

GEM-QUALITY GREEN ZOISITE

By N. R. Barot and Edward W. Boehm

A new transparent, gem-quality green zoisite has been discovered in the Merelani Hills of mineral-rich Tanzania. The gemological properties are identical to those known for violetish blue tanzanite. The main differences are the pleochroic colors and the presence of chromium lines in the absorption spectrum of the green material. Chemical analyses demonstrated the presence of varying amounts of chromium and vanadium relative to the saturation of green.

ABOUT THE AUTHORS

Dr. Barot, managing director of Ruby Centre, Nairobi, Kenya, is a gemologist who specializes in research on East African gemstones. Mr. Boehm, formerly with the Gübelin Gemmological Laboratory in Lucerne, Switzerland, is a geologist and gemologist with Pala International in Fallbrook, California.

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Tanzania has produced fine gems for most of the last century, but the past three decades have brought exceptional finds of both known and new gem materials. These discoveries include transparent green grossular garnet (tsavorite/tsavolite), violetish blue zoisite (tanzanite), "chrome" tourmaline, and ruby, as well as garnets and sapphires in a wide range of colors. The latest (first seen by the authors in February 1991) is a green gem-quality variety of zoisite (figure 1). This green stone exhibits the basic chemical, physical, and optical properties characteristic of zoisite; only the trichroic colors and chromogens are different from those of the well-known violetish blue to violet tanzanite.

Several names have been proposed for this new gem. Local miners first called it *Combat*, because it resembled the green of some military uniforms. *Güblinite* was proposed to the 1991 International Colored Gemstone Association (ICA) congress in honor of Dr. Edward Gübelin's contributions to the industry. Mineralogists prefer to call this material *green zoisite*, while many American dealers have adopted the term *chrome tanzanite*, in reference to the presence of chromium as the apparent coloring element (on the basis of preliminary research performed by the second author while at the Gübelin Gemmological Laboratory [Barot and Boehm, 1991]; further research has shown that the yellowish green to bluish green stones are colored by varying amounts of chromium and vanadium). For the purposes of this article, the authors will use the name *green tanzanite*, which is the one preferred by the Tanzanian Ministry of Water, Energy and Minerals (A. S. Zullu, pers. comm., 1992). Their proposal is based on the use of *tanzanite* for the gem variety of zoisite, in the same manner that *sapphire* is a gem variety of corundum. We hope, for the sake of this and other new gem materials, that an internationally recognized gemstone nomenclature committee will soon designate an official name.

Until 1991, zoisite occurred in Tanzania in only two varieties of interest to the gem trade. The most important has

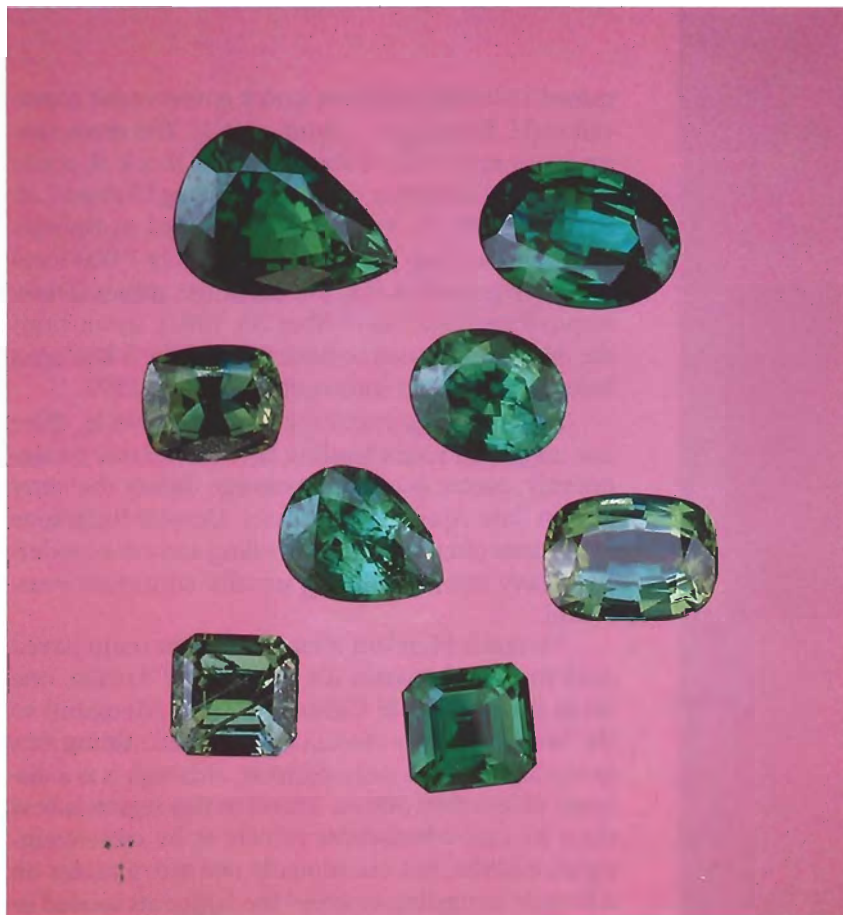


Figure 1. Newly arrived on the gem market are these transparent green tanzanites, first found in the Merelani Hills gem-mining region of Tanzania in early 1991. The stones range from 1.06 to 4.25 ct. Courtesy of Pala International; photo by Shane F. McClure.

