# NOTES
# · AND ·
# NEW TECHNIQUES

## THE SAPPHIRES OF PENGLAI, HAINAN ISLAND, CHINA

*By Wang Furui*

*The sapphire deposit at Penglai, on Hainan Island, is potentially the largest in China. Gem-quality sapphires, at least one as large as 35.5 ct, have been found in alluvial gravels approximately 2 km southeast of the city of Penglai. Gem-quality zircon and a few pieces of what might be considered ruby have also been recovered in the course of the geologic study of this area, which has not yet been commercially developed. The average size of the sapphires is 2–5 mm. They are similar in appearance and gemological properties to sapphires from Australia, Thailand, and Kampuchea.*

*Figure 1. This 2.60-ct faceted blue sapphire is from the deposit near Penglai, on Hainan Island, People's Republic of China.*

Sapphire is one of the greatest potential gem resources in China today. To date, several major occurrences have been identified, including Mingxi, Liuhe, and Jiangsu Province. However, the deposit at Penglai, on Hainan Island in Guangdong Province, appears to be the most promising (figure 1). Although the Penglai sapphire deposit is still in the exploration stage, local government and Bureau of Geology officials feel that it will develop into a major gem field. Already, gem dealers from abroad are coming to Penglai to buy sapphires.

During the spring of 1987, the author had the opportunity to visit and study the sapphire deposit at Penglai. The information provided in this article is based on the author's observations during this visit, as well as on interviews with Penglai residents, various geologists, and members of the local government.

### HISTORY

Sapphires were first discovered by a farmer named Zhang Changde (figure 2) near the town of Penglai in the early 1960s. He found a beautiful stone on

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*Acknowledgments: Robert E. Kane, of the GIA Gem Trade Laboratory in Los Angeles, kindly provided the gemological information in table 1 and the photomicrographs.*

*Figure 2. Farmer Zhang Changde, who was the first to discover sapphire near Penglai, continues to search the alluvium for these valuable gemstones.*

the ground near where his animals were grazing. The stone was light blue, transparent, and luminous in sunlight. He picked it up and searched further until he found more blue stones. Handing them over to the local geologic team, he received one yuan and sixty fens (approximately US$1.00) as a reward. In 1982, a special exploration team was sent to the area to determine the extent of the gem field.

## LOCATION AND ACCESS

The Penglai mine lies approximately 2 km southeast of the town of Penglai, 30 km southwest of Wenchang, in the northeast part of Hainan Island. Access to Penglai requires a three-hour bus ride from Haikou, the capital of the island (figure 3). Although vehicles can easily reach the mining area during the dry season, heavy rains can make the roads impassable. The mine field covers about 25 $km^2$ in an area near the villages of Gaojin and Xinan.

The town of Penglai is an important hub in Hainan Island, with more than 40,000 inhabitants. The climate in this area is tropical, with considerable rainfall, and rice paddies represent the dominant agriculture. Penglai is famous for pineapples and produces much natural rubber and pepper.

## GEOLOGY AND OCCURRENCE

Detailed geologic study of the new mine field is still being done by a geologic team. The region's tropical climate has led to deep chemical weathering and massive erosion. Rock outcrops of any type are very rare, and the sapphires have been found only in alluvial gravels in the rice paddies and on nearby hillsides.

By examining the composition of the alluvium in which the sapphires have been found, geologists have determined that alkali basalt is the basic rock unit, with more than 10 alluvial strata of various thicknesses (Shi Guihua and Li Zhaosong, pers. comm, 1987). The basalt consists mainly of olivine basalt, dolerite, and pyroclastics, of Cenozoic age. The gravels also contain abundant pyrope garnet, black spinel, pyroxene, olivine, and zircon. A few pieces that might be considered ruby have also been recovered.

Field exploration indicates that the sapphire deposits extend to a depth of 1.5–3 m and are scattered in several layers. The sapphire occurrences in this area are similar to the sapphire deposits in Chanthaburi, Thailand (Keller, 1982), the New England district of New South Wales, Australia (Coldham, 1985), and the Mingxi beds in Fujian Province, China (Keller and Keller, 1986). These areas are also deeply weathered and have similar mineral associations. The corundum is either alluvial or eluvial.

