STATUS OF RUBY AND SAPPHIRE MINING IN THE MOGOK STONE TRACT

By Robert E. Kane and Robert C. Kammerling

Burma, now named Myanmar, has for centuries been considered the world's preeminent source of fine rubies. Today, after nearly three decades of limited gem production, there is a resurgence of mining activity at the famous Mogok Stone Tract. New developments include mechanized government mines and joint-venture mining operations with Myanmar nationals. This article, based on two recent visits to Mogok, briefly reviews the mining history and geology of this extraordinary locality, and describes the current status of mining and the methods used to recover rubies and sapphires in the Mogok area. Limited statistics on gem production are also presented, as is a map of the area showing many of the active mine sites.

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Acknowledgments are listed at the end of the article.

Gems & Gemology, Vol. 28, No. 3, pp. 152–174

For centuries, the finest rubies in the world have been associated with the Mogok mining region of upper Burma (now Myanmar). In the 20th century especially, rubies and sapphires from Mogok have played an important role in jewelry of every design (figure 1). Although production in Mogok has historically been sporadic, it appears to have been even more so after all gem mining was nationalized in 1963. Today, however, Mogok is experiencing its greatest mining activity in decades, and perhaps the greatest production of rubies and sapphires ever recorded from this locality.

With nationalization, few non-Myanmar nationals were permitted to visit the Mogok area; as a result, essentially no firsthand information on mining developments appeared in the Western literature for over two decades. Nearly all of the recently published reports are based on information and photographs obtained in the late 1950s (e.g., Ehrmann, 1957) and early 1960s; the last detailed firsthand reports of mining activity in Mogok were issued by Meen (1962) and Gübelin (1963, 1965, 1966a and b, 1977). A. Chikayama recently published several very informative reports, based in part on his visits to Myanmar (Chikayama, 1987a–f); he did not, however, visit the Mogok area.

At the invitation of the Myanmar government, the senior author (REK) visited Mogok in February 1991 and again in March 1992, accompanied on the second visit by the coauthor (RCK). As the first research gemologists to visit Mogok since Dr. Gübelin last traveled there in 1963, we used these opportunities to document the current status of gem mining and production in this famous region. We visited 11 of the more than 165 authorized mining operations active in 1991 and 1992. These included five of the seven government ruby and sapphire mines and six joint ventures. We also saw a number of apparently unlicensed operations.

What we encountered was an exciting mixture of traditional methods of mining that had been used in Myanmar for centuries, together with highly efficient, mechanized open-

Figure 1. This suite of predominantly early-20th-century jewelry is set with fine-quality rubies and sapphires, for which Myanmar (Burma) is renowned. Photo by Shane F. McClure; jewelry from the collection of Donald K. Goodman, Frank Goodman and Sons, Los Angeles, California.

pit and tunneling operations to remove the rubies and sapphires.

Following a brief review of the history and geology of this area, this article examines the different entities—primarily government and joint venture—responsible for the heightened activity at Mogok, and describes the types of mining operations observed there. Also reported are production statistics for the major government operations, observations on cutting factories at Mogok and Yangon (formerly Rangoon), and information on the distribution of many of the stones mined. For information on the known gemological properties of Mogok rubies, the reader is referred to Gübelin (1977), Keller (1983), and Schmetzer (1986). For a discussion of famous rubies from Mogok, see Keller (1983, 1990).

HISTORY

Burma is one of the oldest recorded sources of fine rubies. Although it is not known exactly when mining began there, ancient legends refer to a deep valley in "Old Cathay" that was covered with beautiful red gems. According to one story, natives would throw pieces of meat onto the valley floor. Some of the gems would stick to the meat, which was then eaten by vultures. When the vultures flew up from the valley, the natives would kill them to retrieve the gems (Scott, 1935). The earliest record of actual mining in

Figure 2. The 196.1-ct Hixon ruby, shown here on a locality map from E. C. S. George's 1915 Burma Gazetteer — Ruby Mines District, *is from the historic Mogok Stone Tract. Ruby crystal courtesy of the Los Angeles County Museum of Natural History. Photo by Shane F. McClure.*

this part of the world appeared in the 6th century, when a son of Kun-Lung, founder of the Shan dynasty of Chinese emperors, governed a state that was near a ruby-mining area. Records show that he sent an annual tribute of "2 viss" (approximately seven pounds!) of rubies to the central government (Chhibber, 1934).

In the 15th century, European travelers published two separate accounts of rubies from this area; the first report was by Nicolo de Conti (c. 1430) and the second by Ludovico di Varthema, who visited the land of Pegu (Burma) in 1496. A more direct reference to gems was made by Caesar Fredericke in 1569, who reported on the busy, established trade in rubies at that time and described the King of Pegu as "Lord of the Mines of Rubies, Safires and Spinels." In fact, the court of this king was so rich that the idols were embellished with rubies and sapphires (Chhibber, 1934).

The Burmese monarchy took control of the ruby-mining areas in 1597, and leased the mines to individual operators at a fixed annual rate. Any stones above a certain size were the property of the king, who also had the right to take control of any mine that showed a high yield of gems. It is believed that, because of this dictum, large stones were often broken up to avoid royal intervention (Wynne, 1897).

During the 17th and 18th centuries, under the demanding rule of the Burmese kings, the mines became synonymous with exile. Unrelenting pressure to produce more and more gems took its toll, and miners were literally worked to death. A rebellion in the early 19th century ended this servile system, and the mining areas were deserted until 1863, when they were declared open for any to work. Conditions for the miners might have improved, but the output of gems remained under strict royal supervision, and taxes were levied on both buyers and sellers (Scott, 1935).

After the British took control of the region in 1886, following the Third Burmese War, they set regulations to monitor gem mining and trade. In 1887, a concession was granted to London jeweler Charles Streeter, who formed Burma Ruby Mines, Ltd. (BRM). This company paid £30,000 a year, plus 30% of the profits, for the sole rights to mine the area using heavy machinery. Their contract further stated that the local miners would be allowed to continue to mine using the same methods they had employed since antiquity, but that they must pay BRM 30% of the value of the gems they recovered. Smuggling and theft escalated, and competition among districts and mines made it impossible for BRM to regulate prices. Ultimately, this system was abandoned for one in which miners were required to obtain a license from BRM for a 20-rupee monthly fee. The miners could then sell any gems recovered on the open market (Scott, 1935).

Burma Ruby Mines was in operation from 1887 through 1925 (figure 2). They worked throughout much of what is known today as the Mogok Stone Tract. The company brought hydroelectric power to Mogok to run washing plants, pump water out of waterlogged mine sites, and operate tunneling equipment. Wynne (1897) reported on the costs involved in cutting three drainage tunnels to make areas more accessible for mining. Such mechanized mining was lucrative only from 1890 through 1908, when the

Figure 3. The township of Mogok has been a center of gem mining activity for hundreds of years. In fact, many homes line the shores of an artificial lake that was created by the flooding of an early 20th-century Burma Ruby Mines, Ltd., open-pit operation. Photo by Robert E. Kane.

price of rubies dropped in Europe due to the arrival of synthetics on the market. Prices for top-quality rubies plummeted to one-third of their previous value, and prices for inferior grades fell even further. The outbreak of World War I further depressed the ruby market and, in 1925, Burma Ruby Mines went into voluntary liquidation. BRM continued to mine on a very small scale for another five years until the Great Depression forced the company to disband completely, surrendering its leases to the government on June 30, 1931 (Scott, 1935).

The British did not realize how costly it would be to mechanize mining in Burma. Most of the European methods of hard-rock mining, designed for products like coal, were poorly suited to the geology of the area. Wynne (1897) reported "very hard rock" that "changed to a soft micaceous schist, containing volumes of water, in the presence of which it became almost as soft as mud, and required close and careful timbering," for which it was difficult to get suitable wood. Eventually, the largest drainage tunnel collapsed in places and the mining excavations filled with water. The original town of Mogok, moved in the late 1800s as the main area was turned over to ruby mining, is now covered by a beautiful lake (figure 3).

Following the departure of the British in 1931, mining reverted almost entirely to the native methods that had been effectively used since antiquity (Iyer, 1953; Gübelin, 1965; Nordland, 1982). Only very recently, due to the active participation of the Myanmar government, has modern, mechanized mining returned to the Mogok Stone Tract.

LOCATION AND ACCESS

The town of Mogok is located almost 100 air km north-northeast of the city of Mandalay (figure 4). We traveled by plane from Yangon (formerly Rangoon) to Mandalay (about 500 air km, or 312 mi.), and by four-wheel-drive vehicle along 200 km of rough and twisted paved road to Mogok (six hours in good weather). For the last 25 km, the road ascended sharply in a pattern of severe twists and turns.

The government provided an armed escort to accompany us throughout the duration of our stays in Mogok. Non-Myanmar nationals are rarely allowed in the area, and we strongly advise against travel to or within Mogok without proper authorization.

