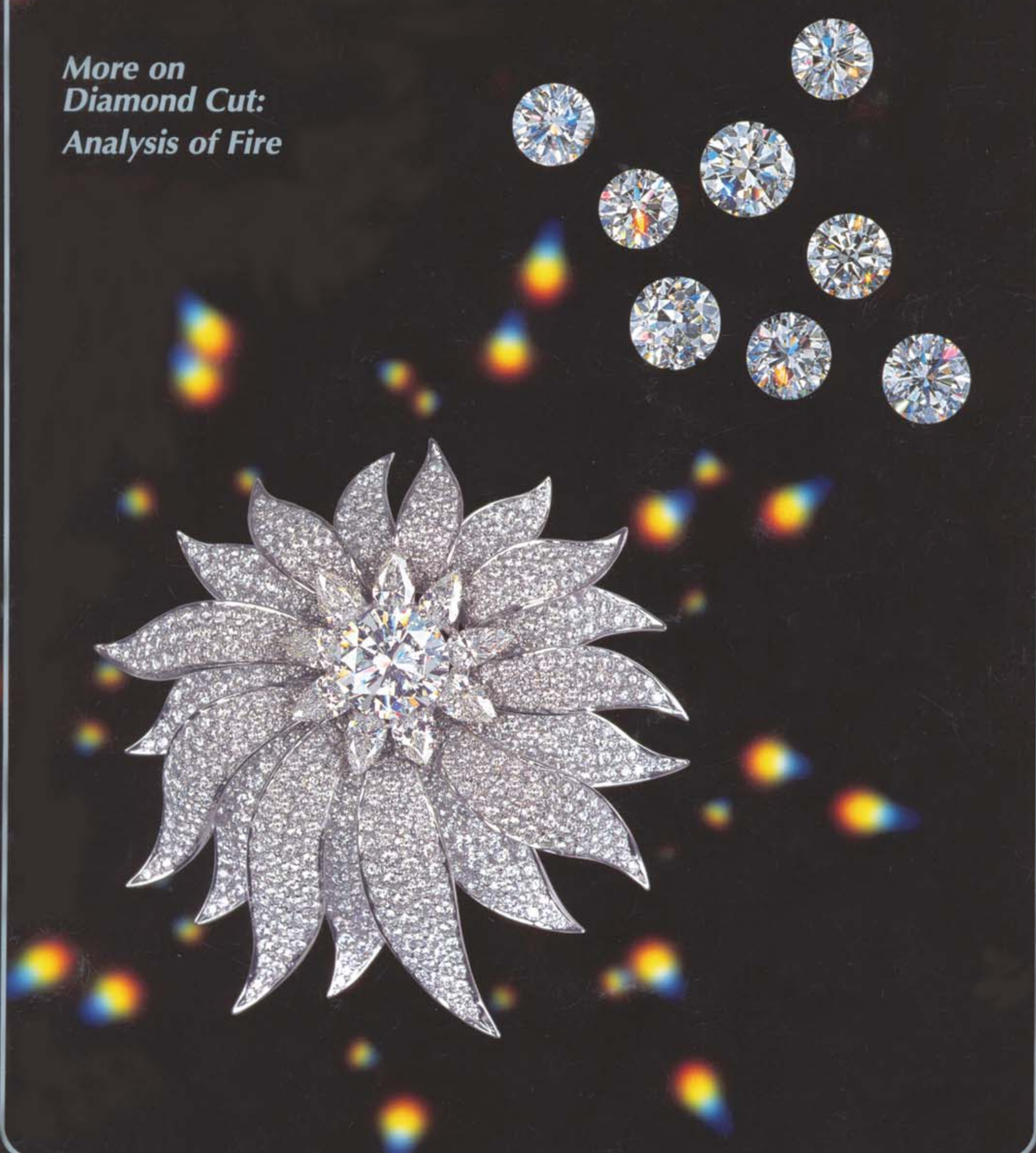
VOLUME XXXVII

FALL 2001

GEMS & GEMOLOGY

More on Diamond Cut: Analysis of Fire



THE QUARTERLY JOURNAL OF THE GEMOLOGICAL INSTITUTE OF AMERICA

JEREMEJEVITE: A GEMOLOGICAL UPDATE

By Kenneth Scarratt, Donna Beaton, and Garry DuToit

The submission of a large (4.54 ct) jeremejevite of an unusual—yellow—color to the AGTA Gemological Testing Center prompted a search of the available gemological literature and a detailed examination of five additional samples to learn more about this rare gemstone. It was found that the information in some English-language texts was either confusing or contributed little to our gemological knowledge. The authors confirm the available standard gemological properties and add pertinent data for the UV-visible, infrared, and Raman spectra, as well as for trace elements measured by EDXRF.

In November 2000, we encountered a light yellow stone that reportedly had been mined from Cape Cross, Swakopmund, Namibia (figure 1). Testing revealed all the gemological properties of jeremejevite ($Al_6B_5O_{15}[F,OH]_3$). The process of identifying this stone led to the current study of this relatively rare gem material, which typically is blue.

Jeremejevite was discovered in the late 19th century and named after Pavel V. Jeremejev, a Russian mineralogist and engineer (Arem, 1987). Most recorded faceted material is under 2 ct, but stones up to 5 ct are possible (Arem, 1987). Until relatively recently, the only two known localities for jeremejevite were at Mt. Soktuj, Transbaikal region, Russia (the type locality; Damour, 1883; Foord et al., 1981) and Cape Cross, Swakopmund, Namibia (Strunz and Wilk, 1974; Bank and Becker, 1977; Hertig and Strunz, 1978; Foord et al., 1981). Since the early 1980s, however, deposits have been reported from four localities in the Eifel volcanic area of Germany, where small or micro-crystals are found (Beyer and Schnorrer-Koehler, 1981; Rondorf and Rondorf, 1988; Blass and Graf, 1999); from the southwestern Pamirs (Ananyev and Konovalenko, 1984); and from the Fantaziya and Priyatnaya pegmatite veins of the eastern Pamirs in eastern Tajikistan (Peretyazhko et al., 1999; Zolotarev et al., (2000); J. Hyrsl, pers. comm., 2001). Earlier this year, an exciting new deposit was discovered in Namibia, about 180 km east of Cape Cross in the Erongo Mountains near Usakos (Gebhard and Brunner, 2001).

