

September 2006 Mineral of the Month: Wavellite

This month's mineral is a rare hydrous phosphate collected from the classic locality at Mauldin Mountain, Arkansas. Its subtle range of colors, unusual chemical composition, and radial crystal structure make it the second most collectible mineral in Arkansas.

PHYSICAL PROPERTIES

Chemistry: $\text{Al}_3(\text{PO}_4)_2(\text{OH},\text{F})_3 \cdot 5\text{H}_2\text{O}$ Basic Hydrous Aluminum Fluorophosphate (Hydrous Aluminum Fluorophosphate Hydroxide), often containing iron and vanadium.

Class: Phosphates, Chromates, Arsenates, and Vanadates

Subclass: Hydrous Phosphates

Group: Wavellite

Crystal System: Orthorhombic

Crystal Habits: Short to long prisms, usually acicular, with parallel striations; individual crystals rare; commonly in flat to hemispherical and spherical radial aggregates and botryoidal crusts; also stalactitic and as coatings, fracture fillings, and rosettes; rarely in opaline masses.

Color: Green, greenish-blue, turquoise-blue, white, near-colorless, yellow, gray, brown, and brownish-black. Often color-zoned. Can appear colorless in transmitted light.

Luster: Vitreous

Transparency: Subtransparent to translucent

Streak: White

Cleavage: Perfect in one direction; good in two others.

Fracture: Uneven to subconchoidal, brittle.

Hardness: 3.5-4.0

Specific Gravity: 2.3-2.4

Luminescence: Usually none; yellow wavellite sometimes fluoresces.

Refractive Index: 1.52-1.55

Distinctive Features and Tests: Radial structure and occurrence as a secondary mineral. Botryoidal wavellite can sometimes be confused with chalcedony, which is much harder.

Dana Classification Number: 42.10.2.1

NAME

This month's mineral is pronounced "WAY-vell-ite" and is named in honor of its discoverer, British physician William Wavell (?-1829). Because of its complex chemistry that confused early researchers, wavellite had a variety of early names including "bialite," "devonite," "fischerite," "kapnicite," "lazonite," and "zepharovichite." English chemist Sir Humphry Davy (1778-1829) referred to the mineral as "hydrargillite."

COMPOSITION

This is now the second mineral we have featured from Arkansas, the first being pink dolomite from Black Rock, Lawrence County, in January 2001. For those keeping score, this is the 32nd mineral we have featured from localities in the United States—ten from California, four from Nevada, three each from Arizona and Utah, two each from Arkansas, Idaho, Missouri, and Tennessee, and one each from Colorado, Michigan, Oregon, and New York.

Wavellite's chemical formula $\text{Al}_3(\text{PO}_4)_2(\text{OH},\text{F})_3 \cdot 5\text{H}_2\text{O}$ identifies its elemental components as aluminum (Al), phosphorus (P), oxygen (O), hydrogen (H), and fluorine (F). The molecular weight of wavellite is made up of 19.20 percent aluminum, 14.70 percent phosphorus, 60.74 percent oxygen, 3.11 percent hydrogen, and 2.25 percent fluorine.

September 2006 Mineral of the Month: Wavellite

Within the wavellite molecule, the three aluminum cations (Al^{3+}) have a collective +9 electrical charge. The compound anion has two phosphate radicals $[(\text{PO}_4)^{3-}]$ and three fluorhydroxyl groups $[(\text{OH},\text{F})^{1-}]$. Each phosphate radical consists of one phosphorus ion (P^{5+}) bound to four oxygen ions (O^{2-}), resulting in a collective -3 charge. The three fluorhydroxyl groups, which each consist of variable amounts of hydroxyl ions $[(\text{OH})^{1-}]$ and fluorine ions (F^{1-}), have a collective -3 charge. Thus, the cumulative -9 charge of wavellite's compound anion balances the +9 charge of its tri-aluminum cation.

