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Features

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Better Know A Meteorite Collection: Fersman Mineralogical Museum in Moscow, Russia

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PSRD highlights places and people around the world who play central roles in caring for and analyzing meteorites. Join us as we visit the meteorite collection at the Fersman Mineralogical Museum in Moscow and talk with the people who help make history and discoveries come alive.

Next to one of Moscow's oldest gardens (the Neskuchny, which aptly translates to "not boring" garden) stands the similarly fascinating Fersman Mineralogical Museum that celebrated its 300th anniversary in 2016. Among the museum's gem and mineral treasures is a collection of meteorites of historical significance, including Pallas' Iron found in 1749 in Siberia, also known as the Krasnojarsk **pallasite**, pictured above [**Data link** from the Meteoritical Bulletin]. **PSRD** had the golden opportunity to visit the Fersman Mineralogical Museum in July 2018, along with other attendees of the 81st Meteoritical Society meeting, in the company of Dr. Mikhail Generalov, Collection Chief Curator, pictured below standing next to a large sample of the Seymchan meteorite [**Data link** from Meteoritical Bulletin]. In this article we highlight a selection of the extraordinary pieces in this meteorite collection.

Collection Chief Curator, Dr. Mikhail Generalov, Fersman Mineralogical Museum

Photo by L. Martel, www.psrd.hawaii.edu

Dr. Mikhail Generalov stands next to a large sample of the Seymchan meteorite.

Seymchan, Pallasite

Photo by L. Martel, www.psrd.hawaii.edu

A closer view of the cut, polished, and etched surface of the Seymchan meteorite showing the large schreibersite mineral grains (darker areas) and Widmanstätten pattern in the iron-nickel metal.

Seymchan

The Seymchan meteorite was first discovered in 1967 in far-eastern Russia. Originally classified as an **iron meteorite**, Seymchan was reclassified in 2007 to a **pallasite** after additional pieces were collected in the same location during a 2004 expedition, and some were found to contain olivine crystals. Researchers paired the collected pieces, with or without olivine, after determining that the composition of trace elements in the metal were identical in all the samples. Dr. Generalov pointed to the eye-catching piece of Seymchan on display in the museum (shown above) with its large crystals of schreibersite, with the chemical formula of $(Fe,Ni)_3P$. Schreibersite is a common accessory mineral in pallasites and one that is of interest to astrobiologists in their studies of phosphorus (potentially delivered to a planetary surface by impacting meteorites) in relation to prebiotic chemistry and the origins of life. The iron-nickel metal displays the **Widmanstätten** pattern on the cut surface that has been polished and etched with acid.

Krasnojarsk (Pallas)

The founding piece of the Museum's meteorite collection is the main mass of the beautiful Krasnojarsk meteorite [**Data link** from the Meteoritical Bulletin], the type specimen of **pallasites**. These stony iron meteorites are known for their olivine crystals encased in iron-nickel metal (for more about pallasites, see **PSRD** article: **Formation of Stony-Iron Meteorites in Early Giant Impacts**). The Krasnojarsk pallasite has an interesting history. It was collected in 1749, according to the Museum's notes, by a blacksmith in the Krasnojarsk region of Siberia who intended to use the iron in his work, but never did. Dr. Ursula Marvin noted in her 2007 paper, on the origins of modern meteorite research, that the blacksmith found the metal "too malleable before heating and too brittle afterward, so he placed it outside his house." Fortunately, German naturalist, historian, and academician Peter Simon Pallas acquired the 687-kilogram oddity during a Siberian scientific expedition in 1772 and had it moved to the Museum when he was museum director. The importance of this particular meteorite, which came to be known as Pallas' iron, cannot be understated, as it figured prominently in Ernst Chladni's book, published in 1794, in which he explained his ideas about fireballs and the cosmic origins of fallen stones and irons. Thus, this meteorite collection actually began before the dawn of the science of meteoritics (read more about the beginnings of meteoritics in **PSRD** article: **Better Know a Meteorite Collection: Natural History Museum in Vienna, Austria**). The historical significance and value of the Fersman Mineralogical Museum's meteorite collection is beautifully represented by the two cut pieces of Krasnojarsk showcased near the museum's entrance.

