Ancient jades map 3,000 years of prehistoric exchange in Southeast Asia

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We have used electron probe microanalysis to examine Southeast Asian nephrite (jade) artifacts, many archeologically excavated, dating from 3000 B.C. through the first millennium A.D. The research has revealed the existence of one of the most extensive sea-based trade networks of a single geological material in the prehistoric world. Green nephrite from a source in eastern Taiwan was used to make two very specific forms of ear pendant that were distributed, between 500 B.C. and 500 A.D., through the Philippines, East Malaysia, southern Vietnam, and peninsular Thailand, forming a 3,000-km-diameter halo around the southern and eastern coastlines of the South China Sea. Other Taiwan nephrite artifacts, especially beads and bracelets, were distributed earlier during Neolithic times throughout Taiwan and from Taiwan into the Philippines.


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Result

This article focuses on the three-pointed lingling-o and animal-headed pendants (see SI Text). To determine the geological sources of the materials used to make these artifacts, we have undertaken a series of mineral analyses using an electron probe microanalyzer (EPMA) at the Institute of Earth Sciences, Academia Sinica, Taipei. This technique, applied with wave-length dispersive spectrometers (WDS-EPMA), has been used to construct a mineral-ogical database for several nephrite deposits, including Fengtian in China, Siberia, Japan, Australia, New Caledonia, New Zealand, and British Columbia, as well as white nephrites from China, Luzon (Philippines), Russia, and Korea. Criteria have been proposed to identify Fengtian nephrite based on the mineral chemistry of both the nephrite matrix and the zinc (Zn)-chromite inclusion.
90° to the axis of the core and finished by manual shaping (see out to help delineate the projections, which were probably drilled finally and between the smaller drilled circles. A drilled core from the center of a lingling-o; become the blank for four lingling-os, drilled in quadripartite fashion (by large bracelet manufacture were brought to Anaro from Taiwan, each to Anaro, Itbayat, northern Philippines. We infer that some large discs produced bracelet and flat ear ring removals could have continued from this point, until an octagonal blank (see discard from a cut square preform do not come from a single manufacturing event). Stage 1: eastern Taiwan, and Anaro, Itbayat Island, northern Philippines (these pieces legas, Manila). (Philippines (National Museum of the Philippines, Manila). (Uyaw Cave, the Tabon Complex, Palawan, Philippines (National Museum of the Philippines, Manila). (D) Double-headed animal nephrite ear pendant from the Philippines (collection of Ramon Villegas, Manila). (E-O) A suggested manufacturing sequence for lingling-o ear pendants, as reconstructed from discarded raw material recovered at Pinglin, eastern Taiwan, and Anaro, Itbayat Island, northern Philippines (these pieces do not come from a single manufacturing event). Stage 1: E is a triangular discard from a cut square preform ~1 cm thick (F), the intention being to shape an octagonal blank (see J); from Pinglin, eastern Taiwan. Stage 2: G and I represent the first bracelet to be drilled from an octagonal blank, in this case, ~2 cm thick, leaving a round core (H). Presumably, the original bracelet outer diameter exceeded the diameter of available bamboo drills, hence this method of manufacturing, allowing the projecting corners to be ground off to give the bracelet a round exterior; from Pinglin. Stage 3: J represents a second (or perhaps third) bracelet drilled from a large core; from Pinglin. Successive bracelet and flat ear ring removals could have continued from this point, until the remaining core became too small to use. Stage 4: Items K-O all come from Anaro, Itbayat, northern Philippines. We infer that some large discs produced by large bracelet manufacture were brought to Anaro from Taiwan, each to become the blank for four lingling-o, drilled in tripartite fashion (P). O is a drilled core from the center of a lingling-o; K–M are discards from around and between the smaller drilled circles. N is part of a much thinner ring drilled out to help delineate the projections, which were probably drilled finally at 90° to the axis of the core and finished by manual shaping (see A–C).

