September 2001Mineral of the Month: Dioptase

> "Dioptase . . . is one of the most beautiful of all minerals, its rich emerald-green color lighting up any collection. Groups of its crystals from Russia were formerly so rare as to be distinguishing marks of the highest grade of mineral collection; now they are seen in many collections of lesser rank."– George Letchworth English, *Getting Acquainted with Minerals*, 1934

PHYSICAL PROPERTIES

Chemistry: $Cu^{2+}SiO_2(OH)_2$ Copper Silicate Hydroxide
Class: Silicates Subclass: Cyclosilicates
Dana's: Six-Membered Rings
Crystal System: Hexagonal-Rhombohedral (Trigonal)
Crystal Habits: Long to short prismatic; Crystalline aggregates; Massive
Color: Bright emerald green
Luster: Vitreous, somewhat greasy on fracture and cleavage surfaces Drawing- Mineralogy
Transparency: Transparent to translucent
Streak: Pale greenish-blue
Refractive Index: 1.652-1.709
Cleavage: Perfect in one direction
Fracture: Uneven to conchoidal
Hardness: 5
Specific Gravity: 3.28-3.35
Luminescence: None
Distinctive Features and Tests: Distinctive color and greater hardness differentiates it from other minerals commonly found in oxidized portions of copper deposits; Soluble in hydrochloric acid, staining the solution blue
Dana Classification Number: 61.1.3.1

NAME

Pronounced dī op´ tās, the name was given in 1797 by French priest and crystallographer René Just Haüy for the crystals found at Altyn Tyube in Kazakhstan, where our specimens come from. He gave it the name based on two Greek words, *dia* meaning "through" and *optazein*, meaning "to see," as explained under *History and Lore*. Other names given our featured mineral in the past included "emerald copper," Congo emerald", and emerauldine, as we will see.

COMPOSITION

The accepted chemical formula for dioptase is written above, while *Dana's New Mineralogy* and other sources prefer to express it as $Cu_6(Si_6O_{18})\cdot 6H_2O$. Viewing it this way reminds us of its internal structure, which is made up of Si_6O_{18} rings linked by copper atoms. Each molecule of dioptase is about 41% oxygen, 40% copper, 18% silicon, and 1% hydrogen. So far, dioptase has only been discovered in arid regions, where it forms from the weathering of copper-rich sulfide minerals like chalcocite [Cu_2S], bornite [Cu_5FeS_4], chalcopyrite [$CuFeS_2$], and tetrahedrite [$(Cu,Fe,Ag,Zn)_{12}Sb_4S_{13}$], among others. Under similar conditions, chrysocolla [$(Cu^{2+},Al)_2H_2Si_2O_5(OH)_4\cdot nH_2O$] seems to form much more readily and commonly.

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COLLECTING LOCALITIES

Dioptase is a rare mineral, found in only a few locations worldwide, almost always in specimens of outstanding beauty. The most outstanding locality in the United States is the Mammoth-St. Anthony mine, near Tiger, Pinal County, Arizona, where thick crusts of drusy dioptase make for superb specimens. Other localities in the U.S. produce mostly very small crystals, whose beauty is appreciated primarily by micromount collectors. These localities include the Harquahala gold mine south of Salome, Arizona, as well as the Ray mine, where our April 2000 featured chrysocolla specimens came from, and several more in that desert state; the Algomah mine, Ontonagon County, Michigan; and the Blue Bell mine, near Baker, San Bernardino County, California. Worldwide localities include Nishapur, Iran; the Malpaso mine, Cordoba, Argentina; and Inca de Oro, Copiapó, Chile.

Our dioptase specimens come from Kazachstan, where dioptase was originally discovered, as detailed later in the write-up. For this reason, Altyn-Tyube, Kazakhstan, is considered the **type locality** for dioptase. Localities in southern and central Africa have also produced outstanding dioptase since the end of the nineteenth century. These include Mindouli, ‘Mbumba, and Pimbi in the southern People’s Republic of Congo (formerly French Congo), where dioptase is the country’s official gemstone; Mavoyo, Angola; the Mashamba West mine, Democratic Republic of the Congo (formerly Zaire); and what most experts agree is the producer od the world’s finest dioptase crystals, the Tsumeb mine, Namibia (formerly East Africa, then South West Africa.) Though fine dioptase crystals were found here in the 1930's, a major discovery was made in the 1970's in the lower oxide zone at the 3000-plus foot level, where water was able to follow a fault down and interact with copper-bearing sulfide minerals to produce the world’s best dioptase crystals. Over the course of several years, miners were able to sneak out hundreds of exceptionally large and beautiful crystals, some up to two inches in length, on a snow white or slightly tinted calcite or dolomite matrix. Some of the crystals were turquoise in color! We have the opportunity to view these from time to time in exhibit cases around the country.