Showcase of Krasnojarsk (Pallas)

Fersman Mineralogical Museum www.fmm.ru

Krasnojarsk (Pallas)

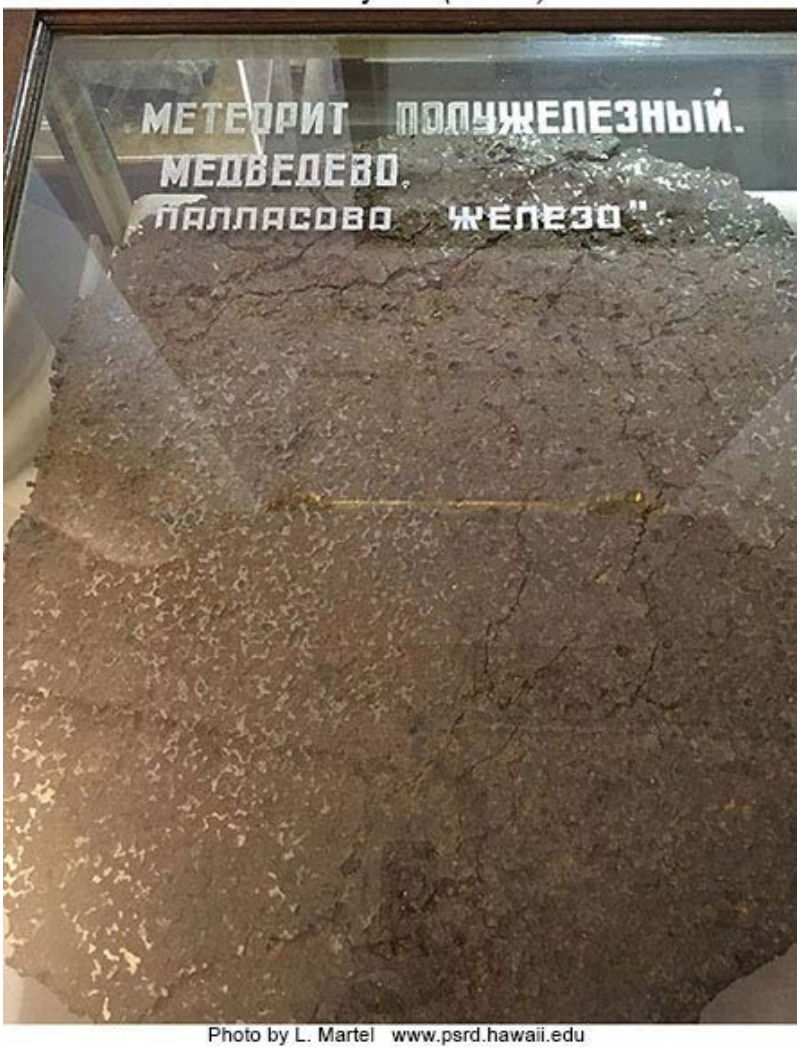

Photo by L. Martel www.psrd.hawaii.edu

[TOP] The glass-topped cabinet with the two pieces cut from the main mass of Krasnojarsk (Pallas) courtesy of the Fersman Mineralogical Museum. [BOTTOM] A closer view of the same cabinet showing the pallasite's olivine crystals encased in iron-nickel metal. Some reflections in the glass slightly distort the view of the meteorite.

Gibeon and Syromolotovo Iron Meteorites

In addition to spectacular pallasites, the collection also contains large iron specimens, including Gibeon [**Data link** from the Meteoritical Bulletin] found in Namibia in 1836 and Syromolotovo [**Data link** from the Meteoritical Bulletin] found in Russia in 1873. Each piece shows dark **fusion crust** and **regmaglypts**, evidence of each **meteoroid's** fall through Earth's atmosphere. For more about the ideas researchers have about the origin of iron meteorites, the stories they tell us about Solar System formation, and to see a picture of a cut slice of Gibeon, see **PSRD** articles: **When Worlds Really Did Collide** and **Iron Meteorites as the Not-So-Distant Cousins of Earth**.

Iron Meteorites Gibeon and Syromolotovo

Photo by Cari Corrigan for www.psrd.hawaii.edu

Two irons and the author together, Gibeon on the left and Syromolotovo on the right.

