An Update on the Ural Emerald Mines

By A. F. Laskovenkov and V. I. Zhernakov

The emeralds of the Ural Mountains, in what is now called the Russian Federation, have been known for more than 160 years. They were famous worldwide during the early part of the 20th century. However, because little information was made available about these deposits in recent years, many in the gem industry concluded that they had been exhausted. This article reveals that mining and processing are ongoing in the region, with significant reserves of gem-quality emerald still to be exploited. In addition, the reopening of four mines promises to increase commercial production.

The famous emerald mines of Russia's Ural Mountains have been worked almost continuously since 1831. Over the next century, annual production of rough emerald and green beryl sometimes reached 2.5 million carats. During World War II, mining concentrated on the production of beryllium ore, but today emerald recovery has again become the primary focus, with Russian emeralds now appearing as center stones in fine contemporary jewelry (figure 1). Contrary to popular belief, there has never been a prolonged interruption in emerald production from this area.

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This article briefly reviews the history and geology of the Ural emerald deposits and then discusses recent developments in mining and processing. For almost three decades, the present authors have studied the geology of the deposit and the mineralogy and gemology of the emeralds produced there (e.g., Laskovenkov, 1991). The information presented in this article is based primarily on the authors' own observations and conclusions. It supplements, to some extent, previous works (Zemjatchensky, 1900; Mikhejev, 1913; Fersman, 1913, 1923, 1925; Pyatnitsky, 1929; Vlasov and Kutukova, 1960; Sinkankas, 1981; and Schmetzer et al., 1991).

HISTORY

The discovery of emeralds in this region (figure 2) is attributed to a local peasant, Maxim Kojevnikov, who reportedly found emerald crystals in the roots of a fallen tree near the Takovaya River in the fall of 1830. Organized mining began soon after, in January 1831.

For most of the 19th century, Uralian emeralds were not available for commercial exploitation, but rather they were considered the property of the Russian crown. In 1898, however, the growing cost

