

## Supplementary

The UV-Vis absorption spectra of the studied garnet samples are tested and described below.

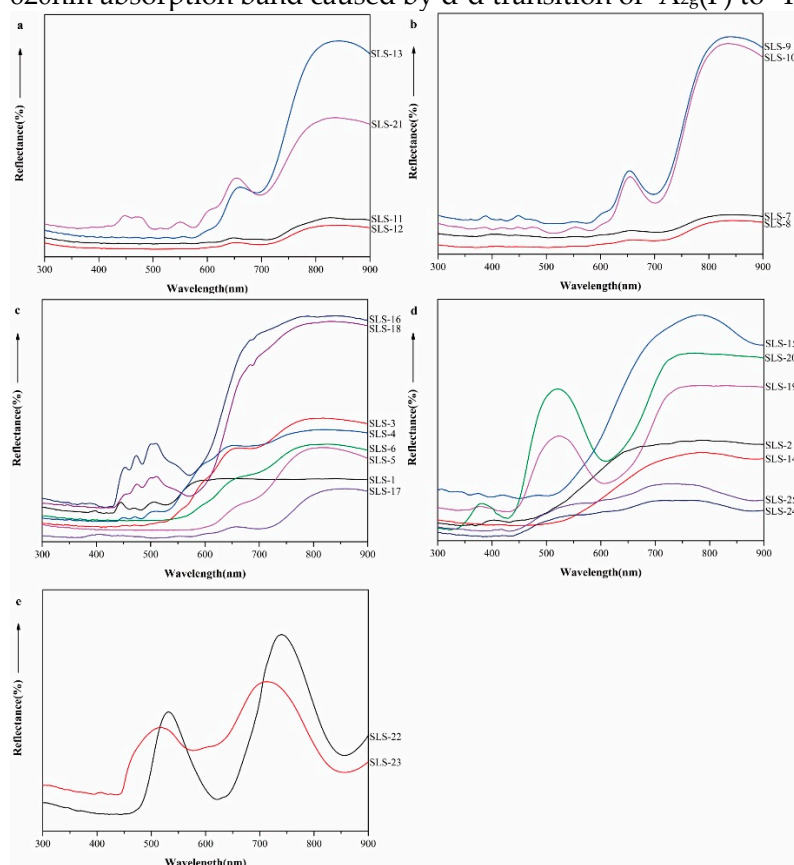
The UV-Vis spectra of pyrope are shown in Figure S1(a), a strong absorption band at 689nm appeared which assignment of  $\text{Fe}^{3+}$  in octahedral site [1]. Other absorption bands at 575, 530 and 505nm are weak, due to the spin-forbidden electron transition of d-d that belong to  $\text{Fe}^{3+}$ . As well as d-d transition  $3d^5$  of  $\text{Mn}^{2+}$  produce a weak absorption at 460nm [1].

The spectra of Almandine (Figure S1(b)), display a strong absorption band at 700nm as the same as pyrope, induced by  $\text{Fe}^{3+}$ . The electron transition of spectral terms splitting of  $\text{Fe}^{2+} 3d^6$  induced weak absorption at 581 nm and 460 nm. In octahedral site, it is only had spin-allowed electron transition  $5T_{2g}$  to  $5E_g$  of  $\text{Fe}^{2+}$  [2].

The spectra of spessartite (Figure S1(c)) mainly appeared absorption band of  $\text{Mn}^{2+}$  and  $\text{Fe}^{2+}$ . 460 and 480nm were induced by d-d transition of  $\text{Mn}^{2+}$ . 505 nm weak absorption peak and 525nm absorption band were attributed to  $^5E_g$  to  $^3E_{1g}(^3H)$  transition of  $\text{Fe}^{2+}$ .  $^5E_g$  to  $^3T_{1g}(^3H)$  transition of  $\text{Fe}^{2+}$  produced 570nm strong absorption band [3].

In the spectra of grossular (Figure S1(d)), cause the  $\text{V}^{3+}$  substituting for  $\text{Al}^{3+}$  in the octahedral site, tsavorite (SLS-19 and 20) display two strong absorption bands centered at about 430 and 610nm [4].

Andradite (Figure S1(e)) display two strong absorption bands centered at about 440 and 620nm. In octahedral site,  $\text{Fe}^{3+}$  produce 440nm absorption band which is due to the electron transition  $^6A_1$  to  $^4A_{1g} + ^4E_g(G)$  and  $\text{Cr}^{3+}$  induce 620nm absorption band caused by d-d transition of  $^4A_{2g}(F)$  to  $^4T_{2g}(F)$  [5].



**Figure S1.** The UV-Vis spectra of gem garnet sample. (a) pyrope; (b) almandine; (c) spessartine; (d) grossular; (e) andradite.

## References

- Glen, A.S.; Chrenko, R.M. Optical absorption of natural garnets from 1000 to 30000 wavenumbers. *Journal of the optical society of America*. **1971**. 61, 1325-1329.

2. Taran, M.N.; Dyar, M.D.; Matsyul, S.S. Optical absorption study of natural garnets of almandine-skiagite composition showing intervalence  $\text{Fe}^{2+} + \text{Fe}^{3+} \rightarrow \text{Fe}^{3+} + \text{Fe}^{2+}$  charge-transfer transition. *American mineralogist*. **2007**. 92, 753-760.
3. Zhang, H.; Liu C.; Song Q.; Shen, H.A. Gemmological and chemical characteristics of spessartine from Zambia. *Journal of Gems & Gemmology*. **2021**. 23, 1-10.
4. Feneyrol, J.; Giuliani, G.; Ohnenstetter, D.; Rondeau, B.; Fritsch, E.; Fallick, A.E.; Ichang'i, D.; Omito, E.; Rakotondrazafy, M.; Ranastsenho, M.; Lallier, F. New typology and origin of tsavorite based on trace-element chemistry. *European Journal of Mineralogy*. **2014**. 26, 293-308.
5. Pei, J.; Huang W.; Zhang Q.; Zhai S. Chemical constituents and spectra characterization of demantoid from Russia. *Spectroscopy and Spectral Analysis*. **2019**. 39, 3849-3854.