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.

Austronesian languages | electron probe microanalysis | nephrite trade | Southeast Asian archaeology | Taiwan

Artifacts of nephrite (jade) have been reported in great variety and large numbers from many Neolithic and Bronze–Iron Age archaeological sites in China, Taiwan, and northern Southeast Asia (especially Vietnam and the Philippines). Many appear to be relatively local in origin, in terms of both raw material and style. But within the broad range of material represented, archaeologists have long been aware that two very specific and fairly standardized forms of nephrite ear ornament occur across a very large region, extending from Taiwan through the Philippines, East Malaysia, central and southern Vietnam, and as far southwest as eastern Cambodia and peninsular Thailand [see supporting information (SI) Table 1]. These two forms are the so-called lingling-o and animal-headed pendants (Fig. 1 A–C) and the double animal-headed ear pendant (Fig. ID) (1–3).

The three-pointed lingling-o is the most widespread form of jade ornament in Southeast Asia, with examples being reported from southeastern Taiwan, the Philippines, Sarawak, central and southern Vietnam, central and southern Thailand, and eastern Cambodia, as listed in Fig. 2 and located in Fig. 3. All of these exquisite ear ornaments share very close similarities in style, manufacturing technology and size, being ~30–35 mm in diameter. The distribution of the double animal-headed ear pendants is similar: Lanyu Island (off southeastern Taiwan), Philippines, central and southern Vietnam, and central Thailand. Radiocarbon dates suggest an age range from 500 B.C. to 500 A.D. for both of these remarkable artifact types in Southeast Asia (SI Table 2), thus placing them within a period of late prehistoric indigenous social complexity and interregional interaction, contemporary with later Zhou to Han Dynasty China and with early trade from India but before the intensive Indian religious, philosophical, and architectural influence that became established during the later first millennium A.D. (4–6).

Archaeologists have long noted the widespread occurrences of these and other jade ornaments in Southeast Asia. In the 1940s, Japanese archaeologist Kano Tadao (7) recognized four types of jade earrings with circumferential projections that he believed originated in northern Vietnam, spreading from there to the Philippines and Taiwan. Beyer (8), Fox (3), and Francis (9) also suggested that the jade artifacts found in the Philippines were of mainland Asian origin, possibly from Vietnam. In Taiwan, it was generally believed that all prehistoric jade artifacts were exotic, until the 1997 Raman spectroscopy sourcing study by Tan and his colleagues (10). This confirmed that the jades from Beinan, the largest excavated collection from Neolithic Taiwan, were of raw material from the Fengtian source in eastern Taiwan. Visual examination had already suggested this, because Fengtian nephrite is often a distinctive translucent green and has black spots in its texture.

Results

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 mineralogical database for several nephrite deposits, including Fengtian in Taiwan and other green nephrites from East Asia and the Pacific (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.


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cJade is a term used in the broad sense of a hard and shiny stone, applied to two monomineralic rocks termed jadeite and nephrite in gemology and geology. Both jadeite and nephrite occur in metamorphic rocks, but their chemical compositions are different. Jadeite is composed of jadeite (sodium clinopyroxene), whereas nephrite is composed of tremolite and/or actinolite (calcium amphibole). All studied Neolithic and Iron Age jade artifacts from Taiwan, the Philippines, and Vietnam are of nephrite.

dA double animal-headed pendant was found in place on the skull of a burial at Giong Ca Vo in southern Vietnam. ref. 2, Fig. 29.1. In the 1940s, American archaeologist H. Otley Beyer noted that some of the jade ear pendants he encountered in the Batangan area were similar in shape to the metal pendants worn ethnographically by the Ifugao, Bontoc, and Kalinga peoples in the Northern Luzon Cordillera region, who termed them lingling-o. The term is now used widely to refer to a general class of earrings with projections, but in this article, with Fox (3), we refer only to the specific three-pointed form in jade.

