

## ***August 2007 Mineral of the Month: Hematite***

This month's mineral, hematite, is something of a paradox, for its color can be red or black. It is very abundant, yet its crystalline and botryoidal forms are relatively rare. And although hematite is mined in enormous quantities as the primary ore of iron, it is also a very attractive and popular gemstone.

### *PHYSICAL PROPERTIES*

Chemistry:  $\alpha$ -Fe<sub>2</sub>O<sub>3</sub>     Iron Oxide (Ferric Oxide)

Class: Oxides

Subclass: Simple Oxides

Group: Corundum-Hematite

Crystal System: Trigonal (Hexagonal)

Crystal Habits: Thick-to-thin tabular crystals, often as sub-parallel growths or rosettes; usually striated; also compact, granular, reniform, radiated, botryoidal, columnar, micaceous, massive, and earthy.

Color: Red and reddish-brown to brown, steel-gray, and black.

Luster: Earthy to submetallic and metallic.

Transparency: Opaque

Streak: Dark red and cherry-red to reddish brown.

Cleavage: None

Fracture: Uneven to subconchoidal, splintery, brittle.

Hardness: 5.5-6.5

Specific Gravity: 4.9-5.3

Luminescence: None

Refractive Index: 2.940-3.220

Distinctive Features and Tests: Best field indicators are red streak and hardness. The deep-red streak of hematite distinguishes it from other iron-based minerals as limonite [an indefinite mixture of hydrous iron oxides] and ilmenite [iron titanium oxide, FeTiO<sub>3</sub>]. Unlike magnetite [iron oxide, Fe<sub>3</sub>O<sub>4</sub>], hematite is not magnetic.

Dana Classification Number: 4.3.1.2

### *NAME*

We often hear this month's mineral mispronounced at shows as HEM-a-tite, but the correct pronunciation is HEE-ma-tite, with the long "e" sound as is hemoglobin, the oxygen-carrying pigment of red blood cells that gives them their red color and serves to convey oxygen to the tissues. Both words stem from the Greek *haimatites*, meaning "blood-like." In the mineral hematite, the reference is to the red color of its streak and its earthy forms.

Because of its abundance, wide distribution, many uses, and occurrence in different forms, hematite has many alternative names. European mineralogists refer to it as "hematit" and "hematita." Other names include "Jernglans," "ematite," "haematite," "red iron," "red iron ore," "tiger ore," "natural ore," "iron glance," "red iron oxide," "red ochre," "ochre ore," "paint ore," "iron ochre," "anhydroferrite," "red ferrite," "sanguine," "Eisenglimmer," and "Roteisenrahm."

Clusters of hexagonal hematite plates in rose-like formations are called "iron rose"—we had the privilege of featuring these in June 2002, from Miguel Burnier (São Julião), Ouro Preto, Minas Gerais, Brazil.

Botryoidal, reniform, and mammillary forms of hematite are known as "kidney ore" or "kidney iron."

"Rainbow hematite" is iridescent, while a crystalline, silvery-gray, lustrous, often micaceous form is known as "specularite" or "specular hematite," marketed in Alaska as "black diamond." A titanium-rich variety is called "titano-hematite." "Martite" refers to a hematite-after-magnetite pseudomorph.

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## *COMPOSITION*

Hematite is a member of the oxide class of minerals. Oxides, which consist of metals or semimetals combined with oxygen, have two subclasses: simple oxides that consist of one metal (or semimetal) and oxygen; and compound oxides, which combine two or more metals with oxygen. The chemical formula  $\text{Fe}_2\text{O}_3$  shows that hematite is a simple oxide consisting only of iron (Fe; the chemical symbol derives from the Latin *ferrum*) and oxygen (O). The molecular weight of the hematite molecule is made up of 69.94 percent iron and 30.06 percent oxygen.