The actual area encompassed by the "Mogok Stone Tract" has been variously described, with reports from "170 square miles" (442 km^2; Iyer, 1953) to "1,040 km^2" (Keller, 1983; Myanmar officials, pers. comm., 1991). Iyer, who published in 1953 what is considered the definitive geologic work on the Mogok Stone Tract, indicated latitude 22°50′45″N to

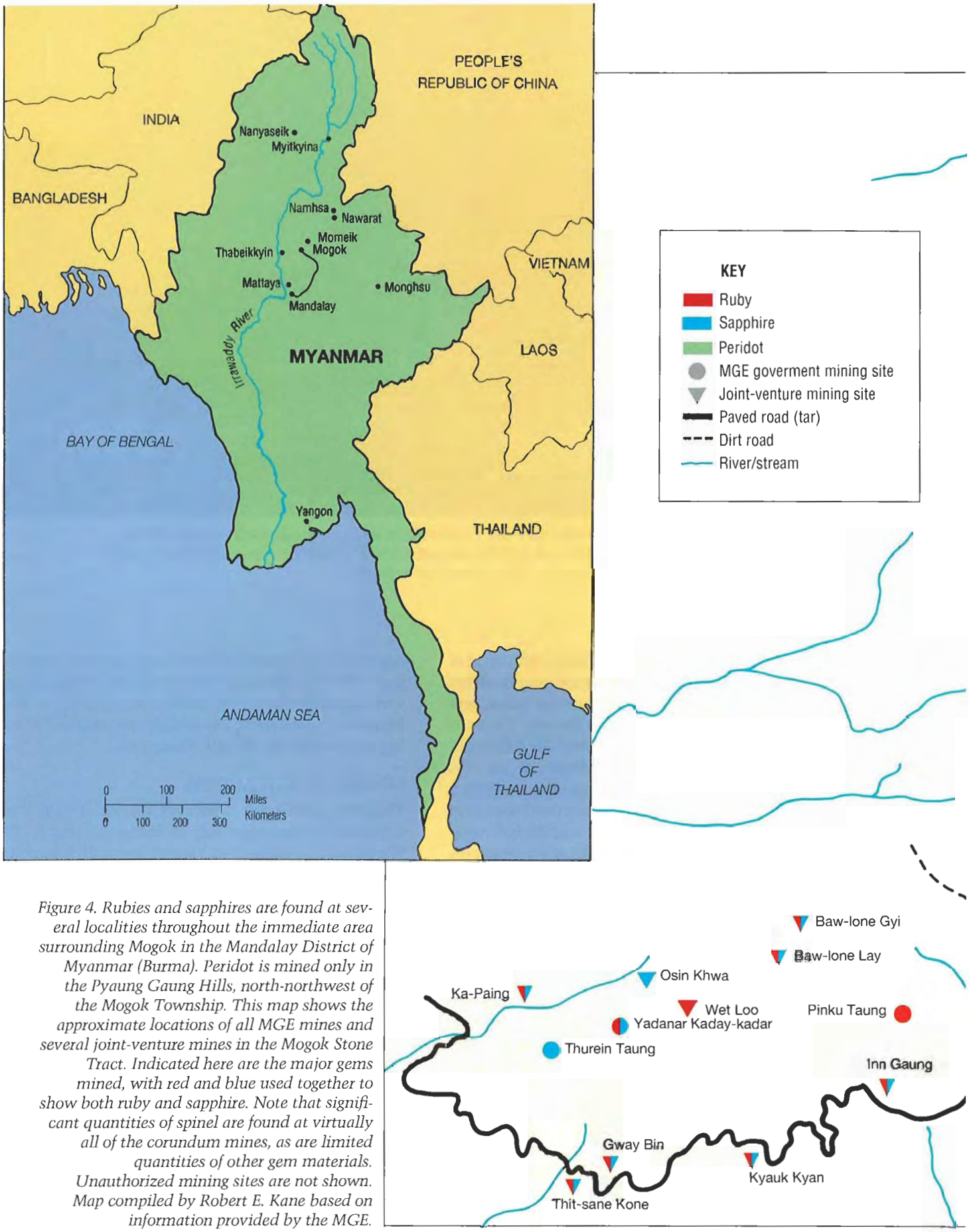


Figure 4. Rubies and sapphires are found at several localities throughout the immediate area surrounding Mogok in the Mandalay District of Myanmar (Burma). Peridot is mined only in the Pyaung Gaung Hills, north-northwest of the Mogok Township. This map shows the approximate locations of all MGE mines and several joint-venture mines in the Mogok Stone Tract. Indicated here are the major gems mined, with red and blue used together to show both ruby and sapphire. Note that significant quantities of spinel are found at virtually all of the corundum mines, as are limited quantities of other gem materials. Unauthorized mining sites are not shown. Map compiled by Robert E. Kane based on information provided by the MGE.


Pyaung Gaung
Ah-Chauk Taw
Lay Thar
Ah-Nee Taw
N
Chaung Gyi
Ho-wine-show
Inn Chauk
Pein Pyit
Dat Taw
Le Oo
Ohn-Bin
Padamyar
Central Washing Plant
Pan Sho
Myaw Pyet
Kyauk Poke
Bawpatan
Ohn Gaing
Lin Yaung Chi
Ho mine
Mye Mar
Kyauk-sar Taung
Kyauk Saung
Than Ta Yar
Shwe Pyi Aye
Ye Bu
Pyaung Pyin
Ha-pha-lar
MOGOK
Ye-Oo Gyi
The-Doot Sho
Lue Hta
Wun-Bear Inn
0 Miles 1
Kilometers 1

*Figure 5. At Mogok, the primary (*in situ*) occurrence of rubies is in a coarse-grained marble. Here at Dat Taw, the white marble tailings cover a large portion of the hillside. Photo by Robert E. Kane.*

23°5′5″N and longitude 96°19′E to 96°35′E for the area. According to the Myanma Gems Enterprise (MGE), the Mogok Stone Tract is bounded on the south by the Nam Pai River, on the north by the foot of the Momeik Scarp, on the east by the town of Momeik, and on the west by the town of Thabeikkyin on the Irrawaddy River ("Role of Gems Mining Department," 1991).

The region is mountainous, with peaks higher than 2,150 m (7,000 ft.); the town of Mogok sits at an altitude of 1,500 m. Mogok receives annual rainfall of more than 350 cm (140 in.). The rainy season is typically from mid-May to mid-October. Malaria is always a concern, but particularly during the rainy months. Small farming villages dot the region amid "forests" of teak, bamboo, and bananas.

Senior MGE employees reported that the indigenous population of Mogok Township is approximately 200,000, with another 200,000 people who have come from other areas of Myanmar.

GEOLOGY OF THE MOGOK AREA

Many regional geologic studies were made of the Mogok area in the late 19th and early 20th centuries (as reviewed in Keller, 1983, 1990). Yet none is more recent, or more authoritative, than that of Iyer (1953), which was based on months of surveying over three years.

Geologic mapping is particularly difficult in this part of the world, because the dense vegetation and a thick cover of residual weathered material (soil, etc.) result in a lack of rock outcrops. Nevertheless, Iyer (1953) produced a geologic map of the Mogok area, which was reproduced in modified form in Gübelin (1977) and Keller (1983). This geologic map shows the distribution of several types of common high-grade metamorphic rocks, that is, gneiss and marble (the latter is referred to as "crystalline limestone" by Iyer and others, but current terminology for "crystalline [metamorphosed] limestone" is marble), as well as intrusive igneous rocks (granite and minor amounts of syenite). Alluvium (unconsolidated material transported and deposited by running water) of Quaternary age has accumulated particularly in valleys and other low-lying areas. Iyer's report and map also revealed gem-bearing pegmatites, peridot-bearing ultramafic intrusives (dikes and sills), quartzites, and several varieties of gneiss (e.g., garnet, scapolite), as well as structural features such as faults, which indicate that the area has been subjected to several major tectonic processes over extended periods of time. The granites are particularly noteworthy because of their abundance (they comprise the western one-third of the map area), the presence of gem materials (e.g., topaz and tourmaline) in the associated pegmatites, and the fact that they may have produced contact metamorphic mineral assemblages in appropriate rocks (e.g., marbles; figure 5), resulting in the formation of corundum and spinel under special conditions. Keller (1990) suggests that regional, rather than contact, metamorphism may have played a major role in the origin of the primary ruby deposits at Mogok. It is also possible that there are actually two generations of ruby at Mogok, one formed by regional metamorphism and the other by subsequent contact metamorphism (A. A. Levinson, pers. comm., 1992).

In areas with tropical climates and high rainfall,

rocks are especially susceptible to chemical weathering; this has been the situation in this part of Southeast Asia for millions of years. As a result, the major rock-forming minerals are altered to clays, iron oxides (e.g., goethite), and other minerals that are stable in the surface environment. These materials accumulate in the form of soils or even laterites (highly weathered red soils rich in iron and aluminum oxides that typically develop in tropical climates) if the weathering process is sufficiently long and efficient. Certain minerals, such as corundum and spinel, that are inherently resistant to chemical weathering, may accumulate within the soils or laterites, frequently concentrating into layers or beds of gravel resting on soft, decomposed rocks. Such gem-bearing beds—which are characteristically brown or yellow and contain clays, iron oxides, and at times sandy material—are locally known as *byon*.

Until recently, only minor amounts of gem minerals have been recovered from their primary (*in situ*) occurrences. Most have been recovered from secondary deposits, the byon (figure 6). Gem minerals within the byon may be classified into two types: (1) *eluvial* (gem concentrations essentially in place that result from decomposition of the host rock), and (2) *alluvial* (gem concentrations that occur following transportation by water, which implies significant movement from the source). As a practical matter, distinction between the two types frequently is not possible.

MINING ENTITIES AT MOGOK

From the nationalization of gem mining in 1963 until April 1990, all legal mining activity in the Mogok Stone Tract was conducted by the Myanmar government. The Myanmar Ministry of Mines still controls all legal mining and exploration in the Union of Myanmar. The Ministry founded the Myanmar Gems Corporation on April 1, 1976, to oversee the Mogok Gems Project, the Pharkant Jade Project of the Mineral Development Corporation, and the Trade Corporation No. 19 (Gems) of the Ministry of Trade. In 1989, the Myanmar Gems Corporation was renamed the Myanma Gems Enterprise ("Role of Gems Mining Department," 1991).

Today, in addition to MGE mining, there are also government-authorized joint ventures between the MGE and private individuals or groups, as well as illicit mining activities. Although both the MGE and joint-venture operations (and even some unauthorized concerns) now mine a small number of primary deposits, most of the mining by all entities at Mogok today continues to be in secondary (byon) deposits.