JEWELRY & DECORATIVE USES , TECHNOLOGICAL USES

As beautiful an emerald green as dioptase can be, (and some say its color is more striking than emerald), its low hardness, perfect cleavage, tendency to be brittle, and scarcity of larger crystals regard it primarily to the realm of collector gems. Dioptase gems are fashioned, but virtually always under one carat in size. Yet even these command high prices! Clusters of small crystals on matrix are also used to stunning effect for pendants, brooches, and pieces that are not subject to the wear and tear of rings.

An ostrich-size dioptase egg was cut from Tsumeb material in the famous German cutting center of Idar-Oberstein, revealing a pocket of brilliant dioptase crystals, enhanced by sparkling quartz in a polished shell. We have on occasions seen geodes containing fabulous dioptase crystals for sale at shows for very high prices.

Though it contains copper, dioptase has never been mined as a source of copper. Interestingly, one source said that the French Bureau of Geological and Mineralogical Investigations mined and shipped tons of dioptase from deposits in Africa. We wonder what ever became of these?

HISTORY & LORE

Around the time the newly-formed United States of America was signing the Treaty of Paris in 1783, in which Great Britain agreed to recognize its thirteen former colonies as a new sovereign nation, a

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Bucharian merchant named Achir Mahmed obtained the first known specimens of gorgeous green crystals from central Kazakhstan. (Mr. Mahmed lived in the fortified city of Semipalatinsk, a major port on the Irtysh river of eastern Kazakhstan, This city, known as Semey after Kazakhstan obtained independence from the U.S.S.R. in 1991, was near the defunct Semipalatinsk Test Site, where most Soviet nuclear testing took place from 1949 to 1991.) We can imagine how Mr. Mahmed and others felt it they turned out to emeralds from a new locality!

Mr. Mahmed eagerly supplied some crystals to a General Bogdanof, who brought them to St Petersburg, Russia for testing, around 1785, and in 1788 one academian declared them to be “Siberian emeralds!” However, as dioptase specimens made their way into the laboratories of other prominent scientists, it became apparent that these were not emerald crystals– though rivaling emerald in color, they were not as hard, and had a greater specific gravity, for starters. Also, when crushed and analyzed, their elemental constituents were different– dioptase containing copper, while emerald contained aluminum, and an element unknown at that point– beryllium (see the March 1999 red beryl write-up under *Technological Uses* for details.)

The first researcher to recognize the copper silicate hydroxide as a new mineral was Benedikt Franz Johann Herrmann (1755-1815), an Austrian Professor of Technology in the Royal Imperial Akademie in Vienna. He gave it the name achirit after the merchant Achir Mahmed who had furnished the first specimens, and it continued to be known as achirit in Russian well into the twentieth century. At the same time, René Just Haüy was also investigating this new mineral. Hauy was particularly interested in what he called the “molecule integrant”– the exact shape of the most primitive unit of a crystal, what is now known as the “unit cell.” He had come to realize, as outlined in the box, that the shape of the unit cell is not always the same at the crystal.

Around the year 1800 A.D., Hauy accidentally dropped an exquisite calcite crystal. He noted that the cleavage planes on the broken pieces were different than the shape of the original crystal. He then reduced the beautiful calcite crystal to dust to see if it would break into any shape other than a rhombohedron (six-sided) form. He was unable to, and a result, concluded that the calcite crystal, no matter what its external shape, consisted entirely of minute rhombohedral **unit cells** stacked in various ways. (A unit cell is the smallest group of molecules in a crystal which has all the properties of the crystal.) When he gazed into the dioptase crystal to try to find the form of the unit cell, he could see through the crystal and make out the edges of the cleavage planes. So he named it dioptase, from Greek words, *dia* meaning “through” and *optazein*, meaning “to see.” For his pioneering work into the forms of crystals, Rene-Just Hauy is rightly known as the father of modern crystallography.

Hauy published his findings about this new mineral in his ground-breaking five-volume work *Traité de Mineralogie* in 1801, and since Herrmann did not publish his find achirit until 1802, the new mineral was named dioptase because Hauy’s work was published first. But even Hauy later wanted to change the name, calling it “cuivre dioptase” in a later work. This was just one of many names associated and discarded in connection with this beautiful new mineral!

Hauy had gave one of his dioptase specimens to French chemist Nicolas-Louis Vauquelin (1763-1829), discoverer of the elements chromium and beryllium. Unfortunately, this piece had calcite on or in it, as explained under *About Our Specimens*, so when Vauquelin analyzed it, he determined it to be a new copper silicate carbonate mineral! This error was not corrected for some time, so that author James Sowerby in his 1817 book *Exotic Mineralogy* also called the new mineral “Calx cupreo-carbonata,” or lime-copper carbonate. Other names used to describe this new mineral at the time include “Kupfer-schmaragd,” “Rhomboedrischer smaragd-Malachit,” “Emerald copper,” “Rhombohedral Emerald Malachite” “Smargo-chalcite,” and Kirghisite, after the Kirghsi Steppes, where Altyn-Tyube is located.

