The Case of the Flying Varistor

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Introduction

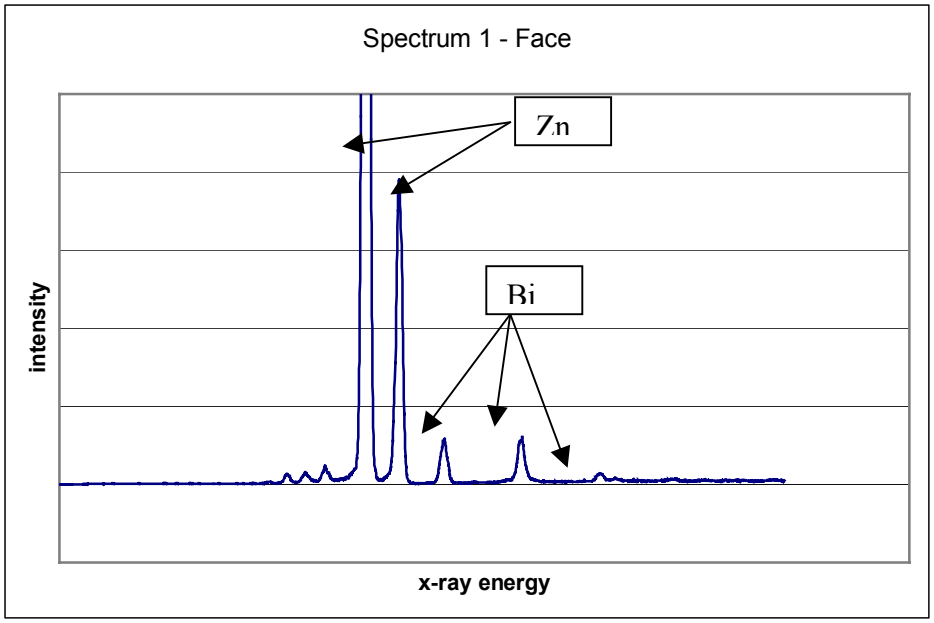
A man was working in his yard about five miles west of Duchesne, Utah during the last week of July 2000 at about 4:00 PM. Unexpectedly, an object flew past his head traveling at high speed, and embedded several inches in the soft sandy soil. According to his testimony, the object flew past him vertically with a rushing sound and missed him by two or three feet. He immediately scanned all sections of the sky to search for an airplane from which the object might have dropped. None were visible in the sky at the time. The witness called his wife and together they decided to dig the "meteor" out of the ground. When held, the object was noticeably warm to the touch. The man had diminished sensitivity to heat in both hands, so the temperature of the object may have been considerably higher than "warm." Upon request, a closer approximation of the temperature of the retrieved object was obtained when the witness agreed to immerse his hands in water at different measured temperatures in the presence of a thermometer and to compare the sensation in his hands to that when he first held the object. Using this procedure, the temperature of the retrieved object was estimated at 120–130°F. It weighed about 6.5 ounces and the family quickly consulted local geologists to find out if it was a meteor. The local community college geology department was certain it was not a meteor, but was unable to identify it. Several local engineers were similarly unable to identify the object.

NIDS was contacted by the family and informed that the object was anomalous and possibly extraterrestrial since it had fallen from the sky. NIDS received the object on February 24, 2001. By visual inspection, it was obvious that the object was manufactured and was not a meteor.

The object was quickly shipped to Earthtech International (www.earthtech.org) for preliminary analysis.

Analysis

At Earthtech International, the object was weighed in air (178.25 grams) and again submerged in water (146.25 grams). These values yield a density of 5.57 gm/cm^3. An x-ray fluorescence spectrum was recorded from the metallic face of the object.