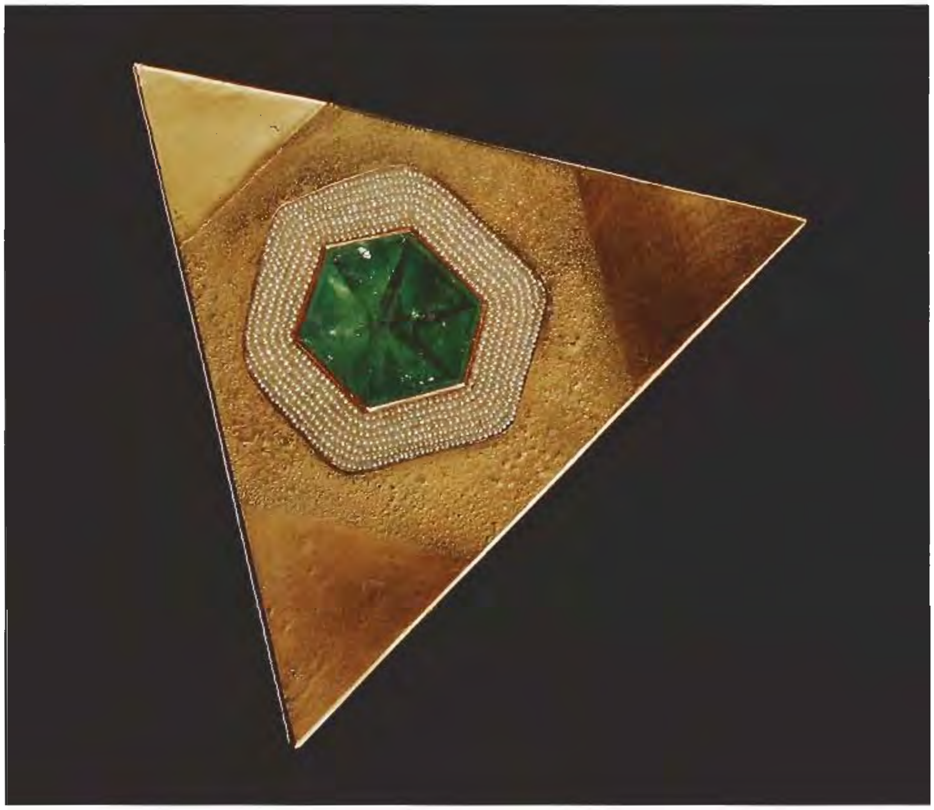

Figure 1. Emeralds from the Ural Mountains are increasingly appearing in contemporary jewelry, like this 21.07-ct stone set with keshi pearls and 24k gold in a pin designed by Michael Zobel. Photo by Fred Thomas.

of operating the mines impelled the Tsar to lease them to the English- and French-held New Emerald Company. The lease lasted 18 years, until 1916, during which time more than 40 million carats of emerald rough were exported (Gomilevsky, 1914; Fersman, 1925).

In 1918, the Soviet government established itself as sole owner of the mines. Five years later, in 1923, the government leased the mines to the Russkiye Samotsvety State Trust, which conducted large-scale mining of emeralds and sold them worldwide through export organizations (Fersman, 1923).

Until the 1930s, production from the Uralian deposits played an important role in the world emerald market, exceeding that from Colombia in some years, when as many as 2.5 million carats of gem crystals were recovered. The rough was cut and polished in jewelry workshops in Ekaterinburg, Paris, London, Berlin, and New York, by such famous jewelers as Cartier, Tiffany, Chaumet, and Fabergé.

Although the search for beryllium ore dominated mining in the area during the 1940s and 1950s, significant quantities of emeralds and green beryls (as much as 3–4 million carats per year in the 1950s) were recovered as a by-product of beryllium production. Since the early 1970s, however, with the discovery of new, more profitable beryllium deposits elsewhere and the increase in world demand for gem emerald, mining attention has gradually shifted back toward emeralds, with annual production as high as 8–10 million carats.

Although a sophisticated complex was developed by Malysheva Mines Management to mine and process the emerald rough, good cutting technology was not equally well developed. As a result, only about 20,000 carats of good-quality cut emeralds were produced per year. Lower-quality translucent to transparent rough was sold to various Indian gem companies. In 1987, cutting stopped completely because of the comparatively low yield of higher-quality finished stones from the raw material. With the establishment of the Russian-Panamanian-Israeli joint venture known as Emural, set up in 1991 by Russian and Israeli companies, Russian emeralds are now being cut on modern equipment using the latest technology to serve the world market.

Until 1945, emeralds were mined from deposits at Aulsky; Mariinsky, the main deposit; Perwomaisky, formerly called Troitzky; Krupsky,