been the gem-quality violetish blue tanzanite, which is colored by vanadium (Schmetzer, 1978). Most of these stones have a strong brown component that is removed by heat treatment. Some greenish blue stones have been found, but the color changes to blue after heat treatment (Schmetzer and Bank, 1978–79). The other gem zoisite from Tanzania is a massive opaque green variety, colored by chromium (Game, 1954; Schmetzer, 1982), that is found in association with amphibolite at the Longido mining area, several hundred kilometers northwest of Merelani. This aggregate of zoisite and hornblende is called anyolite in the trade (Gübelin, 1969), based on the word meaning *green* in native Masai. When associated with opaque ruby, it is known as ruby in zoisite (figure 2). Both anyolite and ruby in zoisite have been used extensively as carving materials. Although thulite—a massive, opaque, pink variety of zoisite colored by manganese—has been found in Norway, western Australia, Italy, Austria, the U.S.A. (Wyoming), and South Africa (Schumann, 1977), as well as Switzerland (Abrecht, 1981), only a few random pieces of transparent gem-quality pink zoisite have been found in Tanzania. A few pieces of transparent yellow tanzanite have also been

seen from Merelani (W. Larson, pers. comm., 1992). While a few pieces of transparent green tanzanite have appeared sporadically over the last 10 years, the recent find represents the first discovery of significant amounts of this material (H. Krupp, pers. comm., 1992).

This article reviews the occurrence and gemological properties of this new gem-quality green tanzanite, investigates the cause of color, and examines the effect of heat treatment on the different hues that have emerged to date. Although relatively small numbers of green tanzanite have been found thus far, this new discovery represents an important development in our understanding of zoisite and its potential as a gem species.

LOCATION AND ACCESS

The only location known to produce any notable quantity of transparent gem-quality zoisite (tanzanite) is in the Merelani Hills of Tanzania. Minor occurrences have been reported at Lelatema in Tanzania, and at Lualenyi and Lilani in Kenya (Naeser and Saul, 1974; Pohl and Niedermayr, 1978). Dr. John Saul has also reported minor occurrences of tanzanite in the Uluguru mountain range just south of Morogoro in

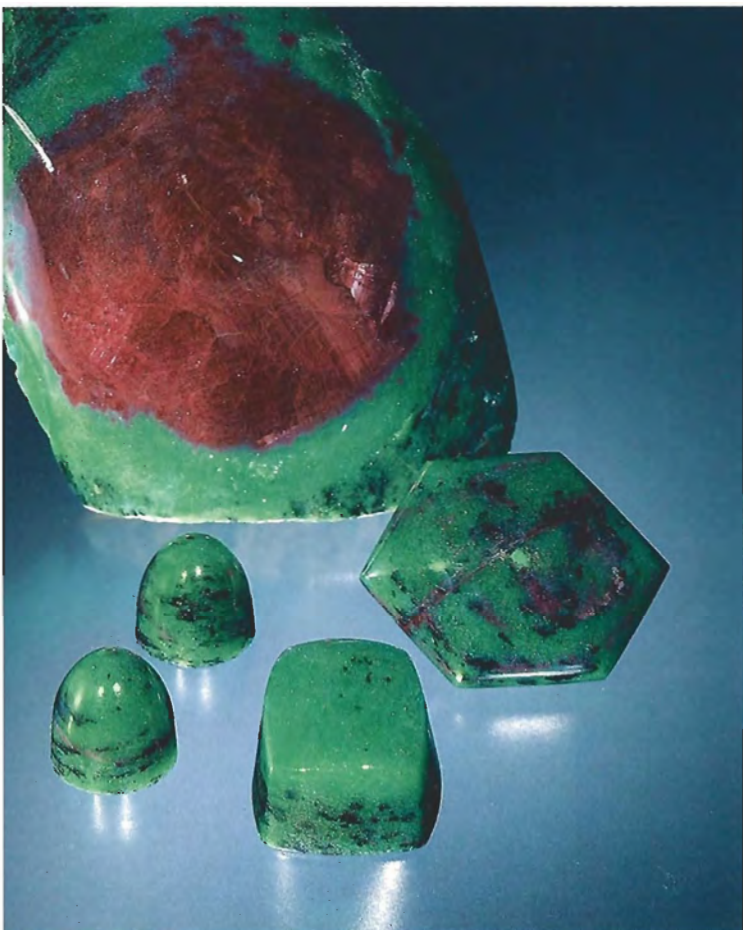


Figure 2. Before transparent green tanzanite was found in 1991, green zoisite was seen only in an opaque aggregate with hornblende known as anyolite, sometimes surrounding large hexagonal ruby crystals. Photo © Harold & Erica Van Pelt.

Tanzania (23rd International Gemological Conference, South Africa, 1991). To date, green tanzanite has been found only at Merelani.

Merelani (3°30'S—37°00'E; Keller, in press) is a hilly region situated south of the Kikuletwa River, 24 km from the Kilimanjaro International Airport near the town of Arusha (figure 3). The area received its name from the mererani tree, which is common to the region. The closest town is Mbuguni, also known by the locals as Zaire; it is presently closed to foreign visitors (H. Krupp, pers. comm., 1991).