## MINING AND PROCESSING

Although the deposit has not been extensively developed thus far, the geologic team has dug a number of trenches 30 × 15 m and up to 3 m deep, from which specimens of sapphire and other gems have been gathered. In addition, local residents sporadically dig for the gemstones in their fields, in ditches, and on the hillside. After a heavy rain, farmers and even government personnel go to the fields to look for gemstones. To process the gem gravels removed by the geologic team, a facility has been set up at the western edge of the mining area, next to the road. First, the gem gravel is poured into a pool and washed. The large pieces are removed by hand, while the smaller gravels are sieved with a mesh and the fine sand is thrown away. Next, the smaller pieces are placed on a driving belt which carries them to a big trough in which they are sorted into several different sizes by means of different meshes (in a manner similar to that used at the Mingxi sapphire deposit, described by Keller and Keller, 1986). Last, the various groups of gravels are sent to a separation room, where the gemstones are removed from the gravels by hand.

## DESCRIPTION OF THE GEM MATERIALS

The Penglai sapphires occur as small- to medium-sized hexagonal prisms and irregularly shaped pieces. The average size observed is 2–5 mm, although the geologic team working the deposit reports that gem-quality pieces as large as 35 × 33 × 32 mm (35.5 ct) have been found.

The sapphires range in color (in order of abundance) from dark blue (figures 1 and 4), blue, and greenish blue, to bluish green, green, and yellow-green, with the smallest quantity found in

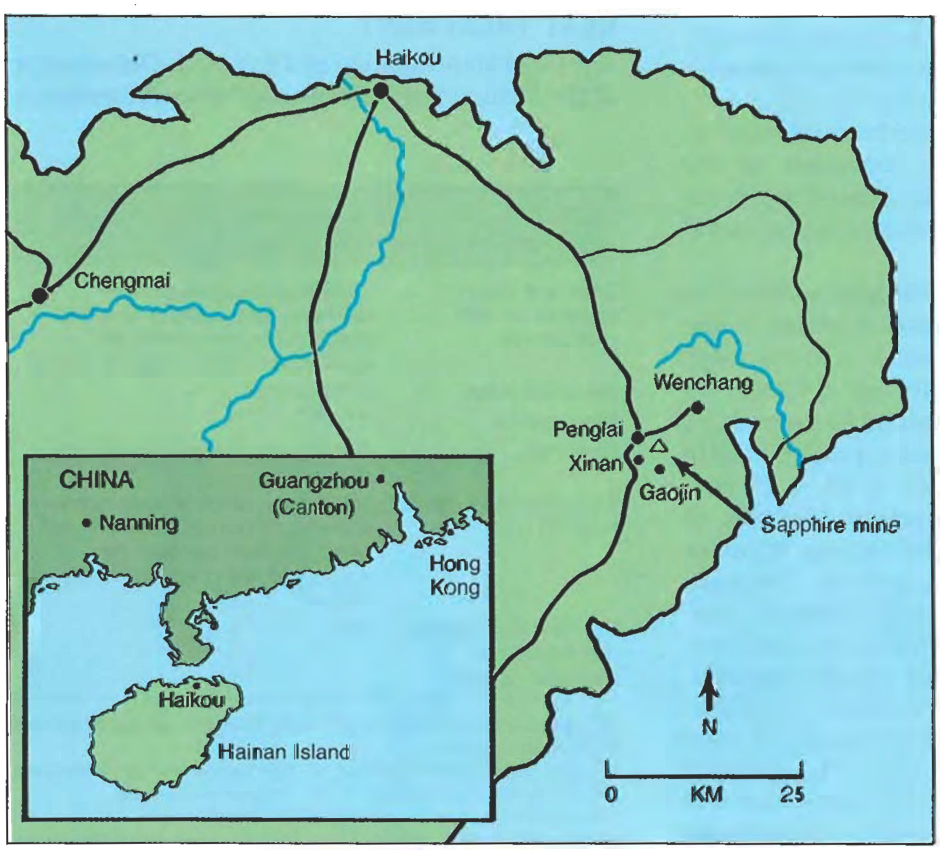


*Figure 3. The Penglai sapphire deposits cover an area approximately 25 km² that begins about 2 km southeast of the town of Penglai. Artwork by Peter Johnston.*

*Figure 4. This dark blue sapphire crystal found at Penglai weighs 13.69 ct. Photo by Shane McClure.*

light bluish green and purplish blue to blue-gray. Most of the sapphires are very dark and appear to contain large amounts of iron ($Fe^{3+}$).

