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ABOUT THE COVER: *Wulfenite on mimetite, 2.6 cm tall, San Francisco mine, Cucurpe, Sonora, Mexico; Les and Paula Presmyk specimen, Jeff Scovil photo. See related article on the Presmyk collection beginning on page 84.*

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Ferruginous Quartz

Tinejdad, Errachidia Province, Drâa-Tafilalet Region, Morocco

Quartz like many minerals is *allochromatic*, meaning that it occurs in a wide variety of colors. In contrast, *idiochromatic* minerals such as azurite, realgar, and sulfur possess a characteristic color. The most common color varieties of quartz—amethyst and smoky quartz—are caused by the chromophores iron and aluminum that substitute for silicon atoms in the quartz structure. Other color varieties—prominently rose quartz (Clifford 2012)—are colored by mineral inclusions. The color, size, and boldness of the ferruginous quartz specimen featured here as figure 1 prompted preparation of this column.

Quartz, more precisely known as alpha-quartz or low quartz, is the common, low-temperature, and low-pressure polymorph of silica, SiO_2. It typically occurs as colorless to smoky formless grains in many igneous, sedimentary, and metamorphic rock types. Quartz has a Mohs hardness of 7 and is very resistant to chemical attack, so it survives weathering and is the principal component of sand and other sediments. Quartz can be pure silica; as such, it ideally is colorless and transparent with a vitreous luster. Amethyst, chrysoprase, citrine, rose quartz, sard, and smoky quartz are varietal names based on color. Its high hardness, attractive colors, and abundance make quartz an important gem mineral.

Quartz crystallizes in the trigonal trapezohedral class (32) of the trigonal crystal system. This crystal class lacks a center of symmetry, so the inherent piezoelectric and pyroelectric properties of quartz make it useful in electronics. This class is also *enantiomorphous*, i.e., quartz occurs as either right-handed or left-handed crystals (which are mirror images of each other) due to a spiral in its atomic arrangement. Crystals are common and may reach more than 10 meters in length (Rickwood 1981; Rykart 1995).

Ferruginous Quartz

Ferruginous quartz is a time-honored varietal name applied to crystals of red, brown, and ochre colors caused by fine-grained inclusions of iron oxide/hydroxide that were incorporated during growth. *Eisenkiesel* (German) and *hematoide* are infrequently used synonyms. Ferruginous implies iron-bearing compounds, not a particular mineral as the color-causing agent. The usual mineral is hematite, Fe_2O_3, but goethite, FeO(OH), occurs in quartz as well. These minerals are routinely distinguished on the basis of the color of their powder (i.e., their *streak*). Hematite's streak is red-brown and goethite's is yellow-brown. The cause of color in ferruginous quartz has rarely been investigated scientifically, which makes color the best guide to the likely identification of the inclusions. The following reviews both varieties of ferruginous quartz.

Inclusions in quartz range from macroscopic crystals down to microcrystalline particles. Quartz with macroscopic inclusions of goethite is commonly called onegite in Colorado where it occurs with goethite and microcline. Smaller, but optically distinct, goethite clusters occur in amethyst from Rio Grande do Sul, Brazil, and elsewhere. Black, well-formed millimeter- to centimeter-sized hematite crystals included in quartz occur in alpine cleft environments such as Cavradi Gorge, Graubunden, Switzerland (Hager et al. 2013) and the Scorpian mine, Tormiq Valley, Pakistan. In their book *Magic World: Inclusions in Quartz*, which documents approximately 140 mineral species as inclusions in quartz, Hyršl and Niedermayer (2003) employ the terms *protogenetic, syngenetic,* or *epigenetic* to describe when (be-

