Characteristics of exceptionally gem-quality untreated blue sapphires from Bo-Phloi gemfield, Kanchanaburi-Thailand

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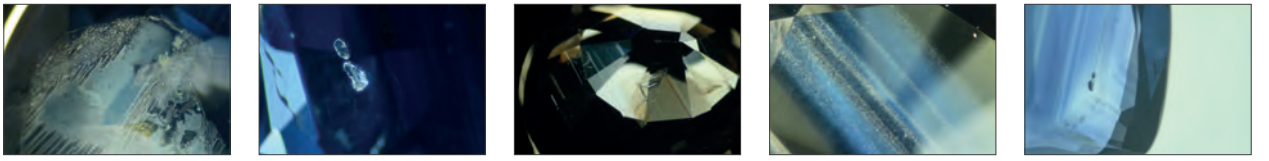
Introduction

The Bo-Phloi gemfield in the Kanchanaburi province of Western Thailand has been known as one of the world important sources of blue sapphire related to basaltic origin. Nowadays, the production output becomes scarce due to the depletion of the resource. In the past decades, majority of the raw materials from this deposit needed to be enhanced by heating to improve their inferior quality, because the commercially gem-quality untreated stones are very rare. As such, the characteristics of those untreated materials have not been well documented in literatures. In early April 2017, the GIT Gem Testing Laboratory (GIT-GTL) had an opportunity to study 29 exceptionally rare gem-quality cut stones of unheated blue sapphires weighing from 0.73 to 2.66 ct (Figure 1) declared to be mined from the Bo-Phloi gemfield by a mine owner. The overall colour of this set of blue sapphires are light to very deep blue. In contrast, the majority of sapphires from this deposit commonly show grayish hue with silky appearance that requires heat treatment, while the unheated gem-quality stones from this source are usually found in medium tone of blue color rather than deep blue like the stones shown in Figure 1.

Figure1. The representative of blue sapphire samples from Bo-Phloi, Kanchanaburi-Thailand.

Basic properties

The gemological properties of all specimens collected by basic instruments showed RI values of 1.770-1.762 and inert under SWUV and LWUV lights. Their inclusions under 60x microscope displayed silks, clouds, fingerprints, strong blue color banding, twining planes, crystals and iron stains as shown in Figure 2. No indications of heating were observed in these stones.



(a) *(b)* *(c)* *(d)* *(e)*

Figure2. The inclusions of blue sapphire from Bo-Phloi: (a) fingerprint with iron stain , (b) crystal inclusions, (c) repeated twinning planes, (d) silks and clouds, (e) angular color banding.

Advanced instruments

The Mid-IR spectra of some samples collected by a FTIR-Nicolet 6700 showed peaks at 3619 cm^{-1}, 3650 cm^{-1}, 3695 cm^{-1} (Figure 3) that indicate a type of mica or kaolinite (Balmer et al., 2007). The OH stretching peak displayed at 3309, 3232 cm^{-1} (Beran et al., 2006.). Nevertheless, some samples did not show any significant peaks.

The UV-Vis-NIR spectra (see Figure 4) of all samples measured by a PerkinElmer spectrometer model Lambda 950 displayed the dominant Fe^{3+}-related absorption peaks at 330, 388, 377 and 450 nm as well as the strong absorption bands caused by Fe^{2+}/Ti^{4+} and Fe^{2+}/Fe^{3+} IVCT around 900 and 575 nm, respectively, that are responsible for its blue colouration (Nassau & Valente, 1987; Burn, 1993; Fritsch & Mercer, 1993 Schmetzer & Schwarz, 2004). These are the typical absorption pattern of blue sapphires from basaltic-type origin.

