TOPAZ, AQUAMARINE, AND OTHER BERYLS FROM KLEIN SPITZKOPPE, NAMIBIA

By Bruce Cairncross, Ian C. Campbell, and Jan Marten Huizenga

This article presents, for the first time, both gemological and geologic information on topaz, aquamarine, and other beryls from miarolitic pegmatites at Namibia's historic Klein Spitzkoppe mineral locality. Topaz from Klein Spitzkoppe was first reported more than 100 years ago, in 1889. Many fine specimens have been collected since then, and thousands of carats have been faceted from colorless, transparent "silver" topaz. Gemological investigations of the topaz reveal refractive index values that are somewhat lower, and specific gravity values that are slightly higher, than those of topaz from similar deposits. In fact, these values are more appropriate to topaz from rhyolitic deposits than from pegmatites, and apparently correspond to a high fluorine content. The gemological properties of the aquamarine are consistent with known parameters.

The perfectly formed, transparent-to-translucent gem crystals from Klein Spitzkoppe, a granitic mountain in western Namibia, are in great demand by mineral collectors. For many years now, gems cut from some of these crystals—topaz, aquamarine, and other beryls—have also been entering the trade (figure 1). The senior author (BC) visited Klein Spitzkoppe in 1975 and 1988 to study the geology of the deposit and obtain specimens, some of which were photographed and used for gemological testing. This article presents the results of this investigation, along with a discussion of the history of these famous deposits and the geology of the region.

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LOCATION AND ACCESS

Klein Spitzkoppe ("small pointed hill") is located in southern Damaraland, northeast of the coastal harbor town of Swakopmund (figure 2). This granite inselberg has an elevation of 1,580 m above sea level and forms a prominent topographic landmark above the Namib Desert (figure 3). Inselbergs (derived from the German word meaning "island mountain") are common geologic features in southern African deserts; they are steep-sided, isolated

Figure 1. Both the 23 ct aquamarine and the 43 ct "silver" topaz were faceted from material found at Klein Spitzkoppe. Courtesy of Martha Rossouw; photo © Bruce Cairncross.

hills or mountains—formed by erosion—that rise abruptly from broad, flat plains. Much of the surrounding desert surface is covered with calcrete, a conglomerate composed of sand and gravel that has been cemented and hardened by calcium carbonate. Approximately 12 km east-northeast of Klein Spitzkoppe is another granite inselberg, Gross Spitzkoppe, which rises 1,750 m above sea level; no gems have been recovered from this area. *Spitzkoppe* has been spelled several ways in the literature, such as *Spitzkopje* (Heidtke and Schneider, 1976; Leithner, 1984) and *Spitzkop* (Mathias, 1962). The spelling used here is the one used on official geologic maps of the region.

Access to Klein Spitzkoppe is relatively straightforward, and the deposits can be reached using a conventional motor vehicle. The main highway (B2) that connects the coastal town of Swakopmund with Okhandja passes south of Klein Spitzkoppe. About 110 km northeast of Swakopmund, a road leads northwest from B2 back toward the coastal village of Henties Bay. About 30 km from the B2 turn-off, this road passes a few kilometers south of the topaz and aquamarine deposits at Klein Spitzkoppe, with the granite inselberg readily visible from the road. Large portions of the diggings are on public land. However, entry to privately owned granite quarries in the area is prohibited. Collecting of specimens by local people is carried out year-round, and a visitor to the site will always be met by these diggers offering specimens for sale.

HISTORY

The Klein Spitzkoppe deposits were first described in the late 19th century German literature (Hintze, 1889). At the time, the locality was known as *Keins-Berge,* although the Dutch name, *Spitskopjes,* was already used for several steep-sided inselbergs and isolated mountains in the Damaraland region.

Figure 2. Klein Spitzkoppe is located in central Namibia, about 200 km northwest of the capital city of Windhoek.

