Lepre et al. 2011), which spread to 'Ubeidiya in Israel and Attirampakan in India ca. 1.5-1.4 Ma (Bar-Yosef and Goren-Inbar 1993; Paddaya et al. 2002; Pappu et al. 2011), and again when "Levalloisian" core-reduction by centripetal flaking appears, ca. 1.3 Ma at Peninj in Tanzania (de la Torre et al. 2003) and at Pirro Nord 13 in Italy (Arzarello et al. 2012). In this regard, it is worth quoting de la Torre et al. (2003), *"For the Peninj Oldowan industries, the idea of the Levallois core obtained by multiple flaking, or Levallois core of recurrent centripetal flaking (Boëda 1993, 1994) is applicable... If Boëda's definition is applied, the technology of the Peninj assemblage would be similar to the Levallois technology; a strategy seemingly typical of later periods. This similarity is observed not only when applying Boëda's criteria, but also when applying the Levallois phases as defined by van Peer (1992). According to him, in the Levallois cores, the original volume of the striking platform is larger than that used for the flaking surface. Therefore, through the whole*

reduction sequence, the core assumes an asymmetrical profile. From the beginning of flaking, each surface adopts a specific role (striking/flaking) not being exchangeable during the reduction process... Once more, the concepts proposed to define Levallois coincide with the features represented in the Peninj Oldowan. The flaking process at Peninj shows continuous stabilization of the hierarchy of both surfaces. This indicates planning in the core flaking sequence... It might not be very useful what can be considered truly Levallois. It is an old debate still unresolved... The technology displayed by the Peninj hominids is fairly complex. Whether this clearly structured and planned set of strategies can be defined as Levallois or not is not relevant, as long as the complexity of the processes involved is assumed" (our emphasis). In like manner we use here "Levallois" *sensu lato*, and specifically we consider it as an appropriate shorthand way of referring to the centripetal flaking of *small* discoid cores such that they bear a central negative scar corresponding to the last flake ("*éclat préférentiel*") to have been struck from them; we have no strong objection to referring to them as both proto-"Levallois" from a *chronological* standpoint at the same time as simply "Levallois" from a *formally descriptive, technological* viewpoint.

Plausibly, ever-widening foraging ranges eventually led to intercontinental dispersal of humans who were capable of knapping stone in complex fashion and sometimes may have taken stone, perhaps for particular purposes, from places not necessarily close to where groups of people spent most of their time together. In Early Pleistocene Africa the maximum distances over which stone raw materials were transported seem to have been greater for "Acheulian" assemblages than for Oldowan ones. Although some of the latter (at Olduvai, Koobi Fora, and the Kanjera Formation) contain artifacts on raw material obtained from as far away as 15 km (Mgeladze et al. 2011; Braun et al. 2008, 2009; Leakey 1971), most sources of stone were no more than 1-3 km from the sites. Some African "Acheulian" assemblages include stone taken from over 15 km away; indeed, at the Olduvai sites of JK, HEB, and Kelogi, and at Gwelo in Zimbabwe, some stone is of raw material that must have been transported over 43 km and even 100 km (Feblot-Augustins 1997). Nevertheless, bifacially-flaked ("Acheulian") artifacts were made on stone obtained close to several Early Pleistocene and early Middle Pleistocene sites in Africa and Asia (Lepre et al. 2011; Paddaya et al. 2006; Roche et al. 2003; Sharon 2008). In Europe systematic provenance studies from Early Pleistocene archaeological sites are scarce, which is a consequence of the small number of sites discovered (cf. Díez-Martín 2007).

Although the term "Oldowan" has been applied to several European assemblages it is best avoided because sometimes it is applied to assemblages that are not altogether commensurable with African

Oldowan ones that typically consist not only of large flakes but also of flaked cobbles, choppers, trihedral picks and large spheroids. Therefore it is inadvisable to apply the term to European assemblages of *small* chipped artifacts simply because they are of irregular shape; these are sometimes called “informal” artifacts to distinguish them from bifacially-flaked artifacts. In Spain, five Early Pleistocene assemblages have “informal” artifacts. They are the Sierra de Atapuerca sites in Burgos dating from ca. 1.3–0.8 Ma of Sima del Elefante (Carbonell et al. 2008; Parés et al. 2006; Rosas et al. 2006) and horizons TD-6,8,9,10 of the Gran Dolina (Carbonell et al. 1995, 1999; Mallol 1999; Terradillos 2010), the site in Catalonia of Vallparadís dating from ca. 0.8 Ma (Martínez et al. 2010), and the sites near Orce in Granada of Fuente Nueva 3 and Barranco León 5 dating from ca. 1.2 Ma (Carbonell and Rodríguez 2006; de Lumley et al. 2009; Fajardo 2009; Gibert et al. 1998; Martínez-Navarro et al. 1997; Oms et al. 2000; Toro-Moyano et al. 2010). Of particular interest is the site near Caravaca in Murcia of Cueva Negra del Estrecho del Río Quípar (Cueva Negra) (Walker et al. 2013) that has an excavated assemblage dating from 0.9–0.8 Ma of small flaked artifacts of chert, quartzite, and limestone (but only one “Oldowan”-like chopper). They show much in common both with those from penecontemporaneous Vallparadís and also the Italian Early Middle Pleistocene site of Isernia La Pineta (cf. Crovetto 1994). Unlike these two assemblages, however, the Cueva Negra assemblage also contains a bifacially-flaked limestone (“Acheulian”) hand-axe. Less than 150 km away, in the Guadiz-Baza Basin of Granada, an assemblage dating from the onset of the Middle Pleistocene containing a hand-axe was excavated at Solana del Zamborino (Botella et al. 1976; Santonja and Villa 2006; Scott and Gibert 2009). Similarly, Cueva Negra and Solana de Zamborino have evidence of fire (Botella et al. 1976; Walker et al. 2013).

For most of those Spanish sites, only general interpretations have been offered about where lithic raw materials could be found in their surrounding landscape. For the most part, procurement was from nearby sources, rarely more than 2 km away (Carbonell et al. 1999; Turq and Martínez-Navarro 2000; Carbonell et al. 2008; Barsky et al. 2010; Martínez et al. 2010), with little evidence for longer distance transport. Research techniques with good discriminatory power are called for in order to identify possibly distant sources of raw material, which then perhaps might allow comparisons to be drawn between late Early Pleistocene sites or regional complexes. Given their geographical proximity in the eastern part of the external Baetic mountain range, a brief comment may be in order on Fuente Nueva 3, Barranco León 5, Cueva Negra, and Solana del Zamborino (for which there is less published information): whereas stone seems to have been acquired nearby at Fuente Nueva 3 and Barranco León, some

pieces at Cueva Negra may have come from up to 30 km away (cf. the Middle Pleistocene “Acheulian” sites of Torralba and Ambrona in northern Spain: Santonja and Pérez-González 2010).

Cueva Negra is one of the earliest assemblages containing a bifacially-flaked (“Acheulian”) stone tool to have been found in Europe. As the ever-prudent scientist Aristotle said, “*One swallow does not a summer make*”, and, indeed, a few well-known Palaeolithic archaeologists have been unwilling to label any African site as “Acheulian” unless half of its chipped stone artifacts show bifacial flaking, though such a condition seems excessive (D.A. Roe, personal conversation) and may well be inappropriate in Europe. Nonetheless, most chipped stone artifacts at Cueva Negra are “informal” or “expedient” and of irregular shape, measure no more than 5 or 6 cm across, and lack edge-retouch. A few also have steep abrupt (“Mousteroid” or “Mousterioid”) retouch. There are a few flakes and cores that point to centripetal repetitive (“Levalloisian”) flaking (cf. de la Torre et al. 2003). It is worth mentioning that “Mousteroid” or “Mousterioid” appear in English-language archaeological publications (e.g. Aigner 1978; Coles and Higgs 1969; Zeuner 1945, 1953, 1958; Müller-Beck 1967; Shaw 1981) and testify to the accurately *descriptive* function of language first and foremost, notwithstanding an opinion that these words either do not or should not exist. We consider them appropriate for artifacts, whether on flakes or fragments, some of which are characterized by steeply retouched edges, others by notched or denticulate edges (“side-scrapers”), and yet others which have keeled (“*limace*”-like) shapes or pointed (“*Tayac*”) shapes and beaked pieces (“*becs*”). We prefer to confine ourselves to drawing attention to technical similarities, and to avoid any hint of ancestry or antecedence that otherwise might be conjectured from application to assemblages of such artifacts by terms such as “Mousterian-like” (Wymer 1982), “pre-Mousterian” (Gamble 1986), or “archaic Mousterian” or “atypical Mousterian”, although it may be in order to remark that comparison with characteristically Mousterian “Charentian” artifacts has been drawn even at such early Middle Pleistocene sites as Caune de l’Arago in southern France (de Lumley 1971, 1975, 1976) and High Lodge in England (Roe 1981, 238). In purely *technologically descriptive* terms only (which certainly do not imply any narrative conjecture of “cultural affinity”, whatever this might mean), we labelled the Cueva Negra assemblage “Acheulo-Levalloisio-Mousteroid” (Walker et al. 2006, 2013).

Site background

The rock-shelter of Cueva Negra del Estrecho del Río Quípar, or Black Cave of the R. Quípar Gorge (at 39° 02' 5" N, 1° 48' 10" W), opens in an Upper Miocene biocalcarene N-facing cliff, at 740 m above sea-level

and 40 m above the R. Quípar flowing N out of the gorge at La Encarnación, a hamlet near Caravaca in NW Murcia (Walker et al. 2013). The river follows the Quípar Fault (part of the extensive, tectonically active, Cadiz-Crevillente Fault system traversing southern Spain from the Atlantic to the Mediterranean). Nowadays the Murcian region has a sub-humid to semi-arid climate, and a thermomediterranean flora with some supramediterranean taxa. However, remains excavated in the 5 m deep Early Pleistocene sediment in Cueva Negra testify to former biodiversity, flora and fauna indicating gallery woodland beside rivers and lakes, because pollen of holm oak and pines, widespread today, is accompanied by that of elm, ash, willow, beech, hazel, maple, rushes, and a deciduous oak (Carrión et al. 2003, 2005) that provided the acorns required by jays (*Garrulus*) whose bones, along with those of waterfowl (*Tadorna*, *Anas*, *Netta*, *Aythya*) and waders (*Calidris*, *Tringa*), themselves silent testimony to vanished wetlands, are among 66 bird species (Walker et al. 1998, 1999, 2004). Pollen and birds indicate different biotopes near the site: lakes and rivers with temperate woodland; open mixed woodland; open grassland and moorland; and mountainsides covered with scrub and evergreen trees.