As a transition metal, iron properties are transitional between the more highly and less highly electropositive elements in the periodic table. In transition metals, valence electrons (electrons that combine with other elements) are present in more than one orbital. Transition metals thus have several oxidation states (the number of electrons that can be lost or gained to combine with other elements). The electronic configuration of iron is 2-8-14-2, meaning it has 2 electrons in its inner orbital, 8 in its second, 14 in its third, and 2 in its fourth (outer) orbital. Iron can contribute both of its outer electrons to other elements to form the ferrous ion  $\text{Fe}^{2+}$ . It can also contribute one additional electron from its third orbital to form the ferric ion  $\text{Fe}^{3+}$ . Chemical formulas are sometimes written to reflect the specific cationic oxidation states. In hematite, iron is present as  $\text{Fe}^{3+}$ , and its chemical formula can be written as  $\text{Fe}^{3+}_2\text{O}_3$  to reflect this ferric oxidation state. In the hematite molecule, the collective +6 charge of the ferric cation ( $2\text{Fe}^{3+}$ ) balances the collective -6 charge of the oxygen anion ( $3\text{O}^{2-}$ ) to provide electrical stability.

The Dana classification number of 4.3.1.2 identifies hematite as a simple oxide (4). The subclassification (3) defines it by the general formula  $\text{A}_2\text{O}_3$ , in which "A" is a trivalent metal ion such as ferric iron ( $\text{Fe}^{3+}$ ) or aluminum ( $\text{Al}^{3+}$ ), while "O" is the divalent oxygen ion  $\text{O}^{2-}$ . Hematite is assigned to the corundum-hematite group (1) as the second (2) of four members. The other group members are corundum [aluminum oxide,  $\text{Al}_2\text{O}_3$ , our December 2007 featured mineral], eskolaite [chromium oxide,  $\text{Cr}_2\text{O}_3$ ], and karelianite [vanadium oxide,  $\text{V}_2\text{O}_3$ ].

In hematite, two ferric ions covalently share electrons with three oxygen ions to form a three-dimensional structure in which six oxygen ions surround each ferric ion. This configuration explains hematite's trigonal (hexagonal) crystal structure and many of its physical properties. Hematite's strong covalent bonding accounts for its lack of cleavage and considerable hardness of Mohs 5.5-6.5. Hematite is quite dense (specific gravity 4.9-5.3) because 69.94 percent of its molecular weight is made up of heavy iron (atomic weight 55.85).

The corundum-hematite group members are structurally similar, with the hematite and corundum [aluminum oxide,  $\text{Al}_2\text{O}_3$ ] being isomorphic (sharing the same form). But because the ionic radius of the ferric ion ( $\text{Fe}^{3+}$ ) is considerably greater than that of the trivalent aluminum ion, hematite and corundum have many physical differences. The smaller aluminum ion permits closer atomic packing within the corundum lattice to provide much stronger covalent bonding. Thus, corundum (Mohs 9.0) is much harder than is hematite (Mohs 5.5-6.5). Also, corundum exhibits no metallic properties because its smaller aluminum ions are completely shielded by oxygen ions. These two properties in corundum account for the great desirability and value of its gemstones: ruby and sapphire! But in hematite, the larger ferric ions are not shielded and impart a submetallic-to-metallic luster to crystalline forms.

Hematite is the most abundant and widely distributed iron mineral. It occurs with albite [sodium aluminum silicate,  $\text{NaAlSi}_3\text{O}_8$ ] and barite [barium sulfate,  $\text{BaSO}_4$ ] in carbonatites (igneous rocks consisting largely of carbonate minerals); with diopside [calcium magnesium silicate,  $\text{CaMgSiO}_6$ ] and epidote [basic calcium aluminum iron silicate,  $\text{Ca}_2\text{Al}_2(\text{Fe,Al})\text{Si}_3\text{O}_{12}(\text{OH})$ ] in hornfels of contact and regional metamorphic rocks;

