# THE CHANGMA DIAMOND DISTRICT, MENGYIN, SHANDONG PROVINCE, CHINA

*By Peter C. Keller and Wan Guo-dong*

*Since the early 1960s, Chinese geologists have conducted extensive exploration for diamonds. One of their most important discoveries to date is the Changma kimberlite district in Shandong Province, which encompasses two pipes and eight dikes. The most active mine currently, the Victory No. 1, produces approximately 6,000 ct of diamonds annually, 20% of which are gem quality. The ore is processed locally and the rough stones are given a preliminary sort before they are sent to special factories for cutting. Large, good-quality stones have been recovered at Changma; the largest to date weighs more than 119 ct.*

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*All of the photos taken at the mine and treatment plant are by Dr. Keller.*



In recent years, the People's Republic of China has taken a keen interest in identifying and developing its gemstone resources. The most notable of these resources is their potentially important diamond deposits. Since the Chinese initiated a concerted diamond-exploration program in the early 1960s, at least six diamond-bearing districts have been brought into production. Four of these—the Yuan River, Changde County, in Hunan Province; Yingcheng in Hubei Province; and Linshu and Tancheng counties in Shandong Province—are secondary or alluvial. In the remaining two districts, diamonds are currently mined from kimberlites: the Binhai mine near Fuxian in Fu County, Liaoning Province, and the Changma kimberlite district in Mengyin County, Shandong Province (see the map in figure 1, Keller and Wang, 1986). The purpose of this article is to describe the little-known Changma kimberlite district, one of the most important in China, and specifically the mining and processing observed at Changma by the authors in September 1985.

Generally speaking, Shandong Province, in eastern China, exhibits extraordinary potential as a diamond producer. Including Changma, a total of 10 diamondiferous kimberlite pipes and dozens of diamondiferous kimberlite dikes have been identified in this mineral-rich province. These kimberlites are concentrated in three districts: Xiyu, Poli, and Changma. While kimberlite bodies in all three have been shown to contain diamonds, only a few of them are believed to contain sufficient quantities to be considered economical by today's standards.

The most important of the three kimberlite districts in Shandong Province, and perhaps in all of China, is the Changma, located near the town of Mengyin in Mengyin County. The Changma kimberlite district is about 14 km long and 2 km wide, and consists of two kimberlite pipes and a series of eight subparallel dikes which generally strike to the north-northwest. The two pipes are situated