Upstream and downstream geological traces of Pleistocene lakes are widespread; tectonic activity and uplift drained them. Hundreds of metres of uplift have occurred since the later Miocene when the Tethys Sea bathed today's valley floors and the foothills of 1,500 m high mountains of Jurassic limestone. Uplift caused great continental erosion in Upper Pliocene and Early Pleistocene times; this matter is relevant to Palaeolithic procurement. The trapezoidal shape of Cueva Negra resulted from endokarst phreatic solution of horizontal fracture-planes and rectilinear fissures (cave-wall "scallopings" and other karst features occur) in Upper Miocene (Tortonian, 11-7.5 Ma) marine biocalcarene strata underneath the Lower Pliocene wetlands that were forming behind newly-emerging sea-shores. Vertical shearing at the Quípar Fault, with differential uplift of the left and right flanks, and ensuing erosion, doubtless exposed the rock-shelter. When fluvial sediment accumulated within, Cueva Negra lay near the water-table; later on, tectonic activity and uplift saved the sediment from erosion by flood-waters.

A new account (Walker et al. 2013) has superseded all previous ones (Walker et al. 1998, 1999, 2004, 2006), because Cueva Negra is now known to be far older than thought hitherto: all of its 5 m deep sediment shows reverse magnetic polarity, thus antedating the 0.78 Ma Matuyama-Brunhes boundary (Scott and Gibert 2009). Abundant extinct arvicolid rodent teeth, found throughout the 5 m depth, belong to the same species found in Atapuerca Gran Dolina TD4-TD8 levels spanning the Matuyama-Brunhes boundary (Walker et al. 2013). Cueva Negra mammals

include *Miomys savini*, *Pliomys episcopalis*, *Microtus* [*Allophaiomys/Euphaiomys*] sp. cf. *chalconi*, *Microtus* [*Allophaiomys/Arvicola*] sp. cf. *deucalion*, *Microtus* [*Terricola/Pitymys/Iberomys*] *huescarensis huescarensis*, *Microtus* [*Iberomys*] *breccensis breccensis*, *Microtus* [*Stenocranius*] *gregaloides*, *Prolagus calpensis*, *Megaloceros* sp., *Dama* sp. cf. *nestii vallonnetensis*, *Equus* sp. cf. *altidens* (or perhaps *sussenbornensis*), *Stephanorhinus* sp. cf. *etruscus*, *Bison* sp. cf. *priscus*, *Macaca* sp. cf. *sylvanus*, Elephantidae [*Mammuthus meridionalis?*], *Ursus* sp., Hyaenidae gen. et sp. indet., Cervidae gen. et sp. indet., *Capra* sp. cf. *ibex*, *Sus scropha*, *Canis* sp. cf. *mosbachensis*, *Felis* [*Lynx*] cf. *lynx*. Faunal analysis is still in progress. Some species from older Early Pleistocene Spanish sites are lacking, hence Cueva Negra probably postdates the (1.07-0.99 Ma) Jaramillo normal polarity episode. Palaeopalynology indicates a warm, moist environment (Carrión et al. 2003, 2005); the new palaeomagnetic dating may imply MIS (OIS) 21. Non-modern human teeth show morphological affinities with Neanderthal ones and so may be "pre"-Neanderthal (i.e. *Homo heidelbergensis*); it may be worth remarking that the contemporaneous *H. antecessor* from the Atapuerca Gran Dolina (ca. 0.78 Ma) may be an early instance of the *H. heidelbergensis* - *H. neanderthalensis* lineage (Dennell et al. 2011; Rightmire 2001).

Disturbed loose soil (unit I) covers 5 m of un-disturbed Pleistocene lithostratigraphical units "II-VI" that, as regards III-IV-V, less reflect distinctive lithological entities than fieldwork methodology, guided by a "precautionary principle", when vughs, calcareous marls, crusts, or fine gravel were encountered during step-wise open-area excavation (Fig. 1). Most sediment is incompletely consolidated, beige-coloured litharenite (not cemented quartz sand because silica particles are outnumbered by CaCO₃ particles in 1:3 or 1:4 proportions). The strongly indurated unit II (1.5-1.8 m thick) comprises near-horizontal cross-bedded fine bands or lenses of silt- and sand-size particles with sparse coarser components. As in deeper units, sedimentary interfaces are hard to pin down and often ephemeral, owing to uniformity of sedimentological components, weak differences between lithofacies, and lateral discontinuities of intercalated bands and lenses. One exception separates unit II from III which ends in an undisturbed eroded surface, disclosed over 12 m², of grey sediment that suggests reducing conditions, caused, perhaps, by organic development or ponding after incursion of a nearby swamp. Minerals and rock fragments are broadly similar throughout units II-VI; alongside clasts (including Miocene marine fossils) derived from the cave walls/roof, there are plagioclase, polycrystalline quartz aggregates, and isolated quartz crystals (with different optical characteristics to quartz from the cave wall, inspected under polarized light using the petrological microscope), which doubtless came from a sandstone outcrop affording

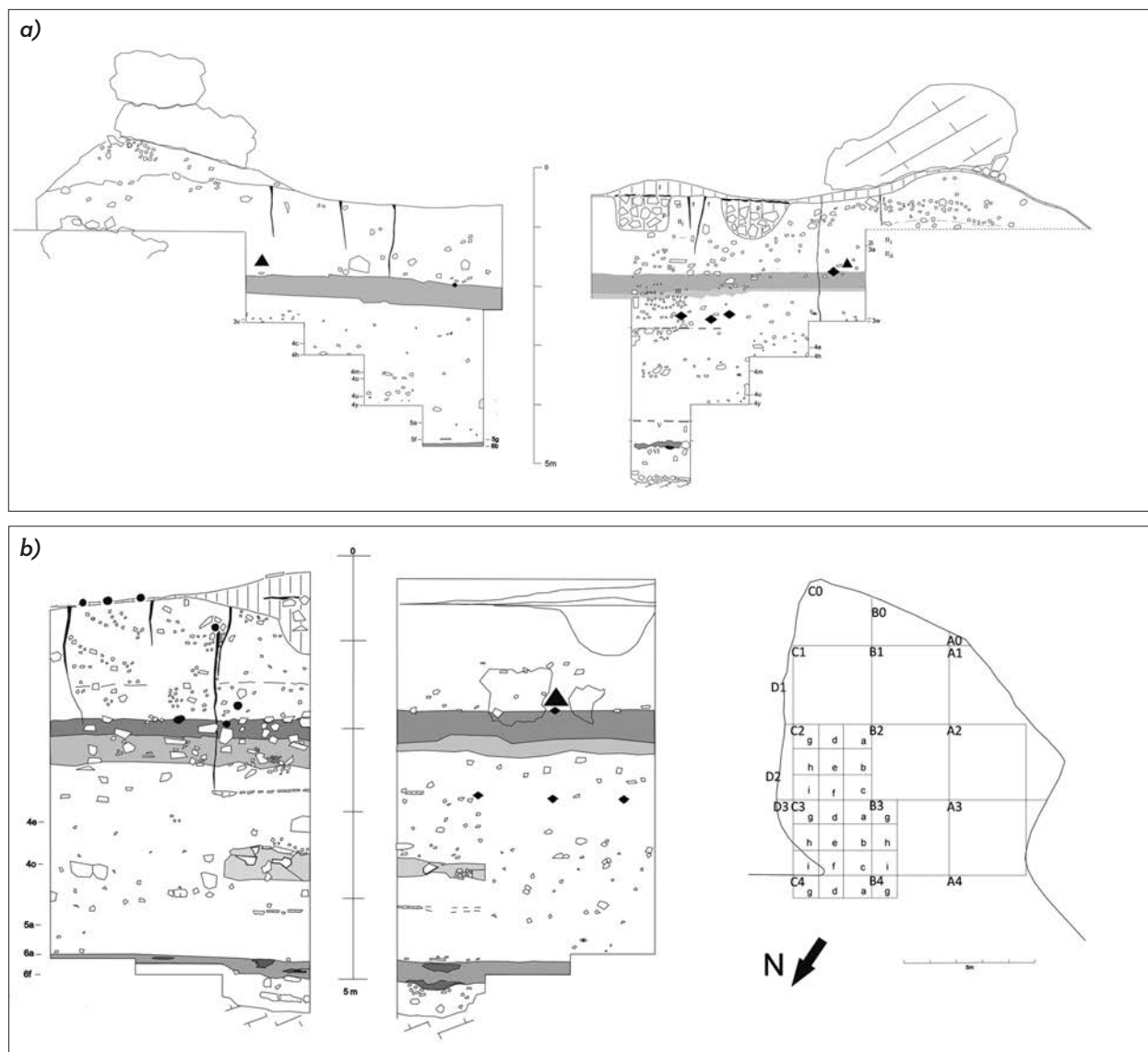


Fig. 1. Cueva Negra: stratigraphical sections. a) E and W vertical sections; b) S and N vertical sections and plan of rock-shelter showing excavated area, and near the base of these sections there occurs the layer with remains of combustion (heat-shattered thermally-altered chert and calcined animal bones). Black triangle = hand-axe. Black lozenges = some flakes struck by centripetal repetitive flaking. Black dots = rounded cobbles. Lithostratigraphical units I – VI are indicated in Roman numerals. (Arabic numerals and letters refer to arbitrary spits during excavation.) Bottom right: plan of rock-shelter showing area under excavation.