Figure 6. Historically, most of the rubies and sapphires found in the Mogok Stone Tract have been recovered from alluvial or eluvial gem gravels called byon *in Myanmar. These are frequently covered by a thick (up to 25 m) overburden of soil, laterite, etc. Here, miners in the trench push the byon into a stream of water that carries it downward for processing. Photo by Robert E. Kane.*

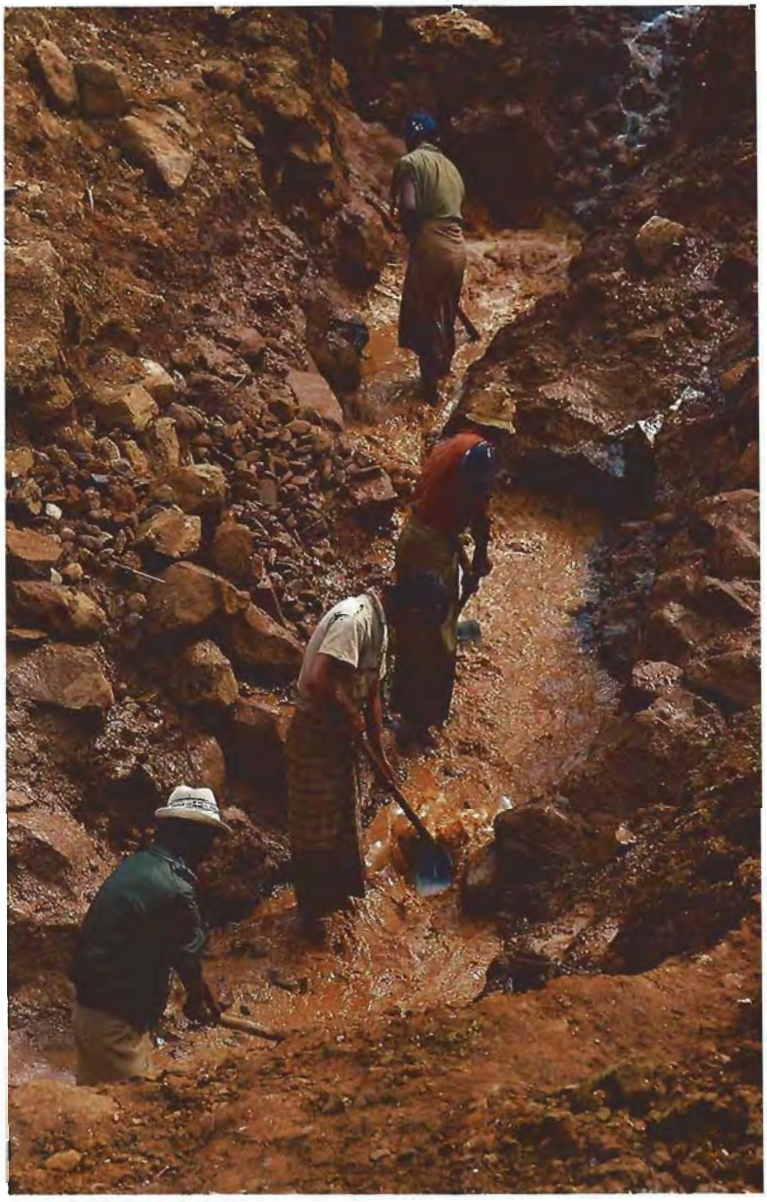


Figure 7. The Myanmar government receives 51.4% of the sale price on all "first-quality" stones recovered from joint-venture operations in the Mogok Stone Tract. The faceted ruby shown here weighs 11.55 ct; the rough crystals, ranging from 16.65 to 278.50 ct, have a total weight of 733.65 ct. Photo by Robert E. Kane.

MGE Mogok Gems Mining Department. All government mining in the Mogok Stone Tract is handled by MGE's subsidiary, the Mogok Gems Mining Department, which has several geologists and mining engineers on staff. Eight mines are currently being worked exclusively by the government: one for peridot and seven for ruby and/or sapphire. All are well-organized, mechanized operations that use various methods of mining such as ground sluicing, open pit, and underground tunnels into the host rock, depending on the type and nature of a particular deposit. The number of MGE-operated mines is limited only by budgetary constraints—additional deposits have been identified (MGE officials, pers. comm., 1991).

Joint-Venture Mining Contracts. On March 9, 1990, in an attempt to drastically curtail illegal gem mining, the Myanmar government announced the availability to Myanmar nationals of joint-venture mining leases in both the ruby and sapphire districts and the jadeite mining areas (*Working People's Daily*, November 20, 1990). All proposals, complete with the exact location to be mined and the amount of money being offered, had to be submitted by April 27, 1990.

From this initial offering, the government allowed 159 joint-venture projects to begin mining in June and July 1990. According to Yong (1990), the one-acre plots were all located within a total of 230 acres in the areas of Mogok, Momeik, Mattaya, and Thabeikkyin. Each approved operator reportedly paid at least "a six figure" amount (in Myanmar kyats). The highest price paid for a one-acre plot was 21 million kyats, or approximately US$3.5 million at the official exchange rate (*Working People's Daily*, November 20, 1990). Joint-venture mines range from the traditional techniques described below to more sophisticated open-pit and tunneling operations. Like the MGE mines, some of the joint-venture mines are mechanized and well organized.

All gems found at a joint venture must be turned over to the MGE for quality grading. First-quality rough must be sold through the MGE at jewelry shops or at the Gems, Jade, and Pearl Emporium held annually (in recent years, every February; in 1992, in February and October) in Yangon; lesser-quality stones are returned to the joint-venture operator after 10% of the value is charged as a mineral tax, and 50% of the value is paid to the MGE (*Working People's Daily*, November 20, 1990). From the sale of first-quality stones (see e.g., figure 7), the Myanmar government receives 32.4% for the Myanma Gems Enterprise, 10% for mineral fees, and 9% for handling charges; the joint-venture operator retains the remaining 48.6% (*Working People's Daily*, November 20, 1990; Yong, 1990). Before the sales are completed, the government will pay joint-venture operators in need of cash 30% of the value of their first-quality stones in Myanmar kyats. When the stones are sold for foreign currency, the joint-venture operators can repay the borrowed money and open foreign-exchange accounts at the Myanma Foreign Trade Bank (*Working People's Daily*, November 19 and November 20, 1990). No mining joint ventures between the MGE and non-Myanmar nationals are presently in operation, but MGE officials we spoke with in March 1992 said they were being considered.

Independent (Illicit) Mining. In Mogok, citizens have found gems even while digging water wells, leading to the mandate that anyone in the area who wants to dig in the earth must first seek approval from the government (*Working People's Daily*, November 20, 1990). Yong (1990) estimated, before the first joint ventures were established, that the government of Myanmar may have controlled as little as 5% of the total gem production, with the rest being smuggled to Thailand and India. MGE officials believe that the many joint ventures now in operation have greatly reduced the amount of illegal mining. On a small scale, however, simple washing of gem gravels with rattan baskets is still common in the streams and rivers in and around Mogok. Illicit miners also use the age-old mining methods described below to reach the gem-bearing gravels. Although we did not witness any unauthorized tunneling operations, we were told they do exist. Presumably, because of the noise the explosives generate, illicit mining of this type takes place in more outlying areas, away from government scrutiny.

MINES AND MINING TECHNIQUES

The mining techniques we observed include some that match descriptions written decades ago, others that involve contemporary variations on these traditional techniques, and a number that use new, more sophisticated, mechanized methods to extract the gems from deposits that may be deeply buried. It is some of the newer, larger operations that are successfully working the primary deposits.

Traditional Techniques and Modern Variations. The simplest method of mining throughout Myanmar, if not all Southeast Asia, is the washing of gravels along local streams and rivers (figure 8). However, a number of basic mining techniques are also used to remove or penetrate the overburden and reach the gem-bearing byon. Several reports have described the classic mining methods used at Mogok (see, e.g., George, 1915; Chhibber, 1934; Iyer, 1953; Gübelin, 1963; Keller, 1983; Hughes, 1990). According to Iyer (1953), three types of operations have traditionally dominated mining in the Mogok Stone Tract: (1) *twinlons*—small round pits, (2) *hmyawdwins*—open trenches through which gravels are washed, and (3) *loodwins*—the recovery of gravels from caverns produced by the chemical weathering of marble. The loodwins represent the richest deposits, with concentrations of gem rubies in the byon as high as 25% (Chhibber, 1934).

Twinlons. The twinlons described by Iyer (1953) were generally small round pits, just wide enough for a man to descend by putting his feet in niches on the sides. These might be as deep as 30 m, depending on where the miners encounter the gem-bearing byon layer or the water table. They are typically lit by mirror-like materials (some as simple as aluminum foil or a tin pan) strategically placed at the surface to direct sunlight into the vertical shaft. Once the byon is reached, the miners tunnel laterally into the gravel layer until air and light are no longer adequate, usually no more than 30 or 40 m. Commonly, more than one tunnel

Figure 8. The centuries-old method of washing gem gravels in and along streams and rivers is still commonly used to recover gems throughout the Mogok region. Photo by Robert E. Kane.