The tanzanite deposit at Merelani was first discovered in 1967 (Bruce, 1968). Although the general mining area has grown, it is still relatively small, approximately 5 km long × 1 km wide. To promote more organized, sophisticated mining in the area, the Tanzanian government recently divided it into four sections (Blocks A–D; again, see figure 3) that are

mined independently but under government supervision (H. Krupp, pers. comm., 1991). The green tanzanite is reportedly being found in Block B, a site 845 m × 1,150 m that is held by Building Utilities Ltd. Rehabilitation (A. Suleman, as reported in Koivula and Kammerling, 1991). Approximately 7,000 local miners currently work the tanzanite mines (*Daily News-Tanzania*, November 30, 1991), down from the 35,000 estimated to have worked the 5 km² area before government intervention in early 1991.

As in most gem-mining areas worldwide, there are no paved roads leading into Merelani; consequently, access is often impossible during the rainy season (late April through June). Despite hazardous conditions often caused by flooding and cave-ins during heavy rainfall, mining usually continues year-round.

To reach Merelani after exiting the main paved road running between the airport and Arusha, one must drive south of Cairo and Zaire (Mbuguni) to the base of the hills. Access to the actual mining area in the hills is even more difficult, although it is a distance of less than 500 m. Travel in this region is best done by four-wheel-drive vehicle or by cross-country motorbike, but occasionally one sees a miner on a bicycle struggling to avoid the large ruts eroded in the dirt road.

Government permission must be obtained to gain admission to the mining area. For the most part, foreign visitors are not welcome by local miners. Mining rights are by government approval only.

GEOLOGY AND OCCURRENCE

Zoisite, a species of the epidote group, is an orthorhombic polymorph of clinozoisite that forms under conditions of regional metamorphism (Hurlbut and Klein, 1977). The Merelani gem belt is located in the center of the Great Rift Valley region, which has undergone extensive regional metamorphism. Although some alluvial material has been found in low-lying areas and ancient streambeds, most violetish blue tanzanite occurs in fault zones (thrust planes) within outcrops of graphitic gneisses and schists. According to Malisa et al. (1986) and Malisa and Muhongo (1990), the primary deposits are located at the crest of the large Lelatema fold.

Mineralization of the zoisite is believed to have occurred some 600 million years ago, after the main phase of the Pan-African tectonothermal event and before the Rift Valley movements. During the

