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Chemical and spectroscopic study of nephrite artifacts from Transbaikalia, Russia: Geological sources and possible transportation routes

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ABSTRACT

The first results of the complex studies of sources of the nephrite raw material that was used by ancient residents of the Baikal region (Russia) are discussed. Non-destructive chemical and physical spectroscopic methods (X-ray fluorescence spectrometry, Raman and photoluminescence spectroscopy) were used to determine the chemical and mineral composition and luminescence properties of nephrite aggregates. Possible regions and deposits of nephrite provenance for several Neolithic artifacts are estimated (Khara-Nurskiy massif, Dzhidinsky district and Vitim River localities, Ospinskoye deposit). It was estimated that the ancient transportation routes of nephrite could be exceptionally long (up to several hundreds of kilometers).

1. Introduction

The work is devoted to the comparative study of chemical and physical characteristics of nephrite artifacts and geological samples from deposits of Transbaikalia. The goal of this paper is the identification of sources of nephrite being used by ancient inhabitants of the Baikal region (Russia). The provenance analysis of mineral materials used in historic and archaeological artifacts is very useful when estimating the transportation routes and cultural interconnections between different regions. The provenance of nephrite artifacts of Neolithic cultures of Siberia and South-Eastern Asia is one of the prominent problems of this kind.

The growing importance of problems of the raw material transportation in prehistoric times has been underlined last years in Russian (Vetrov et al., 2000; Ineshin and Teten'kin, 2011; Yurgenson and Moroz, 2012) and international archaeology (Dibble, 1985; Kostov, 2007; Popov and Tabarev, 2009; Kostov et al., 2012). New trends in the application of natural science methods in archaeology produce more reliable results. In Japan, South Korea and Russian Far-East, the provenance analysis of natural stone materials used in archaeological objects to ascertain cross-regional links between Stone Age people have been widely developed. Supplies of obsidian in Palaeolithic and Neolithic were carried over distances of tens and hundreds of kilometers from the source locations (Popov and Tabarev, 2009; Naoe, 2009; Kim, 2009; Popov, Jia et al., 2010; Kumai, 2013).

The longest distance of nephrite transportation in South-Eastern Asia from the early Neolithic to Middle Ages is estimated as about 3000 km (Hung et al., 2007). On the neighboring territory of China, nephrite was also a favorite material for manufacture of instruments, jewelry and amulets (Huang, 1992; Lu, 1998; Liu, 2003; Baiyinchanghan, 2004). The similarity of Neolithic axes and adzes from the Baikal region and those from the Northern China was taken by Okladnikov (1955) as a basis for the hypothesis of ancient transit routes from Transbaikalian nephrite-bearing areas through Mongolia and then to China.

Nephrite deposits of Transbaikalia belong to the Siberian nephrite-bearing province (Dobretsov and Tatarinov, 1983; Suturin

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and Zamaletdinov, 1984; Sekerin and Sekerina, 2000; Yurgenson, 2001). Nephrite was known by ancient inhabitants of this region since the Neolithic (Okladnikov, 1950). Nephrite was used as material for production of grinded axes and adzes, knives, and different decorations.

Nephrites from the Baikal region belong to two coloration types: light and dark green. Light colored stones are ascribed to the Vitim highland localities. The intensive green nephrite is from the Eastern Sayan region. The attribution of nephrite from archaeological studies to a distinct locality is made only on the basis of its colour in most publications. Goryunova et al. (2005) have determined the provenance of nephrite from Serovo tombs (Priolkhon'e region) as the Eastern Sayan type, while the objects from Glazkovo burials manufactured of light colored nephrite were identified as belonging to the Vitim localities. It is remarkable that the 'Vitim-type' nephrite was used for manufacture of jewelry and the Sayan-type nephrite was mostly utilized as the material for instruments. Although, some probability of usage of light-colored nephrite pebbles from the valleys of Kitoi, Belaya and Onot rivers remains, the nephrites of this type are extremely rare and do not originate from bedrock of the area. Hence, the main hypothesis supposing the prehistoric transportation of the Vitim-type nephrite to the Priolkhon'e region remains (Goryunova et al., 2005, 2007). Light colored nephrite items from Neolithic and early Bronze age burials of Yakutia are also assumed to be the Vitim-type (Alexeev et al., 2006). If so, the ancient transportation routes of nephrite reached 1000 km. The Vitim-type nephrite was the source for objects from several Neolithic sites (Ust-Karenga XII and the burial ground Stary Vitim-2; Vetrov et al., 2000; Alexeev et al., 2006).

Nephrite is a mineral aggregate of metamorphic origin and consists almost completely from calcium–magnesium–iron silicates of the mineral row tremolite – ferro-actinolite with average chemical formula $Ca_2(Mg,Fe)_5[Si_8O_{22}](OH)_2$ (Hawthorne et al., 2012). The name 'nephrite' itself cannot be attributed to a definitive chemical and/or mineral composition because it can be composed either of iron-rich (actinolite) or magnesium-rich (tremolite) varieties. Nephrite is characterized by massive texture and twisted-fibrous microstructure. Its color varies between onion-green to greenish-gray, white, pinky, yellowish, tobacco-brown, bluish to black depending on iron content and some admixtures of other minerals (serpentine, chlorite, calcite, magnesite, and talc) (Bukanov, 2006). There are two main genetic types of nephrite: the first type corresponds to nephrites formed by metasomatic replacement of serpentinite, the second type is represented by nephrite replacing dolomite (Harlow and Sorensen, 2005).

