Journal of African Earth Sciences 63 (2012) 48–61

Contents lists available at SciVerse ScienceDirect

Journal of African Earth Sciences

journal homepage: www.elsevier.com/locate/jafrearsci

Gem-quality Turkish purple jade: Geological and mineralogical characteristics

Murat Hatipoğlu [a,b,*], Yasemin Başevirgen [b], Steven C. Chamberlain [c]

[a] Dokuz Eylül University, İMYO, İzmir Multidisciplinary Vocational School, Gemmology and Jewellery Programme, 35380 Buca-Izmir, Turkey
[b] Dokuz Eylül University, The Graduate School of Natural and Applied Sciences, Department of Natural Building Stones and Gem Stones, 35370 Buca-Izmir, Turkey
[c] New York State Museum, Center for Mineralogy, Albany, NY 12230, USA

A R T I C L E I N F O

Article history:
Received 26 August 2011
Received in revised form 27 October 2011
Accepted 1 November 2011
Available online 16 November 2011

Keywords:
Purple jade
Confocal dispersive Micro-Raman spectroscopy (DCμRS)
XRF and ICP-AES
XRD
Specific gravity (SG)
Polarized-light microscopy

A B S T R A C T

In the Harmancık–Bursa region of the western Anatolia (Turkey), an extensive contact metamorphic aureole at the border between the Late Mesozoic coherent metaclastic rocks of blueschist facies and the Early Senozoic intrusive granodiorite stock hosts an interesting and unique gem material with a mineral assemblage consisting mainly of jadeite, quartz, orthoclase, epidote, chloritoid, and phlogopite as identified by X-ray diffraction spectroscopy and polarized-light microscopy. In addition, chemical analyses performed with X-ray fluorescence and inductive-coupled plasma-atomic emission spectroscopy show that the mass of the metamorphic aureole has a silica-rich, calc-alkaline chemical content. Therefore, some rock building elements (such as Al, Ca, Na, K, P, Sr, and B of which characterize an acidic–neutral rock formation) and trace elements (such as Fe, Cr, Mn, Be, Cu, Ga, La, Ni, Pb, and Zn) are remarkable high ratios.

Pale purple-colored gem material of this composition appears to be unique to Turkey, also is only found in one narrow provenance in Turkey. Therefore, it is specially called "Turkish (and/or Anatolian) purple jade" on the worldwide gem market. Even though the mineral jadeite is the principal constituent, 40% by volume as determined with petrographic thin-section examination under a polarized-light microscope, the material cannot be considered pure jadeite.

Specific gravity measurements of the jade using a hydrostatic balance confirm that it has a heterogeneous structure. The measured average specific gravity of 3.04, is significantly lower than the normal range for characterized jadeites of 3.24–3.43.

Turkish purple jade samples were examined in detail using dispersive confocal micro-Raman spectroscopy (DCμRS) as well as other well-known analytical methods. The resulting strong micro-Raman bands that peaked at 1038, 984, 697, 571, 521, 464, 430, 372, 326, 307, 264, and 201 cm^{-1} are characteristics of the Turkish purple jade. The first most intensive and widest Raman band that peaked at 697 cm^{-1} can be interpreted as the v_2 doubly symmetric bending mode of (SiO_4/M) centers. The "M" includes the some cationic substitutions of Si by Fe, Cr, Mn, Be, Cu, Ni, Pb, and Zn, and also K and Na. The second most intensive and widest Raman band that peaked at 372 cm^{-1} can be interpreted as the v_2 single symmetric bending mode of (SiO_4/M) centers. The third most intensive and widest Raman band that peaked at 201 cm^{-1} can be interpreted as translational libration. Finally, the fourth distinctive Raman bands that peaked at 1038 and 984 cm^{-1} can be interpreted as the v_1 doubly symmetric stretching modes of (SiO_4/M) centers. In addition, both sides of these bands were also barricaded with relatively unimportant Raman bands produced by some structural imperfections.

The measurements of these all analytical parameters are the most trustworthy method to distinguish the purple jade from the other well-known kinds of natural, synthetic, and/or color-enhanced jades. Finally, these parameters provide positive identification of the provenance (geographic origin) of the original Turkish purple jade. The data obtained in this study for dispersive confocal micro-Raman bands, specific gravity values, and trace element contents provide a unique fingerprint for this kind of jadeite-jade gem material.

1. Introduction

The jade as a material is known in many fine nuances of green, but also in shades of white, black, gray, yellow, and orange, and in delicate violet tones. Moreover, all kinds of natural gem-quality

* Corresponding author at: Dokuz Eylül University, İMYO, İzmir Multidisciplinary Vocational School, Gemmology and Jewellery Programme, 35380 Buca-Izmir, Turkey. Tel.: +90 232 3012564.
E-mail address: murat.hatipoglu@deu.edu.tr (M. Hatipoğlu).