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Certainly this confusion helps us appreciate the importance of the modern day Commission on New Minerals and Mineral Names as described in our August 2001 inesite write-up to avoid such confusion!

For most of the nineteenth century, Altyn-Tyube was the only source for this new mineral, making specimens very rare and expensize. At one point early in the century, because of inadequate maps, the locality was lost for about twenty years! All this changed, however, when dioptase was discovered in Mindouli, as described under *Collecting Localities*. After the Russian Revolution of 1917, Altyn-Tyube dioptase was seen only in old collections, until the collapse of the U.S.S.R. in 1991. 1993 saw a virtual flood of Kazakh dioptase on the market, which collectors eagerly drank in; mineral writer Bob Jones said these were "doubtless old stock from museums catering to the Western market." By 1999, the flood had become a trickle, so that the Mineralogical Record recommended it was "probably time to get one of these if you haven't."

With regard to modern-day lore, dioptase is said to be "one of the best healing stones of the age," with the power to clear and stimulate to a higher level of awareness and action, bring an invigoration and a refreshing energy to the physical, emotional, and intellectual bodies, and to help one 'live in the moment,' among many other things.

ABOUT OUR SPECIMENS

According to research done by Peter G. Embrey, mineral curator at the British Museum, as reported in the January-February 1980 Mineralogical Record, the locality for our dioptase should be: "Altyne-Tyube, about 30 miles E. of Karaganda (the nearest sizeable town), Kazakh, U.S.S.R." We must change this slightly in light of world changes since 1980, and the city of Karaganda is referred to in encylopedias and atlases as Qaraghandy, the capital of Qaraghandy Province, Kazakhstan. Various renderings for the locality include Altyn-Tyube, Altyn-Tyube (which is how the MR refers to it), and many others. Therefore, the label should probably read: "Altyn-Tyube, about 30 miles E. of Qaraghandy, Qaraghandy Province, Kazakhstan." The locality was written in an 1843 book as "Russia. Siberia: the west slope of the small mountain Altye-Tebe, near the small river Altyn-Szu, in the region of the central Kirghiz Steppes [a vast, semi-arid, grassy plain], about 100 versts (66 miles) from the Russian settlement of Kar-Karaly; usually crystallized, rarely massive, in veinlets in a compact unfossiliferous limestone." (There is a wonderful and often hilarious account of two American collectors visiting Altyn-Tyube to be found on the Internet at www.) According to one of our sources, the Altyn-Tyube region has been declared a natural preserve, making mineral collecting there illegal. However, this did not stop one man from collecting thousands of specimens in 1997. What did stop him was the local police, who took him into custody and confiscated a large portion of his booty, until the man could pay a penalty and a fine (to the local officials on an unofficial basis, it seems.) What would the local police do with a few thousand specimens of emerald-green dioptase? Why, find some European mineral dealers, and sell it to them, of course! (This is not how we obtained our Club pieces.)

As you can see from the map, Qaraghandy is located in the central part of Kazakhstan, the second largest of the former Soviet Republics, after Russia. It is about four times the size of Texas, with a population of just sixteen million. The region was settled by Turkic tribes from around the eight century, and by the end of the fifteenth century, the Kazahks came from the mingling of Mongol and Turkic peoples, practicers of Islam who spoke a Turkish language. In the 1800's, Imperial Russia colonized the area, and following the Russian Revolution, Soviet leaders gradually took control of Kazakhstan. The U.S.S.R. under Soviet leader Joseph Stalin confiscated all productive land and attempted to force the Kazakh nomads into state-controlled farming, a move which destroyed the Kazakh way of life. The Kazakhs slaughtered their livestock rather than turn them over to Soviet authorities, while a million Kazakhs died from starvation and many more fled to China to avoid the oppression. Now, more than a hundred ethnic groups (some because of an influx of Soviet deportees) make their home there, and 35% of the population is Russian. As quoted previously, our crystals formed in small vein in limestone, the sedimentary rock consisting chiefly of calcite [$CaCO_3$]. Many pieces have a layer of milky massive calcite on the limestone, which shows the characteristic red color common to calcite under shortwave UV light. Some of the dioptase crystals have calcite on them, muting the brilliant green color. Normally, this calcite would be removed to uncover the crystals, but unfortunately, the acid commonly used to dissolve calcite also dissolves dioptase. Most dioptase crystals are small, but when examined under magnification, many sharp crystal faces can be seen, including the rhombohedral faces that form the terminations. And, of course, there is always the color to marvel at. You might like to reread our opening quote, while we add a couple more: “Among the most popular minerals with collectors, dioptase ia a likely occupant of all prize-winning cases, and from dealers it is one of the more costly species.”– Frederick H. Pough, Ph.D. “Surely it belongs in a prominent spot in every collector’s case.“– Bob Jones. We could not agree more!

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