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METEORITE! Quarterly

The Estherville, Iowa meteorite

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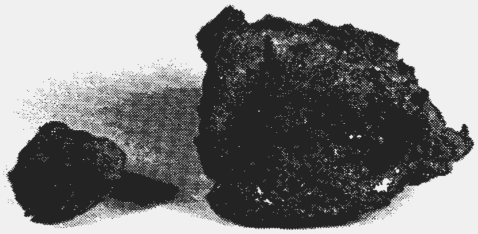
CENTERPIECE

THE ESTHERVILLE METEORITE

By Russell Kempton

From the historic fall in 1803 when more than 3000 "stones" rained down over L'Aigle, France, meteorites have been collected, studied, and stored in university and museum repositories around the world. The curating and conservation of these meteorites over time is enormously important to the generations of researchers (meteoriticists) that will study them. Every recovered meteorite reveals new clues about the formation and conditions present within the early solar system.



496 gram fragment with 37 gram eucrite "pebble"

One meteorite has been yielding important information for more than one hundred years since its fall in Estherville, Emmet County, Iowa, USA. Estherville, a mesosiderite, was one of three falls that occurred in Iowa during the 1800s. Along with L'Aigle and Orgueil, France and Pultusk, Poland, Estherville was one of the more important falls of the Nineteenth Century.

THE FALL

The fall of a meteorite is a wonderous event that all of us would hope to witness during our lifetime. We read of "brilliant fireballs" and "thunderous detonations" that herald the arrival of these natural objects from within our solar system. The fanfare arrival of the Estherville meteorites was all of these and more.

The Estherville meteoroid entered the Earth's atmosphere on May 10, 1879 at 1700 hrs. UT. Its estimated pre-atmospheric mass was more than one hundred tons and was composed primarily of brittle stony matter with blobs of embedded nickel-iron. The atmospheric breakup which occurs to most large stony meteoroids disintegrated major amounts of the stony matrix producing a cloud of dust that remained aloft for several hours. The more resistant metal-rich fragments and metallic inclusions continued their high speed transit through the atmosphere. In Estherville, a young boy was driving the family herd of milk cows towards home past a small shallow lake when, in the words of the late American meteoriticist Dr. Harvey Nininger, "the young boy described a veritable hail storm of little iron nodules peppering the lake and that the cattle stampeded in all directions".

It was learned that the little metal pellets (weighing from 10 to 30 grams) and several larger masses rained down upon an elliptical area 11 kilometers in length. The largest mass to be recovered was 198 kg. More than a dozen smaller masses of 1 to 2 kg were also found. Today approximately 303 kg is represented in major collections and over 600 of the metallic nodules are preserved at Yale University's Peabody Museum.

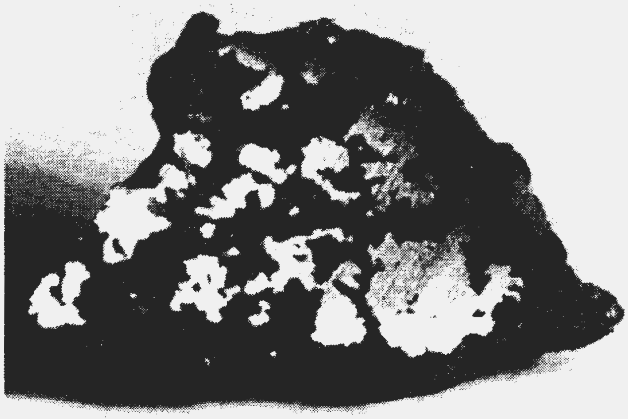
The Estherville meteorite fall clearly demonstrates the effects of atmospheric ablation. Dr. Nininger, while studying many of the small nickel-iron nodules in the Yale collection in 1936, observed many oriented specimens with flight markings. He theorized that they had traveled in a stabilized position without tumbling and that their ablated "noses" were almost perfect hemispheres. Twenty years later, based upon these observations, Dr. Nininger proposed the idea of "blunt noses" for missiles.

The exterior surfaces of all fragmented specimens of Estherville have a jagged and coarse texture. Examination of the interiors of larger specimens reveals an interesting structure of 10-30 mm diameter lumps of iron embedded within a ground mass of stony material. Inclusions and fields of olivine are also found in abundance. Interestingly, the largest olivine field that we have observed to date in any mesosiderite (78 mm x 34 mm) is present within an Estherville specimen!

MESOSIDERITES

The origin of mesosiderites is troubling to meteoriticists. Valuable information has been gained from the examination of Estherville that has contributed to theories on the formation of this group of Stony-Iron meteorites. Briefly, their formation involves an impact or a series of impacts resulting in the breakup and mixing of a differentiated, basaltic body and simultaneously, the heating of these broken fragments (breccia) with either solid or molten iron-nickel. Deep burial of this material as a result of impacts would have caused a period of very slow cooling below 500 degrees centigrade. Later impact events would be needed to excavate this mesosideritic material from the parent body and project it into an orbit that would ultimately encounter Earth.

Other theories on mesosiderite origin include: 1) the collision of a metal-rich asteroid with a differentiated asteroid, 2) segregation of the metal and silicate components during early magmatic activity, with a reheating episode and incorporation of metal into the ground mass *after* cooling below the melting point, and 3) a multistage cooling history in which the silicates cooled rapidly and the metal or iron-nickel cooled very slowly below 400 degrees centigrade.



38 gram slice - 56mm x 30mm x 6mm. Visible nickel-iron inclusions - 5 to 15mm in diameter within the stony matrix

MINERALS AND MAGNETIC STUDIES

In 1980, Estherville contributed to the discovery of a new mineral in meteorites - Tetrataenite. Roy Clarke of The Smithsonian Institution, Washington, D.C. presented his findings on several meteorites and characterized the presence of tetrataenite grains in Estherville as "massive tetrataenite". Tetrataenite is an ordered iron-nickel alloy formed during the development of intergrowths of kamacite and taenite lamellae as the nickel-iron mixture cools slowly from a high temperature to below the tetrataenite ordering temperature of 320 degrees centigrade. Containing 48 to 55% Ni, tetrataenite forms as μm-sized grains and as rims on taenite. Typically tetrataenite appears as 5-50 μm sized grains in slow-cooled chondrites. However in Estherville, which has one of the slowest cooling rates of 0.1 degrees centigrade/m.y., tetrataenite is visible as up to 400 μm sized coarse grains.

More recently, the magnetic properties of Estherville were studied in an attempt to further understand the evolutionary processes in meteorites and magnetic fields in the early solar system. Estherville is strongly magnetized. In studying the natural remnant magnetization (NRM) of Estherville, kamacite and tetrataenite were found to be the dominant magnetic carriers. The NRM in Estherville suggests the presence of a magnetic field on the differentiated parent body from which it originated, at a time when it was cooling from either a magmatic or impact event.

Accumulating evidence from lunar magnetism studies further suggest the exciting possibility of a dynamo-generated magnetic field resulting from the rapid rotation of Estherville's parent body within the solar magnetic field.

From its thunderous, acoustic arrival that caused cattle to stampede in 1879, Estherville has revealed much to the inquiring minds testing, measuring, and probing its structure and composition. Specimens of Estherville were the basis of the ablative shield proposals by Dr. Nininger in 1956, and have been a continuing source of information for developing theories of mesosiderite origins. The presence of a new meteorite mineral and new theories that its astroidal parent body was spinning so rapidly within the early solar magnetic field that it converted some of its mechanical energy into electrical energy, demonstrates Estherville's continuing value to the science of meteoritics.

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