As indicated by the " $5\text{H}_2\text{O}$ " in its chemical formula $\text{Al}_3(\text{PO}_4)_2(\text{OH},\text{F})_3 \cdot 5\text{H}_2\text{O}$, wavellite is a hydrous (or hydrated) mineral, meaning it has attached molecules of water (H_2O) called "water of hydration." Each wavellite molecule has five attached water molecules. Because water of hydration consists not of individual hydrogen and oxygen ions, but of complete, electrically neutral water molecules, it does not alter the electrical balance of the parent molecule. Within each water molecule, the collective charge of the double hydrogen cation 2H^{1+} is balanced by the charge of the single oxygen anion O^{2-} . But because the two hydrogen ions are grouped together on one side of the water molecule, they retain a small positive charge. The opposite side of the water molecule is dominated by the large oxygen ion and retains a small negative charge. This creates a dipolar effect that enables water molecules to act as tiny dipolar magnets, and thus to attach themselves to certain other molecules to create hydrous minerals.

The fundamental building block of wavellite is the tetrahedral phosphate ion $(\text{PO}_4)^{3-}$. The term "tetrahedron," which stems from the Greek *tettares*, meaning "four," and *hedra*, or "seat," meaning "facet," refers to a polyhedron with four triangular faces. Within the phosphate radical, the single phosphorus ion P^{5+} is covalently bonded to four equidistant oxygen ions 4O^{2-} at the corners of the tetrahedron. The resulting collective -3 charge is distributed evenly across the oxygen ions, enabling the phosphate anion to bond ionically with many positively charged metal cations.

To construct the wavellite molecule, two phosphate ions $2(\text{PO}_4)^{3-}$ first bond ionically to three aluminum ions 3Al^{3+} . This creates the unstable aluminum-phosphate ion $[\text{Al}_3(\text{PO}_4)_2]^{3+}$. To provide electrical balance and chemical stability, three fluorhydroxyl groups $[(\text{OH},\text{F})^{1-}]$ satisfy the +3 charge by bonding ionically to the three positively charged aluminum ions. Finally, water molecules attach themselves to residual positive charges on the aluminum ions.

Within the wavellite lattice, these molecules form two different, alternating octahedral structures. In the first, an aluminum ion binds covalently to two oxygen ions, two water molecules, and two fluorhydroxyl groups. In the second, a phosphate ion binds to three oxygen ions, one water molecule, and two fluorhydroxyl groups. These alternating structures form long, zigzagging chains that are bound together by shared oxygen ions among the phosphate radicals. During crystal growth, new aluminum fluorophosphate radicals bind covalently onto the ends of the long chains, thus creating a one-directional growth pattern that explains wavellite's usually acicular crystals and radial and fibrous structure. Layers of these chains that are bound together only by the weak ionic attraction of aluminum ions to water molecules and fluorhydroxyl groups account for wavellite's perfect, one-directional cleavage.

Wavellite has a moderate hardness of Mohs 3.5 to 4.0. This hardness is directional and reflects wavellite's bonding arrangement. It is hardest when scratched longitudinally, that is, in the direction of its acicular crystals and along the plane of strong covalent bonding. Wavellite is softest when scratched against the direction of its acicular crystals in a manner that parts only the much weaker ionic bonds. Although wavellite has a fairly dense atomic packing, its low specific gravity (2.3-2.4) is due to the relatively low atomic weights of its elemental components.

As a secondary mineral, wavellite is the product of the chemical alteration of preexisting primary minerals. Wavellite forms only in mineralogical environments with available aluminum, phosphate, and fluorine ions;

September 2006 Mineral of the Month: Wavellite

a basic (nonacidic) chemistry with an excess of free hydroxyl ions in water; and very specific conditions of temperature and pressure. Given the same conditions of chemistry and temperature, but with greater pressure, the mineral that will form is kingite. Like wavellite, kingite is a basic hydrous aluminum fluorophosphate $[\text{Al}_3(\text{PO}_4)_2(\text{OH},\text{F})_3 \cdot 9\text{H}_2\text{O}]$, but with four additional attached water molecules. Unlike the orthorhombic symmetry of wavellite, kingite crystallizes in the monoclinic system to accommodate the additional water of hydration.

