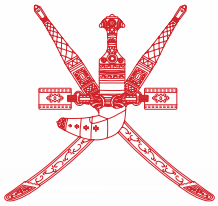
Oman Meteorites

Sultanate of Oman
Public Authority for Mining



Sultanate of Oman
Public Authority for Mining
Directorate General of Researchs and Geological Survey

Oman Meteorites

2018

content

Introduction

Meteorites are considered a valuable scientific treasure that allows the researchers and interested people to discover and study the outer space without the need to go in expensive travels to the Moon or Mars, for example. Hence, it was necessary to preserve this treasure on specific bases and rules that protect this scientific richness of the country. Therefore, the Public Authority for Mining (PAM) established deterrent regulations to avoid that illegal collect and export of meteorites without permission from PAM. It also signed on an agreement with the Museum of Natural History in Bern, Switzerland, to constitute an Omani- Swiss team to collect and study meteorites, which is still in progress. Since 2001, numerous scientific research papers published. The Department of Geological Research and Heritage, which belongs to the General Directorate for Research and Geological Surveys at PAM, is responsible for the management of this scientific resource.

The meteorites of Oman

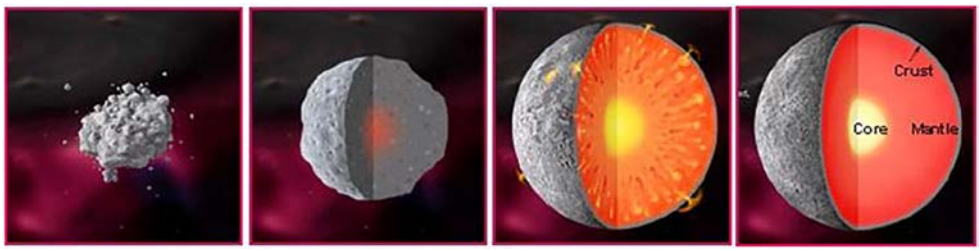
This is the story of space rocks in Oman. Why are some of the largest accumulations of meteorites in the world found in the Sultanate and what can these rocks tell us?

In short

Meteorites are rocks falling from the sky. Like the rocks from Earth they consist of minerals, and their chemical makeup is quite similar to the rocks of the Earth's mantle, as represented in the ophiolite of the Oman Mountains. Meteorites are fragments of our neighbours in the solar system: Most meteorites are derived from asteroids while some rare fragments are pieces of the Moon and of Mars. Meteorites falls are rare: It is estimated that a single square kilometre (size of a town) is hit by a meteorite only once in 12'500 years.
The vast desert areas of the interior of Oman represent one of the few places on Earth where it is possible to search for meteorites systematically. During a collaboration of the Public Authority for Mining (PAM), with Swiss scientists since 2001 numerous meteorites have been recovered from the Omani desert. They represent a good cross section of the composition of our neighbours in space.

The different types of meteorites

Meteorites are quite diverse, just like rocks on Earth. A simple division of meteorites are in stony, stony-iron and iron meteorites. The stony meteorites are further divided into two groups called chondrites and achondrites. Chondrites are rocks composed of solidified melt droplets and dust. Chondrites are derived from asteroids that have never melted. Achondrites, on the other hand, are fragments of asteroids that melted shortly after formation due to heat production from radioactive elements.These have completely decayed since and meteorites are less radioactive than rocks from Earth. Once asteroids were molten, separation into a shell structure, comparable to the Earth, took place. Iron meteorites are hence considered to represent parts of the core of asteroids while achondrites are fragments from the mantle and crustal shells of a molten asteroid.



Four stages of asteroid formation. Chondrites are derived from unmolten asteroids (left two panels) while achondrites are pieces from asteroids that underwent melting and iron core formation as seen in the right two panels. This all happened during the first 5 million years of the 4567 million years old Solar System. Source: Smithsonian National Museum of Natural History.

A 6.8 kg ordinary chondrite found in the Rub' al-Khali area of Dhofar, southwest Oman

Thin section of a diogenite (Jiddat al Harasis 335). This is a brecciated rock (achondrite) consisting mainly of fragments of pyroxenite. This type of meteorite likely is coming from the asteroid Vesta.

