

THE BRITISH MUSEUM
Technical Research Bulletin



VOLUME 1 2007

The emperor's terrapin

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Summary The exceptionally large (48.5 × 32 × 20 cm) and naturalistic stone carving of a terrapin in the collections of the British Museum was found in 1803 in the Mughal fort at Allahābād, northern India, built during the reign of emperor Akbar, 1556–1605. The carving is thought to date from the first half of the seventeenth century, possibly to the reign of emperor Jahāngīr (1605–1627) who was a keen naturalist and a patron of jade carving. The mineralogical composition of the grey-green material of the terrapin was identified by Raman spectroscopy as nephrite jade. Shallow fractures in the material show that a large boulder from an alluvial source was used for the carving. The unusual, banded appearance of the nephrite suggests it was obtained from a small alluvial deposit in central Asia rather than the well-known sources near Khotan, in north western China, or in the region of Lake Baikal, Siberia.

The hardness and exceptional toughness of nephrite render the material difficult to work, and the technology used to carve the terrapin were also investigated. Following an optical survey of the carved features, detailed silicone moulds were made of various features bearing tool marks for examination by scanning electron microscopy. These indicated that the large carving was predominantly worked with non-rotary tools. Diamond, and possibly also corundum, abrasive appears to have been used with various saws and broader files to facilitate the working of the jade. The fine shaping of the terrapin was achieved with diamond-pointed tools. The results demonstrate that an exceptionally large jade boulder was transported from a distant source and carved by skilled lapidaries over a long period of time, suggesting that this terrapin was made for a prestigious person.

INTRODUCTION

The exceptionally large, naturalistic grey-green stone carving of a terrapin in the collections of the British Museum (Figures 1a and 1b) was found during engineering work in 1803 in a cistern within the Mughal fort at Allahābād, northern India, and brought to England by Lieutenant General Alexander Kyd of the Bengal Engineers. The carving has been identified as a female *Kachuga dhongoka*, commonly known as the Indian dhongoka terrapin or three-striped roof turtle, a species native to the tributaries of the River Ganges, including the River Jumna, which joins the Ganges at Allahābād. The fort was built by the third Mughal emperor Akbar (1556–1605) and occupied by crown prince Shāh Selim (1599–1604), who became emperor Jahāngīr (1605–1627). It has been suggested that the terrapin may have decorated a pool in the palace gardens within the fort. On stylistic grounds, the carving is thought to date from the first half of the seventeenth century, possibly to the reign of Jahāngīr who was a patron of jade carving and a keen naturalist.

Museum curators have assumed that the terrapin is jade and, prior to the natural history collections being moved to South Kensington in the late nineteenth century, it was displayed alongside large jade boulders from Siberia in the Mineral Gallery. The first half of the seventeenth century is early for a jade carving as large as the terrapin and the occurrence of such pronounced banding on jade (see Figure 1a) is also unusual. In preparation for a touring exhibition within the 'Museum in Britain' programme, it was desirable to confirm the mineralogical composition and investigate the Mughal techniques of carving. Previous studies undertaken by two of the authors, Sax and Meeks, have shown that the fine detail preserved on the carved features of hard stone artefacts such as jade is ideal for the study of ancient lapidary technology. The use of various tools and techniques can usually be recognized from the characteristic morphology of the 'tool marks'.



FIGURE 1. Seventeenth century, Mughal period, grey-green nephrite jade terrapin (1930,0612.1), 20 cm high, 48.5 cm long, 32 cm wide: (a) front view showing the pronounced grey banding of the material; (b) side view showing shallow fractures around the lower side of the shell that indicate a boulder from an alluvial source was used as raw material

METHODS OF EXAMINATION

The mineralogical composition of the material of the terrapin was identified by Raman spectroscopy (Jobin Yvon LabRam Infinity spectrometer), using a low energy, green (532 nm) laser with a maximum power of 2.4 mW at the sample and an external beam path. The spectra produced were compared with those of standards from a British Museum in-house database. This method of analysis allows totally non-intrusive identification of many minerals and has been widely exploited in the examination of supposed jade objects [1].