Wavellite is a relatively rare mineral that most often develops from low-grade metamorphism of aluminous rocks and phosphate deposits and is associated with such other secondary phosphate minerals as variscite [hydrous aluminum phosphate, $\text{AlPO}_4 \cdot 2\text{H}_2\text{O}$, our April 2000 mineral from Utah], crandallite [basic hydrous calcium aluminum phosphate, $\text{CaAl}_3(\text{PO}_4)_2(\text{OH},\text{H}_2\text{O})_5$], and turquoise [basic hydrous copper aluminum phosphate, $\text{CuAl}_6(\text{PO}_4)_4(\text{OH})_8 \cdot 4\text{H}_2\text{O}$]. Wavellite also occurs associated with quartz [silicon dioxide, SiO_2] and muscovite [basic potassium aluminum silicate, $\text{KAl}_3\text{Si}_3\text{O}_{10}(\text{OH})_2$] in the alteration zones of contact metamorphic rocks. Small amounts of wavellite are associated with turquoise and quartz in the upper alteration zones of epithermal veins.

As an allochromatic (other-colored) mineral, wavellite's colors are due not to essential elemental components or to crystal-lattice structure, but to impurities or elemental substitution. Nearly pure wavellite is colorless or white, with the latter color caused by the light-reflecting property of adjoining faces of the tiny individual crystals that comprise botryoidal and radial forms. Yellow and brown hues are created by ferric iron ions (Fe^{3+}) substituting for aluminum ions (Al^{3+}). Green colors are due to the substitution of vanadium ions (V^{3+}) for aluminum ions.

The Dana classification number 42.10.2.1 first identifies wavellite as a hydrous phosphate or arsenate (42). The subclassification (10) defines it by the general formula $(\text{AB})_3(\text{XO}_4)_2\text{Z}_q \cdot \text{YH}_2\text{O}$, in which "A" and "B" can be aluminum, iron, copper, calcium, cadmium, magnesium or manganese; "X" is phosphorus or arsenic; "Z" is a hydroxyl and/or fluorhydroxyl group; and "q" and "Y" are variable quantities. Next, wavellite is a member of the wavellite group (2), as the first (1) of two members. The second wavellite-group member is "IMA2004.050," a basic hydrous iron phosphate with the chemical formula $\text{Fe}_3(\text{PO}_4)_2(\text{OH})_3 \cdot 5\text{H}_2\text{O}$. The designation "IMA2004.050" refers to an as-yet unnamed mineral that was the 50th candidate proposed for recognition as a distinct species in 2004. Its formal name has not yet been assigned by the International Mineralogical Association's Commission on New Minerals and Mineral Names. Don't worry: most likely, you will not receive a future write-up with the heading: "September 2016 Mineral of the Month: IMA2004.050." But who knows?

COLLECTING LOCALITIES

The best wavellite specimens come from the classic locality at the Montgomery County Quarry at Mauldin Mountain near the town of Mount Ida in Montgomery County in west-central Arkansas, source of our specimens, as we will discuss. Other collecting localities in Arkansas include Dug Hill near Avant in Garland County; the Magnet Cove rutile deposit at Magnet Cove in Hot Spring County; and the Porter, McBride, and Blue Bird mines at Porter Mountain near Gilham in Polk County.

The United States has several other wavellite localities. In Alabama, these include the Red Ball Mine in Calhoun County and Rock Run in Cherokee County. Wavellite occurs at several sites on Peters, Pearis, and Flat Top mountains in Giles County, Virginia. In Pennsylvania, it is found at Moore's Mill at Mount Holly Springs in Cumberland County and at the W. L. Newman phosphate mine at East Waterford in Juniata County.