Meteorite falls and meteorite craters

Meteorite falls are rare. Even though it is estimated that each year about 25 meteorites are falling on the Sultanate of Oman, it is very rare that freshly fallen meteorites are recovered. Worldwide, only a handful of observed falls each year result in the recovery of meteorites.

In space, meteoroids have speeds much higher than a gun bullet. Most meteorites are decelerated by friction with the molecules of the atmosphere and have at the end speeds of a free fall. This friction also leads to melting of the surface (called fusion crust when solidified) and to light emission in association with shooting stars and fire balls. In absence of an atmosphere each collision produces an impact crater on the surface of a planet or a moon. In the case of planets with an atmosphere like Earth, small meteorites are strongly decelerated in the atmosphere and only very big meteorites produce craters. Such events are rare, and in Oman none was found on the surface, but a suspected buried crater was found during oil exploration.

Meteor or fireball resulting from the entry of a meteoroid into the Earth's atmosphere at high speed. Credit: Philipp Lehmann.

Why are meteorites important?

Meteorites are pieces of other worlds. They offer the unique possibility to see, feel and scientifically study objects from other bodies in our solar system. Since it's origin, the Earth has undergone constant change. On Earth, it is not possible, therefore, to find pristine material dating back to the origin of our Solar System. Asteroids, however, are small and have been largely unchanged since they were formed.

Meteorites representing pieces from such bodies do allow a deciphering of the processes in the forming solar system. The age of our Solar System is determined as 4567 million years. This has been found by detailed analysis of meteorites. The rare meteorites from Mars do allow a detailed study of rocks from this planet, long before any samples are being returned. Meteoroids commonly collide in space, and such collisions induce changes in the rocky objects and produce small fragments from bigger ones. The gravity of Jupiter is responsible for disturbing the orbits of asteroids and meteoroids in such a way that they have a chance to collide with Earth.

Meteorites are a source of valuable information about the Solar Systems origin and a possible threat to all life on Earth.

Thus, meteorites are a source for both research and inspiration.

This meteorite with black fusion crust was found in January 2017. Based on traces of radioactive elements, it must have fallen as recently as 2012.

Where are meteorites found?

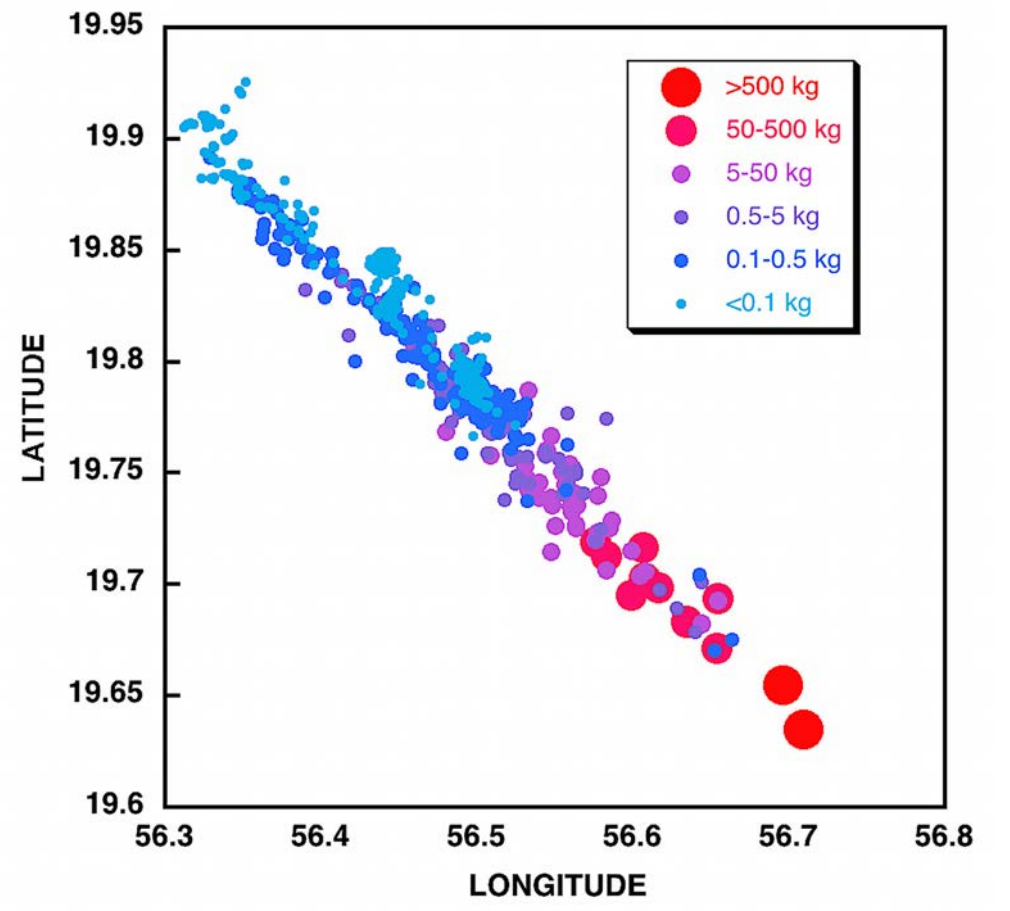
About 1100 meteorites worldwide during the past 200 years have been found after observing their fall. They fall and can be found everywhere, but given that large parts of the surface of the Earth are covered by the sea, most fall into water. Many more meteorites have been found long after their fall, these are called finds. Deserts are the natural places where such objects stay on the surface for long times and remain visible.

