# FEATURES OF RAW MATERIAL USE IN THE PALAEOLITHIC INDUSTRIES OF THE MOUNTAINOUS ALTAI, SIBERIA, RUSSIA

Anton A. Anoikin and Alexander V. Postnov

Institute of Archaeology & Ethnography, Siberian Branch of the Russian Academy of Sciences, Lavrentiev Avenue, 17, Novosibirsk 630090, Russia

ABSTRACT

*Denisova Cave is a multilayered archaeological site in the Mountainous Altai of Siberia, Russia. This site has yielded numerous* Palaeolithic *artifacts made of different types of stone with diverse petrophysical properties. Comparative petrographic analysis of artifacts and pebble raw materials allows us to conclude that the ancient people at this cave selected raw materials purposefully. Comparison between the stratigraphic layers of different ages has revealed essential differences between the Upper* Palaeolithic *and the Mousterian assemblages, according to the following parameters, such as: 1) use of certain stone types as raw materials; and 2) hardness of raw materials. Besides these criteria, the preferential use of particular raw materials to produce specific tool types has been established.*

## INTRODUCTION

The morphology of stone tools depends on the quality of the raw material used. Therefore, defining the criteria of raw material selection is essential for an understanding of flaking technologies and the adaptive potential and migration routes of prehistoric human groups. In order to reveal these criteria, one has to examine the Palaeolithic artifacts made of different rock types with their diverse petrophysical properties. Such artifacts can be found in the Anui cluster of Palaeolithic sites in the Altai Mountains of Siberia, including caves (Denisova Cave) and open air sites (Anui-1, Anui-2, and Ust-Karakol-1). These sites are located in a two kilometre long area in the Anui River valley (northwestern Mountainous Altai).

Denisova Cave is one of the best studied sites in the Anui River cluster, and contains the most representative stone artifact collections among the Palaeolithic sites of the Mountainous Altai. In this cave, traces of Palaeolithic human occupation have been found in 13 lithological units of the Pleistocene, and their age according to the geochronological data has been determined to be between 282,000 years (stratum 22, radiothermoluminescence [RTL] date) and the Pleistocene/Holocene boundary (Derevianko et al. 1998: 24-50) (Fig. 1).

Strata 19 - 12 of the main chamber and strata 10 and 9 of the cave entrance have yielded the most abundant archaeological material for the Middle Palaeolithic period. These illustrate developmental stages of the Middle Palaeolithic industry in the chronological range from about 100,000 to 50,000 years ago. The collection comprises Middle Palaeolithic artifacts homogeneous in their technical and typological features. The primary reduction strategy is based mostly on the following methods: 1) irregular pattern of flaking, 2) radial flaking, 3) Levallois technology, and 4) parallel laminar flaking. The tools associated with these strata are classified into the following categories: Levallois implements, racloirs, grattoirs, burins, borers, knives, truncated spalls, notches, denticulate tools, beaks, spurs, retouched flakes and blades, chopping tools, and an atypical biface.

Strata 11 and 9 of the main chamber and strata 7 - 5 of the entrance have yielded the most abundant archaeological records for the Upper Palaeolithic period. The collection from these strata also contains tools of Middle Palaeolithic type. In addition to the Mousterian series, Levallois points were also identified, comprising typologically distinct specimens. Denticulate tools are common in all assemblages. The series of Upper Palaeolithic tools is represented by typologically diverse grattoirs, burins, borers, and backed blades which display clear Upper Palaeolithic characteristics, and at the same time these tools constitute a diagnostic part of the industry as a whole. For example, foliate bifaces represent a new type in this industry. The recovered collection of bone tools and items of adornment supports the Upper Palaeolithic attribution of the lithic artifacts (Derevianko 2001:78-81; Derevianko et al. 2001:25-83).

In general, the Denisova Cave materials illustrate a developmental sequence from the Middle to the Upper Palaeolithic. It is important to note that assemblages associated with different cultural layers, though displaying some variable characteristics, represent a homogeneous collection from the perspectives of technology and typology.