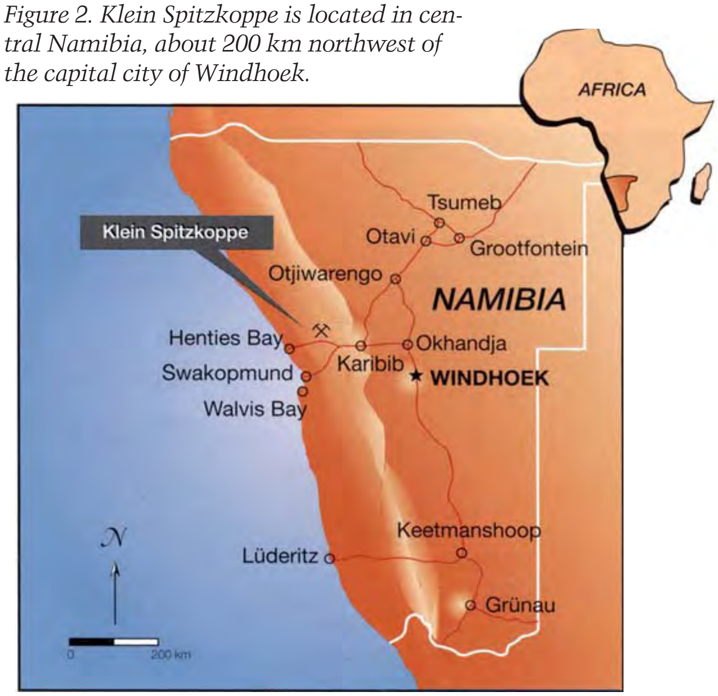

Figure 3. Klein Spitzkoppe mountain is surrounded by the arid plains of the Namib Desert. Photo by Horst Windisch.

For the initial description of the crystal morphology of the topaz from this region, Hintze used crystals that Baron von Steinäcker had originally collected at Klein Spitzkoppe. Hintze (1889) stated that the Namibian specimens were reminiscent of crystals from Russia, as they had a similar morphology and were "water clear."

Figure 4. A Damara woman digs for topaz in a highly weathered, soil-filled cavity in a gem-bearing pegmatite at Klein Spitzkoppe. Wind-blown sand and soil obscure the pegmatite. Photo by Horst Windisch.

It has been reported that 34.5 kg of facet-quality topaz was collected in Namibia, mostly from the Klein Spitzkoppe deposits, during 1930–1938 (Schneider and Seeger, 1992). More recent production figures are not available. Most topaz mining is carried out informally by local Damara diggers (figure 4), who usually sell their wares to tourists and local dealers. Aquamarine is also extracted, but it is less commonly encountered than topaz. Although no production figures are available, many hundreds of carats of aquamarine have been cut from material collected at Klein Spitzkoppe (see, e.g., figure 1). Yellow beryl is also infrequently recovered from the pegmatites, and some fine gems have been cut from this material as well.

Whereas gemstone mining is small-scale and informal at Klein Spitzkoppe, granite is quarried on a large scale. African Granite Co. (Pty) Ltd extracts a yellow granite, known colloquially as "Tropical Sun," which is exported primarily to Germany and Japan (ASSORE, 1996). Topaz crystals are frequently found during these quarrying operations and are collected by the local workers. Aquamarine is found less commonly in the quarries.

REGIONAL AND LOCAL GEOLOGY

Previous Work. The two Spitzkoppe mountains appear on a geologic map (scale 1:1,000,000) of central Namibia (then South West Africa) by Reuning (1923), which is one of the oldest geologic maps of the region. The regional geology was systematically mapped during 1928, revised in 1937, and the combined results published several years later (Frommurze et al., 1942), accompanied by a more detailed geologic map (scale 1:125,000). In their report, Frommurze et al. briefly described the topaz occurrences at Klein Spitzkoppe and provided a map of the localities where topaz had been found.

Geology. Gem-quality topaz and beryl are derived from cavities within pegmatites that intrude the Klein Spitzkoppe granite. This granite is one of several alkali granites in the area that are Late Jurassic to Early Cretaceous in age (approximately 135 million years old; Miller, 1992). Such granites comprise part of the late- to post-Karoo intrusives that occur over a wide area of Namibia (Haughton et al., 1939; Botha et al., 1979). Other, somewhat similar granites in the area contain economic deposits of tin, rare-earth elements, tungsten, copper, fluorite, tourmaline, and apatite (Miller, 1992). The Klein Spitzkoppe granite is medium- to coarse-grained, light yellow to light brown, and consists predominantly of quartz, plagioclase, and microcline, with accessory magnetite, hematite, and limonite.

Menzies (1995) classified the pegmatites at Klein Spitzkoppe as "syngenetic," because they lie within the parent granite. (Ramdohr [1940] refers to these pegmatites as "greisens.") The pegmatites seldom exceed 1 m in width and 200 m along the strike. At least two occur on the eastern and southwestern slopes of Klein Spitzkoppe (Frommurze et al., 1942; Schneider and Seeger, 1992; figure 5). One of these pegmatites was mined via an underground shaft at the so-called Hassellund's Camp (see Sinkankas, 1981, p. 5, for a photo). The pegmatites pinch and swell in thickness; where there is sufficient space, cavities may be found that are lined with euhedral crystals of quartz, microcline feldspar, fluorite, and, locally, topaz and beryl. Some vugs contain euhedral biotite. The topaz and beryl tend to be more abundant when they occur with a quartz-feldspar assemblage, rather than with biotite. Frommurze et al. (1942, p. 121) also report that the beryl crystals are well formed and "invariably very clear and transparent. The colour varies from pale-green to dark sea-green and the bluish-green of precious aquamarine. Occasionally very deep-green varieties approaching emerald, and yellowish varieties known as heliodor are found." Besides topaz and beryl, 24 other minerals have been identified in the pegmatites (table 1), of which approximately a dozen occur as collectable specimens.

