History of the meteorite collection of the Russian Academy of Sciences

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Abstract: The meteorite collection of the Russian Academy of Sciences is the largest and most unique collection of meteorites in Russia, and one of the famous meteorite collections in the world. The collection contains more than 1230 meteorites and approximately 25 000 individual samples. It also has samples of tektites and impactites, rocks from terrestrial impact craters. Practically all types of meteorites are represented in the collection, making it an excellent foundation for scientific investigations in Russia and worldwide. One hundred and ninety of the collection's meteorites came from territory that was under Russian jurisdiction at the time of accession. The meteorites are mostly represented by main masses and most of them are of historical significance.

The Academy of Sciences' meteorite collection played a significant role in the formation of the science of meteoritics. As well as a scientific resource, the Academy of Sciences' meteorite collection is a unique social phenomenon.

1999 marked the 250th anniversary of the Russian Academy of Sciences' meteorite collection, one of the oldest and most famous in the world. Started in 1749, the collection became the foundation for the study of extraterrestrial material in Russia and had an important meaning in the formation of the meteoritical science.

The meteorite collection of the Russian Academy of Sciences has more than just scientific value. It has been built up over 250 years. People of all kinds have contributed meteorites, from rich, educated bourgeois and nobles to ordinary peasants and Siberian nomads. This makes the Academy of Sciences' meteorite collection a unique social phenomenon as well as a scientific resource. The meteorite collection's archives show the evolution of the language, culture and world view of the Russian people, and the rise and fall of social and economic relationships.

Unfortunately, no extensive history of the meteorite collection has been written. Only the period of its birth, which was an important part in the formation of scientific meteoritics, has been studied in detail (e.g. Göbel 1868; Paneth 1940; Massalskaya 1954; Sears 1975; Hoppe 1979; Eremeeva 1982). This article is based mainly on the original paper by Nazarov (2000), the first summary of the history of the collection.

Meteorites in prehistoric times

There is no proven archaeological evidence for the use of iron meteorites by ancient tribes living on the territory of Russia. However, the finding of the Berdyansk meteorite in a Scythian burial dating from the 7th to 3rd centuries BC indicates that people from ancient times were interested in meteorites.

In Russian historical records, the oldest mention of a meteorite fall is in the *Lavrenty Chronicle* of 1091. The sense, if not the sound, could be translated into modern language as: 'This summer, when Prince Vsevolod was hunting not far from Kiev, a gigantic dragon fell down from the sky, terrifying all the people. In that moment the Earth shook and many people heard the noise ...'.

The history of Russian meteoritics may be traced from this record. The *Lavrenty Chronicle* may describe the fall of the Bragin pallasite, a huge meteorite shower found in 1807 about 150 km from Kiev.

From that point on, shooting stars and stones falling from the sky are found several times in the medieval chronicles (Göbel 1868; Sviatsky 1915). Usually the descriptions include black clouds and fiery serpents appearing in the sky. Perhaps meteorites gave birth to the legends and fairy tales of Zmey Gorynich in Russian folklore.

Another unexpected result of meteorite falls is their clear influence on society's morals. In the

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chronicles the falls were seen as evil omens: 'We are afeard as we hear such fearsome tales, and will learn to do good and keep the Lord's gospel so that good may come to us' exclaims one chronicler as he describes the fall of a meteorite near Novgorod. Chapels were often built in the places where meteorites fell, and meteorites were built into the walls of churches and monasteries (Bornovolokov 1811).

Historical manuscripts tell of large meteorite falls. The greatest among them were at Great Ustyug (1290) (Fig. 1), Great Novgorod (1421) and near the village of New Erga (1662). The fall in Great Ustyug was the most tremendous, and legends about it were passed from generation to generation. Even today, local residents point out the place where this great catastrophe occurred (Fig. 2).

It has been suggested that the Great Ustyug fall (estimated as 3 July 1290, new style) and the Tunguska event (30 June 1908) may be linked events, and could have resulted from bombardment of the Earth by a group of cosmic bodies lying on the same Earth-crossing trajectory (Sviatsky 1928). The dates of Tunguska and the Great Ustyug fall are close, and the Great Ustyug fall lies on a projection of the trajectory of the Tunguska body. Like Tunguska, the Great Ustyug shower was travelling away from the Sun at the time of impact. Both falls had similar consequences: forest fires and felled trees. Searches for some of these recorded falls – so far unsuccessful – have been made both at the sites of the falls and in monasteries (e.g. Bornovolokov 1811).

As of this writing, no meteorite whose fall was recorded in the ancient Russian records has yet been found. However, recent studies around the village of Novaya Erga, where a meteorite shower probably fell in 1662, detected increased concentrations of iridium in nearby streambeds (Korochantsev *et al.* 2005). This indicates that a large meteorite fall may have occurred in the area.

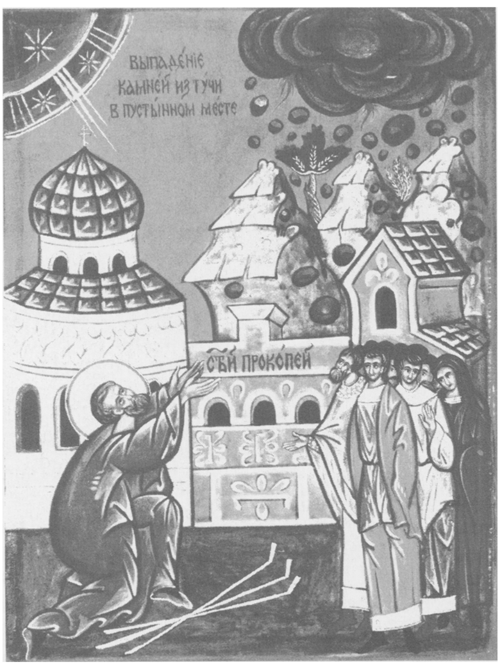


Fig. 1. Icon of St Prokopiy painted by Oleg Tsepennikov. According to ancient legend, St Prokopiy saved the town of Great Ustyug from destruction by a cloud of stones in 1290. His prayers warded off the cloud from the town, and the stone shower fell in a wild forest, knocking down and burning numerous trees. The first icon was painted in 1669, and is now in the regional museum. This modern icon shows a cloud covering Great Ustyug, with stones falling from it.

The founding of the collection

The beginning of the Russian Academy of Sciences' meteorite collection came in 1749, when a huge piece of iron rock, weighing 700 kg, was found in the Krasnoyarsk district. This rock was later named the Pallasovo Zhelezo, or Pallas Iron (Fig. 3). In international catalogues this meteorite is sometimes called Krasnoyarsk, although it was found 150 km away from the city.

The story of the finding of the Pallas iron had three main heroes.

The first was Pyotr Simon Pallas (1741–1811), a German-born scientist, academician, naturalist and traveller. Pallas is usually considered a Russian scientist despite his German origin. He was born in Germany, spent more than 40 years of his working life in Russia and returned to his homeland in his old age. During his years in Russia, Pallas travelled widely, and wrote on the country's geography, geology, zoology, botany and ethnography. He made many discoveries, and a volcano in the Kurile islands, a New Guinea reef and the first Russian meteorite were all named in his honour.