Although no statistics have been released on the production to date, the consensus of the geologic community is that the Penglai sapphires are superior in quality and quantity to those found at Mingxi.

Zircon is another important gem material in this deposit. It appears to equal sapphire in the number of pieces found, although most of these pieces are smaller than the average observed for sapphires. The largest zircon found to date at this deposit, a brown-red tetragonal crystal (partially gem quality) that measures 42 × 20 × 12 mm (41.8 ct), is now at the Geological Museum of China, in Beijing. The Penglai zircons occur in purple, purple-red, brown-red, and red. The commercial potential of the zircons is limited, however, because most of the stones are very small and even the larger ones are usually heavily included.

Government geologist Shi Guihua reports that small amounts of what might be considered ruby have also been found at Penglai. The rounded pieces examined to date are approximately 2–3 mm and "rose" red. Unfortunately, insufficient material is available to draw any conclusions about the potential of the deposit for this variety of corundum.

## GEMOLOGICAL PROPERTIES

I was able to obtain seven gem-quality sapphires from the Penglai mine for examination. Although four were small, three weighed in the 10–15 ct range. Tests on these seven crystals, which ranged in color from purplish blue to blue-gray, revealed a specific gravity of 3.99–4.02, a refractive index of 1.761–1.769, and strong pleochroism. These properties are very similar to those reported for gem corundum found in Australia, Thailand, and Kampuchea. The properties for the 13.69-ct crystal shown in figure 4, as determined by Robert Kane of the GIA Gem Trade Laboratory in Los Angeles, are given in table 1. When Mr. Kane examined this stone for inclusions he found very strong color zoning and dense concentrations of "silk" (both in a hexagonal arrangement following the original crystallographic growth of the sapphire crystal), as evidenced in figure 5. There are also two distinctive types of solid crystal inclusions, illustrated here in figures 6 and 7.

## HEAT TREATMENT

The Gem Identification and Research Department of the Ministry of Geology and Mineral Resources

**TABLE 1.** Gemological properties of a sapphire from Penglai, Hainan Island, China.[a]

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|---|---|
| Color and visual appearance with unaided eye | Dark blue, nearly opaque in overhead light; areas of blue and bluish green, transparent to semitransparent in transmitted light[b] |
| Refractive index | 1.762–1.771 |
| Birefringence | 0.009 |
| Dichroism | Distinct yellowish green and dark blue |
| Absorption spectrum[c] (400–700 nm) | Very strong bands at approximately 450 and 460 nm that nearly merge, and a separate narrower band of strong intensity at approximately 470 nm |
| Reaction to long-wave and short-wave ultraviolet radiation | Inert |

[a]Properties listed were obtained from one 13.69-ct rough crystal with two large polished faces.
[b]Degree of transparency as well as color appearance is dramatically affected by the rough surfaces of the partly polished crystal.
[c]As observed through a hand-held type of spectroscope.