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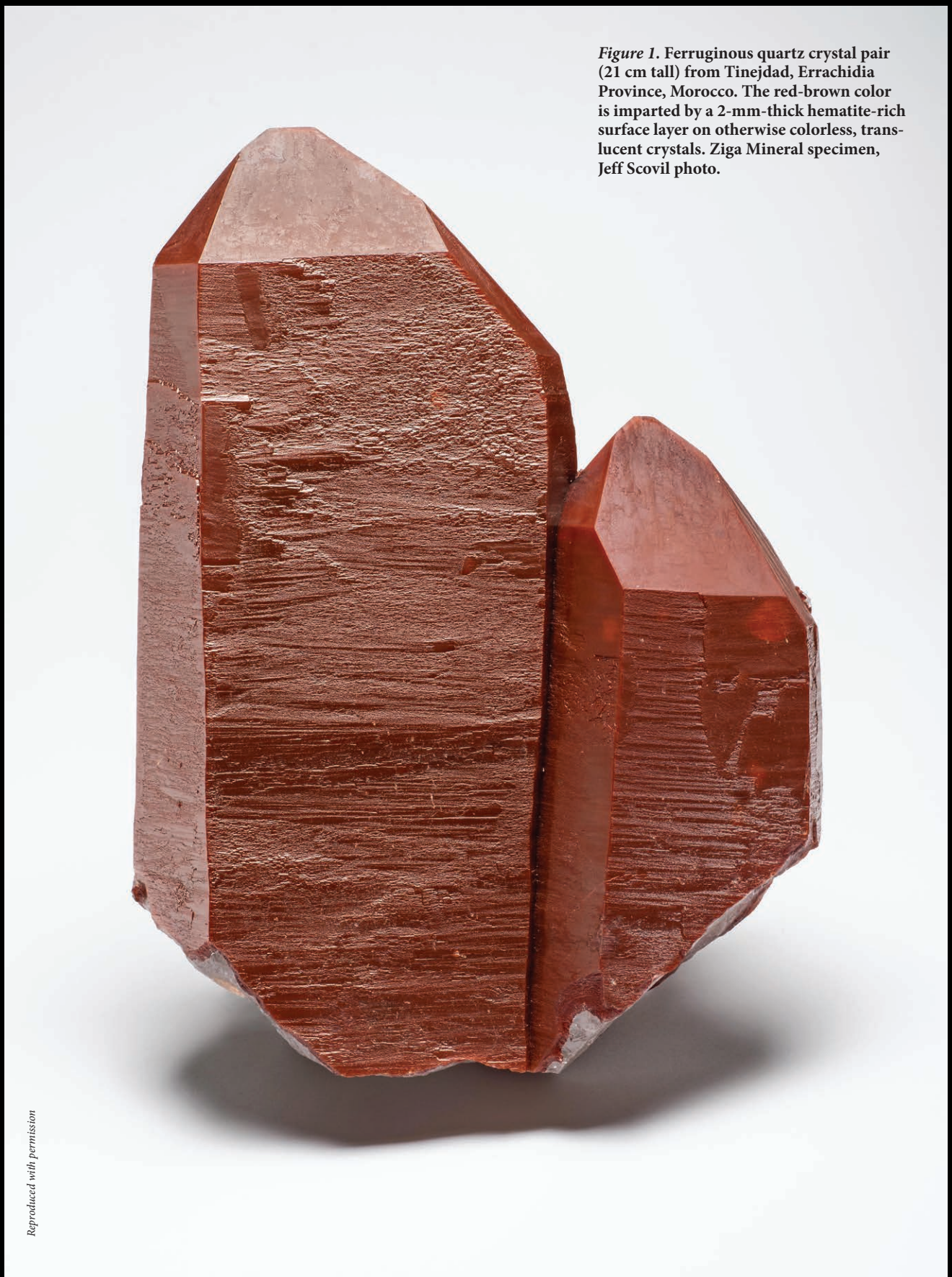

Figure 1. **Ferruginous quartz crystal pair (21 cm tall) from Tinejdad, Errachidia Province, Morocco. The red-brown color is imparted by a 2-mm-thick hematite-rich surface layer on otherwise colorless, translucent crystals. Ziga Mineral specimen, Jeff Scovil photo.**

Figure 2. **Map showing occurrences of ferruginous quartz mentioned in the text; prepared by William Besse.**

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Figure 3 (above). **Display of Tinejdad, Errachidia Province, Morocco, quartz crystal groups offered by Spirifer Minerals at the 2022 Mineral City Show in Tucson. Carl Francis photo.**

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Figure 4 (right). **A tapering, Muzo-habit quartz crystal (6.8 cm tall) from Tinejdad, Errachidia Province, Morocco. Carl Francis specimen, Mark Mauthner photo.**

fore, during, or after) the inclusion(s) formed relative to the enclosing quartz. The hematite and goethite in ferruginous quartz are syngenetic inclusions.