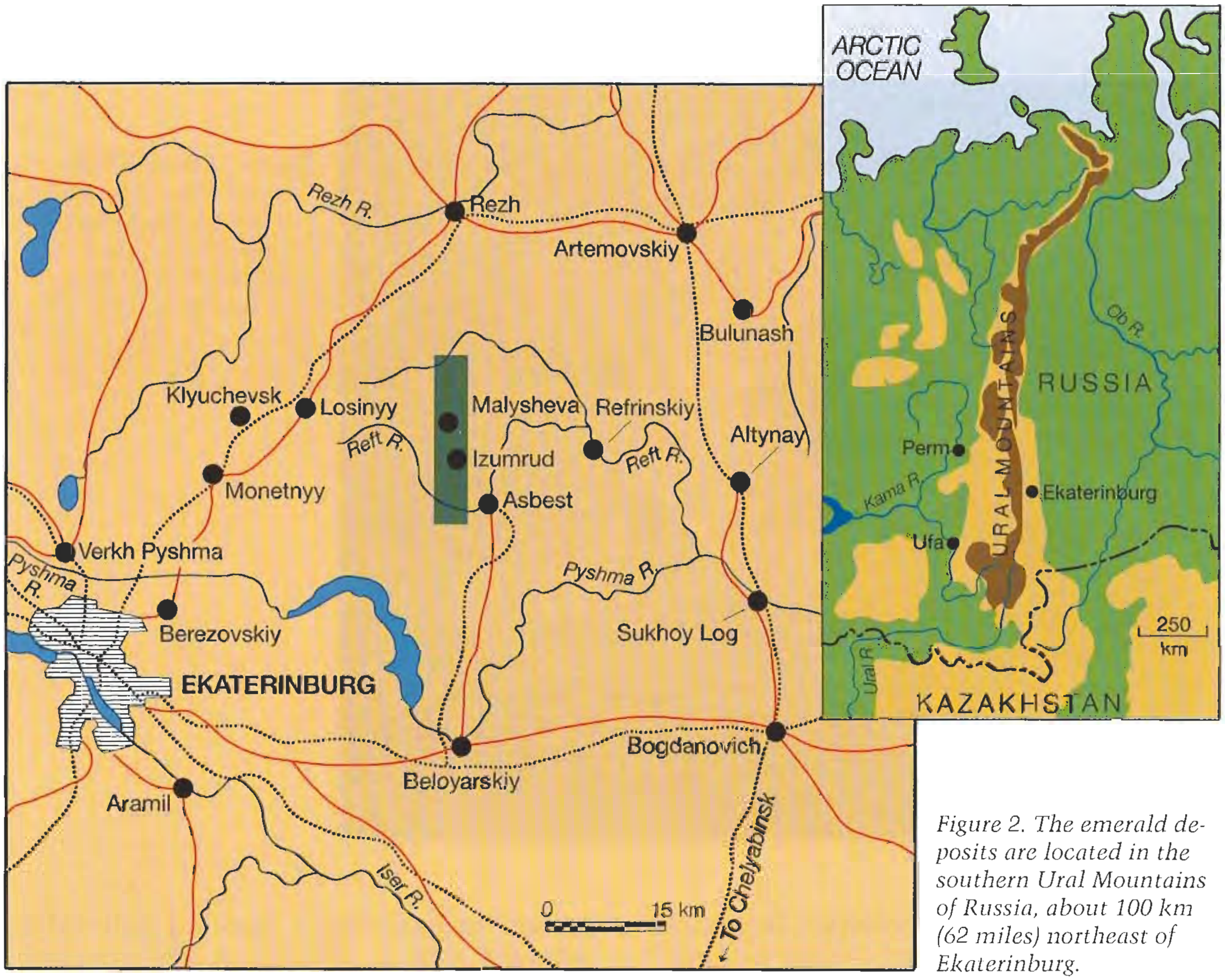

Figure 2. The emerald deposits are located in the southern Ural Mountains of Russia, about 100 km (62 miles) northeast of Ekaterinburg.

formerly Lubinsky or Tokovsky; Sverdlovsky, formerly Stretjensky; Tsheremshansky; Chitny; Krasnobolotsky; and Ostrowsky (figure 3). Since 1945, only the Aulsky, Mariinsky, Chitny, and Tsheremshansky deposits have been worked. At present, emeralds and other beryllium minerals (including alexandrites) are mined only at the Mariinsky deposit.

Although no new emerald deposits have been discovered in the Urals since 1945, recent geologic work has proved that there are significant reserves at Perwomaisky, Krupsky, Sverdlovsky, and Krasnobolotsky, as well as at Mariinsky. Preparations are being made to mine emeralds at the first three, and to mine both emeralds and alexandrites at Krasnobolotsky.

LOCATION AND GEOLOGY

The emerald deposits in this region of the Ural Mountains are located about 100 km (62 miles) by road northeast of Ekaterinburg (formerly Sverdlovsk), in the Russian Federation (again, see figure 2). The area can be reached from that city by train or car.

