The East African nation of Tanzania has great gem wealth. First known by Westerners for its diamonds, Tanzania emerged in the 1960s as a producer of a great variety of other gems such as tanzanite, ruby, fancy-colored sapphire, garnet, uhtu, tourmaline; to date, more than 50 gem species and varieties have been produced. As the 1990s begin, De Beers has reinstated diamond exploration in Tanzania, new gem materials such as transparent green zoisite have appeared on the market, and there is increasing interest in Tanzania's lesser-known gems such as scapolite, spinel, and zircon. This overview describes the main gems and gem resources of Tanzania, and reviews their history, geology, mining, and economic development.

HISTORY
Hominid habitation in this part of East Africa has been documented back to about 6 million years (members of the Leakey family were the first to establish the anthropological importance of Olduvai Gorge). The ancient Greeks knew of Tanzania, which they called Azania. The Bantu people, who...
Tanzania is perhaps best known for the transparent purplish blue variety of zoisite, tanzanite, which was discovered in the 1960s and named by Tiffany & Co. in honor of its country of origin. The tanzanite in this pendant weighs 96.42 ct; the earrings weigh a total of 34.29 ct. Jewelry courtesy of Tiffany & Co.

Currently make up the majority of Tanzania’s population of 26 million, apparently arrived in the region in the 1st century A.D. (Vidal-Naquet, 1987). Because of its strategic location, Tanzania has been a major trading center since the 9th century. About this time, the coastal regions were settled by Moslems from Arabia, Persia (now Iran), and elsewhere, who worked with the Swahili, a people of the eastern division of the Nansa. Together, they established trading centers such as Malindi, Mombasa, and Kilwa. The last, in southern Tanzania, controlled one of the ancient gold routes into the interior and later became the trading center for ivory, rock crystal (quartz), and slaves, as well as gold (Horton, 1987).

Portugal established control over the area in the early 1500s, but it was displaced by Great Britain in the 1600s. Then, in the 19th century, Germany gained control of the mainland, through treaties signed with inland chiefs, and established the German East Africa protectorate; following World War I, this became Tanganyika, under British mandate. Tanganyika gained independence from Great Britain in 1961 and three years later united with Zanzibar, a British protectorate since 1890, to form the United Republic of Tanzania. (Throughout this article we use the term Tanzania even though the country may have been known by another name at the time of the specific event being discussed. For example, when diamonds...
Although over 200 occurrences of gems have been identified in Tanzania, there are 18 main gem districts in this East African nation. These are indicated here with their most important gem minerals. The major geologic environments and rock types, along with key geographic features, are also noted. Most of the colored stone occurrences are in the Mozambique Orogenic Belt, while the diamonds occur on the Tanzanian craton. Map adapted from Malisa and Muhongo (1990), “Gemstone localities of Tanzania” map prepared by John Saul (1970), and “Tanzanian Known Mineral Occurrences” (map, 1982). Artwork by Carol Silver.
were first found, the country was known as German East Africa. Also, for the purposes of this discussion, Tanzania will refer exclusively to the mainland portion of the nation.

Until the late 1960s, gem mining in Tanzania was done primarily by individuals and private companies. In 1971, however, the government nationalized the first mines and established Tanzania Gemstone Industries (TGI), under the National Development Corp., to oversee them (Rwezaura, 1980). In 1972, the government created the State Mining Corp. (STAMICO), with TGI as its subsidiary. Because of all gem production was so poor during this period, in 1976 STAMICO began geologic as well as mining studies in an effort to improve this situation.

During most of the 1970s and into the 1980s, the government required that all mining be controlled by the state. All gem rough had to be bought through STAMICO and sold on the open market. Although foreign companies were discouraged from engaging in mining activity for many years, selective foreign investment has been allowed since the early 1980s. In 1985, the newly enacted Economic Recovery Program established provisions favorable to foreign investment (Northolt, 1990). Today, the government is issuing gemstone prospecting, mining, and “master dealer” licenses under which private individuals may prospect, mine, trade, and export gem minerals (“ICA presents...,” 1991) as well as offering important economic incentives.

REGIONAL GEOLOGY
East Africa has been the subject of formal geologic mapping and exploration projects since the late 1900s. Several major geologic environments have been identified: an Archean craton, orogenic mobile belts, coastal marine sedimentary deposits, rift valleys of various ages, recent (Tertiary) volcanism, and various types of surface deposits. Several of these environments contain gem occurrences.

The main geologic divisions in Tanzania (again, see figure 2) are: on the west, the Tanzanian craton, which is of Archean age (2,500–3,000 My [million years]); and, on the east, the Mozambique Orogenic Belt (1,200–450 My). A craton is an ancient, stable part of a continent that is composed of igneous and metamorphic rocks (see, e.g., Janse, 1992; Kirksey et al., 1991). The Tanzanian craton is surrounded by Middle- to Late Proterozoic (1,600–800 My) mobile belts, which are long, narrow crustal regions subject to geologic forces that resulted in processes such as folding and mountain building. These belts include the Ufendian to the southwest, the Kazungwe–Nkolole to the northwest, and the Usagaran to the east.