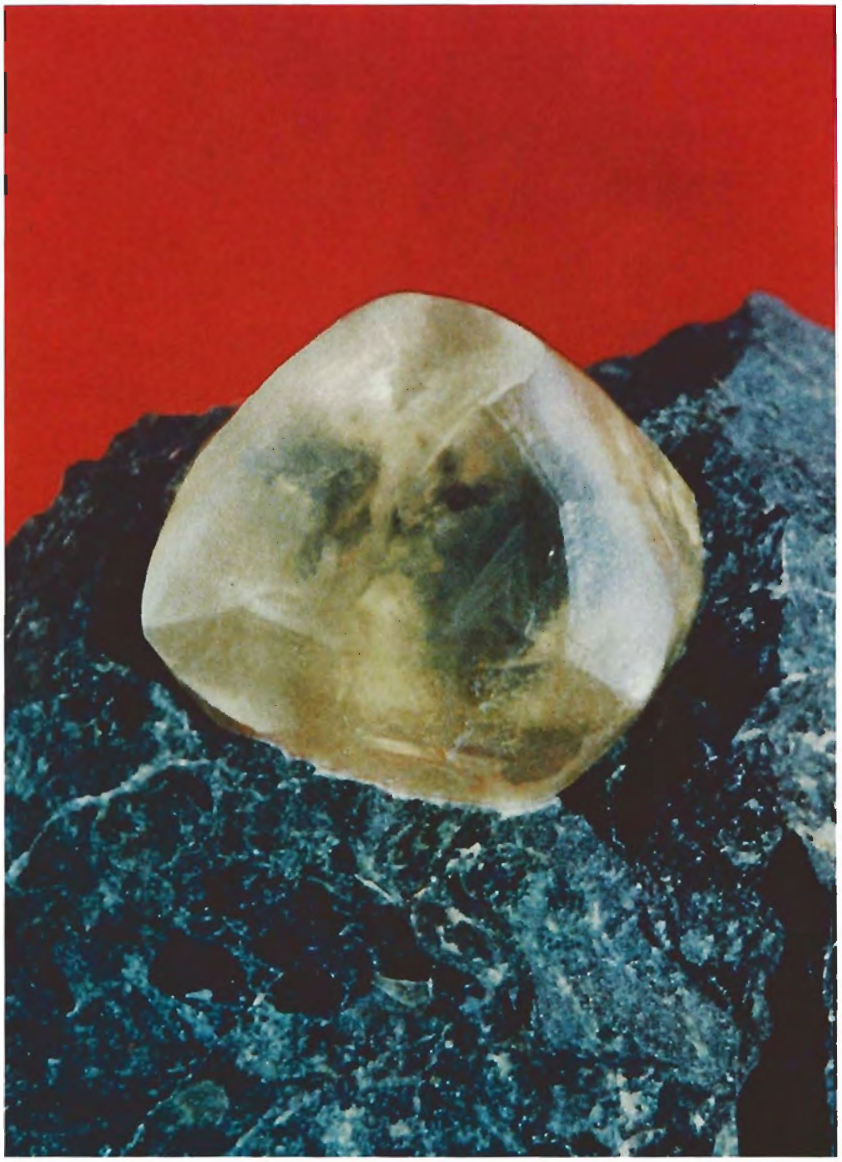

*Figure 1. The largest diamond recovered to date from the Victory No. 1 pipes is this spectacular 119.01-ct yellowish octahedron in kimberlite which is known as the Mengshan No. 1. The crystal, discovered in 1983, measured over 4 cm in diameter. Photo courtesy of the Shandong Bureau of Geology and Mineral Resources, Jinan.*

in the center of the series of dikes and have been given the collective designation of "Victory No. 1." The large open-pit mine that has resulted from the mining of the pipes is also called Victory No. 1, while the most important of the eight dikes have been designated Victory or Red Flag. The Victory No. 1 pipes and the Victory No. 2 and Red Flag No. 1 dikes have been the most significant producers to date.

While the quantity of gem-quality stones produced thus far has not been economically significant on a world scale, fine stones as large as 119.01 ct have been recovered (figure 1). Several rough diamonds recovered from Victory No. 1 and Victory No. 2 were examined at the mine office and are also described here.

## LOCATION AND ACCESS

The Victory No. 1 open-pit mine and its associated treatment plant (figure 2) are located approximately 14 km south of the town of Mengyin, in south-central Shandong Province. Mengyin is approximately 500 km southeast of Beijing (Peking).

Access is by train or airplane from Beijing to the Shandong Province capital of Jinan. The approximately 170-km journey from Jinan to Mengyin requires about four hours of travel by automobile over a well-maintained paved road through beautiful agricultural areas with extensive terracing. At Mengyin, the authors first stopped at a state-owned hotel where the papers authorizing the visit to the mine were cleared with local authorities. From Mengyin, the Victory No. 1

*Figure 2. A view looking west toward the Victory No. 1 open-pit mine. The structure in the foreground is a portion of the diamond treatment plant constructed in 1975.*

mine is an additional 30-minute drive over paved road. It is important to note that the Mengyin area is generally not open to foreigners and special government permission is required to visit the diamond deposit.

## HISTORY AND PRODUCTION

Alluvial diamonds have been found at the Chengjiafu mine, Tancheng County, in Shandong Province since the late 1940s. According to Green (1985), the Chengjiafu mine has produced stones as large as 96.04, 124.27, and 158.79 ct. (The largest stone is known as the Changlin diamond, which—contrary to Green's information—the authors were told came from neighboring Linshu County.) The discovery of the Changma kimberlites was the result of an intensive diamond exploration program that initially concentrated on sampling the region's river gravels. In August of 1965, after more than five years of work, a team of eight geologists from the Shandong Bureau of Geology and Mineral Resources discovered their first kimberlite in the form of a dike (Red Flag No. 1). The dike lay dormant until August of 1970, when mining was initiated and a small treatment plant erected. Red Flag No. 1 produced diamonds until it was shut down in 1981. During its 11 years of operation, the approximately 10,000 tons of ore processed yielded an impressive 20,000 ct of diamonds. The dike is now overgrown by peanut fields, and the treatment plant is in ruins.