1464-343X/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jafrearsci.2011.11.004

jades, either jadeite-jade or nephrite-jade, are extremely rare and highly valued (Harlow and Sorensen, 2005; Harlow et al., 2007). The word "jade" is derived from the Spanish term 'piedra de ijada'. Since, when the Spanish conquered Mexico, they saw that people in Mexico powdered jadeite and sometimes mixed it with water for making a cure against numerous internal diseases. The first recorded use of this term is by Nicol Monardes in a work on medicinal plants of the New World written in 1565 (Crowhurst, 2001; Easby, 1991). The term "jade" as used in the gem trade, in fact, refers to these two minerals: jadeite (pyroxene group) ($Na(Al,Fe)Si_2O_6$) and nephrite (amphibole group) [$Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$] (Prewitt and Burnham, 1966; Morimoto, 1988, 1989; Cameron and Papike, 1981; Htein and Naing, 1994). However, jadeite is different in chemical composition from nephrite, and can exhibit highly saturated colors and a higher degree of translucency, a higher hardness, and a glassy appearance (Harder, 1995). Because of its superior features, jadeite quickly replaced nephrite as the "jade" of choice among art and gem collectors. Contemporary descriptions of "imperial" jadeite cite the following qualitative attributes; a very intense and uniform green color ranging from "apple green" to "spinach green"; a high degree of uniform translucency; and an extremely smooth finish with a greasy feel and lustre (Nassau and Shigley, 1987; Zhao et al., 1994; Nestola et al., 2007; Bersani and Lottici, 2010).

Before the 18th century, only nephrites had been found, mined, and carved into art objects or jewellery. During the 1700's, green and/or white colored jadeites were found worldwide localities. Instead of nephrite, jadeite is closely associated with two ancient civilizations, those of Mesoamerica (Mexico, Guatemala, and Belize) and China. Therefore, jadeite material was also used by most of the major civilizations in ancient Mesoamerica; the Olmec, Aztec, Maya, and so forth. Also, this gem, "royal gem" in China, was used in prehistoric times as an ideal tough material for weapons and tools (Andrews, 1986; Easby, 1991; Middleton and Freestone, 1995; Smith and Gendron, 1997).

The cut and polished jadeites as loose stones and/or mounted stones on historic and archeological artifacts have been extracted from the various archeological excavations in Europe and Turkey so far. However, the reported being in existence of the rough green jadeite occurrences (deposits) in Europe and Turkey are very rare. The Western Alps and Austria in Europe appear to be the main source of jadeite mineral and jadeite-jade material (with including the some other minerals) (Bishop et al., 1977; Biino and Compagnoni, 1992; Adamo et al., 2006; Crowhurst, 2001; Harlow et al.,

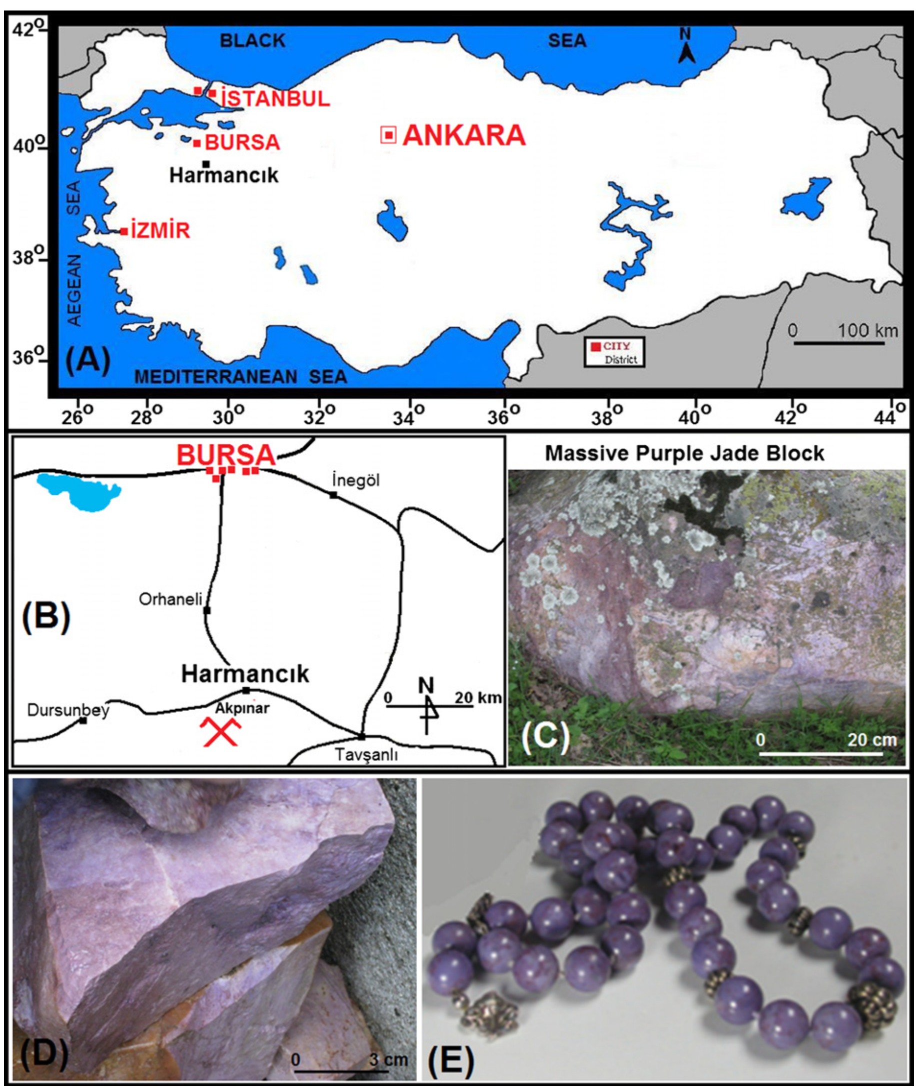

Fig. 1. Location maps showing the Harmancık–Bursa region in Turkey (A) and (B). The fine-grained Turkish purple jade material is found as giant blocks in the field (C). Large-broken fragments of gem-quality purple jade rough are the most valuable on the worldwide gem market (D). Cut and polished gem objects such as these jade and silver prayer beads are widely used in Turkey (E).