The second hero of the story was a German copper miner named Johann Kaspar Mettich, who also came to work in Russia. In 1749 he was the obersteiger (overseer) of the large copper mines of Karysh, and later the Inspector of Mines for Krasnoyarsk Province. In 1771 or 1772 Mettich wrote a report to Pyotr S. Pallas, saying that he had noticed an iron boulder lying in the open about 150 lachters (315 m) from a mineshaft previously discovered by a Cossack

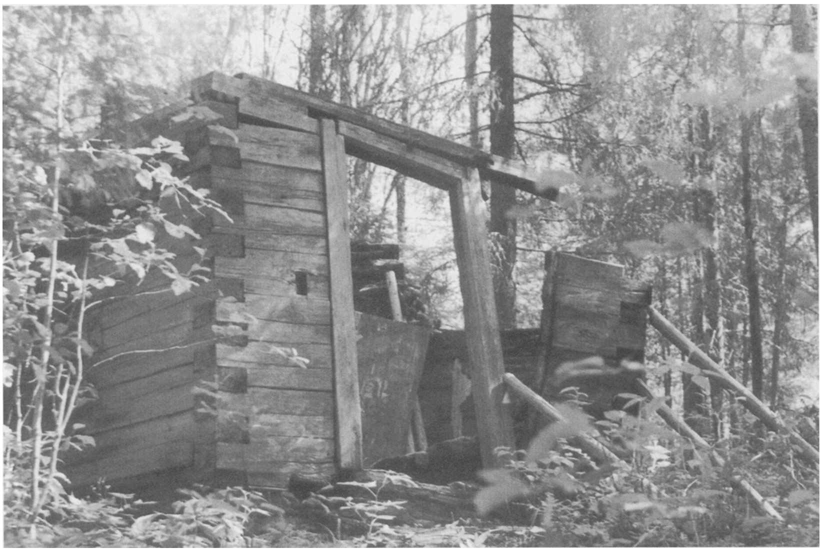


Fig. 2. Popular memory has recorded the time and place where a cloud of stones fell near Great Ustyug. A wooden chapel and later a stone church were built on the site near the village of Olbovo. For several centuries the place has been regularly visited by praying people on the day of the fall. An ukase from the Holy Synod of 7 September 1860 permitted residents of Ustyug 'to carry the Cross from the Ustyug Cathedral of The Assumption to the chapel near Olbovo, where in 1290, as told by the ancient tales, a cloud of stones fell'. The village of Olbovo no longer exists, and the chapel and church are in ruins. But a well-trodden path leads to them through a wood, showing that even today people still remember the place. Many stones lie about, but they are all of terrestrial origin. Photograph from 1998.

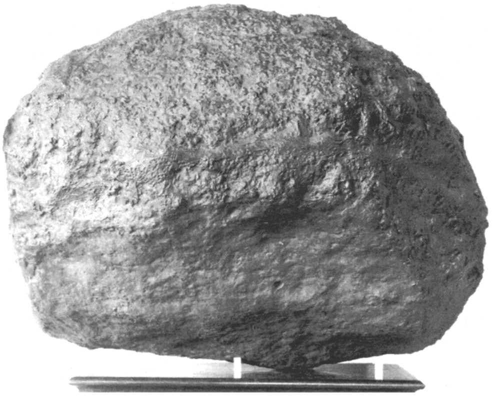


Fig. 3. Plaster cast of the Pallas iron made in 1867 before the meteorite was sawn in half. From A.F. Gebel (1868). The Pallas iron is undoubtedly unique in size and structure among the very rare known pallasites. This alone is enough to make it worthy of special attention. It is even more worthy thereof if one recalls the historical memoirs linked to it, and its scientific significance. From the Pallas iron, 74 years ago, thanks to Chladny, arose a new view of the nature of meteorites; from it, thanks to Berzelius, 34 years ago the era of scientific investigation of meteorites began. We may say that this mass was fated to have a scientific mission, which with its help must be continued and conducted, if it can only ever be completed.

named Medvedev. Based on the report, later authors – A.F. Göbel (1868) and A.I. Eremeeva (1982) – credit Mettich as the finder of the Pallas iron meteorite.

The third hero of the Pallas iron story was a retired Cossack named Yakov Medvedev, mentioned in Mettich's letter to Pallas. Little is known of Medvedev. According to Medvedev himself, he had a hankering for the wandering life, hunted and worked as a blacksmith, and had a great curiosity for prospecting. During Soviet times, Medvedev was often credited as the original discoverer of the Pallas iron (Krinov 1955). Medvedev had found an iron ore deposit and noticed the mysterious iron boulder lying in the open air 300 paces from the vein.

Nazarov (2000) proposed that neither Medvedev nor Mettich was the original finder of the meteorite, but that the iron boulder had already been discovered by local taiga tribes, whom Medvedev called Tartars. In 1786 Medvedev wrote to Pallas and told him, famously, that the local Tartars knew of a holy iron boulder that had fallen from the Heavens. In fact, it seems unlikely that the Tartars would have believed the boulder was sacred if it had been found by Mettich or Medvedev. If the version is correct then the actual discovery may be reconstructed approximately as follows.

At some point in the 17th or early 18th century a large stony-iron meteorite fell on a mountainside in Siberia, by chance near a deposit of iron ore. The local tribes learned of the fall and held the sky-boulder to be holy.

In the 1740s, the Cossack Medvedev was living a wandering life around Siberia. Working as a travelling blacksmith near Krasnoyarsk in 1749, he learned from the local taiga Tartars about the holy and unusual boulder. The Tartars led Medvedev to the boulder and he then found the nearby vein of iron ore.

For duty or for profit, Medvedev reported his discovery to the Krasnoyarsk Department of Mines, where Mettich was overseer. Mettich investigated, and the Cossack showed him the boulder and the ore deposit. Mettich took careful notes about the circumstances of the finds and returned to Krasnoyarsk.

Yakov Medvedev then performed a heroic deed, which played a decisive role in the story of the Pallas iron, scientific meteoritics and, to some degree, opened the road to space for humanity. Some time between 1749 and 1771: 'With great labour he hauled this mass down from the mountain where it lay, and for 30 versts to his home' Pallas later wrote laconically.

Naturally, rumours began to fly that the Cossacks had found and recovered a miraculous boulder, or more likely a golden one. Why else would anyone haul such a heavy weight to his house? As Medvedev later explained to Pallas: 'The amazing whiteness and malleability of the boulder, and its ringing tone when hammered, allowed me to think that the boulder might be of a material more noble than iron. The Tartars, who thought the boulder a holy stone fallen from Heaven, have confirmed me in this opinion ...'.

Eventually the rumours reached Krasnoyarsk. Pallas, the travelling scientist, was passing through the town in 1771 with his servant Yakub, who was helping him 'to collect natural wonders'. Yakub heard the rumours and told them to his master. Pallas then asked the official in charge of mines, Johann Mettich, for comments about this find. Mettich pulled out his old notes and wrote a detailed report, the first document to mention the circumstances and year of the finding of the boulder, 1749. Mettich noted that 'I know that the above mentioned Medvedev later hauled this boulder down from the mountains: but where it had been delivered I don't know'.

Yakub was later sent on some business to Abakansk and learned where Medvedev was living. Yakub visited the old Cossack, chiselled off a piece of the boulder and brought it to Pallas. Pallas wrote, '... it was clear enough that this sample was natural iron ... without delay I ordered that the whole mass, which then weighed 42 poods, be brought to the city'. Pallas then went to see Medvedev and wrote an account of their conversations. He realized the importance of the find and published a description of the unusual iron boulder (Pallas 1786). The boulder was later named in his honour.

Fig. 4. Ehrnst Florenz Friedrich Chladni (1756–1826). A founder of scientific meteoritics, physicist of acoustics and Doctor of Law. Ernst Floren Friedrich Chladni was apparently a Slovak by birth. He was a member of many scientific societies, including the St Petersburg Academy of Sciences for studies in acoustics. Chladni spent much of his life in travels around Europe. During a stay in St Petersburg (1794) he gave a concert on a musical instrument of his own invention, the euphone. But he apparently did not visit the Academy of Sciences Museum or see the main mass of the Pallas iron. Chladni's now-famous book was at first rejected by the scientific community. He was listed as 'one of those, who ... deny the entire order of Creation and ... do so much evil to the moral duty of Humanity' (Chladni 1819). Remembering this time, Chladni wrote in this book in 1819: 'When my book was published, most people said it was foolishness, some of the most authoritative scientific journals wrote that the book did not even deserve refutation, and others thought that this was a trap from Chladni, that if anyone took it seriously then Chladni would reveal the secret and laugh ...'.

A few years later, in 1794, Ernst Florenz Friedrich Chladny (Fig. 4) published the first speculations about a possible cosmic origin for the boulder.

Using Mettich's report, it was possible to determine the place where the iron boulder had first been found. In 1980, a monument was erected on the spot – the only monument to a meteorite in the world (Fig. 5).

Now, looking back, we are faced with important questions. What did Pallas see in this iron boulder that made him decide to report it immediately to the Academy in St Petersburg? Pallas had no suspicion yet that the boulder had a cosmic origin. Why did the Academy, after some hesitation, decide to transport the boulder to the capital? Why did the Konferenz-Secretary of the Academy, Jacob Stehlin, in his 1774 letter to the Royal Society in London about the latest scientific discoveries in Russia report with pride about this first find of natural iron in Siberia?

