An occurrence of nephrite jade in West Pakistan.

By B. C. M. Butler, M.A., Ph.D., F.G.S.

Department of Geology and Mineralogy, Oxford

[Read 8 November 1962.]

Summary. Two pebbles of good quality nephrite from Kohat District are described and the possible origin of the stones is discussed. The discovery is of significance in relation to the unsolved problem of the origin of the raw material of Indian carved jade.

TWO pebbles of the nephrite variety of jade were found by the author in 1955 in the river bed of the Teri Toi in the Kohat District of the former North-West Frontier Province of West Pakistan; the positive identification of the composition of the pebbles was, however, not made until February 1962. Because of the unusual interest attaching to this discovery, which appears to be the first authenticated record of either of the true jade minerals (nephrite or jadeite) of gem quality in Pakistan or India, a full description of the pebbles and the locality where they were found will be given here.

It is remarkable that, in spite of the high esteem in which jade (either nephrite or jadeite) has been held by various peoples from prehistoric times to the present day, the site of origin of the raw material is still in many cases uncertain. Neither in China proper, nor in Pakistan or India, has jade yet been discovered *in situ* (and in Pakistan or India it has not even, until now, been reported in river deposits), although it is in these countries that the tradition of jade carving achieved its finest art. The origin of the nephrite of the Mogul jades of the sixteenth and seventeenth centuries in particular is still unknown. Washington (in Bishop, 1906) states that the majority of the specimens of Indian carved jade (all of which are of nephrite) in the Bishop collection are easily distinguishable from the jades of Burma, the Kunlun, and other localities, by their peculiar texture and colour, and suggests that all the material comes from one locality, and that it is native to India. The discovery of nephrite pebbles in the Indian subcontinent is therefore of considerable relevance to the problem of the origin of Indian nephrite, and shows at least that it may not have been necessary to go as far afield as Chinese Turkestan, as was suggested by Hardinge (1961), in order to obtain the raw material for Indian jade carving.

Description of the pebbles (figs. 1, 2).

The dimensions of the first pebble are $9{\cdot}8 \times 4{\cdot}3 \times 3{\cdot}3$ cm; the weight (after removing a small portion for making a thin section) is 191 g; the specific gravity[1] is 2·954. The surface of the stone is rounded, and is very smooth, but matt, not polished. The colour is a very uniform pale greenish white, and the stone is translucent, so that the effect of a light behind the stone can be seen through 3–4 cm thickness, while the course

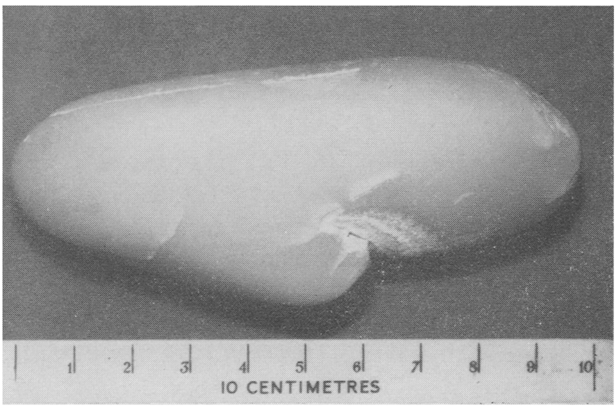


FIG. 1. First pebble, $\frac{3}{4}$ actual size.

of small superficial cracks can easily be followed to the limit of their extent of about 1–2 mm below the surface. Most of these cracks are parallel with the greatest and intermediate axes of the pebble, and the fact that it was also possible to break off a flake parallel to this plane (for the purpose of making a thin section) suggests that the pebble has a very weakly developed schistosity in this direction. Except for the superficial cracks, however, the stone is very compact and even-textured, with no other indication of directional features.