Abb. 1. Cueva Negra: Profile; a) Ost und West-Profil; b) S und N-Profil sowie der Umrissplan des Abris mit dem Grabungsareal; an der Basis der Profile liegen Schichten mit Brandresten (durch Hitze zersprungene Steinartefakte und kalzinierte Tierknochen). Schwarzes Dreieck = Faustkeil, schwarze Raute = Abschlüge durch regelhafte, zentripetale Abbaustrategie; schwarze Punkte = verrundete Gerölle. Die Hauptfundsichten I-VI tragen römische Ziffern.

those 2 km upstream (Walker et al. 2006, 2013). Earth scientists (Angelucci et al. 2013; Walker et al. 2006, 2013) on inspecting the Cueva Negra sediments regard their near-flat bedding, with neither lenses of sorted rolled gravels (river cobbles) nor graded angular clasts (piedmont scree), as indicating gradual cave-mouth infilling by intermittent flooding and low transport energy, albeit with contributions from erosion of the cave wall and adjoining hillside. These are considered more significant by Scott and Gibert (2009) who also regarded Cueva Negra as a tafone, whereas it belongs to a group of trapezoidal endokarst rock-shelters close together on the eastern flank of the

R. Quípar which include the Cueva del Rey Moro or Moorish King's Cave, in contrast to 15 ellipsoidal rock-shelters opposite Cueva Negra, on the western flank, that resemble *tafoni* (and others lie behind and above them, far beyond, high on hillsides west of the river). The cave probably received sediment when water-levels rose intermittently in a swamp beside it, maybe in a backwater behind a sand-bank of the river when its flood-plain was level with the cave mouth, before tectonic activity caused the present-day 40 m vertical displacement between cave and river. Washed into the cave were some loess-size particles showing microscopical pitting due to weathering, probably blown

into swampy sediment ("*Diluvialloess*") from afar. Occasionally, tiny rolled gravel (of grape/orange-pip size) was washed into the cave and incorporated into the surfaces of underlying sediment, especially where these were eroded or softened, and calcretions sometimes formed. In marked contrast, almost no rolled pebbles between 5 and 50 mm in size have been excavated. On the other hand, *larger*-sized rounded cobbles were brought in by Palaeolithic knappers who often split them open in the cave (no rounded pebbles of any size exist in the biocalcarene cave walls). Sharp edges of stone artifacts and hundreds of razor-sharp knapping spalls (<2 mm) excavated show there was no river-bed abrasion. Cueva Negra doubtless was dry for several months each year, when Palaeolithic activity occurred. Excavation in a deep metre-square in 2011 (>4 m below the top of unit II) found unit VI to begin with 0.5 cm grey sediment containing signs of thermal alteration, heat-shattered chert, white calcined bone, and small lenses of dark sediment (Walker et al. 2013). Underlying layers are seen in a vertical section of an adjoining metre-square test-pit, excavated down to bed-rock, namely 1 cm of very dark sediment above 2 cm of reddish sediment (followed by 45 cm of pale sediment above bed-rock) though the two thin layers barely extended into the test-pit where only irregular lenses of dark sediment had been identified. Exploration of unit VI in adjoining squares will occupy future campaigns.

Analysis of the Palaeolithic assemblage (excavated systematically between 1990 and 2011 in units II-VI with wet-sieving of excavated sediment down to 2 mm) affords interesting comparisons, as regards rock types, numbers of different artifact types excavated, and especially their relative *densities* in units II-VI (taking account of the consequence of the step-wise open-area excavation in progress that results in volumes of sediment removed from units II-III surpassing those from IV-V-VI). Interestingly, the highest density corresponds to III, in contrast to II and IV which show low densities (densities are meaningless for V and VI, reached as yet in but two out of 25 metre-squares opened; and in VI numerous tiny heat-shattered splinters are not due to knapping). The relation between low density in unit II and high density in III is the opposite of what would be anticipated were most of the entire assemblage due to use of the cave *after* the surface of unit III underwent erosion. The typological breakdown of lithic elements excavated in units II-VI points far more to similarity among units than to discontinuity between any of them, least of all between II, III and IV. Briefly stated, there is a *consistent* Palaeolithic assemblage throughout the sequence (Walker et al. 2013; *pace* Jiménez Arenas et al. 2011).

As remarked earlier, prudence warns against calling the assemblage either "Acheulian" or "Oldowan". Cueva Negra has so far provided just one

bifacially-flaked hand-axe and just one chopping tool therefore making it unlike either type of African assemblage. In formal *descriptive* terms (Walker et al. 2006, 2013), the assemblage can be called "*Acheulo-Levalloiso-Mousteroid*" because it contains a bifacially-flaked ("*Acheulian*") hand-axe, many chert and some fine-grained limestone and quartzite small tools, of which some show steep, abrupt marginal ("*Mousteroid*") edge-retouch, and a few flakes that were removed from small cores by repetitive ("*Levalloisian*" *sensu lato*), including centripetal, flaking. Using italics and inverted commas indicate that those short-hand tags are *analogies* for considering manual techniques; they imply neither assignment nor equivalence to (much less identification with) discrete technocomplexes which received spatiotemporal referents. In any case, gradual evolution of human cognitive versatility and manual dexterity implies that some ancient assemblages could well include production of a few artifacts that were crude ("*atypical*") precursors of some artifacts that were developed repeatedly later on when they became widespread in the Palaeolithic record.

A small ("*Levalloisian*" *sensu lato*) limestone discoidal core was found near the cave mouth and another of chert was collected 0.8 km to its east at what was probably a procurement or "quarry" site; both have the characteristic central concave scar corresponding to the convex ventral bulb of the last flake ("*éclat préférentiel*") struck from it by a repetitive centripetal core-reduction sequence. The "quarry" is an Upper Miocene (Tortonian) marine in-shore conglomerate outcrop, containing chert, limestone, quartzite, and quartz nodules eroded out of the Jurassic rocks of nearby cliffs: retouched artifacts collected here resemble others from the cave. Despite the "quarry" conglomerate outcropping at the same height above sea-level as Cueva Negra 0.8 km away, there it lies 15 m *below* the mouth of the rock-shelter because neotectonic activity has caused the conglomerate bed to dip steeply (this steepness was underestimated in earlier publications, leading to erroneous inferences and confusion). Most Cueva Negra artifacts are "expedient", or "informal" in shape, suggesting "opportunistic" or "eclectic" technological behaviour. Retouch occurs as often on excavated fragments, as on struck flakes defined by striking platforms and bulbs of percussion. That is unsurprising, given that at 0.8 Ma secant-plane control was in its infancy worldwide, and raw materials to hand were mainly frangible tabular chert nodules, blocks or slabs of sub-parallelepiped shape. These might be called *fissural* because hammering on them often fails either to elicit conchoidal fractures or produce feathered flakes with convex bulbs of percussion ("*Fissural*" (adj.), entered under "Fissure". (Stein 1981, 537). If hammering does not merely shatter blocks into tiny chips and fragments, it may split them open along fissures or fissural flat planes, defined by the internal structure

and impurities of the chert, to produce flattish, sub-rectangular laminar pieces, useful as small tools. Eroded by the Miocene sea from Jurassic rocks exposed as cliffs on mountainsides nearby, the nodules underwent Miocene, Pliocene and Early Pleistocene rolling and battering, during processes of first marine, and then continental erosion and re-deposition in conglomerates or gravels.

Cueva Negra artifacts mostly are <5-6 cm in size (some are <3 cm) and only one chopper occurs. It is therefore inappropriate to claim analogy with the African Oldowan, not least because a bifacially-flaked ("Acheulian") hand-axe, with fresh edges, bifacially-fashioned on a flat cobble, of hard micritic Jurassic Lower Middle Lias limestone was excavated from an undisturbed situation deep in unit II just above the erosion surface of unit III, in a small area with many knapping spalls, bone fragments, and a human tooth (Walker et al. 2006). Furthermore, "Levalloisian" flakes of good quality chert (<6 cm long) come from unit III (ibidem), including: (a) a triangular flake that is a typical example of centripetal flake-removal, with 2 dorsal crests converging on a short single crest leading to the apex of the triangle (in inverted-Y form, indicating prior removal of a small triangular flake), which is either a "second-order *Levallois* point", or a "pseudo-*Levallois*" pointed triangular flake nevertheless "characteristic of particular techniques of preparing the surface of a *Levalloisian* flake core" (cf. Boëda et al. 1990; Debénath and Dibble 1994: 52; Mellars 1996: 65-66), with a retouched dorsal margin of the plane striking platform (to assist hafting?); (b) a sub-square flake with a striking platform prepared with 3 facets of "three-corned-hat" (French: "*chapeau de gendarme*") type; and (c) an oblong flake with 2 well-separated dorsal-surface crests delimiting a flake scar indicating prior removal of a flake, struck probably from the main striking platform or nearby. From unit III there is an elongated, keeled, planoconvex, chert "proto-*limace*". In short, "Levalloisian" core-reduction and flake-preparation techniques occur at a greater depth than that of the "Acheulian" hand-axe, hence ancient contemporaneity of both types of core-reduction is clear: "*façonnage*" (core-tool fashioning) and "*débitage*" (flake-artefact production) core-reduction techniques coexisted >780,000 a (>0.78 Ma). Cueva Negra calls into question a time-honoured methodological notion that a European "Early" Palaeolithic with bifacial core-tools had to precede a "Middle" Palaeolithic with "*Levalloisian*" flake-removal or application of steep abrupt "*Mousteroid*" edge-retouch to flakes.

Cueva Negra small artifacts fall into broad groups with some overlap between them. A sizeable one comprises flakes and flattish or laminar rectangular fragments, with edges often showing steep abrupt ("*Mousteroid*") retouch, typical of "side-scrapers"; steep retouch of the perpendicular edge of laminar fragments can transform it into an acute angle useful for cutting or scraping. It is well-known, of course, that

steep retouch applied to thin feathered flakes may spare them from the fate of accidental breakage by snapping during use, but well-formed feathered flakes with edge-retouch are uncommon at Cueva Negra. Serrated, notched or denticulate edges are common, particularly pieces with one or two large notches. Semi-invasive retouch is uncommon. Steep retouch occurs on several pointed pieces; some are flattish and might be envisaged as fine points, "awls", or "perforators"; others resemble thick ("*Tayac*") "points" often seen in Middle and early Late Pleistocene European assemblages. Common also are "*becs*"; these are usually small chunks of chert from which a delicate elongated tiny spur, or beak, projects incongruously. There are also many steeply-keeled fragments; some resemble steep scrapers on short stumpy cores; others, knapped into an elongated keeled planoconvex shape, can be called "proto-*limaces*". *Limaces* may be interpreted as convergent steep scrapers or as thick double points when both ends are pointed. However, researchers at Isernia La Pineta considered that both "*becs*" and "*limaces*" are merely what are left behind after cores had been reduced by bipolar knapping techniques in order to remove extremely small flakes for subsequent use as unretouched tools (Crovetto 1994; Crovetto et al. 1994; Peretto 1994; Peretto et al. 2004). At Cueva Negra flakes produced by bipolar knapping have been identified but not quantified; this is because quantification of bipolar elements would depend on whether carinated pieces with notches, spurs ("*becs*") or planoconvex double-ended "*limace*" shape, are primarily an outcome of bipolar core-reduction to remove flakes for use, or, instead, were primarily implements fashioned intentionally as such; to complicate matters further, these possibilities need not be mutually exclusive. At Isernia La Pineta researchers argued cogently for the first possibility to interpret artifacts excavated there, which they corroborated by microscopical use-wear analysis and experimental knapping. Nonetheless, elsewhere in the world ostensibly similar lithics, widely separated in both time and space, are interpreted as implements, and microscopical use-wear analysis sometimes has corroborated that view; an extensive literature exists with references both to "*becs*" or similar artifacts such as "microperforators", and "*limaces*", from Pleistocene and Holocene lithic assemblages not just in Europe but also in Africa and the Americas.