As shown in Fig. 4 A–E, the compositions of these 116 jade artifacts can be identified as tremolite and/or actinolite in the Ca-amphiboles, with Mg/(Mg + Fe) ratios <0.93. Based on their chemistry and fibrous textures, all of these artifacts and associated jade manufacturing waste materials are of nephrite. The chemical compositions of their matrices are within the ranges of Fengtian nephrite. Chromites (Cr-rich spinels), black in color, can also be detected as inclusion minerals on the surfaces of most specimens, and these chromites contain zinc in amounts equivalent to Fengtian nephrite (Fig. 4F). The results indicate that all were made of nephrite raw material from eastern Taiwan.

Further EPMA sourcing studies have been undertaken on a range of other, variously colored nephrite artifacts excavated from the Philippines and Vietnam. These results indicate that both countries have thus-far unlocated nephrite sources, used for the manufacture of artifacts since the Neolithic (14) (Fig. 4 C and E and SI Table 7). However, the mineral chemistry of these artifacts is clearly different from that of Fengtian nephrite. Although it is impossible for us to determine the range of chemical variation for every nephrite source in the Asia–Pacific region, given that the locations of many are completely unknown, we feel justified in claiming a very high level of confidence from the matrix and inclusion analyses reported here that the Fengtian nephrite has been reliably characterized.

Discussion

The Fengtian jade artifacts that we have analyzed belong to two phases in Southeast Asian archaeology: the Neolithic in Taiwan (~3000–500 B.C.) and the Philippines (~2000–500 B.C.) and the Early Iron Age in a much vaster region across the South China Sea between 500 B.C. and 500 A.D. In Taiwan itself, tools and ornaments made of Fengtian nephrite have been found in >108 sites dating from the early Neolithic to the Iron Age (~3000 B.C. to 500 A.D.) (15).

Although not the main focus of this article, nephrite adzes, bracelets, bell-shaped beads, and tubular beads are widespread in both Taiwan and the Philippines. Many of these come from Neolithic contexts within Taiwan. Those from Philippine contexts are similar to specimens in Taiwan, and all analyses so far have traced their nephrite to Fengtian. For instance, a Fengtian nephrite bracelet from Nasabaran, northern Luzon, dated between 1800 and 1500 B.C., falls in width and diameter within the ranges for 24 jade bracelets dated 2300–1600 B.C. from Youxianfang in southwestern Taiwan (16). Possibly, some of the Neolithic green jade items found in the Philippines were transported as finished goods from Taiwan during this earlier phase.

After Neolithic migrants settled Luzon from Taiwan ~4,000 years ago (4, 17–21), the export of Fengtian nephrite from Taiwan into the Philippines continued for >2,500 years, until well into the Iron Age. This has recently been determined from three separate archaeological assemblages (Sunget, Anaro, and Savidug—see Fig. 3) in the Batanes Islands, between Taiwan and Luzon, each with Fengtian nephrite present at many dates between 1000 B.C. and 500 A.D. (22). However, the circumstances of manufacture and the scale of the trade both changed dramatically during the Iron Age (~500 B.C. to 500 A.D.).

During this time, the ear pendants described above appeared in an extensive region of Southeast Asia, although only one so far has been found in Taiwan itself—a three-pointed lingling-o from Jiuxianglan in southeastern Taiwan. This situation suggests an export of “blanks” to further regions where artisans manufactured artifacts tailored to local taste. This scenario is supported by a presence of slate cutting tools and pieces of worked Fengtian nephrite, including drilled-out cores, annular rings, rectangular cut pieces and recycled artifacts, in several Iron Age habitation sites in Southeast Asia. These cut nephrite fragments often indicate that lingling-o or animal-headed ear pendants were being made locally by using Fengtian nephrite blanks.