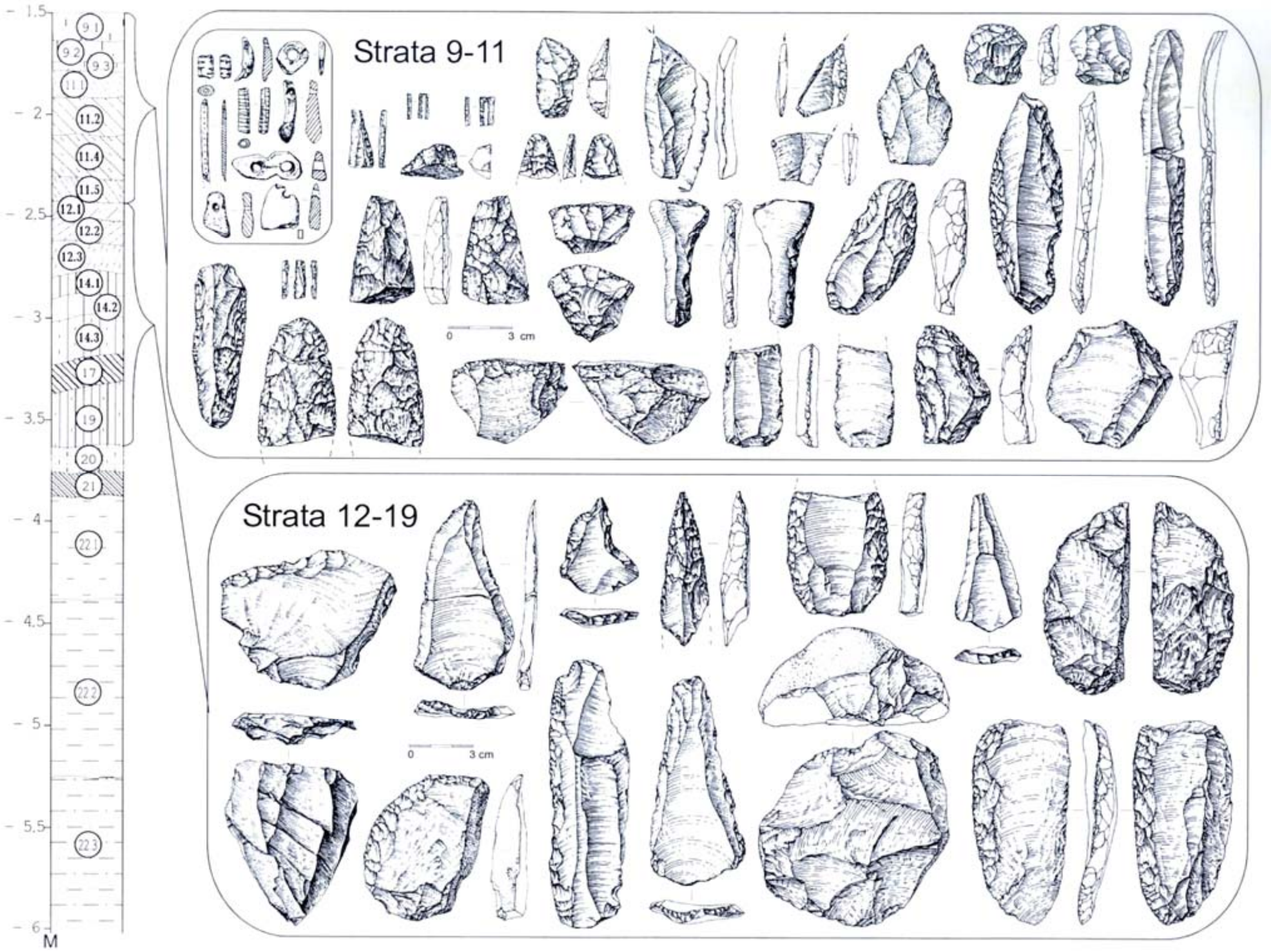


*Figure 1. Stratigraphic column and artifacts from the main chamber of Denisova Cave*

## CHARACTERISTICS OF RAW MATERIAL RESOURCES AND STONE TOOLS OF THE PALAEOLITHIC INDUSTRIES FROM THE ANUI CLUSTER

We consider that only suitable raw materials were selected for tool manufacture by the Altai Palaeolithic humans. Therefore, the notion of 'raw material for a stone industry' implies a set of features that determine flaking properties (shape, size, roundness, homogeneity, character of flaking surface, etc.), as well as features relevant for future use such as massiveness and granularity of rock, and shape and strength of flake edges. It is evident that for prehistoric people the combination of the most important properties of the rocks (hardness, viscosity and degree of anisotropy[1]) was of crucial importance (Postnov et al. 2000:18). This kind of approach to characterizing stone materials allows us to answer the question of whether the ancient tool-makers took the properties of raw material into consideration and selected suitable rocks for tool manufacture, or whether they flaked the first pebble they came across.

The remaining cortex on numerous stone pieces and the petrographic composition of the lithic industries from the Anui River Valley indicate that rocks were chosen from local pebble materials. For characterizations of these, two pre-Holocene alluvial sediments virtually synchronous with the ancient industries were excavated along two stretches of the Anui and Karakol Rivers that were originally dug for gold extraction (Fig. 2). The ratio of rocks of different composition was determined for a selected 3013 rock fragments. We used rocks from these exposed alluvial deposits for comparison with the raw material types used by Palaeolithic humans.

Sedimentary rocks constitute the major part of the pebble material in the Anui River Valley. The predominant rocks are medium-grained sandstone (with a grain size of 0.25 - 0.5 mm) and gritstone (grain size of 0.5 - 1 mm). Their hardness index is more than 5 (according to the Mohs scale), and for quartzitic varieties it reaches 6.5. Aleurolites (0.1 - 0.05 mm grain size) constitute less than 10 % of the debris, and are characterized by a hardness of 4 to 5.5 due to a high concentration of pelitic material.