The approach adopted to study the carving techniques was based upon experience of an earlier investigation to identify methods of engraving on Mesopotamian quartz cylinder seals dating from the late Chalcolithic period to the early Iron Age, c.3000–400 BC, which was subsequently

applied to jade carving in China [2, 3]. The large carving of the terrapin was first examined for tool marks using a headband magnifier ($\times 2.3$). Features bearing evidence of tool marks were selected for examination by scanning electron microscopy (SEM, a JEOL JSM 840), using secondary electron imaging or a scintillator backscattered electron detector. Detailed impressions were made of six features with silicone moulding material without any risk of damage to the terrapin, enabling the tool marks to be examined in the high vacuum chamber of the SEM. Another advantage of moulding is the ability to examine deeply carved parts of an object that are difficult to view directly and would also have been difficult to shape and polish. Because tool marks are often preserved in recessed surfaces, such areas to the side of the neck under the shell were also moulded. The moulds were mounted on aluminium stubs before coating with gold for examination by SEM.

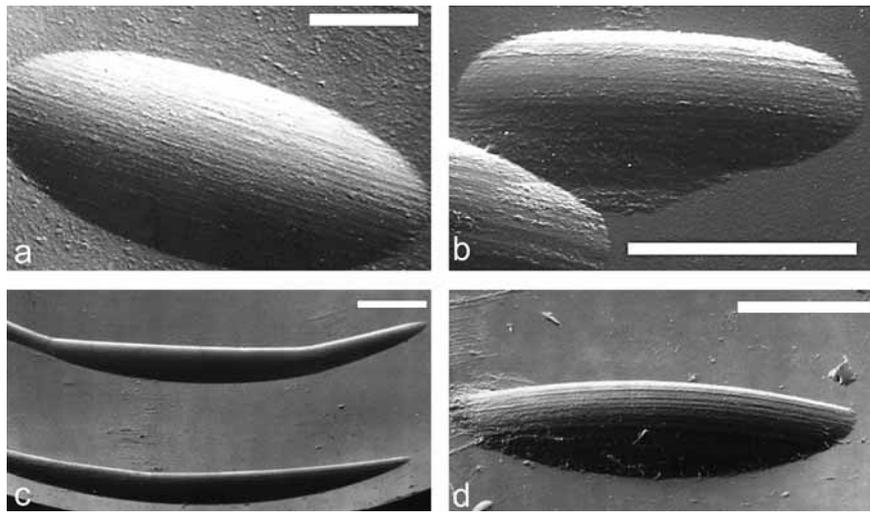


FIGURE 2. SEM images of moulds of features produced experimentally on convex quartz surfaces. The shapes in plan view of (a) sawn and (b) wheel-cut features may be very similar. Profiles of depth, seen from the side of (c) sawn features and (d) wheel-cut features are usually very different, enabling a distinction to be made between the two techniques (scale bars 1 mm)

Following the criteria established by Sax et al., the use of various lapidary tools was recognized by comparing the characteristics of the tool marks on the terrapin with those of standard features produced experimentally on hard stones with a range of techniques, tools and abrasive materials [4]. By considering several characteristics, it is usually possible to distinguish between individual tools, for example, saws and wheels (i.e. disc-shaped tools), Figure 2.

MATERIAL OF THE TERRAPIN

The grey bands and grey-green matrix of the stone were shown by Raman spectroscopy to be nephrite, one of the two main varieties of true jade. Nephrite is an amphibole mineral, the composition of which can vary from the magnesium-containing tremolite ($\text{Ca}_2\text{Mg}_5\text{Si}_8\text{O}_{22}(\text{OH})_2$) to the iron-containing ferro-actinolite ($\text{Ca}_2\text{Fe}_5\text{Si}_8\text{O}_{22}(\text{OH})_2$).

The exceptionally large size and distinct appearance of the jade suggest the raw material originated from an unusual geological source. Textual evidence discussed by Chandra and Skelton indicated that nephrite was obtained by the early Mughal court from sources in Xinjiang, now the westernmost province of China but then an independent central Asian kingdom [5, 6]. During a hazardous journey, the raw jade would have been carried around the Taklamakan Desert to Kashgar and then over the Karakorum Mountains to Kashmir and northern India. The alluvial pebbles and boulders collected from the banks and beds of the Black Jade River and the White Jade River near Khotan are thought to have been used by the Chinese for carving as early as the tenth century BC [7]. The size of these pieces was however generally limited. Larger blocks, such as the colossal slab of dark green jade used to cover the tomb of the Mongol conqueror, Tīmūr, at Samarkand in 1404, appear to have

been obtained occasionally from the primary sources of nephrite in the Kunlun Mountains, south of Khotan. Material was not regularly quarried from these sources until the eighteenth century, in response to increased demand from the Chinese imperial court. Furthermore, the pronounced colour patterning, relatively high opacity and grey-green colouring of the Mughal terrapin contrast with the generally plain colouring and greater translucency of the material from Khotan, which usually ranges from white to dark green or may be yellow-green [8].