Following the discovery of Red Flag No. 1, exploration continued in the area, and in December 1968 the Victory No. 1 pipe was located. However, mining of the pipe did not begin until October 1975, when a large treatment plant was constructed nearby. Today, diamond production appears to be limited to the now relatively large Victory No. 1 open-pit mine (figure 3). The nearby treatment plant processes about 120 tons of ore, yielding 100–150 ct of diamonds, each day. Of these diamonds, an estimated 20% are considered gem quality. After the diamonds go through a rough sort at the treatment plant, they are sent to Shanghai for detailed examination and cutting. Most of the gem diamonds are faceted at the state-owned Shanghai Diamond Factory which, according to Green (1985), employs about 200 cutters. Unconfirmed reports state that diamond cutting also takes place in the Shandong Province coastal city of Yantai (Shor, 1985) and at the collectively owned Beijing Diamond Factory, which employs approximately 100 workers (Green, 1985).

The primary organization within China for marketing and distributing diamonds is the National Arts and Crafts Import-Export Corporation

(Art China). According to Green (1985), domestic gem diamonds meet only 10% of the overall production capability of China's cutting and polishing facilities; the remaining 90% (150,000–200,000 ct of rough per year) are purchased in Antwerp. As recently as 1983, the Chinese were using all of the industrial diamonds they produced and were, in fact, forced to import significant amounts of diamond—358,123 ct in that year alone (Green, 1985)—to meet their growing industrial needs. Industry sources report that this situation has changed in the last three years: With the increased mining of diamonds and the capability of producing synthetic industrial diamonds, the Chinese are better able to meet their own industrial needs and are even offering synthetic industrial material for export (Bruce Komarow, Erwin Komarow, Inc., pers. comm., 1986). Industry sources also indicate that some exporting of domestically mined and manufactured gem-quality rough is being undertaken on a small scale through joint ventures with Western firms.

Official figures on annual diamond production from the Victory No. 1 mine were not available. However, a conservative estimate supports an average production of 600 ct of diamonds each week, or over 31,000 ct a year. About 6,200 ct would be of gem quality. According to Green (1985), China's total annual diamond production was estimated by the China Nonmetallic Minerals Industry Corporation at between 300,000 and 500,000 ct, of which about 15%—or 45,000 to 75,000 ct—are gem quality. Given the importance that the Chinese place on the Victory No. 1 mine, either production estimates for the mine are vastly underestimated, or the figures supplied by Green (1985) are exaggerated. In view of the fact that the Soviet Union produced an estimated 12,000,000 ct of diamonds in 1977, the Chinese production is, by any standard, in its infancy.

Diamonds of notable size have been found in China, however. In December 1977, a farmer from the Changlin Brigade of the Jishan People's Commune of Linshu County, south of Mengyin, discovered the 158.79-ct "Changlin" diamond while plowing a field. The yellowish diamond is China's

*Figure 3. A view looking east in the bottom of the Victory No. 1 open-pit mine. The smaller of two kimberlite pipes is apparent and is being mined using power shovels.*

*Figure 4. This brown modified octahedron measuring 2.47 cm in diameter and weighing 52.71 ct was found in Jiangsu Province. It is now in the collection of the Geological Museum in Beijing.*

largest. Since the discovery of the Changlin diamond, several other large stones have been recovered, mostly from the alluvial deposits south of Mengyin. The Geological Museum in Beijing has a 52.71-ct brown octahedron that was found just across the Shandong Province border in Jiangsu Province (figure 4). Later, we will describe in detail the 119.01-ct diamond in matrix from the Changma district.

## GEOLOGY AND OCCURRENCE

The diamond-bearing kimberlites of Shandong Province appear to be limited to the Menshan anticlinorium of the western Shandong (Huabei) platform. This is part of the Sino-Korean Craton (Zhang et al., 1984) and consists of Precambrian metamorphic gneisses, and Paleozoic and Mesozoic igneous and sedimentary rocks. It is bounded on the east by the north-northeast–trending Tanan or Yishu fault zone (a portion of the Tancheng-Lujiang deep fault belt) and on the west by the Liao Kao fault zone. To date, no kimberlites in Shandong Province have been identified outside the boundaries of the western Shandong platform. The kimberlites of Shandong Province, including the Changma kimberlites, are clustered along the crest of the Mengshan anticlinorium. Geologists from the Shandong Bureau of Geology and Mineral Resources believe that the anticlinorium was uplifted contemporaneously with kimberlite emplacement during the Jurassic period (Geological Bureau of Shandong Province, 1982).