The numerous deposits are found in schists that lie in a zone that extends north-south for a distance of 20 km (about 12.5 miles) along the eastern contact of the Adui gneiss-migmatite complex, the core of which is an Upper Paleozoic granite mass (again, see figure 3). Concordant igneous bodies of Middle Paleozoic age, which are of ultrabasic and intermediate (between felsic and mafic) composition, are interspersed among amphibolites and other schists. All rocks are highly fractured, faulted, and folded, and are stretched out into lenses. The emerald deposits themselves are located within the amphibolite zones. The formation of emerald-containing glimmerite (a rock high in mica, in this case phlogopite) bodies is related to contact-metasomatic phenomena in the fracture zones, following the effect of acidic pneumatolytic-hydrothermal solutions on the ultrabasic rocks. These emeraldiferous glimmerite ore bodies frequently occur as a complex branching system; when close together, they form ore suites that look like columns in the best mining areas. The ore bodies average 1 m thick and 25–50 m (82–164 feet) long, but ore bodies as long as 100 m (328 feet) have been found. The strike of the emerald-bearing zone and the individual ore bodies is southerly, with a steep—65° to 80°—dip to the east (Vertushkov et al., 1978).

The glimmerite bodies are zoned, with a central, highly micaceous section that consists of 95%–99% phlogopite. Smaller pods and lens-shaped masses of plagioclase, tourmaline, quartz, and actinolite are usually present in this high-mica region. A talc or talc-tremolite zone is conformable around the central area. As a rule,

Figure 3. This geologic-structural diagram of the region in which emeralds have been mined in Russia shows that the emerald deposits lie in a narrow strip between the Adui granite mountain-mass to the west and the diorite complex to the east.

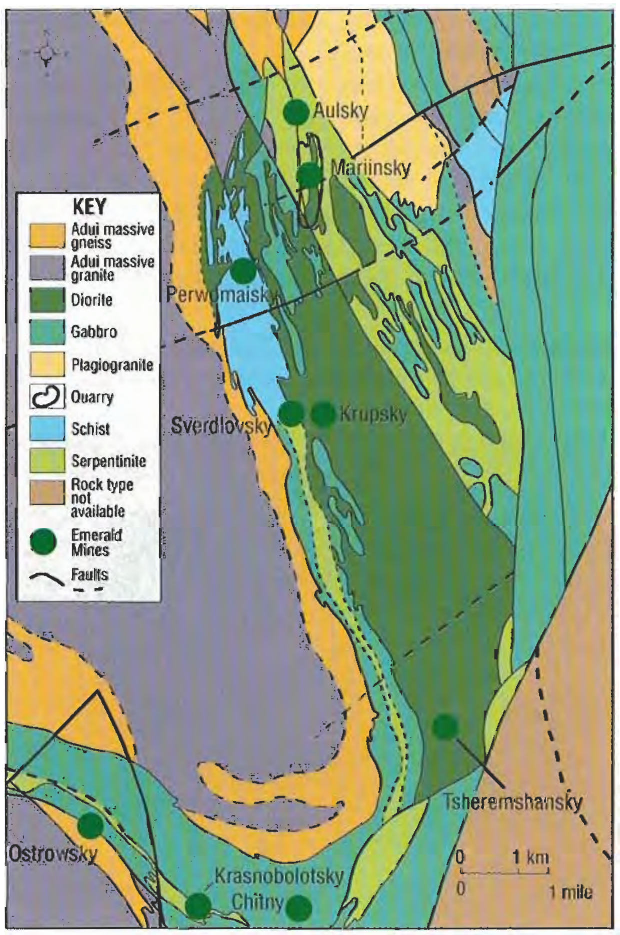

Figure 4. At the Uralian deposits, emeralds typically occur as single crystals, like this 8 × 9 × 12 cm specimen.

emeralds are found only in the highly micaceous zones, although they do occur rarely with plagioclase, quartz, actinolite, or talc. The emeralds typically occur as individual crystals (figure 4) or as subparallel (figure 5) or—less commonly—radiating (figure 6) groups of crystals. Sometimes rounded aggregates of emerald crystals, tightly enclosed in phlogopite, are recovered. Emeralds usually occur in very unevenly distributed concentrations or "pockets." Associated minerals are phenakite, green beryl, chrysoberyl, alexandrite, euclase, bromellite, apatite, and fluorite.