Fig. 1. Green nephrite jade ornaments and manufacturing debitage. (A–C) Nephrite lingling-o penannular earrings with three pointed circumferential projections. (A) Go Ma Voi, Vietnam (Institute of Archaeology, Hanoi). (B) Uyaw Cave, the Tabon Complex, Palawan, Philippines (National Museum of the Philippines, Manila). (C) Duyong Cave, the Tabon Complex, Palawan, Philippines (National Museum of the Philippines, Manila). (D) Double-headed animal nephrite ear pendant from the Philippines (collection of Ramon Villegas, Manila). (E–O) A suggested manufacturing sequence for lingling-o ear pendants, as reconstructed from discarded raw material recovered at Pinglin, eastern Taiwan, and Anaro, Itbayat Island, northern Philippines (these pieces do not come from a single manufacturing event). Stage 1: E is a triangular discard from a cut square preform ~1 cm thick (F), the intention being to shape an octagonal blank (see J); from Pinglin, eastern Taiwan. Stage 2: G and I represent the first bracelet to be drilled from an octagonal blank, in this case, ~2 cm thick, leaving a round core (H). Presumably, the original bracelet outer diameter exceeded the diameter of available bamboo drills, hence this method of manufacturing, allowing the projecting corners to be ground off to give the bracelet a round exterior; from Pinglin. Stage 3: J represents a second (or perhaps third) bracelet drilled from a large core; from Pinglin. Successive bracelet and flat ear ring removals could have continued from this point, until the remaining core became too small to use. Stage 4: Items K–O all come from Anaro, Itbayat, northern Philippines. We infer that some large discs produced by large bracelet manufacture were brought to Anaro from Taiwan, each to become the blank for four lingling-o, drilled in tripartite fashion (P). O is a drilled core from the center of a lingling-o; K–M are discards from around and between the smaller drilled circles. N is part of a much thinner ring drilled out to help delineate the projections, which were probably drilled finally at 90° to the axis of the core and finished by manual shaping (see A–C).
Where were the blanks initially manufactured? The Pinglin workshop in eastern Taiwan, located close to the Fengtian nephrite deposit, was regarded by Kao as the largest ancient jade workshop in Southeast Asia (23). It has very large surface quantities of grooved and drilled jade discards, including drilled-out cores and incomplete or deficient ornaments and tools (Fig. 1 E–J). Recent excavation indicates that Pinglin was used initially during the Middle Neolithic (~1500 B.C. or earlier) and later during the Late
Fig. 4. Chemical compositions of nephrite jade artifacts. (A–E) Chemical compositions of the nephrite jade matrices of studied artifacts from Taiwan (A and B), the Philippines (C and D), and Borneo, Vietnam, and Thailand (E). The x and y axes represent, respectively, Si (atoms per formula unit on the basis of 23 oxygen) and Mg/(Mg + Fe²⁺) ratios, with the ideal chemical formula of calcium amphibole (Ca₂[Mg,Fe]₅[Si,Al]₈O₂₂[OH]₂). Relative standard deviations (1σ) of measurements are shown as error bars. (A) Symbols represent the WDS-EPMA results for 42 artifacts from 17 Taiwan sites. The upper shaded area encloses the chemical compositions of white-colored nephrite jade deposits from China (Liaoning, Xinjiang, Gansu, and Jiangsu Provinces) and Korea (Chuncheon) (11–13). The lower shaded area represents the chemical compositions of green nephrite jade raw materials from the Fengtian deposit (eight hand specimens) and a nearby riverbed (nine hand specimens) in eastern Taiwan (11). The chemical boundary between tremolite and actinolite is marked by the Mg/(Mg²⁺/Fe²⁺) ratio of 0.90 (SI Table 3). (B–E) Analytical results obtained by the noninvasive LVSEM-EDS technique. The enclosed areas delimit the range of chemical compositions for Fengtian green nephrite jades. (B) Yugang and Guanyindong on Ludao Island, Lanyu High School on Lanyu Island, and Liyushan (Wangan Island) and Nangang (Qimei Island), Penghu Archipelago (12 artifacts from five sites, SI Table 