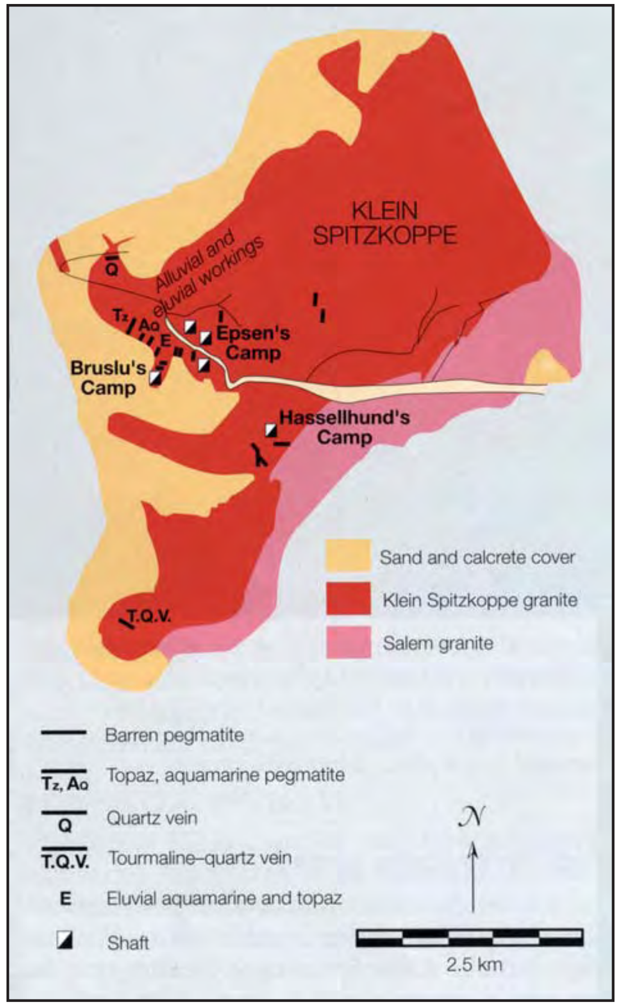

Figure 5. Topaz and aquamarine are mined from alluvial and eluvial deposits derived from miarolitic pegmatites intruding the Klein Spitzkoppe granite. Bruslu's, Epsen's and Hassellhund's camps are historical claims named after their respective discoverers. Redrawn after Frommurze et al. (1942).

MODERN QUARRYING AND MINING

Presently there is relatively little formal mining activity at Klein Spitzkoppe. One company is mining the granite for building stone. Most, if not all, of the topaz, aquamarine, and other gem or collectable minerals are extracted by local workers. They either dig randomly in the weathered granite outcrops, where it is relatively easy to pry crystals loose from their matrix, or they collect (by hand) topaz and beryl from the alluvium (again see figure 4). These alluvial crystals are usually abraded and are more suited for faceting than as mineral specimens.

Figure 6. This 3.8 cm crystal shows the remarkable transparency and complex habit typical of some topaz specimens from Klein Spitzkoppe. The crystal is attached to a feldspathic matrix. Courtesy of Desmond Sacco; photo © Bruce Cairncross.

KLEIN SPITZKOPPE TOPAZ

The worldwide occurrences of topaz were recently the subject of an in-depth publication (Menzies, 1995), but the Klein Spitzkoppe locality received only a brief mention in this article. Very little has been published on the Klein Spitzkoppe deposits, and even less has been written on the topaz per se. The notable exceptions are the few articles that have appeared in German publications, such as Leithner (1984).

Topaz has been found in several localities in Namibia (Schneider and Seeger, 1992), but the first recorded discovery of topaz there was Hintze's (1889) report on Klein Spitzkoppe. Topaz is probably the best-known gem species from Klein Spitzkoppe. Crystals over 10 cm long are well known, and Ramdohr (1940) reported on one specimen measuring 15 × 12 × 8 cm and weighing over 2 kg. Because most of the topaz is found in alluvial and eluvial deposits, matrix specimens are rare (figure 6). Loose colorless crystals 1–2 cm long are abundant; in the past, bags full of this material were collected (Bürg, 1942; "South-West Africa's gem production," 1946). Not all crystals are gem quality, as internal fractures, cleavages, and macroscopic inclusions are fairly common. However, transparent crystals have been cut into fine gems (figure 7). Typically they range from 0.5 to 5 ct, although stones up to 60 ct have been cut.

