

Gemmological and Chemical Characteristics of Yiqisong Peridot, Jilin, People Republic of China

**Tasnara Sripoonjan^{1*}, Montira Seneewong Na Ayutthaya¹, Pimtida Bupparenoo¹,
Nalin Narudeesombat¹, Thanong Leelawatanasuk¹, and Malin Sawatekitithum¹**

¹ The Gem and Jewelry Institute of Thailand (Public Organization), ITF-Tower Building, Silom Road,
Suriyawong, Bangrak, Bangkok, 10500 Thailand

* stasnara@git.or.th

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Introduction

China has traditionally been a territory of a great conundrum with a diversity of natural resources including minerals and gems, and especially green colored stones (e.g. jade, prehnite and peridot). Peridot has been found in a number of different areas of China. Since 1979, China has mined the peridot from the Zhangjiakou-Xuanhua area of Hebei Province (Koivula and Fryer, 1986; Keller and Fuquan, 1986). Recently, the significant deposit of gem-quality peridot has been found in the area called Yiqisong, Yanbian of Jilin province. At first glance, these peridots strikingly show a medium toned yellowish green attribute with high clarity. The average size of relatively clean stones was up to 2 ct. This article describes their detailed gemmological characteristics, namely, basic properties, internal features, absorption spectra and chemical compositions.



Figure 1 Representative samples of Yiqisong peridot from China ranging in weight from 1.60 to 2.80 ct (Photograph by T. Sripoonjan)

Materials and methods

In this investigation, we used a total of 26 peridot samples provided by the Yanbian Fuli Olivine mining Co., Ltd. Of those, there are 9 faceted stones (Figure 1) and 17 rough specimens (5.38 to 26.94 ct). The samples' gemmological properties were collected by basic gem equipment and various advanced instruments, such as UV-Vis-NIR, FTIR, EPMA, and Raman spectroscopies.

Results and Discussion

Gemological properties. Peridots from Yiqisong typically have light yellowish green to yellowish green and generally showed gemological properties similar to those from the other sources (e.g. Vietnam, Arizona, Italy, Pakistan, Nevada).

In detail, the peridot samples displayed identically biaxial positive with RI values of $\alpha = 1.649\text{--}1.655$, $\beta = 1.667\text{--}1.673$, $\gamma = 1.682\text{--}1.690$, and corresponding birefringence of 0.03–0.04. Their SG values ranged from 3.29–3.36. All of them were inert to both short-wave and long-wave UV radiation.

Internal Features. The most prominent inclusions found in almost all Yiqisong peridot samples were various shapes of lily pads (Figure 2A–2C) and delicate wispy veils and tiny crystals (figure 2D and 2E). Protogenetic chromite inclusions (as identified by Raman spectroscopy) exhibit tabular-shaped, brown- to brownish-red crystals (Figure 2F). Partially healed secondary fractures showing iridescent effect were seen in most of the Yiqisong peridot samples (Figure 2G). Other inclusions rarely observed are peculiarly unidentified crystals which have attractive attributes (Figure 2H).

Spectra. Yiqisong peridots have a typical UV/Vis/NIR spectrum characterized by a broad band at 1086 nm, with a shoulder at about 850 nm in the near IR range, and an increasing absorption toward the UV region (Figure 3). Additional weak bands were also observed at 394, 402, 432, 450, 472, 489, 495, 530, 635 nm. The coloration of these peridots can be referred by spectral features found in peridot from the previous works (Adamo et al., 2009), that confirmed the presence iron (Fe²⁺) as a main chromophore of green color (Stockton and Manson, 1983; Thuyet et al., 2016).

The characteristic mid-IR spectra of peridot samples revealed several absorption bands, located at 1046, 980, 951, 899, 835, 626 and 530 cm^{−1} (Figure 4). The peak maxima positions of all samples are almost identical and consistent with their very small chemical ranges. Nevertheless, the peak positions of our spectra were shifted to either slightly lower or higher values depending on their contents of Fe (Fe–O stretching). Namely, the frequency of each band would have a decrease with the increase of iron content and vice versa as previously suggested by Duke and Stephens (1964) and Burns and Huggins (1972).