The Usagaran is the Tanzanian portion of the much larger Mozambique Orogenic Belt (orogenic belts are those that were mobile during major orogenetic stages), which extends under most of East Africa. It is about 250 km wide and runs for about 5,000 km from Madagascar and Mozambique in the south to Ethiopia and Sudan in the north. The rocks in this belt have undergone extensive metamorphism, plutonism, folding, and faulting. This belt has a complex history of several cycles of tectonism (major crustal movements) and at least three stages of regional and contact metamorphism, starting in the Late Proterozoic (1,200 My). These include high-grade metamorphic events that produced several granulite complexes (sets of metamorphic mineral assemblages resulting from high pressures and high temperatures, 650°–800°C). The latest thermal events were caused by the Pan-African Orogeny (800–550 My). East of the Mozambique Belt lies the coastal plain of Tanzania, which is underlain by Mesozoic (225–65 My) and more recent sediments.

The formation of granulites in association with major tectonic events is particularly important, because a wide range of minerals were subjected to heat, pressure, and hot fluids. During such geologic processes, not only are new minerals formed, but chromophores such as chromium and vanadium may also be remobilized from their original mineral hosts. Under favorable conditions, this results in the formation of gem crystals of unusual colors and phenomena, such as “chrome” tourmalines and change-of-color gemsets and sapphires (figure 3). Malaya and Mulungu (1990) outlined 17 major occurrences of granulate-type rocks and identified the eastern granulite complexes in the Mozambique Belt as having the greatest potential for gem materials (again, see figure 2).

MINING
Exploration and Techniques. Until recently, most exploration in Tanzania was based on prospecting using visual observation. In fact, major deposits have been found by local herdsmen familiar with gems (Key and Ochieng, 1991a). Traditionally, mining has been carried out with minimal mechanization. Most of the miners are itinerant laborers who work sporadically, depending on the climatic and political conditions. For example, mining is generally hampered...
from December to May, the wettest months of the year. Furthermore, miners sometimes leave one mining area for another that has just opened up or exhausted, resulting in the temporary abandonment of the first mine.

The only consistently large-scale gem-mining operation in Tanzania has been at the Nyewadi (Williamson) diamond mine. For a time in the 1960s, there were also large-scale operations at the Umba River deposits, but mechanization declined with the onset of nationalization. Although there are some operations that use heavy equipment, most gem mining in Tanzania today is small scale. The deposits mined may be either primary in the host rock or secondary (which includes both alluvial along rivers, or eluvial in the weathered zones above and/or adjacent to the primary deposits). Details relating to the type of mining associated with a particular deposit are provided below in the discussions of specific gem materials.

Small-scale mining in Tanzania—whether by private individuals, mining organizations, or private companies—is labor intensive. For example, in alluvial deposits along rivers such as the Umba and the Lukonde, miners shovel gem-bearing gravels onto screens and wash them in nearby stream waters (figure 4). In primary deposits like the emerald occurrence at Lake Manyara, low-energy explosives are used to break up the rock and then the material is sorted by hand. Only recently have backhoes and mechanized shaker tables again been brought into some of the more accessible mining areas. Today, modern equipment is found at the Mwahidi diamond mine, in some corundum-mining areas (figure 5), and in portions of the Merelani Hills tanzanite area.

It is appropriate to mention here how difficult it can be to ascertain the actual source for most gems. In East Africa, in particular, many gems mined in Tanzania are carried across the border into neighboring Kenya and especially to its cosmopolitan cities Nairobi and Mombasa. Consequently, gems from this area are commonly described simply as coming from East Africa rather than specifically from Tanzania. Even when specific sources are given by the seller, one cannot always depend on the accuracy of the information. An improvement in the reporting of localities is evident in the recent literature (see, e.g., Malisa and Muhongo, 1990; Key and Ochieng, 1991a). Still, we have taken this factor into consideration when evaluating information about specific gem materials.

Environmental and Health Concerns. The problems that face resource-rich but economically poor Tan-
Tanzania are staggering. The temptation is to meet the nation's economic needs by accelerating the exploitation of its mineral resources, including gemstones.

The long-term environmental impact could be severe. The reported use of water cannons to mine gems in some of the Umba River alluvial deposits, a technique outlawed 100 years ago in the U.S. because of the damage it caused, is one example (F. Ward, pers. comm., 1991). At the African Mining Congress held in June 1991, concerns were raised about the inappropriate use of cyanide to process gold at deposits in Tanzania.

Perhaps the greatest challenge is the health of the populace. Just as a cholera epidemic stopped all mining in northern Tanzania in 1978 and again in 1987, so the spread of AIDS is predicted by some to have a major impact on the miners as well as on the population as a whole. It is predicted that, by the end of 1992, there will be 5,000 new cases of the HIV virus each day in East Africa. Tanzania is receiving both financial and educational assistance from international agencies such as the World Health Organization and the World Bank, as well as from regional groups such as the Southern African Development Coordinating Council (SADCC; Jourdan, 1991). Today, warnings against ukitime (the Swahili word for AIDS) are already common at the gold fields. Unfortunately, the problem is compounded by the itinerant nature of the mining population (Bills et al., 1991). Such issues will need to be addressed as part of Tanzania's long-term planning for economic growth in general and for the exploitation of its gem resources in particular.
The Mwadui diamond mine, in northern Tanzania, is currently the largest, most sophisticated mining operation in Tanzania. The kimberlite pipe at Mwadui is about four times the size of the Premier mine. Photo courtesy of the Central Selling Organisation.

