Color Genesis Analysis and Characteristics for Origin Identification of Purple Jadeite

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Introduction

Purple jadeite, renowned for its distinctive purple hues and rich cultural connotations, is highly admired and sought after. This study investigates purple jadeite samples from Burma and Guatemala, each exhibiting different color variations, as shown in Figure 1. The research commences with a conventional gemological analysis, followed by a comprehensive examination of the color genesis through various spectroscopic techniques, including X-ray fluorescence (XRF) spectra analysis, ultraviolet-visible (UV-Vis) absorption spectra analysis, infrared spectroscopy (IR), Raman spectra analysis and Photoluminescence Spectroscopy (PL) analysis.

Figure 1: Purple Jadeite Samples from Burma and Guatemala.

Results

The results reveal that the coloration of purple jadeite is primarily attributed to the presence of manganese ions (Mn), iron ions (Fe), and titanium ions (Ti). The intensity of the purple coloration is directly correlated with the concentration of manganese ions, while iron ions and titanium ions producing a more violet color. Notably, there are significant differences in trace element concentrations between the two sources: Burmese purple jadeite exhibits higher manganese and lower titanium content (MnO: 0.038-0.065%, TiO_2: 0.015-0.200%), whereas Guatemalan purple jadeite shows lower manganese and higher titanium content (MnO: 0.011-0.032%, TiO_2: 0.506-0.697%). Furthermore, the jadeite samples examined in this research all exhibit purple hues, primarily attributed to the chromophoric contributions of manganese (Mn), iron (Fe), and titanium (Ti) ions, with no significant relationship to chromium (Cr) ions. The chromium content is relatively low, as seen in Table 1.

Sample	Fe_2O_3%	MnO%	Cr_2O_3%	TiO_2%	NiO%
B-001	0.098	0.044	0.012	0.024	0.052
B-002	0.073	0.040	0.004	0.015	0.043
B-003	0.115	0.038	0.001	0.029	0.045
B-004	0.246	0.041	0.027	0.079	0.043
B-005	0.087	0.034	0.017	0.054	0.044
B-006	1.291	0.055	0.013	0.200	0.056
B-007	0.093	0.044	0.005	0.025	0.040
G-001	0.210	0.013	0.001	0.643	0.032
G-002	0.193	0.011	0.009	0.557	0.027
G-003	1.063	0.030	0.014	0.506	0.021
G-004	0.133	0.032	0.011	0.697	0.025
G-005	0.188	0.027	0.009	0.559	0.037

Table 1: Trace element content in Burmese and Guatemalan Purple Jadeite.

The ultraviolet-visible absorption spectra of purple jadeite from the two regions exhibit distinct differences. Burmese purple jadeite is primarily characterized by absorptions at 314, 437, and 581 nm, as illustrated in Figure 2, whereas Guatemalan purple jadeite displays characteristic absorptions at 309, 380, 437, 551, 626, 768, and 947 nm, as shown in Figure 3. The absorptions at 381 and 437 nm are attributed to d-d electronic transitions of Fe^{3+}, while the absorption at 581 nm is associated with d-d electronic transitions of Mn^{3+}. The absorption at 626 nm is due to electronic transitions of Ti^{3+}, the absorption at 768 nm results from charge transfer between Fe^{2+} and Fe^{3+}, and the absorption at 947 nm is attributed to d-d electron transitions of Fe^{2+}[which reference?].

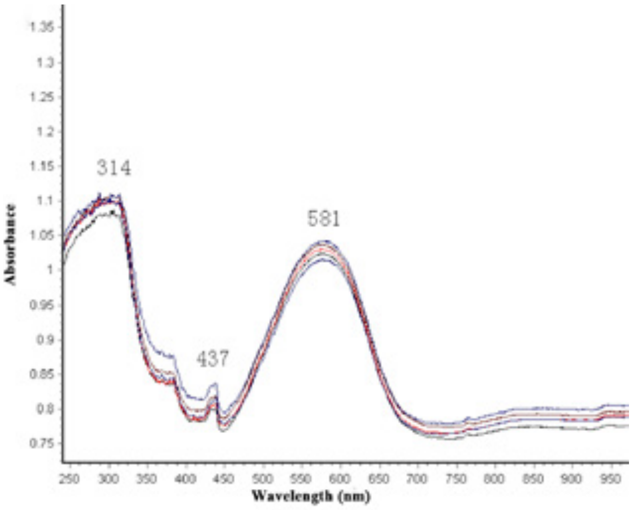

Figure 2: UV-Vis absorption spectra of the purple jadeite from Burma.