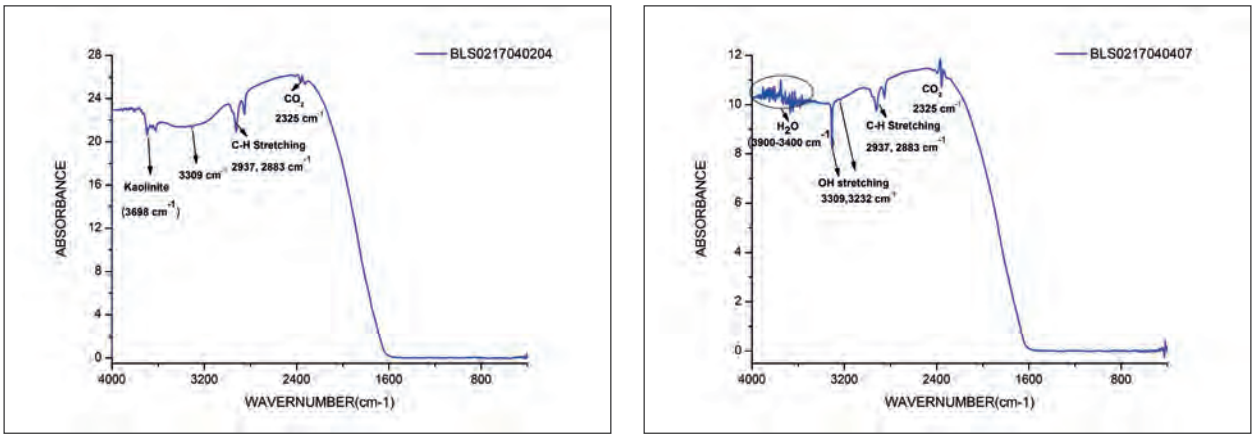


Figure3. FTIR spectra of Bo-Phloi blue sapphires: (a)kaolinite and OH stretching peak (b)strong OH stretching peak.

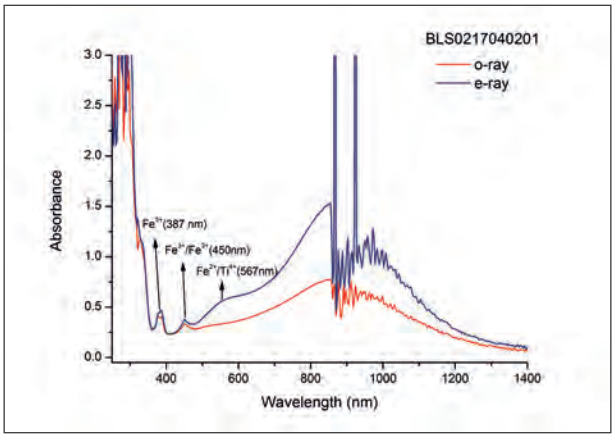


Figure4. A representive UV-Vis-NIR spectra of Bo-Phloi blue sapphire.

The chemical compositions of the stones analyzed by EDXRF-EDAX Eagle III (Table 1) gave rather high Fe contents and moderate Ga contents. The Ti, Ga and Ti/Fe were compared with blue sapphires from other sources in Thailand (Figure 5).

Table1. Chemical compositions of 29 Bo-Phloi blue sapphires by EDXRF.

Element oxide	Concentration range (wt%)	Mean (29 samples)
Al_2O_3	99.66-99.36	99.56
TiO_2	0.02-bdl	0.01
V_2O_5	0.01-bdl	0.01
Cr_2O_3	0.01-bdl	0.01
Fe_2O_3	0.58-0.31	0.40
Ga_2O_3	0.03-0.01	0.02

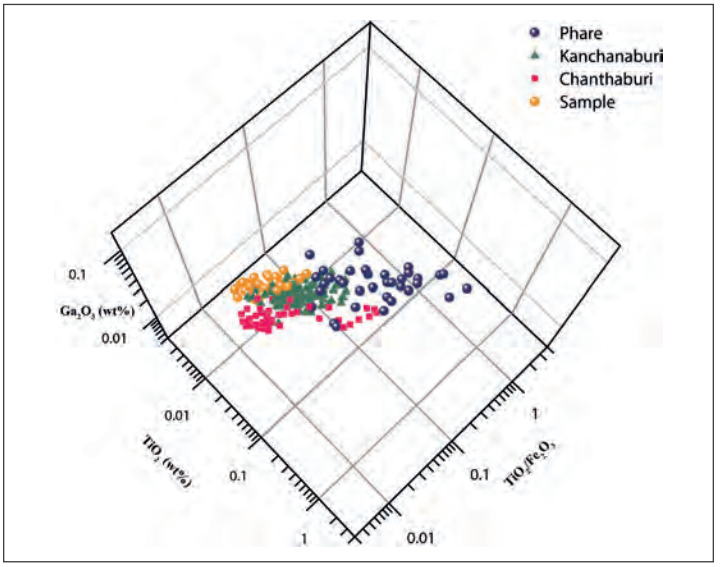


Figure5. The 3-D comparison plot of the samples and blue sapphires from other sources in Thailand.

Conclusion

The diagnostic characteristics of these exceptional gem-quality untreated blue sapphires from Bo-Phloi gemfields are 1) their intense blue coloration and the prominent color banding without any indication of heat-treatment, 2) occasionally with the presence of some kaolinite absorption peaks at 3619 cm^{-1}, 3650 cm^{-1}, 3695 cm^{-1} on the FTIR spectrum. However, the remaining properties, such as their inclusion features, their chemical compositions and the UV-Vis-NIR absorption patterns are consistent with those of blue sapphires from basaltic origin elsewhere. The 3D comparison plot of the chemical data reveals that these stones fall within the area of Kanchanaburi sapphires and can be discriminated from those of Phare and Chanthaburi.

References

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