

## June 2009 Mineral of the Month: Stibnite

This month's mineral is among the most collectible of all minerals. Ours come from a Chinese antimony mine that is now recognized as a classic stibnite locality, and our write-up explains the unusual structure and properties of stibnite, describes its remarkable crystals, and details the many uses of antimony.

### OVERVIEW

### PHYSICAL PROPERTIES

Chemistry:  $\text{Sb}_2\text{S}_3$  Antimony Trisulfide, often containing some bismuth

Class: Sulfides

Group: Stibnite

Crystal System: Orthorhombic

Crystal Habits: Individual bladed or acicular prisms or jumbled aggregates of prisms, striated lengthwise; prisms often bent or twisted; also as radiated groups and granular and massive forms.

Color: Lead-gray and gray-black to steel-gray and silvery-gray, sometimes with a bluish hue; occasionally iridescent; tarnish black.

Luster: Metallic

Transparency: Opaque

Streak: Dark lead-gray

Refractive Index: None (opaque)

Cleavage: Perfect in one direction lengthwise

Fracture: Subconchoidal to irregular; brittle; thin prisms are slightly flexible.

Hardness: 2.0

Specific Gravity: 4.6

Luminescence: None

Distinctive Features and Tests: Best field identification features are softness; flexibility of thin prisms; and long, bladed and acicular crystal habits. Visually similar to bismuthinite [bismuth trisulfide,  $\text{Bi}_2\text{S}_3$ ], which has considerably more density.

Dana Classification Number: 2.11.2.1

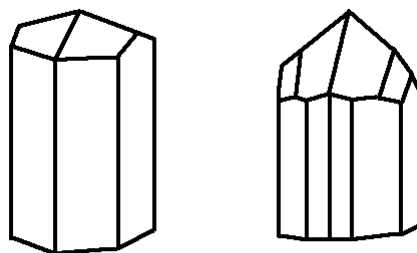


Figure 1. Stibnite crystals.

**NAME** Stibnite, pronounced STIBB-nite, derives from *stibi*, the Greek name for the mineral. Stibnite has formerly been referred to as “antimonite,” “antimonide,” “sulfur antimonide,” “sulfur antimony,” “antimony glance,” “gray antimony,” “gray antimony ore,” “kohl,” “stibi,” “stimmi,” “stibium,” “lupus metallorum,” “platyophthalmite,” and “speissglas.” In current European mineralogical literature, stibnite appears as *stibnit*, *stibnita*, and *stibnine*. Antimony, pronounced ANN-tih-mow-nee, stems from the Latin word for the metal, *antimonium*, which means “opposed to solitude,” in allusion to its rare occurrence as a native element.

**COMPOSITION:** Stibnite's chemical formula  $\text{Sb}_2\text{S}_3$  shows that it contains the elements antimony (Sb) and sulfur (S). Its molecular weight consists of 71.68 percent antimony and 28.32 percent sulfur. Stibnite is a member of the sulfides, a group of more than 350 minerals in which sulfur is combined with one or more metals. Most sulfide minerals, including stibnite, are dense, brittle, dark in color, and metallic in luster. As the most abundant antimony-bearing mineral, stibnite forms in epithermal (low-temperature) veins and hot-spring deposits. It is often associated with realgar, orpiment, cinnabar, arsenopyrite, gold, and calcite. As an idiochromatic or self-colored mineral, stibnite's basic lead-gray color is caused by its essential elemental components and the nature of its crystal structure, rather than by nonessential impurities. Its

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basic color is sometimes affected by tarnish and iridescence. **Stibnite is mildly toxic. As a precaution, it is advisable to wash one's hands after handling a specimen.**

**COLLECTING LOCALITIES:** China now produces most of the world's stibnite specimens with notable localities including the Baoshan antimony-gold deposit in De'an County, Jiujiang Prefecture in Jiangxi Province; the Xikuangshan antimony deposit in Lengshuijiang County in Loudi Prefecture, Hunan Province, which is where our specimens were collected when we first featured stibnite in February 1998; and the Dachang antimony-gold deposit at Qinglong, Qianxi'nan Autonomous Prefecture in Guizhou Province. Japanese specimens, often iridescent, come from the Yohoki and Ichinokawa mines at Saijo in Ehime Prefecture on Shikoku Island. Bolivian specimens are collected at the Itos, San José, and Socavon mines at Oruro in Oruro Department; and at the Siglo Veinte Mine at Llallagua in Potosí Department. European sources include the Luri Mine at Marine de Luri, Corsica, France; the Lichtenberg Absetzer and Reust mines in Thuringia, Germany; Le Cetine di Cotorniano Mine near Chiusdino in Tuscany, Italy; the Craven Dol Mine at Allchar, Macedonia; and the Hiendelaecina Mine in Castile-La Mancha, Spain. In the United States, stibnite localities are found in Alaska, Arkansas, California, Idaho, Nevada, and South Dakota.

