Mineralogical studies of the Niah West Mouth jade *lingling-0*

By

Yoshiyuku lizuka, Peter Bellwood, Ipoi Datan and Hung Hsiao-chun
MINERALOGICAL STUDIES OF THE NIAH WEST MOUTH JADE LINGLING-O

by

Yoshiyuki Iizuka, Peter Bellwood, Ipoi Datan and Hung Hsiao-chun

ABSTRACT

Non-invasive¹ mineralogical studies of a deep green jade earring (lingling-o) from Niah Cave West Mouth in Sarawak have been conducted using a low-vacuum scanning electron microscope with an energy dispersive x-ray spectrometer. The Niah earring is identified as nephrite (tremolite-actinolite) with zinc bearing chromian-spinel (chromite) inclusions. The mineralogical characteristics of this nephrite are very close to those of Fengtian nephrite from eastern Taiwan, this source being located approximately 2500 km to the north of the Niah Caves.

FORMAL DESCRIPTION OF THE STUDIED SAMPLE²

The Niah lingling-o³ (Fig. 1) was excavated on 29th March 1977 during archaeological investigations by Zuraina Majid in Niah Cave West Mouth, Sarawak, East Malaysia. It was found in square M/D3 at 6 inches depth below the surface (Chin, 1980: Fig. 2.14; Zuraina, 1982: 46 and 2003: 198), and was recorded by Zuraina as having been found with sherds stratified seven inches above a burial of unspecified date. This specimen is a penannular earring with three pointed circumferential projections. The matrix has a deep green colour, and the inclusions are black to dark brown. The maximum diameter of this piece is 31.0 mm, thickness 16.0 mm; hole diameter 9.0 mm (outer) and 7.0 mm (inner); slit width 1.8 mm; weight 9.0 gm. The three necked and pointed circular-sectioned projections extend for 4.5 to 5.0 mm beyond the outside of the ring. The date of this specimen is not evident from its burial context, but similar
complete specimens from the Philippines are known to be of Iron Age date, presumably manufactured between 2000 and 1000 years ago (Fox, 1970: 131).

ANALYTICAL METHODS

The analytical procedure used was the same as that described for the analysis of Philippine jade artifacts by Iizuka et al. (2005). Before observation, the sample was well cleaned repeatedly for a few hours in an ultra-sonic bath with distilled water to remove dust and soil from its surface. It was then rinsed in ethanol, and dried in air overnight at 75°C.

A scanning electron microscope (JEOL JSM-6360LV) was used with 15 kV acceleration voltage and 0.18 nA electron beam current, under low-vacuum conditions (25 Pascal). Surface observation and chemical analysis were conducted without the use of gold or carbon
coatings. The analysed points were selected on the relatively flat and well-polished surface of the artifact under the back-scattered electron image. The chemical compositions (greater than 0.5% by weight) of the matrix and inclusion minerals were analysed by EDS (Oxford Instruments INCA-300) at the 1 μm electron beam spot and results were corrected against the X-ray intensities of standard minerals. The number of cations was calculated as atoms per formula unit on the basis of 23 oxygen atoms, and minerals were classified according to the nomenclature of amphiboles (Leake et al., 1997). The corrected data in the cation ratios are based on the ideal chemical formula of calcium amphibole \([\text{Ca}_2(\text{Mg,Fe})_3(\text{Si}_8\text{O}_{22})(\text{OH})_2]\); where a ratio of \(\text{Mg}/(\text{Mg} + \text{Fe})\) less than 0.9 indicates actinolite; greater than 0.9 indicates tremolite.

**RESULTS**

The surface of the lingling-o was well-polished by ancient craftsmen and was therefore no problem to analyse. Fibrous textures were observed on the surfaces of the green coloured matrix at all points studied (Fig. 2). A representative X-ray spectrum by EDS from the matrix is shown in Fig. 3. The quantitative chemical data are shown in Table 1 and plotted in Fig. 4 as a discrimination diagram of calcium (Ca) amphiboles [ratio of Si to \(\text{Mg}/(\text{Mg} + \text{Fe})\)]. The matrix portion can be identified as both tremolite and actinolite in the Ca-amphiboles. Based on the chemistry and surface texture, the Niah lingling-o is of nephrite.