Meteorite accumulations are known from the hot deserts in North Africa, Australia, the western parts of North and South America, Arabia, Iran and China. In Arabia, the deserts of Oman are by far the most explored for meteorites. Many meteorites are also found in cold deserts, like Antarctica. Here, systematic scientific searched are conducted each year since 1973.

The characteristic rounded shape of meteorites is due to melting of the rotating, rocky material during passage through the atmosphere at high speed.

Meteorite strewn fields

Larger meteoroids, having diameters in the order of a few metres, usually are strongly fragmented during the passage through the atmosphere, in particular stony meteorites. This can result in the fall of hundreds to thousands of fusion-crusted individuals.

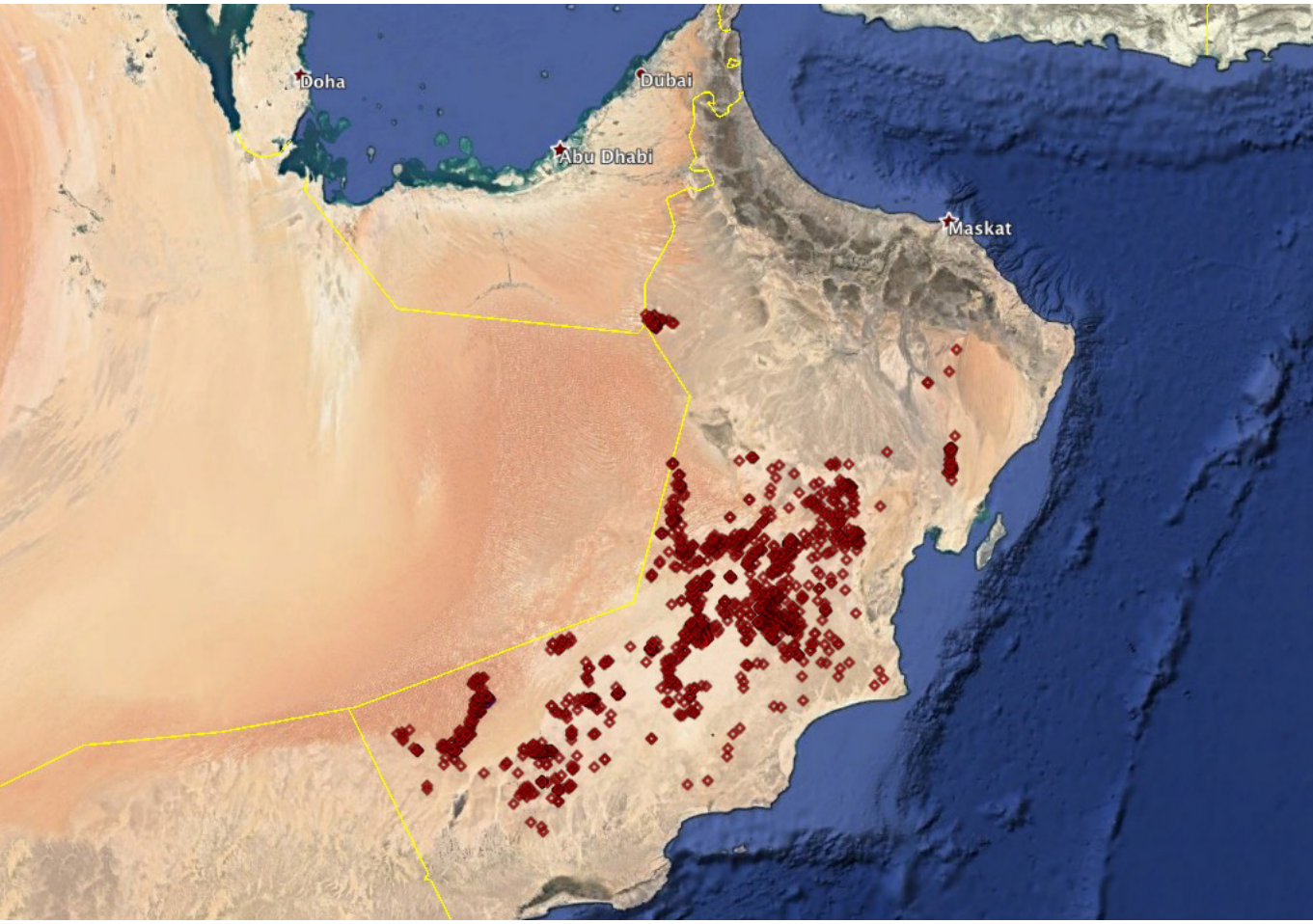


The largest strewn field in Oman and one of the largest in the world: JaH 091, with a total length of 52 km and a total mass of ~4.5 tons on the ground.

Meteorite finds in Oman:(The beginning)

All meteorites found worldwide that have been systematically documented, analysed and classified are catalogued by the Meteoritical Society and made accessible to the public via a database:
https://www.lpi.usra.edu/meteor/

The first few meteorites in Oman were found in the years 1954 (2), 1957 (1) and 1958 (4) in the course of oil exploration. A dedicated exploratory search in 1993 by the EUROMET program only yielded two samples of meteorites that were assumed to be pieces of previously found ones. In August 2000, the Meteoritical Bulletin published by the Meteoritical Society showed entries for 39 new meteorites found in Oman in 1999 and 2000 by private collectors. These included three Martian meteorites and two Lunar meteorites.