The gemological literature contains very little

Figure 1. This 4.54 ct jeremejevite of unusual color is reportedly from Cape Cross, Namibia. The stone measures 14.89 × 7.01 × 4.25 mm. Photo by Sriurai Scarratt.

See end of article for author information and acknowledgments.

GEMS & GEMOLOGY, Vol. 37, No. 3, pp. 206–211

Figure 2. These five jeremejevites were part of the study sample. Two of the predominantly blue stones (2.65 and 0.97 ct) are reportedly from Namibia (the locality of the third blue stone—1.56 ct—is unknown), and the two yellow jeremejevites (0.26 and 0.28 ct) are from eastern Tajikistan. Photo by Sriurai Scarratt.

information on jeremejevite, and most of the available publications list the color as being a blue similar to that of aquamarine (see Liddicoat, 1973, 1976; Webster, 1994). Arem (1987) recorded colorless, pale blue-green, and pale yellow-brown jeremejevite. Strunz and Wilk (1974) refer to the color of the material from Cape Cross as "cornflower" blue. Foord et al. (1981) also report "cornflower" blue as the color of jeremejevite from Cape Cross, and mention colorless material from the same locality.

Therefore, we decided to investigate this unusually colored jeremejevite from Namibia and compare it to other yellow jeremejevites from Tajikistan and some blue jeremejevites. We also took the opportunity to perform advanced testing, to characterize the material further.

MATERIALS AND METHODS

Six samples were examined for this report: The 4.54 ct light yellow jeremejevite reportedly from Cape Cross that came into the AGTA Gemological Testing Center in late 2000 (again, see figure 1); two blue jeremejevites from Namibia that weighed 2.65 and 0.97 ct (GIA collection nos. 5721 and 183); another blue jeremejevite of unknown origin, which weighed 1.56 ct (GIA collection no. 3958); and two yellow jeremejevites (0.26 and 0.28 ct) from the Fantaziya pegmatite in eastern Tajikistan that are in the collection of the senior author (figure 2). All six samples were tested by the standard and advanced methods described below.