September 2006 Mineral of the Month: Wavellite

Moving west, wavellite occurs in Colorado at the King Turquoise Mine in Conejos County, and at the Ida May, Bertha B., and Raven mines in the Cripple Creek district in Teller County. Wavellite is also found at the Harding pegmatite mine near Taos, New Mexico, and at the Bingham Canyon copper mine in the Oquirrh Mountains of Salt Lake County, Utah. In Nevada, wavellite is found at the Willard Mine in the Willard district in Pershing County, and at the Redhouse Barite Mine in the Potosi district in Humboldt County. In Arizona, specimens are collected at the Castle Dome Mine in the Globe-Miami district of Gila County, and in Mineral Park in the Mineral Park district of Mohave County.

In Australia, wavellite specimens are collected in Queensland at the Mt. Oxide copper mine near Mount Isa; in South Australia at the Moculta phosphate quarry at Angaston, the St. John's and Tom's phosphate quarries near Kapunda, and the Oliver phosphate quarry near Noaralunga; and in Victoria at Phosphate Hill and the Howe's Creek Phosphate Belt near Mansfield. In South America, wavellite occurs at two important sites in Bolivia: the Siglo Veinte Mine near Llallagua, Bustillos Province, Potosí Department; and the Itos Mine at Ciudad Oruro, Cercado Province, Oruro Department. In Japan, specimens are collected at the Rendaiji and Kawazu mines near Rendaiji in Shizuoka Province on northern Honshu Island. Mexican specimens have come from the Evans Turquoise Mine near Ensenada in Baja California Norte.

In Europe, wavellite occurs in the Allumiere quarries at Tolfa, Latium, Italy; at the Beauvoir Mine at Ebreuil, Auvergne, France; and at the Griefenstein, Friedrich August, and Johanngeorgenstadt mines at Erzgebirge, Saxony, Germany. In England, specimens are collected at the China clay pits and the Great Beam and Goonbarrow mines at Hensbarrow, Cornwall; and at the type locality at the High Down Quarry at Filleigh, Devon, as explained in *History and Lore*.

JEWELRY & DECORATIVE USES

Although wavellite crystals are too small to be faceted into gems, fibrous masses with compact textures are cut into spheres as large as one inch in diameter and polished to a high luster. These spheres, which are occasionally available through dealers, have a beautiful, green translucency and a distinct, chatoyant, "tiger-eye" effect caused by their radiating, fibrous structure. We rarely see spheres offered for sale at shows. Small pieces of wavellite are also tumbled and polished.

Because of their radiating structure, range of colors, and unusual chemical composition, mineral collectors value wavellite specimens for display and study purposes.

HISTORY & LORE

Because of its occurrence as an oxidized mineral in accessible surface or near-surface deposits, wavellite has likely been known since antiquity, but was confused with other minerals of similar color. Wavellite was brought to scientific attention in 1805 by William Wavell (?-1829), a British physician and amateur earth scientist living in Harwood Parish, Devon, England. After studying specimens collected from the High Down Quarry in neighboring Filleigh, Wavell suspected he had found a previously unidentified mineral species. After British chemists confirmed that Wavell's specimens did represent a new species, Irish physician and mineralogist William Babington (1757-1833) formally named the mineral in Wavell's honor in 1818. (The mineral babingtonite $[\text{Ca}_2(\text{Fe}^{2+}, \text{Mn})\text{Fe}^{3+}\text{Si}_5\text{O}_{14}(\text{OH})]$ was named for Babington in 1824.)

Because wavellite usually occurs only in small quantities, it has had no commercial value or use—with one notable exception, when it was mined as an ore of phosphorus. Although the flammability of phosphorus in air had been long known, the element had no practical use until the 1855 invention of the safety match. The safety match consisted of a tiny wooden stick with a phosphorus coating on one tip; to prevent

September 2006 Mineral of the Month: Wavellite

premature ignition, the phosphorus was hermetically coated with wax. “Striking” the match removed the wax, thus exposing the phosphorus to air and causing it to ignite. Until the late 1800s, elemental phosphorus was prepared only from fluorapatite [calcium fluorophosphate, $\text{Ca}_5(\text{PO}_4)_3\text{F}$, our Mineral of the Month for June 2006] that was obtained by processing animal bones or phosphate rock.