By far the most prominent peak in this spectrum is Zn (exceeding full scale in the plot above by a factor of 5). Other constituents include Bi (marked) and Fe, Co, and Ni (the three peaks to the left of Zn). A similar x-ray spectrum taken from the dark, fractured cylindrical

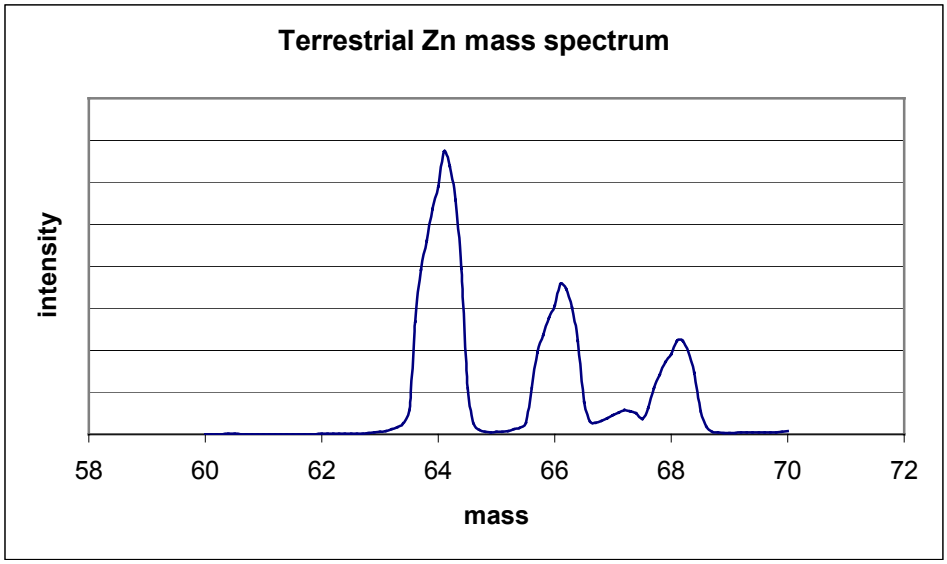
surface showed substantially the same composition as the face with the addition of a little Mn. Another x-ray spectrum, taken with the spectrometer optimized for higher energy x-rays revealed significant levels of Sb in the object as well.

Considering the apparent homogeneity, relatively high density, and the metallic appearance of its faces, it seemed plausible that the object was a solid piece of some Zn alloy, scorched or heavily oxidized on the cylindrical surface. However, the density was not high enough for most Zn alloys (typically 7 gm/cm^3). The only possibility was a Zn alloy high in Al. A search of commercial Zn alloys revealed two compositions whose densities bracketed the measured density of this object. ZA-12 (nominally 12% Al, 1% Cu, balance Zn) has a density of 6.04 gm/cm^3 and ZA-27 (nominally 27% Al, 2.25% Cu, balance Zn) has a density of 5.02 gm/cm^3.

Another x-ray spectrum was recorded from the metallic face of the object, this time with the spectrometer optimized for light element analysis (Al is near the light element cutoff for this particular spectrometer). A strong Al signal was observed in this spectrum.

It now seemed a virtual certainty that the object was a Zn-Al alloy. However, another search of commercial Zn alloys produced no evidence that Bi, Ni, Co, Mn, or Sb have ever been used as alloying agents in Zn. In other words, it was still quite possible that this object was not of terrestrial origin.

To pursue this exciting possibility further, preparations were made for a rough measurement of the isotopic ratios of the Zn in the sample. A high vacuum system equipped with residual gas analyzer (RGA) was employed. The RGA is a quadrupole mass spectrometer with 1 AMU resolution. It is therefore easily capable of resolving the most common Zn isotopes, Zn-64, Zn-66, and Zn-68, which have terrestrial natural abundances of 48.6%, 27.9%, and 18.8% respectively. Near the entrance of the residual gas analyzer (RGA) a nichrome filament was mounted. To validate this isotope ratio measurement, a piece of ordinary Zn metal was drilled with a small twist drill, producing long curly shavings. A single shaving of this Zn metal was wound around the nichrome filament so that it would be heated by intimate contact with the filament. When the system was evacuated thoroughly and the filament heated by passing a current through it, sufficient Zn vapor was produced to collect the following mass spectrum:



The observed peak intensities in this spectrum match the expected terrestrial abundance of these Zn isotopes reasonably well (within 15% relative). As a result, it was decided to remove a similar shaving sample from the object by drilling.