Refractive indices were taken with a standard GAGTL (Gemmological Association of Great Britain Gem Trade Laboratory) refractometer illuminated with a monochromatic sodium-equivalent light source. Specific gravity determinations were made hydrostatically (three sets of measurements per sample) with a Mettler CB203 electronic balance. Microscopic observations were made with a GIA GEM Instruments Gemolite microscope.

Ultraviolet-visible (UV-Vis) absorption spectra were recorded with a Unicam UV 500 spectrometer set to a 2.0 nm bandwidth, 120 nm/minute scan speed, and 1 nm data interval. All samples were analyzed over the range 190–900 nm, both parallel and perpendicular to the c-axis. Infrared spectra in the range of 7500–400 cm^{-1} were recorded with a Nicolet Magna-IR 560 Fourier-transform infrared (FTIR) spectrometer set to 500 scans at a resolution of 4 cm^{-1}, in transmittance mode. We recorded Raman spectra with a Renishaw Raman 1000 microscope system, using a 1 μm analysis area with an argon-ion laser excitation wavelength of 514.5 nm. Chemistry was determined qualitatively with an EDAX DX95 energy-dispersive X-ray fluorescence (EDXRF) unit at 35 kV and 450 μA, using a standard detector and a collection period of approximately 20 minutes.

RESULTS AND DISCUSSION

Visual Appearance. As illustrated in figures 1 and 2, each of the stones examined was step-cut. All were transparent. The three stones from the GIA collection had a similar banded, almost parti-colored, appearance that consisted of both wide and narrow light blue bands set against a colorless background for an overall blue appearance. The two stones from Tajikistan were an evenly distributed light yellow in color, and the 4.54 ct stone reportedly from Cape Cross also was light yellow but more saturated than the two from Tajikistan.

Dichroism in the blue jeremejevites was distinct:

TABLE 1. Optical properties and specific gravity for the six jeremejevites examined.

Property	0.28 ct yellow from Tajikistan	0.26 ct yellow from Tajikistan	4.54 ct light yellow from Namibia[a]	2.65 ct blue from Namibia (GIA 5721)	0.97 ct blue from Namibia (GIA 183)	1.56 ct blue locality unknown (GIA 3958)
Refractive index						
n_ε	1.641	1.642	1.641	1.640	1.640	1.640
n_ω	1.650	1.651	1.650	1.649	1.649	1.649
Birefringence	0.009	0.009	0.009	0.009	0.009	0.009
Specific gravity	3.31	3.31	3.27	3.31	3.30	3.28

[a]*Locality as reported by the client.*

blue and near-colorless. It was weak in the yellow samples: light yellow and near colorless.

Refractive Indices and Specific Gravity. The refractive index and specific gravity data for all the stones (table 1) were consistent with previously published ranges. For the refractive indices, the lower limit was 1.640 and the upper limit was 1.651. The birefringence was constant at 0.009. Specific gravity ranged from 3.27 to 3.31.