Then in the late 1880s, a white-clay deposit was discovered at Moore’s Mill near Mount Holly Springs in south-central Pennsylvania’s Cumberland County. Quarrymen soon learned that this clay contained many “pods,” or inclusions, of an odd, hard material that was identified as wavellite. Since wavellite contains nearly 15 percent phosphorus by weight, chemists suggested its use as a phosphorus ore. In 1898, the newly founded American Phosphorus Company devised an electric-furnace smelting process to recover phosphorus from wavellite. After this recovery method became operational, American Phosphorus mined several hundred tons of wavellite from the quarry each year until 1910.

According to modern metaphysical belief, wavellite helps in assessing situations and making wise decisions and assists the flow of energy to the physical body.

TECHNOLOGICAL USES

Apart from one former use as an ore of phosphorus, wavellite has no technological applications.

CLASSIC MINERAL LOCALITIES

We are pleased that our specimens for this Mineral of the Month again come from a classic locality—the Montgomery County Quarry at Mauldin Mountain in Montgomery County, Arkansas. Mauldin Mountain is designated as the classic locality for wavellite because of the excellent quality of the specimens found there—the color and size of the radiating spheres and hemispheres are, on the whole, better than those found at any other wavellite locality.

Classic localities are not to be confused with type localities. Type localities, as our August 2006 write-up on cornetite explained, are sources of specimens that provide the data used to define new mineral species. Type localities may or may not be classic localities. In the case of wavellite, the type locality is the High Down Quarry at Filleigh, Devon, England. The specimens collected there in 1805 yielded the crystallographic and chemical data that established wavellite as a distinct mineral species. Since the 1880s, the classic locality for wavellite was Dug Hill near Avant, Garland County, Arkansas. Then in the mid-1970s, the newly opened Montgomery County Quarry at Mauldin Mountain, Montgomery County, Arkansas, superseded Dug Hill as the classic locality for wavellite.

The phrase “classic locality” appears widely in mineralogical literature and is a general term with two meanings. In one usage, it refers to a mineral locality that has produced an unusual number of different mineral species. These localities include such familiar names as Mont Saint-Hilaire, Rouville County, Québec, Canada; Franklin and Sterling Hill, Sussex County, New Jersey; the Broken Hill Mining District, New South Wales, Australia, the Lovozero and Khibiny massifs, Kola Peninsula, Russia; and the Tsumeb Mine, Tsumeb, Namibia, each of which have provided several hundred mineral species.

In its more common usage, and in our usage for this write-up, “classic locality” refers to a site that produces specimens that best exemplify the aesthetic appeal and physical properties of a particular mineral species. A good example is Franklin, New Jersey, which is the classic locality for franklinite [zinc iron manganese oxide, $(\text{Zn}, \text{Mn}^{2+}, \text{Fe}^{2+})(\text{Fe}^{3+}, \text{Mn}^{3+})_2\text{O}_4$]. The size and perfection of the franklinite crystals found at Franklin, New Jersey, are superior to those from any other locality.

September 2006 Mineral of the Month: Wavellite

Many minerals, particularly the more abundant species, have several classic localities, each for a specific physical property such as color, crystal size, or crystal habit. As an example, the classic locality for blue barite (barium sulfate, BaSO_4) is Stoneham, Weld County, Colorado, while the classic locality for colorless barite is the Palos Verdes Hills, Los Angeles County, California. We featured the latter barite locality in January 2002, and probably will never feature the former, unfortunately, as Stoneham produces little in the way of new material.

Minerals with different classic localities for specific crystal habits include galena (lead sulfide, PbS) and pyrite (iron disulfide, FeS_2). The classic locality for beautifully developed galena cubes is the Tri-State Mining District in Jasper County, Missouri, while the classic locality for composite galena specimens, specifically galena on colorless quartz, is Naica, Saucillo, Chihuahua, Mexico. The classic locality for near-perfect, individual pyrite cubes is Navajún, La Rioja, Spain (our Mineral of the Month for March 2006!), while the classic locality for pyrite-crystal clusters is the Huanzalá Mine, Dos de Mayo Province, Huanaco Department, Peru (our Mineral of the Month for October 2003!).