Geology. The Tanzanian diamond deposits have certain characteristics that make them unique. The most notable feature is that they occur in kimberlite crater deposits or in closely associated weathered gravels, as well as in the kimberlite pipe itself. Elsewhere in the world, kimberlite crater deposits (by definition, on the surface) normally have been removed by erosion. For example, kimberlites that occur on Precambrian shields (outcropping Archean cratons) have usually been eroded down to their roots and, thus, crop out in the form of small dikes or irregular-shaped pipes. However, the Mwadui kimberlite outcrop is a large (1600 x 1100 m) ellipsoidal crater that is as much as 360 m deep. The diamond deposits are associated with shaley sediments deposited in a crater lake, with breccias derived from a mixture of kimberlite and disintegrated gneiss bedrock, and with gravels derived from these two components and from the overlying calcrete. Because the kimberlite intrusions in Tanzania are relatively young (45-55 My, as compared to 90-120 My for most of the South African pipes), they have not been subjected to the extensive erosion experienced by their older counterparts. Consequently, secondary deposits are minimal.

Although Tanzania is literally peppered with kimberlites, many of them are barren of diamonds. Of those 44 that are diamondiferous, only a few are economically viable and these are all found in a belt on the craton (B. Janse, pers. comm., 1992).
Description of the Material. In addition to its high percentage of gem-quality near-colorless diamonds, the Mwadui mine is also known for producing pink (figure 7) and green diamonds. In 1954, for example, the Mwadui mine produced 105 ct of bright pink diamonds for every 100 tons of ore mined (“Background analysis . . . ,” 1986). The only reported properties for Tanzanian diamonds (from Mwadui) are consistent with those reported for diamonds from other localities (Tsai et al., 1979).

Current Production and Future Potential. Tanzania has produced 18 million carats of diamonds since the end of World War I. More than 90% of these came from the Mwadui pipe (“Tanzania’s latent opportunities,” 1992), with most of the remainder coming from the adjacent Alamasi mine. After reaching a peak of 926,758 ct in 1967, production at the Mwadui mine has declined to between 150,000 and 200,000 ct annually in recent years (Wilson, 1971; Notholt, 1990). The Mwadui deposit has yielded several diamonds over 100 ct; the largest piece of rough on record weighed 366 ct. Williamson presented the largest recorded Tanzanian pink diamond—54 ct in the rough—as a wedding present to then-Princess Elizabeth of Great Britain in 1947. The gem was subsequently cut to yield a 23.68-ct internally flawless round brilliant, now known as the Williamson Pink (Ballou, 1987).

In January 1992, the Tanzanian Ministry of Water, Energy, and Minerals signed a diamond-prospecting agreement with De Beers Centenary AG’s subsidiary Willcroft Co. and Tanex, a locally incorporated subsidiary of Willcroft (“Tanzania signs major diamond deal,” 1992). Using modern geophysical methods like remote sensing, they are scanning an area over 23,000 km² in northern Tanzania, south of Lake Victoria and west of Mwadui. The newly developed method of nickel thermometry, which measures the nickel content of the garnet and chrome indicator minerals found in heavy mineral concentrates from kimberlites, provides a relatively inexpensive and fast test to distinguish between barren and potentially diamondiferous kimberlites (Griffin et al., 1991). Given the number of diamondiferous deposits already known, Tanzania holds the promise for other economically significant diamond mines.

CORUNDUM
Ruby. Background. Rubies and pink sapphires are found in the northern, northeastern, and central eastern areas of Tanzania: Longido, Umba River Valley, and Morogoro (figure 8), respectively (again, see figure 2). Ruby was first discovered in the early 1900s near Longido Mountain, close to the border with Kenya. Following World War I, the German officer credited with making the original discovery founded the Tanganyika Corundum Corp. and began mining at the locality now known as the Longido (also the Mdarara) mine. Longido was operated sporadically until 1971, when it was taken over by the Tanzanian government and subsequently closed. Reopened in 1988, it is now operated by the Longido Gemstone Mining Company—a joint venture between Tofoco, a Swiss company, and Tanzania Gemstone Industries. The mine shaft is 3 m in diameter and 100 m deep. Explosives and pneumatic drills are used to penetrate the host rock, which is then brought to the surface using rail wagons (C. Garcea, pers. comm., 1992).
Ruby was discovered in the Umba River Valley in the 1950s. Umba Ventures, owned by George Papaeliopoulos ("Papas"), mined ruby and sapphire in an area of 2,350 acres from 1961 until it was nationalized in 1972 (Rwezaura, 1990). The government controlled the mines until 1982, when Gupta Exploration and Mining Co. was granted mining rights. In 1989, the Asia Precious Stones and Equipment Co. of Thailand obtained a license to mine in the area. This company formed a joint venture between Thai and Tanzanian groups—the Africa-Asia Precious Stones and Mining Co. (AAPSk—which eventually acquired exclusive mining rights to Umba ("Thai joint venture..."). 1989).

The Morogoro area began producing rubies in the 1970s. Although Morogoro is actually a large province that includes the town of the same name, to this day rubies from any part of this region are referred to as "Morogoro" ruby. In recent years, many new mines have been opened, including the Matombo, Kitenga, Epanko, Roiba, Lukande, Mayote, and Kibuwa (Hanni and Schmetzer, 1991; N. Barot, pers. comm., 1992). As discussed by Hanni and Schmetzer, there are often significant differences from one Morogoro mine to the next in the properties of the rubies found there. They speculate that the "Burma type" rubies and pink sapphires found mixed in parcels of spinel reportedly from Morogoro actually came from the Matombo mine (figure 9). The Marazi deposit in Morogoro has also produced some unusually fine transparent rubies (figure 10).