4). (C) Anaro on Itbayat Island, Sunget on Batan Island, Savidug on Sabtang Island, Nagasaraban in the Cagayan Valley, and Kay Daing in Batangas, northern Philippines (30 artifacts from five sites, SI Tables 4 and 5). The white nephrites (tremolite) artifacts from Uilang Bundok (UB: 1 adze) and Pila (PB: 3 adzes) in Batangas, and 12 adzes and two preforms from H. Otley Beyer’s 1940s Batangas collection in the National Museum of the Philippines, are shown as gray symbols. In terms of their mineral chemistry and archaeological contexts, the white nephrites in the Philippines are probably of local origin (14) (SI Table 7). (D) Tabon Caves, Palawan (22 ornaments from nine sites: see SI Table 6). Seven lingling-o penannular earrings with three pointed circumferential projections and a single bicephalous (double-headed) animal ear pendant are plotted. (E) Artifacts from Niah Cave, Sarawak, (F) Chemical compositions of zinc-bearing chromite ([Mg,Fe,Zn][Al,Cr]O₆) inclusions in the surfaces of nephrite artifacts, analyzed by the noninvasive LVSEM-EDS technique. Symbols represent the value for zinc oxide (ZnO in wt %) and the Cr/(Cr⁴⁺/Al³⁺) ratio for each artifact. Because the chromosome in Fengtian nephrite jade bears significant amounts of zinc (2 to 11 wt % in ZnO) (11) in comparison with the other possible nephrite (actinolite/tremolite) jade sources tested (Chara Jelgra, Siberia and Nanshan, Gansu), the Zn content provides a good clue for the identification of Fengtian nephrite.
having the highest quantities (Fig. 2). However, the combined distributions of the two kinds of ear pendant discussed here do not follow this trend and, instead, correspond closely with the distributions of many important but very far-flung Austroasiatic-speaking populations in early history (e.g., Formosans, Filipinos, Chams of southern Vietnam, and Borneo Dayaks). For instance, although northern Vietnam is closer to Taiwan than southern Vietnam, positively identified artifacts of Taiwan nephrite have never been found there. All come from Sa Huynh sites (500 B.C. to 100 A.D.) in coastal central and southern Vietnam, mostly in association with jar burials, bronze bracelets, bells and small vessels, iron tools, and glass and carnelian beads, all paralleled quite closely in early Metal phase jar burial assemblages in the Philippines and northern Borneo (4). The Sa Huynh culture is regarded as ancestral to the Chamic-speaking (Austroasiatic) ethnic groups of central and southern Vietnam in historical times, whereas the Dong Son of northern Vietnam is geographically associated with Tai and Mon-Khmer (Austroasiatic, including Vietnamese) speaking groups (27).

It is thus interesting to note that the site of Khao Sam Kao in peninsular Thailand, which does have Fengtian nephrite, is located in a Thai-speaking area today. However, in addition to Taiwan nephrite, it has also yielded pieces of worked mica similar in chemistry to mica from Mindoro Island in the Philippines. Pottery found quite close to Khao Sam Kao in Ko Din Cave on Samui Island in the Gulf of Siam is identical in form to Iron Age pottery excavated from Kalanay Cave in the central Philippines (28).

This sourcing study of ancient Fengtian jade has revealed a remarkable pattern of pre-Indic communication across a vast area of mainland and island Southeast Asia. However, we freely admit that this sourcing study of ancient jade in Southeast Asia has only just begun; both Vietnam and the Philippines, in particular, have other nephrite sources of unknown location that were exploited in prehistory, and it is possible that some of these materials were also traded over long distances. Indeed, one nephrite lingling-o with three projections from the Sa Huynh culture site of Go Duau in central Vietnam (Fig. 3; Table 1) is of non-Fengtian origin, based on its inclusions. We are now extending our research to try to identify the several different nephrite sources in Vietnam that were also used for manufacturing many of the lingling-o and animal-headed pendants found on the Asian mainland.

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