# SAPPHIRE FROM THE MERCADERES–RÍO MAYO AREA, CAUCA, COLOMBIA

By Peter C. Keller, John I. Koivula, and Gonzalo Jara

*Commercially important quantities of gem-quality sapphire are being recovered from stream beds and terrace gravels near the Colombian village of Mercaderes, about 143 km southwest of Popayán. The area is currently subject to a high degree of political unrest; nevertheless, about 100 people are said to be sporadically mining the deposit. Sapphire crystals average about one centimeter in length and occur in a variety of colors. Color-change stones are also common. Three inclusions were found to be characteristic: apatite, rutile, and boehmite. The parent rock for the sapphires has not been established, but it is probably one or more of the alkalic basalt members of the Cretaceous-age Diabase Group which outcrops in the area.*

*ABOUT THE AUTHORS*

*Dr. Keller is a research associate with the Mineralogy Section and project manager of the new "Gemstones and Their Origins" gallery at the Los Angeles County Museum of Natural History, Los Angeles, California; Mr. Koivula is senior gemologist in the Applied Gemology Department at the Gemological Institute of America, Santa Monica, California; and Mr. Jara is purchasing advisor and consultant for Kawai (a major emerald firm) in Bogotá, Colombia.*

*Acknowledgments: Our thanks to the people who made this study possible: Bill Kerr faceted the first sapphire used in the research; Harold and Erica Van Pelt provided the rough and cut photograph; the Garzon family of Popayán, Colombia, supplied study material and first-hand knowledge; and George Rossman provided chemical data. John I. Koivula took the photos in figures 4–8.*



Over the last several years, small amounts of gem-quality sapphire, said to originate in Colombia, have occasionally surfaced in the gem trade. Until now, however, little information has been available on their exact source or mode of occurrence and there have not been enough stones available to undertake a meaningful study of the material. Codazzi (1927) noted pale gem-quality sapphire and ruby from the sands of the Río Mayo, which forms part of the border between the departments of Nariño and Cauca. The Río Mayo is the southern limit of the area presently being exploited. The first mention of these sapphires in the gemological literature was a report on a color-change specimen by Bank et al. (1978). Schmetzer et al. (1980) also include a Colombian color-change sapphire in a table of data on color-change sapphires from various localities worldwide.

During a recent visit to the colonial town of Popayán, capital of the Department of Cauca, two of the authors visited a small cutting shop where they examined several hundred carats of rough sapphire and 43 faceted stones averaging about 2 ct each. From this parcel a sample of 16 rough sapphires and two faceted stones were obtained for study. One of the rough crystals was exceptionally sharp; the two faceted stones weighed a total of 4.03 ct (figure 1).

It was hoped that this article would be a comprehensive report on the occurrence as well as the properties of the Colombian sapphires. Since our visit to Popayán in September 1984, however, a great deal of political unrest has erupted in the area, precluding a planned visit to the mine site itself and, consequently, a detailed report on the geology, occurrence, and mining of these Colombian sapphires. Until the authors can gain access to the locality, the purpose of this article is to provide preliminary data regarding the location of, and access to, the sapphire deposit, to discuss the occurrence of the sapphire based on what is known of the local geology, and, finally, to describe in

*Figure 1. This rough sapphire crystal and the two faceted sapphires are all from the Mercaderes–Río Mayo area of Cauca, Colombia. The total weight of the two faceted stones is 4.03 ct. Photo © Harold and Erica Van Pelt.*

detail the gemological characteristics of these Colombian sapphires.

## LOCATION AND OCCURRENCE

The deposit is located on the border of the departments of Cauca and Nariño, near the village of Mercaderes, approximately 143 km southwest of Popayán (figure 2). From Popayán, access to the town of Mercaderes is gained by taking the Popayán to Pasto highway south through the Río Patia valley for approximately 129 km. Near this point, a small road forks SSE some 14 km to Mercaderes. Sapphires are currently being recovered from stream beds and terraces of small tributaries to the Río Patia, a major river whose headwaters are about 25 km west-southwest of Popayán. Most mining activity is in an approximately 50-km$^2$ area to the south and west of Mercaderes. Mining has been taking place for about six years, with never more than about 100 people working the deposit at one time. Current production is said to be about 10,000 ct of sapphire per year (S. Garzon, pers. comm., 1984). Most of the faceting is done in Popayán and Bogotá.