Volcanic rocks occurring as pebble material come from two sources. The first source represents mostly aphyric (containing no impregnations) Devonian effusives

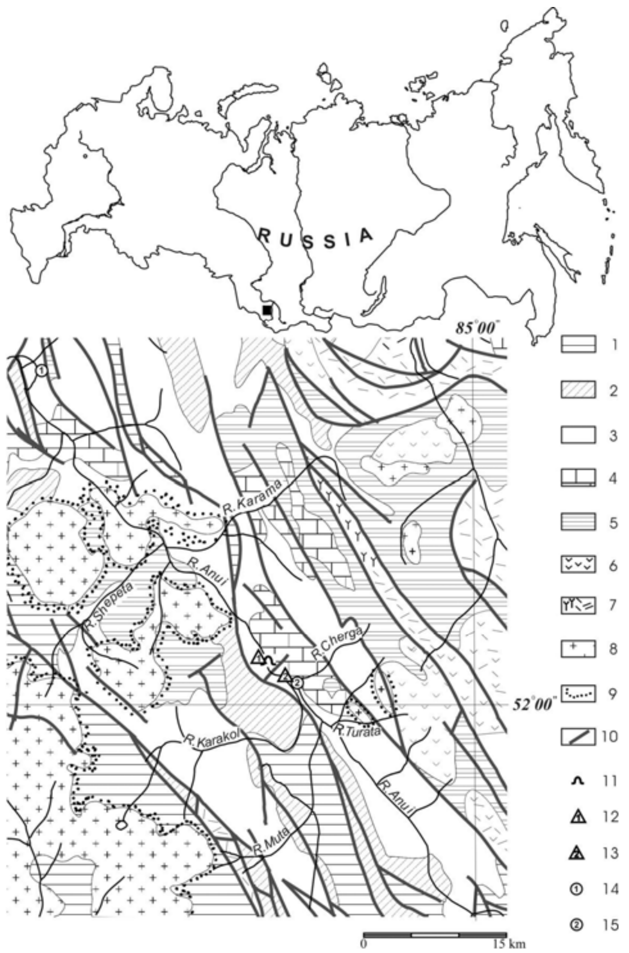


*Figure 2. Map of Russia with insert representing the Anui River Valley.*
*1. (Cambrian-Ordovician) - Suite of Gorny Altai: sandstones, aleurolites, slates;*
*2. (Ordovician) - sandstones, aleurolites, chlorite shales;*
*3. (Silurian) - sandstones, aleurolites, shales;*
*4. (Silurian) - limestones, limestone sandstones, shales;*
*5. (Devonian) - Suite of Baragash: limestones, aleurolites, sandstones, shales;*
*6. (Devonian) - Suite of Kurata: sour effusives;*
*7. (Devonian) –Suite of Kurata: medium, basic effusives;*
*8. (Carboniferous-Permian) Bashchelak massif of granitoid intrusions;*
*9. area of hornfels formation; 10. tectonic faults;*
*11. Denisova Cave; 12. Anui-2; 13. Ust-Karakol-1; 14. Soloneshnoe village; 15. Chorny village.*

of the Anui Ridge exposed by the Turata River, the right tributary looking downstream of the Anui River. The second source consists of andesite porphyrits (diorite analogues), their tuff lavas, and lava breccias from the watershed of the Karakol and Muta Rivers. These volcanic rocks have petrophysical properties (hardness of 5.5 - 6.5 and viscosity) similar to the effusives of the Anui Ridge, but they are distinguished by their porphyric composition: many light-coloured impregnations of plagioclase against a background of dark-grey to black cryptocrystalline groundmass determine changes of firmness (heterogeneity) in the process of flaking.

Hornfels is not numerous among the debris, yet was important as a raw material. This stone type is brought by the Karakol and Muta Rivers to the pebble sediments of the examined areas from the contact aureole of the Bashchelak granitoid massif within the Cambrian-Ordovician flyschoid bulk of aleurolitic sandstones. Hornfels, whose layer thickness rarely exceeds 20 cm, is not typical of the large boulders in the river beds. The heavy tectonic fracturing of hornfels in the zone of the Bashchelak rupture determines the internal fissuring of pebbles and gives rise to numerous fine conchoidal chips on their surfaces (Fig. 2).

Among the other rocks used to manufacture the local Palaeolithic industries, one can mention sparse, mostly large boulder fragments of dike diabase porphyrite with a hardness close to those of effusives and with high viscosity due to finely interwoven thin elongated crystals of basic plagioclase and pyroxene (Postnov et al. 2000). Thus, the geological and petrographic study of the region and its pebble materials allows us to distinguish the following peculiarities of raw material resources for local stone tool manufacture:

1. The quality of pebble material is highly dependent on tectonic fracturing which determines size, extent of fissuring, and partly the shape of the fragments.
2. Considering their petrophysical properties, rocks unsuitable for tool manufacture include limestone and slate (due to low hardness and fragility), granitoids (due to coarse granularity), and vein quartz (due to great extent of fissuring). The most suitable rocks include sedimentary, effusive, and hornfels pebbles.
3. The best material for flaking includes hornfels, aleurolites, and fine-grained sandstones. However, hornfels is poorly represented in the pebble sediments, and moreover, this raw material does not yield long flakes because of a high degree of hidden fissuring. The advantage of the aleurolitic and fine-grained sandstone pebbles is their bar shape. These pebbles are widely distributed and convenient for processing (Postnov et al. 2000:24).
4. The pebbles of effusive rocks are much more difficult to split than the hornfels or sedimentary rock pebbles, but effusive rocks have greater hardness and higher viscosity.
5. The most homogeneous and hence optimal pebbles for flaking are those in the 5 to 25 cm size range, i.e. cobble stones and large pebbles. The advantages of these stone materials are their accessibility, strength of fragments, and the frequent occurrence of bar-shaped sedimentary pebbles among them.