Stehlin named only two discoveries. The first was the discovery of the Aleutian Islands and the second was the Pallas iron (Stehlin 1809). A later author, A.I. Eremeeva (1982), probably correctly determined the reason for the sudden interest. At that time, limited amounts of pure natural iron had occasionally been found, but there were always suspicions that these finds were the remains of ancient metalworks. The Pallas iron was clearly not the product of ancient smiths. It was the first confirmed discovery of naturally occurring pure iron metal. In the 18th century, naturally occurring pure iron might have been of commercial interest. Indeed, if the natural iron occurred in large accumulations, then the process of metallurgy could have been greatly simplified.

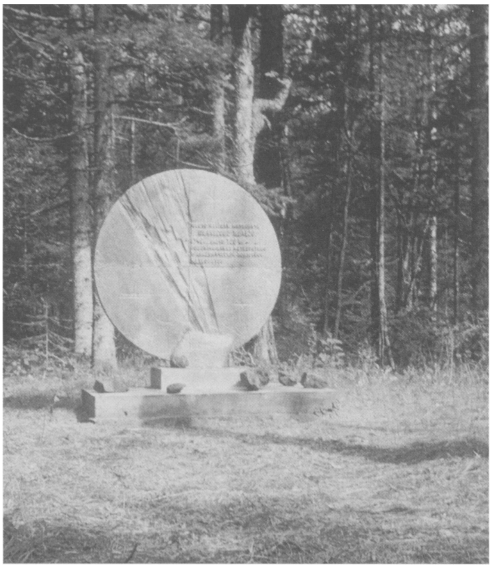


Fig. 5. Photograph taken in 1980 of the memorial at the site where the Pallas iron meteorite was found. A plaque on the memorial says: 'Site of the finding of the Pallas iron, 1749, weight about 700 kg. The Pallas iron was vital to the founding of the science of meteoritics and the Russian Academy of Sciences' meteorite collection'. This is believed to be the only memorial in honour of a meteorite in the world.

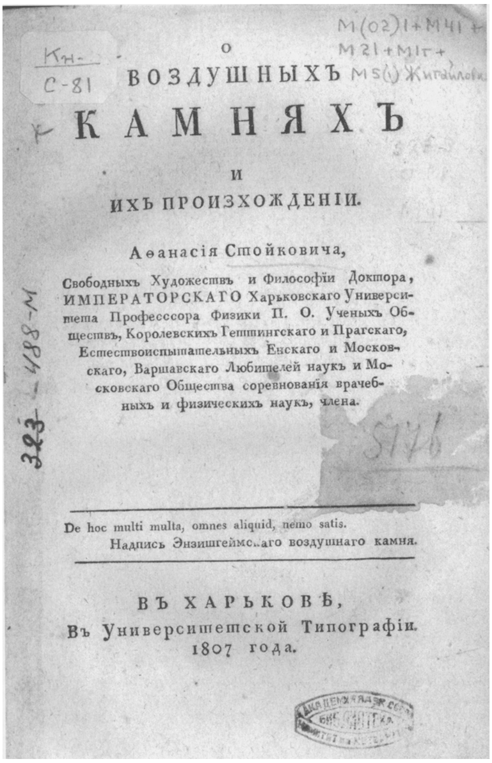
So the origin of the Pallas boulder triggered heavy scientific debates, which became even hotter with the publication in 1794 of a book by E.F.F. Chladni titled *On the Origin of the Natural Iron Mass Found by Pallas and Other Similar Iron Masses and Certain Linked Natural Phenomena*. Chladni was a foreign member of the St Petersburg Academy of Sciences, known for his work in acoustics. His book laid the foundation of scientific meteoritics. It made the first suggestion of a cosmic origin for the Pallas boulder and other 'aerial stones', or aerolites, which had been reported to fall from the sky but were not accepted as true since the scientific community believed it was physically impossible for such a thing to occur.

Chladni's idea was not accepted right away, but it had been stated and gradually opened colossal horizons for the mind. Extraterrestrial material, previously seen only through telescopes, could now be touched directly and studied in the laboratory. A whole range of questions appeared requiring immediate answers. But to solve them, meteorites were needed. Only one practical question remained to be answered – a mere technicality – how to collect meteorites efficiently. It has been long and hard to solve this question.

The 19th century: a time of changes

The Russian scientific community was skeptical of Chladni's ideas. The idea of stones falling from the air did attract some attention and a growing scientific debate. In 1807, a book by A. Stoikovich, *On Aerial Stones And Their Origin*, was published in Kharkov (Stoikovich 1807). It was the first detailed monograph in Russian about meteorites (Fig. 6). In 1819, Mukhin published another fundamental work on meteorites in St Petersburg. Both books gave a critical view of Chladni's ideas.

The Russian Academy of Sciences showed only minor interest in meteorites for many years. No organized attempts to study or collect meteorites were made, although the Academy did not reject the few meteorite samples that were sent to its address. By 1811 the Academy's



О

ВОЗДУШНЫХЪ

КАМНЯХЪ

И

ИХЪ ПРОИЗХОЖДЕНІИ.

Аѳанасія Стойковича,

Свободныхъ Художествъ и Философіи Доктора, ИМПЕРАТОРСКАГО Харьковскаго Университета Профессора Физики П. О. Ученыхъ Обществъ, Королевскихъ Геттингскаго и Пражскаго, Естествоиспытательныхъ Енскаго и Московскаго, Варшавскаго Любителей наукъ и Московскаго Общества соревнованія врачебныхъ и физическихъ наукъ, члена.

De hoc multi multa, omnes aliquid, nemo satis.

Надпись Энзисгеймскаго воздушнаго камня.

ВЪ ХАРЬКОВѢ,

Въ Университетской Типографіи.

1807 года.

Fig. 6. The title page of A. Stoikovich's (1807) book *On Aerial Stones and Their Origin*, the first monograph on meteorites published in Russian. The book compiles information on all meteorite falls known at that time and presents a critical analysis of possible hypotheses on the origin of meteorites. Stoikovich concludes, although not categorically, that meteorites and bolides have an atmospheric origin: 'I suppose for many reasons that falling stars should generally be counted as products of the atmosphere. Although one cannot deny that some of them may have an earthly origin; however given our current level of knowledge, we should not dare to count this possibility as true: because even those falling stars to which a terrestrial origin may be ascribed have many similarities with other phenomena of this kind, which are obviously of earthly origin'.

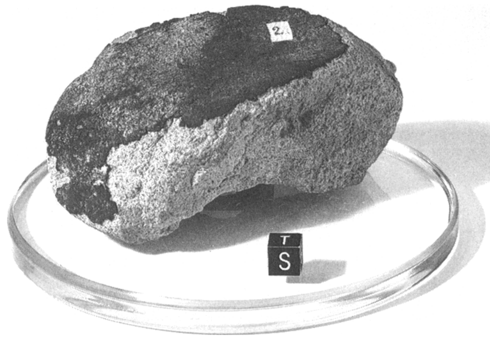


Fig. 7. Zhigailovka, a LL6 chondrite, fell on 12 October 1787 in the Sumy Region. One sample of 1.5 kg. This is the first meteorite fall on Russian territory for which samples have been preserved. The fall was described by the local physician A.R. Grodnitsky, who noted 'We looked at it with great curiousity. Its inside and outside were so remarkable that should I see this stone several years later, I could easily recognize it'.

collection contained seven meteorites (Severgin 1811), and 19 by 1846 (Göbel 1868). The collection included the Zhigailovka chondrite that is the first meteorite fall collected in Russia (Fig. 7).

Large changes occurred after A.F. Göbel published his book *On Aerolites in Russia* in St Petersburg in 1868. Göbel, probably a chemist, was the curator of the Mineralogical Department of the Academy of Sciences and was passionately interested in meteorites. He was the first in Russia to fully accept Chladni's conception of a cosmic origin.

By 1868 the Russian meteorite collection had 45 samples, while the Museum of Vienna had 200. Disappointed by the limited Russian collection, Göbel organized a collection strategy. He understood that 'almost equal numbers of aerolithes fall on equal surface areas of the Earth' and consequently that 'the reasons for the difference must be in the higher population densities ... in Western European countries ...'. However, Göbel noted that the 'mismatch between the number of falls in Russia and abroad is an effect not only of the population density, but should also be changed by improvement of the curiosity, attention and interest to these subjects from our town and rural populations ...'.