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with quartz [silicon dioxide,  $\text{SiO}_2$ ] and siderite [iron carbonate,  $\text{FeCO}_3$ ] in mesothermal and epithermal veins; and with fluorite [calcium fluoride,  $\text{CaF}_2$ ], barite, and calcite [calcium carbonate,  $\text{CaCO}_3$ ] in lode and disseminated replacement deposits. Hematite is a product of the weathering of such iron-bearing minerals as magnetite [iron oxide  $\text{Fe}_3\text{O}_4$ ], siderite, and pyrite [iron disulfide,  $\text{FeS}_2$ ]. Chemical and organic processes also precipitate hematite in seas and lakes. Large ore deposits of earthy, granular, and massive hematite are usually altered sediments. Hematite sediments sometimes occur as intermixed layers with chert and quartz as “banded iron” formations typical of those in Minnesota’s famed Mesabi Iron Range. Finely divided hematite particles are the coloring agent for all reddish soils and sedimentary rocks. Specular or crystalline hematite is deposited by volcanic gases or high-temperature hydrothermal fluids as euhedral or platy crystals associated with quartz in veins and cavities. Hematite also occurs as flake-like inclusions in such minerals as quartz and the feldspars, often imparting a reddish color and a glittering reflection.

Most hematite is relatively pure with only traces of ferrous iron ( $\text{Fe}^{2+}$ ), titanium ( $\text{Ti}^{4+}$ ), aluminum ( $\text{Al}^{3+}$ ), and manganese ( $\text{Mn}^{4+}$ ). Limited solid-solution series occur with magnetite [iron oxide (ferric-ferrous),  $\text{Fe}^{2+}\text{Fe}^{3+2}\text{O}_4$ ], ilmenite [iron (ferrous) titanium oxide,  $\text{Fe}^{2+}\text{TiO}_3$ ], and bixbyite [manganese iron (ferric) oxide,  $\text{MnFe}^{3+}\text{O}_3$ ]. Hematite and maghemite [iron oxide,  $\text{Fe}_2\text{O}_3$ ] are polymorphic minerals that have identical chemistries but different crystal structures. Hematite crystallizes in the trigonal system, maghemite in the isometric system. Also, maghemite is magnetic, while hematite is not. To differentiate these two minerals, hematite’s chemical formula is expressed as  $\alpha\text{-Fe}_2\text{O}_3$  (alpha- $\text{Fe}_2\text{O}_3$ ), while maghemite’s is  $\gamma\text{-Fe}_2\text{O}_3$  (gamma- $\text{Fe}_2\text{O}_3$ ). The name “maghemite” derives from “MAGnetic” and “HEMATite.”

### *COLLECTING LOCALITIES*

Abundant and widely distributed, hematite occurs in all soils, sediments, and metal-ore deposits, and in most igneous and metamorphic rocks. Hematite has thousands of documented occurrences. Our specimens of botryoidal hematite come from a new source, the Oumjrane Mine near Alnif in the Er Rachidia Province of Morocco in northwest Africa, as we will discuss in “About Our Specimens.”

In England, bright black crystals and botryoidal specimens of hematite similar to ours this month are collected at the Frizzington, Berkemet, and Florence mines in the West Cumberland Iron Field in Cumbria. In Switzerland, lustrous, black tabular crystals occur at Tavetsch in the Vorderrhein Valley in Grischun and at Pizzo Lucendro near St. Gotthard in Ticino. Excellent botryoidal specimens are collected in Australia at mines in the Manersley, Hamersley, and Boolegeeda iron fields in Western Australia. Black hematite-on-quartz is found at Torniq, Gilgit, in Pakistan’s Northern Areas. Chinese botryoidal specimens come from two major sources: the Tongguanshan and Changlongshan iron deposits in Tongling Prefecture, Anhui Province; and the Dongangshan and Qidashan iron deposits in Liaoning Prefecture, Manchuria. Most Brazilian hematite specimens are collected at the huge Conceição and Chacrinha iron mines at Itabira in Minas Gerais, though our June 2002 featured “Iron Roses” of hematite were collected at Miguel Burnier (São Julião), Ouro Preto, Minas Gerais, Brazil.