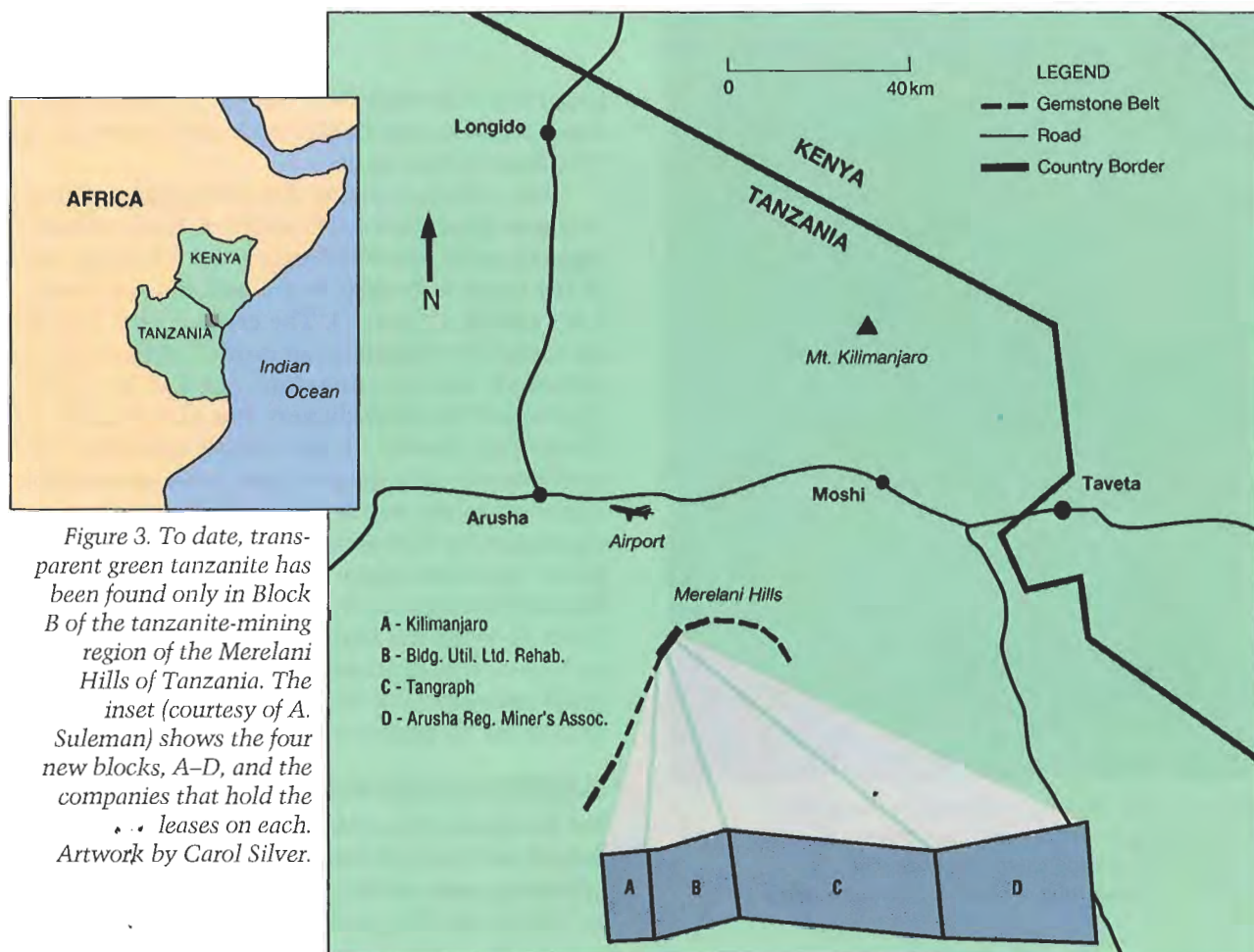


Figure 3. To date, transparent green tanzanite has been found only in Block B of the tanzanite-mining region of the Merelani Hills of Tanzania. The inset (courtesy of A. Suleman) shows the four new blocks, A–D, and the companies that hold the leases on each. Artwork by Carol Silver.

tectonothermal event, in which great variations in temperature occurred, zoisite, together with other silicates, carbonates, and clay minerals, crystallized from hot hydrothermal solutions that traveled through faults and fissures. The gneisses subsequently endured numerous stages of folding during regional tectonic activity (Malisa et al., 1986).

The authors speculate that the new, green tanzanite was formed under basically the same geologic conditions as the violetish blue variety, but within deeper, chromium-rich veins. This theory is partly substantiated by the fact that the green tanzanite is being found at greater depths as the miners continue to work downward (pers. comm. with miners, April 1991). Those stones that are yellowish green or bluish green in color—and, therefore, contain varying amounts of chromium—may have occurred in the zone between the shallower, vanadium-rich veins that host the violetish blue tanzanite and the deeper, chromium-rich veins that contain “pure” green tanzanite.

It is worth noting that green grossular garnet (tsavorite), which is chemically similar to zoisite (also a calcium aluminum silicate and colored by vanadium) but of a structurally different crystal system, is found throughout this region (P. Keller, pers. comm., 1992). Notable sizes of gem-quality tsavorite have been discovered in Block D, formerly known as the Karo pit (Kane et al., 1990).

MINING AND PRODUCTION

Violetish blue tanzanite was first mined by the open-pit method; now, more than 90% of mining is underground (Kane et al., 1990). The gem-quality green tanzanite was discovered in one of the deeper tunnels, at approximately 70 m below the surface. Although the government has assigned the new mining rights to encourage more organized, sophisticated mining, to date there is virtually no heavy equipment at the mines.

The miners rely on dynamite to penetrate the gneisses and schists in which the gem crystals are

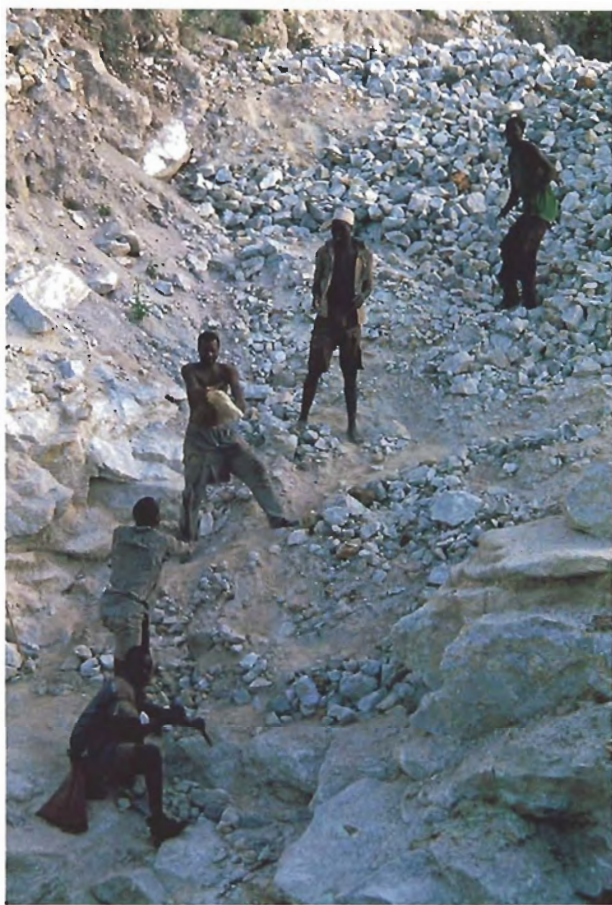


Figure 4. After they have blasted the hard rock, the miners remove the loose pieces from the often steep pits by tossing them "brigade style" from one miner to the next. Photo by Edward Boehm.

found. After blasting, they remove the loose rocks to the surface, tossing them from one miner to the next (figure 4). They then look for pockets of crystals in the newly exposed walls. The miners use picks and shovels to extract the gem crystals from the host rock (figure 5), depending on handmade kerosene lamps for illumination.

During a visit to the Merelani area in April and May 1991, one of the authors (EB) observed that few of the miners wore shoes and there was virtually no protective gear. Nor were there support structures to prevent cave-ins. Access to some of the tunnels was by rope, but only a few ropes served the complex maze. Many miners willingly risked their lives daily in pursuit of the valuable gems just to be able to buy necessities; most lived in thatched huts with mud walls and dirt floors. With the government's reorganization of the mining area, however, conditions should improve.

