Raw material selection and evidence for rhinoceros tooth tools at Dadong Cave, southern China

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Research in Dadong Cave, southern China, has revealed evidence suggesting that non-lithic materials were used in the tool kits of the Chinese Lower Palaeolithic.

Key-words: China, Palaeolithic, Dadong Cave, rhinoceros, tool kit

Standardization in tool form is a highly variable feature of Chinese Palaeolithic assemblages. For example, the site of Guanyindong in Guizhou province and the Bose Basin localities in Guangxi (FIGURE 1) are both assigned to the Lower Palaeolithic (Li 1989) but they have dramatically different lithic assemblages. The Guanyindong assemblage is dominated by scrapers and small flaked tools (Zhang 1985; Leng 1992), while the Bose lithics are primarily very large bifacially flaked cobbles (Huang 1987; Hou *et al.* 2000). Do these differences represent regional distinctions in lithic traditions or differences in subsistence strategies? Does the variation exist because Asian tool kits were not predominantly lithic based?

The technological nature of the Chinese Palaeolithic is largely tied to issues of raw material availability and the constraints that may be imposed by inferior flaking properties of some rock types. Researchers (Boriskovskii 1968; Hutterer 1977; 1988; Pope 1989) have suggested that versatile non-lithic resources, such as bone, bamboo and hardwoods, were used to supplement lithic tool kits in East and Southeast Asia. Bamboo, for example, could furnish flakes, cooking and food storage containers, spears, traps and rope (Pope 1989; Schick & Toth 1993). The lack of fossilized bamboo makes this hypothesis difficult to test. However, there is archaeological evidence for tools made of other non-lithic materials. Harrisson & Medway (1962) report tools made of turtle carapace and pig tusk from Niah Great Cave (about 40,000 BP **??OK/ we don't like 'ka'**) in Borneo. Sohn (1988) reports the modification of bone at the Middle to Upper Palaeolithic Korean locality of Yonggul (Chommal) cave. The argument has been made for bone and antler use at Zhoukoudian (Pei 1938; Breuil 1939) and for worked bone from the Lower Palaeolithic localities of Donggutuo (Wei 1985) and Xujiayao (Jia & Ho 1990). Some authors maintain that the objective of the Asian chopper/chopping tool tradition was principally to produce stone flakes used to manufacture and maintain non-lithic tool kits (Hutterer 1988; Pope 1989), or that it may have developed as an adaptation to heavily forested environments (Watanabe 1985) where stone was difficult to locate and often of poor quality.

These general issues concerning raw material use are being investigated at Panxian Dadong, a middle Pleistocene cave site in Guizhou province. In this paper we propose that humans living in the cave supplemented their lithic tools with faunal raw material, specifically rhinoceros molars, that were selectively transported into the cave.

Panxian Dadong setting and environment

Dadong is a large karst cave located in a small valley on the western Guizhou Plateau (25°37'38" N, 104°44'E) (FIGURE 1). It is the middle cave in a series of three interconnecting caverns stacked within a 230-m high hill. The entrance