The pebble differs from many examples of water-worn nephrite boulders in that the characteristic weathering crust is almost absent. The greater part of the surface is perfectly clean and unweathered, probably because any weathering products that may have formed were removed

[1] Determined by the flotation method, matching the specific gravity of methylene iodide diluted with acetone against that of a small fragment of the pebble, and measuring the specific gravity of the liquid with a Westphal balance. The determinations were made at 18° C, and are accurate to $\pm 0{\cdot}002$. The results are in close agreement with the figure of 2·9505 for the average specific gravity of 491 specimens of nephrite in the Bishop collection (Bishop, 1906).

by the violent abrasion of the pebbles in the brief torrential floods that occur in the river bed where it was found. Only on those sides of the pebble where the schistosity planes are nearly perpendicular to the surface is there any sign of weathering, and here the crust is probably less than 1 mm thick, except in one place where a patch of rusty white weathering product up to 5 mm thick has been protected from erosion by a re-entrant angle in the surface of the pebble.

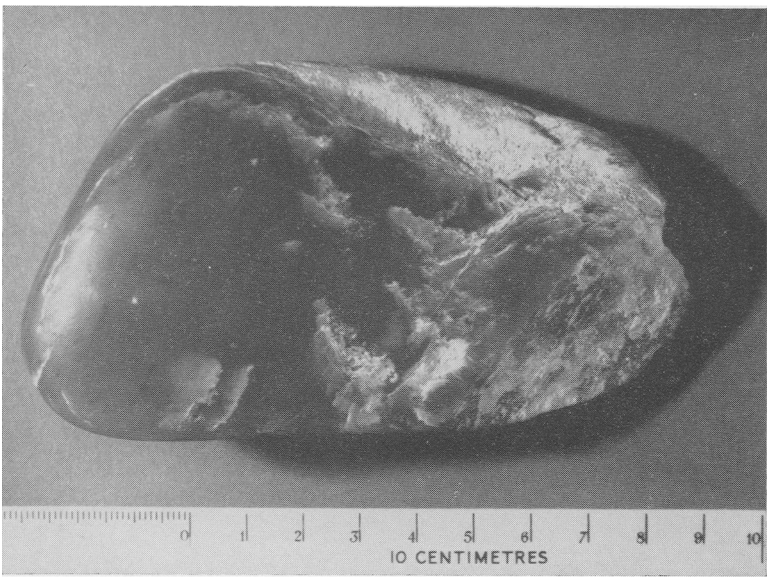
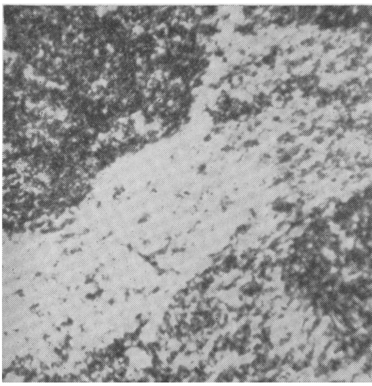


Fig. 2. Second pebble, $\frac{3}{4}$ actual size, showing the less weathered side of the pebble.

The dimensions of the second pebble are 11·8 × 6·7 × 3·9 cm; the pebble is rather wedge-shaped, with the thicker end at the left in the photograph (fig. 2); the weight (after removing a portion for making a thin section) is 379 g; the specific gravity (cf. footnote 1) is 3·021. The colour of the fresh stone is clear spinach green, and the stone is translucent through a thickness of about 1 cm. Thin black streaks, up to 0·5 cm long, and parallel with the length of the broad thick end of the pebble, are composed of grains of spinel. About half the surface of the pebble is clear and unweathered, and is very smooth, like the surface of the first pebble; the remainder is partly or completely weathered to a pale rusty-yellow crust, which extends into the fresh stone along numerous sub-parallel cracks that are parallel with the plane of flattening of the pebble and probably represent a plane of poorly developed schistosity.

It should be pointed out that there is nothing in the shapes of either of the stones to suggest that they might have been cut or carved before becoming included in the river deposits where they were found.