For the most part, the miners are "independent," but they report to the concerns that hold the leases on the various blocks. Virtually all of the gem material

found is sold in rough form through the leaseholders, who have been issued a Master Dealer's license by the Tanzanian government.

The authors estimate that 1,000 grams of green tanzanite have entered the market to date, producing approximately 500–800 faceted gems. Although most of the rough is broken, some well-formed crystals have emerged (figure 6). The crystals seen thus far are typical for tanzanite, an orthorhombic mineral, although the terminations tend to be acute. Production is currently very low (down to 10–20 stones per month). Of the stones available, only approximately 30% are pure green (with no noticeable modifier), while another 30% are bluish green and the remaining 40% are brownish green to yellowish green. The largest piece of rough known is a heavily included dark green crystal of 19 grams (again, see figure 6), while the largest cut stone seen thus far is a 15.61-ct triangular shape. One of the finest gem green tanzanites the authors have seen is the 11.23-ct cushion cut shown in figure 7.

MATERIALS AND METHODS

For this report, the authors examined more than 30 faceted dark green to medium brownish green to light yellowish green zoisites, ranging in weight from 1.06 to 5.86 ct; and 40 crystals, varying in color from dark

Figure 5. Most of the miners use only picks and shovels in their search for gem material. Photo by Edward Boehm.



green to light yellowish green and ranging in weight from 0.5 to 4.0 grams. All of the 70 research stones were submitted to a variety of gemological tests. Refractive indices were recorded with a GIA GEM Duplex II refractometer; specific gravity was measured on a Mettler hydrostatic electronic scale and by heavy liquids; long- and short-wave ultraviolet luminescence was determined using a USVL-15 Mineralight (handheld); and absorption spectra were recorded on a Beck prism spectroscope and a GIA-GEM handheld diffraction-grating spectroscope.

Ten of the sample stones (1.06–4.25 ct), one 4.65-ct medium blue tanzanite, and one 3.70-ct violetish blue tanzanite (figure 8) were also chemically analyzed by Paul Carpenter, of the California Institute of Technology, using a JEOL 733 electron microprobe with corrections based on Armstrong (1982, 1988).

The heat-treatment experiments were performed by the senior author in Nairobi, Kenya, using a Kasermann and Sperisen (Biel-Bienne, Switzerland) electric oven with a temperature/time system that provides a maximum temperature capacity of 1200°C from an electricity supply of 200 volts. A total of 40 gem-quality rough zoisites that showed green on at

Figure 6. Some well-formed crystals of green tanzanite, like this 19-gram specimen, have been found at Merelani. Photo by Shane F. McClure.



Figure 7. This 11.23-ct green tanzanite displays the finest color seen by the authors to date. Photo © Harold & Erica Van Pelt.

least one axis were selected and divided into five groups on the basis of their trichroic colors. The samples were sawed in half, with one half retained as a control while the other half was subjected to heat treatment. The halves to be treated were tightly packed in a plaster-of-paris powder and then placed in a crucible. The temperature of the oven was gradually raised to 650°C, over the course of approximately 30 minutes, and then was maintained at 650°C for an additional half hour. At this point, the oven was allowed to cool down naturally for about six hours. The samples were then removed from the crucible and compared to their untreated counterparts. Pleochroic colors were noted as observed down the three crystallographic axes with unpolarized light.

GEMOLOGY

Most of the gemological properties of gem-quality green tanzanite overlap those already known for the violetish blue variety (table 1). However, there are some differences and similarities worth noting.

Specifically, the refractive indices, birefringence, and specific gravity of green tanzanite are essentially identical to those of the violetish blue variety, but the pleochroism and spectra are quite different (see Bank, 1969; Hurlbut, 1969; Strunz, 1969). Green tanzanite typically exhibits trichroism of a = greenish yellow to yellowish brown, b = yellowish green, and c = bluish green to brownish green (as compared to a =



Figure 8. Microprobe analyses were performed on this group of gem-quality green and violetish blue tanzanites. The order in which they appear here, from left to right and top to bottom, is the same order in which they are presented in table 2. The stones in the bottom row were all heat treated. Courtesy of Pala International; photo by Shane F. McClure.

violet blue, b = violet, and c = brownish red, respectively, for typical violetish blue tanzanite). The stones we tested showed weak to moderate chromium absorption bands at 660 and 680 nm, which are not found in other colors of transparent tanzanite. Note that these spectral features might not be visible with a hand spectroscope in smaller and/or paler stones.

Faceted violetish blue tanzanites tend to be flawless, because most inclusions that could fracture the stones (due to varying thermal expansion) during heat treatment are removed in the cutting process. However, the following have been identified petrographically as inclusions in zoisite: rutile, sphene, xenotime, diopside, quartz, and tremolite (Malisa et al., 1986). In 1975, using X-ray diffraction analysis, Dunn identified black mineral inclusions that had first been observed in tanzanite by Eppler (1969) as graphite. In 1976, Gübelin and Weibel also verified the

presence of tremolite-actinolite as inclusions in tanzanite. Past microscopic and X-ray diffraction analyses have also identified calcite and gypsum in gem zoisite (Malisa et al., 1986).