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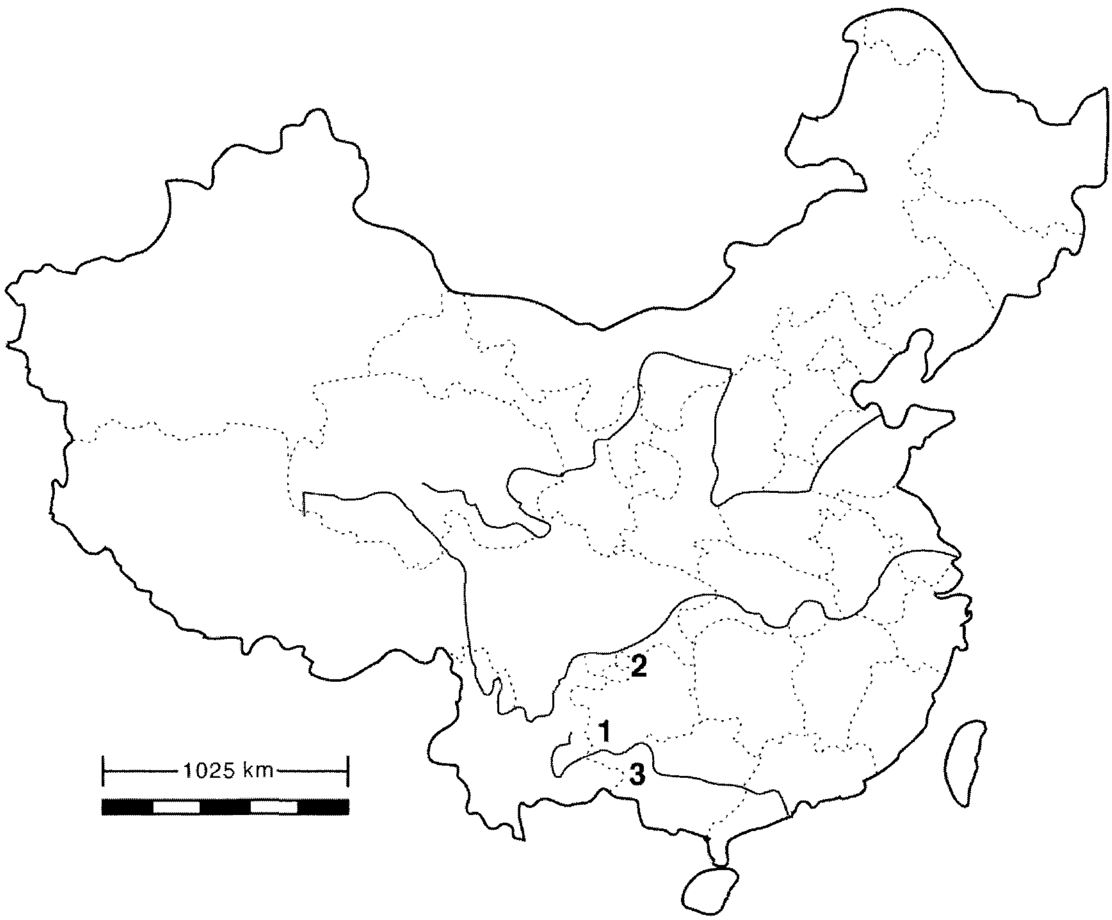

FIGURE 1. *Map of China showing sites discussed in the text.* 1 *Panxian Dadong, Guizhou Province;* 2 *Guanyindong, Guizhou Province;* 3 *Bose Basin localities, Guangxi Province.*

is presently located 32·4 m above the valley floor as a result of recent uplift of the plateau. At the time of its prehistoric occupation, the entrance would have been closer to the valley floor and near the confluence of three small rivers that drained into the porous limestone of the lower cave.

The Pleistocene environment was mixed woodland, as indicated by the presence of water buffalo, musk deer, barking deer and rhinoceros. The occurrence of panda, orangutan and colobine monkeys (Pan & Yuan 1997) suggest some densely forested areas. This range of habitats is characteristic of montane environments with elevational diversity.

Dadong's 8000-sq. m main chamber contains deposits of bedded sandy travertines, clays, breccia, and large limestone blocks. The archaeological levels have stone tools in association with animal bone (Huang *et al.* 1995). Four human teeth were also discovered. In the 1996 and 1998 excavation seasons, 1215 artefacts (lithics 23·9%, bone 57·7%, and teeth 18·4%) were recovered from 53·2 cu. m of sediments. Uranium-series dates (Shen *et al.* 1997) suggest that most of the Dadong deposits are between 130,000 and 250,000 BP.

Lithic resources and expedient tools

Dadong lithics (N=288, *cf.* FIGURE 2) are produced from limestone, chert and basalt. The limestone is readily available either inside the cave or near the entrance. It is an unlimited resource, but of poor quality for tool-making because it breaks in unpredictable ways. Nevertheless, it is the most commonly used lithic material. Small nodules of basalt and chert come from local hillside outcrops and river gravels. The basalt ranges from a porous brown variety to a dark fine-grained type that is a better quality material. While the chert has superior flaking properties, it is difficult to extract from the limestone outcrops and the small nodules constrain tool size.