Petrography. A thin section of the first pebble was cut parallel to the plane of relatively easy fracture and jointing, which, as already explained,



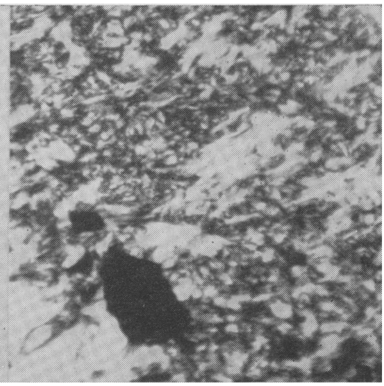


FIG. 3 (left). First pebble. Crossed nicols. Magnification ×60. Individual tremolite fibres cannot be distinguished, but the arrangement of the fibres in patches all of similar optic orientation is clear from the distribution of the interference colours.

FIG. 4 (right). Second pebble. Crossed nicols. Magnification ×60. The tremolite fibres are arranged in sub-parallel bundles. Three grains of spinel (isotropic) appear in the lower left corner.

may be a schistosity plane. The rock consists entirely of tremolite fibres, up to 0·05 mm in length, arranged in sub-parallel bundles that form rounded or polygonal patches up to 0·5 mm across in which all the fibres have nearly the same optic orientation (fig. 3). There is only a small degree of preferred orientation from one bundle to another in the plane of schistosity. Owing to the very small size of the fibres it was not found possible to make any determination of refractive indices or extinction angle of the tremolite in this rock.

A thin section of the second pebble was cut, as with the first, parallel to the probable schistosity plane. The rock consists of tremolite fibres, up to 0·5 mm in length but usually shorter than this, arranged in sub-parallel bundles, which themselves show a distinct, but far from perfect, lineation (fig. 4). The maximum extinction angle of the tremolite is about 20°; it was not found possible to determine the refractive indices accurately enough to be of any diagnostic significance. Red-brown spinel, in grains up to 0·5 mm in diameter, is a rare accessory mineral.

X-ray powder photographs of the fresh nephrite of both pebbles show no measurable differences from the powder photographs of a specimen of nephrite from Siberia (Oxford University Museum specimen number 3916) and of a specimen of tremolite from Haliburton, Ontario (O.U.M. number 18145). Powder photographs of the weathered crust of both pebbles are also identical with the powder photographs of the fresh nephrite and show no additional lines, so evidently the weathering has taken place by mechanical disintegration with no detectable mineralogical changes.

Location and possible origin of the nephrite pebbles.

Both pebbles were found in the bed of the river called the Teri Toi, the first about 3 miles from the junction of this river with the Indus, and the second near the junction with the large tributary on the south side (the Pathan Algad) about 16 miles from the Indus (see fig. 5). The Teri Toi flows from west to east through the central part of Kohat District, and joins the Indus River about 30 miles upstream from Kalabagh where the Indus finally emerges from the hills on to its alluvial plain, although it is there still 800 miles from the sea.

The bed of the Teri Toi is up to a quarter of a mile wide, but it is usually dry except for a few small streams of highly saline water flowing over the pebbly surface of the valley floor. After the rare heavy rainstorms that occur in this area (mainly during the monsoon) the river floods immediately, and the whole of its bed is then occupied by a powerful torrent. The stony bed of the river represents the erosion products brought down by these periodic floods.

Origin of the nephrite. Although the genesis of nephrite rocks is only partly understood, it appears to be generally agreed that they are derived from ultrabasic rocks by metamorphic or metasomatic processes (e.g. Turner, 1935; Korzhinsky, 1941).

The rocks within the area drained by the Teri Toi are of sedimentary origin and of Eocene and younger age. The oldest exposed rocks are the rock-salt and gypsum of the Kohat Saline Series, followed by clays and limestones of the Khirthar (Middle Eocene). The Eocene is overlain by the Nimadric rocks (Murree and Siwalik Series, of Miocene to Pleistocene age), consisting of clays, sandstones, and, at the top of the succession, conglomerates. Metamorphic and igneous rocks *in situ* are absent from the basin of the Teri Toi, and it can be stated with complete certainty that the nephrite pebbles cannot have come direct from any outcrop of nephrite rock *in situ* within the area drained by the Teri Toi.

