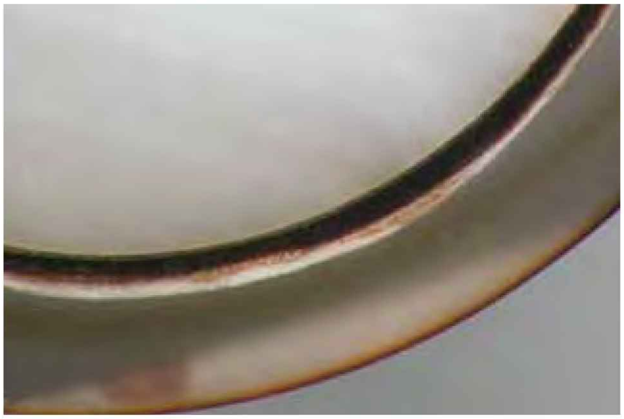


Figure 37. In this cross-section of one of the "chocolate pearls" (middle sample in figure 36), the white bead and a thin ~0.05 mm surface layer of brown coloration is clearly visible, while the nacre underlying the dark surface is lighter and predominantly gray. Photo by H. A. Hänni, © SSEF.

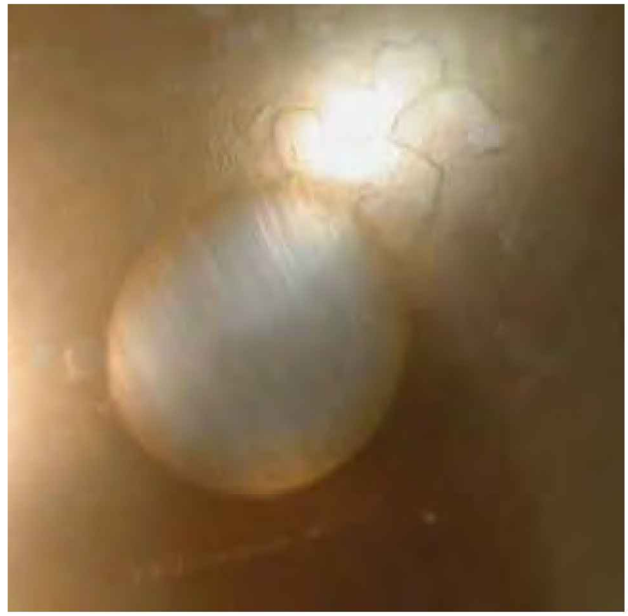
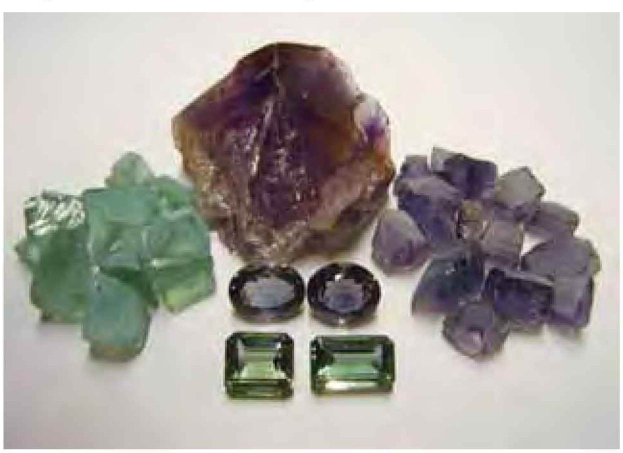


Figure 38. Polishing a small flat area (1.6 mm in diameter) on one of the "chocolate pearls" revealed the shallow depth of the surface-related color concentration. Photomicrograph by H. A. Hänni, © SSEF.

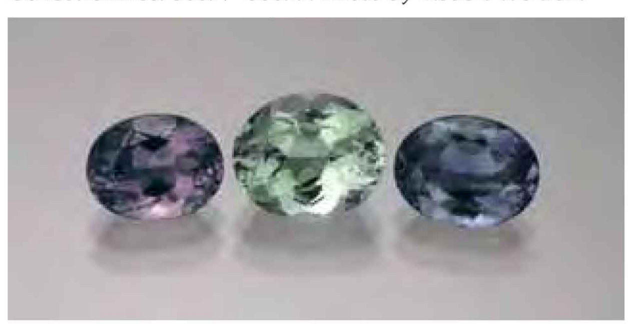
Treated violetish blue to violet quartz from Brazil. Blue quartz is quite rare, and the color of almost all such reported natural material is produced by mineral inclusions (see, e.g., K. Schmetzer, "Methods for the distinction of natural and synthetic citrine and prasiolite," *Journal of Gemmology*, Vol. 21, 1989, pp. 368–391). Such quartz has an orange tint when viewed in transmitted light, due to scattering by the minute particles. Thus far, the only blue quartz not colored by inclusions has been synthetic material that is colored by cobalt or heat-treated and iron-bearing (K. Nassau and B. E. Prescott, "Smoky, blue, greenish-yellow, and other irradiation-related colors in quartz," *Mineralogical Magazine*, Vol. 41, 1977, pp. 301–312).

Figure 39. The Montezuma area in Minas Gerais, Brazil, is once again being mined for amethyst (such as the 4 cm crystal pictured here). This material can be turned green by heat treatment and violetish blue to violet by subsequent irradiation. The cut stones weigh about 3–4 ct. Photo by R. S. Güttler.