During analysis of 1488 artifacts from Denisova Cave, they were shown to be absolutely identical in their petrographic composition with pebble samples from the Anui and Karakol Rivers. Exceptions include a jasperoid rock of sealing wax colour (‘wax-coloured jasperoid’) with very fine quartz veins. This was not encountered in the examined pebble materials or among pebbles from the tributaries of the Anui River below the mouth of the Karakol River. The jasperoid rock is a non-local raw

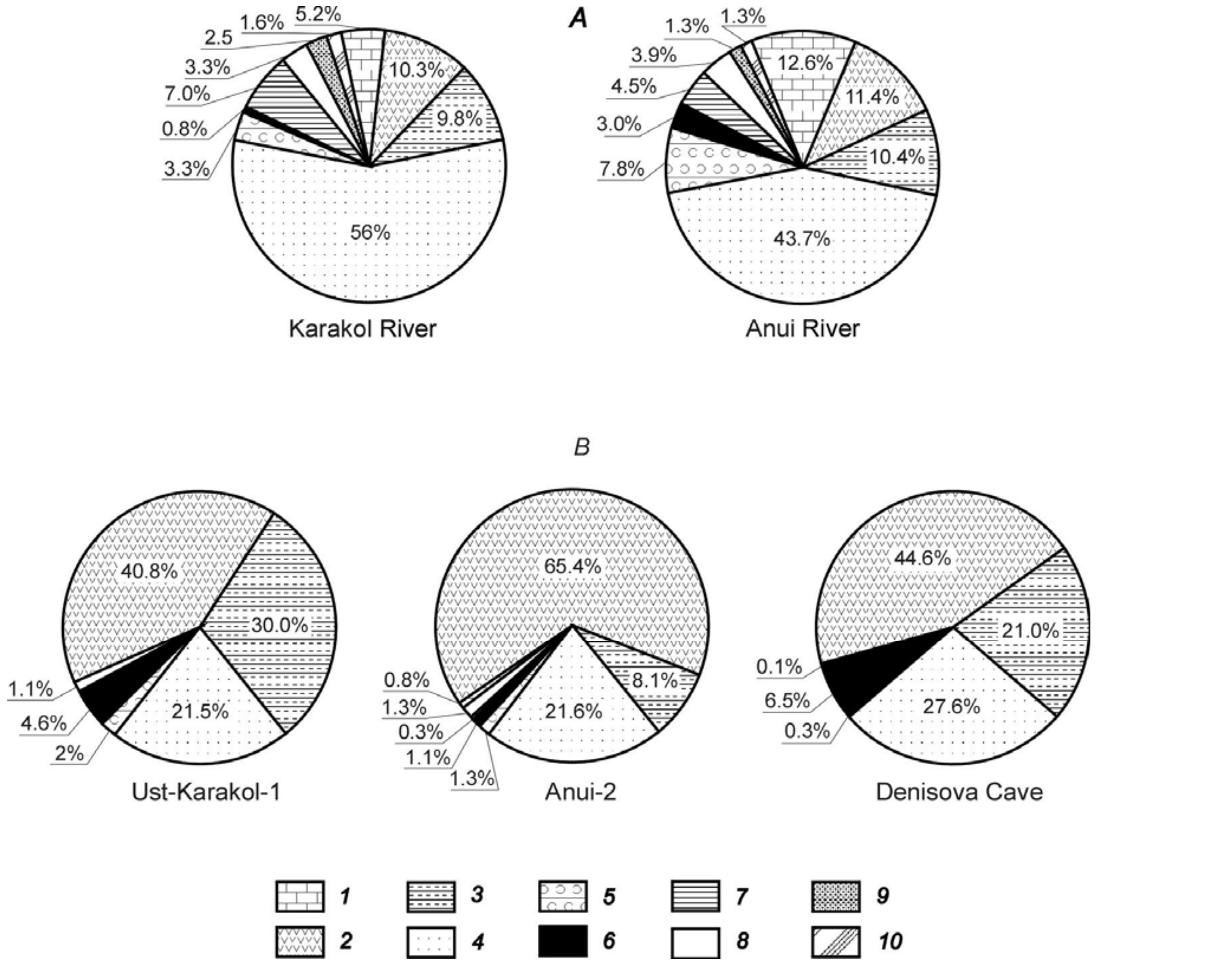


*Figure 3. Comparison of petrographical differences in pebble materials (A) and in the industries of the Palaeolithic sites (B).*
*1. limestones; 2. volcanic rocks; 3. aleurolites; 4. sandstones; 5. gravelites; 6. hornfels; 7. slates; 8. quartz; 9. granite; 10. dike rocks.*

material introduced to the cave by people, while the other raw materials are undoubtedly of local origin (Postnov et al. 2000:19-22).

The data presented provide evidence that the ancient toolmakers selected their raw materials purposefully. This assumption is supported by the results of percentage comparisons among not only effusives but also other types of pebble raw materials and stone artifacts. Also, the distribution of petrographic varieties demonstrates that effusives constitute more than 40% of raw materials in the analyzed part of the Denisova Cave collection. It is a remarkable fact that effusives are four to six times more numerous among the artifacts than among the pebbles of the Anui and Karakol Rivers (Fig. 3).