Visual examination showed that a large boulder from an alluvial source, rather than a block from a mountain source, was used for the terrapin. Numerous shallow fractures on the side of the shell form wave and mosaic patterns (Figure 1b) that are consistent with damage incurred as the jade was carried and tumbled downstream from a mountain source by torrents of water released by melting snow. It is unlikely that the Mughal material originated from the sources of large boulders in the Sayan Mountains to the west of Lake Baikal, Siberia, as these sources were not discovered until the mid-nineteenth century and do not include banded material [9]. Although grey-green and mottled green nephrite is found at Qaidam, Qinghai province, China [8], a more likely source for the material of the terrapin is central Asia, the homeland of the Mughal ancestors. Several small alluvial deposits have recently been reported and grey banded material is known [10].

CARVING TECHNOLOGY

Traditional methods of carving in India

Nephrite is of moderate hardness, with a Mohs' scale of hardness, H, of 6–6.5. It is therefore harder than iron and

bronze so that it cannot be worked using metal tools alone. The mineral is also exceptionally tough and the methods used to shape and decorate nephrite rely on time-consuming abrasive processes rather than techniques of flaking. The fine abrasive sands and ground stones being used in China in the first half of the twentieth century included quartz ($H = 7$), garnet ($H = 7-7.5$) and corundum ($H = 9$, see below) [11]. All are harder than nephrite. The abrasives were graded from coarse to fine, the finest producing the smoothest surfaces. They were mixed with water and applied to iron or steel tools, some of the grit embedding or ‘charging’ itself into the surface of the tool while a slurry remained on the surface to be worked against the jade.

Referring to the Mughal methods of carving jade, Chandra quoted Francois Bernier, who visited the Mughal Empire between 1665 and 1668: “it [jade] is so hard as to be wrought only with diamond powder” [5]. Diamonds, the hardest mineral known ($H = 10$), were available from one or more sources in India, for example, the former kingdom of Golconda, now in the state of Hyderabad [12]. Diamond lapidary tools have a long history in India; quartz beads were perforated with diamond-pointed drills probably as early as the first millennium BC [13], and diamonds may also be crushed for use as an abrasive.

Chandra’s account of the traditional methods employed to work jade in northern India during the early twentieth century provides a further insight into likely Mughal lapidary practices [5]. Initially, the raw material was sawn to size using a wire strung between the ends of a bow. The wire was charged with corundum abrasive and worked backwards and forwards by one or two men; water was used as a lubricant, Figure 3. Opaque crystals of corundum (aluminium

oxide) occur commonly in India [14]. They may also be ground to provide a high-grade natural abrasive, second only in hardness to diamond (the rarer transparent varieties of corundum – ruby and sapphire – are valued as gems). Once the material had been shaped roughly by sawing, the jade surfaces were finely shaped (then polished) with rotary grinding wheels, which were used with bow-driven lathes. A wheel was attached to the end of an iron spindle/axle, mounted horizontally between wood bearings; the string of the bow was wound around the spindle. Sitting on the ground, a lapidary would steady the lathe with one foot, hold the bow in the right hand and move it backwards and forwards to rotate the wheel; the jade was held in the left hand against the revolving wheel. Rotary wheels were also employed for carving jade in Iran during the twelfth century [15].

Methods of carving the terrapin

Traces of tool marks remain on the Mughal terrapin, particularly on recessed features. SEM observation of the fine detail of moulded tool marks provided evidence for several methods of carving. They involved the predominant use of non-rotary tools: saws and broader files (with long straight working edges), riffler files (with shorter working edges) and pointed tools.

Two straight marks or ‘cuts’ under the shell above the proper left rear foot appear to be mistakes made during an early stage of carving. The marks are 63 and 38 mm long and c.1 mm wide; Figure 4a shows a mould of the longer mark. The depth along an incised tool mark can easily be seen