These simple thoughts are the first demonstration of the social aspect of meteoritics in Russian scientific literature. Indeed, because meteorite falls are so rare and there are so few scientists, ordinary people are the main observers and collectors of meteorites. So the number of collected meteorites is determined by the social characteristics of a population – its size, density, economic and cultural levels. The growth curve of the number of Russian-source meteorites in the Russian Academy of Sciences collection clearly confirms these conclusions (Fig. 8).

To expand the meteorite collection it is necessary to go to the people and work actively with them. Fortunately, as further history showed, Russians are very interested in stones falling from the sky, and they respect scientists and have always supported and helped them in the collection of meteorites. It is important that a meteorite fall is an amazing and spectacular

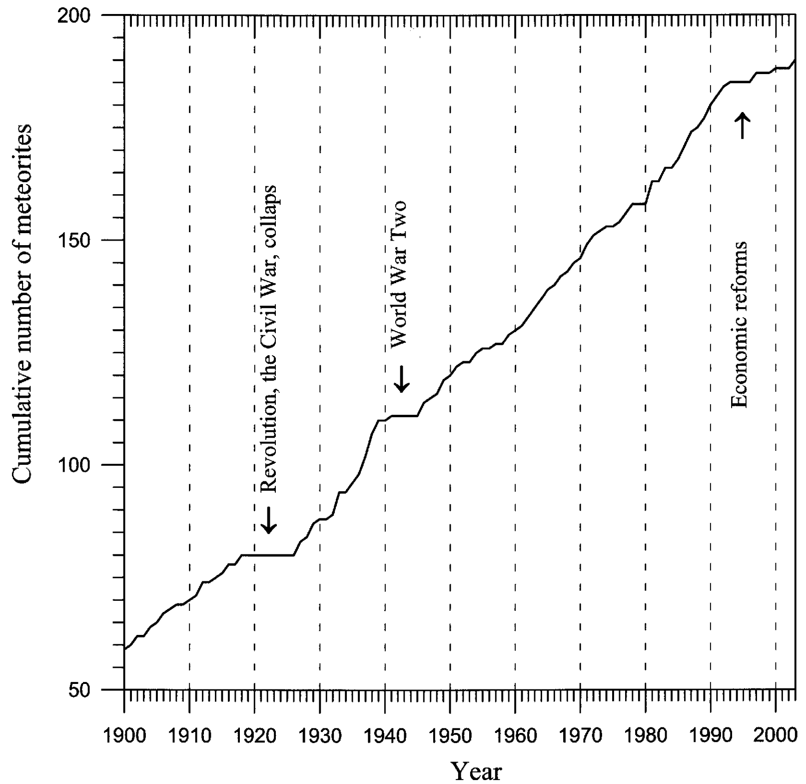


Fig. 8. Cumulative number of meteorites collected in Russia in the meteorite collection of the Academy of Sciences. This curve shows the growth of the collection. The steeper the graph, the more meteorites were entered in the collection. When the graph is flat, no meteorites were added. In the 20th century these plateaus correspond to the crises of Russian history. The highest growth in the 1930s correlated with Stalin's economic reforms.

phenomenon, and is remembered long after. So people sent letters to the Meteorite Committee of the Academy, in which they reported very accurately the circumstances of some meteorite falls even as much as 60 years after they happened.

A mining engineer named Yu.N. Simashko was the first to put Göbel's ideas into practice. Simashko, who was a passionate lover of meteorites, was the first to introduce the terminology and name of a new science – meteoritica. He actively popularized meteoritics, travelled extensively searching for meteorites, and collected information from people about meteorite falls and finds. He also bought and exchanged meteorites with foreign collectors. Simashko collected meteorites not for the Academy of Sciences but for his private collection. At the turn of the 20th century, Simashko's collection contained almost 400 meteorites and exceeded the collection of the Academy of Sciences.

Simashko's meteorite collection had a tragic fate. After Simashko's death, his widow sold the collection and only few samples remained in Russia. Probably this is the fate of most private collections. As a rule they disappear after the owner's death. In the 19th century meteorites occurred in many private collections (Göbel 1868), which unfortunately have all disappeared.

Towards the end of the 19th century interest in meteorites was growing in the Academy of Sciences, and in other scientific and government organizations. Meteorite collections also were formed in Odessa, Kiev, Kharkov and Tartu. Moscow State University began gathering samples of meteorites in its mineralogical collection. A wonderful collection of meteorites was formed in the Forestry Institute (now the Timiryazev Agricultural Academy in Moscow).

Finally, and surprisingly, in 1898 capitalist Tsarist Russia passed a law making all meteorites government property. According to this law: '... meteorites must be transferred to Government Museums. Any person finding a meteorite has a duty to transfer it to a Museum in person, or to submit it to an official of the education ministry or to the local government, or indicate the location of the meteorite for transfer to a Museum'. The Academy of Sciences offered a reward for anyone finding a meteorite. Even during the Soviet period there was no such law, although rewards for the finding of meteorites continued.

It is interesting to note that for the whole period in which rewards were offered for finding a meteorite, only three people refused their awards as a matter of principle. Their names should be mentioned here: A.Z. Feodorov, a geographer who organized the search for the Boguslavka fall in 1916; P.L. Dravert, a professor of Omsk University, who found five new meteorites in Siberia in the 1930s; and V.A. Petrosyan, an engineer who delivered the Erevan howardite to the collection in 1975.

The main result of the 19th century was the complete understanding of the cosmic origin of meteorites and the development of a strategy for collecting them.

The 20th century: the Golden Age

The 19th century had laid the basis for the efficient growth of the meteorite collection. Only organizational and technical issues remained. Academician Vladimir I. Vernadsky (1863–1945) (Fig. 9) was determined to solve them.

V.I. Vernadsky, a well-known scientist, philosopher and politician, was one of the founders of geochemistry and biogeochemistry. But few people know that Vernadsky was also the main leader of meteorite research in the Soviet period. Vernadsky believed that meteorites had a galactic origin. He thought that estimations of meteorite orbits confirmed this directly – and so the study of meteorites opens a door to study the depths of the universe. This expanded understanding increased the urgency of building up a substantial meteorite collection for scientific study (Vernadsky 1941).

Vernadsky fully accepted Göbel's ideas that ordinary people should be encouraged to collect meteorites: 'Especially in this field of knowledge we need the support of the broadest layers of the population. The number of recovered meteorites is directly proportional to the cultural level of the people and its activity in preserving meteorites' Vernadsky wrote in 1941.

With Vernadsky's leadership, the organized study of meteorites began. A special meteorite expedition was organized in 1921. In 1922 a Meteorite Department was opened at the Mineralogical Museum. In 1935 a Meteorite Commission was created, and in 1939 the Committee on Meteorites.

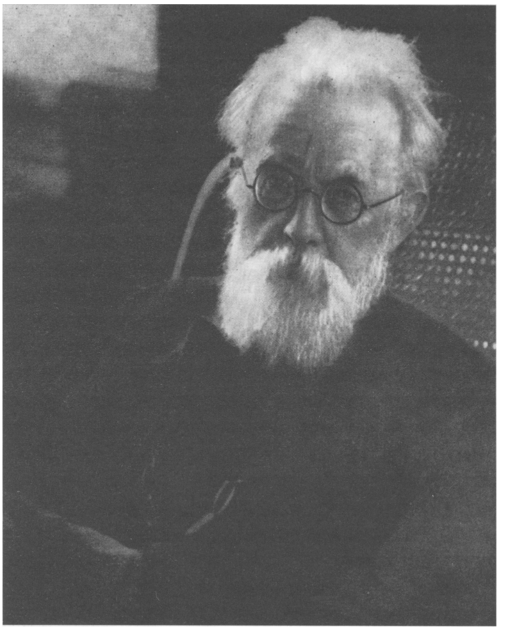


Fig. 9. Vladimir Ivanovich Vernadsky (1863–1944). Scientist, naturalist, philosopher and political figure. Vladimir Vernadsky was one of the founders of geochemistry and biogeochemistry, and invented the concept of the noosphere, the sphere of thought and the mind. Academician Vernadsky was the first head of the Meteorite Committee, from 1939 to 1944. At Vernadsky's urging, fundamental research on meteorites was organized in the USSR, and the Meteorite Committee and the journal *Meteoritika* were founded. Emphasizing the increasing importance of meteoritics, Vernadsky wrote: 'It seems to me that the significance of Meteoritics is only now really entering scientific awareness. We have a large amount of ready material for these studies – This is the meteorite collection of the Russian Academy of Sciences. It could not and should not be untouched museum material, but should simultaneously be both preserved and used as a tool of directed scientific study. Once destroyed, a meteorite cannot be replaced, because each fall is a one-of-a-kind natural body, a unique natural phenomenon sometimes of immense importance. Especially for this field of knowledge, the conscious participation and understanding of the broad masses of the population are needed. The number of meteorites recovered is directly proportional to the cultural level of the population and its activity in recovering them'.