Because most of the green tanzanites are not subjected to heat treatment, virtually all of the samples studied—both rough and cut—contained some type of inclusion. Secondary, fingerprint-like fluid inclusions could be seen in most of the rough (figure 9) and in some of the cut stones. The authors also observed two-phase (liquid and solid) and three-phase (liquid, one or two solids, and gas) inclusions. We believe that the opaque solid observed in some of the fluid-filled cavities in green tanzanite (figure 10) may be graphite, on the basis of crystal morphology and its known occurrence in violetish blue tanzanite. The authors have also observed what resembles a zircon crystal surrounded by small feathers, possibly the

result of thermal expansion or natural radiation in a bluish green tanzanite (figure 11). However, because zircon has never before been reported in zoisite, further testing is needed before a firm identification can be made.

Growth tubes—a common feature in zoisites—and unidentified acicular inclusions were observed in the gem-quality green tanzanites as well (figures 12 and 13), usually throughout the entire stone. These features are believed to be responsible for the chatoyancy obtained in some of the cabochons (figure 14).

TABLE 1. Gemological properties of transparent green zoisite found in the Merelani Hills, Tanzania^a.

Color	
Hue	Bluish green to yellowish green
Tone	Light to dark
Saturation	Light-medium to strong
Refractive Indices	1.688–1.696 to 1.691–1.700
Birefringence	0.008 to 0.010
Polariscope reaction	Doubly refractive
Optical absorption spectrum (hand spectroscope)	Broad absorption of the violet and most of the blue portion of the spectrum and weak-to-distinct absorption bands at 660 and 680 nm
Transmission	Inert
luminescence	
Chelsea color filter	Inert
Fluorescence to U.V. radiation	
Long-wave	Inert
Short-wave	Inert
Phosphorescence to U.V. radiation	None
Specific gravity	3.35 to 3.37
Pleochroic colors	
a-axis	Greenish yellow to yellowish brown
b-axis	Yellowish green
c-axis	Bluish green to brownish green
Microscopy	Multiphase inclusions; possibly graphite, zircon(?); unidentified "needles"; growth tubes

^a Properties listed, except pleochroic colors, were obtained from 17 faceted stones ranging in weight from 0.70 to 4.25 ct. Pleochroic colors were determined from 40 rough samples ranging in weight from 0.5 to 4.0 g. See text for instrumentation used.



Figure 9. Fingerprint-like fluid inclusions, which probably formed after the crystal, were common in the green tanzanites examined. Photomicrograph by N. R. Barot; magnified 70 ×.

CHEMICAL COMPOSITION

Zoisite (tanzanite) is a calcium aluminum silicate, $\text{Ca}_2\text{Al}_3(\text{SiO}_4)_3(\text{OH})$, which may contain varying trace elements substituting for aluminum (Ghose and Tsang, 1971). Gem-quality violetish blue zoisite (tanzanite) owes its color primarily to vanadium (V^{3+}) substituting for aluminum (Al^{3+} ; Hurlbut, 1969), while

Figure 10. The black hexagonal crystals in these two-phase, fluid and solid, inclusions in a bluish green tanzanite are probably graphite. Photomicrograph by N. R. Barot; magnified 70 ×.

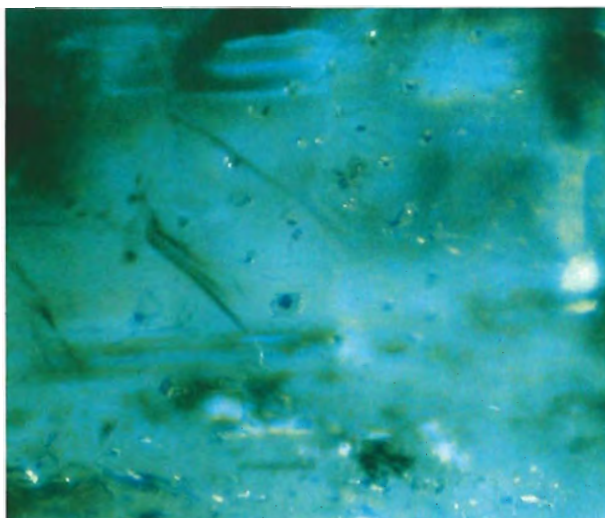




Figure 11. This crystal is believed to be zircon because it is surrounded by "feathers" (tension cracks?), which are usually caused by exposure to natural radiation. Photomicrograph by N. R. Barot; magnified 70 $\times$.

opaque green zoisite (anyolite) and the new translucent to transparent green tanzanite receive their color primarily from chromium (Cr^{3+}), also substituting for aluminum (Game, 1954; Schmetzer, 1982; table 2). However, all the stones we tested contained at least minor amounts of both vanadium and chromium (for more information, see Beckwith et al., 1972; figure 15). Chemically, the structure of zoisite is amenable to substitution of aluminum by chromium and/or vanadium because the atoms of all three elements are of similar size.

Again, it is interesting to note the presence of another calcium aluminum silicate, tsavorite, in this area. In fact, tsavorite sometimes occurs in nodules

Figure 12. Growth tubes were common in the green tanzanites examined. They appear to intersect in this 1.11-ct gem-quality stone. Photomicrograph by E. Boehm; magnified 28 $\times$.