The morphology of Uralian emerald crystals has been studied extensively by Zhernakov (1980) and Schmetzer et al. (1991), and depends entirely on the conditions of formation. Typical emerald or green beryl crystals are 2–3 cm (about 1 inch) long, although specimens 9–12 cm long are not uncommon (again, see figure 4). Rarely, they exceed 14 cm (over 5 inches). Crystal aggregates usually consist of two to three crystals, but aggregates of eight to 10 crystals have been seen.

Figure 5. Also found in the Ural Mountains are subparallel groups of emerald crystals. The longest crystal in this specimen, currently in the Fersman Mineralogical Museum, is 7.5 cm. Photo by Jeff Scovil.

PROSPECTING

In the early days, prospecting and mining were often carried out at the same time, since most of the emerald deposits outcropped on the surface. Systematic prospecting began in the 1950s, when sufficient labor and materials were invested in the region to exploit both the emeralds and beryllium ore. At present, the deposits at Mariinsky, Perwomaisky, Krupsky, and Sverdlovsky have been explored to an average depth of 500 m (1,640 feet) by means of bore holes and underground workings.

To prospect for emeralds, we use both geophysical and mineralogical techniques. Neutron-activation analysis is widely employed, in the form of special portable "beryllometers," to locate emerald occurrences on the basis of the beryllium content of the surrounding rock. The identification of minerals known to be associated with emeralds has also proved helpful. To determine potential emerald content, bulk samples of as much as 200 tons of ore are processed in a concentration mill. The bulk samples are taken throughout the entire deposit, from layers 2.5–3 m (8–10 feet) thick at 100-m intervals along the ore zone. Experience has shown that this is the most efficient and reliable method of prospecting under these very complicated geologic conditions, in which concentrations of emeralds are distributed extremely unevenly.

MINING

Until 1970, the main emerald deposit, at Mariinsky, was worked by open-pit or underground mining to depths as great as 100 m. Along with emerald, beryllium ore—containing beryl, beryllium, margarite, chrysoberyl, phenakite, bertrandite, and bavenite—was recovered for industrial uses.

Today, this deposit is mined only for emeralds and only by tunneling (figure 7). It is worked year-round, at horizons more than 250 m (820 feet) below the surface. To minimize damage to the emerald crystals during extraction from the host rock, the miners (figure 8) use specially designed blast-hole patterns together with

Figure 6. Less commonly, the Uralian emeralds occur as radiating groups of crystals. This specimen is 8 × 9 × 14 cm.

Figure 7. Today, all mining at Mariinsky is done underground. As evident here, the tunnels are quite large, well lit, and well equipped.

sequential firing by "low-impact" explosives. In some instances, explosives are avoided altogether, and the host rock is broken by means of expanding plastics and hydraulic wedge devices inserted into the fractures.

The emeralds are removed from the mined ore in special concentration mills (figure 9), where the ores are disaggregated during slow rotation in a drum as they are washed by water. This ore material is then separated into five sizes by a complex screen system, after which the gem material is manually sorted out on a low-speed (15 cm per second) conveyor belt by highly skilled workers (figure 10). Even today, the most reliable instrument in sorting is the human eye.

PHYSICAL AND CHEMICAL PROPERTIES OF URALIAN EMERALDS

Uralian emeralds and green beryls are typically

Figure 8. In this tunnel at Mariinsky, miners prepare to remove the emerald-bearing ore.