The topaz crystals are usually colorless, referred to as "silver" topaz, although pale blue (figure 8) and pale yellow (figure 9) crystals also occur (Beyer, 1980); brown topaz is not recorded from Klein Spitzkoppe. The blue and yellow colors are produced by color centers activated by radiation, either natural or artificial (Hoover, 1992). Blue usually results from electron or neutron bombardment (D. Burt, pers. comm., 1997). The less valuable yellow or brown hues can be removed by heating. They are also destroyed by prolonged exposure to sunlight, which may explain why most of the Klein Spitzkoppe topaz that is collected from exposed or weathered surfaces is colorless.

Several generations of topaz are found in the peg-

TABLE 1. Minerals from Klein Spitzkoppe.[a]

Mineral	Composition
Albite	$NaAlSi_3O_8$
Axinite	$(Ca,Mn^{+2},Fe^{+2},Mg)_3Al_2BSi_4O_{15}(OH)$
Bertrandite	$Be_4Si_2O_7(OH)_2$
Beryl	$Be_3Al_2Si_6O_{18}$
Biotite	$K(Mg,Fe^{+2})_3(Al,Fe^{+3})Si_3O_{10}(OH,F)_2$
Bixbyite	$(Mn^{+3},Fe^{+3})_2O_3$
Chabazite	$CaAl_2Si_4O_{12} \bullet 6H_2O$
Columbite	$(Fe^{+2},Mn^{+2})(Nb,Ta)_2O_6$
Euclase	$BeAlSiO_4(OH)$
Euxenite-(Y)	$(Y,Ca,Ce,U,Th)(Nb,Ta,Ti)_2O_6$
Fluorite	CaF_2
Gibbsite	$Al(OH)_3$
Goethite	$\alpha\text{-}Fe^{+3}O(OH)$
Microcline	$KAlSi_3O_8$
Molybdenite	MoS_2
Muscovite	$KAl_2(Si_3Al)O_{10}(OH,F)_2$
Phenakite	Be_2SiO_4
Pyrophyllite	$Al_2Si_4O_{10}(OH)_2$
Quartz	SiO_2
Rutile	TiO_2
Scheelite	$CaWO_4$
Schorl	$NaFe_3^{+2}Al_6(BO_3)_3Si_6O_{18}(OH)_4$
Siderite	$Fe^{+2}CO_3$
Topaz	$Al_2SiO_4(F,OH)_2$
Wolframite	$(Fe^{+2},Mn^{+2})WO_4$
Zircon	$ZrSiO_4$

[a]*After Ramdohr, 1940; Frommurze et al., 1942; and Beyer, 1980.*

Figure 7. Faceted, colorless topaz from Klein Spitzkoppe is commonly marketed as "silver" topaz.The emerald-cut stone in the left foreground is 1.4 cm long, and the stones average about 5–6 ct. Courtesy of Rob Smith; photo © Bruce Cairncross.

matite cavities, in five commonly occurring crystallographic forms (Beyer, 1980):

Type I: Simple forms; usually colorless (figure 10).
Type II: Complex habits; usually colorless, (again, see figure 6).
Type III: Complex prismatic, stubby crystals; yellow (again, see figure 9).
Type IV: Simple prismatic forms; yellow; associated with unaltered microcline.
Type V: Long, thin prismatic crystals; yellow.

Types I and III are always transparent with highly lustrous crystal faces. These occur in vugs with microcline, and occasionally with black tourmaline (schorl). Type V is the last form to crystallize, and it is always associated with needle-like crystals of aquamarine and highly corroded microcline. Types I and II are associated with large quartz crystals, biotite, light green fluorite, tourmaline, and rutile.

Outstanding specimens of gem-quality, euhedral topaz crystals perched on, or partially overgrown by, highly lustrous smoky quartz are among the most sought-after collector pieces. Also desirable are matrix specimens consisting of topaz on white or pale yellow feldspar (again, see figure 6). In rare instances, topaz and green fluorite are found together. The value of mineral specimens is well recognized by the local diggers, as is evident from the availability of some fake specimens of topaz fashioned from locally mined pale green fluorite. The crystallographic configuration of the topaz is easily recognized and very well copied by the local diggers. (Fake specimens of aquamarine are also known from Klein Spitzkoppe—see figure 12 in Dunn et al., 1981.) Detailed crystallographic descriptions of Spitzkoppe topaz are published elsewhere (Hintze, 1889; Ramdohr, 1940; Beyer, 1980).