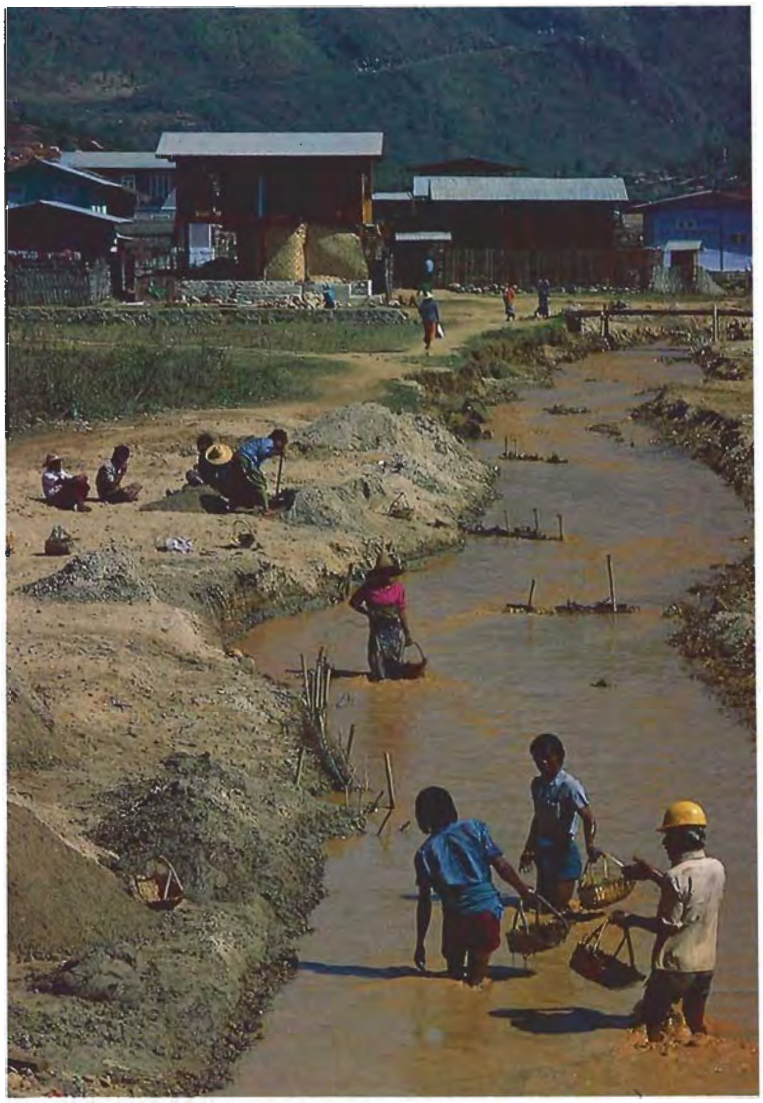


Figure 9. A variation of the classic twinlon *mining method, a* lebin *is a square pit reinforced with timber and large leaves. Note the use of aluminum foil to reflect light into the mine and of a hand-cranked winch to hoist dirt and gem gravel to the surface in tightly woven bamboo buckets. Photo by Holly Kane.*

will be dug into the byon from the main shaft to remove the gem-bearing gravels. Flooding usually forces a halt to mining during the rainy season.

Once gems have been found at any twinlon, miners will descend on the area and dig dozens of pits often quite close to one another. Typically each pit is operated by only three people—two who dig and a third who hauls up the overburden and byon.

We did not visit any circular twinlons but, around some of the joint-venture mines we visited, we saw a variation—a *lebin* (Halford-Watkins, 1932; Iyer, 1953). Although both twinlons and lebins are vertical shafts and have similar "lighting" systems, a lebin is square and reinforced by timber and large leaves (figure 9). Our guide explained that twinlons are used only in areas where the soil is compact enough to allow simple excavation; lebins are used where the soils are less cohesive.

Earlier reports (Halford-Watkins, 1932; Iyer, 1953; Gübelin, 1965) described the use of long bamboo levers or cranes to lift the dirt- or gravel-filled buckets. The miners we observed used a hand-hoist operation (again, see figure 9). The same reports also described and illustrated a clever indigenous hand pump that was used to remove water from the bottom of the vertical shafts. At the mines we visited, however, modern pumps—powered, for the most part, by diesel engines—were used to move water.

Hmyawdwins. Chhibber (1934) and Iyer (1953) describe hmyawdwins as "cuttings" or trenches dug into the sides of hills and steep valleys to expose the byon layer. After the overburden has been removed, the gem-bearing gravels and soil—which may lie more than 10 m below the original surface—are tossed into the trenches and water is used to force them down the slope to a flat circular "floor" or pit. Some of the trenches may require years to make when dug by hand. The critical water supply is obtained from various sources (streams, reservoirs, etc.) in the area through carefully engineered channels.

We visited a large open-cast mine that used what appeared to be the mechanics of a hmyawdwin at Yadanar Kaday-kadar (meaning "billions of precious stones"), approximately 23 km by road southwest of Mogok Township, just north of Kyaukpyatthat Village. The site is a natural basin approximately 200 m in diameter, with an area approximately 30,000 m^2, situated near the base of two hills, Thurein Taung and Katheyaike (Yadanar Kaday-kadar Camp, 1991).

MGE mining began at this locality on May 14, 1985. Before 1962, local miners had worked the basin, then known as Loke Khat Inn (meaning "difficult to work") because considerable overburden had to be removed to reach the gem-bearing gravels. In addition, the basin would fill with water during the rainy season.

Although excavation still takes place primarily by hand, the MGE now uses a truck as well as manual labor to move the larger rocks. They solved the problem of flooding by excavating a drainage tunnel—approximately 275 m (900 ft.) long and 1.5 m square—through the marble hillside to a valley beyond. Between visits in 1991 and 1992, the size of the mining operation had increased significantly.

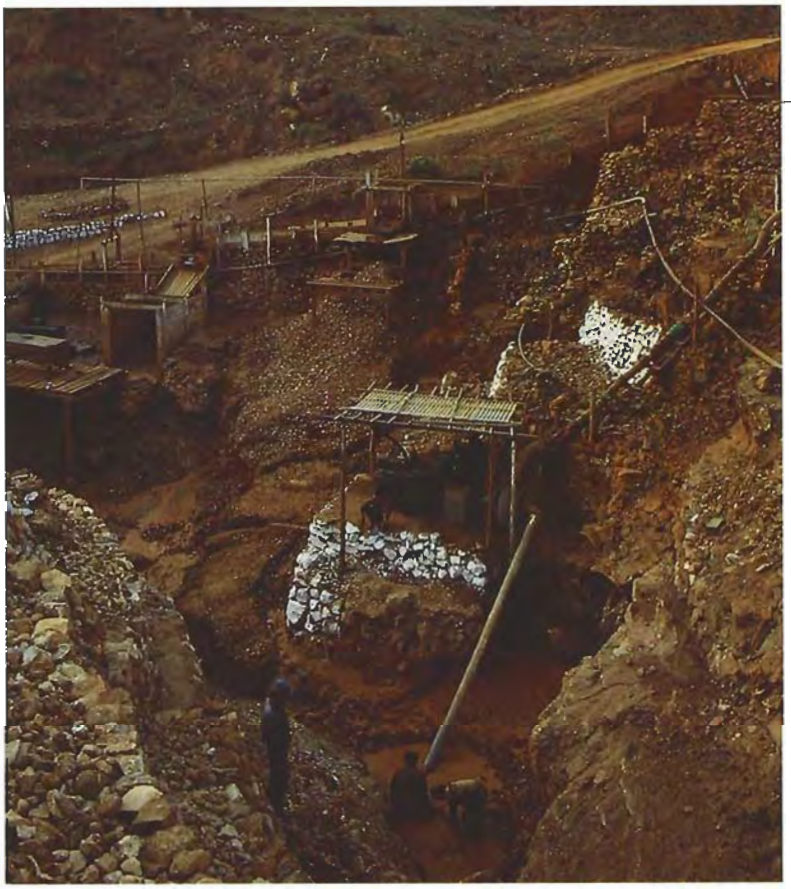


Figure 10. At a hmyawdwin, *as shown here at the Yadanar Kaday-kadar mine, the water and gravel that are collected are subsequently pumped upward for processing. The gravels are then washed and large rocks removed before they are sent through a series of sluices (shown running diagonally at top center) in which the denser materials are trapped and hand sorted. Photo by Robert E. Kane.*

Consistent with descriptions of hmyawdwin mining, a sloping trench had been cut into the side of the large open pit. Water was transported by pipe to the top of the trench, through which it flowed downward until it reached a smaller, flatter pit. Workers positioned along the slope used hand tools to attack the byon at the sides of the trench, forcing it into the flowing water (again, see figure 6), which softened the earth and separated some of the clay particles from the gem-bearing gravels. The water and gravels that collected in the pit at the bottom of the trench (figure 10) were then pumped into a hexagonal holding tank, where the gravels were washed with clean water and any remaining large rocks were removed by hand. The recovery process then followed a standard sluicing operation (again, see figure 10), and the remaining gem gravels were sorted by hand on site.

In both the 1990–91 and 1991–92 fiscal years, Yadanar Kaday-kadar was the most productive MGE mine (see table 1). Although the production is primarily blue sapphire, ruby and pink sapphire are also recovered (figure 11). Our hosts reported that, shortly before our 1992 visit, a 384-ct blue sapphire of "very good quality" was recovered from this mine, and even larger stones have been found in the past.

Loodwins. Gems are also recovered from "holes," often large and cavernous, in the marbles in which pockets of byon concentrate. As the main component (calcite) of the marble was dissolved by the action of groundwater, the heavy minerals—including corundum and spinel—in the marble were resis-

Figure 11. The combined open-cast/hmyawdwin operation at Yadanar Kaday-kadar produces blue and pink sapphires as well as lesser amounts of ruby and other gem materials, as shown by the loose stones here. The two specimens of sapphire in matrix are from the nearby Thurein Taung hard-rock mine. Photo by Robert E. Kane.