Geology. Pohl and Horlzel (1980) identified four types of primary ruby-bearing deposits in East Africa: (1) desilicated pegmatites (i.e., that have been depleted of silica as a result of the breakdown of silicates through reaction with magmatic fluids in ultramafic intrusions), (2) desilication zones at the contacts of the ultramafic and metasedimentary country rocks, (3) metamorphosed aluminous sediments (not economically important), and (4) marbles associated with red spinel. Key and Ochieng (1991a) maintain that only those ruby deposits that form in association with chrome-bearing ultramafics have economic potential.

One of the coauthors (A.B.) draws on his experience as former manager of the Longido mine to provide the following information about the geology of the northern localities. The Longido mine is in a "reef" of anyolite—a rock composed of opaque green zoisite with dark green to black amphibole that occurs with opaque to transparent ruby. This "reef," about one-half to one meter thick and approximately 500-600 m long, lies within a weathered peridotite that was intruded into a sequence of high-grade metamorphic rocks including marble (the second of the four types of primary ruby deposits listed above). The ruby is recovered as hexagonal crystals and irregular masses embedded in the green zoisite and/or black amphibole.

Smaller deposits of ruby in anyolite are found nearby, as well as at Lossogoni and Naberera, 60-70
Figure 9. Rubies (here, the two large crystals) have been found mixed with spinels in parcels from the Morogoro area. These pseudo-octahedral ruby crystals are rimmed by seven smaller spinel octahedrons, all from Morogoro. Photo by Shane McClure.

Figure 10. Spectacular rubies, like this 1-gram crystal and 0.87-ct pear shape, are being produced at the increasingly important Marazi deposit in Morogoro. Stones courtesy of Dr. Hoist Iznpipi and Pala International; photo © GIA and Tino Hammid.

Description of the Material. For the most part, the gemological properties of the various Tanzanian rubies are consistent with those of rubies from various other localities (Bank, 1970; Zwaan, 1974; Schmetzer, 1986). However, differences in chemistry, crystal morphology, and internal features have been reported, even for rubies that are believed to come from the same area (e.g., Morogoro; Hanni and Schmetzer, 1991).

Recent geochronological studies help explain the hues of rubies from the various Tanzanian deposits as compared to rubies from other localities. Although the chromium content of Morogoro and Umba rubies is relatively low in comparison to those from Myanmar (Burma), the amount of iron is similar to that in Burmese rubies and is considerably less than that identified in other Southeast Asian stones. Typical Morogoro-area rubies have the least iron, Longido has more, while Umba River specimens have the most (Hughes, 1990; Hanni and Schmetzer, 1991; Key and Ochieng, 1991b). Some of the Tanzanian rubies are heat treated in Thailand in an attempt to improve color and clarity. To date, such treatment has had mixed results (K. Schmetzer, pers. comm., 1992).
Current Production and Future Potential. Mining at Longido produces, at best, about one ton of ruby per month; only about 1% of this is cabochon grade and an even smaller fraction is facetable, with the remainder suitable for carving. Faceted transparent stones seldom exceed one carat. Reserves at Longido appear to be sufficient to maintain production at this level for several years.

In the 1960s and 1970s, miners at Umba occasionally found pieces of rough that yielded cut rubies as large as 20 ct (R. Naftule, pers. comm., 1992). Although official reports indicate that there is now virtually no production from the Umba River region, mining of both primary deposits and alluvial gravels continues, and is now done with the help of bulldozers and backhoes (figure 11). This level of activity, and the extent of gem trading in nearby villages and towns, suggests that economic quantities of gem-quality ruby and sapphire are being recovered, and such mining will undoubtedly continue in the future (Ward, 1991).

Currently, hundreds of miners are operating at the various localities in the Morogoro area (Msolo, 1992). Dr. N. Barot (pers. comm., 1992) estimates that the total production from these deposits is approximately 200 kg per month of gem ruby—mostly cabochon and carving grade.

Sapphire. Background. The Umba River Valley has yielded sapphires in virtually every color as well as change of color. To date, this is the only region that produces gem-quality sapphires, although there are reports of other sapphire occurrences in the vicinity and pink sapphires have been identified with rubies in the Morogoro area, as noted above. Sapphires were first discovered in the 1950s, in alluvial gravels of the Gerevi Hills north of the Umba River (Solesbury,
Figure 13. The Umba Valley is also noted for its production of color-change sapphires. This 8.74-ct sapphire is blue in day or fluorescent light and purple in incandescent light. Courtesy of S. L. Dillon; photo © Tino Hammid.

1967). As mentioned above, Umba Ventures was formed in 1961; they worked the nearby primary deposit as well as the alluvial deposits (Sarofim, 1970). As with the other gem deposits, mining was halted for much of the 1970s and early 1980s, but activity resumed in 1986.

Geology. At Umba, the sapphires—like the rubies—formed in association with pegmatite veins that cut a serpentinite body in the Umba River Valley metasediments (Solesbury, 1967). Today, the miners are working secondary deposits almost exclusively. The main mine now extends to 100 m below the surface, with tunnels radiating from the primary shaft on the gem-bearing levels (N. Barot, pers. comm., 1992; again, see figure 9).