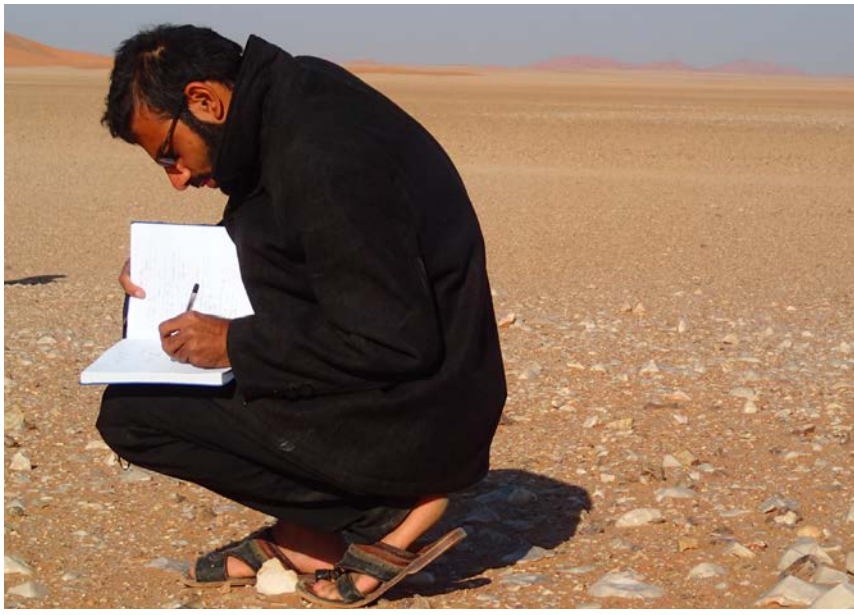


Distribution of meteorite finds made during the Omani-Swiss project. Map: Google Earth.

The Omani-Swiss meteorite search project

Based on the August 2000 report in the Meteoritical Bulletin, a collaboration project between the Directorate General of Minerals, now the Public Authority for Mining (PAM), and a group of Swiss geologists were rapidly constituted and a first test search campaign was conducted in January-February 2001. The success of this first search campaign with 187 meteorite finds led to an on-going collaboration with 16 campaigns conducted until 2017. A total of 48 persons were involved in searching meteorites, together they spent more than 5 years in the desert! The joint project has produced more than 6000 meteorite samples representing about 1000 different meteorite falls. One can see from these numbers that most meteorite falls produce more than one stone on the ground. In rare cases thousands of stones belonging to the same fall event may be found. Such events are called meteorite showers and the result on the ground is a meteorite strewn field. Documenting coordinates, weight and shape of each stone is necessary for being able to reconstruct the fall trajectory, and in combination with other data the original size of the object in space.

The meteorites collected during this project for a collection that is unique: It is the only large collection of meteorites from a hot desert that is well documented with known place of find, allowing the reconstruction of paired meteorites and strewn fields. Even the large collection of meteorites from Antarctica does not allow this, because the movement of the ice has disturbed the original distribution of the meteorites.



Geologist from the Public Authority of Mining (PAM) taking notes at the site of a freshly found meteorite.

Oman meteorites: How many of each type?

The number of officially named meteorites from Oman is at 3613, a surprisingly high number (6.4% of known meteorites), the highest for any country. Higher numbers are known from Antarctica with 36662 and Northwest Africa with 7340, (but these are not countries). Among the Oman meteorites, 70 are Lunar, 17 Martian and 53 HED's from the asteroid Vesta. Nearly a quarter of the known Lunar meteorites are from Oman.