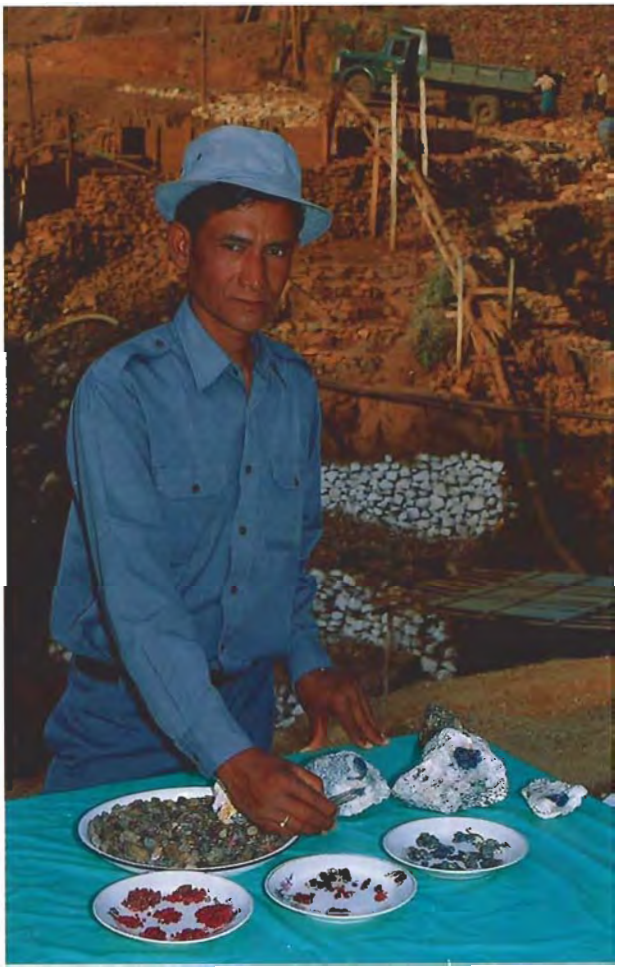


Figure 12. At the bottom of a 100-m-deep shaft at Than Ta Yar, workers use a hand winch to haul out buckets of waste material. The wide plastic tube to their left carries water and gem-bearing gravels to the surface for processing. Photo by Robert E. Kane.

tant to dissolution and movement, and tended to settle at the bottom of the cavem or in crevices or other natural cavities. Some of these marble caverns have been described by Iyer (1953) and others as running as deep as 60 m. To reach and remove the byon is often laborious and may be quite dangerous.

The joint-venture ruby mine Than Ta Yar, located about a kilometer from the Kyauk Saung mine (see below), appeared to be a variation of loodwin mining in which explosives were used to widen some areas of the naturally occurring marble openings. We entered the mine through a downward-sloping tunnel that led to a vertical shaft approximately 100 m deep, which we then descended on damp wooden ladders and scaffolding. At the bottom of the shaft, which contained about a meter of water, workers used a hand winch to haul out buckets of what appeared to be waste rock and debris (figure 12). A wide plastic tube carried water and gem-bearing gravels from a nearby concentration to a washing plant at the surface.

Within approximately 50 m of the mine entrance was a small but efficient recovery plant surrounded by bamboo and barbed-wire fencing for security. The water and gravel pumped from the mine shot out of the pipe and showered into a sluice. As the gravels traveled down the inclined trough, workers raked the larger waste rock over the side. The gravels were then processed in the sluicing/sorting operation typical of this area (see, e.g., the discussion of the MGE Central Washing Plant below).

The joint-venture leaseholder showed us two days' production that consisted of what appeared to be several thousand carats of predominantly rubies with some red spinels, moonstones, and undoubtedly other minerals. As noted above, deposits of this type in marble cavities are naturally concentrated and typically very rich. However, they are also very dangerous: A few days before our 1992 visit, we were told, several workers died in a cave-in at Than Ta Yar.

Contemporary Mechanized Mining at Mogok. Today, some mines are far more mechanized and efficient than any previous operations in the history of this famous mining area. Open-pit mining that was once done entirely by hand is now accomplished with bulldozers and backhoes, resulting in the removal of many tons of overburden and byon in a few weeks or even days. Historically rare at Mogok, tunneling operations are now being conducted at a number of primary occurrences.

Open-Pit Mining. This form of mining, also known as open cast, involves the removal of large amounts of overburden over a wide area to reach the layer of gem-bearing gravels. It is used for gem mining the world over, as well as in many areas of the Mogok Stone Tract. At some Mogok operations, like Yadanar Kaday-kadar, open-cast mining is used in conjunction with other methods such as hmyawdwins.

We visited another open-pit mine, Shwe Pyi Aye, that is located within the township of Mogok, approximately 1 km north of the MGE headquarters and adjacent to the Mogok ("Rubyland") Golf Club. The site is known for the high-quality rubies it has produced since it opened on December 11, 1987 (Shwe Pyi Aye Camp, 1991, 1992). A superb 5.56-ct oval faceted stone, known as the Crown of Mogok, was cut from a 10.95-ct crystal found at Shwe Pyi Aye.

At the time of the March 1991 visit (figure 13, inset), Shwe Pyi Aye—a secondary deposit—was being mined predominantly by hand. The 12- to 25-m-thick overburden had been removed from one area by bulldozer, and laborers were working the exposed byon layer, which was about 2–3 m thick. In addition to the mine manager, three engineers, and a geologist, 36

Figure 13. In 1991, the MGE open-pit mine at Shwe Pyi Aye was being worked by hand (inset); through the use of heavy earth-moving equipment, many tons of overburden had been removed by the time of the 1992 visit (main photo). The backhoe shown was removing byon, which was subsequently taken by truck to the Central Washing Plant. Photo by Robert E. Kane.

miners and other personnel were at the site. At the time of this visit, the bulldozer was not working in this area and mechanization consisted entirely of pumps for transporting gravel and water to the on-site processing operation.

The site had changed dramatically by the 1992 visit (figure 13). Significantly more overburden had been removed, expanding the diameter of the pit, and the bulldozer was working above the original site, stripping additional overburden. The recent earth-moving had exposed some old timbers, the remnants of pre-MGE mining in the area. According to the mine manager, military personnel had worked the site from 1965 to 1987.

Heavy equipment was also being used in the recovery of the gem-bearing gravel. A large backhoe removed the byon and loaded it onto a truck for shipment to the MGE's Central Washing Plant, as washing was no longer done on site. Gravels are transported from Shwe Pyi Aye to this recovery plant only during the dry season (mid-October to mid-May). During the rains, when this facility is not in operation, the gravels are stored on site in a holding pen. Because of the additional mechanization, 10 fewer men were working the mine during the 1992 visit (Shwe Pyi Aye Camp, 1991, 1992).

We also visited the MGE open-pit operation at Pan Sho, approximately 1.5 km north of central Mogok Township and about 500 m from the Central Washing Plant (see below). A bulldozer and excavator were used to remove first the overburden and then the byon. Dump trucks carried the byon to the Central Washing Plant for processing. In the 1990/1991 fiscal year (see table 1), Pan Sho was the second most productive ruby mine run by the MGE; it also produced significant amounts of blue sapphire and other gems.

Tunneling. The MGE is currently mining hard rock at two locations: Lin Yaung Chi is presently worked primarily for ruby, whereas Thurein Taung is mined strictly for sapphire. We also visited two joint-venture tunneling operations, Dat Taw and Kyauk Saung, both of which produce rubies. Pointed out, but not visited, was another joint-venture tunneling operation approximately 30 m from Thurein Taung.

MGE-operated Lin Yaung Chi is situated just

north of Mogok Township, on the east side of the Panlin Bernard road. The site is surrounded by the Lot Nye, Shwe Taing, Min Phaya, and Ye-kan Mountains. It has been worked for many years: Before MGE involvement, local miners recovered rubies by removing the topsoil and processing the gem-bearing gravels found in the weathered faults and fractures in the marbles. Rubies were first found *in situ* at Lin Yaung Chi in 1970, by local miners. Government mining began on April 18, 1977 (Lin Yaung Chi Camp, 1991, 1992).

At the mine, we were told that rubies are found in brecciated marble associated with veins in a fault zone. The veins are undoubtedly igneous; hence, the rubies associated with them would be of contact metamorphic origin. The brecciated fault zone in which the veins occur lies between a massive marble and a diopsidic marble. The tunnel runs in the fault zone between the two rock types. The area around Lin Yaung Chi is in a zone characterized by many faults, and the tunnel intersects at least one minor fault plane.

The main tunnel, which was started at a vein outcrop high on the hill, was about 150 m long in 1992; the slope distance from top to bottom was about 50 m. At the time of our visit, ruby was found only in the main-tunnel workings. A secondary shaft, called lateral cut number 2, ran perpendicular to the main shaft. It was wide enough to accommodate several people in places, was illuminated by electric lamps, and had steps cut into the ground for ease of access. Forty-seven people were directly involved in working the mine, in addition to the site manager.

The deposit was worked by conventional tunneling, using drilling and blasting. Holes were made with a jackhammer, loaded with explosives, sealed with mud, and then the explosives were detonated (figure 14). After blasting, rock was collected in baskets and taken by wheelbarrow from the mine to the sorting operation, just at the entrance to the main shaft. The broken pieces of rock were first sorted with screens of different-size meshes (figure 15), and then the rubies and other gems were picked out by hand and placed in a sealed metal cannister with a small, one-way opening. Three generator-powered water pumps were used to keep the tunnels from flooding and to supply water for the washing operation.

We were told that a ruby recovered from Lin Yaung Chi was cut into a 4.70-ct stone that sold at the February 1992 Emporium in Yangon ("Lot 1") for US$282,000 ($60,000 per carat). MGE officials reported that a secondary mine on the other side of this hill produced large sapphires exhibiting good habit

TABLE 1. Production[a] of ruby, sapphire, and other gem rough at the seven Mogok corundum mines currently operated by the Myanma Gems Enterprise (MGE), 1989–1992.