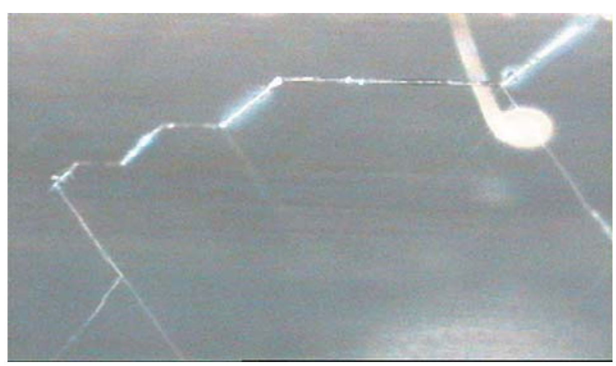
Webster (1994) in his identification tables (p. 898) lists jeremejevite as having a uniaxial optic character with a negative optic sign, and refractive indices of 1.639–1.648 (birefringence 0.009). However, in his text (p. 346) he states that jeremejevite belongs to the orthorhombic system (implying a biaxial optic character) and has a pseudo-hexagonal habit. Liddicoat (1973) also states that jeremejevite is uniaxial negative, but with indications of being biaxial with a very small 2V angle. These bewildering anomalous optical properties are explained by Foord et al. (1981) as being related to growth zoning in jeremejevite: The optic character of the rim of a crystal is different from that of the core. They state that the material from Mt. Soktuj consists of a biaxial core and a uniaxial rim; whereas the situation is reversed in jeremejevite from Cape Cross, which has a uniaxial core and a biaxial rim. Ananyev and Konovalenko (1984) expand on this further. However, for the stones reported here (possibly because fashioning removed the rim), there was no difficulty in obtaining clear and unambiguous R.I. measurements; all of the samples were uniaxial. Because the optical data are very similar to those of apatite, Foord et al. (1981) suggest that some confusion in identification might occur unless care is taken. However, the smaller birefringence of apatite, generally 0.002 to 0.004, should clearly separate it from jeremejevite.

Features Seen with the Microscope. All of the stones examined for this study contained healing "feathers." Strunz and Wilk (1974) also reported healing feathers as well as (unidentified) included crystals in jeremejevite from Cape Cross. We were unable to locate any other gemological references to inclusions in jeremejevite.

A series of growth features that resembled "steps" similar to those sometimes seen in chrysoberyl (Webster, 1994) were observed in several stones. These features manifested themselves as a "lightning strike" growth phenomenon in one of the blue jeremejevites (figure 3), as well as in the 4.54 ct yellow stone.

Several stones had included crystals, all of which appeared to be the same mineral. The 1.56 ct blue jeremejevite contained a multitude of crystals that were aligned along a plane that ran across the width of the stone and from the table to the keel line.

Figure 3. A "lightning strike" growth phenomenon is seen here in one of the blue jeremejevites from Namibia. Such features are actually a manifestation of "step" growth features, which also were seen in the 4.54 ct yellow stone. Photomicrograph by Kenneth Scarratt; magnified 20×.



Raman spectrometry identified these inclusions as feldspar (figure 4).

Figure 4. Feldspar crystals such as this were seen in most of the stones. Here, they occur along a plane in the 1.56 ct blue jeremejevite. Photomicrograph by Kenneth Scarratt; magnified 40×.

Chemical Properties. The chemical formula of jeremejevite is $Al_6B_5O_{15}(F,OH)_3$, and Si, Ga, Be, and Fe and several other elements are reportedly present in minor-to-trace amounts (Foord et al., 1981). The method (EDXRF) used by the authors to obtain chemical data on these jeremejevites cannot detect elements lighter in atomic weight than Na (i.e., B, O, and F) and it is not quantitative. However, such analyses may add useful identification information.

We recorded major Al and traces of Si, Mn, Fe, Cu, Zn, and Ga, although not all of the trace elements were detected in all samples. The most consistently present trace elements (detected in all the stones) were Fe and Ga.

UV-Vis Spectroscopy. The UV-Vis absorption spectra for the 4.54 ct light yellow jeremejevite recorded both parallel and perpendicular to the c-axis show a gradual but only slightly increasing absorbance from 400 to 900 nm (figure 5). Below 400 nm, the absorbance increases sharply to a point of total absorbance at about 280 nm (perpendicular to the optic axis). For both spectra, we noted one very weak band between 600 and 700 nm, and another between 400 and 450 nm. Similar spectra were recorded for the other two yellow samples.

For the blue jeremejevites, in all three samples a broad, slight absorbance was noted between 510 and 680 nm and a lesser absorbance between 350 and 450 nm, especially perpendicular to the optic axis (figure 6). Total absorption perpendicular to the optic axis was reached at 284 nm.

If we compare the UV-Vis spectra of the light

Figure 5. The UV-Vis absorption spectra of the 4.54 ct light yellow jeremejevite are comparable to those recorded for the other yellow samples. The absorption edge perpendicular to the optic axis is at about 280 nm.