Description of the Material. For the most part, the gemological properties reported for Tanzanian sapphires overlap those of sapphires from other localities (Webster, 1961b; Bank, 1970; Zwaan, 1974; Schmetzer, 1986). They are most notable for their great range of colors: colorless, violet, purple, blue, green, orange, yellow, yellow-orange, red-orange, pink, parti-colored, and change of color (figure 12). The parti-colored sapphire crystals tend to be pale in the center and have a deeper hue around the edges (Pough, 1971; Bridges, 1982). Many of the Umba sapphires exhibit change of color such as greenish to grayish blue in day or fluorescent light and deep purple to purplish red in incandescent light (figure 13). This unique range of colors is caused by variations in the proportions of the chromophores chromium, iron, manganese, nickel, titanium, and vanadium (Zwaan, 1974; Schmetzer, 1978).

Alluvial sapphire rough is usually found as rounded pebbles that produce stones of one carat or less. However, faceted stones as large as 40 ct and cabochons up to 90 ct have been cut from pieces of rough weighing hundreds of grams (R. Natulé, pers. comm., 1992).

Some members of the trade label Umba’s orange sapphire “African padparadscha” (figure 14), although the trade name padparadscha is usually restricted to the delicate pinkish orange Sri Lankan sapphire. In the past, orange sapphires did not meet the generally accepted criteria for “padparadscha” (Crowningshield, 1983; Hetn and Bank, 1992). However, East African sapphires with the more classic hues of padparadscha were seen at both the 1991 and 1992 Tucson shows.

Some of the pale sapphires are being heat treated in Thailand. Although all of the stones will be affected, the resulting color is often not commercially desirable (K. Schmetzer, pers. comm., 1992). The GIA Research Department heat treated three orange-pink sapphires from the Umba River region in a strongly reducing atmosphere, at 1700°C, for 18–21 hours.

Figure 14. The orange sapphires from Umba are distinctive for their saturation. Here, the orange rough is 3.80 ct and the cut stone is 1.04 ct. Courtesy of Don Clay; photo by Robert Weldon.
Figure 15. The Umba Valley sapphires reportedly do not respond to heat treatment as well as sapphires from some other localities. These sapphires from the Umba Valley were cut and the left half of each heated to provide some idea of the extent of the change produced. Stones and experiment courtesy of the GIA Research Department, photo © GIA and Tino Hammid.

Figure 16. The earliest variety of zoisite seen in the gem industry was the opaque green material that commonly occurs with ruby. It is a superb carving material, as illustrated by this ruby field mouse sitting on a green zoisite leaf. The carving—actually made from a single piece of ruby on zoisite—measures 45.13 mm high by 62.64 mm wide by 55.72 mm deep. Carving by Gerd Dreher, courtesy of Silverhorn, Santa Barbara, CA; photo © GIA and Tino Hammid.
of Tanzanian deposits until nationalization was started in 1971. The supply of tanzanite was sporadic until 1988, when the government temporarily opened the area and 20,000 miners descended on it. Working day and night, they dug hundreds of pits and recovered many thousands of carats of tanzanite. In late 1990, however, the government sought to establish greater control over the number of miners and the flood of tanzanite into the world market. Ultimately, the Tanzanian army was deployed to remove the miners and patrol the locality (Fedeman, 1991).

The government has since divided the tanzanite area into four sections, or blocks, and awarded mining contracts for each block to a different joint venture (see A. Suleman’s report in Koivula and Kammerling, 1991c). Today, all are being mined and are beginning to be mechanized. The government also marked out several small blocks southwest and northeast of blocks A and D, respectively, and has already invited offers from Tanzanian firms and individuals.
Geology. Tanzanite is found in both primary and secondary deposits. Malina (1987) describes the primary tanzanite deposits as occupying the crest of the large Lelatama fold, which is composed of metamorphic rocks (e.g., dolomite marbles, graphitic gneisses, and schists) and is separated from the surrounding plateau by large faults. Hydrothermal solutions injected into local faults and fissures reacted with the bedrock to begin the tanzanite mineralization. The gneisses at Merelani were folded during the many stages of movement that followed. As a result, tanzanite—sometimes associated with green grossular garnet—is most commonly found in cavities in the metamorphic rocks or at the contact with quartz veins in the hinges of folds that can be tens of meters wide.

Description of the Material. One of the most notable features of tanzanite is its strong pleochroism, which is usually grayish blue, purple, and brown, green, or yellow. Red replaces brown in some crystals (figure 18; see also A. Bassett, as reported in Koivula and Kammerling, 1991b). Most of the gem-quality tanzanite recovered appears brown face-up which can be the color in approximately 95% of the purplish blue tanzanites on the market today has been produced by heating the crystals to approximately 600°-650°C, which results in a change in the valence state of the vanadium (V^3+ to V^4+). Anderson, 1968; R. Naftule, pers. comm., 1992) and converts the brown (or yellow or green) pleochroitic color to blue. The extensive mining in recent years has produced unusually large quantities of tanzanite as well as extremely large crystals, some well over 100 grams. Small quantities of transparent zoisite crystals are also found in other colors: greenish blue, green, yellow, and pink, as well as violet to reddish purple, colorless, change of color, and bicolor (Barot and Boehm, 1992). R. Kane and R. Naftule, pers. comm., 1992; figure 19). The most significant recent development has been the commercial production of transparent green zoisite (Barot and Boehm, 1992). Found at Block B, gem-quality pieces as large as 19 grams have been recovered from this primary deposit. The color ranges from a dark petroleum-like green to yellowish (“olive“) to bluish green to green to a greenish blue. The “purity“ of the green depends on the amount of chromium relative to vanadium present in the stone. “Pure” green stones show more chromium than vanadium, yellowish or bluish green stones show a higher vanadium content (Schmetzer and Bank, 1979; Barot and Boehm, 1992).