The Changma kimberlite penetrates over 12,000 m of Taishan gneiss, dated at about 2,400 million years and predominantly consisting of a hornblende gneiss in the Changma area. Geologists from the Shandong bureau have further subdivided the gneiss into four units based on variations in mineralogy. While it is beyond the scope of this article to provide a detailed description of the stratigraphy of the Changma district, such can be found in the report of the Seventh Geological Exploration Team (1984). A brief synopsis is as follows: The Taishan gneiss is unconformably overlain by over 800 m of Paleozoic limestones, shales, and sandstones. Particularly important is a thin layer of sandy conglomerate near the top of the section which contains alluvial diamonds. The Paleozoic rocks are, in turn, overlain by approximately 1,000 m of red to greenish gray sandstone of Mesozoic (Jurassic?) age. The Mesozoic sandstones have been called the Mengyin group, and the entire section is capped by about 2,000 m of volcaniclastic rocks of probable Cretaceous age.

According to the report of the Seventh Geological Exploration Team (1984) and He (1984), the two Changma pipes intersect at a depth of 250–300 m to become one, known as the Victory No. 1 pipe. The eight subparallel dikes strike to the north-northwest, and vary from 100 to almost 1,500 m in length. The average width of the dikes varies from 0.1 m to 0.6 m.

## THE KIMBERLITE BODIES

The Victory No. 1 pipes are mined by the open-pit method, which provides good exposure of their form and size (figures 3 and 5). One of the kimberlite dikes, the Victory No. 2, outcrops as a highly serpentinized dike less than a meter wide, in the northeast and southwest walls of the mine (figure 6). In the bottom of the open pit, the two pipes are visible as an elliptical body almost 100 m across on the west, and a much smaller, "L-shaped" pipe about 15 × 65 m to the east. At the time of our visit in September 1985, most of the mining appeared to be on the smaller pipe.

The Changma kimberlites, bluish gray in color, range from a fine-grained to a highly por-

*Figure 5. Mrs. Wan Guo-dong, a member of the geological team that discovered the Changma diamond district in 1965, stands on a ledge overlooking the Victory No. 1 mine. Note the terracing in the background created by the open-pit method.*

*Figure 6. The highly serpentinized Victory No. 2 dike can be seen in the wall of the open-pit mine.*

phyritic rock. Locally, pyrope garnet is common enough to call the rock a porphyritic pyrope-kimberlite. Other important minerals include serpentinized olivine, phlogopite, chromite, ilmenite, and chrome diopside. Minor minerals include rutile, perovskite, anatase, magnetite, and apatite. Wherever the kimberlite has been exposed to the elements, it has undergone rapid weathering and takes on a green to yellowish color. The weathered kimberlite is extensively serpentinized, carbonatized, and silicified.

The kimberlite found in the Victory No. 1 pipe locally contains abundant breccia fragments of gneiss, limestone, sandstone, and other unidentified rocks. Small rounded mantle xenoliths (inclusions of mantle rock in the basalt) were also collected. Diamond concentrations in the pipes are said by mine officials to average one carat per cubic meter, which is comparable to that obtained at most other, well-known diamond deposits. Recovery estimates at the treatment plant appear to substantiate this figure.

*Figure 7. The diamond treatment plant is adjacent to the Victory No. 1 mine. The plant, which has been in operation since 1975, processes about 120 tons of kimberlite ore each day.*

The age of the kimberlites is still a matter of debate. The geologists working in the area contend that the kimberlites were emplaced during Jurassic time, basing their conclusions on field relationships, including the fact that older, Paleozoic limestone fragments, as well as fragments of Precambrian gneiss, have been found in the kimberlite. The Institute of Geochemistry, Chinese Academy of Sciences, in Beijing undertook potassium/argon whole-rock analysis of the kimberlites and found one age of 81–88 million years. Other ages, however, were placed at 341–530 million years (He, 1984). It is entirely possible that there may have been more than one episode of kimberlite emplacement in the region. The argument for an older (Precambrian) kimberlite age is somewhat substantiated by the presence of alluvial diamonds in the Paleozoic conglomerates.

## TREATMENT AND RECOVERY

The ore-treatment plant (figure 7), located approximately 1 km east of the Victory No. 1 mine, has been in operation since 1975. It processes about 120 tons of ore daily.

Kimberlite is brought to the treatment plant from the open-pit mine by dump truck. When the ore arrives at the plant, it is deposited through a series of evenly spaced rails known as a "grizzly," which allows only chunks of ore less than about 15 cm in diameter to pass into the treatment plant for preliminary jaw crushing (figure 8). Pieces of ore larger than 15 cm are removed and broken down by hand before going into the crusher.