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minerals (11). For the artifacts, many of them precious museum antiquities, a low-vacuum scanning electron microscope (LVSEM) equipped with an energy dispersive x-ray spectrometer (EDS) offers a completely noninvasive analytical technique (12, 13). So far, mineral analyses have been carried out on 144 jade artifacts from 22 archaeological sites in Taiwan (Taiwan proper, Penghu, Ludao, and Lanyu) and 27 sites in Southeast Asia (Philippines, Sarawak, central Vietnam, and southern Thailand). One hundred sixteen specimens from 38 sites have already been confirmed as being of Taiwan jade (SI Tables 3–7).

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 azdes, 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 Nagsabaran, 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 has so far 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.
Table 1

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<th>Region</th>
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<td>Southeast Asia</td>
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*Note: NT: not yet tested.*

**Fig. 2.** Sites with nephrite artifacts in Southeast Asia.

Where were the blanks initially manufactured? The Pinglin workshop in eastern Taiwan, located close to the Fengtian nephrite deposit, was regarded by Kano 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–I). Recent excavation indicates that Pinglin was used initially during the Middle Neolithic (~1500 B.C. or earlier) and later during the Late

**Fig. 3.** The distribution of Taiwan nephrite artifacts in Southeast Asia. The green zone represents the currently known distribution of Taiwan nephrite artifacts. The green triangle locates the Fengtian nephrite deposit. Yellow stars represent sites outside Taiwan with positively identified Fengtian nephrite artifacts (Taiwan itself has > 108 jade-bearing sites, and these cannot be shown individually). Blue stars represent sites with jade artifacts of possible Fengtian origin, based on visual examination but not yet demonstrated in terms of mineral chemistry. Black circles represent sites that have identified nephrite of non-Fengtian origin. Identified Fengtian and possibly Fengtian nephrites: WG, Liyushan, Wangan Island; QM, Nangang, Qimei Island; Penghu Archipelago; JX, Jiuxianglan, eastern Taiwan; LD, Yungang and Guanyindong, Ludao Island; LY, Lanyu High School Site, Lanyu Island; AN, Anaro, Itbayat Island; SK, Sunget, Batan Islands; SD, Savidug, Sabang Island; NG, Nagsabar, Cagayan Valley; KD, Kay Daing, Batangas; EN, Leta-Leta and Ille Caves, El Nido, Palawan; TC, Tabon Caves, Palawan; NC, Niah Cave West Mouth, Sarawak; AB, An Bang; GM, Go Mun; DL, Dai Lanh; GMV, Go Ma Voi; BY, Biing Yen (these five sites in Quang Nam Province, central Vietnam); GCV, Giong Ca Vo, Ho Chi Minh City; SS, Samrong Sen, Cambodia; UT, U-Thong, Suphanburi; BDT, Ban Don Ta Phet, Kanchanaburi; KSK, Khao Sam Kao, Chumphon. Identified non-Fengtian nephrites: BTG, Uilang Bundok and Pila, Batangas; TX, Trang Kenh; YB, Yen Bac; MB, Man Bac; QC, Quy Chu; GB, Go Bong; XR, Xom Ren; GD, Go Dua; GL, Giorgi Lon. The red dashed lines enclose the major Austronesian language subgroups according to Blust (17) (SH/WNG, South Halmahera/West New Guinea).
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/(Mg + Fe) 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, Nagasarbaran 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), Go Ma Voi (GMV) (central Vietnam), and Khao Sam Kaeo (KSK) in peninsular Thailand are represented here, including the lingling-o penannular earrings with three pointed circumferential projections from Niah and GMV (10 ornaments and worked pieces from three sites: see SI Table 4). White to green nephrite artifacts from northern Vietnam (MB, Man Bac; TK, Trang Kenh; XR, Xom Ren; GB, Go Bong; QC, Quy Chu; YB, Yen Bac), from central Vietnam (GMV; GD, Go Dua), and from southern Vietnam (GL, Giong Lon), shown by gray and black symbols, are not of Fengtian nephrite in terms of their mineral chemistry (see SI Table 7). (F) Chemical compositions of zinc-bearing chromite ([Mg,Fe,Zn][Al,Cr]₂O₆) 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/(Cr + Al) ratio for each artifact. Because the chromite 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.
Neolithic (~800 B.C. to 150 A.D.) (24). The Pinglin workshop might have been a major producer of the jade blanks found in Taiwan and the Philippines, but no complete three-pointed lingling-o or animal-headed pendants have ever been found there. The sites that contain manufacturing fragments that appear to be from three-pointed lingling-o ear pendants, or closely related forms, are Youzihu on Ludao Island and the Lanyu High School site on Lanyu Island, both off southeastern Taiwan, Anaro on Ibtayat Island and Savidug on Sabtang Island (Batanes), and sites in Batangas Province in southern Luzon. In Vietnam, unfinished animal-headed ear pendants are reported from Dai Lanh in Quang Nam Province, and nephrite blocks possibly intended for making similar pendants are reported from Giong Ca Vo, southeast of Ho Chi Minh City. From Khao Sam Kaeo in peninsular Thailand, there is at least one recycled Taiwan Neolithic adze that was being worked into an animal-headed pendant when discarded (SI Table 1). These distributions are consistent with a multiregional manufacture of these ear pendants, despite the raw material origin from Fengtian.