**HISTORY, LORE, & USES:** Stibnite is too soft (Mohs 2.0) for use in jewelry. But its bright metallic luster and well-formed, long, striated crystals that are often distorted into unusual shapes rank it among the most collectible minerals. Early Egyptians and Hindus used powdered stibnite as an eye-shadow cosmetic; later, Roman and medieval physicians prescribed powdered stibnite to treat a variety of ailments. Many black or near-black paints used by Renaissance artists contained powdered stibnite as their primary pigment. Modern metaphysical practitioners believe that stibnite enhances knowledge, guidance and direction, facilitates understanding of the natural world, helps to improve relationships, increases the ability to understand one's soul, alleviates stomach discomfort and relieves muscle stiffness. Stibnite was known as "stibium" before receiving its current name in 1854. Stibnite is the primary ore of the semimetal antimony, which serves as an alloying metal and semiconductor. Antimony compounds are used as flame retardants, pigments, and glass additives.

**ABOUT OUR SPECIMENS:** Our specimens were collected at the Wuling (Wuning) underground antimony mine at Qingjiang, Wuling County, Jiujiang Prefecture, Jiangxi Province, in the People's Republic of China. The Wuling mine, located in south-central China some 350 miles north of Hong Kong, began production in 1982 and is expected to close when its stibnite-ore reserves are depleted in 2012. The mine gained fame in 1997 for its superb stibnite specimens and is now recognized as a classic stibnite locality. The Wuling antimony deposit was emplaced some 130 million years ago when antimony-rich hydrothermal solutions associated with volcanic activity penetrated faulted limestone country rock to precipitate stibnite within faults and shear zones.

**10 YEARS AGO IN OUR CLUB:** We featured Rutile from near Novo Horizonte, Bahia, Brazil, in June 1999. We sent specimens much smaller than what we typically do—clusters of golden needle-like crystals jutting in every direction in a starlike pattern, some overgrown on flat crystals of lustrous grey hematite. Large specimens more than a couple of inches across are very rare and valuable. We still see a smattering of these lovely specimens offered by Brazilian dealers and others, but we usually resist purchasing them because of their delicacy and tendency to get damaged in hauling and handling. Let us know if you'd like one and we'll look for another small lot to offer you! Of course, most desirable to gemstone cutters are lovely, thin, golden crystals of rutile encased in quartz. Rutilated quartz, as this combination is known, is now among the most sought-after stones by designers of high-end, one-of-a-kind jewelry, and high quality cutting rough and specimens have skyrocketed in price as a result, so much so that we rarely see top quality rutilated quartz crystals offered for sale at shows—they sell so quickly!

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### **COMPREHENSIVE WRITE-UP**

#### *COMPOSITION*

The chemical formula  $\text{Sb}_2\text{S}_3$  shows that stibnite contains antimony (Sb) and sulfur (S). Stibnite's molecular weight is made up of 71.68 percent antimony and 28.32 percent sulfur. The stibnite molecule consists of a simple cation (positively charged ion) and a simple anion (negatively charged ion). Both antimony, which is a semimetal or metalloid (see "The Semimetal Antimony") and sulfur have multiple oxidation or valance states. The three common oxidation states of antimony are +5, +3, and -3; those of sulfur are +6, +4, +2, +1, 0, and -2. In stibnite, antimony is present in its +3 oxidation state, while sulfur has a -2 oxidation state. The stibnite molecule achieves electrical balance and stability because the cumulative +6 cationic charge of its two antimony ions  $2\text{Sb}^{3+}$  equals the cumulative -6 anionic charge of its three sulfur ions  $3\text{S}^{2-}$ .

Stibnite is one of the more than 350 sulfide minerals, a group in which sulfur is combined with one or more metals. Generally, almost all sulfide minerals, including stibnite, are dense, brittle, dark in color, and metallic in luster. Because antimony is a semimetal, stibnite does not precisely fit the definition of a sulfide, and might seemingly be better categorized as a sulfosalt, a mineral in which sulfur is combined with one or more metals and one or more semimetals. But in stibnite, antimony functions as a metallic cation with a positive oxidation state, forms metallic bonds, and occupies distinctly metallic positions within the crystal lattice, thereby justifying stibnite's classification as a sulfide.