Dana (1892, p. 188) describes ferruginous quartz under the heading "Impure from the presence of distinct minerals," and The Quartz Page (http://www.quartzpage. de/eisen kiesel.html; accessed November 2021) emphasizes that ferruginous quartz "specimens are usually **translucent to almost opaque**, but never transparent." Clearly, ferruginous quartz only refers to quartz colored by dense concentrations of microcrystalline inclusions of iron oxides.

Quartz colored by hematite is some shade of red to brown, rather like brick in appearance. Prominent localities

Some occurrences of ferruginous quartz.

Country	State	County	Town/Village	Locality	Authority
Red, hematite-included, ferruginous quartz					
Brazil	Bahia		Jacobina	Grota do Coxo	Cornejo and Bartorelli 2010, p. 654
Canada	Ontario	Rainy River district	Atikoken	Steep Rock mine, Hogarth pit	Jaszczak 2019
Canada	Ontario	Thunder Bay district	McTavish Township	Diamond Willow mine	Kile 2019
Canada	Ontario	Algoma district	Wawa		Dibble 2002, p. 34
China	Shanxi	Yuncheng Prefecture			J. Scovil photo: 2020-05-0203
China	Hubei	Daye County		Fengjiashan mine	N. Prenn specimens
China	Hunan	Changning County	Shuikoushan ore field	Kangjiawan deposit	Mindat photo: RYY-4NX
Czech Republic	Ústí nad Labem region	Teplice district	Cinovec		Dibble 2002, p. 55
Germany	Bavaria	Upper Palatinate	Wölsendorf	Johannesschacht	Mindat photo: L5Y-1F4
Morocco	Draa-Tafilalet region	Errachidia Province	Tinejdad		this study
Namibia	||Karas region		Warmbad	Orange River	J. Scovil photo: 2019-10-0057
Namibia	||Karas region		Warmbad	Skimmelberge	N. Prenn specimens
Russia	Primorsky Kray		Dalnegorsk	2nd Sovetskii mine	Dibble 2002, p. 36
South Africa	Northern Cape Province		Onseepkans	Orange River	B. Cairncross specimen
South Africa	Northern Cape Province		Pella	Orange River	Mindat photo: MLF-93V
Spain	Valencian Community	Valencia	Domeño	CV-35 highway cut	Mindat photo MG3-N20
UK	England	Cumbria	Frizington	Cleator mine	J. Scovil photo: 2019-01-0162a
USA	Arizona	Yavapai County	Bagdad	Bagdad mine	J. Scovil photo: 2014-07-0736
USA	Colorado	Larimer County	Red Feather Lakes		New Mexico Museum 18738
USA	New Mexico	Doña Ana County	Palm Park	Palm Park mine	New Museum Museum 13018
Brown, goethite-included, ferruginous quartz					
Canada	Ontario	Rainy River district	Atikokan	Steep Rock mine, Errington pit	M. Hedtke specimens
France	Auvergne-Rhône-Alpes	Puy-de-Dôme	La Chappelle-sur-Usson	Pégut	Mindat photo: Q6R-WDJ
Germany	North Rhine-Westphalia		Hermer	Felsenmeer near Sundwig	J. S. White specimen
Kazakhstan	Mangystau region	Tupkaragan district		Temirtaushik	Mindat photo: PGG-PP1
Morocco	Marrakesh-Safi region	Youssoufia Province		Irhoud mine	Mindat photo: C16-XU0
Namibia	Erongo		Brandberg area	Goboboseb Mountains	N. Prenn specimen
USA	California	El Dorado County		BBC mine	Mindat photo: 821-9EH
USA	Colorado	Park County	Lake George	2nd Mesabi claim	N. Prenn specimen
USA	Colorado	Park County	Lake George	Rosa claim	Mindat photo: 220-497

are discussed in the following paragraphs with additional occurrences noted in the table.