Chromium (Cr)-spinel, black in colour, were also observed at the surface of the specimen as inclusion minerals (Figs. 1b and 5). The sizes of these inclusions vary from a few μm to 2 mm. A zoned inclusion, spinel-rich \((\text{AlMg}_2\text{O}_4)\) in the inner part and chromite rich \((\text{CrFe}_2\text{O}_4)\) in the outer part, can be observed in the back-scattered electron image (Fig. 5). A representative EDS spectrum from a Cr-spinel (chromite) inclusion is shown in Fig. 6. It shows strong intensities of iron (Fe) and chromium, and minor peaks of manganese (Mn) and zinc (Zn). The highest value recorded for \(\text{ZnO}\) was 4% by weight. Based on these results, the inclusion can be termed Zn-chromite.
Table 1: Chemical compositions of the Niah Cave *lingling-o* and Fengtian natural nephrite from Taiwan.

<table>
<thead>
<tr>
<th></th>
<th>Niah Cave <em>lingling-o</em> (EDS: n=14)</th>
<th>Fengtian nephrite* (EPMA: n=675)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>avg.</td>
<td>max.</td>
</tr>
<tr>
<td>SiO₂</td>
<td>58.19</td>
<td>59.32</td>
</tr>
<tr>
<td>TiO₂</td>
<td>0.82</td>
<td>1.75</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>0.63</td>
<td>1.10</td>
</tr>
<tr>
<td>Cr₂O₃</td>
<td>3.76</td>
<td>4.45</td>
</tr>
<tr>
<td>FeO</td>
<td>22.80</td>
<td>21.58</td>
</tr>
<tr>
<td>MgO</td>
<td>13.01</td>
<td>14.07</td>
</tr>
<tr>
<td>Na₂O</td>
<td>0.03</td>
<td>0.29</td>
</tr>
<tr>
<td>K₂O</td>
<td>98.29</td>
<td>99.98</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cation ratios (O = 23)</th>
<th>7.950</th>
<th>7.995</th>
<th>7.894</th>
<th>7.968</th>
<th>8.000</th>
<th>7.386</th>
</tr>
</thead>
<tbody>
<tr>
<td>Si</td>
<td>7.995</td>
<td>7.931</td>
<td>7.986</td>
<td>7.919</td>
<td>7.936</td>
<td>7.965</td>
</tr>
<tr>
<td>Al (iv)</td>
<td>0.005</td>
<td>0.069</td>
<td>0.014</td>
<td>0.102</td>
<td>0.081</td>
<td>0.064</td>
</tr>
<tr>
<td>Al (iv)</td>
<td>0.083</td>
<td>0.208</td>
<td>0.013</td>
<td>0.066</td>
<td>0.111</td>
<td>0.073</td>
</tr>
<tr>
<td>Ti</td>
<td>0.002</td>
<td>0.011</td>
<td>0.000</td>
<td>0.034</td>
<td>0.614</td>
<td>0.000</td>
</tr>
<tr>
<td>Cr</td>
<td>0.430</td>
<td>0.509</td>
<td>0.335</td>
<td>0.493</td>
<td>1.082</td>
<td>0.357</td>
</tr>
<tr>
<td>Fe (iv)</td>
<td>0.021</td>
<td>0.083</td>
<td>0.000</td>
<td>0.021</td>
<td>0.083</td>
<td>0.000</td>
</tr>
<tr>
<td>Mg</td>
<td>4.533</td>
<td>4.710</td>
<td>4.386</td>
<td>4.458</td>
<td>4.677</td>
<td>3.756</td>
</tr>
<tr>
<td>Ca</td>
<td>1.938</td>
<td>2.058</td>
<td>1.775</td>
<td>1.950</td>
<td>2.020</td>
<td>1.700</td>
</tr>
<tr>
<td>Na</td>
<td>0.009</td>
<td>0.078</td>
<td>0.000</td>
<td>0.009</td>
<td>0.078</td>
<td>0.000</td>
</tr>
<tr>
<td>K</td>
<td>0.002</td>
<td>0.014</td>
<td>0.000</td>
<td>0.002</td>
<td>0.014</td>
<td>0.000</td>
</tr>
</tbody>
</table>

| Mg/(Mg+Fe)           | 0.913  | 0.933  | 0.896  | 0.929  | 0.918  | 0.917  |

Fig. 2: Electron back-scattered micrograph of the surface of the Niah lingling-o. Scale bar: 20 μm.