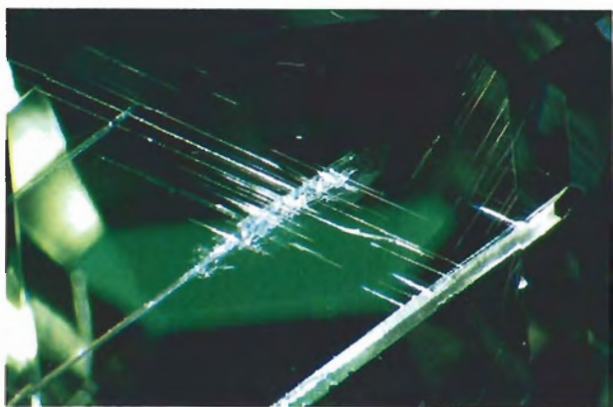


Figure 13. The growth tubes observed in the green tanzanites sometimes displayed interference colors. Photomicrograph by E. Boehm; magnified 30 $\times$.

surrounded by kelyphitic shells of tanzanite (Kane et al., 1990). Although tsavorite receives its color primarily from V^{3+} substituting for Al^{3+} , traces of chromium are also present (Manson and Stockton, 1982). Chrome-bearing tourmaline also occurs just south of Merelani in Lossogonoi. The presence of chromium in the bedrock and in other gem minerals in this region could explain why gem-quality green zoisite is also emerging with an influencing amount of chromium (Bank and Henn, 1988).

Figure 14. Densely packed acicular growth tubes produced chatoyancy in this 0.95-ct green tanzanite. Photo by Shane F. McClure.



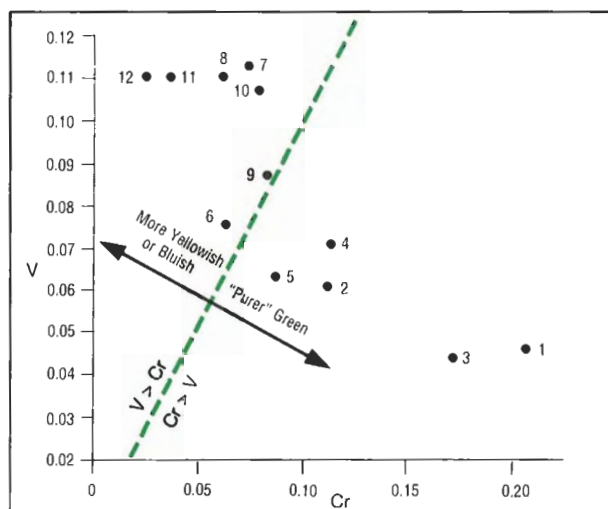


Figure 15. A comparison of the weight percentages of vanadium to chromium in the 12 faceted tanzanites analyzed (see table 2) shows the relationship of color to these chromogens. As chromium increasingly dominates vanadium, the color becomes a "purer" green; on the other hand, as vanadium increases, the color becomes more bluish or yellowish.

EFFECTS OF HEAT TREATMENT

The violetish blue color commonly associated with tanzanite is usually the result of heat treatment, at approximately 500°C, of zoisites with strong brown to yellow modifiers (that is, the conversion of V^{3+} to V^{4+} ; Schmetzer and Bank, 1978–79). The authors subjected the five groups of rough gem-quality green tanzanites described above and in table 3 to temperatures up to 650°C. The seven stones that were dark green to medium slightly bluish green down the c-axis showed no change in color (figure 16, left). This lack of response is most likely because the color in these stones is due to appreciable amounts of Cr^{3+} (again, see figure 15), which does not respond to heat the way V^{3+} does. However, the remaining 33 stones did change on heating (figure 16, right).

Specifically, tanzanites that showed bluish green (figure 17, left) to brownish green responded to heat treatment by turning greenish blue (figure 17, right). This corresponds to the response reported by Schmetzer and Bank (1978–79) for bluish green zoisites with nearly equal amounts of chromium and vanadium.

TABLE 2. Results of electron microprobe analyses^a of gem-quality green and blue zoisites.

	Green—yellowish green (not heated)								Blue (heated)			
Sample no.	1	2	3	4	5	6	7	8	9	10	11	12
Weight (ct)	1.06	4.25	2.38	1.49	1.48	1.81	1.33	1.11	4.14	1.49	4.65	3.70
Color ^b	med G	dk G	dk b G	med b G	med b G	med y G	med y G	lt y G	med sl g B	med sl gr B	med B	med v B
Oxide (wt.%)												
MgO	0.09	0.03	0.06	0.05	0.02	0.05	0.04	0.04	0.05	0.04	0.05	0.05
Al ₂ O ₃	32.89	33.41	33.23	33.11	33.01	33.25	33.24	33.34	33.25	33.24	33.20	33.42
SiO ₂	39.82	39.61	39.80	39.76	39.49	38.91	39.10	39.59	39.58	38.30	39.89	39.02
CaO	23.91	24.01	23.93	24.15	24.02	23.91	24.00	24.25	24.16	23.98	23.88	24.12
TiO ₂	0.04	0.03	0.06	0.03	0.01	0.04	0.03	0.01	0.05	0.02	0.03	0.04
V₂O₃	0.07	0.09	0.06	0.10	0.09	0.11	0.17	0.16	0.13	0.16	0.16	0.16
Cr₂O₃	0.30	0.16	0.26	0.17	0.13	0.09	0.11	0.09	0.12	0.11	0.05	0.04
MnO	0.02	n.d.	0.01	0.01	0.01	0.01	n.d.	n.d.	0.01	0.01	n.d.	0.02
Fe ₂ O ₃	0.01	0.01	0.01	n.d.	n.d.	0.01	n.d.	0.01	0.01	0.01	0.02	0.01
ZnO	0.02	0.01	0.02	0.01	n.d.	n.d.	0.01	0.01	n.d.	0.02	0.01	0.01
SrO	0.27	0.26	0.27	0.27	0.35	0.23	0.06	0.14	0.21	0.13	0.54	0.09
Ga ₂ O ₃	0.03	0.01	0.03	0.03	0.02	0.04	0.01	0.02	0.03	0.01	0.03	0.03
	97.47	97.63	97.74	97.69	97.15	96.65	96.77	97.66	97.60	96.03	97.86	97.01