The original (in situ) source of the Colombian sapphires has yet to be determined, but the geology around Mercaderes suggests that these may be similar to occurrences in basalt recorded from other countries. Many major sapphire deposits around the world originated in alkalic basalts, including the deposits in Cambodia (Jobbins et al., 1981), Thailand (Keller, 1982), and Australia (Thompson, 1982). In most of these deposits, accessory minerals include black spinel, ilmenite, zircon, olivine, pyrope garnet, and augite. All of these, with the exception of zircon, have been identified by the authors in gem concentrate from the Mercaderes workings. It is, therefore, reasonable to assume that the ultimate source for the Colombian sapphires is an alkalic basalt. According to Marin and Paris (1979), who extensively mapped and studied the geology of the Department of Cauca, the only alkalic basalts in the region belong to the Diabase Group of Cretaceous age. Their geologic map shows some outcrops of this unit in the Río Patia area. Until further field work can be undertaken, it can only be speculated that the original source for the Colombian sapphires is a basalt of this group.

## DESCRIPTION

**Visual Appearance.** The crystals examined for this study are simple hexagonal prisms, typically tabular to elongate, exhibiting well-developed parting parallel to (0001). Pyramidal and bipyramidal forms are rare. The crystals are commonly rounded as a result of extensive stream wear. A few very sharp crystals were observed, however; apparently these were collected close to their source. The crystals range in size from under 1 mm to over 3 cm, with 1-cm pieces being most common. The largest faceted sapphire reported to date is an almost flawless 16-ct light blue stone. The color range of the Colombian sapphires is reminiscent of material from the Umba Valley in Tanzania. Blue stones and green stones with a brownish cast are most common, but yellows, pinks, and even reds were observed in lesser quantities. Very typically, the sapphires are color-zoned with a brownish yellow core that is the result of their unusually high iron content, which will be discussed later in this article. Some asteriated material has been ob-

