After the Fall

In 1794, a heavenly epistle heralds the study of meteorites

By RON COWEN

—SIENA, ITALY, JUNE 16, 1794

Everyone knows that rocks don't just fall out of the sky. It goes against common sense. It violates the laws of physics. But don't tell that to the people of this Tuscany resort town. They saw it happen.

Things started going haywire about 7 p.m. today, when a dark, high cloud approaching from the north threatened to spoil a picture-perfect sky. Some heard lightning, others likened the noise to artillery fire. After an earsplitting cannonade, the dark cloud flamed red and stones hissed through the air, landing at the feet of bewildered spectators.

Of course, everyone is trying desperately to find an explanation for what happened. Some believe that the stones must have come from Mount Vesuvius, which erupted just 18 hours earlier. But others point out that Vesuvius lies 320 kilometers southwest of here and that the dark cloud approached from the north.

Just about everyone seems dumbstruck, even those who only heard about the falling stones secondhand. Comments Frederick A. Hervey, the visiting Earl of Bristol: "My first objection was to the fact itself, but of this there are so many eyewitnesses, it seems impossible to withstand their evidence."

Seven years would pass before astronomers discovered the first "minor planet," or asteroid, one of the many rocky objects that roam the region between Mars and Jupiter. It would take nearly 70 more years for scientists to realize that most large meteorites, such as those in the memorable shower that hit Siena, represent asteroids flung into Earth-crossing orbits. And only in the last decade or so have researchers directly examined meteorites known to originate from the moon or Mars—an invaluable link to objects that originate far beyond Earth and may date back to the birth of the solar system.

Historians have often argued that another meteorite fall, the spectacular shower of 3,000 stones at l'Aigle in the French province of Normandy in 1803, sparked the early investigation of meteorites. But last month, Ursula B. Marvin of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., presented evidence that the modern science of meteoritics had its roots in the Siena fall 9 years earlier.

Before the Siena event, few believed that a shower of stones could come from the sky. Afterwards, skeptics could no longer dismiss accounts of falling rocks as the tall tales of unschooled peasants, notes Marvin. The time and place of the fall prompted the first serious studies by scientists and astronomers in Italy and England, she maintains.

For these reasons, the Siena event represents the most significant fall in modern times, Marvin asserted in September at the annual meeting of the Meteoritical Society in Washington, D.C.

No backwater town, Siena in 1794 had a population of nearly 30,000 and its own university. Moreover, by the early 1790s, the city had become popular with English tourists. After the fall, visitors returned to England with exciting tales and stony specimens—real or bogus. (A cottage industry in fake stones sprang up in Siena soon after the meteorites fell.) These firsthand accounts "helped to make the idea of fallen stone more acceptable [in England] than it would have been based solely on published reports," Marvin says.

By the end of the year, two treatises had been published on the fall—one by Abbé Ambrogio Soldani, a mathematics professor at Siena, and the other by Abbé Domenico Tata, professor of physics and mathematics at Naples, and William Thomson, an English scientist living in Naples. Both works concluded that the stones had "congealed" in the high, dark cloud and had no link to the eruption of Vesuvius.

Tata and Thomson described, in general terms, the mineral content of the stones and named the material soldanite. Marvin notes that soldanite may well have been "the first official name for meteoritic stone."

Early in 1795, Sir William Hamilton, the English ambassador to the court of Naples, published a brief account of the Siena meteorite fall in a 43-page report on Vesuvius in the PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY. He called the event "a very extraordinary circumstance indeed . . . although it might have no relation to the eruption." Indeed, most scientists of the time concluded that the Siena fall had nothing to do with the eruption of Vesuvius.

The fall came at an opportune time—less than 2 months after the publication in Germany of Ernst F.F. Chladni's *On the Origin of Iron-masses*. Chladni espoused the heretical notion that stones and masses of iron fall from the sky and de-

Ernst F.F. Chladni. His 1794 book, in conjunction with the Siena fall, helped spark the modern study of meteorites.

Marvin photo from *A Chapter in the History of Meteoritics* (1887, London, Walter Flight)

serve recognition as natural phenomena. He asserted that the falling masses might create fireballs in the atmosphere or even originate in "cosmic space." What's more, the objects might be remnants of planet formation or planetary debris from explosions or collisions.

In his prescient speculations, Chladni battled the consensus that small bodies did not exist beyond the moon.

Aristotle had said so in the fourth century B.C., and Isaac Newton reiterated the idea in 1704. "[T]o make way for the regular and lasting motions of the planets and comets, it's necessary to empty the heavens of all matter except perhaps . . . a very thin, invisible aether," Newton wrote.