Flakes are 50% of the Dadong lithic assemblage. Cores and finished tools (scrapers, borers, denticulates) are rare (7% and 16% respectively). Flaking technology is predominantly hard hammer direct percussion. Retouch is not common but is most often found on chert artefacts. Overall, there is limited standardization in the configuration of the retouch and it is not very intensive. In most cases, the retouch is in the form of a notch or denticulated edge or it is limited to only part of the flake or chunk. Bifacial retouch occurs on only a few pieces.

Constraints imposed by poor quality raw material are less of an obstacle in retouching (Perlès 1992). It may be easier to obtain the desired tool shape by retouch rather than by direct production of a blank of appropriate shape. We might expect retouch to be more common in shaping the Dadong tool kit, as the raw material is of a generally poor quality. The fact that retouch is rare is indicative of the expedient nature of this lithic assemblage. The Dadong lithics were simply and rapidly made without a great deal of effort to standardize form or retouch the majority of flakes. The expedient nature of the Dadong lithics may reflect the fact that stone was not the most favoured raw material.

Rhinoceros teeth at Dadong

The faunal assemblage includes the remains of many large-bodied animals that ordinarily would not inhabit caves, such as the elephant-like *Stegodon*, *Rhinoceros* and the giant tapir *Megatapirus*. Expected cave-dwellers (humans, big cats, hyenas, wolves, foxes and porcupines) are also found. Carnivore remains are scarce and the evidence for carnivore damage on the recovered bones is limited (3% of the 1998 sample, N=389). The Dadong faunal collection does not show indications of being a carnivore-generated assemblage.

Fauna from the 1998 excavation season were classified into body size category and taxon. The following analyses are based on number of specimens, not individual animals. The same patterns are evident in the 1996 sample and a much larger collection of fauna recovered from earlier explorations of the cave. The assemblage