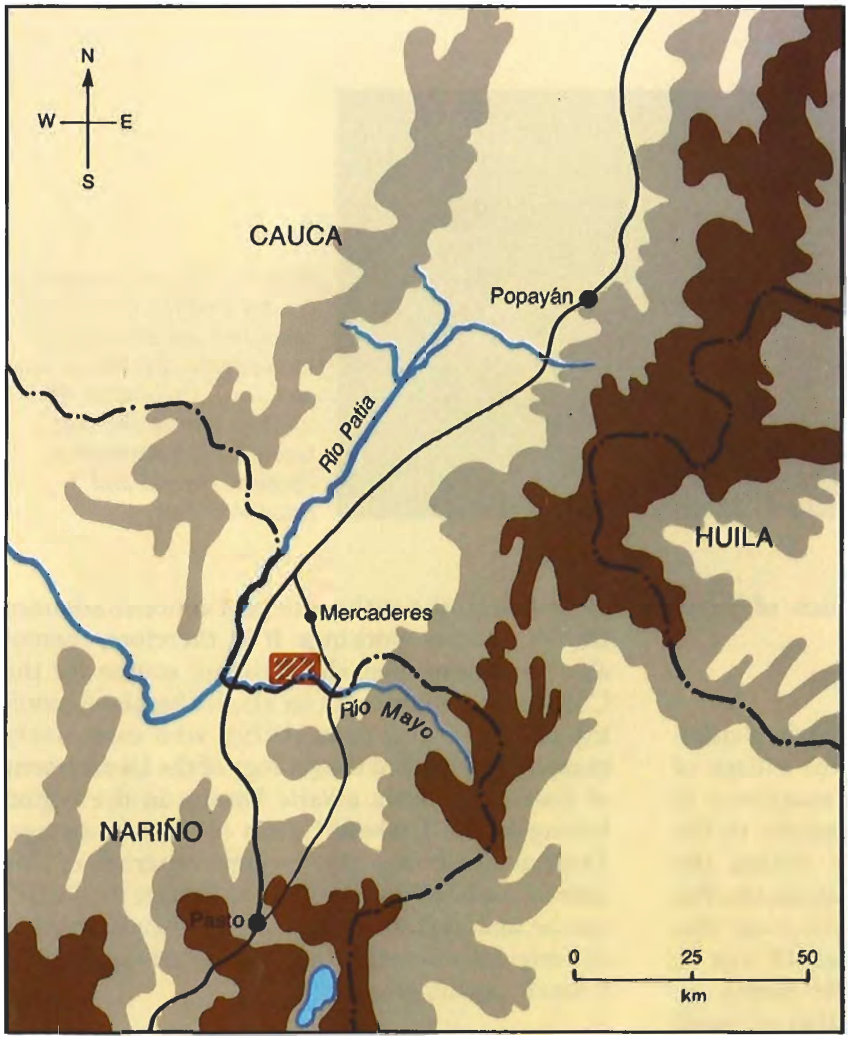



*Figure 2. Location map for the Mercaderes–Río Mayo sapphire deposit in Cauca, Colombia. Sapphires have been found throughout the general area shaded in red, on both sides of the Río Mayo. Artwork by Lisa Joko.*

served. Although the blue stones are usually somewhat paler than their counterparts from Thailand, Cambodia, and Australia, some very attractive stones have been faceted from this pastel material (figure 3).

The most interesting feature of the Colombian sapphires is the relative abundance of color-change stones, from bluish purple in daylight to violetish red in incandescent light. One such stone was described by Bank et al. (1978). Preliminary chemical (XRF) analysis by George Rossman of the California Institute of Technology on three of the stones (two color-change faceted stones and one blue crystal, the same shown in figure 1) revealed $Cr_2O_3$ contents of 0.02 to 0.05 (table 1), with stones containing the greater amount having the greater color change. This supports the contention of Schmetzer et al. (1980) that the intensity of the color change depends on the concentration of the chromium present. Table 1 also shows that the

*Figure 3. A 1.48-ct blue sapphire from the Mercaderes–Río Mayo deposit. Photo © 1985 Tino Hammid.*

*Figure 4. A sample of the 16 rough sapphire crystals examined in this study. Note the rounding, which suggests extensive alluvial wear, in most of the stones.*

sapphires are very poor in titanium content and exceedingly rich in iron. No vanadium was found. Heat treatment experiments were also undertaken by George Rossman on a number of pale blue stones. As would be expected from a titanium-poor sapphire, the heat treatment resulted in the oxidation of the iron to produce a golden color (Keller, 1982) rather than a deeper blue.

All of the 16 sapphire crystals, some of which are shown in figure 4, were tested using standard gemological techniques. The results are described below.

**Refractive Index.** Three of the crystals were tested for refractive index using a sodium vapor monochromatic light source and a GIA GEM Instruments Duplex II refractometer. All three subjects gave refractive indices of 1.762–1.770 with a birefringence of 0.008 and a uniaxial negative optic character.

**Specific Gravity.** A Voland double-pan balance, modified for hydrostatic specific-gravity determinations, was used to determine a range of 3.99 to 4.02 in the 16 crystals. The crystal with the greatest number of rutile inclusions gave the highest value.

**TABLE 1.** Minor-element analytical data (in wt.%) for three Colombian sapphires.[a]

| Element | Color change no. 1 | Color change no. 2 | Blue crystal |
|---|---|---|---|
| $TiO_2$ | 0.04 | 0.003 | — |
| $Cr_2O_3$ | 0.05 | 0.02 | — |
| $Fe_2O_3$ | 0.77 | 0.22 | 0.36 |

[a]*The XRF analyses reported here represent bulk analyses of the entire sample; the error factor is ±20% of the figure reported.*

**Ultraviolet Fluorescence.** All of the crystals were inert to short-wave ultraviolet radiation, but they varied in their reactions to the long-wave lamp. Seven of the crystals (all of which showed a color change) exhibited orange to red, weak to moderate, long-wave fluorescence; four (grayish to brownish green) stones were almost inert; five distinctly color-zoned crystals showed small, irregular orange fluorescent patches.