The usage of the name 'nephrite' is also complicated because the external form of the nephrite mineral aggregate cannot be easily distinguished jadeitite, a rock formed of jadeite ($Na(Al,Fe)Si_2O_6$) and also characterized by massive texture and green color. Both minerals are often designated under the name 'jade'. The historic descriptions of 'nephrite' may also include some other mineral aggregates with massive texture that can be distinguished both from nephrite and jadeitite using simple mineralogical methods such as hardness testing (serpentinite etc.).

Analytical methods used for chemical characterization of archaeological nephrite artifacts are limited by non-destructive varieties. Except for 'classical' X-ray fluorescence (XRF) spectrometry, some innovative techniques such as PIXE (Zhang et al., 2011; Kostov

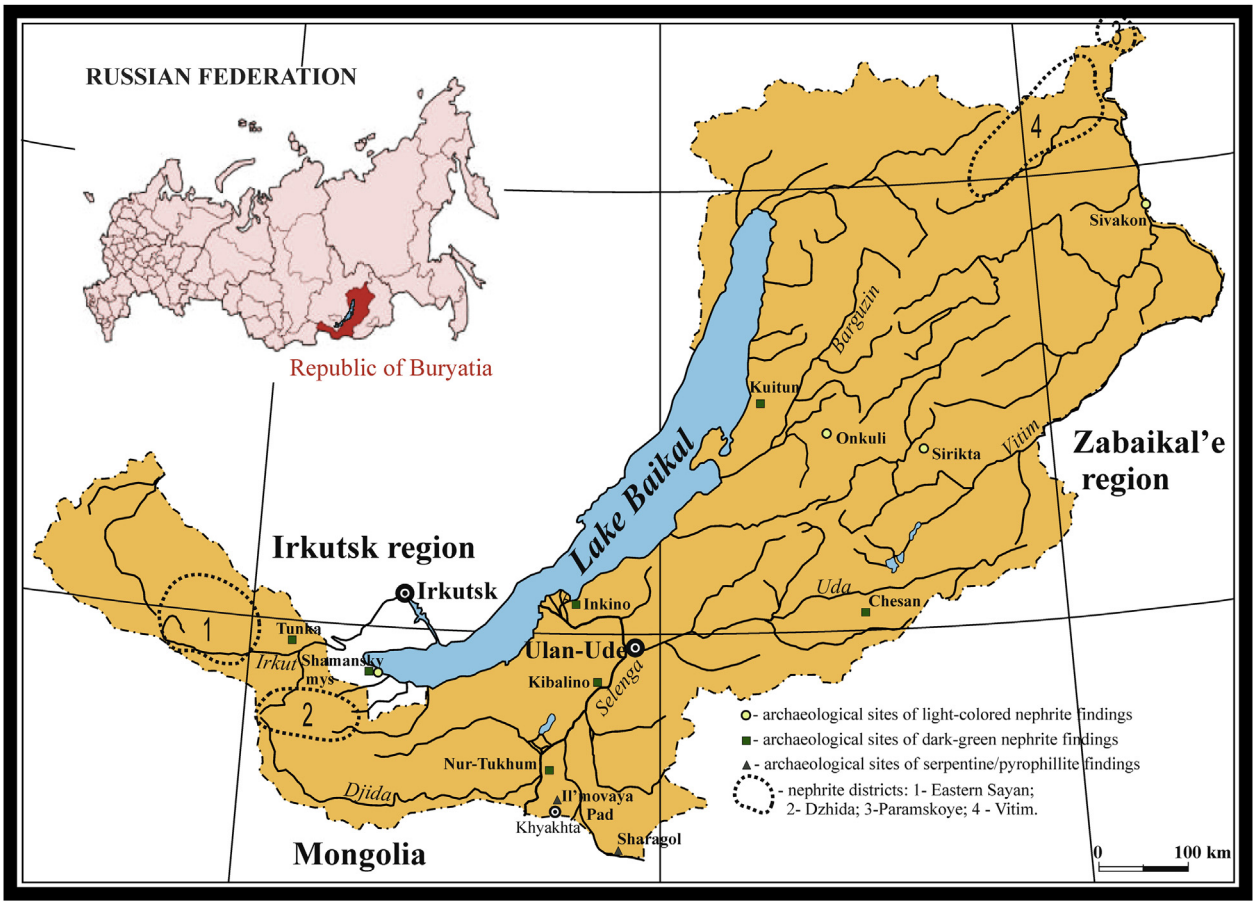

Fig. 1. Map of the archaeological sites with the nephrite finds and nephrite regions.