KLEIN SPITZKOPPE BERYL

Beryl (figure 11) is found in miarolitic cavities in pegmatites associated with microcline, smoky quartz, topaz, bertrandite, phenakite, and fluorite (De Kock, 1935; Frommurze et al., 1942; Schneider and Seeger, 1992). Aquamarine forms elongate hexagonal prisms with flat or bipyramidal terminations; the semitransparent crystals commonly

Figure 8. This pale blue topaz, 2.8 cm long, displays unusual, multiple terminations. Photo © Bruce Cairncross.

Figure 9. The topaz at Klein Spitzkoppe may be pale yellow as well as pale blue or colorless. This 1.4 cm high yellow topaz crystal has a complex termination. Photo © Bruce Cairncross.

attain sizes up to 6 cm long and 1 cm in diameter (Leithner, 1984). The largest documented aquamarine from Klein Spitzkoppe measured 12 cm long and 5 cm in diameter (Ramdohr, 1940). Faceted aquamarine over 20 ct is common (again, see figure 1).

Figure 10. Most of the topaz specimens are broken off their host rock, as it is extremely difficult to remove specimens from the vugs intact. The crystal on the right is 5 cm. Photo © Bruce Cairncross.

Other varieties of gem beryl include hexagonal, prism-etched, transparent-to-translucent green and yellow varieties up to 6 cm long (Heidtke and Schneider, 1976). One crystal described by Beyer (1980, p. 16) measured 2 cm, and was colorless with a "rose" pink ("rosaroten") core! Yellow beryl (heliodor) is usually associated with fluorite and finely crystalline mica, or is intergrown with orthoclase (Heidtke and Schneider, 1976; Strunz, 1980; Schneider and Seeger, 1992). Heliodor was originally described from a pegmatite situated close to Rössing, located about 70 km northeast of Swakopmund (Kaiser, 1912), and it was described further by Hauser and Herzfeld (1914). Klein Spitzkoppe heliodor ranges from deep "golden" yellow to light yellow to yellow-green (figures 12 and 13). Crystals up to 12 cm long and 5 cm in diameter, some of which are transparent, have been recovered. Some heliodor crystals display naturally etched crystal faces, the most common feature being hook-shaped patterns on the *c* faces (Leithner, 1984).

MATERIALS AND METHODS

Gemological properties were obtained on five topaz (figure 14) and four aquamarine (figures 11 and 15) crystals from Klein Spitzkoppe. All of the topaz crystals and two of the aquamarines were obtained by two of the authors (IC and BC) from reliable dealers; the other two aquamarine crystals were loaned by Bill Larson of Pala International, Fallbrook, California. Although we were able to obtain cut stones for photography, we were not able to keep them long enough to perform gemological testing.

Refractive indices were determined using a Rayner Dialdex refractometer with a sodium light source. We obtained good readings from crystal faces and spot readings from cleavage surfaces on the crystals that did not have original crystal faces. One of us (IC) has performed R.I. measurements on gem rough for decades using this method, with reliable results. Luminescence tests were done in complete darkness, using a Raytech LS-7 long- and short-wave UV source. We determined specific gravity by the hydrostatic method. Distilled water softened with detergent was used to reduce surface tension.

Absorption spectra were observed with a calibrated Beck desk-model type spectroscope. We used an SAS2000 spectrophotometer with a dual-channel dedicated system, PC based, with a fiber-optic coupling in the visible to near-infrared range (380–850 nm), to obtain transmitted-light spectra.

Pleochroism was observed using a Rayner (calcite) dichroscope with a rotating eyepiece, in conjunction with fiber optics and a Mitchell stand with a rotating platform. Optic character was observed with a Rayner polariscope. The Chelsea filter reaction was determined in conjunction with a variable-power 150 watt fiber-optic tungsten light. All of the crystals were examined with a Wild Heerbrugg gemological binocular microscope under 10×, 24×, and 60× magnification.

The two aquamarine crystals loaned by Bill Larson were examined by Brendan Laurs at GIA in Carlsbad, California, with the following methods. Refractive indices were measured on a GIA Gem Instruments Duplex II refractometer, using a monochromatic sodium-equivalent light source. Pleochroism was observed with a calcite-type dichroscope. Fluorescence to short- and long-wave UV radiation was tested with a GIA Gem Instruments 5 watt UV source, in conjunction with a viewing cabinet, in a darkened room. Internal characteristics were examined with a standard gemological microscope, a Leica Stereozoom with 10×–60× magnification. Absorption spectra were observed with a Beck spectroscope.

RESULTS

Topaz. *Visual Appearance.* The topaz crystals (5.2 to 28.5 ct) were all colorless, except for one extremely light blue specimen. Light brown iron-oxide minerals (e.g., limonite) caused a brown discoloration to some of the crystal faces. All of the crystals were somewhat stubby, displaying short, prismatic forms with wedge-shaped terminations.