The comparative petrographic characterization of artifacts and pebble raw materials allows us to draw the following conclusions:

a) Raw materials were selected consciously at a high level of associative and logical reasoning by the Palaeolithic humans who were capable of choosing rocks with the necessary properties from a variety of raw materials.
b) The purposeful choice of raw materials entails the elaboration of certain criteria in their selection. The principal criteria might have been the following: 1) pebble size, shape, and colour; 2) character of the pebble surface; and 3) the sound made by striking pebbles against each other (the slight smell of certain rocks emitted on splitting could also have been a factor in selection) (Postnov et al. 2000:23-24).

## CORRELATION OF DENISOVA CAVE TOOL COMPLEXES BASED ON PETROGRAPHIC AND PETROPHYSICAL PROPERTIES

The data on the core and tool collections from the cave entrance and the main chamber (in total, 1488 specimens) were analyzed independently of one another. A comparison of the results obtained allows us to substantiate the conclusion about the connection between

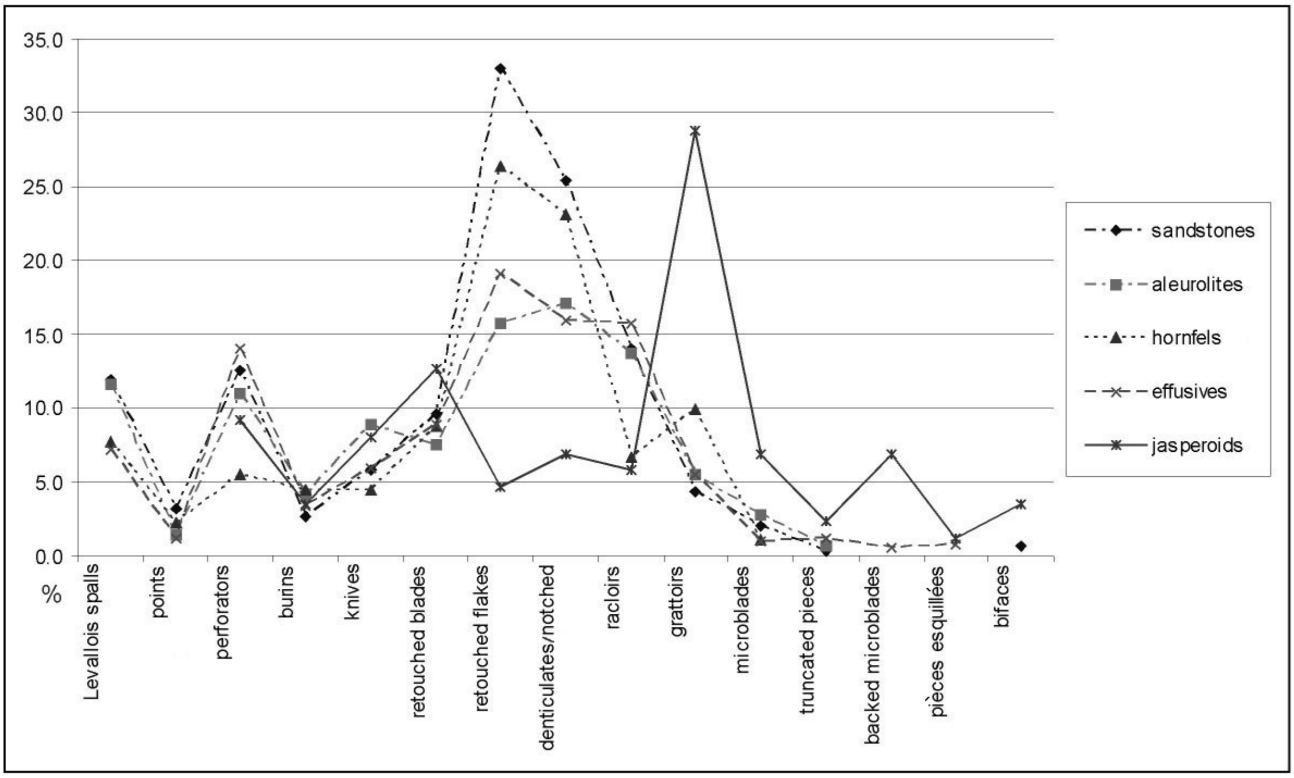


*Figure 4. Correlation of raw materials and tool types.*

the archaeological age of the cores and tools and their petrophysical characteristics. The cores and tools from both collections were divided according to their stratigraphic position into two cultural-chronological groups: Upper Palaeolithic and Mousterian.

The comparison revealed that there is an essential difference between the Upper Palaeolithic and the Mousterian groups in the collections of the main chamber and entrance, as well as some similarity within the Upper Palaeolithic and Mousterian groups in both collections. The differences are calculated in terms of the use of certain rocks as raw materials, and their hardnesses.

The data show an intensive utilization of jasperoids in the Upper Palaeolithic, and of sandstones and effusives in the Mousterian. The analysis of hardness also indicates a discriminative choice of rocks. In the Upper Palaeolithic horizons, the prevailing artifacts have hardnesses of 4, 5.5, and 7. The artifacts from Mousterian horizons do not reflect any preferences of this kind, and rocks with a hardness of 7 were rarely used. On the whole, we can register a greater hardness of raw material used for Upper Palaeolithic tools than for Mousterian tools.