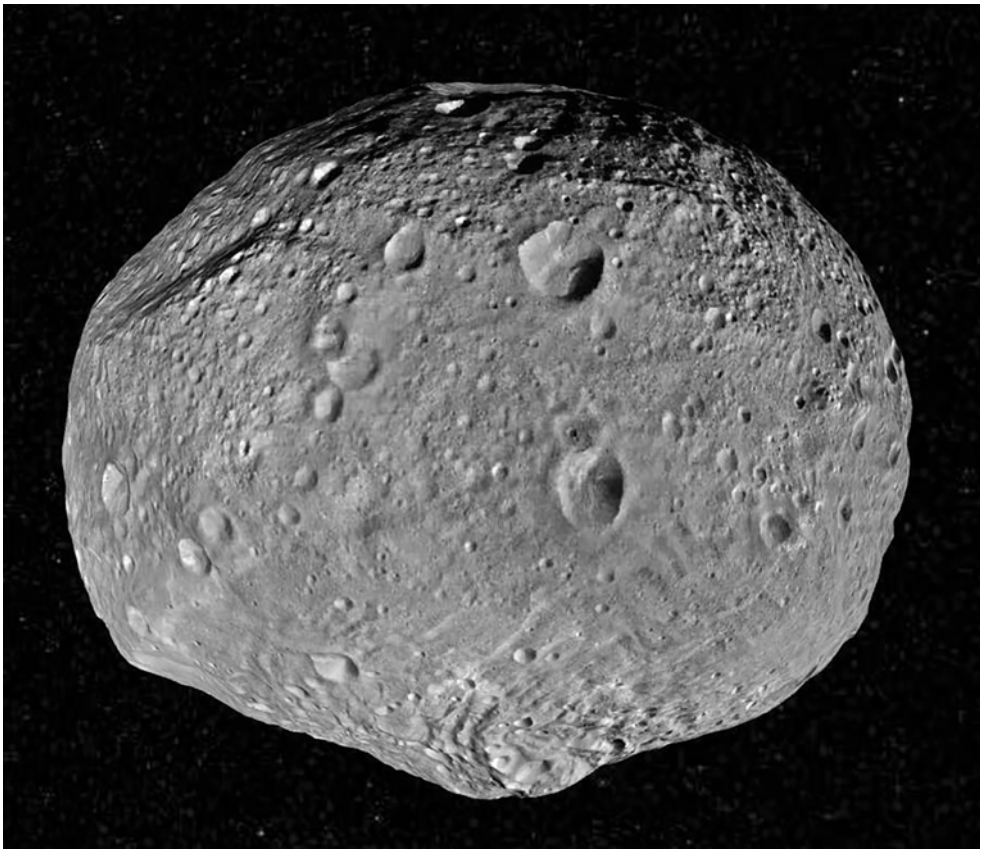
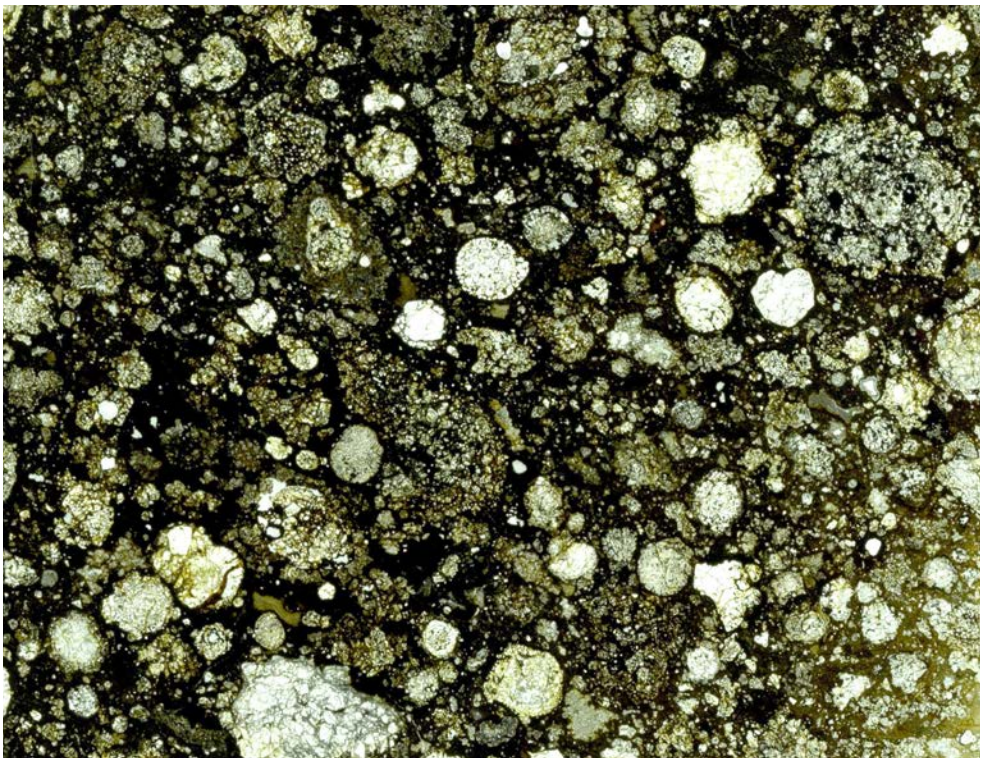