Observed Falls: Sikhote-Alin, Boguslavka, and Chelyabinsk

Very few, about 2%, of the meteorites in the world's collections were observed to fall (see **Some Meteorite Statistics** from Randy Korotev of Washington University in St. Louis). Officially called "falls" by meteoriticists, these samples are prized for several reasons including their "pristine" condition if found soon after falling and before they have been altered by terrestrial **weathering**, which tells us chemical information of their parent asteroids. The tracking data collected on fireballs are also invaluable for understanding orbits and trajectories of the incoming bodies. Of course collection of falls requires accurate eyewitness accounts of the fireball paths, some geometry to triangulate the best places on the ground to look for the meteorites, and sometimes bold expeditions into the wilds. Cameras are now part of the observation network—for example, read D. Venton's overview in *PNAS*: **Inner Workings: Networks of Cameras are Tracking Meteorites with Unprecedented Precision**.

Among the Fersman Museum displays are three observed falls important to Russia, the 1947 Sikhote-Alin iron [**Data link** from Meteoritical Database], the 1916 Boguslavka iron [**Data link** from Meteoritical Database], and the 2013 Chelyabinsk ordinary **chondrite** [**Data link** from Meteoritical Database].

Iron Falls: Sikhote-Alin and Boguslavka

Photo by L. Martel www.psrd.hawaii.edu

Chelyabinsk

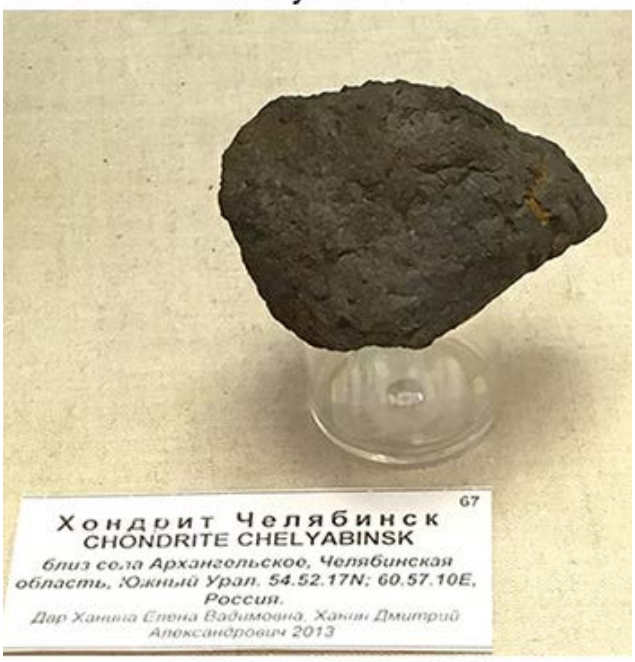

Photo by L. Martel www.psrd.hawaii.edu

[LEFT] The largest mass collected of Sikhote-Alin is displayed in the foreground of this photo with another iron meteorite displayed in the case behind on the right, Boguslavka, an observed fall in Siberia from 1916. [RIGHT] Small fragment of the Chelyabinsk ordinary chondrite with fusion crust, displayed at the Fersman Mineralogical Museum.

Sikhote-Alin was an iron meteorite shower in Siberia in 1947, one of the world's largest known meteorite showers. The huge mass shattered in the atmosphere before impact, resulting in thousands of fragments strewn over a tree-covered hilly area of 1.6 square kilometers. Field expeditions found cracked trees, more than 100 impact holes (0.5–26 meters in diameter) containing multiple fragments, and they collected ~8500 pieces totaling more than 23,000 kilograms. On display at the museum is the largest recovered piece of the Sikhote-Alin iron, 1745 kilograms, showing elongated regmaglypts radiating from a point (akin to the nose of a broad-shaped cone) aligned to the direction of flight. Not all fragments developed regmaglypts, some pieces have ragged, sharp edges and some have been described as looking like twisted taffy candy (see **Exploring Meteorite Mysteries Lesson 15: Historical Meteorite Falls**).

Thirty-one years prior to the fall of Sikhote-Alin, in the same region of Siberia, people witnessed the fall of Boguslavka. According to the Museum's notes, the two pieces on display (198.6 and 58.1 kilograms) are parts of one crystal of kamacite. Kamacite is one of the two iron-nickel minerals, along with taenite, responsible for the Widmanstätten pattern in iron meteorites.