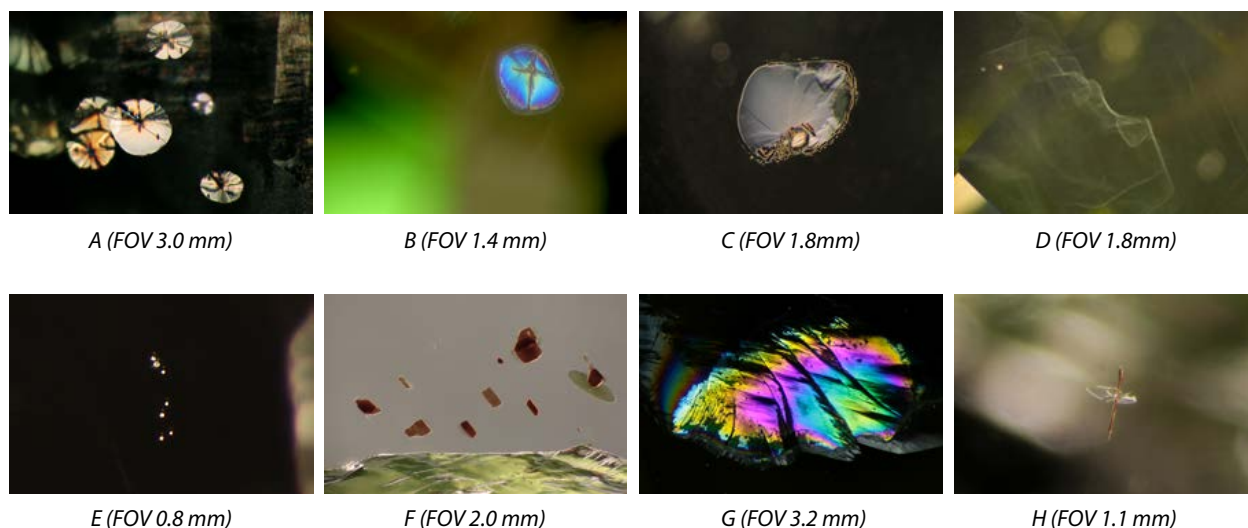


Figure 2 Internal features of Yiqisong peridots from China (see text for further details)
(Photomicrographs by T. Sripoonjan)

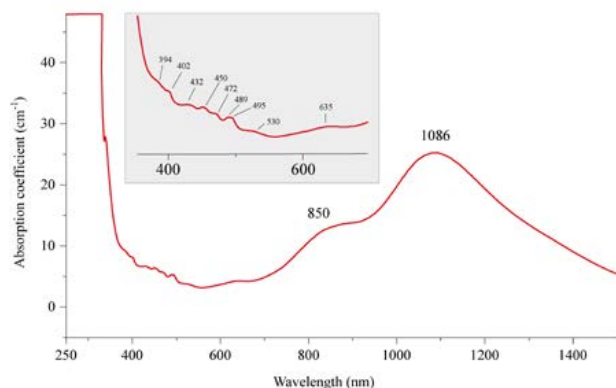


Figure 3 UV-Vis-NIR spectrum of a representative Yiqisong peridot sample.