The scientist L.A. Kulik brought many of Vernadsky's ideas to life (Fig. 10). Kulik was undoubtedly the single most important figure in the history of Russian meteoritics. His name became well known after his first heroic expeditions to the taiga to study the giant Tunguska explosion of 1908 – the most tremendous and unusual meteorite fall in human history. Kulik made great strides in studying the Tunguska event (Fig. 11), mounting several expeditions to the site and recording the devastated forest landscape. However, all of his efforts to find fragments of the Tunguska object proved to be in vain, as the body apparently exploded and broke up in the atmosphere.

In addition to Tunguska, Kulik's main achievement was the collection of meteorites. Kulik took charge of the meteorite collection efforts with great enthusiasm, organization and heroism. At first he worked almost unaided. He went on solo expeditions and suffered deprivations. A great writer and speaker, L.A. Kulik actively spread information about meteorites among the Soviet population. He organized a group of volunteer observers and correspondents in the Meteorite Department.

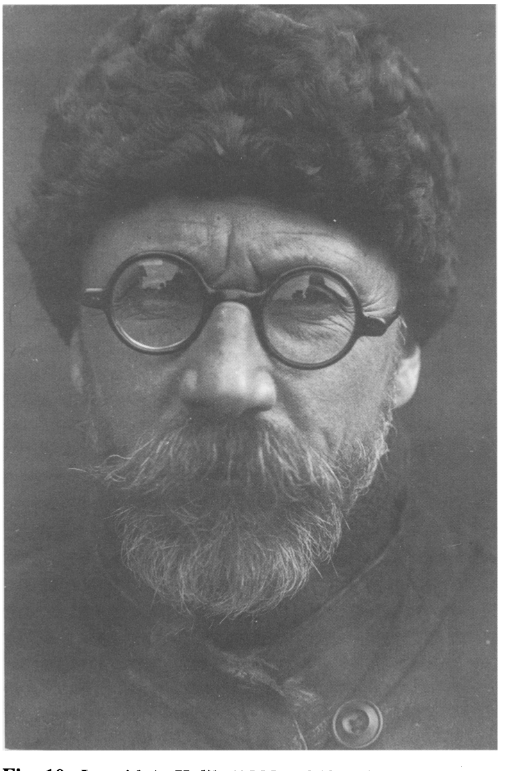


Fig. 10. Leonid A. Kulik (1883–1942). Photograph by E.L. Krinov during the Tunguska expidition of 1929. At the outbreak of war in 1941, Kulik joined the Communist Party and went to the front. The Academy of Sciences sent a request to the Defence Commissariat to request the scientist's demobilization. The order was received but Kulik refused to leave his militia unit. In October 1941 Kulik was wounded and captured during the German attack on Moscow. He was held prisoner in Spas-Demensk, a town in the Kaluga region. He worked as a nurse in a prisoner-of-war hospital. In April 1942 he contracted typhus and died shortly after. He was buried in the city graveyard. In 1960 the Academy of Sciences raised a simple memorial over his grave.

From then on an increasing number of reports about meteorites began to arrive in the Meteorite Department. Based on these reports, Kulik visited the sites of finds and falls, and bought and traded meteorites from persons and museums. Piece by piece, Kulik collected every sample he could in a Russia devastated by the Civil War. He raised the meteorite collection from near destruction, enriched it and supported the development of fundamental investigations of extraterrestrial material in Russia.

After Vernadsky's death in 1945, Academician Vasilii G. Fesenkov (1889–1972) became Head of the Committee on Meteorites. Fesenkov was one of the USSR's leading astronomers. Eugeny L. Krinov (1906–1984) became the scientific secretary of the Committee on Meteorites after beginning his scientific career in the 1920s in the Meteorite Department. Krinov continued Kulik's collection work, based on the same method of active work with the people.

On 12 February 1947, came the giant fall of the Sikhote-Alin meteorite (Fig. 12). The impact site with its numerous craters was found 2 days later by airline pilots en route to Khabarovsk. Dr Krinov organized many expeditions to the region of the Sikhote-Alin fall. It was hard work to recover the huge, heavy iron boulders from the craters (Fig. 13). Teams of soldiers worked with the scientists and pulled out several 1-ton stones (Figs 14 & 15). Numerous small and middle-size meteorites were strewn across the taiga, and a total of more than 20 tons of meteorite material have been recovered. Sikhote-Alin brought wonderful new samples and caused a flood of interest in meteorites in the USSR.

This research was strongly supported by academician Aleksandr P. Vinogradov (1895–1975), a student and colleague of V.I. Vernadsky. Vinogradov became the first Director of the Vernadsky Institute of Geochemistry and Analytical Chemistry, which was founded in Moscow in 1947 shortly after the Sikhote-Alin fall. Under Vinogradov's leadership, the Vernadsky Institute conducted wide-ranging investigations into the chemical composition of meteorites, their ages and radiation history. The institute actively collaborated with the Committee on Meteorites and other organizations.

Meanwhile, fundamental aspects of meteorite formation, or cosmogony, were studied by

Fig. 11. There was terrible destruction in the taiga around the Tunguska catastrophe (photograph taken in 1929). L.A. Kulik was astonished: 'I can barely imagine the tremendous picture of this unique event ... From where I stand I see no old forest at all: everything is knocked down and burned, and a young, green 20-year growth has covered the dead area. It is terrifying when you see giant trees, 0.5–1 metre in diameter, which were knocked down in the blink of an eye ... It was very dangerous to go ahead, especially in the first part of the day when the weather was windy. Giant twenty-metre trees, decayed at their roots, often fell down with a huge crash. We needed to watch carefully the burned, dead upper part of the trees, ready to jump suddenly out of the way if they fell, and at the same time not forget to look at our feet, because this place is abundant in poisonous snakes'.

O.Yu. Shmidt's laboratory at the Institute of Physics of the Earth (Moscow), meteorite geochronology was investigated at the Institute of Geochronology of The Precambrian (Leningrad), and meteorite astronomy and orbit dynamics were studied at the Russian Astronomical Society (Moscow).

Step by step, Russian meteoritics was taking a leading role in the world. *Meteoritika*, an annual magazine, was organized and summary monographs were published. Yearly all-USSR meteorite conferences were organized, starting in 1949. The future appeared promising.

In the 1970s huge changes occurred in methods of collecting meteorites, and wide new horizons were found. It was shown that meteorites may be effectively collected in Antarctica (Kojima 2006) and in hot deserts (Bevan 2006), where they are usually well preserved. Professional meteorite collection expeditions were organized. Huge numbers of meteorites began flowing into meteorite collections around the world. Among them completely new types of meteorite material were found.

Unfortunately, these sources of meteorites were unreachable for Russian investigators. For various reasons, Russia, the country that discovered Antarctica and maintained an active network of Antarctic stations, was unable to organize search and collection of meteorites on the icy continent. Several Russian attempts were made to collect meteorites in Antarctica, but unfortunately finished unsuccessfully. In the desert regions of the USSR, the climate appeared unfavourable for the preservation of meteorites. The Russian meteorite collection rapidly fell behind other world collections in both quantity and scientific significance.