Stibnite molecules form square-based, pyramidal structures arranged in parallel, chainlike ribbons that are joined together primarily by covalent bonding between the sulfur and antimony ions. Within the stibnite lattice, antimony and sulfur ions exhibit two different types of coordination. Half the antimony ions are surrounded by five sulfur ions, each of which is bonded to three antimony ions. The remaining antimony ions are surrounded by three sulfur ions, each of which is bonded to two antimony ions. The pyramidal structures are joined by strong covalent bonds at their apexes to form double-pyramidal layers. The bases of the pyramids in adjacent layers are joined mainly by weak metallic bonding to form the plane of stibnite's perfect, one-directional cleavage. The weak metallic bonding along this plane also explains stibnite's considerable softness of Mohs 2.0. Because heat easily breaks these weak metallic bonds, stibnite has a low melting point of 1015° F. (546° C.)—low enough for it to fuse in a candle flame.

Stibnite's plane of one-directional cleavage also functions as a gliding plane during crystal growth and explains two of its other diagnostic features: lengthwise striations and curvature of its long prisms. Stibnite is a textbook example of a mineral with prominent gliding planes. As stibnite crystals grow, this plane often displaces or "glides" under the stress of growth to cause twinning, in which the crystal continues to grow, but along new axes. Repeated displacement of the glide planes creates new crystal-face edges that manifest themselves in one of stibnite's most prominent features—the pronounced longitudinal, parallel, hairline grooves called striations. This same secondary twinning that creates striations also creates additional, internal lattice stresses that can cause prisms to bend or curve, an effect most noticeable in longer prisms.

Stibnite crystallizes in the orthorhombic system, which is characterized by three mutually perpendicular axes of different lengths. When one axis of an orthorhombic crystal becomes notably longer than the other two, the crystal will appear as a long, thin prism, blade, or needle. The rate of growth in orthorhombic crystals can vary radically along different axes to determine crystal habit. The long chains that characterize the stibnite lattice cause a single axis to grow much faster than the other two axes, thus creating its characteristic long prisms, blades, or needles. Minerals that are chemically complex or, in the case of stibnite, have complex bonding arrangements commonly crystallize in the orthorhombic system.

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Stibnite is the most abundant of all antimony minerals. Small deposits of stibnite are common, but large deposits are quite rare. Stibnite usually forms in epithermal (low-temperature) vein and hot-spring deposits in association with realgar [arsenic sulfide,  $\text{As}_4\text{S}_4$ ], orpiment [arsenic sulfide,  $\text{As}_2\text{S}_3$ ], cinnabar [mercury sulfide,  $\text{HgS}$ ], arsenopyrite [iron arsenic sulfide,  $\text{FeAsS}$ ], and calcite [calcium carbonate,  $\text{CaCO}_3$ ]. Stibnite also occurs as an accessory mineral in many gold [Au] deposits. Stibnite is dimorphous (has an identical chemistry but a different structure) with metastibnite [antimony trisulfide,  $\text{Sb}_2\text{S}_3$ ], an amorphous mineral with no recognized crystal structure. Because bismuth substitutes readily for antimony and vice versa, stibnite forms a complete solid-solution series with bismuthinite [bismuth trisulfide,  $\text{Bi}_2\text{S}_3$ ]. In the upper, oxidized zones of antimony deposits, stibnite alters to stibiconite [basic antimony oxide,  $\text{Sb}^{3+}\text{Sb}^{5+}\text{O}_6(\text{OH})$ ].

As an idiochromatic or self-colored mineral, stibnite's basic lead-gray color is caused by its essential elemental components and the nature of its crystal structure, rather than by nonessential impurities. Except in very thin section, stibnite is opaque, meaning it reflects but does not transmit light. Stibnite's distinct metallic luster is caused by the weak metallic bonding that exists between its antimony ions (metallic bonding is one of antimony's metallic properties) and the inability of its sulfur ions to completely shield this bonding. Metallic bonding creates a pool of free-moving electrons, and the manner in which these free electrons at the surface of stibnite interact with light accounts for the mineral's opacity, color, and metallic luster. These surface electrons absorb all incident light more-or-less equally across the visible spectrum to become energized. To return to their normal levels, they release their excess energy in wavelengths that we perceive as lead-gray and gray-black to steel-gray and silvery-gray with an occasional bluish tint. Because of the manner in which light interacts with these constantly moving free electrons, stibnite exhibits a bright, diagnostic metallic luster.