It is probable that the immediate origin of the nephrite pebbles, as of all the igneous and metamorphic rocks in the Teri Toi river bed, is from

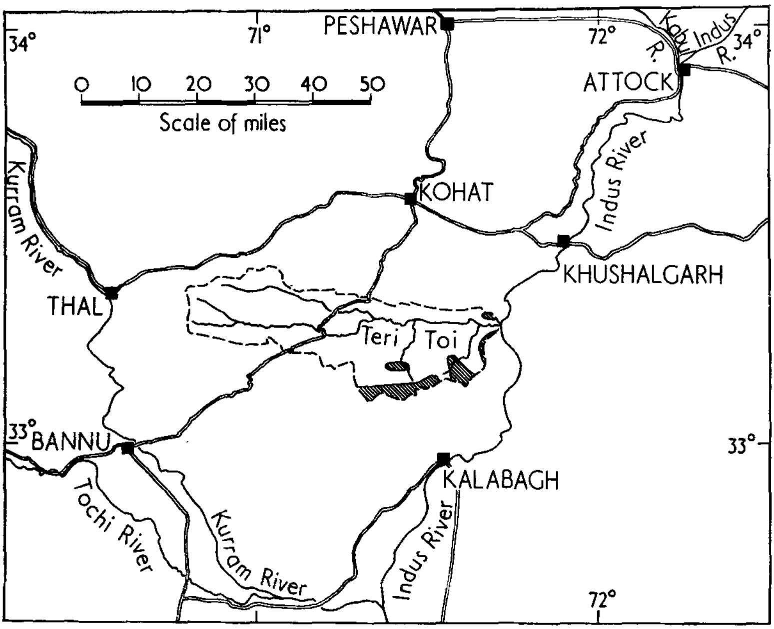


FIG. 5. Sketch-map of the area of Kohat District, showing the principal roads and rivers. The dashed line marks the watershed of the Teri Toi river basin. The Siwalik conglomerates within the Teri Toi basin are indicated by the shaded areas (the author is indebted to Dr. E. R. Gee for data on the distribution of the conglomerates). The localities where the pebbles were found are described in the text.

the massive conglomerates of Middle to Upper Siwalik age (late Pliocene–Pleistocene) that occur on the north and south sides of the eastern part of the Teri Toi basin (the shaded areas in fig. 5). This does not, of course, provide a complete explanation of the provenance of the pebbles, and it is useful to speculate further on the location of the nephrite mass from which they must have originated.

It is not known from which direction the Siwalik conglomerates in Kohat were derived, but it is probable that they were the products of erosion of the rising Himalayan Tertiary mountain chain to the north-east, north, or north-west of the Kohat area, and that they were deposited by a river, now represented by the Indus, that probably flowed south-westwards across the southern part of Kohat District in Middle and Upper Siwalik times (Gee, 1951).

The assemblage of rock types represented in the Siwalik conglomerates has not been studied in detail, and the author did not make any systematic observations on the pebbles of the Teri Toi (other than to note their diversity of composition), since the full significance of the nephrite pebbles was not appreciated until their composition had been ascertained.

Of the known sources of nephrite, the nearest[1] to the Kohat District are those in the Kunlun Mountains of Chinese Turkestan (about 400 miles north-east of the area where the pebbles were found), which have been famous for centuries as the main source of Chinese jade. The nephrite is obtained from quarries and mines, and also as boulders in the Khotan and Yarkand rivers, which flow northward into the Tarim Basin. Both the quarries and mines and the alluvial workings are on the north side of the Karakoram Range, which forms the watershed between the Indus River system and the Tarim Basin. Thus, if the nephrite pebbles came from this area, nephrite rocks must have been exposed to erosion in Middle or Upper Siwalik times, and the watershed of the Tertiary mountain chain must at that time have lain farther north than it does now.