Current Production and Future Potential. Although there are more fine, large tanzanites on the market today than ever before, we do not know if the level of production achieved before the block system was established will be maintained. Even so, it appears that there is still a large stockpile of tanzanite among the independent miners. Many used the money they originally received for their tanzanite to purchase more tanzanite. “While termites will eat paper money, they are no threat to the gems,” which can be safely stored for future sales (H. Krupp, pers. comm., 1992).

GARNET

A number of unusual garnets have been found in Tanzania: pyrope-sphene-zoisite (malaya), pyrope-almandine (rhodolite), green grossular (tsavorite), pyrope, and change of color. In fact, changes recommended in the gemological classification of species of the garnet group are largely the result of the availability of these...
new garnets (see Stockton and Manson, 1985, for an in-depth discussion of this new classification). The hues represented by Tanzanian garnets include green, purplish red, orange, and various pastel shades (figure 20)—the result of variations in iron, manganese, chromium, and vanadium content. The most economically important garnets from Tanzania—malaya, tsavorite, rhodolite, and change of color—are discussed individually below.

Malaya (Malaii). This red-orange to yellow-orange garnet (figure 21) is found in alluvial deposits along the Umba River and in several plains that stretch from the Tanzanian border with Kenya north to the Mgama Ridge in the Taita Hills (Curtis, 1980). Malaya garnet was discovered in the mid-1960s by miners extracting rhodolite for George Papas in the Umba River Valley (R. Naftule, pers. comm., 1992). First thought to be spessartines, in the early 1980s they became known by the Swahili name malaya (which translates as “out of the family,” or “outcast”), because their properties did not place them into traditional garnet categories.

Malaya garnet is a member of the garnet solid-solution series pyrope-spessartine, with significant amounts of almandine and grossular; the Umba Valley malaya garnets show a broad variation in chemistry (Schmetzer and Banlz, 1981; Stockton and Manson, 1982). After cutting, malaya garnets often exhibit red scintillation flashes, possibly the result of traces of vanadium and/or chromium, that enliven their appearance.

Tsavorite. This transparent green grossular garnet has been found in the hills southeast of the village of Komolo (figure 22), in the Lelatema Mountains (Bank et al., 1970), and in the Merelani Hills (Kane et al., 1990) of Tanzania, as well as in Kenya. Tsavorite
Figure 20. As with many of the other gem materials found in Tanzania, garnets occur in various hues. These garnets range from 0.85 ct to 1.14 ct. Courtesy of Mayer d Watt, Beverly Hills, CA; photo © G1A and Tino Hammid.

and tanzanite are often found together, but not both in commercial quantities in the same deposit [Kane et al., 1990].

Like tanzanite, tsavorite was also named by Tiffany & Co. The name tsavorite, which first appeared in September 1974, was derived from the garnet’s occurrence near the Tsavo National Game Park in Kenya. Geologist Campbell Bridges had pegged the first claims of this gemstone in Tanzania, at the Komolo occurrence, for the Costas Lycos family. It was tsavorite from Komolo that Bridges first showed Tiffany & Co President Henry Platt (C. Bridges, pers. comm., 1992). Shortly thereafter, lighter green grossular was found in the Lelatema Mountains (Muije et al., 1979). Since 1987, small amounts of large gem-quality tsavorite crystals, of exceptional form, have been recovered from pockets at the Kando tanzanite pit in the Merelani Hills [Kane et al., 1990].

Tsavorite occurs in graphitic gneisses [Bridges, 1974; Key and Hill, 1989]. Although the material found in the Merelani Hills is well-crystallized, tsavorite usually occurs as “potato shaped” nodules in pockets in replacement zones within the graphitic gneiss, immediately beneath an impermeable limestone band [Bridges, 1987; Malisa and Muhongo, 1990]. The unique color of these Tanzanian garnets was first attributed to chromium [Rank et al., 1970] and later to vanadium as well [Schmetzer, 1978].

Rhodolite. A member of the pyrope-almandine series, rhodolite comes from many localities in Tanzania, most notably (since 1964) from Umba. Rhodolite has been found in hues ranging from dark red to purplish red (figure 23) to reddish purple. Currently, purplish red rhodolite is also being recovered from Komolo and from a locality near the town of Same, which is on the road between Moshi and Tanga. A relatively new find of rhodolite from Kangala is described as “raspberry” in color, ranges from 5 to 10 ct, and in rare instances exhibits asterism. Rounded “pebbles” of darker tone up to 50 grams (although commonly 1–3 grams) are produced from the area called Titi, in northeast Tanzania. Most of these stones have the to heavy “silk” and can produce four- to six-ray stars (Koivula and Kammelring, 1989). Although there is currently little production, the area has been active for 15 years. Rhodolite garnets are also found in nearby Nyirinyori and Nyamberera, and—in situ—at Handeni. The Handeni material is a very fine, light reddish purple and is usually free of any “silk” (N. Barot, pers. comm., 1992).