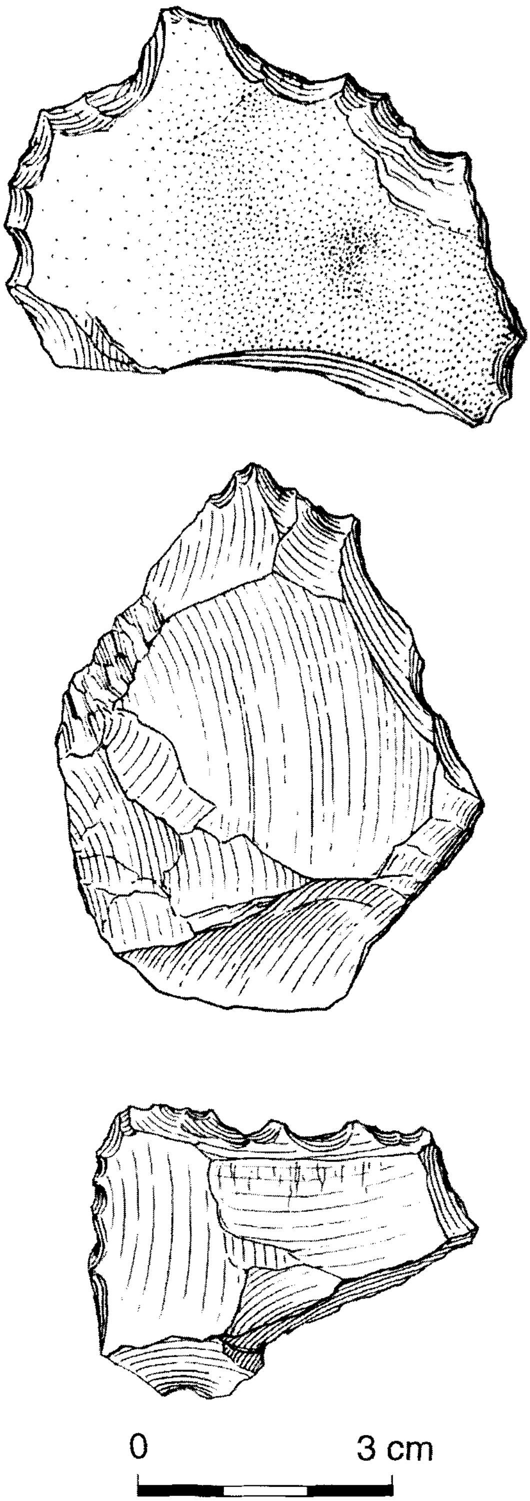

FIGURE 2. *Lithics.* a *tool possibly used as a borer;* b *flake tool;* c *flake tool with denticulated edges.*

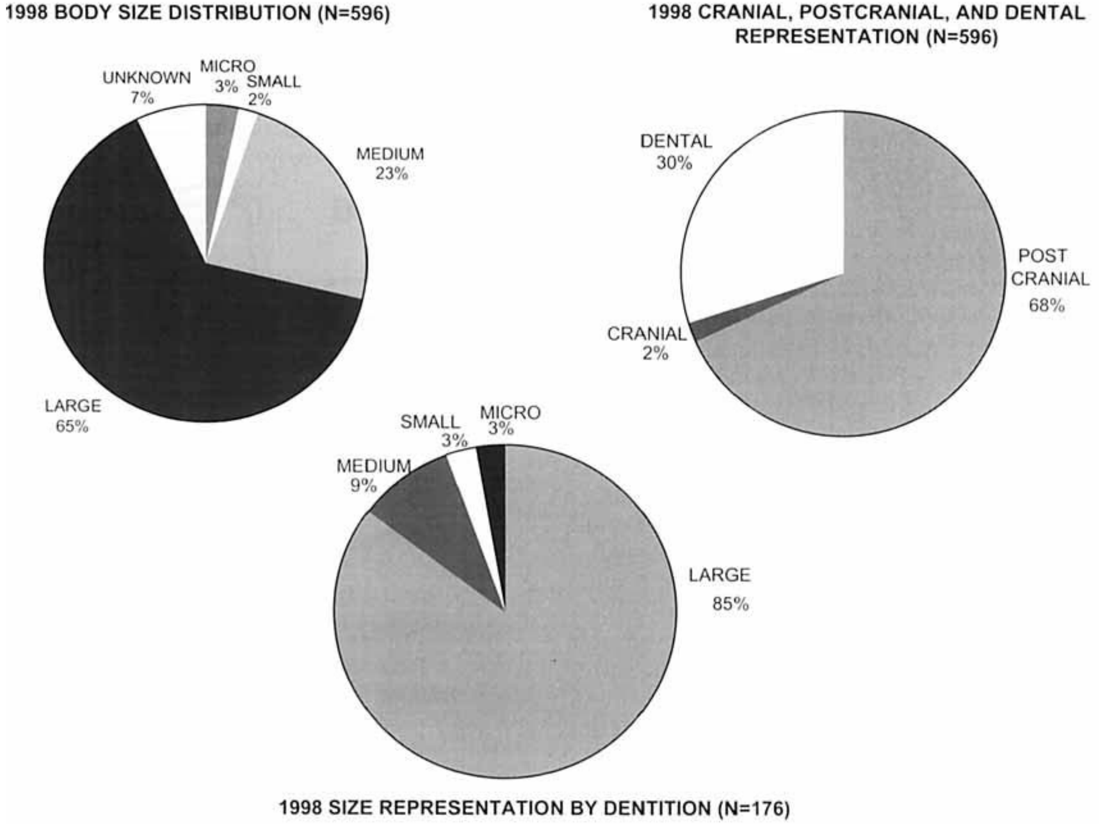

FIGURE 3a. *Mammalian body size distribution. Large: adults of 100 kg or more. Medium: adults 18–100 kg. Small: adults about 9–18 kilos. Micro: adults 9 kg or less.* N *is number of specimens.*

3b. *Cranial, postcranial and dental representation of mammalian fauna.* N *is number of specimens.*

3c. *Body size representation by dentition, based on remains identifiable to species.* N *is number of specimens.*

is dominated by the largest taxa, even though some of the small mammals and microfauna display better preservation of individual elements. The large body size taxa comprise 65% of the sample, the medium 23%, and the contributions of the small and micro groups are very minimal (FIGURE 3a).