*Figure 5. A view of the base of the Penglai blue sapphire crystal shown in figure 4 (after it had been partially polished) reveals prominent angular growth zoning as well as "fingerprints" and stringers of rutile "comet tails." The growth zoning, evidence of the changes that took place in the chemical environment as the sapphire crystal grew, represents a combination of color zoning and varied concentrations of fine particles of rutile. Fiber-optic illumination; magnified 15×. Photomicrograph by Robert E. Kane.*

*Figure 6. The Penglai blue sapphire shown in figure 4 also contained a small brown crystal surrounded by a tension halo and trailed by a "comet tail." Oblique illumination; magnified 40×. Photomicrograph by Robert E. Kane.*

*Figure 7. This white crystal, set against a backdrop of dense rutile particles and color zoning, was also observed in the Penglai blue sapphire shown in figure 4. Oblique illumination; magnified 40×. Photomicrograph by Robert E. Kane.*

and the Laboratory of the Bureau of Geology and Mineral Resources in Guangdong Province have been experimenting with heat treatment to lighten these sapphires. Both laboratories obtained favorable results. On October 10, 1986, the newspaper *China Geology* reported that "the treated sapphires acquired a good medium indigo-blue color, good transparency, and generally were free of color banding. The chemical and physical characteristics of the treated sapphires are the same as the untreated sapphires." No precise details of the heat treatment method used have been revealed to date.

## PROSPECTS FOR THE FUTURE

Current operations at the Penglai mine are mainly for exploration and research. However, the Bureau of Geology and local government officials hope to establish an economic operation, including mining, treatment, faceting, and selling, in the near future. Chinese gemologists are enthusiastic about the results of prospecting efforts and the heat treatment of the gems.

For the Penglai mine to achieve its potential, I believe that a regular mining effort is needed. Efficient mining methods, such as a high-power water cannon to break up the alluvial material, would help increase production. The future prospects for sapphire (and zircon) mining at Penglai appear to be excellent.

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# CONGRATULATIONS!

The following readers received a perfect score (100%) on the second annual *Gems & Gemology* Challenge, which appeared in the Spring 1988 issue.