The 20th century had been a Golden Age for the Russian meteorite collection, with more collected than in the previous 150 years combined. But the century ended with a depression. Since 1992 the number of meteorites arriving in the collection from the Russian territory has fallen sharply (Fig. 8). The reasons for this crisis are obvious: we are all witnesses and participants to the fall of the Soviet Union and the ensuing difficult times. The growth curve of the Russian meteorite collection has reacted to the negative social, political and economic processes in our society, and has shown that the scale and influence of the crisis for scientific investigations are comparable

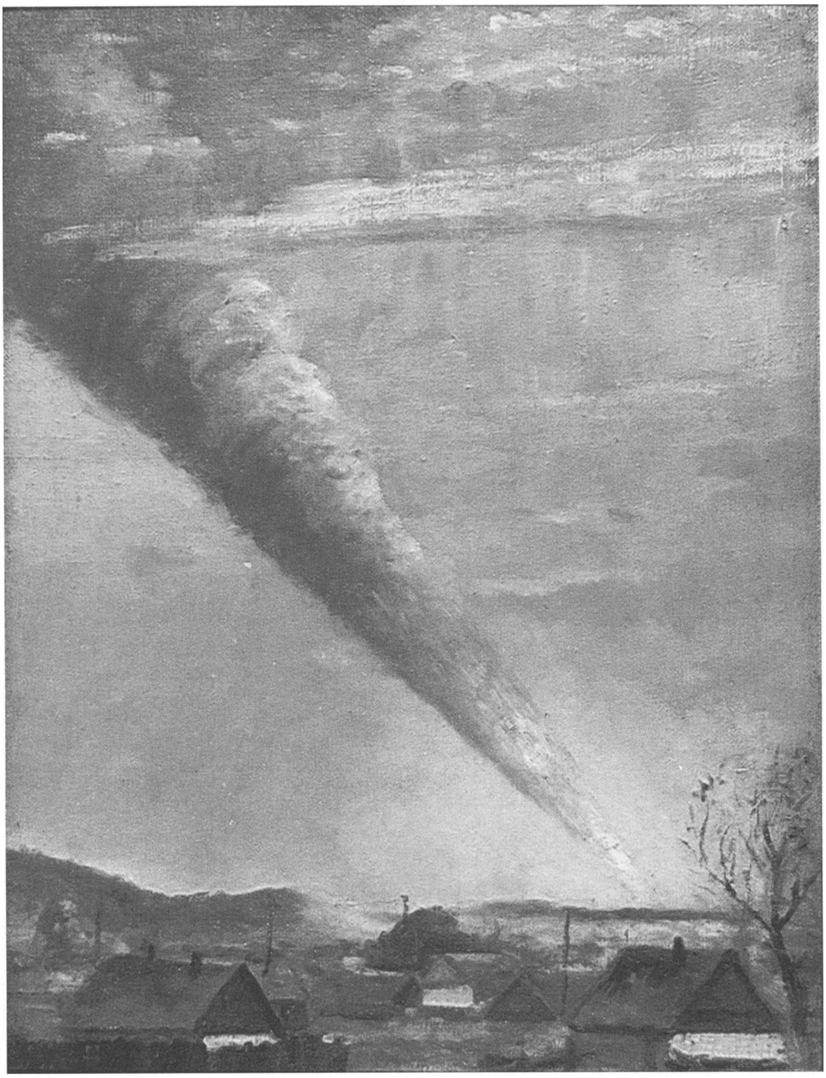


Fig. 12. The fall of the Sikhote-Alin meteorite, 12 February 1947, 10:38 a.m., Iman, Primorsky Kray. Drawing by P.I. Medvedev, an eyewitness (the original is at the offices of the Meteorite Committee of the Russian Academy of Sciences). According to E.L. Krinov (1981): 'The Sikhote–Alin meteorite shower was a unique natural event. It was the largest known metal meteorite shower, far exceeding all other known showers both in the number of individual impactors and their total mass'.

only with the damage of the Revolution and civil wars (Fig. 8).

The present: current condition of the collection

The meteorite collection of the Russian Academy of Sciences is the largest and most unique collection of meteorites in Russia today. The collection contains more than 1230 meteorites and approximately 25 000 individual samples. It also has samples of tektites and impactites, rocks from terrestrial impact craters. Practically all types of meteorites are represented in the collection, making it an excellent foundation for scientific investigations in Russia and worldwide.

One hundred and ninety of the collection's meteorites came from territory that was under Russian jurisdiction at the time of accession. The meteorites are mostly represented by main

Fig. 13. Aerial view of Sikhote–Alin Crater No. 1.

masses and most of them are of historical significance. Foreign meteorites were received by exchanges or represented by type specimens, including a large number of type specimens of meteorites from Oman and NW Africa (Fig. 16).

In number of meteorites, the Academy's collection is smaller than several other worldwide collections, such as those of Japan, the USA, Austria, Great Britain, Germany and France, but it is significantly bigger than the collections of such countries as Canada and Italy. Moreover, according to the number of meteorites collected on the territory of the host country, the Russian meteorite collection holds second place in the world after the United States. This is an excellent result given Russia's low population density, huge areas of taiga and tundra, and long winter. These factors greatly complicate collection of meteorites on Russian territory. Despite Russia's current economic depression, the country remains one of the world's leading holders of meteorite material. As mentioned above, the major weak point of the Russian Academy

Fig. 14. Engineers recovering the largest fragment of the Sikhote–Alin meteorite, 1745 kg, from the crater. Photograph taken in 1950.

Fig. 15. A large fragment of meteorite iron being recovered from the crater by a team of engineers, 1950.

collection is the lack of numerous Antarctic finds, which are poorly represented in the collection. We hope that the situation will change in the future.

The collection is held at the Laboratory of Meteoritics of the Vernadsky Institute of Geochemistry and Analytical Chemistry of the Russian Academy of Sciences. The Laboratory head is Dr Mikhail Nazarov.

Parts of the collection are on exhibit at the Vernadsky Institute (Fig. 17) and the Fersman Mineralogical Museum of the Russian Academy of Sciences. Every year 50–100 samples of meteorites are provided to Russian and international scientific laboratories. Samples for investigation, exhibits and educational purposes are provided based on detailed requests sent to the Laboratory of Meteoritics (www.meteorites.ru).

Histories of some meteorites of the collection

Several meteorites of the collection of the Russian Academy of Sciences have very interesting stories of their discoveries, such as the Pallas iron and Sikhote-Alin, and some of them are of historical significance. Below we present several stories of famous finds and falls from the whole history of the meteorite collection (Fig. 18). This information was taken from the archives of the Meteorite Committee.

By coincidence, the first meteorite ever identified in Russia was the Pallas iron, the original pallasite. The second meteorite ever found in Russia was Bragin, a pallasite, in 1807. Initial debris of Bragin was found by the farmers of Kaporenki, a village in the estate of Bragin. The estate belonged to His Brilliance Graf Rakitsky, State Advisor, Ex Honorio Inspector of The Schools of Rechitsky Uezd and a cavalier. Rakitsky gave the debris to scientists. Additional fragments of Bragin have been found frequently up to the present day. During the Second World War samples of Bragin were stolen from Kiev by German soldiers. Samples of Bragin in Minsk also disappeared without trace during the war.

The famous fall of the Borodino meteorite really had an historical significance. It fell the day before the Battle of Borodino, 5 September 1812, during the war with Napoleon, into the position of a Russian artillery battery near the village of Gorki. A sentry picked up the fallen stone and handed it to the battery commander, A.I. Dietrichs, an officer of the 11th Pskov infantry regiment of Lieutenant General Kaptsevich's 7th Infantry Division. The meteorite was kept for a long time in the Dietrichs family, and only in 1892, 80 years after its fall,