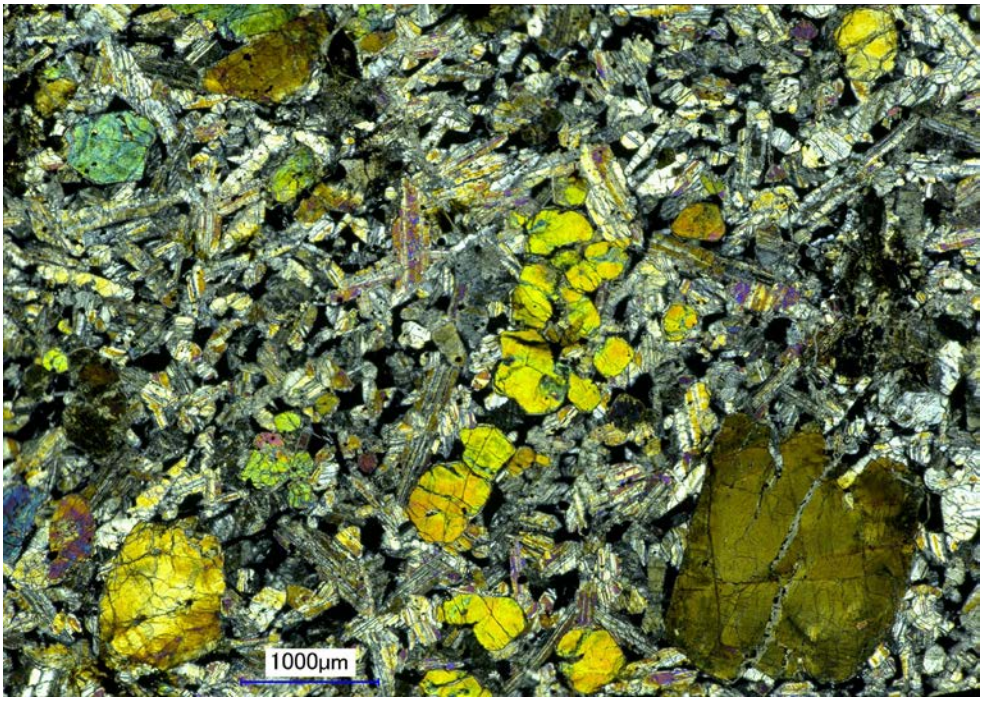