Therefore, 581 nm represents a characteristic peak for Burmese purple jadeite (Minghui *et al*., 2023), while 551 nm is a characteristic peak for Guatemalan purple jadeite. The 581 nm feature appears as a peak in the UV-Vis spectra of Burmese purple jadeite, whereas it manifests as a trough between 551nm to 626nm in the spectra of Guatemalan purple jadeite. The UV-Vis spectra of Burmese purple jadeite in the 580–950 nm range exhibit a single peak, whereas the spectra of Guatemalan purple jadeite within the same range display multiple peaks.

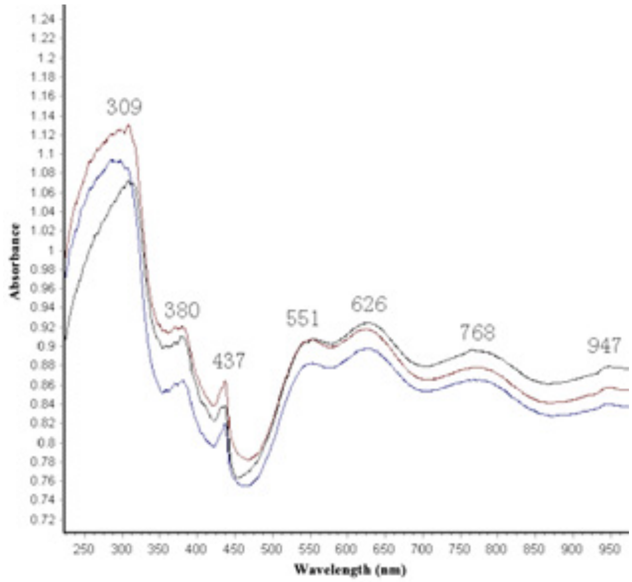

Figure 3: UV-Vis absorption spectra of the purple jadeite from Guatemala.

In terms of infrared spectroscopy, Guatemalan purple jadeite lacks the absorption lines at 1167 cm^{-1} and 745 cm^{-1}. However, no significant differences were observed in the Raman spectroscopy and photoluminescence spectra. The Raman spectral results indicate that purple jadeite from both sources is relatively pure jadeite.

Conclusion

The findings of this study indicate that both Burmese and Guatemalan purple jadeite are primarily composed of relatively pure jadeite. However, significant differences in trace elements are observed, with Burmese purple jadeite exhibiting elevated manganese and lower titanium concentrations, whereas Guatemalan purple jadeite displays reduced manganese and higher titanium levels. These compositional variations contribute to the distinct differences in their absorption spectra. Through detailed compositional analysis and ultraviolet-visible absorption spectroscopy, a reliable distinction between Burmese and Guatemalan purple jadeite can be made.

The samples examined in this abstract predominantly consist of purplish-red jadeites from Burma and bluish-purple jadeites from Guatemala. However, it should be noted that bluish-purple jadeites are also present in Burmese jadeite on the market, and premium-quality Guatemalan jadeite may exhibit purple hues similar to that of the Burma origin. For instance, B-004 (purple jadeite sample from Burma) and G-002 (purple jadeite sample Guatemala) display remarkably similar purple coloration in both hue and saturation, rendering them difficult to differentiate by visual observation alone. Therefore, I conducted a comprehensive analysis using several types of advanced instrumentation. Among these, the ultraviolet-visible (UV-Vis) absorption spectroscopy proved to be diagnostically significant, offering an effective means of distinguishing the origin of the jadeite samples.

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Acknowledgements

I would like to express my sincere gratitude to Professor Lijian Qi and Zhengyu Zhou of Tongji University for providing access to advanced gemological analytical instrumentation. I also gratefully acknowledge Professor Lijian Qi and Doctor Xueliang Liu of East China University of Science and Technology for their valuable academic guidance throughout the course of this research.