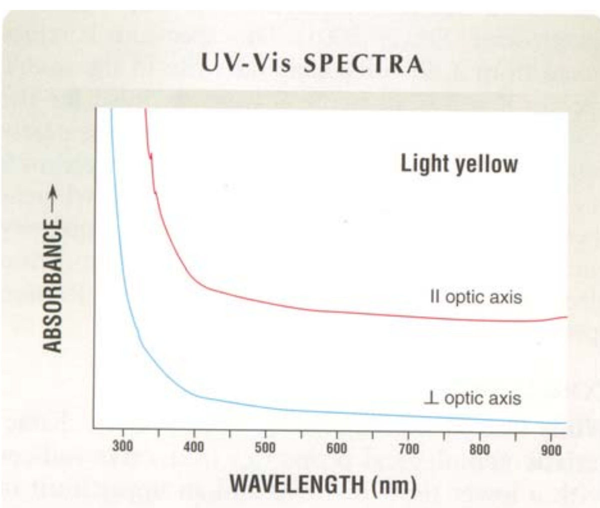
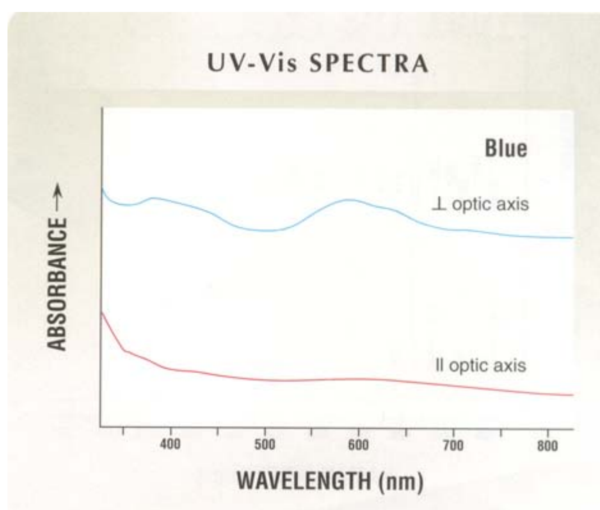


Figure 6. The UV-Vis absorption spectra recorded for the 1.56 ct blue jeremejevite are consistent with those recorded for the other two blue jeremejevites. The absorption edge perpendicular to the optic axis is at 284 nm (not shown).



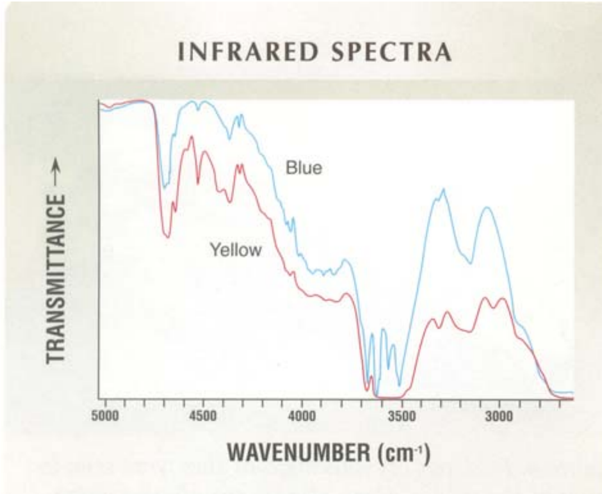
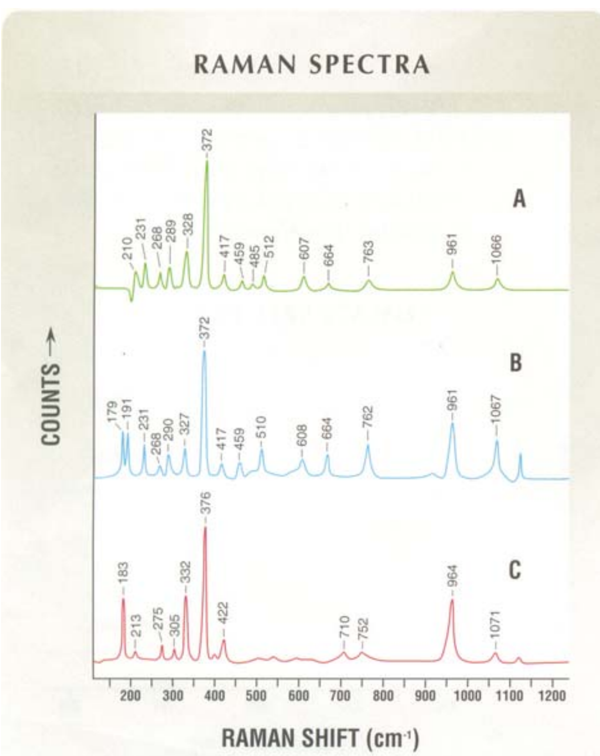