Stibnite's basic color is affected by tarnish and iridescence. Tarnish occurs when microscopic particles of antimony separate from both the crystal lattice and the metallic-bonding free-electron pool to form a thin surface film. Because of diminished metallic-bonding strength, they reflect less light, have no metallic luster, and appear as a dull, dark tarnish. This microscopically thin film of tarnish can also cause the phenomenon of optical interference that creates rainbow-like flashes of iridescent colors. Interference occurs when two or more light waves overlap. When incident light strikes the surface of tarnished stibnite, a portion of the incident light is reflected from the top of the tarnish film, while the remainder penetrates the film to be reflected from the surface of the stibnite itself. When these two reflected light waves reinforce each other in frequency, phase, and amplitude, the colors we perceive have the vivid, "electric" character of iridescence.

The Dana classification number 2.11.2.1 first categorizes stibnite as a sulfide (2), a group that includes the selenides (minerals consisting of metals and selenium) and tellurides (minerals consisting of metals and tellurium). Stibnite is subclassified (11) by the general formula  $\text{A}_m\text{B}_n\text{X}_p$ , in which "A" can be such metals as iron (Fe), cobalt (Co), nickel (Ni), or the platinum-group metals iridium (Ir), ruthenium (Ru), or osmium (Os); "B" can be the semimetals antimony or arsenic (As); and "X" is sulfur. In the general formula  $\text{A}_m\text{B}_n\text{X}_p$ , the ratio of  $m+n:p$  must be 2:3, which is seen in the stibnite formula  $\text{Sb}_2\text{S}_3$ . Stibnite is then assigned to the stibnite group (2) as the first (1) of four closely related members that also include antimonoselite [antimony selenide,  $\text{Sb}_2\text{Se}_3$ ], bismuthinite [bismuth trisulfide,  $\text{Bi}_2\text{S}_3$ ], and guanajuatite [bismuth selenide,  $\text{Bi}_2\text{S}_3$ ].

### ***COLLECTING LOCALITIES***

Although large deposits are rare, stibnite is widely distributed and has numerous collecting localities. Our specimens were collected at the Wuling (Wuning) underground antimony mine at Qingjiang, Wuling County, Jiujiang Prefecture, Jiangxi Province, in the People's Republic of China. Specimens are also collected at the Baoshan antimony-gold deposit in nearby De'an County. Other noted Chinese localities are the Xikuangshan antimony deposit in Lengshuijiang County in Loudi Prefecture, Hunan Province; and

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the Dachang antimony-gold deposit at Qinglong, Qianxi'nan Autonomous Prefecture in Guizhou Province. Japanese stibnite sources include the Tsugu and Furikusa mines at Kita-Shidara-gun in Aichi Prefecture in the Chibu Region of Honshu Island; spectacular iridescent crystals come from the Yohoki and Ichinokawa mines at Saijo in Ehime Prefecture on Shikoku Island. In Russia, stibnite is collected at the Nikolaevskiy Mine at Dal'negorsk, Primorskiy Kray in the Far-Eastern Region. Indonesian specimens come from the Busang gold prospect in the Central Kalimantan region of Borneo.

In Europe, stibnite is collected in France at the Luri Mine at Marine de Luri at Bastia in Haute-Corse on the island of Corsica; in Germany at the Lichtenberg Absetzer and Reust mines at the Ronneburg uranium deposit, Gera, Thuringia; in Italy at Le Cetine di Cotorniano Mine near Chiusdino in Tuscany; in Macedonia at the Craven Dol Mine at Allchar in Roszdan; in Spain at the Hiendalaecina Mine in the Hiendalaecina district at Guadalajara in Castile-La Mancha; in Romania at the Felsöbanya Mine at Baia Sprie in Maramures County; and in England at the Robin Hood Mine at Bassenthwaite, Cumberland, Cumbria.

Stibnite specimens are also collected in South Africa at the United Jack Mine in the Zoutpansberg district of the Murchison Range in Limpopo Province; in Mexico at the Ojuela Mine at Mapimí in Durango; in Canada at the McKenzie Mine on McKenzie Island in the Kenora district of Ontario, and at the Lac Nicolet Mine (Quebec Antimony Mine) at South Ham in Wolfe County, Québec. Bolivian specimens come from the Itos, San José, and Socavon mines at Oruro, Cercado Province, Oruro Department; and the Siglo Veinte Mine at Llallagua, Bustillos Province, Potosí Department. Peruvian localities include the Hercules Mine in the Tiacampa district, Recuay Province, Ancash Department; the mines of the Castrovirreyna district, Angaraes Province, Huancavelica Department; and the Raua district mines in Cajatambo Province, Lima Department.