Microscopic Examination. One crystal contained partially healed fractures, as irregular planes ("fingerprints") of fluid and two-phase (fluid-gas) inclusions. We also observed isolated two-phase (fluid-gas) inclusions (figure 16). Acicular greenish blue crystals of tourmaline (identified optically) were seen slightly below the crystal faces in two of the specimens; some of these penetrated the surface of the host crystal (figure 17).

Gemological Properties. The results of the gemological testing are summarized in table 2. The R.I. values of the topaz were 1.610 and 1.620, although one specimen had a slightly lower maximum value of 1.616; birefringence was constant (0.010) for the other four samples. All the specimens appeared yellow-green through the Chelsea filter and were also inert to short- and long-wave UV. The specific gravity for all samples was 3.56. No spectral characteristics could be resolved with a desk-model spectroscope. All samples showed similar transmittance spectra with the spectrophotometer (figure 18): A steady increase in transmittance occurs from approximately 380 nm, at the violet end of the spectrum, to 600 nm, with a more gradual increase from 600 to 850 nm. There were no unusual features in the spectra that could be used to identify material as coming from this locality.

Figure 11. These aquamarine crystals, part of the test sample for this study, show the typical color and crystal form of specimens from Klein Spitzkoppe. The standing crystal measures 1.0 × 4.8 cm. Courtesy of William Larson; photo © Harold & Erica Van Pelt.

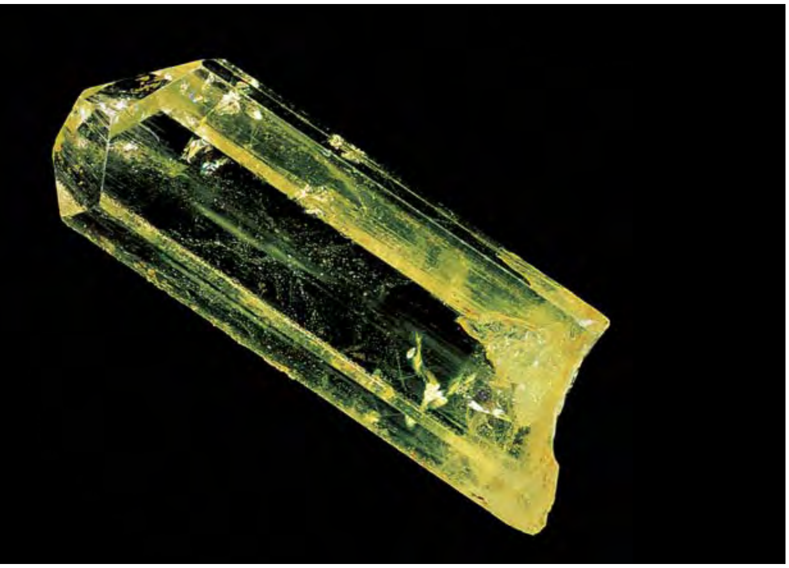

Figure 12. In addition to aquamarine, the deposit also produces fine crystals of yellow beryl, like this 3.4 cm specimen. Johannesburg Geological Museum specimen no. 65/116; photo © Bruce Cairncross.

Aquamarine. *Visual Appearance.* The samples studied were light greenish blue prismatic crystals of faceting quality. The two crystals studied by the authors (figure 15) weighed 5.5 ct and 8.6 ct, with smooth, shiny prism faces and etched terminations. The crystals studied at GIA weighed 90.3 and 158.9 ct, and were color zoned—light greenish blue with near-colorless terminations. Most of the prism faces were striated parallel to the c-axis, and the terminations were sharp and unetched.

Figure 13. Large stones have been faceted from the yellow beryl. The largest, a Portuguese-cut specimen at the top, weighs 42 ct. Courtesy of Desmond Sacco; photo © Bruce Cairncross.

Microscopic Examination. "Fingerprints" consisting of irregular planes of fluid and fluid-gas inclusions were the most common internal feature. Fractures were also common, and were iron-stained where they reached the surface. Hollow or fluid-and-gas-filled growth tubes were noted in the crystals examined at GIA; these tubes were oriented parallel to the c-axis. Large (up to 3 mm), angular cavities were also noted in these crystals. Both the growth tubes and the cavities locally contained colorless daughter minerals.

One specimen examined by the authors had brightly reflecting pinpoint inclusions of an unidentified material; these could be fluid inclusions. At 60↔ magnification, we saw radial stress fractures surrounding the inclusions. We saw similar pinpoint inclusions, but without the fractures, in another crystal. A feather-like, partially healed fluid inclusion extended from the base of this crystal to halfway up its length.