The featured specimen (fig. 1) is an unusually tall and broad pair of crystals with smaller secondary crystals and a later druse attached to the reverse side. The red-brown color is imparted by a 2-mm surface layer heavily included with hematite. The interiors are colorless and translucent. The locality is an area near Tinejdad in the western part of Errachidia Province of Morocco. Specimens may also be labeled as near Alnif in Tinghir Province, which is only about 40 kilometers (25 miles) southwest of Tinejdad. Single crystals and fine groups from here were first found in April 2014 (Moore 2020, who reported the locality as Tinjoad), and production continues sporadically. They were plentiful at the 2022 Tucson Show. The crystal habit is usually prismatic but tapering; Muzo-habit crystals have been noted. A late druse partially coating the crystals seems characteristic.

The Orange River area in both southern Namibia and northern South Africa became a significant source of beautiful quartz crystals and crystal groups in the late 1990s. The diggings are in quartz–K-feldspar veins. Specific locality in-

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Figure 5. **Ferruginous quartz group (11.2 cm wide) from the Orange River area south of Warmbad, Namibia. Spirifer Minerals specimen, Jeff Scovil photo.**

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Figure 6. **Ferruginous quartz group (6.5 cm wide) from Onseepkans in the Orange River area, Northern Cape Province, South Africa. Bruce Cairncross specimen and photo.**

formation is sparse. Details for Namibia are provided by von Bezing, Bode, and Jahn (2014), who recommend using "Orange River Area south of Warmbad" on labels. On the South African side of the Orange River, specimens from Pella were collected as late as 2020 (Mindat.org; accessed May 2022). Riemvasmaak has also been a source of specimens.

In the 1990s the Second Sovietskii mine at Dalnegorsk, Primorsky Krai, Russia, produced splashy sprays of orange crystals to 4 cm in length. Crystals on some specimens have colorless tips, and another pocket had orange crystals with a later overgrowth of white quartz.

Since opening to western markets, China has supplied fine specimens of ferruginous and hematitic quartz from several locations including Yuncheng Prefecture in Shanxi Province.

The classic British locality for ferruginous quartz is the West Cumbrian ore field centered around Egremont, Cumbria (formerly Cumberland), west of the Lakes District National Park. This is the iron mining district that produced the great British barytes, calcites, and botryoidal hematite specimens in the later nineteenth century. Regrettably, there is no modern description of the history and minerals of those mines. Doubly terminated quartz crystals lacking prism faces occur commonly on the massive hematite. This distinctive habit is so characteristic of the district that it was named the Cumberland habit long ago. Crystals are color-

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Figure 7. **Orange quartz crystals with colorless tips on sphalerite matrix (9 cm wide) from the Second Sovietskii mine at Dalnegorsk, Primorsky Krai, Russia. Terry Huizing specimen, Jeff Scovil photo.**

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Figure 8. **Doubly terminated ferruginous quartz crystal (9.1 cm tall) from Yuncheng Prefecture, Shanxi, China. Gloria Olson specimen, Jeff Scovil photo.**

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Figure 9. **Group of ferruginous quartz crystals (9.1 cm tall) labeled New Parkside mine, Frizington, Cumbria, United Kingdom. Harvard Mineralogical and Geological Museum specimen. Kevin Czaja photo.**

Figure 10 (left). **Classic *eisenkiesel* (ferruginous quartz) on the specularite variety of hematite (6.8 cm tall) from Frizington, Cumbria, United Kingdom. Scott Rudolph specimen, Jeff Scovil photo.**

Figure 11 (above). **Ferruginous quartz crystal group (12.5 cm wide) from Fischbach, Rhineland-Palatinate, Germany. Harvard Mineralogical and Geological Museum specimen, Kevin Czaja photo.**

Figure 12. **Ferruginous quartz on purple fluorite cubes (7.5 cm wide) from Wolsendorf, Upper Palatinate, Bavaria, Germany. Harvard Mineralogical and Geological Museum specimen. Kevin Czaja photo.**

less, smoky, and occasionally bright red and are often labeled *eisenkiesel*. Associated with black, shiny hematite (specularite) crystals on red-brown massive hematite, they make striking specimens—the very best matrix specimens of ferruginous quartz available.