			1989–90[b] Actual production in carats[c]				1990–91 Actual production in carats[c]				1991–92 Actual production in carats[c]			
Name of mine	Year that MGE first started mining	Occurrence	Ruby and pink sapphire	Blue sapphire	Other gems	Total	Ruby and pink sapphire	Blue sapphire	Other gems	Total	Ruby and pink sapphire	Blue sapphire	Other gems	Total
Yadanar Kaday-kadar	1985	Secondary	2,113	34,463	1,139	37,715	17,098	185,735	30,005	232,838	17,746	102,116	3,184	123,046
Pan Sho	1989	Secondary	811	2,228	4,771	7,810	11,156	15,387	15,829	42,372	2,275	1,534	2,771	6,580
Lin Yaung Chi	1977	Primary	835	188	6,065	7,088	1,536	1,241	10,298	13,075	2,446	102	1,247	3,795
Shwe Pyi Aye	1987	Secondary	1,360	28	2,836	4,224	4,150	133	3,290	7,573	8,435	583	4,738	13,756
Pinku Taung	1989	Secondary	1,668	NR[d]	NR[d]	1,668	362	NR[d]	NR[d]	362	2,008	35	30	2,073
Thurein Taung	1987	Primary	NR[d]	134,209	NR[d]	134,209	NR[d]	24,111	NR[d]	24,111	NR[d]	17,653	NR[d]	17,653
Padamyar	1985	Secondary	3,739	11	1,435	5,185	3,921	58	830	4,809	6,188	60	220	6,468
Total			10,526	171,127	16,246	197,899	38,223	226,665	60,252	325,140	39,098	122,083	12,190	173,371

[a]*Statistics provided by the Myanma Gems Enterprise (MGE), Mogok Gems Mining Department, Mogok, Mandalay Division, Myanmar (Burma). The production figures provided here represent only a portion of the total gem rough produced annually in the Mogok Stone Tract. See text for a discussion of the many other mining activities in the Mogok area.*

[b]*Fiscal year ends March 31.*
[c]*Carat weight figures are approximate. No distinction is made between non-gem and facet- or cabochon-grade materials.*
[d]*NR = No production reported during this period.*

Figure 14. A major tunneling operation underway at the MGE Lin Yaung Chi mine involved the extensive use of explosives to reach the gem-bearing fault zone, that is, the primary occurrence of the gems. A jackhammer was used to drill holes, which were then packed with explosives, sealed with mud, and the fuse lit. Photo by Robert E. Kane.

as well as spinel, garnet, apatite, and green tourmaline (Lin Yaung Chi Camp, 1991 and 1992).

The second tunneling operation visited, the Thurein Taung mine, is located approximately 23 km west of Mogok Township. To reach the site, we first drove to the Yadanar Kaday-kadar mine and then walked approximately 1 km over a rough footpath. At this locality, where mining began on December 12, 1987, alkali-rich mafic igneous rocks (technically, urtites) have been intruded into marble. The sapphires are found *in situ* in these unusual igneous rocks and biotite-bearing gneiss. At the time of the 1991 visit, a staff of 25 were employed at this site. Drilling and blasting were used to tunnel into the rock along the sapphire-bearing vein (Thurein Taung Camp, 1991; "Role of the Gems Mining Department," 1991).

Located about 5 km northeast of Mogok Township, the joint-venture Dat Taw mine is reached by driving along a narrow dirt road, followed by a steep climb by foot that takes approximately one hour. The bright, white marble tailings are visible from quite a distance (again, see figure 5). Some of this very white marble is also exposed on the face of the mountain itself, where several tunnels are located at various elevations.

Figure 15. Just outside the entrance to the Lin Yaung Chi mine, the broken marble is passed through a series of screens. The large pieces are removed and sorted by hand in the screens on the left, while the smaller fragments continue downward through a series of sluices on the right, from which the gems are also recovered by hand. Photo by Robert C. Kammerling.

Figure 16. The 496.5-ct Nawata, later rechristened the SLORC, ruby is an example of the exceptionally large crystals recovered from Dat Taw. Photo by Robert E. Kane.

We entered through an excavated tunnel that leads into a natural marble cave that is as high as 10 m (about 30 ft.) in some areas. Tunnels have been excavated from this natural cavern, one of which we followed to an area that was being prepared for blasting.

This locality is known to produce exceptionally large rubies. Among these is the 496.5-ct crystal (figure 16) that was originally named the Nawata but was later rechristened the SLORC ruby (after the acronym for State Law and Order Restoration Council, the ruling government body). This crystal, recovered in early 1990, weighed 504.5 ct and measured 43 mm × 37 mm × 33 mm before it was trimmed (MGE catalog, 1990). It is considered a national treasure, and was depicted on a Myanmar postage stamp (Koivula and Kammerling, 1991). While at this mine, we were shown another unusually large crystal, although of lesser quality than the Nawata/SLORC ruby. According to the leaseholder, this crystal weighed 560 ct and was recovered March 19, 1992 (figure 17).

A number of joint-venture mines operate in the Kyauk Saung area, on the northwestern outskirts of Mogok Township. These mines, all of primary deposits, are located on one side of the access road, stretched out along approximately 1.5 km of a ruby-rich marble contact zone. Again, explosives were used to remove the hard rock and reach the gem-bearing zone. On the other side of the road, secondary, mostly lebin, mining was in progress.

RECOVERY

Kanase. We observed a variety of recovery operations at Mogok. The most rudimentary of these are performed by the *kanase*—traditionally women, although

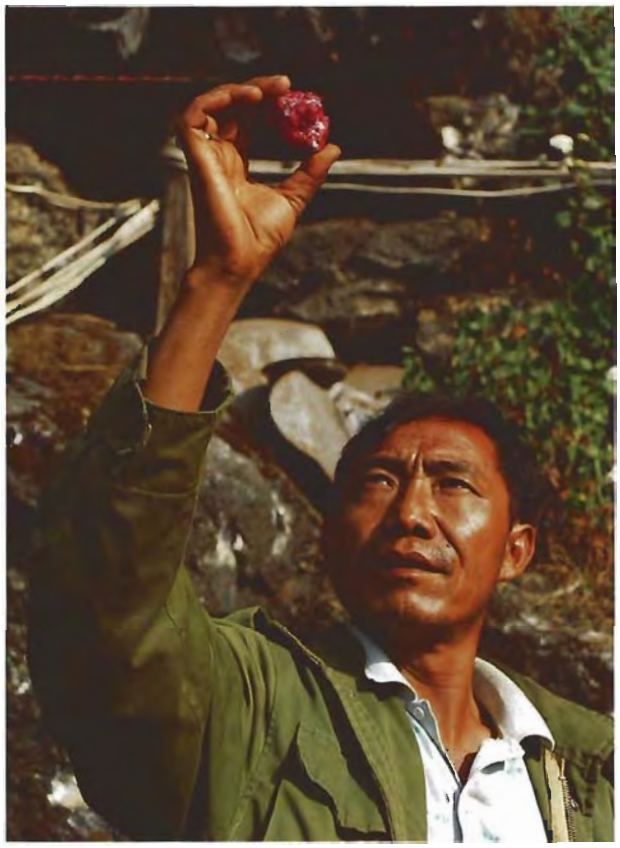


Figure 17. This 560-ct ruby crystal was found at Dat Taw on March 19, 1992. Photo by Robert C. Kammerling.

Figure 18. For decades, if not centuries, kanase *women have searched the discarded gravels at Mogok (here, at Than Ta Yar) for rubies and other fine gems overlooked in the original recovery operation. Photo by Robert C. Kammerling.*

Figure 19. Processing at the Central Washing Plant begins with trucks unloading byon from MGE-operated mines onto a large metal grate. Photo by Robert E. Kane.

we saw men as well, who work the discarded gravels and mine tailings in search of gems that were overlooked. At Than Ta Yar and throughout the gravel workings, the *kanase* could be found rewashing the discarded gravels (figure 18). At Kyauk Saung and other primary mines, they could be seen hammering on marble in the tailings piles. The "right" of the *kanase* to work the abandoned rocks and gravels in Mogok and keep any gems they find is centuries old and continues to the present day (see, e.g., O'Connor, 1907; George, 1915; Halford-Watkins, 1932; Iyer, 1953; Hughes, 1990).

Joint-Venture and Unlicensed Operations. As described above, the primary deposits are processed via a very simple method whereby the host marble is broken down and passed through screens of different-size meshes, where they are hand sorted.

In most of the secondary deposits, the gravels are either washed in baskets or, more commonly, processed in a series of sluices placed along an incline (see, e.g., figure 10). The heavier materials are trapped in the sluices, while the lighter materials pass downward. At each sluice, the gravels are checked for gems and then discarded.

Central Washing Plant. The most sophisticated recovery operation at Mogok is the Central Washing Plant, an MGE facility used to process gem-bearing gravels from the government mines. The plant, which began operation in 1989, has the capacity to process 100 tons of material a day (Central Washing Plant, 1991, 1992). From November 1989 through December 1990, the plant recovered a reported 7,471 ct of ruby, 7,851 ct of sapphire, and 8,054 ct of spinel. The largest ruby recovered at the plant weighed 21 ct, and the largest sapphire weighed 155 ct, before faceting.

Processing begins with the unloading of trucks filled with byon that has been removed from various MGE mine sites. During our 1992 visit, the Central Washing Plant was processing gem gravels from both the Pan Sho and Shwe Pyi Aye mines. A truck backs up to a concrete slab and dumps its load of byon onto a large metal grate (figure 19). High-pressure water cannons are then directed at the byon, washing the smaller, gem-bearing gravels into a concrete pen (figure 20). Large rocks are trapped by the grating and discarded by laborers. From platforms on either side of the pen, additional water cannons attack the gravels and wash the lighter soil down a wastewater chute, while the gravels pass through a series of vibrating screens and cement chutes. One of these screens separates out all stones over 2 cm, which are then collected and hand sorted on a nearby table.