The rhodolite garnets in Tanzania occur widely in Precambrian metamorphic rocks. Although most, of the Umba production has been from alluvial deposits in the Umba River area (Malisa and Muhongo, 1990), Umba Ventures mined the primary deposits there in the mid- to late 1980s (R. Natrule, pers. comm., 1992).

Change-of-Color Garnets. Crowningshield (1970) first identified this unusual type of garnet (see, e.g., figure 3) when a waterworn pebble was submitted to the GIA Gem Trade Laboratory for identification. The pebble was blue-green in day or fluorescent light and purple-red in incandescent light. Further investigations have established that this material is a special type of pyrope-spectrum (Stockton and Manson, 1982, 1985; Manson and Stockton, 1984; Koivula and Kammelring, 1988).
The only confirmed locality for change-of-color garnets in Tanzania is in the alluvial deposits at Umba, where they are usually found during the sorting process that follows recovery of other gem materials from this area. Color changes from red to orange, orange to pink, pink to purple, and orange to yellow have also been seen (see, e.g., Figure 3).

Current Production and Future Potential. At present, there is a continuous and significant production of garnets from most of the numerous localities in Tanzania. However, at a recent, much-publicized gem auction in Arusha, only 31 grams of tsavorite were offered for sale. Currently, garnets are found in the fol-
Figure 24. Tanzania is noted for the superb "chrome" tourmalines found there. This approximately 2.5 x 4 cm rough crystal and the accompanying 5.10 ct faceted "chrome" tourmaline are from Landanai. Courtesy of Pala International, Fallbrook, CA; photo © Harold & Erica Van Pelt.

lowing relative abundances (from most to least): rhodolite, malaya, tsavorite, change of color.

TOURMALINE

Background. A number of species of the tourmaline group—elbaite, uviite, and dravite—are found scattered throughout northern and eastern Tanzania (Webster, 1961a; Zwaan, 1974; Herschede, 1986; Dietrich, 1985). However, there is little organized mining of tourmaline in Tanzania. Most of the material produced to date is the result of two small operations in Landanai, as well as those tourmalines found as byproducts of alluvial mining for ruby, sapphire, and garnet at Umba. Tourmaline of a magnificent bluish green color occurs near Daluni.

Geology. In Tanzania, tourmaline is typically found in either crystalline limestone or in pegmatites associated with limestone and/or ultramafics (Bridges, 1982). Elbaite is found primarily in pegmatites, whereas dravite and uvite occur in various types of metamorphic rocks.

Description of the Material. The most notable Tanzanian tourmaline is the bright green variety of dravite called "chrome" tourmaline in the trade (Schwartz and Bank, 1979, figure 24). Other colors and phenomemonal varieties include yellow, ranging from "gold- en" to orange, change of color (dark green in day or fluorescent light, and red in incandescent light), cat's-eye, and, on rare occasions, bicolored—green and yellow—stones (figure 25).

The term "chrome" tourmaline has been used in the trade because chromium was originally thought to be the cause of color, as well as to distinguish these stones from the less "pure" green tourmalines typical of Brazil and other localities. W. Hasse reported this occurrence in the geologic literature in 1956, and subsequently identified vanadium as the cause of color. Bank (1982) found very little chromium present in the stones he examined at that time, although some green tourmalines from Tanzania tested since then have had higher contents of chromium than vanadium (Bank and Hema, 1988).

Current Production and Future Potential. Production of tourmaline reached a peak in the 1960s, when several hundred kilograms were recovered. Although most of the stones were under one carat, approximately 20% of the rough yielded 1- to 10-ct stones (R. Naftule, pers. commun., 1992). By the early 1980s, only 2,400 grams of rough were recovered annually, which yielded about 2,400 ct of faceted stones (Herschede, 1986). Since then, production has been sporadic. Today, although thousands of carats of low-grade tourmaline are recovered in Tanzania, only a small quantity of new facet-grade material enters the market each year.

EMERALD

Background. The primary emerald deposit in Tanzania is about 3 km west of Lake Manyara and south of Maiti Matoke Springs. Themelis (1989) reports that emerald is also being recovered near Sumbawanga, in southwest Tanzania (again, see figure 2).

The first emerald crystals were found in eluvial gravels by a local farmer and identified by H. P. Kristen in 1969. Kristen, a prospector, discovered the primary deposit at Lake Manyara the following year and immediately started mining the area. He worked for Galai Mining Company, owned then by George Papas, who subsequently established 25 claims around Lake Manyara (Rwezaura, 1990). During the period 1970–1973, before the mining operation was nationalized, Kristen recovered 253,677 carats of emerald, with some crystals as large as 130 grams (Gübelin, 1990).
1974). Today, small-scale mining continues and, at present, the mine is leased by Tofo.
Mining at Sumbawanga has progressed rapidly since the discovery of emeralds there in early 1988; the main shaft is more than 13 m deep, with at least 18 tunnels radiating from it. Although the heavily included crystals average 20-30 ct, specimens up to 100 ct have been recovered (Themelis, 1989).