Image of the asteroid Vesta, the source of the most common group of achondrite meteorites (HED-group: howardites, eucrites, diogenites). The diameter of this asteroid is 516 km. Craters are the result of meteorite impacts. Some of the material thrown out finds its way to Earth as meteorites. Credit: NASA (Dawn mission).



Typical structure of a chondrite seen in thin section (Uruq al Hadd 008, carbonaceous chondrite of type CV)

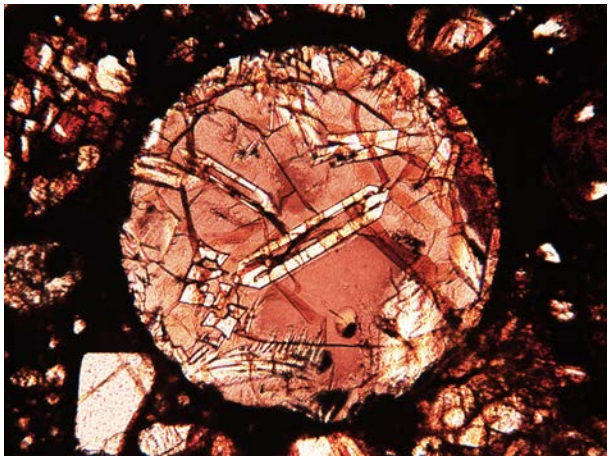


Thin section of Mars meteorite SaU 094. Such a rock is comparable to a coarse-grained terrestrial basalt.

Mesosiderite Ramlat as Sahmah 384 showing a large fragment of basaltic rock (lower right) in a mixture of silicates and metallic iron (dark and mostly weathered to rust). Thin section in polarized light.

When did the meteorites of Oman fall?

Although there are so many meteorites found in Oman, there is not a single one that has been recovered after observation of a fall. So, for how long are the meteorites lying in the desert? This can be estimated by investigating how strongly meteorites are weathered, and in more detail by measuring traces of radioactive atoms that were produced in the meteorite in space, such as carbon-14. With this method, Prof. Tim Jull in Arizona has analyzed many of the Oman finds. Most commonly, the fall age is in the order of 20'000 years, but only very few are older than 50'000 years. A few meteorites are very young and must have fallen just a few years before collection.