Gemological Properties. The R.I. values were 1.561–1.562 (n_ε) and 1.569–1.570 (n_ω), and the birefringence was 0.007–0.009. Dichroism was strong, colorless to greenish blue. The specific gravity was 2.68–2.69. All of the aquamarine samples appeared yellow-green through the Chelsea filter, and all were also inert to both short- and long-wave UV radiation. No spectral characteristics were resolved by the authors using the desk-model type spectroscope; at GIA, a faint line was seen at 430 nm in

Figure 14. The test sample included these five topaz crystals, which weigh, clockwise from top left: 13.7 ct, 5.2 ct, 28.5 ct, 15.4 ct, and 6.6 ct. The largest crystal (top right) is 21 mm along its longest axis. Photo © Bruce Cairncross.

both samples. The spectrophotometer results were identical for the authors' two specimens (figure 19): a small minimum at 425 nm, with a transmittance maximum at about 500 nm, and generally decreasing transmittance at higher wavelengths.

DISCUSSION

Topaz. The gemological results obtained from the Klein Spitzkoppe topaz are interesting for several reasons. The R.I. values (1.610 and 1.620) are relatively low compared to pegmatitic topaz from other localities (typically 1.614 to 1.635; Hoover, 1992). These R.I. values are similar to those of topaz from rhyolitic deposits, such as at the Thomas Range (Utah) and at San Luis Potosí, Mexico (Hoover, 1992); however, no rhyolites occur at Klein Spitzkoppe. The R.I. values of the Klein Spitzkoppe topaz are significantly lower than those for topaz from hydrothermal deposits, such as Ouro Preto, Brazil (1.630–1.638; Sauer et al., 1996), and Katlang, Pakistan (1.629–1.643; Gübelin et al., 1986). The variation in R.I. is caused by substitution of the hydroxyl (OH) component by fluorine in the topaz [$Al_2SiO_4(F,OH)_2$] structure (Ribbe and Rosenberg, 1971). The Klein Spitzkoppe topaz is fluorine rich with nearly the maximum amount possible (about 20.3 wt.% F), similar to rhyolite-hosted topaz from the Thomas Range (Ribbe and Rosenberg (1971; as reproduced in Webster and Read, 1994).

Hoover (1992) and Webster and Read (1994) both state that the birefringence for colorless (and blue) topaz is 0.010, which is identical to the birefringence determined for the Klein Spitzkoppe material. The birefringence of hydrothermal topaz from Ouro Preto is somewhat lower, 0.008 (Keller, 1983), which is in agreement with similar values quoted for brown and pink topaz (Hoover, 1992). It is interesting to note that the pink topaz from Pakistan also has a birefringence of 0.010 (Gübelin et al., 1986).

The 3.56 S.G. for Klein Spitzkoppe topaz is identical to the value obtained for colorless and light blue topaz from localities in Russia, Germany, and the United States (Webster and Read, 1994). This is somewhat higher than the S.G. values (3.51–3.54) for pink and orange topaz from Pakistan (Gübelin et al., 1986) and Ouro Preto (Sauer et al., 1996). Like R.I., the S.G. values of topaz also vary with fluorine content; that is, they rise with increasing fluorine (Ribbe and Rosenberg, 1971). This relatively high

Figure 15. These two aquamarine crystals were also characterized for this study. The longest crystal is 22 mm. Photo © Bruce Cairncross.

Figure 16. Fluid and two-phase (fluid and gas) inclusions such as these were seen in a topaz from Klein Spitzkoppe. Photo © Bruce Cairncross; magnified 24×.

Figure 17. Dark greenish blue tourmaline crystals, up to 0.8 mm long, form conspicuous inclusions near the surface of a topaz crystal from Klein Spitzkoppe. Photo © Bruce Cairncross.

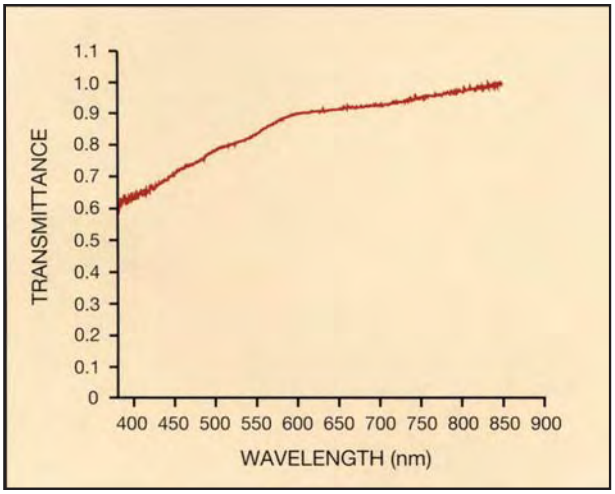

Figure 18. This transmittance spectrum is typical of the spectra recorded on the topaz specimens from Klein Spitzkoppe. A gradual increase in transmittance is seen over the entire range measured.