Recently, cut Fengtian nephrite fragments, some interpreted as discards from the manufacture of lingling-o earrings, have been excavated in layers dated between 500 B.C. and 50 B.C. in the defensive hilltop habitation site of Anaro on Ibtayat Island in the northern Philippines (22, 25). Anaro is the most important workshop found so far in the Philippines because it illustrates the full production sequence for making these artifacts (Fig. 1 J–N). Slate knives, both rectangular and pointed, the latter reworked from Taiwan slate projectile points, were found here with the nephrite fragments. Slate is common in the central mountain range of Taiwan but absent in volcanic and raised coral landscapes such as the Batanes and Babuyan Islands and Luzon. This indicates that these slate tools were also imported from Taiwan, where such knives and points are very common. At Anaro, they were used for grooving the nephrite before snapping, as in the Pinglin workshop in Taiwan.

Experimental archaeology indicates that jade manufacture required not only high levels of skill, but also considerable labor input. For example, 8 hours of sawing using a stone knife and sand will cut a groove only 11 mm deep, and 1 hour of drilling using a hollow bamboo with sand and water will cut only 10 mm below the surface (26). So far, no iron tools that can be associated with nephrite working have been identified in Southeast Asia.

We suggest that the ear pendants of Fengtian nephrite in Southwest Asia (outside Taiwan) were made by a small number of highly skilled and perhaps itinerant jade craftsmen using stone cutting tools and perhaps bamboo drills. During the Iron Age, such jade craftsmen, with or without the help of transporting middlemen, carried or acquired their raw materials from Taiwan, then traveled and/or resided along the shorelines of the South China Sea to produce extremely uniform jade ear ornaments to suit the demands of local elites. The most extensive evidence for such trade postdates 500 B.C., by which time the use of jade in Taiwan itself was already in decline (15).

In general, the quantity of Fengtian nephrite decreases with distance from the source, with sites on the eastern coast of Taiwan 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 Austroasian-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 Cham-speaking (Austroasian) 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 Kaeo 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 Kaeo 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 Dua in central Vietnam (Fig. 3; SI Table 7) 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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Global warming could lead to increased severe thunderstorms

Scientists anticipate intensified precipitation by the end of the century as increased anthropogenic greenhouse gas concentrations are expected to raise average temperatures by 2–6°C around the world. Robert Trapp et al. used global and high-resolution regional climate models to examine whether the intensified precipitation will arise from severe thunderstorms. The authors evaluated two quantitative measures of thunderstorm environments: the convective available potential energy (CAPE), a measure of a storm’s energy, and the storm’s wind shear. High CAPE and shear values in localized areas are known to promote damaging storms that produce large rainfall rates, hailstones, destructive surface winds, and tornadoes. The authors discovered that under greenhouse gas emission scenarios predicted by the Intergovernmental Panel on Climate Change, the number of days on which meteorological conditions occur that would support the formation of severe thunderstorms increases by 100% in the United States. The increase will be particularly notable in densely populated regions of the southern and eastern United States, including cities such as Atlanta and New York. Reduced emissions, the researchers say, could reduce the increases they have projected. — F.A.