Chondrule (originally a melt droplet) consisting of glass with inclusions of olivine crystals. Ramlat as Sahmah 337, H 3.6 chondrite. Diameter of the chondrule is approximately 0.5 mm.

To whom belong the meteorites of Oman?

Even though meteorites appear “common” in Oman, they still are exceedingly rare and represent an easily exhaustible scientific resource. Therefore, meteorites are protected by conditions to aviod of the PAM that prohibit collecting and exporting of meteorites without permission from PAM. Since the beginning of intensified meteorite search in Oman, several incidents have been reported of foreign meteorite collectors active in Oman without permission. Such activity has been stopped by the government and meteorites had to be delivered.
In case you think you have found a meteorite in the desert, the best thing is to leave it in place, take a photograph and exact coordinates with a global positioning device (or portable phone) and report the finding to the Public Authority for Mining.

How to recognize a meteorite?

Because there are different types of meteorites, there is no easy recipe for recognizing them. You can use the following checklist:

This IS possibly a meteorite:
- heavy, rusty and magnetic (possibly an iron meteorite).
- rock with thin black crust, under the crust it is grey, yellowish or greenish, magnetic or not.
- grey or brown rock, weakly to significantly magnetic.

This most likely is NOT a meteorite:
- heavy, rusty but NOT attracted by a magnet
- rocks with small or big holes (volcanic rocks or slags)
- rocks made up of glass
- light-feeling rocks

Small Mars meteorite as found in the Rub'al-Khali of southwest Oman in 2016.

Conclusion

Protection of meteorites and handling collected specimens according to international scientific standards to provide a fertile source for researchers and for those who strongly seek knowledge, receives a great deal of attention by the Public Authority for Mining (PAM). The authority, in cooperation with the Swiss team, seeks to establish this scientific basis and provide the Omani museums with a number of meteorites in order to be available for interested people who seek a deep and broad understanding of the outer space by conducting research. In addition, it protects this wealth from loss, either by natural factors or by humans.

It is worth mentioning that in case of discovering a meteorite people have to take the coordinates of the site and send them to PAM, which in turn will deal with it in the right scientific way.

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Glossary

- Achondrite: Rock formed on asteroids by melting of chondritic precursor material.

- Chondrite: Most common type of meteorite, consisting of millimetre-sized spherules that were formerly molten droplets of rock floating in space in the Early Solar System.

- Crystal: Solid material in which atoms are arranged in a systematic geometric way.

- Fusion crust: Thin (1 mm), dark and glassy crust formed by melting of a meteoroid's surface as a result of friction while passing through the atmosphere.

- Individual: A complete, rounded meteorite, it's shape being due to ablation of material in the atmosphere. A single fall event can produce one, a few or many individuals, depending on the way a meteoroid breaks up.

- Iron meteorite: Meteorite consisting of iron with typically 5-15% of nickel and some characteristic trace elements. Iron meteorites are pieces of cores of formerly molten asteroids.

- Meteorite: Extraterrestrial rock that fell on the surface of Earth (or any other celestial body).

- Meteor: The light phenomena produced by the passage of a meteoroid through the atmosphere.

- Meteoroid: A piece of extraterrestrial rock (up to a few metres) in flight, before falling on Earth, smaller than an asteroid.

- Mineral: A natural crystal such as feldspar. The Earth, the other rocky planets and asteroids mainly consist of minerals.

- Ophiolite: Fragment of ocean floor thrust onto a continent as block of many km in size.

- Strewn field: Pieces of meteorites from a single fall event, distributed on Earth due to fragmentation of the entering meteoroid in the atmosphere. A strewn field can consist of hundreds to thousands of individuals.

- Thin section: A sliver of rock, so thin that one can see through (0.03 mm), glued on a glass plate, used for microscopic examination of rocks from Earth and meteorites.

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