As FIGURE 3b shows, 68% of the fauna is postcranial material, 30% is dental and 2% is cranial. This is what might be expected for a site with fairly good preservation of bone, but with an apparent under-representation of crania. The robust aspects of the mandible and petrous portion of the temporal bones should be preserved if crania were present. In addition, very few of the dental specimens are found with any surrounding alveolar bone. While this might be predicted for smaller animals with fragile alveoli or single-rooted teeth that commonly fall out of their sockets postmortem, the lack of alveolar bone for the large-bodied taxa is anomalous.

The most numerous taxon is *Rhinoceros* (over 25% of the 1998 faunal sample currently identifiable to species, or 77/302), followed by large bovids and cervids, and then *Stegodon*. When only the teeth are considered, the overwhelming proportion of large-bodied taxa is even more striking (FIGURE 3c). They make up 85% of the dental sample, with medium represented by only 9%. For *Rhinoceros*, 74% of the specimens are teeth. As the proportion of teeth for the entire faunal sample is only 30%, the number of *Rhinoceros* teeth is far greater than would be expected given the general robusticity and high density of *Rhinoceros* bone.

The apparent over-representation of *Rhinoceros* teeth in Dadong could be due to differential preservation, differential representation or a combination of those factors. These teeth are extremely durable, yet many of them are also found as fragments. The same is true of the molars of *Stegodon*, large bovids such as *Bubalus* (water buffalo) and cervids. Even taking into account the greater likelihood that larger teeth will preserve, it is still necessary to explain why so many of these teeth are in the cave. Given the body mass of *Rhinoceros*, it is unlikely that hominids or large carnivores would be able to transport entire carcasses or that they would select the lower utility cranial elements. Instead, we propose that the isolated teeth of large-bodied animals, especially rhinoceros, were selectively introduced to the cave by hominids.

An interesting contrast to the Dadong faunal assemblage comes from La Cotte de St Brelade, a cave site roughly contemporaneous with Dadong located on the Channel Island of Jersey. Scott (1989) analysed the clustered and stacked remains of over 20 mammoths and 5 rhinoceroses preserved within two distinct layers of the deposits. The densest portions of the skeleton, such as the skull, tusks and denser portions of the scapula and innominate, were best represented. Unlike Dadong, only three isolated teeth were found. Scott (1989: 337) suggested that hominids had driven the animals over sheer cliffs surrounding the site. Animals either fell directly into the site, or were dragged into the cave from the foot of the cliff or nearby chasms. Interestingly, less weighty but meat-bearing portions of the skeleton (the lower limbs, feet and mandibles) are under-represented, leading Scott (1989: 344) to hypothesize that they were removed by hominids or carnivores. Although the patterning is quite different, the faunal evidence from La Cotte de St Brelade, like that from Dadong, indicates that hominids of the time were capable of organized processing and selective transport of certain large mammal elements.

Why would hominids carry isolated large teeth into the cave? We have some evidence indicating that teeth can provide an alternative to poor-quality lithic raw material. Of the large-bodied animals, the teeth of *Rhinoceros* fracture naturally into useful portions of durable enamel and dentine that can be flaked to produce a sharp edge. Unlike the bovid, cervid and *Stegodon* teeth that have intricate and enfolded layers of enamel and dentine, *Rhinoceros* maxillary molars and premolars have large, flat enamel plates that are easily separated from the rest of the tooth (FIGURE 4). *Rhinoceros* teeth naturally crack and begin to fracture as they dry out. Several of the complete teeth we recovered display these first stages of fragmentation. Aside from breakage that might occur with desiccation, trampling and profile compaction, destruction to *Rhinoceros* teeth occurs through the gnawing activity of rodents, principally the porcupine *Hystrix*. Many middle and upper Pleistocene faunal assemblages from caves in southern China and northern Southeast Asia are characterized by heavily gnawed teeth and