FIGURE 3. Pencil and ink drawing by John Lockwood Kipling of a lapidary at Agra, India, 1870, using a traditional wire saw to cut a small stone mounted on a post. One end of the bow was hand held whilst the opposite end was balanced with a weight; the wire was charged with an abrasive mix from the bowl. *Drawing (0929/52) is reproduced by kind permission of Victoria and Albert Museum, London*

from the side of a mould, for example, in the SEM micrograph of the shorter cut, Figure 4b. In this oblique view of the mould, the cut protrudes upwards: the straight profile along the feature reflects the linear depth along the cut in the jade. Groups of relatively continuous, parallel linear striations are present along the surfaces of both features, Figure 4b. Straight features with similar characteristics of depth and surface texture to those of the two cuts were produced experimentally on hard stones, using a long straight metal blade or a metal wire held rigidly between the ends of a bow. The experimental tools were charged with an abrasive considerably harder than nephrite, either emery or diamond; they were applied with a lubricant in a backwards and forwards sawing motion, Figure 2a and 2c [2, 4]. The two cuts under the shell of the terrapin show that the jade boulder was initially 'rough' shaped as closely as possible to size using hand-held straight saws or wire saws. The width of the cuts indicates that the Mughal saw was less than 1 mm thick. It may have been iron or steel, similar to the traditional Indian saw illustrated in Figure 3 and those still retained in Hong Kong for the primary shaping of large jade boulders.

Numerous tool marks were seen on the mould of the recessed surface to the side of the neck under the shell. They

comprise two principal types: relatively broad marks and fine striations, made during the fine shaping and smoothing of the terrapin. Three broad marks are indicated with arrows on the SEM micrograph in Figure 5a. The features may be straight or curved and as long as 2 to 3 cm. Experiments with diamond points and flint (a variety of quartz) tools showed that both materials are sufficiently tough and hard to score nephrite without an abrasive. The tools produce different surface textures. Features worked with diamond points (Figure 5b) are more sharply defined than those worked with flint tools (Figure 5c) and resemble those on the terrapin, Figure 5a. Following the evidence documented by Bernier (alluded to above) that diamond powder was available in the seventeenth century, it seemed reasonable to infer that the fine shaping of the terrapin was mainly achieved by scoring the surfaces in multiple directions with diamond-pointed tools [5].

Examples of the second type of mark, fine striations, can be seen in the upper left corner of Figure 5a. Elsewhere on this mould, the marks clearly form groups of parallel linear striations, characteristic of hard abrasives. Observation of features produced experimentally on hard stones with metal files separately charged with emery and diamond

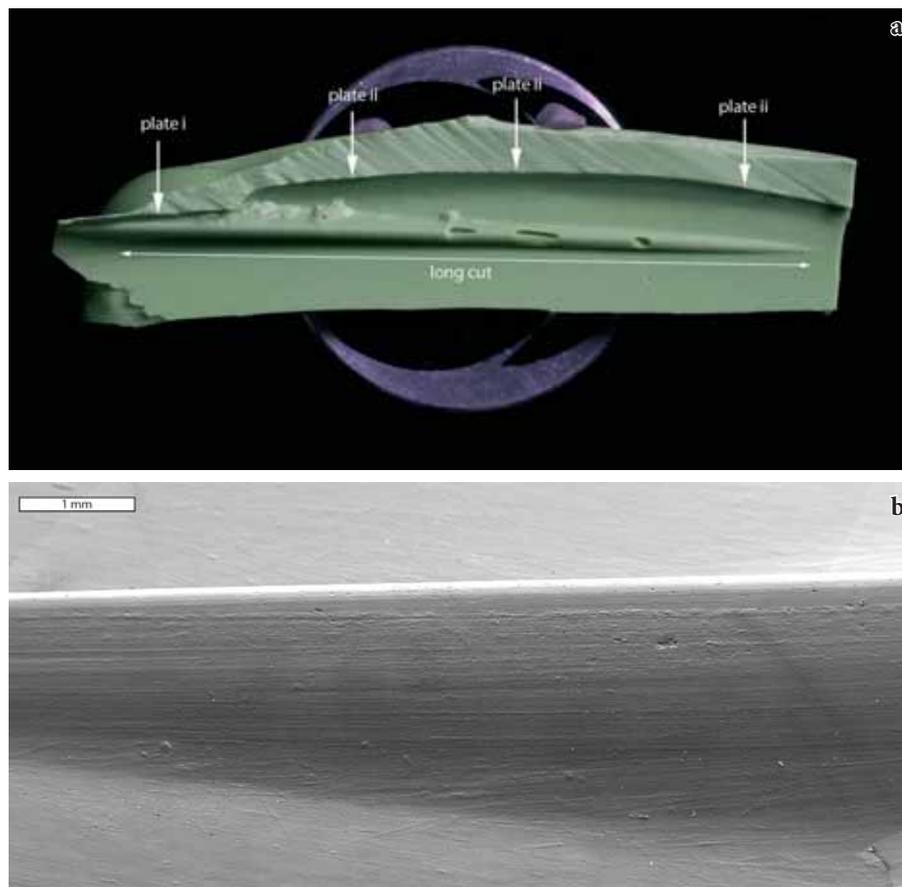


FIGURE 4. (a) Green silicone mould (mounted on an aluminium disc, appearing purple) of a 63 mm long cut in the surface under the shell. Vertical arrows point to the edge of the shell across two adjacent plates (i and ii); (b) SEM image showing the moulded side of a similar cut, 38 mm long. The cut protrudes upwards on the mould, across the image: the profile of depth along it is straight and the groups of parallel linear striations along the sides of the feature demonstrate that a non-rotary saw was used with a hard abrasive (scale bar 1 mm)

