GEM-QUALITY FRIEDELITE FROM THE KALAHARI MANGANESE FIELD NEAR KURUMAN, SOUTH AFRICA

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Gem-quality frielite was discovered by chance during shaft-sinking operations in a new, deep manganese mine near Kuruman. This article reports on the general geology and mineralization of the frielite, speculates on the age and origin of the deposit, and describes the gemological properties of this material.

The comparatively rare mineral frielite was first reported in 1876 by Bertrand. This occurrence was in the manganese mine at Adervielle, in the Vallée du Luron of the Hautes Pyrénées, France. The mineral was named in honor of Charles Friedel, the French chemist and mineralogist.

Since then, frielite has been recorded as occurring sporadically in other manganese silicate deposits worldwide, including the Hartig mine near Pajsberg, Sweden (Lindström, 1891); the Sjö mine near Örebro, Sweden (Ingelström, 1891); the mines near Veitsch, Austria (Hoffmann and Slavik, 1909); the Buckwheat mine and Parker shaft, Franklin Furnace, Sussex County, New Jersey (Palache, 1910); the Taylor mine, Franklin Furnace, and the mines at Sterling Hill, Sussex County, New Jersey (Palache, 1935); the Fe-Mn deposits at Dshumart and Kamya, Central Kazakhstan, U.S.S.R. (Kuyapova, 1960); and the deposits of the Atasu region of Central Kazakhstan (Kuyapova, 1968).

It appears that only the occurrences at Franklin Furnace and Sterling Hill have produced gem-quality frielite (Sinkankas, 1959; Sinkankas, 1962; Arem, 1977; Webster, 1978). The suitability of this comparatively rare mineral for gem cutting has been mentioned by Sinkankas (1968), Vargas (1969), and Vargas (1979).

In November 1980, a little more than 100 years after its original discovery, a new occurrence of gem-quality frielite was discovered, at the Kalahari manganese field in the Republic of South Africa. A brief description of the mineralization of this rare gem material and the circumstances that led to its discovery is presented here.

MINERALIZATION

The frielite was found during shaft-sinking operations at the Middelplaats mine in the Kalahari manganese field, near Kuruman, northern Cape Province, Republic of South Africa (figure 1). It is associated with the lower manganese ore zone indicated in figure 2. The ore itself is a fine-grained mudstone into which the ore mineral, braunite, is incorporated in a highly disseminated state (Middelplaats Manganese Ltd., 1981).

Koekemoer, a mineral dealer, relying on information supplied by the miners who removed the frielite from the shaft, originally placed the occurrence in the upper portion of the 25-m-thick ore zone at a depth of about 395 m below the surface and a distance of about 75 m from the main shaft (personal communication, 1981). Subsequent follow-up investigations by Zaayman, the resident mine geologist, placed the frielite locality at the base of the lower ore body near the old ventilation shaft. Unfortunately, the precise underground position could not be determined, inasmuch as that portion of the mine, once it was worked out, had been converted into maintenance workshops and all the rock faces covered by "shotcrete," a cement aggregate applied at high pressure. Nevertheless, small fragments of frielite were subsequently found in this vicinity (Zaayman, personal communication, 1982).

On the basis of information received from the miners, it is estimated that originally two to three tons of low-grade manganese ore were collected, from which about 100 kg of frielite (then thought to be a variety of rhodochrosite) and gan-

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Acknowledgments: The author wishes to thank Crystal World Inc., Los Angeles, for specimens; the Geology Department of the Middelplaats manganese mine for supplying relevant information; and the technical staff of the Department of Geology, Stellenbosch University, for processing the manuscript.

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Figure 1. Locality map of mines in the Kalahari manganese field, Republic of South Africa.

gue were later separated. According to the miners, the friedelite occurred in three discrete, near-horizontal veins within the low-grade manganiferous ironstone. As seen in large hand specimens, two of these "veins" have a thickness of about 10 mm and contain the pure cryptocrystalline friedelite; the third is about 35 mm thick and is criss-crossed by veinlets of carbonate-rich minerals, which give it a composite, matrix-like appearance.

Figure 2. Generalized section through the Middelplaats manganese mine, modified after Middelplaats Manganese Ltd. Report (1981). Vertical scale exaggerated.

The friedelite mineralization tends to follow the general bedding of the sediments, with a slight cross-cutting relationship in places. Consequently, the origin of the friedelite occurrence is not clear. It could be metasomatic and associated with the nearby 1750-m.y.-old basic dykes, or it could be the metamorphic product of a discrete layer within the original banded ironstone formation. It is, however, definitely younger than the 2220-m.y.-old Ongeluk volcanic rocks onto which the banded ironstone formation was deposited.

GENERAL GEMOLOGICAL DESCRIPTION

Two forms of gem-quality friedelite have been found. The one is evenly colored and translucent, and has a rose red to carmine red appearance (figure 3). The other form is also predominantly rose red to carmine red, but it is streaked by pink and white veinlets of rhodochrosite and other carbonate minerals. It is referred to here as matrix friedelite (figure 4).

Ideally, the chemical composition of friedelite is $Mn_8Si_6O_{15}(OH,Cl)_{10}$. However, according to the accompanying electron probe analysis by D. H. Cornell of the Department of Geology, University of Stellenbosch, the friedelite from this occurrence has some of the manganese replaced isomorphously by iron and magnesium (table 1).