The Cueva Negra assemblage is mostly an "expedient" or "opportunistic" one of very small flakes or fragments removed from small cores by both unipolar and bipolar reduction techniques. It might be termed "*Isernian*" as it resembles much of the Isernia La Pineta industry in Italy (cf. Crovetto 1994; Crovetto et al. 1994; Peretto 1994; Peretto et al. 2004); Isernia begins just before 0.73±0.04 Ma but most is rather later. Despite absence there of "Acheulian" bifacial reduction and "*Levalloisian*" repetitive centripetal core-reduction, the Isernia La Pineta

industry could be "an 'opportunistic facies' of a cultural model which was not manifested and which could be... even that of the Acheulian" (Crovetto et al. 1994). Isernia researchers who conducted knapping experiments on local chert found "it was possible to produce 'protolevallois' type blade forms, Acheulian type bifaces and Levallois type artifacts" (ibidem). A Spanish assemblage perhaps comparable to Cueva Negra comes from Vallparadís, where many small artifacts were excavated, often prepared by bipolar core-reduction, including "becks", denticulate and notched pieces, and "a few examples of centripetal cores and débordant flakes", as well as artifacts on cobbles which include a chopper (Martínez et al. 2010); ESR, U-series, and palaeomagnetic determinations indicate an age of 0.83 ± 0.07 Ma.

Raw Material Procurement

Chert, and some fine-grained limestone, quartzite and quartz, are the main rock-forming minerals of the Cueva Negra assemblage. All can be found in conglomerates and gravels on the flanks of the Quípar valley. Further away from this valley outcrops of chert have been identified although they are scarce overall. Nodules and cobbles of chert, fine-grained (including dolomitic) limestone and quartzite are found in lacustrine, alluvial and colluvial deposits, having formed during different geologic periods and having unequal knapping properties.

First, the closest outcrop of conglomerate lies barely 0.8 km east of Cueva Negra and 0.5 km south of the R. Quípar (Fig. 2). It was laid down under the Tethys Sea during the Upper Miocene Tortonian, 11.5-7 Ma; it contains fossil seashells of large extinct scallops and oysters (Walker et al. 1998), which has led to our calling it the Fossil Beach or "Playa Fósil", and nodules of chert, fine-grained limestone and quartzite, eroded from cliffs and escarpments of Jurassic rocks. Although most of the chert is tabular and fissural, tending to break up into cubical or laminar pieces with perpendicular fracture planes, some nodules are of better quality chert that permits conchoidal fracturing and removal of feathered flakes with convex bulbs of percussion. The outcrop was undoubtedly a procurement or "quarry" site; a small discoidal "Levalloisian" chert core was collected here as well as chert artifacts with steep abrupt edge-retouch resembling several excavated in Cueva Negra, although no precise association can be made between this artifact and the Cueva Negra assemblage.

Secondly, at 750-900 m above sea-level there are widespread remnants of what was once an enormous, thick spread of poorly consolidated gravels (including chert blocks weighing up to 3 kg), outcropping 2-3 km upstream from (i.e. south of) Cueva Negra. High mountains nearby fringed an inlet of the Lower Pliocene Tethys Sea, but neotectonic uplift greatly reduced its extent by the Upper Pliocene when the landscape became continental, albeit with marshes

and lakes that at first would have been close to sea-level (itself higher than today); artist reconstruction of the palaeo-lake boundaries is shown in Figure 3. Volcanic eruptions in southern Murcia continued until at least 2.5 Ma according to K-A dating (Montenat, 1975, p. 162; Bellon et al., 1976, p. 43) and possibly even during the Early Pleistocene (Pavillon 1972; Dumas 1977: 174, 272), and barely 15 km upstream from Cueva Negra Plio-Pleistocene conglomerates (see below) underwent diapiric deformation (cf. Iburgüen & Rodríguez-Estrella 1996). The course of the R. Quípar itself follows the tectonically active Quípar Fault, the flanks of which have undergone differential uplift. In broad terms, the general rate of uplift was considerable overall, and so, in consequence, was the rate of erosion which must have caused the vast, thick, spread of poorly consolidated gravels.

Thirdly, extensive lakes covered what nowadays are the upper valleys of the R. Quípar and its northern neighbour the R. Argos (initially the Argos perhaps drained both: cf. González et al. 1997). Today, the watershed between them lies at 780 m above sea-level 1 km west of Cueva Negra. Their separation most likely occurred after most of the enormous, thick, spread of poorly consolidated Upper Pliocene gravels had been washed down-slope if not downstream. Nonetheless, significant vestiges remain on both flanks of the Quípar valley, near La Encarnación and Singla, only a few km upstream from Cueva Negra. Their survival is hardly surprising, given that the spread had attained a thickness of >100 m, despite the infrequency of outcrops of cemented conglomerate among them. Further upstream, the upper Quípar valley is called the Rambla de Tarragoya. The Quípar Fault is crossed by minor faults (lying perpendicularly across the main fault, or "normal" to it), and activity at them was undoubtedly responsible for what seem to have been a step-wise series of Plio-Pleistocene lakes lying at different heights relative to each another; today, at equivalent relative heights above those, are what seem to be comparable remnants of the vast, thick, spread of poorly consolidated Upper Pliocene gravels that everywhere contain nodules or cobbles of chert, fine-grained limestone and quartzite. As at the Tortonian outcrop near Cueva Negra, much of the chert is tabular, with a tendency to break up into cubical or laminar pieces with perpendicular fracture planes, though some nodules are of "better quality" chert that allows conchoidal fracturing and removal of feathered flakes with convex bulbs of percussion. The surface of this large spread of gravels rises in height as the valley is ascended, and at the head of the valley lies at 1,100 m above sea-level at Junquera, 20 km from Cueva Negra. There is no higher-level Tertiary conglomerate from which they might have been eroded; only steep Jurassic escarpments of overshadowing mountainsides tower over them. At Junquera we have collected very many chert items, among them

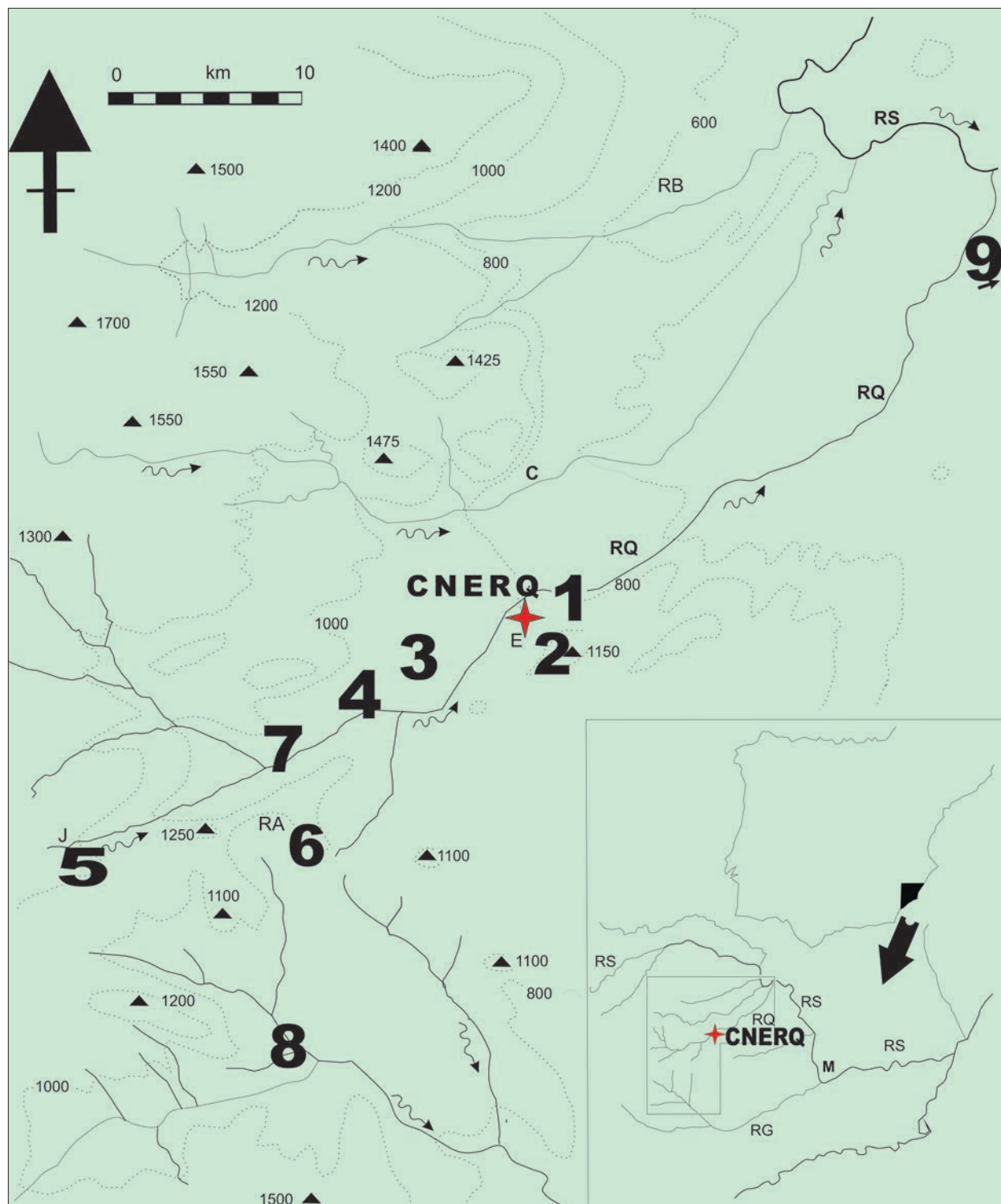


Fig. 2. Map of the Quípar valley. CNERQ Cueva Negra del Estrecho del Río Quípar; M Murcia, RS Río Segura; RQ Río Quípar; RG Río Guadalentín; C Caravaca; E La Encarnación; RA Royos de Arriba; J Junquera. Heights in metres, rounded to nearest 25 m. Outcrops: 1 PF "Playa Fósil"; 2 SdlC Sierra de las Cabras; 3 SC Singla Chapel; 4 RT Rambla de Tarragoya; 5 BP Barranco de Perigallo; 6 CG Collado del Gitano; 7 LC La Clavelina; 8 Río Caramel (mentioned in text, not analyzed); 9 Barranco de Vite (only known radiolarite outcrop in Murcia; a knapped radiolarite artifact was excavated at Cueva Negra in 2013).