Geology. The Lake Manyara emeralds are found in biotite schists interspersed with pegmatite and quartz segregations (Bridges, 1982). Several gems in addition to emerald are known to occur in the Lake Manyara vicinity. These include: apatite, garnet, spinel, ruby, sapphire, yellow chrysoberyl, and alexandrite (Göbelin, 1974). Eight areas have been identified on the Ufipa plateau as having potential for green beryl (Rwezaura, 1990). The Sumbawanga emerald deposit also occurs in a biotite schist. In both mining areas, blasting and backhoes are required to break up the host rock and remove it for processing.

Description of the Material. The properties of the Lake Manyara and Sumbawanga emeralds are, for the most part, consistent with those of emeralds from other biotite schist localities, especially those from the Ural Mountains. In both cases, the crystals are usually heavily included or, more accurately, fractured. Some of the material from Lake Manyara is facetable (figure 26); virtually all of the Sumbawanga material (being of a "milky" nature) is suitable only for carving or cutting into cabochons (Themelis, 1989).

OTHER GEMS IN TANZANIA
Most gemologists are unaware of the vast majority of Tanzania’s gems. In addition to those discussed above, the list of gem materials that have been found in Tanzania includes actinolite, alexandrite, almandine,
Tanzania is especially rich in its variety of gems. Shown here are a 12.62-ct golden scapolite, a 3.63-ct purple scapolite, a 3.48-ct iolite, a 1.80-ct zircon, a 2.15-ct spinel, a 1.29-ct alexandrite chrysoberyl, and a 1.39-ct peridot. Photo © GIA and Thilo Hamann.

Alexandrite. The change-of-color variety of chrysoberyl, alexandrite, occurs in association with the emerald deposits at Lake Manyara. They are found in what Dr. E. Gübelin has described as “actinolite schists” of metamorphic origin.

Lake Manyara alexandrites exhibit a distinct change of color from bluish green in day or fluorescent light to purplish red in incandescent light. Dense-packed actinolite fibers produce chatoyancy in some of the material. Unlike other natural alexandrites, which are inert to ultraviolet radiation, Lake Manyara alexandrites fluoresce a strong to medium dull red to long-wave U.V., and may fluoresce a weak yellow to short-wave U.V. (Gübelin, 1976).

Amethyst. Purple quartz appears in the early geological literature of Tanzania. It is one of the more abundant gemstones, with over 12 occurrences recorded. It has been found within an area from just southeast of Lake Victoria in the northwest part of the country to Kigoma in the northeast to Mtwara just west of Dar es Salaam.

Scapolite. The major locality for golden yellow and purple scapolite is in the Mwanga region near Dodoma. Many kilograms of yellow crystals, usually 2-5 cm long, have appeared on the market in recent years. Yellow cat’s-eye scapolite has also been found at Mwanga. In addition, some yellow scapolite is recovered at Umba (Seaberry, 1967; Zwaan, 1971). Considerable research has been done on the gemological properties and chemical composition of this complex gem mineral (Graziani et al., 1983).

Spinel. Fine spinels have been discovered with rubies in the Mtwara region, particularly at the Matombo mine (Hann and Schmetzer, 1991). Spinel’s in a variety of unusual colors were shown at the 1992 Tucson Gem and Mineral shows. They were reported as coming from the Umba Valley (Koivula and Kammerling, 1991a).

Zircon. Tanzanian zircon in a variety of colors has appeared at the Tucson Gem and Mineral shows since the late 1980s (Koivula and Kammerling, 1990). Keller (in press) names Mavumbi and Handeni, in the Tanga province, as localities. Zircon is also found in the Umba area. Experiments by one of the authors (AB) revealed that dark purple zircon, on heating, turns bright yellow.

CONCLUSION

The complex geologic environment of East Africa has resulted in an unparalleled diversity of gem materials in an equally diverse range of colors, dramatically illustrated by the gem riches of Tanzania. Production of diamonds, rubies, sapphires, tanzanites, and garnets is already significant and promises to increase.
There is considerable potential for other gem materials such as tourmaline, emerald, aquamarine, alexandrite, amethyst, peridot, scapolite, spinel, and zircon. Perhaps a virtually unknown stone, such as vandurite, will emerge from Tanzania as a major gem material, as tanzanite and tsavorite have done. Tanzania's ultimate success as a gem-producing nation, however, depends as much on international cooperation and economic support as it does on its gem resources. Now that the Tanzanian government is actively promoting its gem resources to the international community, the promise may become fulfilled. Under the auspices of the Ministry of Water, Energy, and Minerals, on May 26 and 27, 1992, the Tanzanian Miners' and Dealers' Association (TAMIDA) held its third gem auction since the early 1980s. More than 60 miners and dealers, including buyers from more than a dozen countries worldwide, participated in the sale at Arusha of more than a ton of ruby, sapphire, tsavorite, tanzanite, rhodolite, and other gem materials (C. Bridges and A. Suleman, pers. comm., 1992). A second auction is scheduled for October 1992, apparently signaling that Tanzania will continue: its open-door policy in the future—a promising sign for the international gemological community.

REFERENCES
GEM WEALTH OF TANZANIA

Gems & Gemology, Vol. 25, No. 2, pp. 48-49.


Tiffany discloses findings which may be a new gem (1988). Wall Street Journal, October 14, p. 4.