When referring to a particular mineral, the term “classic locality” indicates the source of specimens that represent the best aesthetic and physical qualities that the species has to offer. In collectors’ markets, as we might expect, specimens from classic localities tend to command premium values.

ABOUT OUR SPECIMENS

As noted, our wavellite specimens come from the Montgomery County Quarry on the southeast side of Mauldin Mountain in Montgomery County, Arkansas. Montgomery County is located in west-central Arkansas, not far from the Oklahoma line. The open-cut Montgomery County Quarry is four miles northwest of the town of Mount Ida and one mile north of U.S. Highway 270. Mount Ida is 35 miles west of the city of Hot Springs, Arkansas.

In Arkansas, wavellite occurrences are hosted primarily by two types of rock: Big Fork Chert and the closely related Arkansas Novaculite (no-VOCK-u-lite). Both are hard, fine-grained, flint-like sedimentary rocks comprised mainly of fibrous chalcedony, cryptocrystalline (microcrystalline) quartz, and amorphous silica. Novaculite, finer in grain, somewhat harder, and more dense than chert, is actually chert that has been recrystallized through low-grade, regional metamorphism.

Mauldin Mountain is part of the Ouachita (WASH-eh-tah) Mountains, a series of 2,000-foot-high ridges that trend east-west across west-central Arkansas and adjacent Oklahoma. The formation of the Ouachitas began some 600 million years ago in Paleozoic time with the formation of a rift along the southern margin of the North American tectonic plate. As the crust of the Earth stretched and subsided, a section separated and drifted south, leaving in its place marine basins that extended inland. For 150 million years, massive deposits of silica-rich marine sediments accumulated on the floors of these basins. These deeply buried sediments later lithified into massive chert formations, some of which eventually recrystallized into novaculite.

Next, during the Mississippian Period some 360 million years ago, distant tectonic collisions thrust the separated section of crust back to the north, forcing it beneath the North American Plate. This buckled the overlying formations of chert, novaculite, and other sediments, uplifting them as much as 10,000 vertical feet to form the original Ouachita Massif, a range of intensely deformed, fold-type mountains that are structurally similar to the Appalachians. Surface erosion has since reduced the mountains by many thousands of feet to their present topography.

September 2006 Mineral of the Month: Wavellite

The Big Fork Chert not only hosts our wavellite specimens, but is connected to the myriad of hot springs for which Arkansas is famous. In the Ouachitas, both chert and novaculite outcrop as steeply tilted formations. Porous and highly fractured, these formations act as giant water traps, absorbing rain and conducting it slowly downward into regions of elevated temperatures as deep as 8,000 feet. After it is heated, this water rises back to the surface through faults in the overlying (and aptly named) Hot Springs Sandstone, creating surface hot springs with an average temperature of 143° F. Radiometric dating has revealed that today's hot-springs water originated 4,000 years ago as rainwater.

During most of that time, the water slowly descended through the Big Fork Chert and Arkansas Novaculite formations. But the upward journey of the hot water takes only about one year. Because of its hardness (Mohs 7.0) and durability, novaculite (the name stems from the Latin *novacula*, meaning "razor" or "sharp") makes a superb whetstone for sharpening knives and edged tools. Arkansas Novaculite has been quarried for whetstone use.

Novaculite mining first brought Arkansas wavellite to the attention of mineralogists in the early 1800s. But it wasn't until the 1930s that wavellite became a popular mineral collectible in Arkansas. Its popularity continued to grow and, by the 1960s, specimen miners were collecting wavellite commercially at several sites in the Ouachita Mountains. By far the biggest source of wavellite in Arkansas was then Dug Hill near Avant in Garland County.