Figure 7. These infrared spectra are representative of those recorded perpendicular to the optic axis for the three yellow and three blue jeremejevites studied.

Figure 8. The Raman spectra for an unoriented blue jeremejevite (A) from the Mineral Spectroscopy Server (2001) is similar to the spectra obtained for the 4.54 ct light yellow stone in directions nearly parallel (B) and perpendicular (C) to the optic axis. Spectrum C shows the variations in peak intensity and position that are due to sample orientation effects.



yellow 4.54 ct (figure 5) and blue 1.56 ct jeremejevites (figure 6) taken perpendicular to the optic axis, it can be seen that the absorption between 510 and 680 nm of the blue jeremejevite is the strongest disctinction.

Previously published UV-Vis spectra for jeremejevite have been for those with a blue color (Foord et al., 1981; Mineral Spectroscopy Server, 2001). The spectrum published by Foord et al. is in reflectance mode; it shows two minima at 280 and 600 nm and a maximum at 465 nm, which are responsible for the blue color. The spectrum on the Internet is in absorbance mode and shows a distinct band from approximately 500 to 700 nm and centered at approximately 600 nm.

Infrared Spectroscopy. Foord et al. (1981) published near- and mid-infrared spectra for both blue and colorless jeremejevite, and revealed that the relevant ranges were 800 to 2500 nm (4000 to 250 cm^{-1}). However, their spectra were obtained from crushed specimens embedded in KBr pellets, and in gemological laboratories normally only nondestructive FTIR analyses are carried out.

In our FTIR analyses of the six samples, we found the most useful data to be between 5000 and 2500 cm^{-1} (figure 7). The features at 3700–3500 cm^{-1} recorded in this study resemble those reported by Foord et al. (1981). Below 2500 cm^{-1} the FTIR features were totally absorbed, so we did not record any of the fine detail that Foord et al. revealed in this region.

Raman Analysis. We explored the possibility of a distinctive Raman spectrum and found only one reference: a single spectrum on the Mineral Spectroscopy Server (2001). This spectrum is reproduced from a downloadable data file in figure 8A. Spectra B and C in figure 8 were recorded for the 4.54 ct light yellow jeremejevite in directions nearly parallel and perpendicular to the c-axis. Spectrum B is a near-perfect match with spectrum A, whereas spectrum C shows the variations in peak intensity and position that are due to sample orientation effects. All six stones showed the same Raman spectra for the two orientations.

CONCLUSION

While faceted jeremejevite appears to have characteristic gemological properties (refractive indices with a lower limit of 1.640 and an upper limit of 1.651, birefringence constant at 0.009, and specific gravity ranging from 3.27 to 3.31), some of the data reported in standard gemological textbooks might cause confusion.

When gemstones, rare or otherwise, are set in jewelry or other objects, the examination restrictions placed on the gemologist can be formidable. The data gained by more sophisticated yet still nondestructive means can be particularly useful in such situations. The chemical data established the elements that should be present (major Al, and traces of Si, Mn, Fe, Cu, Zn, and Ga in the case of jeremejevite), the FTIR spectra (figure 7)—generated by instrumentation that is now available in major gemological laboratories—revealed areas of absorption that are common to this material, and the oriented Raman data (figure 8) readily identified this gem mineral as jeremejevite.

ABOUT THE AUTHORS

Mr. Scarratt is laboratory director, Mrs. Beaton is a laboratory gemologist, and Mr. DuToit is laboratory manager at the AGTA Gemological Testing Center, New York.