Abb. 2. Karte des Quípar Tales mit der Höhle Cueva Negra del Estrecho (roter Stern) und den geologischen Aufschlüssen des Silex (1-9). Gestrichelte Linien markieren den Verlauf ehemaliger pleistozäner Seen und das ehemalige Abflusssystem des Río Quípar. Höhenangaben in Metern, gerundet auf 25 m.

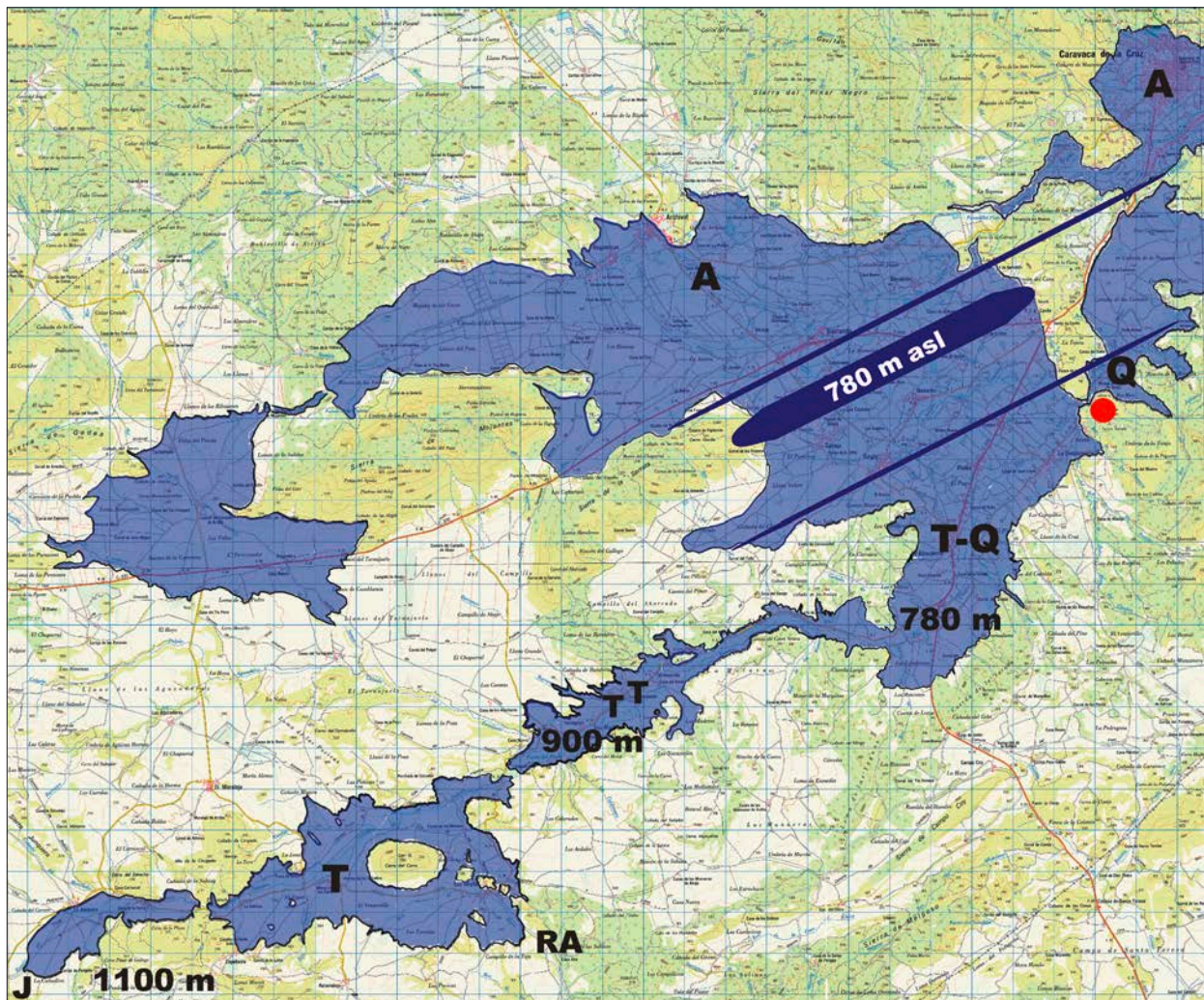


Fig. 3. Evolution of Early Pleistocene fluvial-lacustrine palaeogeography of the headwaters of the Río Quípar (Q)-Rambla de Tarragona (T) and Río Argos (A). North of Cueva Negra (red dot; 740 m above sea level), a ridge at 780 m above sea level nowadays separates the Argos and Quípar valleys, being an outcome of Early Pleistocene neotectonic uplift dividing what once had been an Upper Pliocene lake. Although the Quípar below Cueva Negra probably still joined the Argos downstream in a lake at Caravaca (top right-hand corner of map), subsequent neotectonic uplift has impeded the Quípar from reaching Caravaca so that today it flows NE to join the Río Segura separately (see Figure 2). Upstream the Quípar valley is called the Rambla de Tarragona, the grade of which is reflected by the heights of the river bed above sea level shown at 780 m, 900 m, and 1,100 m at Junquera (J) at the head of the valley. Neotectonic activity affected landscape evolution in a dynamic manner that involved formation of temporary “hanging” lakes or swamps which received gravels that in turn were exposed as the dynamic processes continued to develop, and hence visible for Palaeolithic extraction of chert nodules. These were secondary gravels derived by erosion from Upper Pliocene primary gravels lying at high altitudes immediately below the mountainside escarpments, especially about 3 km south of Cueva Negra, on the slope of the Sierra de las Cabras above La Encarnación. The erosion responsible for these primary gravels was considerable, depositing them as a vast gravel spread, most of which was removed by later erosion though a remnant is present at the Singla chapel on the opposite side of the valley. A primary outcrop of Pliocene biogenic chert occurs at Collado del Gitano, 2 km south of Royos de Arriba (RA).

Abb. 3. Karte des Quípar-Tarragona Tales (Q, T) flußaufwärts der Cueva Negra (roter Punkt) und des Argos Tals (A) im Norden. Die Karte zeigt, wie das frühpleistozäne Abflusssystem der spätpliozänen Seen aufgrund tektonischer Hebungen durch einen Kamm, der heute 780 m ü.NN liegt, in zwei Täler getrennt wurde.

a well-knapped proto-*limace*, which is clearly a Palaeolithic artifact. However, in Spain surface finds of fractured chert pieces must be treated with the utmost caution, and are usually rejected as Palaeolithic, because chert was smashed up with sledgehammers, even in the twentieth century, for burning in lime-kilns or inserting into wooden threshing sleds drawn by donkeys or mules. At between 50 and 30 m below the remnants of the aforementioned ancient

spread of poorly consolidated high gravels, horizontal conglomerates flank the upper Quípar valley, from Cueva Negra to its headwaters. They lie at equivalent relative heights above the valley floor even though this rises with increasing altitude above sea-level. Their horizontality implies palaeoclimatic synchrony with the step-wise development of the lakes to whose ancient shore-lines they attest. Their components are without doubt derived from the high gravels, but they

are often more heavily cemented than are those. They were formed in at least two palaeoenvironmental or palaeoclimatological cycles, each characterized by lacustrine sedimentation followed by a drier phase indicated by deposition of conglomerate and/or orange-coloured lateritic sediment. The conglomerates are the result of the cementation of the shoreline gravels of Early Pleistocene lakes. They contain nodules or cobbles of chert and fine-grained limestone identical in composition to those of the high gravels. In the Rambla de Tarragoya (i.e. upper Quípar valley) they outcrop on its northern flank. Just above Cueva Negra they occur on both flanks though they seem to contain more chert on the right-hand side of the valley (i.e. below the thickest remnants of the earlier gravel cover) than on the left-hand side (where they barely retained a thickness of 50 m following separation of the Quípar and Argos valleys).

Any or all of the aforementioned gravels and conglomerates offered possible sources for procurement of raw materials for the Cueva Negra assemblage. However it also contains chert that may hint at other sources. On the other hand, the more that we sample the conglomerates and gravels, the more we collect less usual kinds of chert or flint. Among other possible sources of raw materials for a few pieces at Cueva Negra, there are two small chert outcrops, both of which lie on the southern side of the watershed separating the Rambla de Tarragoya from the headwaters of the R. Guadalentín to the south (which, like the R. Quípar, drains eventually into the R. Segura). Both lie to the south of the hamlet of Royos de Arriba, which is in the Rambla de Tarragoya. One lies about 2 km to the south on the hill of Cuesta del Gitano and is an outcrop of grey-blue chert about 0.3 km across. It is 15 km from Cueva Negra. This is primary chert that takes the form of large, frondiose, "cactus"-like masses, covered by a thick calcrete crust, reduction of which seems to have been the object of an abandoned lime-kiln there. When hit, the chert offers conchoidal fracturing readily, though the resulting flakes are generally irregular and can be large (looking rather like typical "Clactonian" flakes from England): one flake excavated at Cueva Negra shows possible resemblance to them. The outcrop was formed in continental Upper Pliocene beds, probably by biogenic processes in lacustrine conditions. The exotic form of the masses may perhaps be compared to that of the well-known Lake Magadi chert in the African Rift Valley. Further south, over 20 km from Cueva Negra, as the crow flies, in the upper reaches of the small valley of the R. Caramel which feeds the R. Guadalentín, there is a Miocene outcrop barely 0.5 km across which contains primary honey-coloured chert that has a mainly tabular or laminar structure. Honey-coloured chert items have been excavated at Cueva Negra. Nevertheless, we have collected, albeit very occasionally, chert fragments of that colour on the surface of the

conglomerate outcrop 0.8 km from the cave. Among pieces of honey-coloured chert excavated at the cave are a few well-formed flakes, which hardly correspond to forms likely to have been struck from tabular or laminar nodules.

