Garnet from Eldorado Bar, Montana, USA

The alluvial sapphire deposits of the Eldorado Bar area on the Missouri River near Helena, Montana, USA (Hsu et al., 2017) have yielded small quantities of garnets as a by-product of mining for gem corundum. Although much research has focused on sapphires from this area, little is published on the garnets. During the February 2017 Tucson gem shows, some rough and cut samples of Eldorado Bar garnet were loaned for examination by Todd Wacks (Tucson Todd's Gems, Tucson, Arizona, USA). The stones consisted of two pieces of rough (0.83 and 0.87 g) and one faceted trilliant (0.94 ct; see Figure 16). He had obtained the rough material from Farooq Hashmi (Intimate Gems, Glen Cove, New York, USA), who in 2016–2017 saw 200–300 g of facetable stones of mostly sub-gram size; the largest pieces weighed 2–3 g.

Gemmological characterisation was performed by authors CW and BW. The rough stones consisted of waterworn dodecahedral crystals that were deep orangey red. The faceted stone was deep reddish orange, and its RI was 1.750 and hydrostatic SG was 3.80. It showed patchy anomalous double refraction in the polariscope. A rare-earth magnet was able to lift and hold the faceted stone. An ultraviolet-visible (UV-Vis) spectrum (Figure 17) obtained with an Ocean Optics USB4000 spectrometer recorded features corresponding to both almandine (Fe^{2+}) and spessartine (Mn^{2+}), and Raman spectroscopy with a GemmoRaman-532SG instrument showed the closest match to pyrope-almandine reference spectra. EDXRF chemical analysis indicated major Si, Al, Fe and Mg, and moderate Ca and Mn.

Figure 16: These rough (0.83 and 0.87 g) and cut (0.94 ct) garnets from Eldorado Bar, Montana, were examined for this report. Photo by B. M. Laurs.

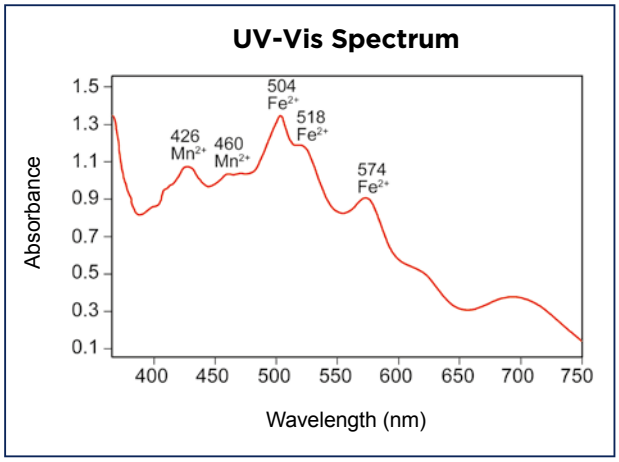

Figure 17: UV-Vis spectroscopy of the faceted Montana garnet showed absorptions at 426 and 460 nm attributed to spessartine (Mn^{2+}), and at 504, 518 and 574 nm attributed to the almandine (Fe^{2+}) component.

Chemical analysis of one of the rough stones and the faceted garnet by laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) was performed by author ZS using a Thermo Fisher Scientific iCAP Qc ICP-MS, coupled with an ESI NWR-213 laser ablation system with a frequency-quintupled Nd:YAG laser (213 nm wavelength). The data showed the samples were pyrope-almandine (~$Pyr_{62}Alm_{30}$) with minor grossular and spessartine components (Table I). The data were quite consistent within each stone, indicating that they contained very little chemical zoning. Among the trace elements, Y was most abundant (Table II).

Garnet from Eldorado Bar is sometimes referred to as 'malaya' (or 'malaia') because of its colour, but this term should be reserved for pyrope-spessartine rather than pyrope-almandine.

Cara Williams FGA and Bear Williams FGA
(info@stonegrouplabs.com)
Stone Group Laboratories
Jefferson City, Missouri, USA

Ziyin (Nick) Sun FGA
Gemological Institute of America
Carlsbad, California, USA

Brendan M. Laurs FGA

Reference

Hsu T., Lucas A., Kane R.E., McClure S.F. and Renfro N.D., 2017. Big Sky Country sapphire: Visiting Montana's alluvial deposits. *Gems & Gemology*, **53**(2), 215–227, http://dx.doi.org/10.5741/GEMS.53.2.215.

Table I: Average chemical composition of two Montana garnets by LA-ICP-MS.*

Composition	Faceted	Rough
Oxide (wt.%, converted)		
SiO_2	40.16	39.85
Al_2O_3	23.45	23.07
FeO	15.34	15.67
MnO	0.85	1.88
MgO	18.00	16.48
CaO	2.02	2.98
Total	99.83	99.93
Ions per 12 oxygens		
Si	2.93	2.93
Total tet.	2.93	2.93
Al	2.02	2.00
Total oct.	2.02	2.00
Mg	1.96	1.81
Fe^{2+}	0.94	0.96
Mn	0.05	0.12
Ca	0.16	0.23
Total dodec.	3.10	3.13
Mol.% end members		
Almandine	30.1	30.4
Grossular	5.1	5.9
Pyrope	63.1	61.3
Spessartine	1.7	2.4

* Analytical parameters: 55 µm diameter laser spot size, fluence (energy density) ~10–12 J/cm^2 and 15 Hz repetition rate. Argon was used as nebuliser gas (0.95 L/min), auxiliary gas (0.8 L/min) and cooling gas (14 L/min). Helium, used as part of the carrier gas, had a flow rate of 0.8 L/min. Argon and He gas flow, torch position, sampling depth and lens voltage were optimised to achieve maximum sensitivity (counts per concentration) and low oxide production rates ($^{232}Th^{16}O/^{232}Th$ <1%). Ablated material was vaporised, atomised and ionised with a plasma power of 1,550 W. Data acquisition was performed in time-resolved mode. Dwell time of each isotope was 0.01 s except ^{27}Al and ^{28}Si, which were measured for 0.005 s. Gas background was measured for 20 s, while dwell time of each laser spot was 40 s. Only the second half (20 s ablation) of the laser profile was used to calculate concentrations, which eliminated surface contamination. ^{29}Si was used as an internal standard and GSD-1G, GSE-1G and NIST 610 were used as external standards. Three spots on each sample were analysed. V and Cr were not detected.

Table II: Average trace-element composition of two Montana garnets by LA-ICP-MS.*

Element (ppmw)	Faceted	Rough
Li	4.38	2.90
Na	104	45.8
P	92.2	54.4
Sc	91.6	36.5
Ti	52.0	59.5
Co	27.5	23.4
Ni	0.775	0.786
Zn	35.0	38.1
Ga	4.61	5.32
Ge	3.08	2.94
Y	515	84.5
Zr	19.3	34.1
Sn	1.17	0.350
Ce	0.088	0.123
Pr	nd	0.091
Nd	1.60	2.05
Sm	5.21	5.235
Eu	1.04	1.77
Gd	28.7	13.5
Tb	8.90	2.37
Dy	86.1	16.0
Ho	18.8	3.01
Er	55.2	9.13
Tm	7.42	1.31
Yb	50.8	9.46
Lu	6.70	1.27
Hf	0.508	0.664

* Abbreviations: ppmw = parts per million by weight; nd = not detected.