ACKNOWLEDGMENTS: The authors appreciate the permission given by Neal Litman, Neal Littman Co., to publish the data on the 4.54 ct yellow jeremejevite. We thank Jo-Ellen Cole of GIA in Carlsbad for loaning the three stones from the GIA collection. The advice and assistance of Tom Moses in the GIA Gem Trade Laboratory is also noted and appreciated. Alan Jobbins is thanked for locating various references and for his overall advice.

REFERENCES

Ananyev S.A., Konovalenko S.I. (1984) Influence of internal stress upon the optical properties of jeremejevite. *Geologiya i Geofisika*, No. 9, pp. 97–103 [in Russian with English abstract].

Arem J. (1987) *Color Encyclopedia of Gemstones*, 2nd ed. Van Nostrand Reinhold, New York, 118 pp.

Bank H., Becker G. (1977) Blauer scheifwürdiger Jeremejewit aus SW-Afrika. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, Vol. 26, No. 3, pp. 161–165.

Beyer H., Schnorrer-Koehler G. (1981) Jeremejewit-Neufund in der Eifel und die Beteiligung von Bor bei der Mineralbildung in Schlackenauswuerflingen Eifler Vulkane. *Der Aufschluss*, Vol. 32, No. 4, pp. 125–129.

Blass G., Graf H.-W. (1999) Die Wannenköpfe bie Ochtendung in der Vulkaneifel und ihre Mineralien. *Mineralien Welt*, Vol. 10, No. 6, pp. 20–47.

Damour M.A. (1883) Note sur un borate d'alumine cristallisé, de la Sibérie. Nouvelle espèce minérale. *Bulletin de la Société Minéralogique de France*, Vol. 6, pp. 20–23; or *Comptes Rendus de l'Academie des Sciences, Paris*, Vol. 96, pp. 675–677.

Foord E.E., Erd R.C., Hunt G.R. (1981) New data for jeremejevite. *Canadian Mineralogist*, Vol. 19, pp. 303–310.

Gebhard G., Brunner J. (2001) Mineral News: Jeremejevite from Ameib, Erongo, Namibia—A new and probably the best find ever made. http://www.mineralnews.de/New_finds/Jeremejevite/jeremejevite.html [date accessed: 8/16/01].

Hertig S., Strunz H. (1978) Jeremejewit von Cape Cross in SW-Afrika. *Der Aufschluss*, Vol. 29, No. 2, pp. 45–53.

Liddicoat R.T. (1973) Developments and highlights at GIA's lab in Los Angeles. *Gems & Gemology*, Vol. 14, No. 5, pp. 144–151.

Liddicoat R.T. (1976) Developments and highlights at GIA's lab in Los Angeles. *Gems & Gemology*, Vol. 15, No. 5, pp. 138–142.

Mineral Spectroscopy Server (2001) California Institute of Technology, Division of Geological and Planetary Sciences, Pasadena, California, http://minerals.gps.caltech.edu [date accessed: 08/29/01].

Peretyazhko I.S., Zagorsky V.E., Prokof'ev V.Yu., Gantimurova T.P. (1999) Miarolitic pegmatites of the Kukurt Group of gemstone deposits, central Pamirs: The evolution of physical conditions in the Amazonitovaya vein. *Geochemistry International*, Vol. 37, No. 2, pp. 108–127.

Rondorf A., Rondorf E. (1988) Jeremejewit von den Wannenköpfen bei Ochtending (Eifel). *Lapis*, Vol. 7, No. 8, pp. 70–82.

Strunz H., Wilk H. (1974) Jeremejewit als Edelstein aus SW-Afrika. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, Vol. 23, No. 2, pp. 142–150.

Webster R. (1994) *Gems—Their Sources, Descriptions and Identification*, 5th ed. Rev. by P.G. Read, Butterworth-Heinemann Ltd., Oxford, England, 1026 pp.

Zolotarev A.A., Dzhuraev Z.T., Pekov I.V., Mikhailova K.V. (2000) Jeremejevite from pegmatite veins in the Eastern Pamirs. *Proceedings of the Russian Mineralogical Society*, No. 2, pp. 64–70 [in Russian with English abstract].