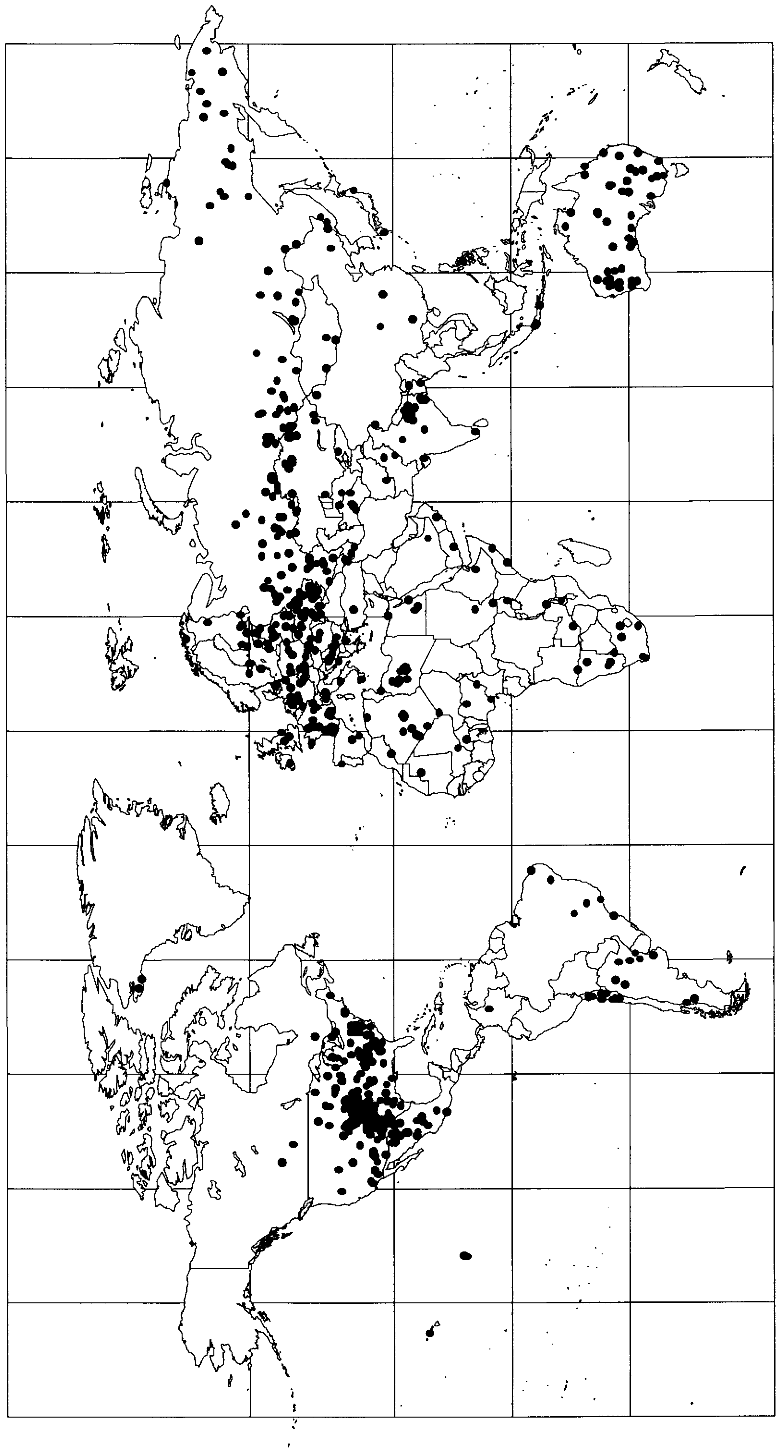


Fig. 16. World map. Showing locations of finds and falls of meteorites represented in the meteorite collection of the Russian Academy of Sciences.

Fig. 17. Part of the meteorite exhibition at the Vernadsky Institute.

was it submitted to the Russian Academy of Sciences by Dietrichs' descendants.

The Novy Urey meteorite is the type specimen of a new type of meteorites, ureilites. Erofeev and Lachinov, Russian scientists, first discovered diamonds of cosmic origin in Novy Urey. It fell on 4 September 1886 and P.I. Baryshnikov, a teacher from Kirensk town, wrote: 'In the morning several peasants ploughed their field 3 km from a village. The day was gloomy, the whole northeastern sky was covered by clouds. Suddenly a light appeared all around. In several seconds a strong report was heard, like a cannon or explosion. Then came a second, louder noise. With a loud noise a fireball fell to Earth a few meters from the peasants. Frightened, they did not know what to do. They fell to the ground and could not move for a long time. They thought it was a strong thunderstorm, and that thunderbolts were falling from the sky. Finally, one of them, more brave, came to the place where the thunderbolt had fallen, and to his surprise found only a shallow hole. In the middle of the hole a black stone lay half-buried in the soil'.

In 1913 the prospector N.M. Chernichevich sent to the Imperial Academy of Sciences 30 samples of iron meteorites of different sizes and weights. The samples were found by the workers A.V. Rodakov, I.M. Petrov and D.P. Afanasiev while panning for gold along the Chinge stream in Uryankhaysk district. V.G. Hlopin and the geologist O.O. Baklund investigated these samples. Baklund concluded that 'the samples are not characterized by any peculiarities of iron having meteorite origin' and 'that there are some indications that they formed from mafic terrestrial rocks'. However, recent investigations by G. Perelman, C.A. Pogodin, A.N. Zavaritskiy and L.G. Kvasha have demonstrated a meteorite origin of the iron samples from the Chinge stream. The Chinge littoral gold field was worked by prospectors for 30 years. In that period large amounts of iron were found, and the prospectors used much of it for making nails, brackets and other prospecting equipment. The Meteorite Committee conducted systematic searches for meteorites along the Chinge stream in 1963 and 1986.

Another famous event was the Boguslavka meteorite fall – the first observed fall of an iron meteorite in Russia. The fall was at 11:45 a.m. on 18 October 1916, the sky was clear and weather was warm. The fall was seen from Vladivostrok to the Han Dao He Tse rail station 300 km away and accompanied by light and sound phenomena. The fall occurred 200 cubits (~500 m) south of a Korean village (fan-za), and location of the fall was shown by a resident of this fan-za, Ma Tomu Ni. The first fragment fell near a

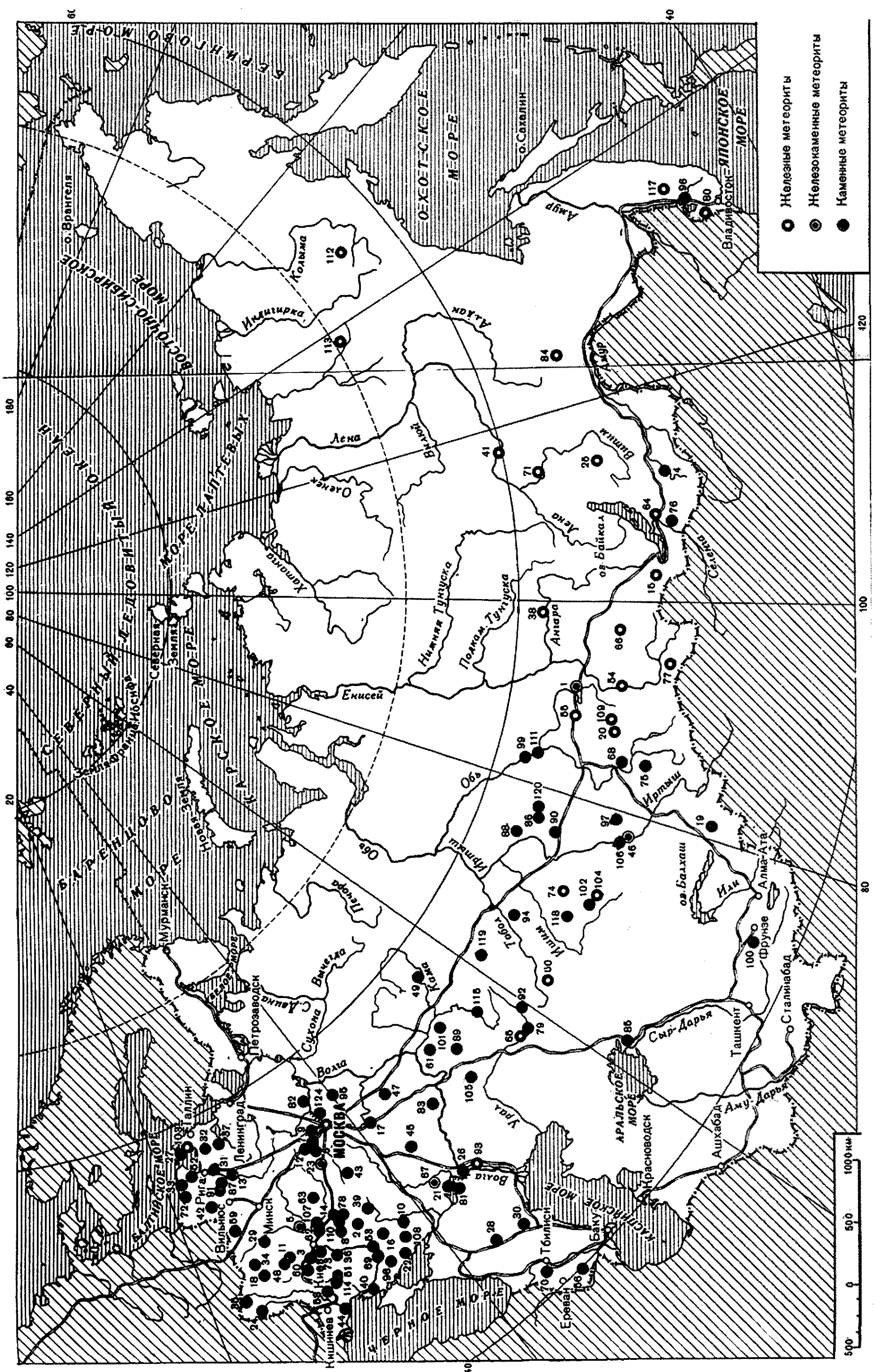


Fig. 18. Map of Russia showing the recovery sites of iron, stony–iron and stony meteorites in the collection of the Russian Academy of Sciences (taken from Krinov 1955). Note the lack of meteorite recoveries in the less populated areas.