Thus far, no discrete crystals have been found in this locality. All the material examined was cryptocrystalline and optically anisotropic; it produced a typical aggregate reaction when exam-

Figure 3. Cryptocrystalline friedelite cabochons, 16 × 10.1 mm (5.42 ct) and 10.4 × 8.8 mm (3.83 ct). Photo by Tino Hammid.

ined under crossed polarizing filters. However, the X-ray diffraction powder pattern for this material agrees well with that published by Frondel and Bauer (1953) for friedelite and which they placed in the trigonal crystallographic system.

Refractive index determinations using immersion techniques gave values of $\omega = 1.657$ and $\epsilon = 1.630$. However, measurements made on a standard gemological refractometer result in a general single value of 1.64. Moreover, some gems do display "form birefringence" (Webster, 1978, p. 189) and show two distinct shadow edges, which can be separated in the usual way by a polarizing filter. The "form birefringence" values determined on 10 examples with flat facets varied from 0.005 to 0.020, usually symmetrically placed around the mean value of 1.64.

An examination of oriented petrographic thin sections revealed that the friedelite crystallites are spindle-shaped, with their long axes more-or-less coinciding with the crystallographic c-axis. The vein-like infill is such that the spindles tend to be oriented preferentially at right angles to the plane of the bedding of the rock in which the friedelite occurs. Refractive index measurements made on polished sections oriented first parallel and then perpendicular to the plane containing the "vein" gave values of 1.64 and 1.63–1.65 respectively.

The luster on freshly broken surfaces is waxy to dull. On polished surfaces, however, it is vitreous. Polished cabochons are translucent to semitranslucent.

None of the samples of friedelite examined displayed fluorescence when exposed to long-wave ultraviolet (365 nm), short-wave ultraviolet (254 nm), or X-rays.

On the hand spectroscope, the absorption spectrum shows a clear absorption band from 535

to 595 nm, with a general absorption from 400 to 480 nm. This absorption pattern is persistent and was observed in all specimens tested. Furthermore, as may be concluded from its absorption spectrum, friedelite has a vivid red appearance when observed through a Chelsea dichroic filter.

Other physical properties include hardness, which falls between 4½ and 5 on the Mohs scale; relative density for the pure material, which is 3.066 ± 0.003 , with a slight increase up to 3.11 for matrix samples; fracture, which is even to semigranular; structure, which is massive; and toughness, which may be regarded as fair to good.

Although most of the examples of massive friedelite examined were free of any characteristic inclusions, some did show small white blebs of carbonate mineralization.

DISCUSSION

Friedelite, schallerite, and pyrosmalite form a group of minerals collectively referred to as the pyrosmalite group, with the general formula $(\text{Mn,Fe})_8\text{Si}_6\text{O}_{15}(\text{OH,Cl})_{10}$. Although these minerals are known to occur at times as single crystals, it is mainly the massive forms of friedelite that have been used for gem cutting.

Palache (1935) mentions a number of color varieties of friedelite occurring in the Franklin and Sterling Hill areas. These include the compact forms tinted brownish red, through the flesh-colored shades, to a "lively pink." By comparison, the friedelite from Middelplaats displays very little color variation and its reddish appearance is its main attraction. The Kazakhstan cryptocrystalline forms of friedelite described by Kuyapova in 1960 are reddish brown or a light somewhat greenish brown.

The cause of the color cannot be explained with any certainty. In broad terms, it may be as-

Figure 4. Matrix friedelite cabochon (28 × 14 mm).

sumed that friedelite is an idiochromatic mineral with compositional manganese as the principal colorant. Since the ferroan-friedelite described by Kuyapova (1968) is dark brown with an iron content of about 10% (reported as an oxide), and the pink friedelite described by Palache (1935) has a low iron content ($\pm 0.7\%$ oxide), the lightness or darkness of the tonal quality of the reddish color could very well be associated with the amount of iron that has isomorphously replaced the manganese. It should be pointed out, however, that the pink friedelite is also described as being a low-chlorine friedelite and its unusual pink color could also be associated with the low chlorine content ($\pm 0.25\%$) reported by Palache in 1935.

The comparative rarity of friedelite is emphasized if one considers that this occurrence is the first to be reported in the Kalahari manganese field (which extends for about 500 km²; see figure 2), that manganese ore has been mined in a number of mines during the past 25 years, that the present discovery is limited to the originally recovered 100 kg of friedelite and gangue, that the geologist at Middelplaats mine had great difficulty in relocating the mineralization and could only find tiny fragments of friedelite, that the method of underground mining at depths of 250 m and more is highly mechanized thereby minimizing in-situ discoveries, and that the friedelite mineralization did not occur in the present ore horizons.

To date, friedelite has been encountered as a gem only rarely, while neither schallerite nor pyrosmalite has ever been recorded as such. It is quite possible that these minerals do exist as gems, but because of their similarity in appearance and durability to reddish brown varieties of bowenite serpentine, they were misidentified as

TABLE 1. Electron microprobe analysis (in wt. %) of friedelite from the Kalahari manganese field.

SiO ₂	35.82
Al ₂ O ₃	0.06
MgO	1.43
FeO	1.29
MnO	52.33
CaO	—
TiO ₂	—
K ₂ O	—
Na ₂ O	0.04
Cl	3.59
	94.56
O—Cl	— 0.81
	93.75
H ₂ O ⁺ (by difference)	6.25

such. They do, however, display slightly higher values for their physical and optical properties.

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