^aAnalyses were performed by Paul Carpenter of the California Institute of Technology on a JEOL 733 electron microprobe operating at 15 keV, a current of 35 nA, and a spot size between 10 and 25 μ m. Each specimen was analyzed at three randomly selected locations; an average analysis is shown for each sample; n.d. = not detected.

^bColor key: sl = slightly, lt = light, med = medium, dk = dark, y = yellowish, g = greenish, b = bluish, gr = grayish, v = violetish, G = green, B = blue.

TABLE 3. Results of heat treatment of 40 gem-quality green zoisite crystals.^a

Group	No. of samples	Before heat treatment			After heat treatment		
		a-axis	b-axis	c-axis	a-axis	b-axis	c-axis
I	3	Greenish yellow	Yellowish green	Dark green	—————	No change	—————
II	4	Greenish yellow	Yellowish green	Medium slightly bluish green	—————	No change	—————
III	8	Greenish brown	Yellowish green	Dark bluish green	Light bluish green	Yellowish green	Dark greenish blue
IV	10	Yellowish brown	Purple	Dark brownish green	Light blue	Light purple	Medium greenish blue
V	15	Yellowish brown	Purple	Medium brownish green	Light blue	Light purple	Light greenish blue

^a See text for full description of experimental materials and methods.

Even though our research showed that dark bluish green to medium brownish green tanzanites will respond to heat treatment, our experience is that such enhancement has not been routinely practiced on such stones thus far because of the rarity of the green color and the risk of damaging stones that have inclusions. From this research, we also know that not all green tanzanites will respond to heat treatment, and it appears that a “pure” green color can only occur in nature.

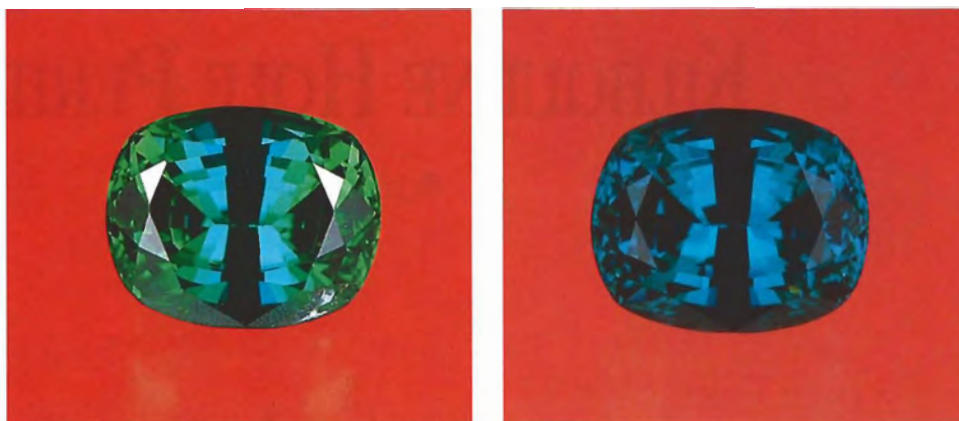
CONCLUSION

To date, limited quantities of green tanzanite have been found in one small area deep in Block B of the Merelani Hills, the primary source of fine violetish blue tanzanite. Approximately 30% of the 1,000 grams of green tanzanite that have reached the market thus far are a “pure” green, colored primarily by chromium, that does not respond to heat treatment; the remaining yellowish green to brownish green stones, which we found to be colored by varying amounts of



Figure 16. For the heat-treatment experiments, crystals were cut in half, with one half used as the control specimen and the other heated to 650°C. Here the halves of two specimens show, on the left (total weight, 3.64 ct), that there was no change in the “pure” green material and, on the right (total weight, 5.94 ct), the change produced in material that was originally brownish green. Photo by Shane F. McClure.

Figure 17. When the 4.14-ct bluish green tanzanite on the left was heated to 650°C, a deep, slightly greenish blue (right) was created. Photos by Shane F. McClure.



vanadium and chromium, will be affected by heat enhancement.

Because the supply of these stones has been irregular since their discovery in early 1991, it is uncertain how much green tanzanite actually exists. However, active mining and exploration continue in this area.

Prospective buyers should beware, however, as recent parcels presented as green tanzanite have included tsavorite, chrome tourmaline, apatite, glass, and YAG, all of which may be separated from green tanzanite by the simple use of a dichroscope to verify the latter's trichroic colors.

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