**Spectroscopic Examination.** Using a GIA GEM Instruments spectroscope unit, we determined that all of the specimens except one showed a medium to strong absorption line at 457 nm. The one exception was a muddy green crystal, with blue, gray, and brown overtones, of moderate color intensity that showed an absorption band from 455 to 468 nm. Several of the crystals also showed weak absorption lines at 475 and 481 nm. Those crystals with a distinct bluish to purplish red-orange color that displayed a color change from fluorescent (day) light to incandescent light also had an absorption band of moderate strength situated from 540 to 590 nm and absorption lines in the deep red at 680 and 690 nm, attributable to chromium as per the chemical analyses (table 1). These spectra overlap with those observed in sapphires from other localities, and so are not distinctive of Colombia.

**Microscopic Observation.** The 16 sapphires were examined carefully under magnification using a

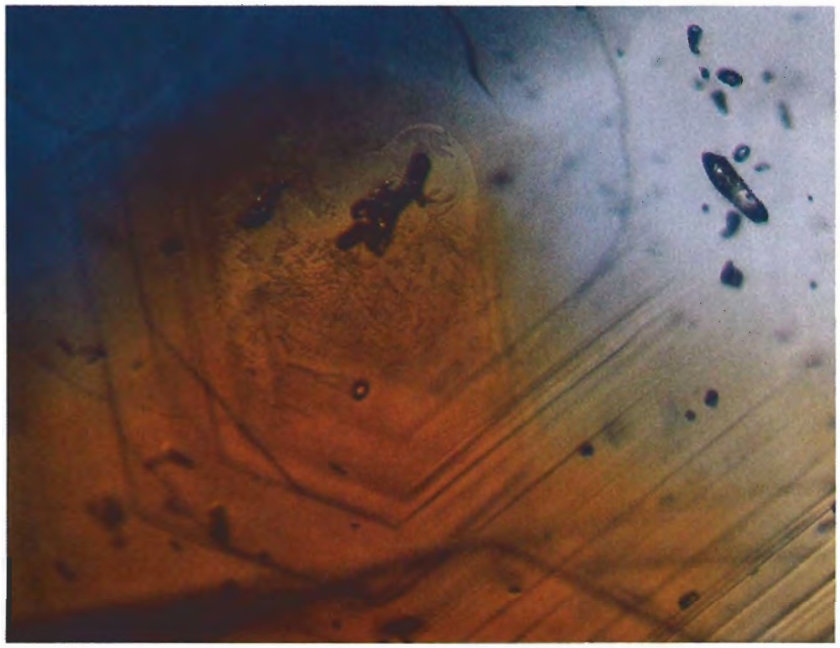

*Figure 5. Hexagonal color and growth zoning is observed parallel to the c-axis of this crystal. The orange color is the result of heat-treatment experiments. The small, rounded, crystals are believed to be apatite. Shadowing, magnified 40×.*

gemological stereo microscope. Several notable internal features were observed.

*Color Zoning.* All 16 sapphires showed some color zoning that ranged in intensity from very weak to strong. Commonly, the color zones were oriented perpendicular to the c-axis, parallel to the pinacoid. However, the most prominent color zoning was displayed by two pale bluish purple crystals with bright orange cores of hexagonal to trigonal cross sections that ran parallel to *c*. One of these color-zoned crystals is shown in figure 5.

*Growth Zoning.* One of the two crystals that had a strong orange-colored core showed prominent hexagonal growth zoning as well. This growth zoning is also evident in the stone shown in figure 5.

*Twinning.* Some traces of lamellar twinning were present in six of the crystals. The most prominent evidence of twinning was the presence of fine needles of boehmite (figure 6) interspersed along the twin planes.

*Figure 6. These fine needles of boehmite delineate twin planes in a Colombian sapphire. Transmitted and oblique illumination, magnified 25×.*

*Mineral Inclusions.* In addition to the boehmite inclusions, two of the Colombian sapphires were found to contain transparent, deep brownish red to opaque gray, elongated prisms with a submetallic luster that suggest rutile (figures 7 and 8). Undercutting during polishing showed that the inclusions are softer than the host sapphire; microscopic hardness testing placed these inclusions between 6 and 6.5 on the Mohs scale. Several of the inclusions reaching the surface were scraped with the fine edge of a tiny diamond cleavage fragment epoxied into the end of an aluminum rod. The resulting powder was removed carefully and