Cossack who happened to be riding nearby, Ivan Ovchinnikov O.O. Baklund wrote in 1916: '... The meteorite Boguslavka was the first observed fall of an iron meteorite in the Russian Empire. Based on its main mass it was a huge fall in comparison with others, and has a beautiful external structure and fantastic shape'.

The Khmelevka meteorite, an ordinary 5 chondrite, had been recognized quite occasionally. A bright bolide was observed on 1 March 1929 in the Omsk region and triggered an 8-year search for the meteorite. Mr P.L. Dravert searched and searched for the meteorite, and at last his persistence was rewarded. The first, main fragment of the meteorite, weighing 6.1 kg, was found in a peasant house, on top of a barrel of sauerkraut. Owing to the lack of other rocks nearby, the meteorite was being used as a weight to hold down the top of the barrel.

P.L. Dravert wrote in his letter to L.A. Kulik, on 10 December 1936: 'I read an article about Khmelevka in *Komsomolskaya Pravda* with great surprise. I was especially surprised by the end of the article, to hear I was to be issued a prize. Some comrades raised this question about that here but I was against the idea. The search for the meteorite was my duty as a naturalist and I was not looking for any personal reward. The Regional Bureau covered all my expenses for the long search and thus, I owe no one any money and am owed no money. I hope this question has not been discussed officially and I ask that it not be pressed. The moral support of the Academy of Sciences and my friends are very important for me and I repeat that I was not expecting financial gain for myself while performing my duty of serving the interests of science'.

The Kaidun meteorite is a highly unusual meteorite consisting of clasts of unusual compositions and chondrite fragments of different petrological and chemical types. It was found by a military unit of the USSR army in the People's Democratic Republic of Yemen. The deputy commander of military division 443888 Colonel-General A. Pavlov wrote, on 22 April 1981, to Academician A.M. Prohorov, Secretary of the Department of General Physics and Astronomy of the Academy of Sciences of the USSR: 'On December 8, 1980, a meteorite fell on the territory of the People's Democratic Republic of Yemen, in the Husa-El-Abr region about 450 km northeast of Aden. Witnesses confirmed the sighting. We are submitting pieces of this space material to your attention ... Regards'. Some time later General of the Army P. Ivashutin wrote to President of The Meteorite Committee, Doctor of Geological–Mineralogical Sciences, E.L. Krinov: 'According to your request I am sending a paper with confirmed information about the meteorite fall on the territory of the People's Democratic Republic of Yemen and a piece of the meteorite of 12 g'.

The first meteorite found on the ocean bottom was the Clipperton meteorite, ordinary chondrite, H3. It was found by St Petersburg geologists S.M. Tibunov, Yu.I. Tomanovskaya and G.N. Starukhina during a petrographical study of trawl samples from the Central Pacific. The samples were raised from a depth of 5200 m, 2000 km SE of Hawaii, near the Clipperton and Clarion faults in 1986.

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References

BEVAN, A.W.R. 2006. Desert meteorites: a history. *In*: MCCALL, G.J.H., BOWDEN, A.J. & HOWARTH, R.J. (eds) *A History of Meteoritics and Key Meteorite Collections: Fireballs, Falls and Finds*. Geological Society, London, Special Publications, **256**, 325–343.

BORNOVOLOKOV, T.S. 1811. On stone falls from the atmosphere. *Technological Journal*, **VIII**, 120–129 (in Russian).

CHLADNI, E.F.F. 1794. *Über den Ursprung der von Pallas gefundenen und underer ihr ähnlicher Eisenmassen und über einige damit in Verbindung stehende Naturerscheinungen*. I.F. Hartknoch, 1740–1789, Leipzig, Riga, 63 (in German).

CHLADNI, E.F.F. 1819. *On Fire-Meteors And On Masses Fallen With The Same*. I.G. Heubner, Vienna (in German).

EREMEEVA, A.I. 1982. *The Birth of Scientific Meteoritics*. Nauka, Moscow, 253 (in Russian).

GÖBEL, A.F. 1868. *On Aerolithes in Russia*. Imperial Academy of Sciences Press, St Petersburg, 136 (in Russian).

HOPPE, G. 1979. CHLADNI, E.F.F. Über den kosmischen Ursprung der Meteoriten u. Feuerkugeln (1794). *Ostwalds Klassiker der exakten Wissenschaft*, **258**, 104 (in German).

KOJIMA, H. 2006. The history of Japanese Antarctic meteorites. *In*: MCCALL, G.J.H., BOWDEN, A.J. & HOWARTH, R.J. (eds) *A History of Meteoritics and Key Meteorite Collections: Fireballs, Falls and Finds*. Geological Society, London, Special Publications, **256**, 291–303.

KOROCHANTSEV, A.V., LORENZ, C.A., IVANOVA, M.A. & NAZAROV, M.A. 2005. Geochemical evidence for the Novaya Yerga meteorite fall, 1660. *Meteoritics and Planetary Science*, **40**, A86.

KRINOV, E.L. 1955. *Principles of Meteoritics*. Fesenkov, V.G. (ed.). State Publishers of Technical/Theoretical Literature, Moscow (in Russian).

KRINOV, E.L. 1981. *Iron Rain*. Moscow. Nauka, Moscow, 192 (in Russian).

MASSALSKAYA, K.P. 1954. E. F. Chladny – a founder of scientific meteoritics. *Meteoritika*, **11**, 33–46 (in Russian).

MUKHIN, I.M. 1819. *On Miraculous Showers of Stones Falling From the Air (Aerolithes)*. Imperial Foundling-Hospital Publisher, St Petersburg, 207 (in Russian).

NAZAROV, M.A. 2000. The meteorite collection of the Russian Academy of Sciences. *In*: ALEKSEEVA, T.I. (ed.) *Museums of the Russian Academy of Sciences*. Scientific World, Moscow, 47–62.

PALLAS, P.S. 1786. *Travels in Various Provinces of the Russian State*, Volume 2, 2, 385–482. Imperial Academy of Sciences Press (in Russian, the book was also published in German and French).

PANETH, F.A. 1940. *The Origin of Meteorites. Halley Lecture*. The Clarendon Press, Oxford, 26.

SEARS, D.W. 1975 Sketches in the history of meteoritics 1: the birth of the science. *Meteoritics*, **10**, 215–226.

SEVERGIN, V.M. 1811. A report on air stones or airolithes preserved in the Museum of the Imperial Academy of Sciences. *Technological journal*, **VIII**, 129–132 (in Russian).

STEHLIN, JA. 1809. On a New Map of the Northern Archipelago, and specimen of native iron. *Philosophical Transactions of the Royal Society of London*, **LXIY**, 1774, 461.

STOIKOVICH, A. 1807. *On Aerial Stones and Their Origin*. University of Kharkov, Kharkov, 271 (in Russian).

SVIATSKY, D.O. 1915. *Astronomic Phenomena in Russian Historical Chronicles Considered from a Scientific Point of View*. Bulletin of the Department of Russian Language and Linguistics of the Imperial Academy of Sciences 20, book 1 and 2. Petrograd, 214 (in Russian).

SVIATSKY, D.O. 1928. Similar features of meteorite phenomena at Tunguska in 1908 and Great Ustyug in XIII century. *Mirovedenie*, **17**, 117–119 (in Russian).

VERNADSKY, V.I. 1941. Some thoughts on problems of meteoritics. *Meteoritika*, **1**, 3–22 (in Russian).