It seems from the foregoing that the chert used at Cueva Negra came mainly from the Quípar valley and no more than 25 km from the cave. Trace-element analysis has been undertaken of chert samples excavated at Cueva Negra and samples collected at the nearby "quarry" site outcrop of Tortonian conglomerate, gravel outcrops on the flanks of the upper Quípar valley, and outlying chert outcrops beyond it, which points to a general similarity between excavated samples and the conglomerate and gravel outcrops.

Methodology

Geological Samples

The vast majority of lithic raw material recovered from Cueva Negra is composed of chert (86.5%) and therefore chert was singled out for this study. Because all of the lithic samples analyzed were recovered when cleaning vertical profiles during the excavation campaign their precise stratigraphical provenance is indeterminate, though nevertheless they appear to be representative of the chert assemblage from the site considered altogether. All the pieces analyzed are classified as residual débitage and therefore of less interest for further study than are retouched artifacts. Pieces were chosen preferentially so as to cover as broad diversity of chert colours as possible, in order to see if particular chert colours might correspond to unique sources in the landscape (the colours were recorded but are not discussed here).

All of the sampled chert sources originated from gravel or beach deposits. Once again, a diversity of chert colours was sought, given that different chert colours may correspond to minor impurities caused by different quantities in major and trace element composition (Mull 1995) from different sources (Fig. 4).

Sampled sources were selected according to several criteria. Because chert forms primarily in limestone, this type of bedrock was primarily sought. The sampled sources had to have been visible to the occupants of Cueva Negra, and not obscured underwater by lakes that were present in the valley at the time the site was occupied. We were able to visit many possible outcrops thanks to the vehicular access offered by numerous local roads and tracks.

Sample Preparation

Only the interior portions of the chert samples were pulverized. Any cortex still present on the chert samples was removed prior to pulverization. All chert pieces were pulverized to a fine powder using a ceramic mortar and pestle until at least two grams of chert powder was created. Each pulverized chert



Fig. 4. Chert samples collected from different sources in or near the Tarragoya-Quipar valley (see text and Figure 2).

Abb. 4. Silexproben, die von verschiedenen Aufschlüssen des Tarragoya-Quipar-Tales stammen (s. dazu auch Text in Abb. 2).

sample was deposited in a labeled, closed plastic bag, placed in a plastic vial for storage. Careful steps were taken to reduce cross-contamination of samples. All mortars and pestles used were washed thoroughly in acetone after each sample was pulverized in order to reduce cross-contamination. Only a trivial trace of abrasion from the ceramic mortar and pestle was noticed upon completion, and it was regarded as negligible contamination.

Instrumentation and operating conditions

Approximately 50 mg of the crushed material from each sample were digested in a mixture of concentrated HNO_3 and HF in 15 mL Teflon beakers. The beakers were sealed and heated on a hot plate at 130°C for 48 hours during which time they twice were subjected to ultrasound treatment. After cooling, the solution was dried down and then brought back into solution with 5% HNO_3 . Visual inspection revealed that the samples had dissolved completely.

The solutions yielded up approximately 100 µg/ml of total dissolved solids. An analytical blank solution was prepared using the same procedure. Finnigan Element2 HR-ICP-MS was used for analysis. Solution standards consisted of known amounts of the analyzed elements and were prepared using multi-element solutions obtained from High-Purity Standards (Charleston, SC). A standard-blank solution was prepared at the same time using successive dilutions of the 5% HNO₃ standard-carrier solution. Sample concentrations were determined by subtracting blank signal intensities from those obtained from the sample and standard solutions. A calibration curve was obtained by performing a linear least-squares regression for each element using the blank-subtracted counts and the known concentrations in each standard solution. In all cases, the regression coefficients were 0.998 or higher.

Data Analysis

Standard statistical procedures were employed using SPSS software. Exploratory data analysis using factor analysis was carried out. Factor analysis was selected given the quantity of trace element variables being analyzed (n=19) in order to highlight differences between geologic samples and to detect which elements were primarily responsible for any patterning. The extraction method is equivalent to principle components analysis (PCA), and includes varimax rotation and Kaiser Normalization.

Samples from the Miocene conglomerate "Fossil Beach" ("Playa Fósil") were chosen to be the factor proxy with which all other sampled locations would be compared, in order to determine which variables (trace elements) corresponded most similarly in the creation of the factors. All chert samples collected from each source, with the exception of Cueva Negra itself, were assumed to have been deposited from local sources by natural processes, except for Collado del Gitano which seems to be a primary outcrop of biogenic chert. Three hypotheses were tested.

- Each sampled source would exhibit discretely different clustered values.
- Most sampled sources would exhibit discretely different clustered values with some possible source overlap due to the relative homogeneity in the formation of chert, the close geographical proximity of the sampled sources, and the number of sampled sources under comparison.
- Few or none of the sampled sources would show discretely different clustered values, thereby making the results inconclusive.

Results

Geological ICP-MS Data

ICP-MS was used to analyze the abundance of 19 different trace elements (Sc, V, Cr, Co, Zn, Ga, Ge, Rb,

Sr, Y, Zr, Nb, Cs, Ba, La, Ce, Pr, Nd, Sm) from 56 chert samples. All 19 elements produced detectable values. The majority of the samples were analyzed from the archaeological site, with fewer samples from the remaining seven sources (Fig. 5). Two factors were derived from the PF samples, and all 56 samples were analyzed using those two factors. All sampled geological sources were first transposed onto a graph (Figure 6 a) in order to identify how discrete each sampled source compared to every other source. The Cueva Negra samples were added thereafter (Figure 6 b) in order to see which archaeological samples corresponded most similarly to the geological sources.

Two factors with eigenvalues greater than two were examined from the PF samples. Factor 1 (36.3% of the total variance) is constructed from the rare earth elements (REE's) and Y (0.763), and the alkali metals Ce (0.896) and Rb (0.769). Factor 2 (14.0% of the total variance) is constructed from the transition metals V (0.842) and Sc (0.653), and the alkali earth metal Sr (0.935).

Figure 6 shows some separation between the different sampled sources, although some sources overlap with each other and outliers are present. Samples from PF are generally closely clustered, with the exception of two outliers that exhibit stronger than expected values from factor 2. The 2 RT samples overlap the cluster of PF samples, making those two sources visually indistinguishable; sampled sources RT and PF are geographically separated on the landscape by almost 30 km but formed during similar geological periods. Two SdIC samples are closely associated with the PF and RT cluster, although there is one obvious SdIC outlier with a stronger than expected value for factor 1. Chert from SdIC was sampled just 2.5 km west of PF, on the other side of the Sierra de las Cabras limestone formation, and these two sources should be considered geologically related and not necessarily

Source	Number of Samples (n)	Deposit type
Cueva Negra (CN)	31	Archaeological
"Playa Fósil" Conglomerate (PF)	14	Secondary
Sierra de las Cabras (SdIC)	3	Secondary
Singla Chapel (SC)	1	Secondary
Rambla del Tarragoya (RT)	2	Secondary
Barranco de Perigallo (BP)	2	Secondary
Collado del Gitano (CG)	1	Primary
La Clavelina (LC)	2	Secondary
TOTAL	56	

Fig. 5. Sampled Sources.

Abb. 5. Beprobte Aufschlüsse.

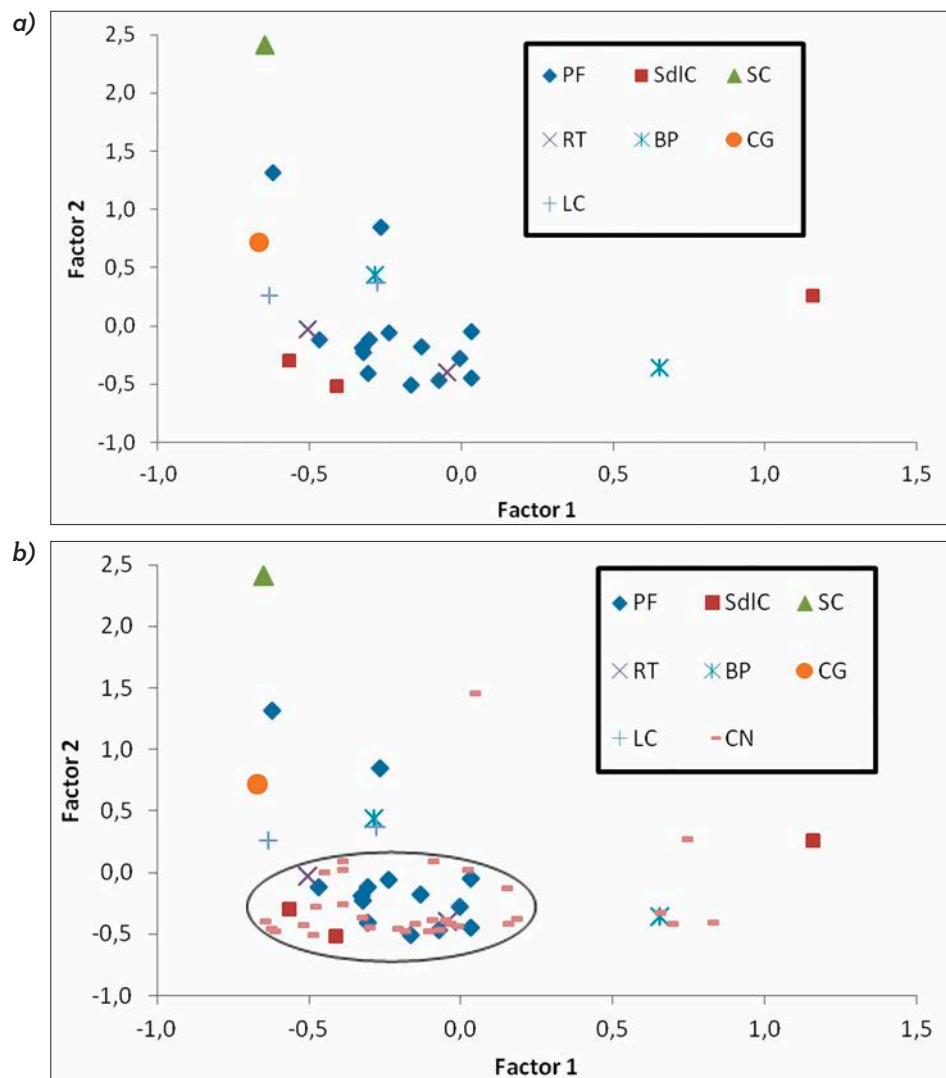


Fig. 6. a) Distribution of geological sources by factorial analysis; b) Cueva Negra (CN) archaeological samples added to Figure 6 a.