In the United States, the iron ranges of Michigan and Minnesota, once the world’s richest iron deposits, provide specimens of black specular and reddish-brown reniform hematite. In Michigan, specimens come from many mines in the Menominee Iron Range in Dickinson County, the Gogebic Iron Range in Gogebic and Iron counties, and the Marquette Iron Range in Marquette County. In Minnesota, hematite specimens are found in the Cuyuna North Iron Range in Crow Wing County. In Wisconsin, specimens of a red oolitic hematite occur at the Iron Ridge Mine in the Iron Ridge District of Dodge County. Other sources are the many mines of De Kalb, Jefferson, and Etowah counties in Alabama; Mine Ledge at Surrey in Cheshire County, New Hampshire; and Peters Mountain in Allegheny County, Virginia. Platy, black hematite crystals on quartz occur at The Cove at Topaz Mountain in the Thomas Range of Juab County, Utah; an iridescent

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variety is found at the Graves Mountain Mines on Graves Mountain, Lincoln County, Georgia. Specimens of bright, drusy hematite coatings on quartz are collected in New York in St. Lawrence County at the Sylvia Lake Mine at Gouverneur and the Sterling Mine at Antwerp. Iron Hill in Doña Ana County, New Mexico, is a collecting site for several hematite forms. In Arizona, reniform hematite occurs at Aztec Peak in the Sierra Ancha Mountains in Gila County, while brilliant, black platy crystals on quartz are found in the Plomosa District mines near Bouse in Yuma County.

### **HEMATITE: COLOR AND STREAK**

*Hematite's primary diagnostic feature is its distinctive red streak. Streak, also called "powder color" or "true color," is a mineral's color when it is ground to a fine powder. Some minerals have two general colors, which may not be similar: apparent color and streak color. Apparent color refers to the color of macro specimens and varies considerably with trace impurities and crystal-structure variations. Trace impurities and the nature of the crystal structure can determine light absorption-reflection characteristics and thus apparent color. Powdered minerals, however, consist of randomly oriented, microscopic particles in which trace impurities and crystal structure only minimally alter color, thus making the much more consistent streak color an important diagnostic tool in mineral identification.*

*To determine streak color, a tiny mineral specimen is ground to a powder with a mortar and pestle. A simpler method is to rub a mineral firmly across a tile of unglazed white porcelain (called a streak plate) to produce a line or "streak" of color. Streak is most useful for identifying dark-colored minerals such as metal sulfides and oxides. It is least useful for sulfates, carbonates, silicates and other light-colored minerals. Also, minerals that are harder than the plate (Mohs 6.5) cannot be tested by the plate method. Streak color is sometimes surprising. Some minerals, such as cinnabar and azurite, have streaks identical to their apparent colors. Fluorite, even in its green and purple forms, always has a white streak. Galena, which is similar in appearance to crystalline hematite, leaves a gray streak.*

*Hematite's streak is among the most interesting and diagnostic of all minerals. All hematite, including its steel-gray and black crystalline forms, produces a distinctive red streak. Hematite is an idiochromatic or "self-colored" mineral, meaning its color is caused by essential elemental components or inherent crystal structure. Hematite's basic red color is due to its high iron content. Distortions in the crystal lattice and impurities, usually of ferrous iron ( $Fe^{2+}$ ), titanium, or manganese, vary this basic color. All earthy, massive, granular, particulate, and microcrystalline forms of hematite are some shade of red.*

*But crystalline hematite can be deceptive. Because hematite is opaque and does not transmit light, its perceived color therefore is dependent upon surface reflection and absorption of white light. The surface of the hematite lattice absorbs white light equally across all wavelengths to reflect a neutral, gray-black color. And because the hematite lattice has a small degree of metallic bonding, this color is accompanied a metallic or submetallic luster. Thus, crystalline and botryoidal hematite forms can appear steel-gray or black, yet their streak color is always red.*

### ***JEWELRY & DECORATIVE USES***

Specular hematite has served as a gemstone since antiquity. Hematite first appeared in modern jewelry in the early 1800s, when Alexander Baronoff (1747-1819), the first governor of Russian America, encouraged Aleut silversmiths in what is now Alaska to mount polished hematite in rings and pendants. Baronoff presented a collection of this jewelry to Czar Alexander I (1777-1825) as a gift from his native

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subjects. Hematite-in-silver remains a traditional form of Alaskan jewelry today. In the 1880s, highly polished specular hematite, with its gray-black color and bright, metallic luster, gained great popularity in the mourning jewelry of Victorian England.

