Figure 12. The fibrous crystals on this andradite specimen were identified as a mixture of calcite and asbestiform amphiboles. Photomicrograph by J. I. Koivula; field of view ~5.1 mm.

were identified as a mixture of calcite and asbestiform amphiboles (by MG) using a combination of XRD analysis and scanning electron microscopy. It is possible that needles of one or both of these minerals formed inclusions in the garnet that were subsequently etched away by late-stage hydrothermal fluids and/or weathering, leaving the empty channels documented in our samples.

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Andradite from Baluchistan, Pakistan. In recent years, some unusual gem materials have been found in Pakistan's Baluchistan region, such as quartz with petroleum inclusions (Spring 2004 Gem News International, pp. 79–81) and color-zoned axinite (Fall 2007 GNI, pp. 254–255). We were therefore curious to examine three unidentified faceted stones from Baluchistan that were loaned to GIA by Farooq Hashmi (Intimate Gems, Jamaica, New York). He obtained ~0.5 kg of the rough material in 2004 in Peshawar, Pakistan; the lot consisted of opaque dodecahedral crystals and gemmy broken pieces weighing 1–4 g.

Examination of the cut stones (0.65–0.99 ct; figure 13) showed the following properties: color—brownish yellow-orange to yellowish orange-brown; RI—over the limits of the standard gemological refractometer; hydrostatic SG—3.87–3.94; Chelsea filter reaction—none; fluorescence—inert to long- and short-wave UV radiation; and absorption to 500 nm visible with the desk-model spectroscope. These properties are consistent with those reported for andradite by C. M. Stockton and D. V. Manson ("A proposed new classification for gem-quality garnets" Winter 1985 *Gems & Gemology*, pp. 205–218). Microscopic examination revealed planes of one-, two-, and three-phase inclusions, as well as transparent angular graining.

Mr. Hashmi indicated that he has not seen any more of this andradite in the Peshawar market, although occasionally a similar "honey" colored garnet (grossular) has been produced from an area near the bastnäsite mines in the Peshawar region (H. Obodda and P. Leavens, "Zagi Mountain, Northwest Frontier Province, Pakistan," *Mineralogical Record*, Vol. 35, No. 3, 2004, pp. 205–220).

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Two axinite species from Tanzania. Axinite, $Ca_3Al_2BSi_4O_{15}(OH)$, is an uncommon biaxial gem material with a triclinic crystal habit. Much variation in the composition can occur, owing to the replacement of Ca by Fe, Mg, or Mn (W. A. Deer et al., *Rock-forming Minerals:*

Figure 13. These three gems (0.65–0.99 ct) from Baluchistan, Pakistan, proved to be andradite. Courtesy of Intimate Gems; faceted by Matt Dunkle (Aztec, New Mexico). Photo by Robert Weldon.

Figure 14. These three magnesio-axinites (0.20–0.42 ct) from Tanzania were characterized for this report. Courtesy of Rock Logic; photo by Robert Weldon.

Figure 15. These ferro-axinites (1.30 and 4.40 ct) are also from Tanzania. Courtesy of Intimate Gems; photo by Robert Weldon.

Disilicates and Ring Silicates, 2nd ed., The Geological Society, London, Vol. 1B, 1997, pp. 603–623). Ferro-axinite is the species that is most commonly cut into gems (e.g., Fall 2007 Gem News International, pp. 254–255), while magnesio-axinite has been faceted only rarely (see Summer 2005 Lab Notes, pp. 170–171).

At the 2007 Tucson gem shows, Alexandra Woodmansee (Rock Logic, Glencoe, Minnesota) had some light bluish violet magnesio-axinite that was reportedly from the tanzanite mining area at Merelani, Tanzania. She initially obtained a faceted example (0.72 ct) of this magnesio-axinite in the mid-1980s. However, additional material did not become available until a small quantity of rough appeared at the 2006 Tucson shows. In Tanzania, the rough has been sold inadvertently as low-quality tanzanite, but it can be easily separated by its orangy pink UV fluorescence and subtle color shift (see below). From a total of 29 grams of rough, Ms. Woodmansee has cut about two dozen stones, typically weighing <1 ct, although a few larger included stones up to ~2 ct also were faceted.

Ms. Woodmansee loaned 11 faceted magnesio-axinites to GIA for examination, and we obtained gemological properties on three of them (0.20, 0.23, and 0.42 ct; figure 14). In daylight-equivalent illumination, they ranged from pale violet to pale grayish violetish blue with weak pleochroism in shades of light purple, yellow, and yellowish green. In incandescent light, all of the samples shifted to a more intense and uniform violet. The stones showed the following properties: RI—1.660–1.672; birefringence—0.012; hydrostatic SG—3.08–3.30; fluorescence—strong to very strong orangy pink to long-wave UV radiation, and medium orangy pink to short-wave UV; and an absorption line at 410 nm with a weak 580 nm cut-off seen with the desk-model spectroscope. These properties are comparable with those reported for a 0.78 ct transparent magnesio-axinite by E. A. Jobbins et al. ("Magnesioaxinite, a new mineral found as a blue gemstone from Tanzania," *Journal of Gemmology*, Vol. 14, 1975, pp. 368–375), who gave RIs of 1.656–1.668 (birefringence of 0.012) and an SG value of 3.18. Our variable SG values are probably due to the effect of the numerous fractures and inclusions in the stones we examined. Microscopic examination revealed fluid-filled "fingerprints" composed of thread-like and two-phase inclusions, thin fluid films with polygonal shapes, and numerous fractures and cavities with dark brown staining.