The typical Mousterian tools, such as Levallois spalls, racloirs, and points, have a hardness index of 4 to 5, whereas Upper Palaeolithic tools, such as grattoirs, borers, and microblades, have an index of 5 to 7. The positive peak for microblades at a hardness index of 4 is associated with the extensive utilization of aleurolites for their manufacture. It should also be noted that the only microblades to be retouched were made of rocks with a hardness index of 6 and higher.

The data presented here show a certain change in the approach to raw material selection in the later, i.e. Upper Palaeolithic, period. This may be connected with a general tendency toward reduction of tool size. On the one hand, this tendency promoted a more demanding approach to the quality of raw materials used; on the other hand, it allowed the tool-maker to utilize larger quantities of small high-quality fragments for the manufacture of miniature implements (approximately 60% of tools with a length of less than 4 cm). In this context, the utilization of imported, high-quality raw material - the wax-coloured jasperoids - in the Upper Palaeolithic is of special interest. Processing this material was aimed at producing tools of Upper Palaeolithic types. One can conclude that the change to the new types of raw material was conditioned by technological innovations, i.e. the emergence of new stone-working techniques, new tool types, and changes in the quantitative ratio of tool forms within the stone industries of Upper Palaeolithic type.

A correlation between raw material types and certain tool types (racloirs, grattoirs, microblades and backed microblades) can be traced with a fair degree of certainty (Fig. 4). Thus, several kinds of sandstone were more frequently used to manufacture points, denticulates/ notched tools, and some Levallois spalls, and less frequently than other rocks to produce racloirs, grattoirs, burins, and knives (Figs. 3 and 4). It should be noted that sandstone was used to produce a high proportion of typologically undiagnostic tools (broken tools that cannot

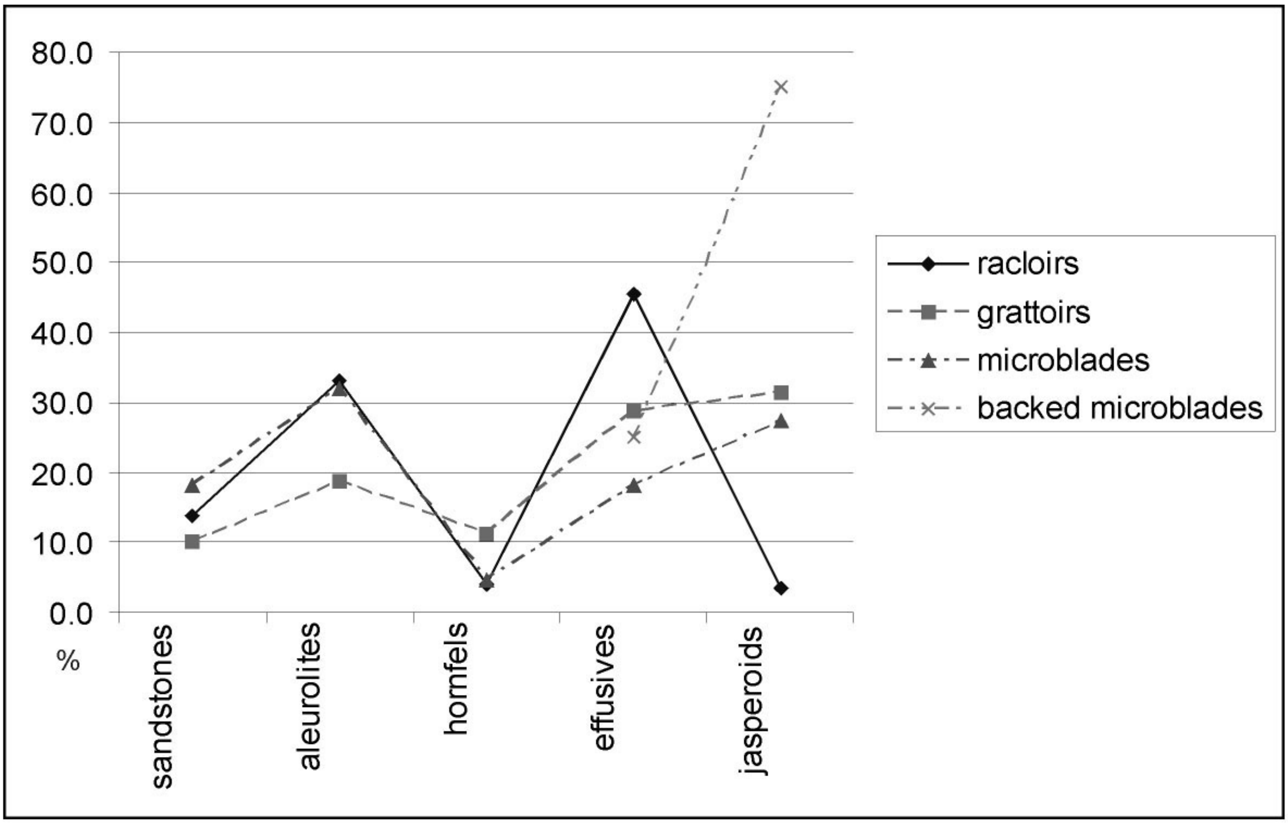


*Figure 5: Correlation of tool types and raw materials.*

be placed within a definite category, and flakes with irregular retouch). This is explained by the fragility of this rock and by the fact that sandstone, as the most widely distributed and most easily accessible raw material, was perfect for short-term operations where no meticulous preparation of the striking platform was required.