Today, hematite cabochons and spherical, faceted, and irregularly-shaped, tumbled beads are often used in jewelry. Small hematite beads closely resemble black pearls, and pearl-type, multi-stone necklaces and earrings are popular despite complaints that the mineral's considerable weight makes them uncomfortable for prolonged wear. Flat pieces of botryoidal hematite, polished to emphasize intricate surface patterns, are mounted in pendants. A rainbow variety of foliated, specular hematite has a lively, iridescent play of color. Specular hematite is also fashioned into paperweights, figurines, and spheres. We have sold hundreds of wholesale flats of specular hematite from northern Michigan, cut into thin slices and coated with acrylic, to wire wrappers and to rock shops around the country.

Cutable pieces of specular hematite can be synthesized by sintering (consolidating under heat and pressure) splinters and particles of natural hematite. Synthetic hematite, often marketed as "hemalyke" and "hematine," has the same chemical composition as natural hematite. But while the streak of natural hematite is red, that of the synthetic material is gray. Synthetic hematite closely imitates the natural stone and is ideal for inexpensively mass-producing beads, figurines, and other detailed, molded shapes. Much hematite sold in jewelry and as decorative objects today is synthetic. Because natural hematite cannot be magnetized, all magnetic hematite jewelry, considered by some to provide magnetic therapy, consists of synthetic hematite.

Mineral collectors value hematite in its crystalline and botryoidal forms, both as individual specimens or as composite specimens, the latter usually with quartz.

### *HISTORY & LORE*

Hematite has been used since the earliest days of human civilization. Powdered hematite is the red pigment in the Paleolithic cave paintings at Lascaux, France and the tribal body paints of many cultures worldwide. Ancient Egyptian royalty used hematite-based rouges, while the Babylonians engraved crystalline black hematite as intaglio seals. The reflective faces of crystalline hematite also served as mirrors, hence the name "specular" hematite, from *speculum*, the Latin word for "mirror." Metallic iron, crudely smelted from hematite, was used for decorative objects as early as 3500 B.C. The abundance of hematite and the development of early smelting techniques made possible the Iron Age, one of the great advancements in technology. Egyptians fashioned crude iron tools as early as 3000 B.C. Greeks and Romans believed that deposits of red hematite marked the sites of bloody, ancient battles. Red hematite was associated with Mars, the Roman god of war, and was thought to grant invincibility to warriors in battle. Roman scholar Pliny the Elder (Gaius Plinius Secundus, A.D. 23-79) believed that hematite talismans assured their wearers of favorable petition hearings and lawsuit settlements.

In the late 1700s, scientists recognized that the dark and red forms of hematite were variations of the same mineral. The Nobel Prize-winning American quantum chemist and crystallographer Linus Carl Pauling (1901-1994) used X-ray diffraction methods to define hematite's atomic structure in 1926. Dr Pauling spent his latter years at his home on California's Big Sur shore, just north of Cambria where we live. Friends of ours served as his caretakers before his death, and told us that he had on display in his home several magnificent specimens of the symmetrical cubic pyrite from Spain that we love so well!

The state of Alabama designated hematite as its official mineral in 1967. An estimated 375 million tons of hematite, known locally as "red iron ore," were mined in eight Alabama counties from 1840 to 1975. Large

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deposits of coal and red iron ore sustained Birmingham's steel industry for over a century. In 1904, locally-mined red iron ore provided the iron for the statue of Vulcan, the Roman god of fire and metalworking, that stands atop Red Mountain near Birmingham. It is the largest cast-iron structure ever made. In 1998, Central Africa featured specimens of specular hematite on its 400-franc stamp.

Ancient physicians used hematite to treat circulatory, heart, and kidney disorders. Modern metaphysicians believe that hematite enhances energy, vitality, intellect, and memory, helps the body to tolerate stress, and aids overall healing.