Tanzania is also the source of some very different axinite, which gem dealer Farooq Hashmi obtained in Arusha in 2006. It had a brown color that resembled zoisite before it is heat treated to tanzanite, and its trichroism could easily cause further confusion with zoisite. Although the material was offered as tanzanite, Mr. Hashmi suspected that it was axinite and therefore obtained only a small amount of the cobbed rough from which two stones were faceted (figure 15).

Mr. Hashmi loaned the two cut stones (1.30 and 4.40 ct) to GIA for examination, and we obtained the following properties: color—brown to reddish brown (showing no significant color shift in different light sources), with strong purple, yellow, and brownish orange pleochroism; RI—1.668–1.680; birefringence—0.012; hydrostatic SG—3.20; fluorescence—inert to both long- and short-wave UV radiation; and a weak 415 nm absorption line seen with the desk-model spectroscope. These properties are comparable to those reported for ferro-axinite by M. O'Donoghue (*Gems*, 6th ed., Butterworth-Heinemann, Oxford, UK, 2006, p. 386), except that publication listed somewhat higher RI and SG values, as well as additional absorption features at 444, 512, and 532 nm, with two broader bands at 466 and 492 nm. Microscopic examination revealed large fractures, "fingerprints" consisting of orderly parallel inclusions (figure 16), and thread-like or irregular fluid remnant inclusions (figure 17). There was also subtle straight and angular growth zoning in both stones.

Figure 16. The ferro-axinite contains "fingerprints" composed of orderly parallel inclusions. Photomicrograph by D. Beaton; field of view 4.8 mm.

Figure 17. Thread-like and irregular fluid inclusions are visible through the bezel of this ferro-axinite. Photomicrograph by D. Beaton; field of view 7.2 mm.

Electron-microprobe analyses (table 1) of one sample each of magnesio- and ferro-axinite showed similar compositions to those reported for these minerals by Jobbins et al. (1975) and Deer et al. (1997), except that the magnesio-axinite analyzed for this study contained somewhat more Mn (~2.0 vs. 0.4 wt.% MnO). The composition of the ferro-axinite closely resembled that of the material from Pakistan reported in the Fall 2007 GNI entry.

TABLE 1. Average electron-microprobe analyses of two axinites from Tanzania.[a]

Chemical composition	Magnesio-axinite 0.42 ct	Ferro-axinite 1.30 ct
Oxides (wt.%)		
SiO_2	43.84	42.97
B_2O_3 calc.	6.35	6.22
Al_2O_3	18.56	17.77
FeO	0.05	7.80
MnO	1.99	0.62
MgO	6.27	2.94
CaO	20.46	20.10
Na_2O	0.02	0.05
K_2O	0.02	0.04
H_2O calc.	1.64	1.61
Total	99.22	100.12
Ions per 16 (O,OH,F)		
Si	3.998	3.999
B calc.	1.000	1.000
Al	1.995	1.950
Fe^{2+}	0.004	0.607
Mn	0.154	0.049
Mg	0.852	0.408
Ca	1.999	2.005
Na	0.004	0.009
K	0.002	0.005
OH calc.	1.000	1.000

[a]*Average of five points per stone. Ti, Cr, V, Bi, Pb, Zn, and F were analyzed, but not detected.*

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Baddeleyite from Mogok, Myanmar. Baddeleyite was first documented in faceted form in the Fall 2001 Lab Notes section (p. 212), as a 0.54 ct very dark greenish brown cushion cut that was represented as being from Sri Lanka. More recently, baddeleyite was recognized as a mineral associated with painite from Myanmar (unpublished data; see also Winter 2005 Gem News International, p. 356). Small quantities of baddeleyite from the Thurien-taung painite deposit in the western Mogok area have been faceted recently for gem collectors, according to Mark Smith (Thai Lanka Trading Ltd., Bangkok, Thailand). Mr. Smith reported that the rough baddeleyite is sometimes mixed in parcels of rutile, black amphibole, and schorl fragments, but it can be easily separated according to its higher specific gravity, as well as the distinctive bladed crystal shape and submetallic luster. The crystals are black (dark brown on a thin edge) and measure up to 2.5 cm long; some are intergrown with small red spinel crystals.

Since mid-2005, Mr. Smith has faceted nearly 100 pieces of the baddeleyite. The cutting yield is very low due to cracking and the thin bladed shape of the rough. Most of the stones were cut from broken crystals weighing 0.2–1 g. The shape of these pieces is most conducive to cutting flat rectangular stones. Most of the cut gems ranged from 0.2 to 3 ct, and a few weighed 5–6 ct. In addition, one exceptional faceted stone weighed 26.36 ct; it was cut from a broken piece of rough that was much larger than any other pieces Mr. Smith has seen.