More recently, the meteoroid that broke through Earth's atmosphere over the city of Chelyabinsk, Russia in the winter of 2013, seen by people and car-dash video cameras, brought unfortunate injury to over a thousand people and structural damage to city buildings. The 540-kilogram main mass of the Chelyabinsk LL5 ordinary chondrite meteorite fell into frozen Lake Chebarkul, creating a seven-meter-diameter hole in the ice through which it was

hauled out eight months later. See **PSRD** article: **The Surprise Meteorite Fall in Russia, February, 2013**.

Visiting the Museum

Photo by Cari Corrigan for www.psrd.hawaii.edu

Photo by Cari Corrigan for www.psrd.hawaii.edu

The Fersman Mineralogical Museum of the Russian Academy of Sciences includes 45 meteorites, and dozens of mineral species found in meteorites, among the 135,000 samples in its collection. About 12,000 items are displayed today inside its exquisite hall, pictured on the right.

Address: Fersman Mineralogical Museum, Russian Academy of Sciences, Leninsky Prospect 18, Building 2, 119071 Moscow, Russia
Hours: The museum is open Wednesday through Sunday from 11:00 a.m. to 5:00 p.m.
Admission: Free on the first and last Wednesday of each month; otherwise single and family-pass tickets for a fee.
Website: **www.fmm.ru**.

Additional Resources

LINKS OPEN IN A NEW WINDOW.

- Bottke, W. F. and Martel, L. M. V. (July, 2006) Iron Meteorites as the Not-So-Distant Cousins of Earth, *PSRD.* **http://www.psrd.hawaii.edu/July06/asteroidGatecrashers.html**
- Cooper, K. (Sept. 2016) Did Meteorites Bring Life's Phosphorus to Earth? *NASA Research Highlight from Astrobiology Magazine.* **astrobiology.nasa.gov/news/did-meteorites-bring-lifes-phosphorus-to-earth**
- *Educational activity:* **Exploring Meteorite Mysteries Lesson 15: Historical Meteorite Falls**. The 12-page pdf document contains reading selections and questions for students about five historical meteorite falls; from NASA publication EG-1997-08-104-HQ [link to **entire Teacher's Guide with Activities**].
- **Fersman Mineralogical Museum**.
- **Fireballs in the Sky**, outreach project of the Desert Fireball Network.
- Martel, L. M. V. (Feb. 2013) The Surprise Meteorite Fall in Russia, February, 2013. *PSRD, CosmoSparks Report* **http://www.psrd.hawaii.edu/CosmoSparks/Feb13/Chelyabinsk.html**
- Martel, L. M. V. (July, 2009) Better Know A Meteorite Collection: Natural History Museum in London, United Kingdom, *PSRD.* **http://www.psrd.hawaii.edu/July09/Meteorites.London.Museum.html**
- Martel, L. M. V. (May, 2009) Better Know A Meteorite Collection: Natural History Museum in Vienna, Austria. *PSRD.* **http://www.psrd.hawaii.edu/May09/Meteorites.Vienna.Museum.html**

- Marvin, U. B. (2007) Ernst Florens Friedrich Chladni (1756-1827) and the Origins of Modern Meteorite Research, *Meteoritics & Planetary Science,* v. 42(9) supplement, p. B3-B68, doi: 10.1111/j.1945-5100.2007.tb00606.x [**article**]
- Scott, E., Goldstein, J., and Yang, J. (June, 2010) Formation of Stony-Iron Meteorites in Early Giant Impacts, *PSRD.* **www.psrd.hawaii.edu/June10/pallasites-origin.html**
- Scott, E., Yang, J., and Goldstein, J. (April, 2007) When Worlds Really Did Collide, *PSRD.* **www.psrd.hawaii.edu/April07/irons.html**
- Van Niekerk, D., Greenwood, R. C., Franchi, I. A. Scott, E. R. D., and Keil, K. (2007) Seymchan: A main Group Pallasite–Not an Iron Meteorite, *70th Annual Meteoritical Society Meeting,* abstract **#5196**.
- Venton, D. (2017) Inner Workings: Networks of Cameras are Tracking Meteorites with Unprecendented Precision, *Proceedings of the National Academy of Sciences,* v. 114, p. 7472-7474, doi: 10.1073/pnas.1709062114. [**article**]

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