In the United States, stibnite is found in Alaska in the old mines of the Kantishna district and in Denali National Park and Preserve in Denali Borough, and in the Fairbanks district mines in Fairbanks North Star Borough; in Arkansas in the Gillham mines in Sevier County; in Colorado at the Zuni Mine at Anvil Mountain near Silverton in San Juan County; in California at the Shriver Mine at Hollister in San Benito County; in Nevada at the Murray Mine in the Independence district in Elko County, and the White Caps Mine in the Manhattan district of Nye County; in Oregon at the Parker mine in the Rock Creek district of Union County; in South Dakota at the French Mine in Lawrence County; in Utah at the Mecur district mines in the Oquirrh Mountains of Tooele County; and in Maryland at the Delight Mine at Delight in Baltimore County. Idaho has produced many fine stibnite specimens, notably from the Stanley antimony mine at Burke, the Gold Hunter Mine at Mullan, and the Enterprise and Sunshine mines at Kellogg, all in Shoshone County's Coeur d'Alene district. The mines at the old Stibnite town site in the Yellow Pine Mining District of Valley County, Idaho, were once prolific specimen sources.

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

Because of its considerable softness (Mohs 2.0), stibnite has no use in jewelry. However, it makes especially desirable collectors' specimens because of its bright, metallic luster and long, well-formed, striated crystals that are often curved and distorted into unusual shapes. Beautiful stibnite specimens are displayed in the mineralogical collections of most museums around the world. Fine, undamaged specimens of stibnite with individual crystals approaching 10 inches in length sell for thousands of dollars.

The world's largest and arguably finest stibnite specimen was placed on permanent display at the American Museum of Natural History in New York City in April 2007. This 1,000-pound matrix specimen, with its hundreds of curved stibnite blades, some as long as 15 inches, was recovered in late 2006 from China's Wuling antimony mine--the source of our specimens! This huge specimen was discovered by Chinese miners who had blasted open a large pocket. Mine supervisors immediately contacted

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commercial specimen collectors who successfully extracted sections of the pocket wall with undamaged crystals. World-renowned mineral collector Marc Weill of New York City purchased the specimen for an undisclosed sum and donated it to the American Museum of Natural History. At the unveiling of this remarkable stibnite specimen, Curator George Harlow of the museum's Department of Earth and Planetary Sciences called it a "miracle" that the specimen had survived the mining process. Harlow also explained how recent industrialization in China has made Chinese miners aware of the value of fine mineral specimens, while museums and collectors around the world have become aware of the availability of remarkable Chinese specimens.

### ***HISTORY & LORE***

Stibnite has been known since antiquity and was probably first used by early Egyptians and Hindus in powdered form as an eye-shadow cosmetic. Roman and medieval physicians later prescribed powdered stibnite to treat a variety of ailments, most often as an emetic (an agent that causes vomiting) to purge harmful "humors." Many black or dark-colored paints used by Renaissance artists contained powdered stibnite as a pigment. Prior to 1854, when it received its current name, stibnite was known as "stibium." The atomic structure of stibnite was defined by X-ray diffraction in 1933 and finally explained the cause of its prominent striations and unusual crystal habits.

Stibnite crystals have been featured on Turkey's 10-lira postage stamp of 1979, China's eight-fen stamp of 1982, Romania's four-leu stamp of 1985, Austria's four-schilling stamp of 1986, Kyrgyzstan's 14-tiyin stamp of 1994, and Macedonia's 27-denar stamp of 1997. Modern metaphysical practitioners believe that stibnite enhances knowledge, guidance and direction, facilitates understanding of the natural world, helps to improve relationships, increases the ability to understand one's soul, alleviates stomach discomfort and relieves muscle stiffness.

### ***TECHNOLOGICAL USES***

Stibnite is the primary ore of antimony (see "The Semimetal Antimony"). China is the leading producer of primary (newly mined) antimony, accounting for 88 percent of world output, and also has most of the world's reserves of stibnite ore. Bolivia and Russia rank second and third in primary antimony production, followed by Tajikistan and Australia. Some 170,000 metric tons are now recovered worldwide each year from stibnite ores. Fifteen nations recover significant amounts of antimony as a by-product of smelting precious- and base-metal ores and by recycling lead-antimony alloys. The United States is a minor producer of antimony and relies heavily on foreign imports. Refined antimony sells for \$2.70 per pound.

### ***THE SEMIMETAL ANTIMONY***

*Antimony, the cationic component of stibnite, is a dull, brittle, silvery-gray to bluish-white semimetal with an atomic number of 51, an atomic weight of 121.74, and a melting temperature of 1166° (630° C). Ranking 64<sup>th</sup> in crustal abundance (about 0.000002% of the crust), antimony is about as common as silver. Antimony's chemical symbol Sb is derived from the old Latin stibium.*

*Unlike silver and other metals which are malleable and have high electrical conductivity and a bright, metallic luster, antimony is dull and brittle and has poor electrical conductivity. But because it forms weak metallic bonds and metal-like cations in stibnite and other minerals, it is classified as a semimetal or metalloid, meaning it shares certain characteristics of both metals and nonmetals. The periodic table of elements places antimony in Group Va (15), along with the closely related elements arsenic (As) and*

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bismuth (Bi). With the exception of aluminum (Al), the semimetals are grouped at the right of the periodic table along both sides of the "staircase" line that separates metals from nonmetals.