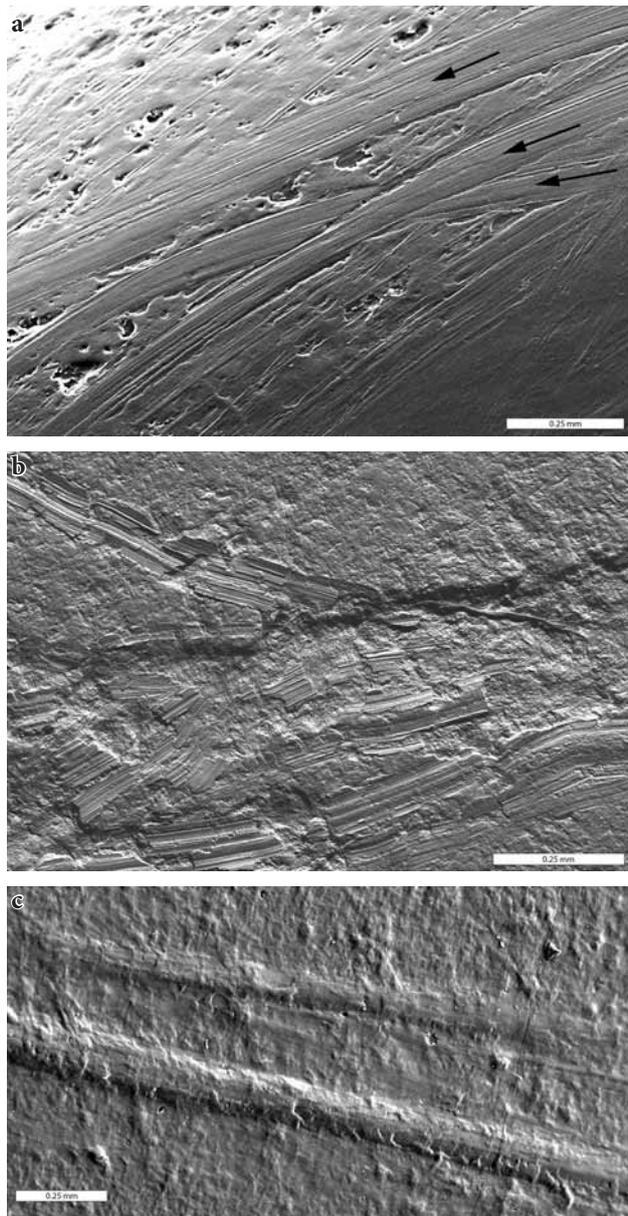


FIGURE 5. SEM images of moulds of: (a) recessed surface to the side of the neck under the shell of the terrapin (cavities in the surface are moulding faults); features produced experimentally on rough nephrite surfaces, using (b) a diamond-pointed tool and (c) a flint tool without an abrasive. The three broad tool marks arrowed across (a) were apparently cut with diamond-pointed tools (scale bars 0.25 mm)

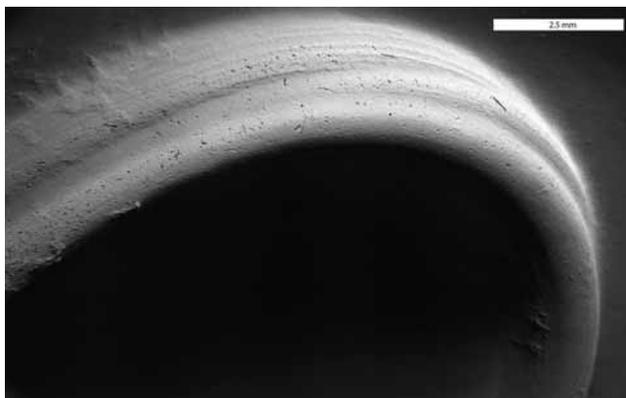


FIGURE 6. SEM image of the moulded details of an eye showing the outer edge was incised with a tubular drill (scale bar 2.5 mm)