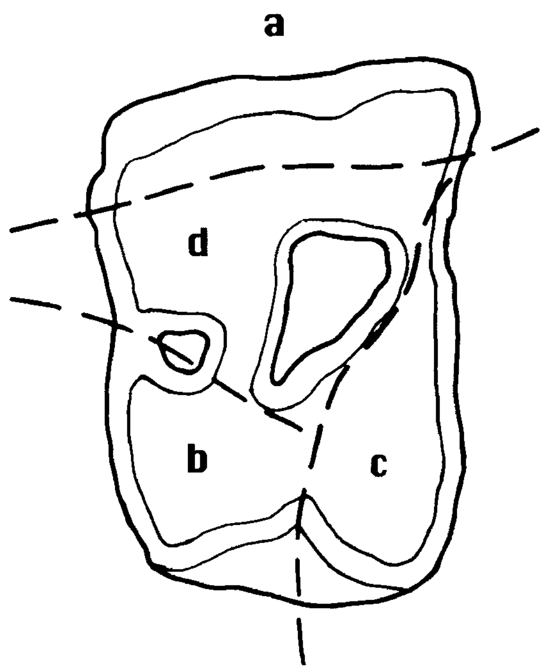

FIGURE 4. *Diagram of a* Rhinoceros *maxillary molar occlusal (chewing) surface, displaying a moderate stage of wear illustrated by the ring of enamel surrounding the exposed dentine center. The tooth consists of four structural portions that characteristically crack along the dotted lines:* a *the large buccal plate;* b *and* c *two conical lophs, and* d *the central infundibular region. The major planar surface is the buccal plate. While all four sides of the tooth form roughly planar surfaces, the lower crown height along the other three faces results in less enamel surface area. The frequent cracking or fracturing of teeth along the lines depicted results in fragments suitable for flaking.*

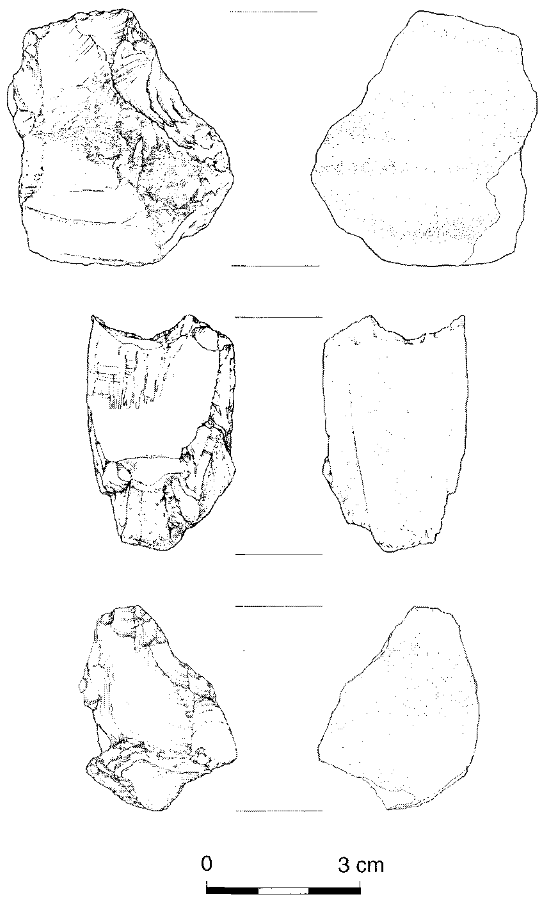

FIGURE 5. Rhinoceros *tooth tools.*

specimen no.	**length (mm)**	**width (mm)**	**thickness (mm)**
1	43.5	30.5	12.9
2	45.3	26.8	7.0
3	35.4	23.1	11.4

TABLE 1. Rhinoceros *tooth tools. (Length = maximum dimension measured from the working edge to the opposite edge. Width taken at approximate midpoint.)*

bones. At Dadong only 9·2% of 542 *Rhinoceros* teeth (including whole and fragmentary portions recovered from earlier explorations of the cave breccia) exhibited gnawing of the dentine or root.