Antimony has been known since antiquity. Early metallurgists reduced antimony to its elemental state by heating mixtures of finely ground stibnite and iron in charcoal-drafted furnaces. Egyptian, Greek, and Roman metallurgists mixed antimony with various metals to improve the casting qualities of the resulting alloys. Roman scholar Pliny the Elder (Gaius Plinius Secundus, A.D. 23-79) referred to both stibnite and elemental antimony as stibium. Muslim alchemist Abu Musa Jabir Ibn Hayyan (Geber, ca. 721-ca. 815) was the first to document the isolation of antimony and is thought to have assigned it the name antimonium, from the Latin words anti and monos, meaning "opposed to solitude," alluding to its rare elemental occurrence in nature. Other scholars, however, believe that the word "antimony" stems from the Arab expression "Anton Ammon," meaning "bloom of the god Ammon." A legend regarding the origin of the word "antimony" has European farmers feeding small amounts of antimony to pigs, resulting in a noticeable weight gain. Monks who became aware of this tried adding antimony to their diet in an effort to gain weight prior to extended fasts, but the antimony proved toxic to the monks, and many died as a result. If we look again at the word "antimony," we find it is made up of "anti," meaning "against," and "mony," a form of "monus," meaning "solitude." The word "monk" also derives from "monus," so some say "antimony" originally meant "against monks." Factual? Probably not.

German alchemist Basil Valentine (Basilius Valentinus, ca. 1394 - ?) also isolated the semimetal from stibnite about 1450, renaming it "antimony" and classifying it as an element. Alchemists of the period considered antimony a candidate for transmutation into gold. In 1680, French chemist Nicolas Lémery (1645-1715) became the first scientist to study antimony in detail. Nevertheless, antimony was not formally described in modern literature until 1832.

The primary use of antimony is in the form of antimony trioxide ( $\text{Sb}_2\text{O}_3$ ) as a flame retardant for rubber, textiles, plastics, paints, and other combustibles. Although antimony trioxide itself is not a flame retardant, it participates in two chemical reactions that inhibit ignition and combustion. In the first reaction, antimony trioxide and compounds of the halogen elements chlorine and bromine are incorporated into combustible materials. At temperatures above  $600^\circ\text{F}$  ( $301^\circ\text{C}$ .), these halogen compounds form hydrochloric and hydrobromic acids which convert the antimony trioxide to antimony halides and oxyhalides. In combustion reactions, heat creates free radicals that propagate flames, but antimony halides and oxyhalides "trap" these free radicals to suppress ignition and combustion. In the second reaction, antimony trioxide, when exposed to heat, promotes the formation of a carbon coating called "char" on material surfaces to reduce the release of the free radicals and volatile gases that encourage combustion.

Ironically, while antimony trioxide retards combustion under certain conditions, the trisulfide can promote combustion. Because antimony trisulfide can melt and ignite at relatively low temperatures, it serves as a combustion-supporting ingredient in tracer bullets, smokescreen compounds, and the striking surface of safety matches. Antimony trisulfide also produces the "glitter" effect in fireworks. Other antimony compounds serve as catalysts in the production of plastics and as clarifying agents in the manufacture of optical glass. Antimony oxides are used as brilliant-yellow pigments.

Antimony is among the few materials that expand as they cool and solidify (bismuth and water are two others). Solid antimony occupies three percent more volume than it does in its molten state. When mixed with lead, antimony produces a superb alloy that completely fills molds to make perfect metal casts. Antimony-lead alloys were used for centuries to cast "hot lead" printing type, a use that has now declined

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*with the emergence of offset and digital printing methods. Because antimony imparts hardness to lead alloys, it is used to make solder, ammunition, sheathing for electric cables and, most importantly, battery terminals for automotive and marine batteries. Low-wear machine bearings usually consist of such soft, slippery antimony alloys as babbitt metal. Highly purified elemental antimony is employed in transistors and other solid-state, semi-conducting devices.*

### **ABOUT OUR SPECIMENS**

Our specimens were collected at a recently recognized classic stibnite locality—the Wuling (Wuning) antimony mine at Qingjiang, Wuling County, Jiujiang Prefecture, Jiangxi Province, in the People's Republic of China. This area is in south-central China, roughly 350 air miles north of the coastal city of Hong Kong. It is more precisely located in northwestern Jiangxi Province, 60 miles northwest of the provincial capital of Nanchang. The mine and its support buildings are perched at an elevation of 2,000 feet on Tuobeishan Hill in the pine-forested Jiulingshan Mountains overlooking the Xiushui River and the hamlet of Qingjiang.