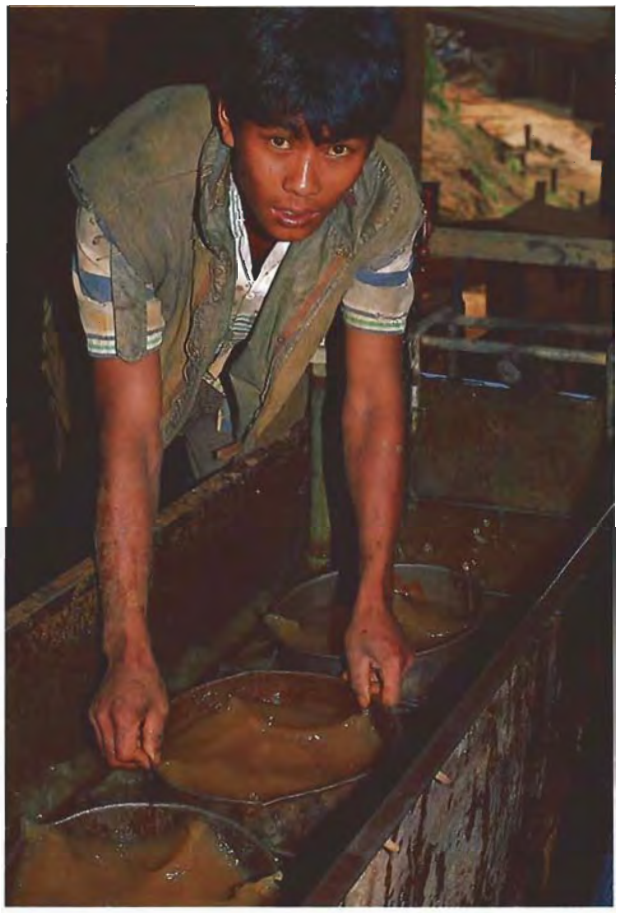
The smaller gravels continue downward until, near the end of the operation, they reach a large cement holding tank with a drain pipe. From this pipe, the gravel is collected into shallow, circular

Figure 20. High-pressure hydraulic cannons are next directed at the off-loaded material. Large rocks are trapped by the metal grating while the smaller, gem-bearing gravels are washed into a concrete pen. Photo by Robert C. Kammerling.

pans with fine-mesh-screen bases. These pans are then placed in a small vibrating jig for several minutes. The vibrating action causes the corundum and spinels (as well as other heavy minerals) to settle to the bottom center of the pans (figure 21). The pans are then taken to a sorting table, where they are skillfully and rapidly turned over so that the heavy minerals lie at the top center of the pile, from which they are sorted by hand (with either fingers or tweezers). The sorted gems (figure 22) are then placed in locked metal containers.

Although the different types of gems were mixed when placed in the locked containers on site, the sorters displayed for our benefit their skill in rapidly distinguishing the corundum from spinel on the basis of crystal morphology and nuances of color. This is in dramatic contrast to a practice used in Myanmar in the earlier part of the 20th century: immersion of the gem rough in a solution of thallium silver nitrate (specific gravity just under 4.00). In this solution, the spinels would float to the surface (Calhoun, 1929).

Figure 21. The vibrating action of the jig causes the denser minerals, including corundum and spinel, to settle in the bottom center of the pans. Photo by Robert E. Kane.



PRODUCTION, MANUFACTURING, AND DISTRIBUTION

Production. MGE officials provided statistics for the production of ruby, sapphire, and other gem rough from their seven current corundum mines at Mogok for the last three fiscal years (1989–90, 1990–91, 1991–92; see table 1). The MGE also reported total production of gem rough at all of the joint ventures from the beginning of joint-venture mining in June 1990 to February 1991 as 432,909 carats (pers. comm., 1991).

Figure 22. After processing in the vibrating jig, the gem materials are removed by hand. Here, the mine manager displays some of the production for that day in a metal tray. Photo by Robert E. Kane.

They indicated that the Dat Taw, Than Ta Yar, and Kyauk Saung operations were the most productive joint ventures in terms of total carats of gem rough. Specific information regarding the percentage of material that was facet or cabochon grade was not available.

Manufacturing. During the 1991 trip, a visit was made to a small cutting factory/school at the MGE headquarters in the town of Mogok. The 13 people who did the cutting were reportedly relatives of MGE mine staff. At the time of this visit, they were fashioning cabochon sapphires (some asteriated). The stones were first preformed on a motorized grinding wheel. The apprentices then finished the sapphires entirely by hand, using a series of wooden boards—some coated with silicon carbide (figure 23), others with diamond powders #120 and #320.

There are also many unauthorized cutting operations in Mogok. Reportedly, most of these operations still use the traditional pedal-driven benches described by Gübelin (1963, 1966b). Some rubies as well as sapphires (see, e.g., figure 24) are fashioned at a more modern factory in Yangon, where motorized grinding wheels and other types of modern equipment are used throughout the cutting process (figure 25).

Distribution. Thousands of carats of fine rubies, sapphires, spinels, and other gems are offered at the Gems, Jade, and Pearl Emporium in Yangon. At the 1991 Emporium, total sales of US$11,030,128 were reported ($6,925,251 in jade, $2,828,806 in pearls, and $1,276,071 in "gems"—primarily ruby, and sapphire, as well as spinel, with lesser amounts of stones such as diamond, peridot, zircon, aquamarine, garnet, and amethyst). At the February 1992 Emporium, total sales of $8 million were recorded ($4.5 million for jade, $800,000 for pearls, and $2.7 million for other Myanmar gems (Clark, 1992). The October 1992 Emporium produced more than $8.9 million in sales ($6.37 million for jade, $470,000 for pearls, $1.76 million for other "gems" and $300,000 for jewelry and jade carvings). Sales at the two 1992 Emporiums exceeded the single 1991 Emporium by almost $7 million.

JewelSiam reports that other sales are made by special arrangement with the government ("Neigh-

Figure 23. Some of the gem materials recovered from MGE-operated mines are fashioned at a small cutting factory/school within the MGE headquarters compound in Mogok. This young woman is using a traditional method—a wooden board coated with silicon carbide—to polish a sapphire cabochon. Photo by Robert E. Kane.

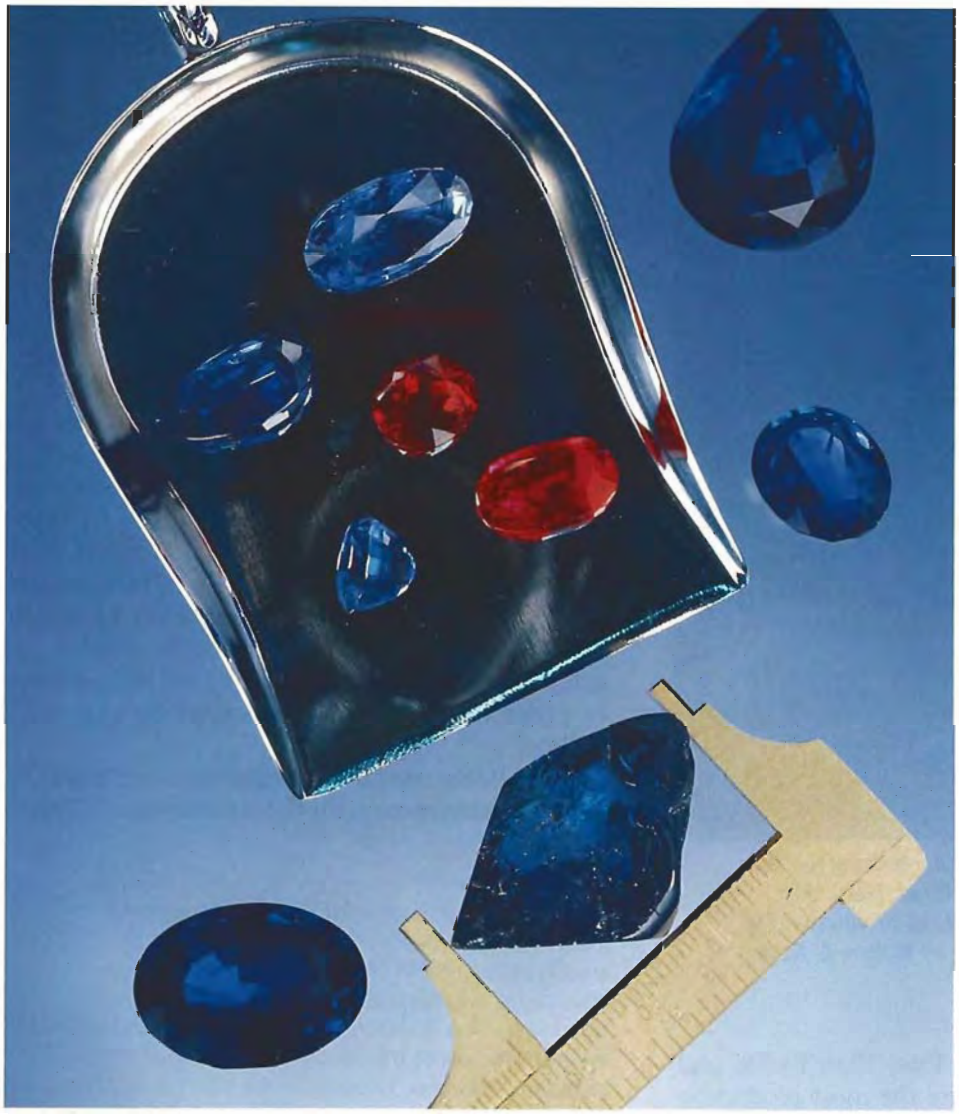


Figure 24. The end result of the MGE's operations: exceptional rubies and sapphires from the Mogok Stone Tract. Shown here are faceted rubies of 9.36 ct and 11.55 ct and sapphires ranging from 6.68 ct to 142.20 ct (the largest is the partially fashioned stone in the calipers). Photo by Robert E. Kane.

borly Burma," 1990). Dealers in Bangkok confirm that large numbers of gems continue to cross the Myanmar borders illegally. We observed Myanmar gem materials openly traded at the town of Mae Sot, on the Thailand side of the border with Myanmar.

OTHER RUBY OCCURRENCES IN MYANMAR

Known and as-yet-undiscovered ruby and other gem deposits are believed to extend far beyond what is commonly called the Mogok Stone Tract. Ruby is known to occur, and has been mined, in several other areas. In 1934, for example, Chhibber identified two important stone tracts in upper Burma in addition to Mogok—Nanyaseik (Myitkyina District) and the Sagyin Hills (Mandalay District)—and reported the existence of corundum-producing stone tracts in the districts of Kengtung and Mongmeik.