After crushing, the ore is carried on a conveyor belt upward (figure 9) into a series of trommels, crushers, and screens which ultimately break down and sort the ore into sizes suitable for treatment in the water-filled rotary washing pans, where it forms a muddy slurry. The lighter rock fraction and water pass through an opening in the top part of the washing pan as it is stirred by a series of large vertical arms, while the heavier concentrate, including diamonds, is removed through an opening in the bottom of the pan.

After washing, the heavier concentrate is passed over a grease belt (figure 10). The diamonds, being water resistant, adhere to the grease on the belt, while mineral and rock fragments are washed

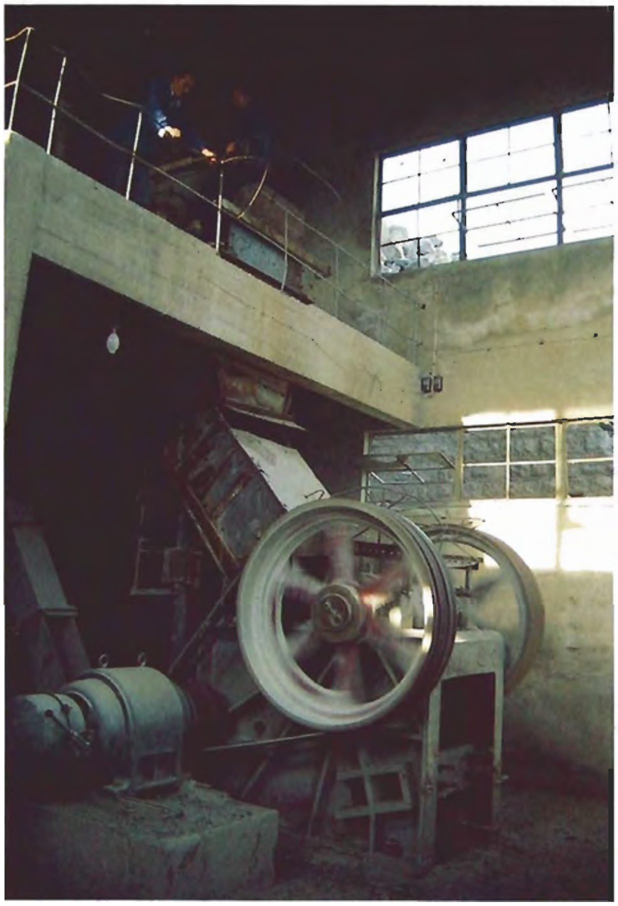

*Figure 8. Ore from the Victory No. 1 mine first passes through a 15-cm "grizzly" and jaw crusher.*

*Figure 9. After initial crushing, the kimberlite ore is taken by conveyor belt through another series of crushing and screening, to break the ore further for treatment in the rotary washing pans.*

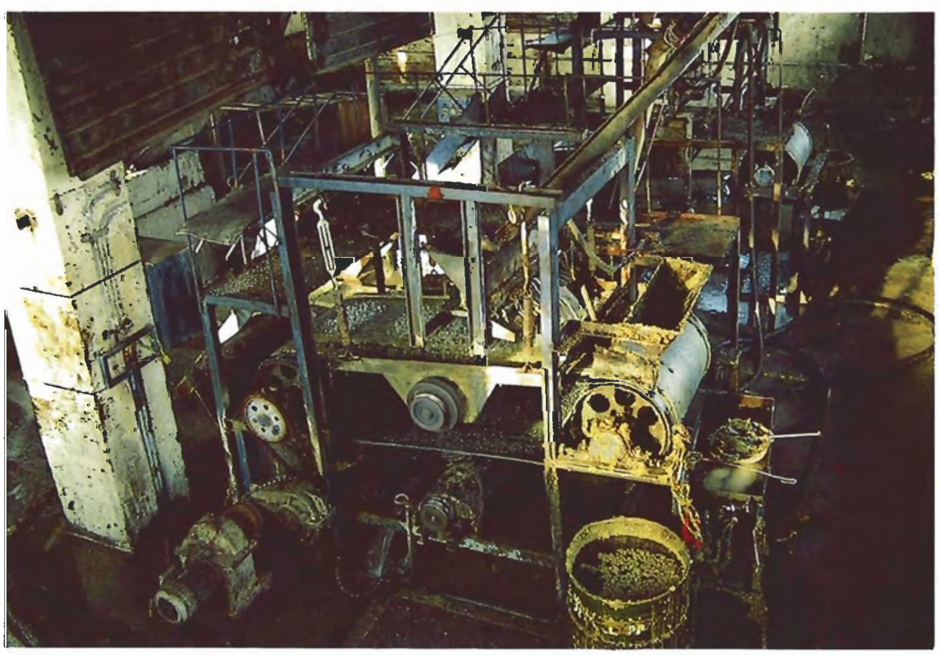

*Figure 10. The final step in the recovery process is to pass the heavy concentrate over grease belts. Diamonds, being resistant to water, stick to the grease while other material passes over the belt. Periodically, the grease is scraped off and boiled to free the diamonds.*