China has four major belts of antimony mineralization: the West Yunnan Belt, Qinling Belt, Jilin-Daningshan Belt, and South China Belt. The Wuling deposit is in the South China Belt, a mineralized zone of continental-volcanic origin at the edge of a volcanic-fault basin. Volcanic fault basins are areas where volcanic activity has fractured the crust into complex fault systems that have been penetrated by associated surges of superheated, acidic, antimony-rich mineral solutions. The Wuling deposit was emplaced some 130 million years ago during volcanism related to the Late Yanshanian-Himalayan Orogeny, a mountain-building episode created by the collision of the edges of distant tectonic plates. As acidic, antimony-rich hydrothermal solutions penetrated the faulted-limestone country rock, the calcite [calcium carbonate,  $\text{CaCO}_3$ ] within the limestone neutralized their acidity, causing antimony to precipitate from solution as a complex series of stibnite veins. Some vein sections remained as hollow voids or pockets, providing space for the growth of especially large, well-developed stibnite crystals. These pockets, which are the source of our specimens, are typically lined with thick layers of massive stibnite which are the matrix for the growth of stibnite crystals. Associated minerals include colorless to white calcite, colorless quartz [silicon dioxide,  $\text{SiO}_2$ ], pale-yellow barite [barium sulfate,  $\text{BaSO}_4$ ], arsenopyrite [iron arsenic sulfide,  $\text{FeAsS}$ ], pyrrhotite [iron sulfide,  $\text{Fe}_{1-x}\text{S}$ ], and tetrahedrite [copper iron zinc antimony arsenic sulfide,  $\text{Cu}_6\text{Cu}_4(\text{Fe,Zn})_2(\text{Sb,As})_4\text{S}_{13}$ ]. In the upper, oxidized zone of the Wuling deposit, the stibnite has partially or completely altered to stibiconite [basic antimony oxide,  $\text{Sb}^{3+}\text{Sb}^{5+}\text{O}_6(\text{OH})$ ].

Chinese government prospectors discovered the Wuling antimony deposit in 1962, and the Wuling municipal government opened the Wuling Mine in 1982. As part of China's subsequent policy of controlled industrial privatization, the mine was sold to the Star Antimony Limited Company in 1995. The underground workings are served by three shafts and have now reached the lower limits of the ore bodies some 200 feet below the surface. The Wuling Mine is largely dependent upon manual labor and employs 300 workers. The stibnite ore, which grades 15-20 percent antimony, is crudely crushed, then cobbled (hand-separated) to yield a concentrate containing about 50 percent antimony. The mine annually produces 1,200 tons of antimony concentrate, which is trucked to smelters in nearby Hunan Province.

During the mine's first 15 years of operation, many superb stibnite specimens were doubtlessly lost in the mining process. The mine's fame as a specimen locality began in 1997, when miners encountered the first of a series of spectacular stibnite pockets. The first pocket measured 9x18x60 feet and was completely lined with stibnite crystals ½-inch thick and up to 3 feet in length. This find came to the attention of mineral dealers and commercial collectors in the city of Changsha, 80 miles to the southwest in Hunan Province. The individual crystals and crystal clusters that they recovered were the first Wuling



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specimens ever preserved. When miners encountered two smaller pockets in 2000, supervisors again contacted Changsha collectors who removed many specimens intact. At the 2002 and 2003 mineral shows at Tucson, Arizona; Denver, Colorado; and Munich, Germany, these recoveries were ranked with the best Chinese stibnites ever found and compared favorably with the classic specimens from Saijo on Japan's Shikoku Island. This acclaim firmly established the Wuling Mine as a new, classic stibnite locality. Additional fine specimens came from the Wuling Mine in 2004 and 2006.

Almost all Wuling stibnite specimens are individual crystals or crystal clusters. Because of the softness of the massive stibnite that lines the pockets, removal of large, intact matrix specimens is very difficult and rarely accomplished. Collecting undamaged, individual stibnite crystals and crystal clusters requires experience and great patience. Unfortunately, the Wuling Mine will produce specimens for only a few more years. With three-quarters of its known stibnite-ore bodies mined out, production is expected to end in about 2012.