Aleurolite served more often as raw material for Levallois spalls, racloirs, knives, and burins. This is probably associated with the higher tractability of this material for 'correct' blade detachment. Aleurolite is the easiest rock type to flake due to its fine granular structure and lower hardness with reference to the Mohs scale. Therefore, worked aleurolites do not normally produce accidental, typologically undiagnostic artifacts.

Effusives are fairly hard. We argue this quality determined that many tool forms were made in this raw material, such as racloirs, various kinds of perforators, and more rarely burins. At the same time, this material is poorly suited for the manufacture of Levallois spalls. Effusives are difficult to splinter, because the flaking surface may be deformed due to the fluid structure of effusives, quartziferous amygdales, and impregnations. Yet, on the whole, effusives represent a class of multifunctional raw material utilized for the production of all types of tools in equal proportion. The combination of petrophysical features and easy availability which was optimal for tool manufacturing made effusives the predominant material.

Hornfels was also among the intensively used raw materials, but it was more rarely used to produce racloirs because the high internal fissuring of hornfels pebbles (with an approximate length of 10-15 cm) put limitations on core size, and the fine conchoidal chips typical of flaked hornfels produced uneven (denticulate) edges. Owing to these features (naturally indented edge), hornfels was the preferred rock for denticulate pieces. We presume that internal fissuring was also the reason for the large number of retouched hornfels flakes which were discarded during the tool-making process or during the exploitation of finished but frequently broken tools.

Jasperoids most frequently served as a raw material for two tool types, scrapers and microblades (about 30% of these artifacts were made of jasperoids). All the other tool categories, except for burins and knives, have a negative correlation with this type of material. The most specialized material in the group of jasperoids is the wax-coloured variety, and 14 out of 19 typologically distinct artifacts made of this material are backed microblades and grattoirs. Single pieces of other types (perforators on small fragments and a knife) most likely resulted from the accidental use of stone debris. On the other hand, they could also represent transitional forms from racloirs to grattoirs, with proportions and shape of the working edge close to those of side-scrapers, but with stepped vertical retouching typical of grattoirs.

Of special interest is a comparison of the racloirs and grattoirs types (Fig. 5). These tool types are close to each other functionally, and this indicates that similar raw materials would have been selected for their manufacture. However, the graphs reveal a different picture: While grattoirs were typically made of hard, easily flaked rocks, primarily jasperoids and hornfels, racloirs were made of medium-hard rocks. This may be explained by narrower functional specialization of grattoirs in contrast to a wider application of racloirs (as racloir-knives etc.). This assumption can, however, only be verified by use-wear analysis.

The tendency that diagnostic tool forms were manufactured on specific raw materials is demonstrated by the data on grattoirs and backed microblades (Figs 4 and 5). The main raw material for these types of artifacts is the jasperoid rock, perhaps due to the specifics of the stone-working technique as well as the need for hardness.

Based on these findings, we conclude that the Palaeolithic humans in the Altai had precise criteria for selecting raw materials for making certain types of tools. Along with the required external parameters (shape, size), other properties such as hardness, viscosity, and smoothness of the flaking surface were also taken into account. This conclusion is supported by the connections between artifact categories and the source materials of which they were made. The source materials may be conventionally divided into three groups:

a) Multifunctional materials (aphyric and porphyric effusives), which were used with equal frequency for making all tool types. Such materials have an optimal combination of application features and accessibility.
b) Specialized materials (hornfels, sandstones, aleurolites), suitable for making only a limited number of tool categories due to their specific features (hardness, viscosity) or technical limitations of the flaking process (fissuring, fluid structure, etc.).
c) Materials of narrow specialization (jasperoids), which occurr rarely and were normally used for only a few types of Upper Palaeolithic artifacts, the production and exploitation of which imposed high requirements on the application qualities of the raw material (Fig. 6).

Alongside classifying raw materials into groups based on their use for specific tool types, one can distinguish analogous groups among the artifacts. The results of our analysis demonstrate that certain specialized tool forms exist (end-scrapers, backed microblades) made of rocks of a certain appearance and quality, whereas other tools such as side-scrapers, points, and burins, were fashioned of more diverse raw materials.

## DISCUSSION AND CONCLUSION

The Palaeolithic human choice of raw material for tool manufacture was not accidental. The selection of rocks for use in manufacturing the industries of Denisova Cave and the nearby sites occurred on the banks of the Anui River. The selection was purposeful, i.e. it involved the selection of specific rocks for specific types of tools. Moreover, for the manufacture of backed microblades and grattoirs in the Upper Palaeolithic, the ancient tool-makers had to utilize raw material from rather distant sources, located up to 30 - 50 km away.