Figure 9. Disaggregation of the emerald-bearing rocks at the Malysheva processing plant is accomplished in a rotating drum, or scrubber.

Figure 10. Highly trained workers sort out emeralds on a slow-moving conveyor belt at the Malysheva processing plant.

bluish green of varying intensity (figure 11), but some are slightly yellowish green. The finest gems are light to medium green. As reported by Zhernakov (1980) and, more recently, Schmetzer et al. (1991)—and confirmed by our own physical, chemical, and spectroscopic analyses—the green color is due to the presence of chromium. We have found typical chromium contents of 0.15–0.25 wt.% Cr_2O_3 with contents as high as 0.38 wt.% in areas near inclusions of chrome

Figure 11. Uralian emeralds are typically bluish green and of varied saturation. These emeralds, 0.5 to 6 ct, illustrate the effect of different cuts.

spinel. Admixtures of iron, titanium, vanadium, cobalt, and nickel can also be responsible for variations in the coloration (Zhernakov, 1980). Other elements detected in Uralian emeralds, in addition to those intrinsic to the mineral structure, include Mg, Ca, Na, Rb, Cs, Sc, and F.

A detailed study of inclusions observed in Uralian emeralds, as well as other gemological, spectral, and chemical characteristics of this material, was published by Schmetzer et al. (1991). In summary, and confirmed by our own observations, the internal features of the emeralds are characterized by zoning, mineral, and two-phase (usually liquid-gas) inclusions, and cracks caused by crystal-lattice stress. The zoning is caused by the uneven distribution of color-causing trace elements during crystal growth; the zoning parallels the basal pinacoid or prism faces. The quantity and nature of mineral inclusions varies widely and usually depends on the nature of the enclosing rock: For example, emeralds from phlogopite schist contain phlogopite, and those from talc schists contain talc, tremolite, and chromite. Frequently seen in faceted emeralds are phlogopite crystals, actinolite needles, liquid-gas inclusions, and minute fractures. The liquid-gas inclusions may occur as elongate channels; some channels display a symmetric "fencing" parallel to the optic axis.

LARGE SPECIMENS PRODUCED

The Ural emerald mines have produced some remarkable specimens, both historically and recently (i.e., since 1978). Perhaps the most famous is Kochubey's emerald, an 11,000-ct crystal of intense "grass" green color that was found in 1831. It is now at the Fersman Mineralogical Museum of the Russian Academy of Sciences, in Moscow.

A 3,370-ct emerald of excellent color, named Glorious Ural Stone, was mined in 1978. It is now in the State Treasury of Valuables of Russia (Gokhran). Also in the State Treasury of Valuables is the group of six crystals named Miner's Glory (approximately 10,000 ct and 10 × 12 × 30 cm), which was found in 1989. The year 1990 gave us two very rare and beautiful emeralds: the unusually clean 4,400-ct (6 × 7 × 10 cm) New Year's Stone and the 37.5-ct faceted Vitaly emerald (figure 12).

SUMMARY AND CONCLUSIONS

Large quantities of emeralds have been mined from deposits in the Ural Mountains, about 100 km northeast of Ekaterinburg, since 1831. Although during and immediately following World War II, the mines were worked primarily for beryllium ore, today they are exploited exclusively for the typically bluish green gem emeralds and green beryls. Little information on these deposits was released during the last 60 years, so many believed that they had been exhausted. However, geologic information gathered over the last three decades reveals that only about 30%–35% of known reserves have been worked to date.

Currently, only the Mariinsky mine is being worked, and production figures are not available. However, plans to begin mining at Perwomaisky, Krupsky, Sverdlovsky, and Krasnobolotsky promise an even greater supply of rough in the near future. The apparent success of the Emural joint venture in modernizing the cutting of the Urals production should further increase the availability of fine cut Russian emeralds and green beryls in the world marketplace.

Figure 12. The 37.5-ct Vitaly emerald is one of the largest stones faceted from rough found at the Ural emerald mines.

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