### *TECHNOLOGICAL USES*

As the primary ore of iron, hematite has yielded about 85 percent of all the iron mined throughout history. Initially, all smelted iron was wrought iron containing very little carbon. But by 1400 A.D., wrought iron had been largely replaced by pig iron containing two to four percent carbon. Modern mass-production of iron began in 1855, when British engineer Sir Henry Bessemer (1813-1898) developed the Bessemer furnace, or Bessemer converter, which used blasts of air to refine molten iron.

Today, metallic iron is produced with the same basic processes that were devised in antiquity. A charge of finely ground iron ore (consisting of iron oxide and silicate gangue minerals), coke (a distilled form of coal), and powdered limestone (primarily calcium carbonate,  $\text{CaCO}_3$ ) is fired, melted, and oxygenated with blasts of air. The coke serves as a fuel and converts to carbon monoxide (CO), which reduces the iron oxide to metallic iron according to the basic formula  $\text{Fe}_2\text{O}_3 + 3\text{CO} = 3\text{CO}_2 + 2\text{Fe}$ . The limestone also contributes carbon monoxide and acts as a flux to form calcium silicate ( $\text{Ca}_2\text{SiO}_4$ ). Without limestone in the charge, much iron would convert to iron silicate ( $\text{Fe}_2\text{SiO}_4$ ), thus rendering the process inefficient. When smelting is complete, molten pig iron collects at the bottom of the furnace, while calcium-silicate slag floats to the top. This pig iron consists of about 92 percent iron, 3-4 percent carbon, 1-3 percent manganese, and small amounts of silicon, phosphorus, and sulfur. Pig iron can be refined into other types of iron and is the raw material for producing a broad variety of carbon and alloyed steels.

Until 1900, most iron ores consisted of high-grade hematite called "natural ore." Natural ore contains about 66 percent iron by weight and can be direct-smelted, that is, reduced to metallic iron without prior concentration. Most hematite ore today is much lower in grade and is concentrated by heavy-liquid separation. Finely ground ore is passed through an aqueous suspension of bentonite clay in which the hematite sinks, while the silicate gangue minerals float off. Some 1.3 billion tons of iron ore, mostly of hematite, are mined worldwide each year. China is the leading producer, followed by Australia, Brazil, and India. Small amounts of hematite are also used as red pigments, polishing powders, and industrial abrasives.

### *ABOUT OUR SPECIMENS*

August 2007 marks the second mineral we have featured from Morocco, after the attractive aragonite specimens we featured in June 2000, from the Tazouta Mine, Sefrou, Sefrou Prefecture, Fès-Boulemane Region, Morocco. This month's specimens of botryoidal hematite were collected at the Oumjrane Mine near Alnif in the Er Rachidia Province in Morocco's Meknès-Tafilales region. The Kingdom of Morocco is located on Africa's northwest shoulder directly south of the Strait of Gibraltar. The Atlantic Ocean lies to Morocco's northwest, the Mediterranean Sea to the north, Algeria to the east and southeast, and Western Sahara (territory claimed and administered by Morocco) to the southwest. Morocco's 172,413 square miles make it slightly larger than the state of California. Morocco is roughly bisected by the southwest-northeast-trending greater Atlas Mountains, made up of the High (Haut, Grand) Atlas Mountains and

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several sub-ranges, including the Middle Atlas and the Anti Atlas mountains. Morocco's population, industrial development, and agriculture are concentrated north and west of the Atlas Mountains along the Mediterranean and Atlantic coasts. Er Rachidia Province is located south of the Atlas Mountains in an arid, sparsely populated, and undeveloped area bordering the Sahara Desert. The Oumjrane silver-copper mine is 20 miles south of Alnif and the same distance north of the Algerian border. The town of Alnif, population 1,800, is at an elevation of 2,900 feet near the eastern end of the Anti Atlas Mountains.

The Anti Atlas Mountains were created in two uplifts. The first occurred 300 million years ago when crustal stresses associated with the rifting of the Pangaeen supercontinent uplifted huge blocks of sandstone and limestone. These original Anti Atlas Mountains may have been as high as the Himalayas are today. Long after erosion had nearly leveled them, the collision of the African and Eurasian plates about 80 million years ago generated a second uplift. As the crust fractured, magma forced its way upward to form igneous intrusions within the ancient sedimentary country rock. Accompanying surges of mineral-rich hydrothermal fluids emplaced scattered vein systems rich in silver, copper, and iron minerals. Over eons of erosion and weathering, groundwater leached the uppermost veins, altering, transporting, and concentrating their mineral content in nearby, lens-shaped, sedimentary traps.