High folate levels are linked to exacerbation of vitamin B₁₂ deficiency

The metabolism of the vitamins folic acid and B₁₂ is linked and deficiency in either can lead to anemia and macrocytosis. Deficiency in vitamin B₁₂, but not folate, may also be associated with neurological and neuropsychiatric abnormalities. Previous research has shown, among participants in a United States survey, that prevalence of anemia and cognitive impairment is ap-
proximately five times higher in people who have low vitamin B12 status and high blood folate levels, compared with those who had low vitamin B12 status but normal blood folate levels. These data seem to suggest that high blood folate is associated with amplifying clinical manifestations of vitamin B12 deficiency. Jacob Selhub et al. show that high folate may worsen clinical manifestations of B12 by altering the activity of two enzymes that require B12 to function. In people with vitamin B12 deficiency, high blood folate levels are linked to higher levels of homocysteine and methylmalonic acid, biomarkers of B12 status, versus individuals with B12 deficiency and normal blood folate levels. These data relating high folate and low B12 to clinical and biochemical outcomes were obtained from a sample of the elderly population in the United States after foods such as flour and cereal were mandated by the U.S. Food and Drug Administration to be fortified with folic acid in 1998. The authors conclude that the levels of folate associated with adverse effects are only attainable through folic acid supplements and fortified foods, not from natural folate. — B.T.

“In vitamin B12 deficiency, higher serum folate is associated with increased total homocysteine and methylmalonic acid concentrations” by Jacob Selhub, Martha Savaria Morris, and Paul F. Jacques (see pages 19995–20000)

NEUROSCIENCE

Touch of a vanished hand

The lack of feedback provided by touch typically limits amputees’ use of prosthetic arms. This limitation could be partially alleviated if sensors in artificial fingertips could connect to nerve endings on an amputee’s body. Todd Kuiken et al. have taken a step toward this solution by rerouting the major hand nerves to the pectoral muscle in a 54-year-old man and a 24-year-old woman who had lost arms. This surgery allowed the nerves to reinnervate the chest skin, where they established sensation of the missing hand. Although signals from the transferred hand nerves overlapped in some areas with those from the chest, no confusion arose; the patients reported feeling being touched in two places simultaneously. The authors characterized the results of the surgery by measuring thresholds for touch, heat/cold, and electrical-induced pain, and noting which areas of the patient’s chest corresponded to which region of the phantom hand. Despite the fact that the transferred hand nerves were integrated over the new area in a complex manner, the transferred hand sensation thresholds did not differ much from normal skin in all modalities. With appropriate hardware connections, the authors say, this type of surgery could allow patients more sophisticated use of prostheses. — K.M.

“Redirection of cutaneous sensation from the hand to the chest skin of human amputees with targeted reinnervation” by Todd A. Kuiken, Paul D. Marasco, Blair A. Lock, R. Norman Harden, and Julius P. A. Dewald (see pages 20061–20066)
東南アジアに台湾産玉石

台湾で採れた緑色の玉石が、フリビンやベトナム、タイでも装飾品として見つかったことがあがった一同も「台灣産玉石」の起源については諸説あるが、飯塚さんが調査したところ、台湾から南下して各地に広がっていたことを裏付ける根拠としている。

台湾の研究所分析で判明

一方、南島語族は東南アジアから南太平洋、ニウージランド、アフリカのマダガスカルまで広く分布していた。これらの人々は台湾から南下し、各地で玉石を博物館にかたどり、取っ套餐パワーライreffを伝承してきた。

南島語族の「起源知る一助に」

台湾産の玉石でつくられた耳飾り。Aがベトナム中部、BとCがフリビンのパラワン島で出土したもの。飯塚さんは「台湾産玉石の分布は南島語族の分野を示し、各地の玉石の交流があったと考えられる。玉石の分布は民族の地元を示し、文化の交流を示す指標である。米科学アカデミー紀要に論文が掲載された。
東南亞館藏古玉
八成來自台灣豐田玉