Based on conversations with various Myanmar Government officials at the 1986 Emporium in Yangon, Chikayama (1987e) reported that ruby min-

Figure 25. Traditional as well as more modern techniques are used to fashion gems at MGE headquarters in Yangon. The latter includes the use of motor-driven grinding wheels. Photo by Robert E. Kane.

ing was also taking place at Tha Fain Pin and Inyyauk. He noted as well the "new" locality of Blin-Thandaung in Karen State between Yangon and Mandalay, at about 19°N.

One of the more recent and potentially most important new ruby sources is the Nawarat Stone Tract, also referred to as Pyinlon, in Shan State (*Working People's Daily*, November 8, 1990; Aye, 1992). Immediately after the 1991 Emporium, one of us was shown a ring-set 5.25-ct faceted ruby of exceptional color and clarity that was subsequently christened the "Nawarat Tharaphu." This gem was reportedly cut from a 9.70-ct piece of rough that was recovered in the Nawarat Stone Tract on April 23, 1990 (Aye, 1992).

Another recent discovery is at Namhsa, in the northern section of Shweli and approximately 15 km north of the Nawarat Stone Tract. Rubies and other gem materials are being recovered from this area. Exploration and mining are being jointly carried out by the Geological and Mineral Exploration Department and the Myanma Gems Enterprise; actual mining began on September 26, 1990. Both of the above two sites—Nawarat and Namhsa—are near the border with the People's Republic of China (*Working People's Daily*, November 8, 1990; Aye, 1992).

An even more recent, and also very promising, discovery is the Monghsu Stone Tract. In an official notification dated July 16, 1992, the boundaries of this new locality in the Saihlian region of Monghsu Township, southern Shan State, were delineated in detail (*Working People's Daily*, July 18, 1992). In a subsequent press conference, MGE officials stated that exploratory extractions were being carried out by the government in a "one square mile block" of the new deposit. Among the materials recovered to date and displayed at the press conference were 1,162 rubies with a total weight of 1,181 carats. The exploratory production included facet- and cabochon-grade material as well as asteriated stones. The MGE also announced that 200 additional blocks would be designated in the new tract for joint-venture mining

Figure 26. This diamond-and-ruby bracelet, once owned by the late Mrs. Harry Winston, is an example of the exquisite jewelry in which gems from the Mogok Stone Tract have been set. The total weight of the 40 cushion-shaped rubies is approximately 81.25 ct. Jewelry courtesy of Harry Winston, Inc.; Photo by Michael Oldford.

CONCLUSION

The historic Mogok Stone Tract has long been known as the premier source of fine-quality rubies. During the 20th century, Burmese rubies became a staple of jewelry fashioned in the finest jewelry houses in the world, including Tiffany's, Cartier, Van Cleef and Arpels, and Harry Winston (figure 26). Not since Burma Ruby Mines ceased mining in 1931 has there been such a high level of organized activity at Mogok. The Myanmar government's renewed interest in developing this national resource has led to the use of new techniques (and new variations on old techniques) to recover the gem gravels, or byon. Pneumatic drills and explosives are now employed in the extensive working of hard-rock deposits. Recent advances include the establishment of a Central Washing Plant to process material from a number of mines.

In addition to modernizing mining techniques at MGE operations, the Myanmar government has initiated a more open development policy in licensing joint-venture operations with Myanmar nationals, making further resources available. All these factors, combined with recent discoveries of additional ruby and sapphire deposits, indicate that greater amounts of these highly desirable gems will be reaching the international markets.

Acknowledgments: The authors are grateful to officials of the Myanmar government and especially the Myanma Gems Enterprise for giving them the opportunity to visit Mogok and providing information on the mines. E. Joe Shein and the staff of Pan American Myanmar Ltd. were instrumental in arranging the 1992 trip to Myanmar and helpful during the visit. Fred Ward helped arrange the 1991 trip. Dr. A. A. Levinson, of the University of Calgary, provided information on the geology of the Mogok Stone Tract. Elise Misiorowski, of the Richard T. Liddicoat Library and Information Center, provided the historic information. Gustav Calderon, Cheryl Wentzell, and Maung Htut, of the GIA Gem Trade Laboratory, assisted in archival research. Holly Kane helped with the original draft. Thein Zaw Lwin and Myo Myint provided English spellings for Myanmar names. Tamara Green and Aye Aye Lwin assisted in the review process.

REFERENCES

Aye M.M. (1992) Opportunities at hand. *Working People's Daily*, September 26, p. 5.

Calhoun A.B. (1929) An important source of precious and semi-precious gems. *Engineering and Mining Journal*, Vol. 127, No. 18, pp. 708–712.

Central Washing Plant (1991) Myanma Gems Enterprise Mogok Gems Mining Department private government briefing report, February 3.

Central Washing Plant (1992) Myanma Gems Enterprise Mogok Gems Mining Department private government briefing report, March 20.

Chhibber H.L. (1934) *The Mineral Resources of Burma*. MacMillan and Co., London, England.

Chikayama A. (1987) Gemstone locality series — gem occurrences in Burma. *Gemmological Review*, (a) Vol. 9, No. 2, pp. 2–11; (b) No. 3, pp. 2–8; (c) No. 4, pp. 2–8; (d) No. 5, pp. 2–7; (e) No. 6, pp. 6–9; (f) No. 7, pp. 2–6.

Clark C. (1992) Ancient allure meets modern reality. *JewelSiam*, Vol. 3, No. 3, pp. 40–48.

Ehrmann M. (1957) Gem mining in Burma. *Gems & Gemology*, Vol. 9, No. 1, pp. 3–30.

George E.C.S. (1915) *Burma Gazetteer — Ruby Mines District, Vol. A*. As reprinted in 1962 by Government Printing and Stationery, Rangoon, Burma.

The Government of the Union of Myanmar, Ministry of Mines Notification No 62/92, Determination of the Monghsu Stone Tract. *Working People's Daily*, July 18, 1992.

Gübelin E. (1963) *Mogok, Valley of Rubies*. 16mm film, 65 minutes.

Gübelin E. (1965) The ruby mines in Mogok, Burma. *Journal of Gemmology*, Vol. 9, No. 12, pp. 411–425.

Gübelin E. (1966a) The ruby mines of Mogok, Burma: Part one. *Lapidary Journal*, Vol. 20, No. 3, pp. 418–422.

Gübelin E. (1966b) The ruby mines of Mogok, Burma: Part two. *Lapidary Journal*, Vol. 20, No. 4, pp. 522–525.

Gübelin E. (1977) Im tal der Rubine. *Lapis*, Vol. 2, No. 8, pp. 12–26.

Halford-Watkins J.F. (1932) Methods of ruby mining in Burma. *The Gemmologist*, Vol. 1, No. 12, pp. 367–373.

Hughes R.W. (1990) *Corundum*. Butterworths, London.

Iyer L.A.N. (1953) *Memoirs of the Geological Survey of India, Volume 82, The Geology and Gem-Stones of the Mogok Stone Tract, Burma*. Government of India Press, Calcutta, India, 100 pp.

Keller P.C. (1983) The rubies of Burma: A review of the Mogok Stone Tract. *Gems & Gemology*, Vol. 19, No. 4, pp. 209–219.

Keller P.C. (1990) *Gemstones and Their Origins*. Van Nostrand Reinhold, New York.

Koivula J.I., Kammerling R.C. (1991) Gem news: Postage stamp commemorates large Burmese ruby. *Gems & Gemology*, Vol. 27, No. 3, p. 182.

Lin Yaung Chi Camp (1991) Myanma Gems Enterprise Mogok Gems Mining Department private government briefing report, February 3.

Lin Yaung Chi Camp (1992) Myanma Gems Enterprise Mogok Gems Mining Department private government briefing report, March 20.

MGE Catalog (1990) *Catalog of the 27th annual Myanma Gems, Jade & Pearl Emporium*. Myanma Gems Enterprise, Yangon, Myanmar.

Meen M.A. (1962) Gem hunting in Burma. *Lapidary Journal*, Vol. 16, No. 7, pp. 636–656.

Neighborly Burma (1990) *JewelSiam*, Vol. 1, No. 4, p. 35.

Nordland R. (1982) On the treacherous trail to the rare ruby red. *Asia*, Vol. 5, No. 3, pp. 35–55.

O'Connor V.C. (1907) *Mandalay and Other Cities of the Past in Burma*. Hutchinson, London.

Press conference dealing with demarcation of Monghsu stone tract held. *Working People's Daily*, July 18, 1992, pp. 12, 6.

The role of the Gems Mining Department (1991). Myanma Gems Enterprise Mogok Gems Mining Department private government briefing report, February 3.

Schmetzer K. (1986) *Natürliche und synthetische Rubine-Eigenschaaften und Bestimmung*. Sweizerbartsche, Stuttgart, Germany.

Scott W.H. (1935) *American Consulate Report of Winfield H. Scott, Rangoon, Burma*. As published in condensed form by D.H. Howell, The ruby mines of Burma, *Gems & Gemology*, Vol. 2, No. 1, pp. 3–6, and Vol. 2, No. 2, pp. 31–34.

Shwe Pyi Aye Camp (1991). Myanma Gems Enterprise Mogok Gems Mining Department private government briefing report, February 3.

Shwe Pyi Aye Camp (1992). Myanma Gems Enterprise Mogok Gems Mining Department private government briefing report, March 20.

Thurein Taung Camp (1991). Myanma Gems Enterprise Mogok Gems Mining Department private government briefing report, February 3.

Working People's Daily (1990) November 8, 19, 20.

Wynne T.T. (1897) The ruby mines of Burma. In A.C. Claudet, Ed., *Transactions of the Institution of Mining and Metallurgy, London, Sixth Session*, Institution of Mining and Metallurgy, London, pp. 161–175.

Yadanar Kaday-kadar Camp (1991). Myanma Gems Enterprise Mogok Gems Mining Department private government briefing report, February 3.

Yong M. (1990) At Burma's door. *JewelSiam*, Vol. 1, No. 4, pp. 30–32.