The classic North American locality for ferruginous quartz is the Diamond Willow mine, now, in part, the Blue Points mine, at Pearl Station, Thunder Bay district, Ontario, Canada. Amethyst typically occurs as coarse druses lining large cavities in breccia zones in Precambrian quartz monzonite (granite). Although the hematite-included amethyst is best known, crystals range from transparent pale purple to dark purple to red. The mineralogy of the Thunder Bay amethyst mines has been closely studied by Kile (2019), who demonstrated with illustrations that the hematite inclusions are hollow spherulites on the order of 100 microns in diameter. It is hardly surprising that amethyst can be ferruginous. When the amount of iron in solution exceeds the ability of the quartz structure to absorb it (leading to its purple color), the excess iron can precipitate as hematite or goethite. Attractive specimens of reddish amethyst occur at several localities mentioned next.

In 2018 Minnesota field collector Michael Hedtke found and excavated a "red quartz" pocket at the Hogarth pit of the Steep Rock Iron mine near Atikokan, Rainy River district, Ontario. He donated a handsome 3-cm matrix plate of ferruginous quartz crystals on dolomite to the A. E. Sea-

Figure 13. **Quartz variety amethyst (10.9 cm wide) with dense inclusions of hematite at the surface from the Thunder Bay district, Ontario, Canada. David and Karen DeBruin specimen, Jeff Scovil photo.**

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Figure 14. **Ferruginous quartz crystals (7.5 cm tall) collected by Michael Hedkte at the Hogarth pit, Steep Rock mine, near Atikokan, Rainy River district, Ontario, Canada. Carl Francis specimen, Mark Mauthner photo.**

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Figure 15. **Strawberry quartz crystals (5.5 cm tall) with colorless calcite from Uruáchic, Chihuahua, Mexico. Joseph and Susan Kielbaso specimen, Jeff Scovil photo.**

man Mineral Museum at Michigan Technological University (Jaszczak 2019).

Ferruginous quartz forms primarily in hydrothermal deposits but also occurs in sedimentary rocks. Small, doubly terminated crystals that grew in gypsum rock are known in New Mexico as Pecos Valley diamonds. Albright and Lueth (2003) thoroughly document their occurrence at thirteen localities in the Permian Seven River Formation of Chavez and neighboring counties. Crystals range from colorless to pink to red to brown and black taking on the color of the enclosing gypsum matrix. They note (Albright and Lueth 2003, pp. 65–66):

> Strikingly similar authigenic quartz crystals are common in the Triassic Keuper gypsiferous facies of Spain, where they are known as "Jacintos de Compostela"—literally, Hyacinths from Compostela, an allusion to red-orange precious stones from that locality popular during the Middle Ages. . . . A comparison of Pecos diamonds from diverse localities cannot be distinguished from the Spanish Jacintos insofar as size, color, form, and inclusions.

Jacinto de Compostela quartz occurs as fine, red, doubly terminated crystals 1–3 cm in length and in clusters at Chelva and Domeño in Valencia, Spain (Mindat.org; accessed January 2022). Many additional images are posted on the Galería de Minerales FMF (http://www.mineralogia.es/index.php?searchterms=chella&searchauthor=-&level=search; accessed May 2022). Dolomite crystals are associated in both the Spanish and New Mexican occurrences. The Spanish dolomite crystals are known as "teruelite" for their occurrence at Teruel.