abrasive mixes suggested the particularly sharp definition of some striations on the terrapin was achieved using diamond rather than corundum abrasive, as described by Bernier. The widths of the striations moulded from the terrapin vary, reflecting the use of abrasives of different grain sizes; increasingly fine abrasives appear to have been employed to smooth the surfaces of the terrapin prior to polishing. The linear characteristics of the striations indicate that the abrasives were applied with files (broader saws); these were frequently used alternately in perpendicular directions. Although fewer tool marks remain on the shell, these areas appear to have been ground smooth in a similar manner with hand-held tools. Smoothing the largely convex surfaces of the terrapin with the long working surfaces of files would have been straightforward, but smoothing the recessed surfaces that were inaccessible to straight files would have necessitated the use of riffler files, with shorter working surfaces. The rippers may have been specially shaped with a curved surface or the end of a straight file may have been employed. The folds in the skin of the protruding neck were incised with small hand-held tools using a similar approach.

No evidence, such as curved striations or pronounced concave depths, was found on the terrapin for lathe-mounted rotary wheels. However, drills were employed to work the nostrils and the eyes. Although deposits of dirt/soil in the nostrils precluded moulding, a small wood rule revealed that the circular cavities, which are 3.5 mm in diameter, are remarkably deep at c.16 mm. The moulded details of the eye are seen in Figure 6: the annular mark and circumferential striations show that a tubular drill, c.17 mm in diameter and c.1 mm thick, charged with an abrasive mix, was used to outline the eye. The drills may have been lathe-mounted or hand-held, for example over a capstone, but in either case in the Mughal period the drill would probably have been bow-driven.

Thus, the jade was finely carved to reflect the natural form of a terrapin using predominantly non-rotary tools. The attention to fine detail is exemplified by the plates forming the shell. These were individually shaped with sloping surfaces so that the separation between plates was accentuated by the different heights of adjacent plates. This can be seen on the mould of the surface under the shell shown in Figure 4a, where the vertical arrows point to the profile of the edge of the shell across two adjacent plates (i and ii).

It is interesting to speculate on the time spent carving the terrapin. Hansford observed that it would take three lapidaries several weeks to saw a block of raw jade, estimated to be about 35 cm long and 24 cm high, in two [11]. Although the carving of the terrapin was accomplished with the advantage of diamond-pointed tools and diamond abrasive, both of which were rarely used for working jade in China, its production, achieved almost entirely with hand-held tools, would probably have taken at least a year.

CONCLUSIONS

The composition of the Mughal grey-green stone carving of a terrapin was confirmed to be nephrite jade by Raman spectroscopy. A single large boulder from an alluvial source was used for the carving. On the basis of the size of the boulder necessary and the distinct grey-green colouring, pronounced colour variation and low opacity of the material, it is unlikely that the raw jade originated from the well-known sources of nephrite in the region of Khotan, now in Xingian province, China. It is also unlikely that the boulder was obtained from the sources currently mined near Lake Baikal, Siberia. It seems possible, however, that the material derived from a small alluvial source in central Asia.

Optical and SEM observations of the tool marks remaining on the terrapin enabled the sequence and range of carving methods to be identified. The large piece was roughly shaped using non-rotary saws with long thin working edges, charged with an abrasive mix considerably harder than nephrite. Finer shaping appears to have been achieved mainly by scoring the jade surfaces with diamond-pointed tools. In the final stages of shaping and smoothing prior to polishing, files (or broader saws) and riffler files with shorter working edges were employed. These tools were charged with hard abrasives of successively finer grain size. Diamond abrasive and possibly also corundum abrasive were probably used. The only rotary tools used were drills, which were employed for working the nostrils and outlining the eyes. The examination demonstrated that, firstly, the exceptionally large jade boulder was transported from a distant source and, secondly, the carving was executed by skilled lapidaries over a long period of time. This suggests the terrapin was worked for a prestigious person.

ACKNOWLEDGEMENTS

At the British Museum, we thank our colleague Andrew Middleton. We are also grateful to Brian Jackson (National Museums of Scotland), Alan Jobbins (formerly of the Geological Museum, London), Robert Skelton (formerly of the Victoria and Albert Museum, London), David Smith (Natural History Museum, London) and Susan Stronge (Victoria and Albert Museum) for contributing to this research. We acknowledge the Renaissance Trust, whose generosity enabled the Raman spectrometer to be purchased.

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