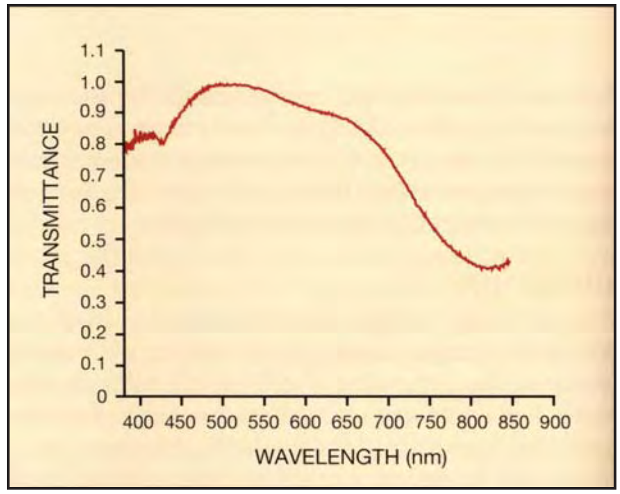

Figure 19. This transmittance spectrum is typical of the aquamarines examined from Klein Spitzkoppe, and shows a small minimum at 425 nm, a transmittance maximum at about 500 nm, and generally decreasing transmittance at higher wavelengths.

S.G. of Klein Spitzkoppe topaz is consistent with its low R.I. values and high inferred fluorine content.

The Klein Spitzkoppe topaz samples we examined had few inclusions compared to topaz from other localities. Some exceptions are the specimen illustrated in figure 16, which contains well-developed fluid and fluid-and-gas inclusions, and the one shown in figure 17, which encloses small, greenish blue tourmaline needles. However, there are no inclusions, fluid or solid, that could be used to distinguish Klein Spitzkoppe topaz crystals from those of other deposits.

TABLE 2. Summary of the gemological properties of topaz and beryl (aquamarine) from Klein Spitzkoppe, Namibia.

Property	Topaz	Aquamarine
Color	Colorless ("silver") to very light blue	Light greenish blue
Refractive indices		
Lower	n_α=1.610	n_ε=1.561–1.562
Upper	n_γ=1.620[a]	n_ω=1.569–1.570
Birefringence	0.010[a]	0.007–0.009
Optic character	Biaxial (+)	Uniaxial (–)
Luminescence (SW and LW UV)	Inert	Inert
Specific gravity	3.56	2.68–2.69
Dichroism	None	Pale blue to colorless
Chelsea filter	Yellow-green	Yellow-green
Absorption spectrum	No features noted with the spectroscope; increasing transmittance from 380–850 nm noted with the spectrophotometer	Faint line at 430 nm, or no features noted with the spectroscope; small minimum at 425 nm, and maximum at 500 nm, with the spectrophotometer
Inclusions	"Fingerprints," two-phase inclusions, tourmaline crystals	"Fingerprints," fractures, growth tubes, two- and three-phase inclusions

[a] *For one topaz specimen, R.I. values were 1.610–1.616 (birefringence 0.006), which is slightly outside the range reported here.*

We do not know of any published data on the effects of irradiation or heat treatment on Klein Spitzkoppe topaz.

Beryl. For the most part, the results obtained from the aquamarines tested were typical for the species. The R.I. values (n_ε=1.561–1.562, n_ω=1.569–1.570) are low compared to typical values (n_ε=1.567–1.583, n_ω=1.572–1.590; Webster and Read, 1994), but low R.I. values are characteristic of beryl that contains little or no alkali impurities (Černý and Hawthorne, 1976). The birefringence (0.007–0.009) is relatively high for aquamarines with low R.I. values (typically 0.005; Webster and Read, 1994). However, the S.G. (2.68–2.69) is typical for aquamarines with low concentrations of alkalis (Webster and Read, 1994). The growth tubes and fluid inclusions also are typical of beryl from other pegmatitic deposits (see, e.g., Lahti and Kinnunen, 1993).

Webster and Read (1994) reported that some of the yellow beryls from Klein Spitzkoppe show radioactivity due to the presence of uranium oxide. To check this, we tested three crystals of yellow beryl using an Eberline ion chamber, but no radioactivity was detected.

FUTURE POTENTIAL

Topaz and, to a lesser degree, aquamarine have been found at Klein Spitzkoppe for more than 100 years. Local diggers collect most of the gems from weathered miarolitic pegmatites and alluvium. The quarrying of granite for building stone also yields some specimens and gems. The supply of gem-quality material, as well as specimen-grade crystals, will most likely continue for some time.

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