台灣留澳學者洪曉純研究

佐證台灣是南島語族起源地

洪曉純指出，之前的研究者以電子探測儀分析了一百四十四件出土於台灣及東南亞各地的玉器標本，證實其中一百一十六件玉器的原料都來自台灣花蓮的豐田地區。

洪曉純表示，這些原料在台灣花蓮被發現，根據這個發現，可以佐證台灣是南島語族的起源地。
Ancient jade study sheds light on sea trade

By Tan Ee Lyn
Mon Nov 19, 5:06 PM ET

Over 100 ancient jade artifacts in museums across southeast Asia have been traced back to Taiwan, shedding new light on sea trade patterns dating back 5,000 years, researchers said.

Using X-ray spectrometers, the international team of scientists analyzed 144 jade ornaments dating from 3,000 BC to 500 AD and found that at least 116 originated from Fengtian in eastern Taiwan.

"The chemical composition of jade reveals its origin and ... their analysis determined the relative amounts of iron, magnesium, and silicon in the jade," the scientists wrote in a paper published in the latest issue of the Proceedings of the National Academy of Sciences.

"Based on elemental composition, 116 artifacts were identified as originating in Fengtian. The source of the others remains unknown."

Fengtian jade has a distinctive translucent green hue and black spots.

The 144 artifacts were unearthed in archaeological excavations in Taiwan, the Philippines, Malaysia, Vietnam, and Thailand.

ANCIENT FACTORIES

Odds and ends of Fengtian jade were found at several sites in the Philippines, Thailand and southern Vietnam, which the lead researcher Hung Hsiao-chun said may have been workshops.

"Fengtian jade was shipped to these workshops in southeast Asia, which dated from 500 BC to 100 AD. They were very small and they churned out these ornaments that were then exported to other places," said Hung, of the Australian National University in Canberra.

"What's really interesting is their products (from different countries) were very similar," she told Reuters in a telephone interview.

Jade earrings, beads, bracelets and pendants, some depicting two-headed animals, were popular in southeast Asia during the early Iron Age between 500 BC and 500 AD.

Prior to this period, however, Taiwan's jade ornaments were likely to have been crafted back home in Fengtian.

"There was a very huge workshop in Fengtian, dating back to 3,000 BC," Hung said, adding that one of the earliest pieces of Fengtian jade found in the Philippines dates back to 2,000 BC.

"Before, researchers thought all the jade in the Philippines was from China or Vietnam. With our analysis ... we found that most of the ornamental jade in the Philippines was from Taiwan."

The findings of Hung and her team revealed one of the largest prehistoric trades in semiprecious stone.

"Their seafaring methods must have been very superior, even back then," Hung said.

"What we know now is the origin of the jade. We need to find out who these craftsmen were and what tools they used. We know very little about their manufacturing process."

(Editing by Rosalind Russell)
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OBSERVATORY

Ear Pendants Reveal the Antiquity of Commerce in Jade

By HENRY FOUNTAIN

Jade has been prized for thousands of years, and has been traded for nearly as long. The extent of the trading has been demonstrated by Hsiao-Chun Hung of the Australian National University and colleagues in a study of jade ornaments from Southeast Asia.

The researchers analyzed nephrite jade pieces dating back to 3000 B.C. In particular they looked at ear pendants dating from about 500 B.C. to A.D. 500. They were from around the South China Sea: coastal Cambodia and Vietnam, peninsular Thailand, western Philippines, southern Taiwan and Sarawak in Borneo.

As described in The Proceedings of the National Academy of Sciences, the researchers found that most of these ear ornaments were made of jade from one location in eastern Taiwan, Fengtian.

Archaeological evidence suggests that the jade was distributed as blanks. The researchers suggest that itinerant craftsmen may have traveled among the coastal lands, fashioning these decorative pendants for wealthy locals.

However the items were made, their distribution from one source across hundreds of miles of ocean represents one of the most extensive trading networks of a single mineral among ancient peoples.