Abb. 6. a) Verteilung der beprobten Aufschlüsse anhand einer Faktorenanalyse; b) Faktorenanalyse mit den archäologischen Proben aus der Cueva Negra (CN).

mutually exclusive; they seem to be remnants of a spread of gravel that plausibly resulted from Upper Pliocene erosion of the escarpment of the Sierra de las Cabras.

The 2 samples from LC show reasonable association despite the small sample size. One BP sample overlaps one of the 2 LC samples, whereas the second BP sample is distinctly separate. The distance between the 2 BP samples is not necessarily abnormal for factor analysis plotting, although given BP's small sample size, it is not immediately clear if one sample may represent a coincidental outlier.

Sources CG and SC are represented by 1 sample each. Both of these two sources appear to exhibit discrete trace element values (especially SC) from all other sources. Sample CG may be geologically related to the 2 LC samples given its close association with the

two LC values in Figure 6, and their relatively close proximity on the landscape separated by just 3.4 km (as the crow flies).

Archaeological ICP-MS Data

When the 31 archaeological samples are overlain with the geological samples (Figure 6 a), clear associations become apparent. There is a large cluster of CN samples in association with the PF, SdIC and RT samples. Of the 31 CN samples, 26 (83.9%) correspond closely to these three geological sources. Another small cluster of 4 CN samples (12.9%) is associated closely with one of the BP samples. There is 1 outlier from the CN samples (3.2%) which does not correspond closely to any of the other sampled sources. This last sample may originate from some geological source not yet sampled.

Overall, these results come as little surprise. Comparing a large sample of archaeological material against several geological sources gives a strong indication as to where these early humans were procuring their raw material stone. It is almost certain that the bulk of the chert recovered from Cueva Negra originated from local sources, within 3 km. Yet the association of a small quantity of Cueva Negra chert from BP is more interesting.

As mentioned earlier, it has been shown that some Acheulian assemblages not only in Africa, but also from the Spanish Middle Pleistocene, contain lithic artifacts transported from distant sources. Our findings suggest that a few lithic artifacts were transported from a source almost 30 km to the west of Cueva Negra and formed part of its late Early Pleistocene "*Acheulo-Levalloiso-Mousteroid*" assemblage. This conclusion has implications about how late Early Pleistocene humans may have taken decisions, engaged in planning, and undertaken mobility strategies in Spain, and possibly elsewhere in the Eurasia or Africa.

Summary and Discussion

The results from our analysis of geological samples are interesting and accord with our second hypothesis that most sampled sources are distinguishable although some sample overlap does occur. First, it can be shown reasonably that some of the geological sources in the drainage basin of the Segura river system, just north of the watershed that separates it from the Baza-Guadix Basin, exhibit discrete trace-element differences identified using ICP-MS and factor analysis. Secondly, some geological sources overlap each other to the point that geographically distant sources cannot be distinguished definitively; this is a not uncommon phenomenon, which in our case may be due to considerable widespread homogeneity in chert composition, given that the chert sources we sampled may have formed contemporaneously and under similar environmental conditions. Thirdly, the weight of the evidence, from data both at Cueva Negra and many other archaeological sites (Brantingham 2003), points to an origin from local sources, less than 3 km away, for the bulk of the raw material that was used. Finally, while not analyzed in depth here, physical characteristics of chert, such as colour or texture, did not correspond directly to any single source we sampled.

In line with provenance findings from Middle Pleistocene Spanish Acheulian assemblages, the mineralogical analysis of the Cueva Negra limestone hand-axe (Walker et al. 2006) supports the view that the raw material was obtained nearby, and no doubt the Miocene conglomerate "Fossil Beach" or "Playa Fósil" (PF) afforded a suitable quarry, being only 0.8 km from the rock-shelter. Brantingham (2003) has suggested that, in general, the closest raw material

stone sources contribute the greatest quantities to an assemblage, while the most distant sources contribute increasingly lesser quantities. Therefore it can be inferred reasonably that the majority, if not the entirety of the archaeological samples overlapping the PF, SdIC, RT cluster in Figure 6 originate from PF and/or SdIC. Nonetheless, given the strong relationship between a small quantity (<15%) of Cueva Negra artifacts to the distantly sampled source BP, it cannot be ruled out altogether that some of the Cueva Negra samples that overlap with RT may in fact originate from RT.

The close association of four Cueva Negra samples around one of the BP samples is most intriguing. This indicates that, indeed, a small fraction of Cueva Negra lithics came from this most distantly sampled source. The reason hominids acquired chert from this former lacustrine or alluvial location is unclear and worth investigating further. It is not surprising, though, that hominids would be attracted to secondary alluvial or lacustrine gravel deposits, and artifacts from such sources consistently appear in the early Palaeolithic record (Santonja and Villa 2006; Harmand 2009). Altogether, this result was also not completely unexpected. Both the two Middle Pleistocene Acheulian Spanish sites of Torralba and Ambrona contained lithic material transported from at least 30 km away, and therefore it may not be too great a leap of the imagination to envisage that technologically-comparable earlier humans may well have behaved in like manner. Therefore, we suggest, albeit tentatively, that assemblages, such as that at Cueva Negra, which show a technological and cognitive complexity greater than that of the African Oldowan, had no difficulty in obtaining raw material from sources that were not always close at hand.

As mentioned previously, there appear sometimes to be discrete differences in Africa between the Acheulian and Oldowan techno-industries with regard to the distance that Early Pleistocene hominids transported artifacts from source to site. Stronger comparisons can be made between these two techno-groups when both types of assemblages are identified in close geographical space and temporal proximity. Such comparisons can be made in Africa and perhaps now in Spain, and may have been a common occurrence across the entire Old World as increasing Palaeolithic technological and cognitive complexity developed. The late Early Pleistocene "*Acheulo-Levalloiso-Mousteroid*" assemblage at Cueva Negra exemplifies this complexity (Walker 2009; Walker et al. 2006, 2013). There may be numerous reasons influencing the different artifact transport decisions of the makers of Oldowan artifacts and those who made stone tools that were more technologically and cognitively demanding. Those influences include, but are not limited to, the symbiotic relationships between planning, economizing, and risk-management behaviours of: 1) raw-material selection; 2) territorial

Overall	Chert		Quartz		Quarzite		Limestone		Marble		Total	
	n	%	n	%	n	%	n	%	n	%	n	%
Large lithics (>60 mm)	19	65.5	0	0	0	0	10	34.5	0	0	29	100
Small lithics (<60 mm)	621	83.5	2	0.2	36	4.8	84	11.3	1	0.1	744	100
Total	640		2		36		94		1		773	

Fig. 7. Distribution of raw material and lithic cutting tool size at Cueva Negra.

Abb. 7. Verteilung des Rohmaterials unter den Steinartefakten mit Schneidekante der Cueva Negra nach Größenklassen.

size and proximity to reliable sources of raw material, in relation to foraging decisions; 3) expediency of artifact manufacture; 4) artifact function as it relates to rates of exhaustion, rejuvenation, or replacement; and 5) weight, size, quantity, and portability of artifacts (Blumenshine et al. 2008; Brantingham 2006, 2003; Bousman 1993; Clark 1969; Close 1996; Kuhn 1991).

Certainly, the primary reason for moving around a landscape must have been related to foraging activities (Brantingham 2003). Travelling long distances with lithic tools was likely a risk-management buffer (Geneste 1989). This would have afforded the user greater opportunistic hunting and scavenging capabilities, especially when early human groups were competing against carnivores for limited faunal resources. In other cases, this would be an advantageous planning strategy if areas were known to be deficient in stone of good quality for knapping, or when travelling to unknown locations (Bousman 1993).

Selection of specific types of raw-material stone is archaeologically apparent in the earliest stone-tool industries of East Africa (Stout et al. 2005, 2010; Harmand 2009; Semaw 2000), and the trend has continued through to modern assemblages. For these earliest techno-industries, more so with the Oldowan than the Acheulian, selection of raw material seems to have been constrained by the local geology in the immediate vicinity of a site. The simple manufacturing style of Oldowan tools may have afforded fewer restrictions on raw-material type, quality, and clast size, which may have allowed for almost any immediately available stone to be utilized, within some reasonable knapping parameters. By contrast, the preparation in the African Early Pleistocene of bifacial cores and flakes, whether by Acheulian or Levalloisian knapping, may have required more specific properties from stone, leading knappers to pay regard to outcrops further away from their home base. At Cueva Negra the primary raw material found on cutting tools in this assemblage is chert (82.8 %) with lesser quantities of limestone (12.2 %) and quartzite (4.7 %), and trivial amounts of quartz (0.3 %) and marble (0.1 %) (Fig. 7) (Walker et al. 2013). This distribution of raw material is typical of other Early Pleistocene assemblages in Spain regardless of technological label (Barsky et al. 2010; Martinez et al. 2010; Santonja and Villa 2006; Rosas et al. 2006; Carbonell et al. 1999; Martínez Navarro et al. 1997), and above all seems to

correspond with local and regional geology. At Cueva Negra the predominant chert is seldom of high quality, which reflects the characteristics of what was available locally.

Chert was a raw material close to hand, in addition to dolomitic limestone, and lesser quantities of quartzite, all available within 3 km of the site. The nearby chert resources were exploited quite intensively, with approximately 83.9 % of the chert artifacts sampled from Cueva Negra originating from the "Fossil Beach" PF conglomerate, and colluvium, SdLC, deposits. Despite the intensive exploitation of the chert sources nearby, the quality is generally-speaking poor, and the size of the chert fragments is small (most being less than 60mm long); experimental knapping demonstrates just how very brittle and uncontrollable this raw material is to work with. Higher quality chert is found much further west, such as at BP, where approximately 12.9 % of the artifacts from Cueva Negra originated. To procure and transport chert artifacts from this BP source almost 30 km away meant interacting with a territory equally as large, and understanding where sources of raw material were located across a large landscape. We cannot know whether the occupants of Cueva Negra directly visited the BP chert source to obtain raw material, or whether this raw material was traded to them by other groups in a social sphere of interaction. What seems plausible, however, is that the foraging distance from Cueva Negra extended to approximately 30 km, as measured by the maximum distance raw materials were transported, and that this reflects the range of their resource exploitation (Brantingham 2006). Indeed, this range seems likely to have remained throughout the later Early Pleistocene Palaeolithic of the Old World.