Hematitic quartz is a catch-all term used here to encompass all specimens that don't rise to the standard of opacity for the term *ferruginous,* regardless if the hematite inclusions (not coatings) are macroscopic or microscopic. They may be reddish, partially red, or crystals with red phantoms. Strawberry quartz is a name for colorless quartz with multiple, optically distinct, wispy red inclusions that is used as a gem material (Sinkankas 1962). A principal occurrence is Uruáchic, Chihuahua, Mexico. White (2000) documented strawberry quartz from a then-new occurrence in Kazakhstan and established that the red inclusions are hematite but are frequently mislabeled lepidocrocite (a rare polymorph of goethite). Amethyst reddened with visible hematite inclusions comes from the Kakamunurle mine, Karur district, Tamil Nadu, India, and the Goboboseb Mountains, Brandberg area, Namibia. Similar specimens from Denny Mountain in King County, Washington, are described as "raspberry" quartz (Mindat.org; accessed January 2022).

Hematitic quartz occurs widely. In the United States an outstanding example is the Soudan mine located in the Vermillion Iron Range of northeastern Minnesota about 100 miles north of Duluth. It is noted for beautiful transparent quartz crystals that frequently have red phantoms (Wilson

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Figure 16. **Quartz variety amethyst reddened by hematite inclusions (7.8 cm tall), an example of hematitic quartz, from the Kakamanurle mine, Karur, India. Kristal Ocean Exports specimen, Jeff Scovil photo.**

and Olson 2017). Crystals are typically only a few centimeters in length, and some also have green chlorite or black hematite inclusions. The mine closed in 1962, and specimens are now scarce. They are highly appreciated locally and nearly impossible to purchase (M. Hedtke, pers. comm., January 2022).

Quartz colored by goethite is brown and much rarer than hematite-included quartz. The classic European occurrence cited by Frondel (1962) is Sundwig, Westphalia, Germany, which was an independent municipality from 1841 to 1929. Sundwig is now a district in the town of Hemer in the state of North Rhine-Westphalia. The specific locality is Felsenmeer, site of ancient iron mines, which produced groups of small, opaque, ochre-colored crystals. These were formerly well known and are represented in the older museum collections in North America. Familiarity with this occurrence has apparently been lost by most contemporary European collectors and dealers (John White, pers. comm., May 2021). Hematite pseudomorphs after calcite scalenohedra also occur there.

Onegite, named for Lake Onega, Karelia, in the Northern Region of Russia bordering Finland, is a varietal name for quartz heavily included with goethite. It also occurs associated with goethite crystals in the amazonite-bearing pegmatites of Park and Teller counties, Colorado, and at the BBC mine, El Dorado County, California (Mindat.org; accessed May 2022).

Among the occurrences listed in the table, the plates of lustrous brown quartz points to 10 × 10 cm from Temirtaushik, Tupkaragan, in western Kazakhstan, are especially notable. Many unreported occurrences must exist. For example, Michael Hedtke has collected specimens similar to the Sundwig material at the Errington pit of the Steep Rock Iron mine near Atikokan, Ontario.

Conclusion

Ferruginous quartz is a well-established variety of impure quartz caused by dense concentrations of fine-grained hematite or (less commonly) goethite that precipitated while crys-

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Figure 17 (above). **Classic goethite-included ferruginous quartz (9.8 cm) from the ancient iron mines at Felsenmere in the Sundwig district of Hermer in North Rhine-Westphalia, Germany. John White specimen, Ray McDougall photo.**

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Figure 18 (right). **Goethite-included ferruginous quartz (3 cm tall) from the Errington pit, Steep Rock mine near Atikoken, Rainy River district, Ontario, Canada. Michael Hedkte specimen. Barbra Barrett photo.**

tals of colorless quartz were growing. With few exceptions, the identification of the inclusions in quartz cited and the table are based upon visual determinations, not actual analyses. Occurrences of ferruginous quartz from hydrothermal and sedimentary environments are known worldwide. The contemporary occurrence near Tinejdad, Morocco, which is particularly notable for its abundance of fine crystal groups, may rank as the world's premier occurrence of ferruginous quartz.

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