*Figure 11. The diamond concentrate recovered from the boiled grease is sent to the sorting room, where any remaining kimberlite material is removed and the diamonds are separated into initial grades. The sample shown here is representative of mine-run diamonds from the Victory No. 1 pipe.*

off by a steady stream of water. Periodically, the grease belts are scraped and the diamonds are subsequently freed from the grease when it is boiled in water. The diamonds are then sent to a sorting room to remove any remaining kimberlite debris and for a preliminary sort into industrial grade or gem quality (figure 11), the latter subsequently divided into 40 different categories based on color, clarity, shape, and size. Lastly, all of the diamonds are shipped to Shanghai for final grading and distribution.

### THE CHANGMA DIAMONDS

By international standards, the quality and quantity of the diamonds recovered from the Changma kimberlite are not particularly noteworthy. Most stones tend to be yellowish in color, and the average weight is less than one carat. As figure 1 shows, however, stones of considerable size have been recovered. This 119.01-ct diamond, discovered in 1983 during the initial crushing of ore from the Victory No. 1 pipe, is the largest recovered to date from the Changma kimberlite. The modified octahedron crystal was over 4 cm in diameter and, although yellowish, was relatively free of inclusions; it must be considered one of the finest matrix specimens of diamond ever found. Unfortunately, the diamond was removed from its kimberlite matrix and faceted in Shanghai. Its final yield in cut stones and their whereabouts today are unknown.

During our visit to the Victory No. 1 open pit on September 28, 1985, a 1.1-cm yellowish diamond octahedron in kimberlite was found in a pile of loose ore by one of our drivers (figure 12). This find provides some indication of the potential of this district. Six other significant diamonds were studied by the authors at the mine office (figure 13) and exhibited an interesting range in characteristics of the Chinese diamonds. The stones varied in color from an extraordinarily high-grade colorless to a particularly rich coffee-brown. The stones were predominantly modified octahedrons. Inclusions were difficult to study given the limited

*Figure 12. This 1.1-cm diamond in kimberlite was found on September 28, 1985, at the Victory No. 1 mine.*

*Figure 13. A collection of six rough diamonds examined at the Changma mine office. The stones ranged in weight from approximately 2 to 13 ct.*

gemological facilities available in the mine office; however, a pyrope inclusion was noted in one crystal, while the other stones appeared to be relatively free of inclusions. The six specimens ranged in weight from approximately 2 to 13 ct. The largest stone was a glassy octahedron that weighed 12.88 ct and measured 1.41 cm in diameter, of a color that would be relatively high on the GIA diamond-grading scale if the stone were faceted; this stone contained the pyrope inclusion noted above. The highest-color (comparable to E, F, or G on the GIA color-grading scale) stone was a rounded and highly distorted octahedron, almost 12 ct in weight and 1.4 cm in diameter, with, as indicated above, few if any inclusions. The other stones examined were a glassy macle, one small twinned octahedron, a fine glassy octahedron, and a 7.41-ct rich coffee-brown modified octahedron.

At the sorting table, the authors observed a much larger production sample (figure 11) and made additional notes. Modified octahedrons up to 1.3 cm in diameter were common, although most were less than 0.5 cm in diameter. Macles were present, but seem to be quite rare. The most common crystallographic forms were modified cube-octahedrons. The stones varied greatly in color, ranging from very high quality whites through the cape series to fancy browns and canary yellows. A few light pink diamonds were also observed. A more detailed study will be undertaken when a representative sample is received in the United States.

## SUMMARY AND CONCLUSION

Diamond mining in China is a relatively new endeavor. While some very fine and very large diamonds have been mined since the first stones were discovered in the late 1940s, the total production is small at this time. However, exploration continues throughout the Changma district and other promising areas of China, and outside assistance is being sought to make the mining and recovery operations more efficient. Given the vast size of China and the performance of the deposits uncovered to date, the long-term prospects for diamond production are promising.

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