There are no other known occurrences of nephrite, either *in situ* or as boulders, closer to Kohat than the Chinese Turkestan localities, but this does not necessarily represent the only possible source of the material. Ultrabasic rocks occur in the Tochi River in Waziristan (Hayden, 1896) and in northern Afghanistan (Hayden, 1911), while Herbordt (1925) records fibrous asbestos in veins in serpentine near Khost, west of the Kurram River, in Afghanistan. Morris (1938) states that serpentine appears among the igneous and metamorphic rocks found as fragments in the Bain Boulder Bed (near Shekh Budin), which is considered by him to represent the melt products of a glacial tongue derived from Waziristan during the Gunz episode of the Pleistocene, and thus perhaps contemporaneous with the formation of the Siwalik conglomerates of Kohat. These observations do not prove anything about the origin of the nephrite pebbles in the Teri Toi, but they indicate that derivation from a locality nearer than Chinese Turkestan is at least geologically feasible.

A final but remote possibility remains to be considered—that the

[1] A poorly documented account (Schwarz, 1925) mentions a nephrite occurrence near Kandahar, 350 miles west-south-west of the Teri Toi, but this is in any case an unlikely source for pebbles in the Siwalik conglomerates of the Kohat District.

pebbles were brought to Kohat by human agency, and were accidentally dropped, say, by a careless traveller or trader. The fact that both stones are of good quality material suggests that they would have been worth carrying. There are, however, several arguments against this possibility. There was a high degree of selection in the finding of these particular pebbles, which the author only picked up and retained because of their attractive colour and lustre, and there may well be other pebbles of nephrite and associated rocks of less distinguished appearance still to be found in the Teri Toi and other rivers in the area. Further, the stones are too small and flawed to be worth carving except as very small objects, and in view of the toughness of the stone it is unlikely that they were much larger when they first came into the drainage area of the Teri Toi. So far as the author is aware, there is no record of a trade either in the raw material or in carved jade through the Kohat area; if this is correct, it nullifies not only the argument that the nephrite pebbles might have been dropped by a trader, but also that boulders from the rivers of this area might have provided a source of raw material for Indian jade carving.

The significance of the discovery of these two pebbles in the Teri Toi river bed in Kohat District is not necessarily that this particular area might have provided a source of supply of Indian nephrite, but that it is likely that the pebbles came from the Siwalik conglomerates in southern Kohat, and that, this being so, it is geologically possible that nephrite pebbles and boulders might occur elsewhere in the Siwalik conglomerates, which have a very wide distribution in the foothills of the Tertiary mountain chains of West Pakistan and India. The size of the boulders in these conglomerates is, however, not great, and the abundance of nephrite boulders must in any case be extremely small, so that their value as a source of supply of nephrite would still be limited. The greater significance of the pebbles is that they indicate that nephrite rock was probably exposed to erosion within the drainage area of the Indus River system in Middle or Upper Siwalik times, and that nephrite rocks may still remain to be discovered *in situ* on the south side of the Himalayas.

References.

Bishop (Heber R.), 1906. Investigations and studies in Jade, (2 vols.), privately printed, New York (The De Vinne Press).

Gee (E. R.), 1951. Contribution to discussion of paper by Gill (W. D.), 1951. Quart. Journ. Geol. Soc., vol. 107, p. 375.

Hardinge (C.), 1961. Jade, fact and fable, London (Luzac & Co. Ltd.).

HAYDEN (H. H.), 1896. Rec. Geol. Surv. India, vol. 29, p. 63.
—— 1911. Mem. Geol. Surv. India, vol. 39.
HERBORDT (O.), 1925. Zeits. prakt. Geol., vol. 33, p. 193.
KORZHINSKY (D. S.). [Коржинский (Д. С.)], 1941. Compt. Rend. (Doklady) Acad. Sci. URSS, vol. 33, p. 133 (foreign language edition).
MORRIS (T. O.), 1938. Quart. Journ. Geol. Soc., vol. 94, p. 385.
SCHWARZ (V.), 1925. Oesterreichische Chemiker-Zeitung, Neue Folge, Jahrg. 28, p. 186.
TURNER (F. J.), 1935. Trans. Roy. Soc. New Zealand, vol. 65, p. 187.