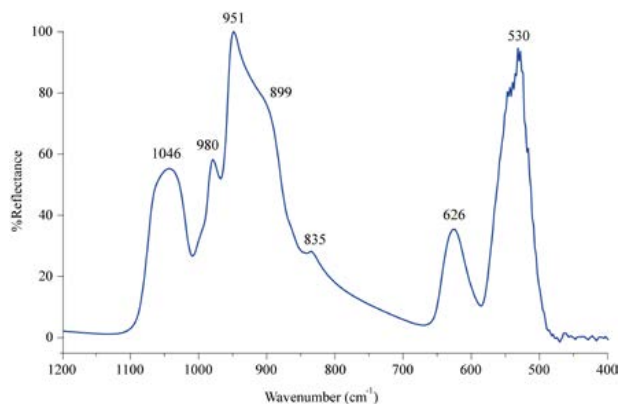


Figure 4 FTIR spectrum of a representative Yiqisong peridot sample

Chemical Composition

The chemical components of Yiqisong samples mostly range from 90.06 to 91.46 % forsterite and 8.38 to 9.83 % fayalite. Their MgO contents vary from 49.43 to 50.87 wt.% that are similar to peridot from Vietnam, Italy and Pakistan, but slightly higher than those from Arizona and Nevada. Their FeO contents range from 8.25 to 9.62 wt.%, that are nearly the same as those from Arizona, Sardinia, and Vietnam, but a bit lower than the specimens from Black Rock, Nevada in the USA (see Table 1). The average MnO content is 0.10 wt.%, while the average NiO content is 0.40 wt.%, that also indicate the mantle's olivine (Jan and Khan, 1996; Ishimaru and Arai, 2007).

Table 1 Chemical composition of Yiqisong peridots and other countries by EPMA (in wt.%).

Source	Yiqisong, China (26 samples)	Central Highlands, Vietnam ^a (9 samples)	Arizona ^b (2 samples)	Sardinia, Italy ^c (2 samples)	Kohistan, Pakistan ^d (7 samples)	Black Rock Summit, Nevada ^e (3 samples)
SiO₂	39.69-41.16 (40.60)	40.27-42.64 (41.02)	40.55-40.77	40.69-40.83	38.75-41.57 (40.47)	37.90-40.55
FeO	8.25-9.62 (8.69)	8.24-9.90 (8.68)	9.68-9.73	8.77-8.98	2.74-9.69 (6.54)	10.27-13.81
MnO	0.06-0.16 (0.10)	0.03-0.24 (0.12)	0.12-0.17	0.11-0.15	0.06-0.15 (0.11)	0.16-0.20
MgO	49.43-50.87 (50.21)	47.22-52.25 (50.36)	48.22-48.98	50.15-50.17	48.52-53.49 (50.80)	47.34-47.62
NiO	0.34-0.48 (0.40)	0.24-0.54 (0.36)	0.37-0.39	0.38-0.39	0.17-0.38 (0.26)	0.27-0.28
CaO	0.00-0.04 (0.01)	0.03-0.1 (0.06)	0.06-0.11	n/a	0.00-0.03 (0.01)	0.15-0.22
Total	99.48-100.89 (100.02)	99.17-100.99 (100.61)	99.29-99.77	100.12-100.50	97.43-99.38 (98.21)	99.92-100.03

^aThuyet et al (2016); ^bStockton and Manson (1983); ^cAdamo et al. (2009); ^dJan and Khan (1996); ^eFührbach (1998)

n/a: not applicable

Conclusion

Peridots from Yiqisong, Yanbian of Jilin province, China appeared in light yellowish green to yellowish green colors. Their RIs, birefringence, SGs and fluorescence are similar to those from the other sources. Internal features showed various shapes of lily pads, wispy veils, tiny crystals and protogenetic chromite crystals (brown to brownish red). Secondary healed fractures showing iridescent effect were also found. The presence of unusual tabular shape protogenetic chromites (brown to brownish red) have never been reported in peridots from other sources; however, only black and octahedral shape chromite crystals were found in peridot from San Carlos (Koivula, 1981).

The result of UV/Vis/NIR spectrum significantly related to iron (Fe^{2+}). Mid-IR spectra showed several absorption bands from 1046 to 530 cm^{-1} . Contents of MgO (49.43 to 50.87 wt.%) and FeO (8.25 to 9.62 wt.%) were similar to peridots from Vietnam, Sardinia (Italy) and Pakistan.

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