Erosion has since reduced the Anti Atlas Mountains to their present topography and a maximum elevation of about 8,000 feet. Erosion has also exposed dozens of silver-copper vein emplacements and secondary, lens-type deposits of varying sizes and depths. The most accessible of these silver deposits were first worked more than 1,200 years ago. Modern mineral exploration has led to a revival of mining activity in the Anti Atlas region. The largest modern mine, the Imiter, works a complex system of underground veins and lenses to produce about 250 metric tonnes (about 7.7 million troy ounces) of silver per year.

The Oumjrane Mine, the source of our hematite specimens, exploits a much smaller underground silver-copper deposit. Production at Oumjrane began in 2004. The first mineral specimens—botryoidal pocket linings of brilliant, blue azurite crystals on pale-green malachite [azurite and malachite are basic copper carbonates with respective formulas  $\text{Cu}_3(\text{CO}_3)_2(\text{OH})_2$  and  $\text{Cu}_2(\text{CO}_3)(\text{OH})_2$ —were recovered in February 2005. Later that year, these specimens were widely acclaimed at mineral shows in western Europe. Many azurite-malachite pockets at Oumjrane also contain fine hematite specimens. Now aware of the value of these mineral specimens, Oumjrane miners also collect botryoidal hematite to sell to dealers.

The Oumjrane mine is one of the most recent developments in Morocco's long mining history. This mining tradition began about 1000 B.C. when Morocco's coastal areas were a Phoenician colony that exported silver, lead, copper, iron, and salt. Mining boomed again in 1400 A.D. to supply a brisk trade with Portugal. French engineers began modernizing Moroccan mining in the 1920s. Today, Morocco is the world's third



Figure 1. A Casbah, or fortress, in Morocco, probably inhabited by an extended family.



Figure 2. Women on donkeys returning from Souk. All photos by Leven Jester.

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largest producer of phosphate rock and also a major supplier of barite.

Together, the Imiter, Oumjrane, and other mines now produce 300 metric tonnes (9.3 million troy ounces) of silver each year. With increasing mineral exploration and the development of new metal mines, Morocco's reputation as a source of fine mineral specimens and fossils continues to grow.

Alnif is the nearest town of any size to the Oumjrane Mine. Its merchants, who now market azurite-malachite and hematite specimens, have much experience to draw upon. Alnif is well-known among fossil collectors as the source of some of the world's finest

Devonian trilobite specimens. These fossils are found in the uplifted and exposed limestone layers in the nearby foothills of the Anti Atlas Mountains. Collecting these fossils, exposing them in relief, and selling them from shops and roadside stands have long been cottage industries in Alnif.



Figure 3. Mineral dealer in Mibladen, Morocco.

All our hematite specimens display rounded bulges, and if you examine your specimen along the edges with a loupe or magnifying glass, you may see the hairlike hematite crystals extending upward toward the top. You may also notice the growth layers. The three terms employed to describe the crystal habits of our hematite are reniform, botryoidal, and mamillary. "Reniform" means "kidney-shaped," referring to minerals that have the form or shape of a kidney, as many of ours do. When the protruding rounded bulges on top are small and shaped rather like grapes, the crystal habit is called "botryoidal," from the Greek word meaning "bunch of grapes." Our September 2005 prehnite specimens from the new find in Mali certainly fit this description. When the mineral surface is in the form of large rounded prominences, as some of our hematite pieces are, the habit is called "mammillary," derived from the Latin word for "breast." African malachite often shows these same three crystal habits. Some of our specimens also show a flowing, almost stalactitic form, another attractive feature of these specimens. And a very few pieces were red, perhaps due to a slight difference in composition or natural alteration. Yes, many of us may never have been fans of "Heavy Metal"—until we became mineral collectors!

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