Joseph N. Autore, West Paterson, NJ; Bernice Backler, Pinetown, South Africa; Linda Anne Bateley, Kent, England; Rebecca Ann Bell, Joshua Tree, CA; Ernesto J. Belmont-Moreno, Mexico City, Mexico; Maria Lourdes Berre, Coral Gables, FL; Susan Bickford, San Francisco, CA; Linda Blum-Barton, Aiken, SC; R. F. Brightman, Fraser, Queensland, Australia; Arline E. Broad, Thames, New Zealand; Kim L. Brown, Overland Park, KS; Patricia A. Brozovic, Fairfax, VA; John Patrick Bugara, São José Dos Campos, S.P., Brazil; Ned Burns, Phoenix, AZ; Richard H. Cartier, Toronto, Ont., Canada; JoAnne Chisholm, Thornhill, Ont., Canada; Alice J. Christianson, St. Catharines, Ont., Canada; Yale Chussil, West Hartford, CT; Peggy Sue Clark, Bethesda, MD; Ron Conde, Santa Monica, CA; Fontaine F. Cope, Lamesa, TX; Patricia Corbett, Toronto, Ont., Canada; Robert Cotellesse, Cibolo, TX; Elizabeth Cressey-Plummer, Tucson, AZ; Florence May Davenport, West Paterson, NJ; Ellen J. Dean, Cambridge, England; Shane Denney, Jacksonville, IL; Mario Detrano, Canton, OH; Don Devenney, Victoria, B.C., Canada; Lorraine D. Dodds, Greensboro, NC; J. H. Eigenbauch, York, PA; Sandra Rose Engeberg, Los Angeles, CA; Michael T. Evans, Huntington Beach, CA; Ed Fasnacht, Logansport, IN; Roberto Filippi, Lucca, Italy; Danielle M. Finney, Palm Springs, CA; Wayne Neal Fleischer, Oxnard, CA; John R. Fuhrbach, Amarillo, TX; Rhoda Gheen, Foster, OR; Raymond Giroux, Dollard Des Ormeaux, Que., Canada; Elaine A. Gregory, Choctaw, OK; Sharon Griffith, Eagan, MN; Phyllis M. Gunn, Spokane, WA; Loreen N. Haas, Sherman Oaks, CA; Brian Halawith, Phoenix, AZ; William D. Hannah, Louisville, KY; Joop G. Heetman, Rotterdam, Netherlands; Graziella Hess, Marina del Rey, CA; Harold E. Holzer, Cape Coral, FL; Robert P. Hord, Laguna Park, TX; Alan R. Howarth, Braintree, MA; R. Fred Ingram, Tampa, FL; Mary Margaret Jackson, Dallas, TX; Michael A. Jaegel, Mountain Home, AR; Joyce G. Jessen, Western Springs, IL; Chris Johnson, Capistrano Beach, CA; Felicitas Johnson, Boulder Creek, CA; Mark. A. Kaufman, San Diego, CA; Elmer E. Kitchell, Tulsa, OK; Neil A. Kitzmiller, Columbus OH; Helen Klages, Orlando, FL; Kay Koeppel, Green Bay, WI; Charles M. Koslow, Phoenix, AZ; Jim J. Kovacs, Dartmouth, N.S., Canada; Peggy J. Kramer, Austin, TX; Don O. Kuehn, New Braunfels, TX; Ingrid Langdon, Corpus Christi, TX; Richard Larson, Drummond, MT; Bert J. Last, Sydney, N.S.W., Australia; Robert S. LeFevre, Jr., Virginia Beach, VA; Sandra MacKenzie-Graham, Burlingame, CA; Brent Malgarin, Bellevue, WA; Janet Rae Malgarin, Bellevue, WA; George F. Martin, Woodstock, VT; Warner J. May, Ozark, AL; Brenda Meier, Victoria, B.C., Canada; Daniel Meier, Victoria, B.C., Canada; Betty Sue Melton, Macomb, IL; Paul B. Merkel, Rochester, NY; Grenville Millington, Birmingham, England; Richard Moreno, Calabasas, CA; Richard L. Murray, Santa Clara, CA; Morris D. Neuman, Atlanta, GA; Ben Nibert, Mission, TX; Mary Olsen, Salt Lake City, UT; Mary D. O'Mara, Quincy, MA; Mark Osborn, Bothell, WA; James O'Sullivan, Boca Raton, FL; Philip L. Papeman, Chico, CA; Carole S. Parker, Portland, OR; Graeme Petersen, Wellington, New Zealand; Mike Peterson, Santa Monica, CA; Mary M. Poche, New Orleans, LA; Janice A. Prudhoe, Paris, France; Renee M. Pypiak, Monmouth Junction, NJ; Elizabeth L. Ralls, Spokane, WA; Michael W. Rinehart, Walnut Creek, CA; Morton Samson, New Haven, CT; Vora Sarju, Los Angeles, CA; Jack Schatzley, Toledo, OH; Pinchas Schechter, Miami Beach, FL; David A. Schultz, New York, NY; Corey Lee Shaughnessy, Sun City, AZ; Kathleen A. Smith, Toronto, Ont., Canada; Peter R. Stadelmeier, Levittown, PA; John Stennett, Temple, TX; John R. Swallow, Stratford, NJ; J. Brian Swirk, Kansas City, MO; Milan Tankosic, St. Catherines, Ont., Canada; Alice Rhodes Thie, Mediapolis, IA; Blair Tredwell, Advance, NC; Starla Turner, Redwood City, CA; Bruce William Upperman, Decatur, IL; Barbara J. Wallace, Lynnwood, WA; Joe C. Weng, Capitola, CA; P. A. Westrich, St. Louis, MO; Joseph R. White, Bessemer, AL; Colleen Witthoeft-Nayuki, Montreal, Que., Canada; Charles C. F. Yen, Taipei, Taiwan; Geraldine M. Zwack, San Francisco, CA.

Answers to the *Gems & Gemology* Challenge (see pp. 54 and 56 of the Spring 1988 issue for the questions) are as follows: (1) C, (2) C, (3) C, (4) C, (5) D, (6) A, (7) A, (8) D, (9) D, (10) C, (11) C, (12) A, (13) B, (14) B, (15) D, (16) C, (17) B, (18) D, (19) D, (20) B, (21) B, (22) A, (23) C, (24) D, (25) D.

Once again, the response to the Challenge was excellent. Congratulations also to the literally hundreds who received a passing grade on the exam. For those of you who were reluctant to try this time (and those who did), we will offer another opportunity (covering the 1988 issues) in the Spring 1989 issue.