Rhinoceros tooth tools

Rhinoceros tooth fragments with planar surfaces have a shape and structure (relatively flat with a durable, yet workable dentine–enamel junction at the occlusal surface) that is similar to lithic flakes. During our analysis of the Dadong fauna, we identified three fragmentary *Rhinoceros* tooth specimens as tools (TABLE 1, FIGURE 5). They share common features, such as their overall shape and location of the flaked working edge. In all cases they preserve dentine and enamel of the buccal plate and are rectangular fragments. To facilitate their description, we use the analogy of a scraper made on a flake, where the enamel surface represents the dorsal side and the dentine is the ventral side of the flake. On all three pieces, the flaked working edge occurs at the dento-enamel junction and the tool can be easily held along the blunt opposite edge. The flake scars that form the working edge are shallow and invade the dentine. Flaking along the dento-enamel junction of these specimens makes practical use of the structural properties of dentine and enamel. While enamel is more durable (composed by weight of 96—97% inorganic hydroxyapatite; Scott & Symons 1974), its large crystallites make it difficult to flake predictably. Dentine has a higher organic composition (only 75% inorganic material; Williams & Elliott 1979), but has shorter crystallites similar to those in bone (Scott & Symons 1974). At Dadong it appears that the tools were fashioned such that the easier to work dentine was modified to prepare a durable enamel edge.

Specimen 1 is a small scraper made on a fragmentary buccal plate. The modified edge is approximately 29 mm long and extends along the top and lateral edge of the fragment. The retouch is shallow and invades the dentine in small even flake scars. Specimen 2 is a less clear example of intentional flaking. It is the only one of the three that has evidence of gnawing on part of the dentine surface. Some of this rodent damage may be a later occurrence that obscures the intentional working. There are three small flake scars that form the flaked edge. The worked edge of specimen 3 is a shallow notch formed by 3 flake scars. In addition, some edge damage is visible in the form of small flake scars. Interestingly, a similar shallow notch morphology is a common feature on stone flakes at Dadong.

Discussion and conclusions

The modifications of *Rhinoceros* teeth at Dadong do not involve use of the anatomical or functional properties of the tooth beyond initial selection of a broad, flat enamel plate. The occlusal chewing surfaces were not the edges used. Instead, the inhabitants of Dadong made use of the natural fragmentation properties of *Rhinoceros* molars to produce small scrapers. The morphology of a *Rhinoceros* molar makes it highly amenable to use as an expedient tool. In essence, it is a 'pre-form' that is easily fabricated into a completed tool. The tendency of *Rhinoceros* teeth to fracture into large buccal plates naturally constrains the type of tool produced. This is a feature of other artefacts made of non-lithic materials such as bone, antler and shell as well as lithic materials like petrified wood. For example, some Early Anyathian implements from Burma were fashioned on fossil wood. Movius (1943) points out that these tools, so-called 'hand-adzes', are clearly influenced by the fact that fossil wood breaks into rectangles.

It is clear that assemblage composition and variability are the result of complex interactions of behaviour, environment and the physical properties of tool raw materials (Martinez 1998). Early humans colonizing the New World used a bone technology based on flaking techniques similar to those employed in working stone (Bonnichsen 1979; Frison & Zeimans **??Zeimens in refs??** 1980; Guthrie 1983). Earlier evidence for the production of bone tools by percussion comes from several Italian Acheulean sites and Bilzingsleben in Germany, where elephant-bone bifaces and scrapers were recovered (Klein 1999). The production of tools from *Rhinoceros* teeth at Dadong employed a similar technique early in the Asian Paleolithic. This innovative strategy may be a precursor to later technologies that regularly used bone and antler as raw material.

The use of teeth as a modified raw material may not be limited to Dadong. Since it is probable that most faunal dental collections have not been examined from this perspective, a re-examination of other faunal collections might verify the more widespread use of this technology.

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