In studying your specimen, compare its physical properties with those listed at the beginning of this write-up. Our specimens consist of jumbled aggregates of long, bladed or acicular prisms. Notice how their basic crystal form has two short axes and one very long axis, a relationship that is typical of orthorhombic minerals (such as stibnite) that have chain-type structures. The massive stibnite that appears at the base of the crystal cluster is part of the stibnite pocket-wall lining on which the crystals grew. Massive stibnite has a dull, dark color, a fine granular texture, and no metallic luster, while stibnite crystals have a silvery-gray color and a bright metallic luster. Now rotate the specimen slowly so that the light reflects from all crystal faces and look for areas of dark, lead-gray tarnish. Note how the tarnish also has an iridescent bluish hue, which results from optical interference caused by light waves reflecting from both the surface of the tarnish film and the underlying surface of the stibnite. Stibnite is also quite soft (Mohs 2.0) and its crystal faces can be easily scratched by the point of a needle.

Two other diagnostic features of stibnite are its lengthwise striations and a curvature or distortion of some its longer prisms. These striations are the prominent longitudinal, parallel, hairline grooves on the prism faces. They result from repetitive stress-displacement of gliding planes with subsequent crystal twinning and continued growth along new axes to produce parallel crystal-face edges. Internal lattice stresses created by twinning along the glide planes have also caused the distortions in many prisms that range from barely perceptible curves to sharp bends. It is not surprising that stibnite, with its many unusual properties and beautiful luster, is one of our most collectible minerals!

**Antimony is toxic and its presence makes stibnite mildly toxic. Our specimens are stable and do not pose a health risk under normal conditions of storage and display. As a precaution, it is advisable to wash one's hands after handling stibnite specimens.**

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Since we have no photos of the Wuling mine to include in the write-up—the wholesaler who provided the specimens has never been to Wuling and his source there did not send us any photos—we thought we'd include portions of our "Tucson Report 1999" that you might enjoy and that gives you an idea of where our thinking was ten years ago:

"Approximately 25,000 gem and mineral lovers from all over the planet converge each February (now starting end of January) on Tucson, Arizona, to be bewitched, bothered, and bedazzled. This includes about 4000 dealers, set up at the (at least) 25 shows taking place virtually concurrently. No human could begin to see all there is to see, especially when they must spend the first twelve days at their ballroom booth selling wholesale their leftover Mineral of the Month Club specimens. (Mental note: Become a billionaire, then send agents with blank checks to buy every fabulous specimen.)

"Who knows what future treasures will come out of China? We have seen extraordinary pieces of fluorite, calcite, orpiment, and have featured azurite, realgar, and stibnite from China in our Club. We picked up a long, slender emerald crystal on matrix from China this year, and saw some fluffy looking pieces of light manganocalcite that disappeared before we could appropriate one. We did score some Herkimer Diamond-like enhydro crystals. And best of all, most Chinese material is low priced! Bring on much much, more. (Mental note: Become President of China . . .)

"Our first year in the Main Exhibit Hall at the Tucson Gem & Mineral Show was thrilling, and humbling. When one ponders the inventory of incredible specimens offered by many of the dealers there, one cannot help but feel a little small. Now, if we could just convince them all to lower their prices by 50%, we would really have something!

"An examination of the exhibit cases causes goose bumps. The TGMS pays insurance so that some of the world's finest mineral pieces can be on display, from places such as the Smithsonian, the Harvard Mineralogical Museum, and the Canadian Museum of Nature."

Rereading this information, we're glad to see that even ten years ago we felt that many dealers were asking too much for their minerals! Nothing has changed in the interim, the situation seems only to have gotten worse. Of course, one-of-a-kind, highest quality, superlative specimens from classic localities are certainly worth a lot of money, and there are many dealers there that have those, in everything from azurite to rhodochrosite to tourmaline and tanzanite. It's the very nice but not highest quality specimens that often seem overpriced, at least to us.

And a couple of years later, we quit selling at the Tucson Gem & Mineral Show altogether. The primary reason was one of fatigue—after selling for a week and a half at the Inn Suites, we were just too exhausted to set up and sell at the TGMS, too. We still remember the utter exhaustion we felt during our final year there in 2002! Plus it was an expensive show—\$1500 for a double-size booth and we had to pay more for electricity. And the setup was heavily regimented, as you might expect it to be, with all those dealers coming in and out, and the exhibitors setting up their cases, many with specimens of enormous value. And on top of all of this, sales were never very good there! The huge amount of dealers, the fact that it was at the end of all the events, the high cost of parking and admission—whatever the reasons, we just never did well there. We do two to three times better at the Denver Gem & Mineral Show in September than we ever did at the Tucson Gem & Mineral Show—who knows why?

Now, we finish out the show at the Inn Suites on Saturday, make last minute sales and then pack up our booth, and visit the TGMS show on Sunday to marvel at everything. And this has worked out quite well!