Then in 1974, Montgomery County began developing a chert quarry on Mauldin Mountain to provide cement-aggregate and road-fill material. Quarrying revealed the largest and most well-developed radial and botryoidal forms of wavellite ever seen. Mauldin Mountain immediately became Arkansas' primary wavellite source and was regularly visited by both private collectors and mineral dealers, the latter making special arrangements with the county to obtain the best rock for trimming.

Within a short period of time, collectors were eagerly snapping up Mauldin Mountain wavellite specimens to enhance their collections. The find drew the attention of the mineral publications—the oldest reference we could find to Mauldin Mountain was in the "World News on Mineral Occurrences" in the 1980 *Rocks and Minerals* magazine. By 1985, the *Mineralogical Record* saw fit to present an article on Mauldin Mountain and the rare phosphate minerals found there, including of course, wavellite.

The article noted that Mauldin Mountain wavellite occurs as spheres, hemispheres, botryoidal coatings, single crystals, and groups of divergent crystals. We observed all these forms on our specimens here, except for the single crystals, which we would have loved to have seen! Of course, we didn't get an opportunity to examine all of the 586 pieces we picked out! The *MR* article contains a black and white photo of single wavellite crystals from Mauldin Mountain, but the longest crystal was only 2mm long. Some of our specimens contained broken spheres, which allowed us to observe the aesthetically pleasing nature of the radiating, concentric structure. Yes, get your magnifier out, and enjoy the beauty of your specimen!

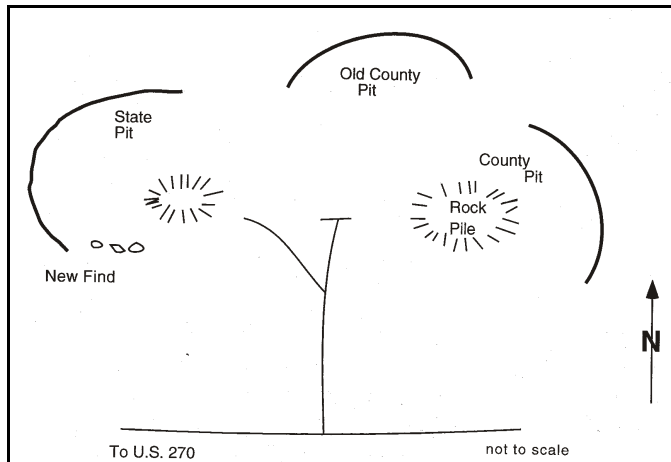


Figure 1. Mauldin Mountain map, showing pit locations. Courtesy of Art Smith.

September 2006 Mineral of the Month: Wavellite

The "What's New in Minerals" section of the Jan-Feb 1990 issue of the *Mineralogical Record* mentions 250 flats of new wavellite specimens that had come to market, while the same section in the May-June 1994 issue describes "flats upon flats of excellent thumbnails and miniatures of radial green wavellite . . . another instance of long-familiar material coming back strongly." Other issues and other mineral magazines have celebrated this exceptional find, including the February 1999 Mineral News, which reported on a new find at Mauldin Mountain, and stated "the wavellite from this find reached world class status when Joel Bartsch [president of the Houston Museum of Natural Science] bought a large 'killer' specimen for the Houston Museum of Natural Science. So better line-up and get yours."

We were able to "get ours" through the effort of former jewelry store owner and avid Arkansas collector Clyde Hardin. His favorite collecting spot was Magnet Cove, Hot Spring County, Arkansas, "the most mineralized five square miles in Arkansas," as one geologist put it. Clyde's was said to be the world's best collection of Magnet Cove minerals, and he would trade self-collected material for worldwide specimens brought to him by eager collectors. Clyde also spent lots of time collecting wavellite at Mauldin Mountain, and it was in the 1980's that he collected the specimens we obtained this year. His collection was willed to his niece upon his death in 2002—she sold his private collection to a dealer in Texas, and the bulk material, which filled a 14-foot trailer, to a dealer in Utah, who immediately thought of us.