Fig. 3: A representative EDS spectrum from the matrix (nephrite) of the Niah lingling-o.
As shown in Fig. 4, the chemical composition of the Niah lingling-o is closely comparable to that of Fengtian nephrite [Mg/(Mg+Fe)=0.933-0.896] from eastern Taiwan. Additionally, the studied sample has Zn-chromites as inclusion minerals. Iizuka & Hung (2005) demonstrate that the chromites in Fengtian nephrite contain significant amounts of zinc (up to 7% by weight), in comparison to chromites in other green-coloured nephrite sources in the western Pacific and East Asian regions. They suggest that the presence of zinc in spinel inclusions can be used as a clear marker of a Fengtian nephrite source.

CONCLUDING REMARKS

Jade lingling-o earrings almost identical in size, shape and material to that from Niah are very widely reported (Loofs-Wissowa, 1980-1; Hung, 2005) (Fig. 7). In 2004 and 2005, a workshop for
Fig. 5: Electron back-scattered micrograph of a Cr-spinel inclusion at the surface of the Niah lingling-o (see Fig. 1-b). This is spinel-rich (AlMg₂O₄) in its inner part (darker) and chromite rich (CrFe₂O₄) in its outer part (lighter). The chromite contains zinc. Scale bar: 100 μm.

Fig. 6: A representative EDS spectrum from a Zn-chromite inclusion on the surface of the Niah lingling-o (see Fig. 5).
making forms like *lingling-o* earrings, with discarded cores from the central holes and other debitage, was excavated at Anaro on Itbayat Island in the Batanes group, northern Philippines. At Anaro, the workshop activity dates to between 2000 and 1000 years ago (Bellwood and Dizon, 2005). Several complete *lingling-o* earrings are reported from Iron Age (first millennium AD) contexts in the Tabon Caves on Palawan (Fox, 1970; Iizuka et al., 2005). All of the examples listed above, when analysed, have been determined to be
of Fengtian nephrite (Iizuka and Hung, 2005). In addition, many specimens have been reported from locations in southern Vietnam belonging to the Iron Age Sa Huynh and Dong Nai cultures. Some of these Vietnamese *lingling-o* earrings are very similar to those of Niah and the Philippines in shape, but none have yet been investigated for their nephrite sources (plans are afoot to do this in 2006). They can only be dated approximately between 500 BC and AD 500 (Bellwood, 1997: 271-5), and their relationships with the *lingling-o* earrings from Niah and the Philippines cannot be discussed further at this point. In southern Vietnam and the Tabon Caves there have also been discoveries of jade or glass pendants with double animal heads (Fox, 1970; Loofs-Wissowa, 1980-1; Bellwood, 1997: Fig. 9.3; Dang et al., 1998), but this type of ornament has not yet been reported from Niah.

The Anaro (Itbayat, Batanes Islands) discovery is particularly important for understanding the manufacture and distribution of the jade *lingling-o* earrings from Niah and the Philippines because the manufacture of them here, flourishing during the first millennium AD according to the current radiocarbon chronology for the site, used nephrite imported entirely from Fengtian (Bellwood and Dizon, 2005; Iizuka et al., 2005). The Anaro site is, to date, the only workshop for these ornaments to be excavated archaeologically, although it is very likely that another one exists still unexcavated on Lanyu Island, and possibly a third in Batangas Province on Luzon. It is most interesting to observe that *lingling-o* earrings have never been reported from Taiwan itself, suggesting that the nephrite raw material was exported to the Philippines prior to the actual manufacture of the artifacts. Given this information, it is very likely that the Niah *lingling-o* earring was manufactured somewhere in the Philippines.

Notes

1 The term “non-invasive” refers to data collection directly and non-destructively off the surface of an object.
The specimen was collected from the Sarawak Museum by Peter Bellwood in April 2005, taken by air to Yoshiyuki Iizuka in Taipei for analysis, then returned undamaged by Peter Bellwood by air a week later. We wish to thank the Sarawak Museum for permission to have these analyses undertaken.

Beyer (1948: 69) initially compared these earrings to ethnographic lingling-o ornaments of the Ifugao of northern Luzon, and the term lingling-o was applied directly to them by Fox (1970: 126).

REFERENCES

Bellwood, P.

Bellwood, P. and E. Dizon

Beyer, O.

Chin, L.

Dang Van Thang, Vu Quoc Hien, Nguyen Thi Hau et al.

Fox, R.

Hung H-C.
Iizuka, Y. and H-C. Hung

Iizuka, Y., P. Bellwood, H-C. Hung and E.Z. Dizon

Leake, B.E. and 21-authors

Loofs-Wissowa, H.

Zuraina Majid

2003 *Archaeology in Malaysia*. Penang: Centre for Archaeological Research Malaysia.