It is reasonable to assume that tools prepared on raw materials acquired from more distant sources should decrease in relative abundance with distance travelled, because stone tools are subject to extensive use-wear and often need to be replaced. It is thought that optimal time-and-energy trade-offs should reflect this pattern of near-versus-distant procurement strategies (Brantingham 2003). A means of measuring raw-material procurement, transport decisions, and foraging territory, with respect to planning, appeals to distance-decay models. Distance-decay models, as borrowed from economic geography (Renfrew 1977),

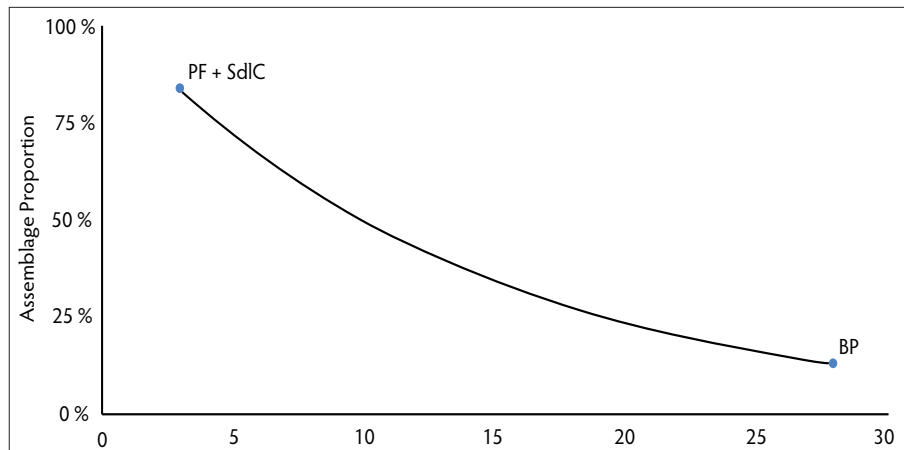


Fig. 8. Proportion of PF/SdIC and BP chert in the Cueva Negra assemblage and distance from the site.

Abb. 8. Anteil der Silexvarietäten PF/SdIC und BP im Inventar der Cueva Negra und ihre Entfernung vom Fundort.

predict that as distance from a stone source increases artifacts made from that material should show more thorough working and use, and should occur in lower quantities, both absolutely and relative to more local materials (Blumenschine et al. 2008; Brantingham 2003; Féblot-Augustins, 1993; Kuhn 1991). Such measures are often applied when comparing multiple sites to their proportion of a particular type of raw material originating from a known source (e.g. Blumenschine et al. 2008; Brantingham 2006). However, single sites also can be measured when raw-material sources and the relative abundance of raw materials are known. In the case of Cueva Negra, two chert sources have been identified, along with the approximate proportion of that chert occurring in its Palaeolithic assemblage. The Cueva Negra distance-decay trend for the proportion of chert from these two sources is shown in Figure 8 and is represented by an exponential line. Overall, the distance-decay trend fits the intended expectations of reduced raw-material quantity the further it is transported away from its source.

The “expediency” by which artifacts are made can also play a role in the desire to transport artifacts long distances over the landscape. Oldowan assemblages are primarily composed of “expedient” unifacial artifacts, whereas traditional African Acheulian assemblages are expected to have 40% or more bifacially-flaked artifacts (Kleindienst 1962) (by contrast, often the label “Acheulian” is applied to European assemblages even if only one or two bifacial tools are present in them). An ‘expedient artifact’ is “characterized morphologically by little alteration or secondary shaping” (Bousman 1993) Nelson (1991) suggests that expedient technology incorporates little repair of tools, a short period of use, and discard near the source.

The bulk of the “Acheulo-Levalloiso-Mousteroid” Cueva Negra assemblage consists of very many

“informal” or “expedient” artifacts. Nevertheless, the presence of a few artifacts that are more technologically and cognitively demanding is of great interest. The Cueva Negra knappers were economical in so far as they exploited nearby chert resources despite the poor quality and overall small size of the nodules and blanks available. The general form of many of the chert artifacts at Cueva Negra appears expedient until you take into account local resource limitations, as discussed earlier, and the higher than expected quantity of small artifacts on flakes or fragments with denticulated and retouched edges (some retouched pieces are less than 3 cm long: Walker et al. 2013); very small artifacts, and artifacts with retouched edges are extremely rare in African Oldowan assemblages. The Cueva Negra assemblage points to a facility to prepare a wide variety of small artifacts. Moreover, a small proportion of these artifacts are on raw material originating from sources further away than is typical for African Oldowan assemblages of large expedient unifacial stone tools.

Tool use will cause edges to dull and certain tasks in conjunction with stone types will cause those edges to wear down at different rates. Different geographical and geological circumstances can influence the type and abundance of raw materials selected for task-specific purposes. Therefore, “the activities in which tools are most often employed constitute one potential influence on reduction not strictly related to raw material transport costs” (Kuhn 1991). Tougher materials (hardwoods or bone) and weaker stones (e.g. carbonate-rich limestone) will cause the edge of a tool to wear out more quickly, requiring frequent edge re-sharpening if it is not practical to make new implements (Kuhn 1991; Hayden 1979). Activities conducted on softer materials (cutting meat) and stronger raw materials (e.g. silica-rich chert) will produce the slowest rates of edge-dulling and less frequent re-sharpening.

Very likely, artifact activity-use changed little between Oldowan and post-Oldowan industries in Africa (and elsewhere), comprising primarily butchery, working hides, processing plants, and working wood (Keeley & Toth 1981). In addition, and depending upon the local geology, Early Pleistocene and Middle Pleistocene stone-working throughout the Old World involved similarly durable raw materials (basalt, quartz/quartzite, and chert/flint). In the Early Pleistocene African Oldowan the decision to transport lithic artifacts over short distances was not influenced necessarily by intensive use-wear processes, and there is low frequency of retouched artifacts in the assemblages. More intensive use and recourse to more complex knapping procedures developed gradually in Africa during the second half of the Early Pleistocene. During that time it is plausible to assume that the distance grew to around 30 km between sources of stone procurement and places where replacement was necessary of stone tools worn out by continual use. By contrast, for Oldowan artifacts the rate of replacement does not appear to reflect influence of heavy use.

Factors potentially influencing decisions about carrying stone are weight, size, quantity, and portability. This matter works in concert with distance-decay model predictions, such that as load increases so, too, does the cost of transport. Therefore reducing transport-load costs increases the potential distance artifacts can be moved across the landscape. The quantity of artifacts being transported is then related to the combined weight of those artifacts, such that more small artifacts may be moved than larger artifacts, all weight being equal. This alone may skew the results of archaeological analysis when just the quantity, and not the weight, of artifacts is being analyzed. In addition, carrying implements, such as bags or baskets, may increase the quantity of artifacts that can be carried.

At Cueva Negra, predominance of chert may be more a consequence of the limited raw-material available close by than of choice. Size of available blocks of raw material was no doubt an important factor that has determined the composition of the excavated lithic assemblage. Whereas 82.8% is chert and 12.2% limestone, these values need to be considered from the standpoint of differences in size of the manufactured lithics. Walker et al. (2013) broke down the Cueva Negra lithic assemblage into two size classes: 'Large' (greater than 60mm) and 'Small' (less than 60mm) artifacts (.). The 'Large' chert cutting tools (bifacial handaxe, chopping tool, worked cores/nodules) comprise a reasonable 65.5% of the assemblage (n = 19), and limestone increases to 34.5% (n = 10). Although chert still appears to be the preferred raw material even for large artifacts, the overall sample size is still very small. The remaining 'Small' lithic cutting tools are similar in abundance to the overall assemblage where 83.5% is chert (n = 621)

and 11.3% is limestone (n = 84). A knapped radiolarite scraper was excavated in 2013; the only known outcrop of radiolarite in Murcia is beside the Barranco de Vite 40 km NE of Cueva Negra, not far from the Quípar-Segura confluence. In general, there is a clearer preference here for chert to be used for smaller cutting implements, and a greater preference for limestone to be used for larger cutting tools rather than small ones. This makes intuitive sense and fits our sampling observations that the small blocks of local chert would have restricted the size of most knapped chert artifacts.

Looked at in a different way, if the quality of the raw material available for stone knapping and the size of the stone blocks available were the same during the Lower Pleistocene as they are today, then these two factors together very likely have influenced the composition of the excavated assemblage. Taken overall, smaller cutting tools provide a shorter cutting edge, which translates into a lower efficiency for the effectiveness of a task than is the case with larger cutting tools, all raw material being equal (Barton 1997). It is reasonable to assume that the Cueva Negra knappers, mainly relying working nearby chert, would have exhausted their smaller chert lithics at a faster rate, and therefore required a larger amount of small lithics to complete a task, than would have been the case had they been able to use larger lithic tools. This assumption may explain, in part, the large number small chert lithics at Cueva Negra.

Conclusion and Future Work

The results of this study are a welcome addition to a better understanding of the procurement behaviours of late Early Pleistocene humans in Spain. They suggest that Cueva Negra Palaeolithic knappers were able, and no doubt willing, to transport raw material from further afield than was usually the case in the African Oldowan. Undoubtedly differences in technological complexity and cognitive versatility had evolved, which affected planning, economical use of resources, and risk-management behaviours towards the end of the Early Pleistocene in several parts of the Old World. We hope that this study may stimulate further methodological inquiry. We acknowledge fully that our small sample-sizes are a drawback with regard to several of the geological sources analyzed. It is desirable to analyze at least five samples for each source in order to improve the credibility of the values presented in Figures 3 and 4. Budgetary constraints on the number of laboratory analyses that could be undertaken meant that some geological sources could be investigated with fewer samples than would have been preferable. However, that does not render our findings invalid, because at least two chert sources were identified, whereas none of the remaining five sources had an archaeological match. Future sampling should aim to take at least five samples for analysis

from each source. Greater emphasis should be placed on chert deposited in river gravels across the landscape, and additional analysis of more distant sources is needed in order to inquire into a possibility that the Cueva Negra foraging area might have extended even beyond 30 km. Most important, the sample size from Cueva Negra itself needs to be increased, in order to account for as much variation in as possible in the sources from which raw material may have been obtained, as well as possible differences in procurement strategies between the different stratigraphical units that have been defined by excavation.

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