At Mauldin Mountain, wavellite occurs within vugs, seams, and fissures of the Big Fork Chert. The origin of the wavellite began when groundwater, slightly acidified by dissolved carbon dioxide and rich in aluminum, fluorine, and phosphate ions from contact with surface minerals, percolated downward through the chert. Under just the right combination of temperature and pressure, and in a chemical environment that changed from acidic to basic, wavellite precipitated from solution onto the walls of fissures, faults, and vugs. At Mauldin Mountain, the host Big Fork Chert has unusually wide fractures and large vugs in which the wavellite could develop into large, flat radial patterns, hemispheres, and spheres. The quarry has yielded spectacular specimens in colors from turquoise-like green-blue to apple-green, yellow-green, and near-colorless, and in sizes from micromount to cabinet. Mauldin Mountain wavellite is associated with small amounts of planerite [basic hydrous aluminum phosphate, $\text{Al}_6(\text{PO}_4)_2(\text{PO}_3\text{OH})_2(\text{OH})_8 \cdot 4\text{H}_2\text{O}$], variscite [hydrous aluminum phosphate, $\text{AlPO}_4 \cdot 2\text{H}_2\text{O}$], crandallite [basic hydrous calcium aluminum phosphate, $\text{CaAl}_3(\text{PO}_4)_2(\text{OH}, \text{H}_2\text{O})_5$], and small amounts of turquoise [basic hydrous copper aluminum phosphate, $\text{CuAl}_6(\text{PO}_4)_4(\text{OH})_8 \cdot 4\text{H}_2\text{O}$].

Thanks to the superb specimens found at the Montgomery County Quarry, wavellite is now considered the second most collectible Arkansas mineral, after its beautiful and abundant quartz. Although quarrying operations ended in 1999, the quarry is still a popular collecting site. But because "new rock" is no longer being broken, the supply of good wavellite specimens is decreasing. How happy we all are to be able to add a wonderful wavellite from this classic locality to our collections!

References: *Dana's New Mineralogy*, Eighth Edition; *Encyclopedia of Minerals*, Second Edition, Roberts, et al, Van Nostrand Reinhold Co.; *2004 Fleischer's Glossary of Mineral Species*, Joseph Mandarino and Malcolm Back, The Mineralogical Record Company; *Mineralogy*, John Sinkankas, Van Nostrand Reinhold Co.; *Manual of Mineralogy*, Cornelius Hurlbut and Cornelia Klein, Twenty-first Edition, John Wiley & Sons; *Handbook of Mineralogy*, Volume 4, "Arsenates, Phosphates, and Vanadates," J. Anthony, R. Bideaux, K. Bladh, and M. Nichols, Mineral Data Publishing Company; "Chronicles of Central Pennsylvania Mineralogy: Part One," Jay L. Lininger, *Rock Buster News* (Central Pennsylvania Rock & Mineral Club), Spring 1999; "The Crystal Structure of Wavellite," Takaharu Araki and Tibor Zoltai, *Zeitschrift für Kristallography*, June 1968; "Notes on Selected Hydrous Aluminum Phosphate Occurrences in Nevada," M. C. Jensen, *Mineral News*, June 1999; "Arkansas Phosphate Minerals: A Review and Update," H. L. Barwood and H. S. deLind, *Rocks & Minerals*, July-August 1989; "The Aluminum Phosphate Minerals from Mauldin Mountain, Montgomery County, Arkansas," A. E. Smith, Jr., *The Mineralogical Record*, July-August 1985; *Mineral Species of Arkansas: A Digest*, J. M. Howard, Arkansas Geological Commission Bulletin 23, 1987; "Phosphate Minerals of Arkansas," A. L. Kidwell, *Rocks & Minerals*, March-April 1981; "What's New in Minerals—Denver Show 1989," W.E. Wilson, *The Mineralogical Record*, January-February 1990; "What's New in Minerals—Tucson Show 1994," Tom Moore, *The Mineralogical Record*, May-June 1994; "The New Wavellite Find at the State Pit, Mauldin Mountain, Montgomery County, Arkansas," Art Smith, *Minerals News*, February 1999.