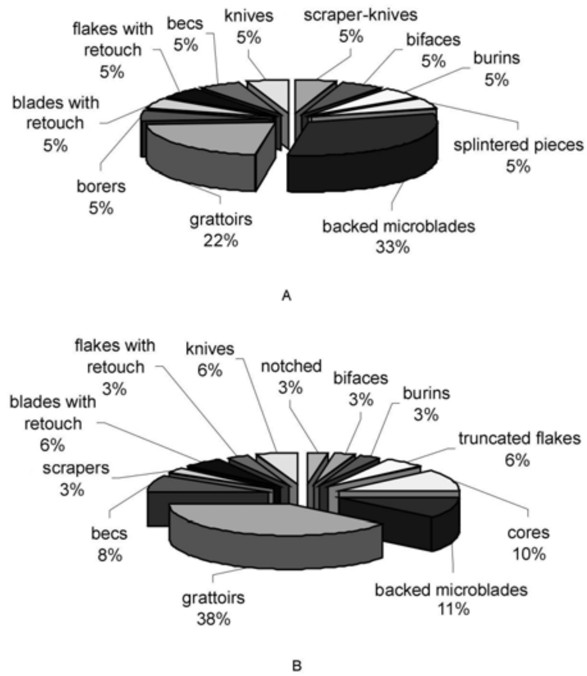


*Figure 6: Upper* Palaeolithic *tools made of imported jasperoids in the main chamber (A) and entrance (B) of Denisova Cave.*

Such a correlation of tool types and raw material can be traced at many European sites, for instance, at Palaeolithic sites in France (Rolland and Dibble 1990). But the correlations between types of tools and kinds of raw material, revealed in the course of investigating the Denisova Cave collections, are somewhat different and more complex than in the European cases. Various opinions are given in the literature on what may constitute the basis of these correlations (Binford 1992; Mellars 1996; Rolland and Dibble 1990). Basic factors may include the size of the original raw material blocks, remoteness of their sources, possible distant transportation of tools made of higher-quality raw material, technological requirements for raw material quality, and processes of reshaping and rejuvenating tools. We believe that each site or group of sites had its own factors determined by local specifics and cultural traditions of the ancient population.

Comparison of stone material and artifacts provides evidence for a high level of associative thinking of the ancient humans, which allowed them to select rocks with the necessary qualities based on a limited number of external features. Together with the determination of the selection place, such activities were evidently purposeful and conscious. The process of selection itself implies the acquisition of certain skills. Put another way, it is not a sporadic action but a form of regular, time-consuming labour. The evidence of sufficiently developed rationalization can also be found in the high level of adaptation of the Anui River valley stone industries to local conditions.

In the practical situation, despite the fact that utilization of local high-quality raw material was registered at synchronous Palaeolithic sites in the neighboring areas of the Mountainous Altai, the Denisova Cave inhabitants preferred to use their own local material even though it was difficult to flake, and made efforts to select and process it. thus, in our case the specifics of the local raw material were not a decisive factor in the choice of living area. There might have been more important motives that kept the ancient humans within the Anui River basin. The low quality of raw material was obviously compensated for by technical methods and skills that allowed people to adjust themselves successfully to the local conditions.

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## NOTE

1. The terms *hardness*, *viscosity* and *anisotropy* are defined as follows:
*Hardness* - the property of being rigid and resistant to pressure; not easily scratched; measured on the Mohs scale from 1 (graphite) to 10 (diamond).
*Viscosity* - resistance of a material to a change in shape, or movement of neighbouring portions relative to one another. Viscous materials (liquid or gas) deform steadily under stress. Rocks may behave like viscous materials under high temperature and pressure.
*Anisotropy* - the property of a material having a different value when measured in different directions (ant: isotropy).

## REFERENCES

Binford, L.R. 1992. The hard evidence. *Discovery* 2:44-51.

Derevianko, A.P. 2001. The Middle to Upper Palaeolithic transition in the Altai (Mongolia and Siberia). *Archaeology, Ethnology & Anthropology of Eurasia* 2(3):70-103.

Derevianko, A.P., A.K. Agadjanian, G.F. Baryshnikov, M.I. Dergacheva, T.A. Dupal, E.M. Malaeva, S.V. Markin, V.I. Molodin, S.V. Nikolaev, L.A. Orlova, V.T. Petrin, A.V. Postnov, V.A. Ulianov, I.N. Fedeneva, I.V. Foronova and M.V. Shunkov. 1998. *Arkheologia, geologia i paleografia pleistotsena i golotsena Gornogo Altaya* [Archaeology, geology and paleogeography of the Pleistocene and Holocene of the Mountainous Altai]. Novosibirsk: Izdatelstvo Instituta Arkheologii i Ethnografii Sibirskogo Otdeleniya Rossiiskoi Akademii Nauk. (In Russian.)

Derevianko, A.P., S.V. Markin, M.V. Shunkov, V.T. Petrin, M.M. Otte and A. Sekiya. 2001. Palaeolithic *of the Altai.* Brussels: Richard Liu Foundation, European Institute of Chinese Studies.

Mellars, P. 1996. *The Neandertal Legacy An Archaeological Perspective from Western Europe.* Princeton: Princeton University Press.

Postnov, A.V., A.A. Anoikin and N.A. Kulik. 2000. Criteria for the selection of raw materials in Palaeolithic industries of the Anui River basin (Gorny Altai). *Archaeology, Ethnology & Anthropology of Eurasia* 1(3):18-30.

Rolland, N. and H.L. Dibble. 1990. A new synthesis of Middle Palaeolithic variability. *American Antiquity* 55:480-99.