A new variety of violetish blue to violet quartz (figures 39 and 40) has recently been produced through the heating and gamma irradiation of amethyst from a mine near Montezuma, in the Rio Pardo region in northern Minas Gerais. This deposit, often called the Montezuma mine, initially became famous during the 1960s for amethyst that could be turned green by heating, known today as "prasiolite" or "greened amethyst" in the trade (J. P. Cassedanne and J. O. Cassedanne, "Axinite, hydromagnesite, amethyst, and other minerals from near Vitória da Conquista (Brazil)," *Mineralogical Record*, Vol. 8, 1977, pp. 382–387; Summer 2004 Lab Notes, p. 167). One of the

Figure 40. These samples show the coloration of the Montezuma mine quartz as untreated amethyst (left, 2.40 ct), heated green quartz (center, 3.54 ct), and heated and irradiated violet quartz (right, 2.37 ct). Gift of Henrique Fernandes and Gabriel Freitas, Pinkstone International, Governador Valadares, Brazil; GIA Collection nos. 36697–36699. Photo by Robert Weldon.



veins at this deposit is now being mined again, yielding about 500 kg/month of amethyst, of which about 1–2% is gem quality.

It is well known that heat may reduce the oxidation state of iron in amethyst, and at about 300–500°C the purple color will change to colorless or yellow or green (see, e.g., E. Neumann and K. Schmetzer, "Mechanism of thermal conversion of colour and colour centres by heat treatment of amethyst," *Neues Jahrbuch für Mineralogie Monatshefte*, Vol. 6, 1984, pp. 272–282). The resulting green quartz is quite stable to heat, unlike the pale green quartz that has been produced with gamma irradiation (but no heat treatment) from colorless to very slightly green quartz from Rio Grande do Sul State. This latter quartz loses much of its green color when heated to about 150–200°C or exposed to strong sunlight. The two types of treated green quartz may be distinguished by their different responses to the Chelsea filter (see H. Kitawaki, "Green quartz," www.gaaj-zenhokyo.co.jp/index-e.html) or the Aquamarine filter (Göttinger Farbfilter, Germany). Viewed with each of these filters using incandescent light, the heated variety (derived from amethyst) appears green due to absorption in the red part of the spectrum at about 750 nm (produced by Fe^{2+}), whereas the irradiated material (derived from colorless quartz) appears red due to an as-yet-unexplained weak absorption peak at about 620 nm and efficient transmission in the red spectral region.

Gamma irradiation experiments were undertaken by one of us (HCK) to improve the green color of heated (350–450°C) Montezuma amethyst at Embrarad Ltda., a commercial irradiation facility near São Paulo. The irradiation unexpectedly produced a range of colors from violet to violetish blue to deep blue. According to the Color Atlas 5510 (Mitsumara Suiko, Shoin, Japan, 1986), the colors ranged from 4.25PB2/10 to 8.75PB4/3 (deep blue to deep purplish blue). The optical properties were typical for quartz, but with strong violetish blue and reddish orange pleochroic colors when viewed with a dichroscope perpendicular to the c-axis. Although the coloration appears to be distributed evenly in cut material, detailed microscopic examination showed color concentrations along zones parallel to the rhombohedral sectors. Preliminary experiments by HCK have shown that the stability of the coloration is comparable to that of amethyst when exposed to strong UV radiation or moderate heating (400–500°C).

The color-producing mechanism has not yet been investigated, but it may involve a charge transfer between traces of Fe^{2+} and Fe^{3+} in interstitial sites of the quartz structure (G. Lehmann, "Farben von Mineralien und ihre Ursachen" *Fortschritte der Mineralogie*, Vol. 56, No. 2, 1978, pp. 172–252), which produces absorption in the red end of the spectrum and enhances transmission in the blue-to-violet range.

About 100 kg of rough gem-quality green quartz have been stockpiled. At the time of this report, only a small amount had been irradiated to violetish blue. Research is currently being undertaken to improve the process for producing the blue color, and initial contacts are being made with gem suppliers to develop the market for this unique treated gem.

Rainer Schultz Güttler (rainersg@usp.br)
University of São Paulo, Brazil

Hisahiro Claudio Kohigashi
São Paulo, Brazil

Circular ring-like inclusions in a diffusion-treated sapphire. The Gem Testing Laboratory, Jaipur, India, recently examined an interesting 6.64 ct blue oval mixed cut. The refractive indices of 1.762–1.770, birefringence of 0.008, and hydrostatic specific gravity of 3.98 identified the sample as a natural or synthetic corundum. It was inert to UV radiation (both long- and short-wave) and displayed a weak iron-related band at 450 nm in the desk-model spectroscope.

When viewed face-up, the sample showed uneven coloration (figure 41). The cause of this became evident when it was immersed in methylene iodide: The areas of patchy coloration followed the facet outlines, and the facets around the culet appeared colorless or pale colored (figure 42). This confirmed the material as diffusion treated; the colorless areas likely resulted from repolishing after treatment.

Microscopic examination revealed straight, hexagonal zones that were slightly cloudy and whitish (figure 43, left), which were indicative of natural origin. In addition, the stone contained some irregular cloudy patches. At higher magnification, these milky zones were seen to consist of fine pinpoint inclusions (figure 43, right), as are commonly encountered in heat-treated natural corundum.

The stone displayed an interesting feature when viewed with magnification and illuminated with a fiber-optic light:

Figure 41. This 6.64 ct blue sapphire showing uneven patchy coloration owes its color to diffusion treatment. Photo by G. Choudhary.