*Figure 7. A typical scene of the interior of a Colombian sapphire, showing random orientation of numerous submetallic, elongated rutile prisms. Transmitted and oblique illumination, magnified 20×.*

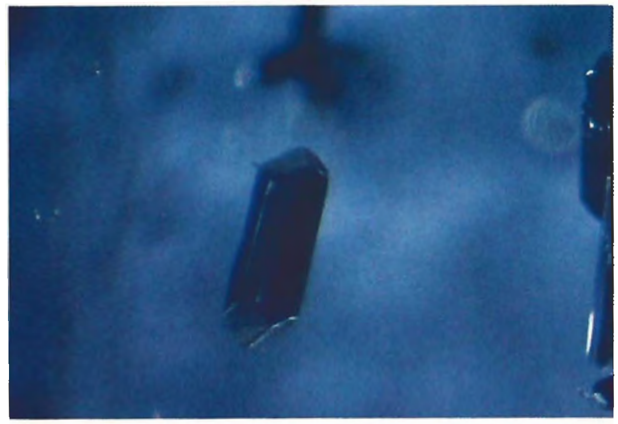

*Figure 8. Under higher magnification (50×), the faces of one of the rutile crystals in the stone shown in figure 7 are apparent. Transmitted and oblique illumination.*

fused on a charcoal block with an equal portion of anhydrous sodium carbonate. Then a droplet of concentrated sulphuric acid and an equal portion of distilled water was mixed with the powdered fused inclusion in a test tube. Lastly, a tiny droplet of hydrogen peroxide was placed in the solution of powdered inclusion and liquid $H_2SO_4$ (for more information on this classic technique for chemical analysis, see Brush, 1898). The resulting yellowish color of the solution suggests that titanium is present. Microprobe analysis by Carol Stockton of GIA confirmed the predominance of titanium.

Two of the sapphires also contained short, stout, rounded hexagonal prisms that are transparent and colorless (figure 5). Their external morphology suggested that they may be apatite. A thin slice containing several of these inclusions was cut from the end of one of the crystals. The excess corundum was first ground away. The slice was then crushed into a coarse powder and placed on a glass microscope slide. No cleavage of the inclusions was noted during crushing. Using the Becke line method, we found that the powdered fragments had a refractive index near to, but slightly higher than 1.630, the index of the immersion fluid. Under polarized light, the fragments proved to be doubly refractive, although no optic figure could be resolved. These optic constants suggest fluorapatite (R.I. 1.633–1.636).

## FUTURE OF THE DEPOSIT

Political problems aside, the Mercaderes sapphire deposit shows great potential. The quality of the sapphire is generally good, and there is ready availability of the material in commercially useful sizes. The unusually high concentration of stones exhibiting color change will be of particular interest to gem collectors. The presence of very sharp edges on some of the crystals suggests that the current alluvial mining is close to the source, and in-situ sapphire mining is a distinct possibility in the future.

## REFERENCES


Bank H., Schmetzer K., Maes J. (1978) Durchsichtiger, blau-rot changierender Korund aus Kolumbien. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, Vol. 27, No. 2, pp. 102–103.

Brush G.J. (1898) *Manual of Determinative Mineralogy with an Introduction on Blow Pipe Analysis.* John Wiley & Sons, New York.

Codazzi R.L. (1927) *Los Minerales de Colombia.* Biblioteca del Museo Nacional, Bogotá, Colombia.

Jobbins A.E., Berrangé J.P. (1981) The Pailin ruby and sapphire gemfield, Cambodia. *Journal of Gemmology*, Vol. 17, No. 8, pp. 555–567.

Keller P.C. (1982) The Chanthaburi-Trat gem field, Thailand. *Gems & Gemology*, Vol. 18, No. 4, pp. 186–196.

Marin P., Paris G. (1979) *Generalized Geologic Map of the Department of Cauca.* National Institute of Geological and Mineralogical Investigations, Bogotá, Colombia.

Schmetzer K., Bank H., Gübelin E. (1980) The alexandrite effect in minerals: chrysoberyl, garnet, corundum, fluorite. *Neues Jahrbuch für Mineralogie Abhandlungen*, Vol. 138, pp. 147–164.

Thompson D. (1982) *Sapphires in New South Wales.* Department of Mineral Resources, Sydney, Australia.