Initially, virtually every German critic vilified Chladni's book. "By all means you must read Chladni's infamous book on iron masses," Alexander von Humboldt wrote to Carl Freisleben in October 1794. The following year, Georg C. Lichtenberg, who had encouraged Chladni to begin his investigation, had even harsher words. According to one account, Lichtenberg said he "wished Chladni had not written his book. He felt as if he had been hit on the head with one of his stones."

After all, who was the upstart Chladni to refute the ideas of the great Newton?

Then Mother Nature struck again.

At 3:30 p.m. on Dec. 13, 1795, three laborers reported a huge explosion in Wold Newton, England. A black stone emerged from a cloud and gouged a hole in a field outside Wold Cottage. The landowner built a monument over the hole and displayed the stone at the Gloucester Coffee House in London.*

Sir Joseph Banks, president of the Royal Society, obtained a sample of the stone and noted that it resembled the one he had received from the Siena fall.

Reprinted with permission of Houghton Library from *Campi Phlegrae, Observations on the Volcanoes of the Two Sicilies* (1799, Sir William Hamilton)

Eruption of Mount Vesuvius in 1799. An eruption 5 years earlier occurred just 18 hours before the Siena meteorite fall, initially prompting some scientists to link the two events.

Early in 1796, Edward King, a fellow of the Royal Society, published the first English-language book on fallen stones. He cited both the Siena and Wold Cottage events. Rather than attribute the falls to a celestial source, he suggested that the Wold Cottage event might have resulted from the ashes spewed by Mount Hecla, a volcano in Iceland.

At the end of his dissertation, however, King cites "a very singular tract, published in 1794 at Riga by Dr. Chladni." King did not comment on Chladni's claims that the stones represented debris from the heavens, but he asserted that the facts merited further study.

That same year, news of the Siena fall finally reached Germany. At least one scientist, astronomer Heinrich Wilhelm Olbers, had begun to accept the notion of a heavenly origin for Chladni's stones. In 1795, Olbers suggested that the fallen chunks might represent debris ejected from lunar volcanoes. Two years later, Lichtenberg, the scholar who had panned Chladni's book, embraced Olbers' hypothesis. Wrote Lichtenberg in 1797: "[T]he moon must be an uncivil neighbor to welcome the Earth with stones."

Two other falls, one near Evora, Portugal, on Feb. 19, 1796, and the other in Benares, India, on Dec. 19, 1798, also garnered wide publicity. Following the spectacular shower of stones from an exploding fireball in Benares, Banks called for a scientific investigation.

He asked the young English chemist Edward Howard to analyze specimens from Siena and Wold Cottage, which Banks conjectured came from meteors. Meteor displays—streaks of light in the atmosphere—were well known to science, but Banks now connected them with the flight of stony objects. He even predicted that the study of the fallen rocks would open a new field of science.

For his comparative study, begun around 1800, Howard also obtained other pieces of stone and metallic material, called native irons, that Chladni deduced must have fallen from the sky. The timing of Howard's study proved opportune: Scientists had published the first quantitative test for nickel—a key component of many meteorites—only 3 years earlier.

Later, French chemist Nicolas-Louis Vauquelin would write: "While all Europe resounded with the report of stones fallen . . . and philosophers divided in opinion were forming hypotheses to explain the origin of them . . . Mr. Howard, an able English chemist, was pursuing in silence the only route which could lead to a solution of the problem."

Howard analyzed samples whose density and magnetic characteristics had already been assessed by mineralogist Count Jacques-Louis Bournon. Howard found that the iron samples, as well as metal grains from the stones, contained considerable amounts of nickel.

"This linked the irons with the stones and set them both apart from terrestrial rock," Marvin notes.

Howard and Bournon reported their findings in 1802. Echoing the sentiments of Olbers, French scientists Pierre Simon Laplace, Siméon-Denis Poisson, and Jean-Baptiste Biot speculated that the stones and irons came from volcanoes on the moon.

In adopting this view, the researchers still clung to Newton's dictum of a vast void beyond the moon, Marvin notes. But they clearly agreed that the stones came from a heavenly source.

Thus, says Marvin, "the fall at Siena began a line of investigations that led to acceptance of Chladni's hypothesis in 1802—a full year before the famous showers of 3,000 stones in Normandy.

"That is why I conclude that Siena was the most consequential of historic meteorite falls." □

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* *To mark the 200th anniversary of the Wold Cottage meteorite fall, the Royal Astronomical Society and the Mineralogical Society will hold a meeting on Dec. 7 and 8 in London.*