Instead of curly metallic shavings, a green powder came out of the hole! By looking in the drilled hole it was now clear that the metallic faces on the object were just thin coatings. The object was apparently composed of a dark greenish material throughout.

Unfortunately, the green powder could not be presented for mass spectrum analysis but, at this point, that analysis was not so interesting anymore. Now, the thin metallic faces of the object were more suggestive of electrical contacts…but for what? The electrical resistance of the object was measured: 6100 ohms (the same resistance was observed in both directions).

The object was clearly very high in Zn content but was non-metallic, yet somewhat electrically conductive. It was then learned that Zn oxide has a density of 5.61 gm/cm^3, a nearly perfect match to the measured value of 5.57 gm/cm^3 for the object. Unfortunately oxygen is far below the light element cutoff for the x-ray spectrometer, so a direct confirmation of its presence could not be performed.

Colm Kelleher produced the final piece of this puzzle by discovering that electrical devices know as varistors are commonly made from semiconductors composed of ZnO doped with Mn, Co, Sb, and Bi. Varistors are widely used in electronic devices such as surge arrestors. They essentially do not conduct as long as the voltage across them remains low but they become good conductors when the voltage becomes too high. Thus they can be used to shunt dangerous voltage spikes safely to ground.

Further investigation revealed that very large varistors shaped exactly like the object (i.e. a 40 mm diameter cylindrical disk) are commonly used in lightning arrestors on power lines. Cooper Power Systems makes varistor disks that look very much like this object (see page 3 of www.cooperpower.com/Library/pdf/96042.pdf).

Discussion

We then had two hypotheses regarding how the varistor became airborne: (a) it fell from a high-flying aircraft and (b) the object originated at a local power facility and was ejected at high speed from a local transformer.

It was decided to test the second hypothesis first, since it was deemed unlikely that a varistor of this size and weight would be used on an aircraft.

Accordingly, NIDS contacted the senior engineer from Moonlake Electric, the company that provides power to the residents of Duchesne and surrounding areas. The engineer informed NIDS that normally several varistor wafers are enclosed in a porcelain protective sheath and are widely used on transformers and even power lines as surge arrestors and lightning protectors in the area around Duchesne, Utah. The engineer also confirmed to NIDS that the scenario of a varistor "wafer" being forcibly ejected from the porcelain casing, possibly as a result of a lightning strike, was possible but would be a very rare event. He further confirmed that July 2000 was a particularly bad month for lightning associated damage to Moonlake transformers and power protectors in Duchesne county.

NIDS also interviewed the line supervisor from Moonlake Electric, who supervises repair crews from the area. The supervisor confirmed that the varistor wafer could be ejected during a catastrophic failure induced by a lightning strike, but said that a 50–100 feet was the maximum distance he could imagine an object flying.

Next, NIDS sent an investigator to the home of the man who had witnessed the flying varistor. The investigator confirmed that indeed there was a power pole located on the man's property about 100 feet from where the varistor had landed in July of 2000 (see photo below).

NIDS conducted a search of discarded Moonlake surge arrestors and in the process discovered that Moonlake Electric over the years has used approximately thirty different varistors from four different suppliers. These suppliers included Cooper, General Electric and Westinghouse.

Finally, after a lengthy search of old discarded surge arrestors in both Utah and Colorado, NIDS obtained several similar varistor wafers from Moonlake Electric.

Therefore, the most parsimonious explanation is that the object is a varistor that had been launched from a pole 100 feet away and landed near the owner of the property in July 2000 during or following a lightning strike. It is even possible that the lightning strike occurred further down the line. The varistor would have been ejected after failure due to a power surge and would have been still warm when the witness retrieved it from the soil.

NIDS and Earthtech decided to publish the investigation and analysis of this case because it is illustrative of the value of scientific analysis, including materials analysis, during investigations of apparent anomalies. A relatively prosaic explanation emerged from the elemental analysis of the object that appeared to fit all of the facts.