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RESEARCH ARTICLE

Isotope Ratios and Chemical Analysis of the 1957 Brazilian Ubatuba Fragment

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HIGHLIGHTS

Analysis of the trace elements in a metallic sample from a 1957 ‘UFO’ were inconclusive about its non-terrestrial origin. But tests indicated that the debris was mostly composed of extremely pure magnesium with an odd strontium impurity. This formula was not used in the manufacture of magnesium at the time.

ABSTRACT

A sample from the Ubatuba fragment collected in Brazil in 1957 was tested with the intent of examining the isotope ratios of its primary element, magnesium, and the trace elements strontium, barium, copper, and zinc. As background, the history of chemical testing of the Ubatuba fragments during the 1960s-1980s at multiple labs with varying capabilities is reviewed and then the remainder of the paper examines recent tests completed in 2017 and 2018 that for the first time used HR-ICPMS techniques to look at the isotopic ratios of the minor constituents as well as the primary magnesium component of the sample. The magnesium isotope ratios were found to fall within terrestrial limits while the results on the isotope ratios of the trace elements were inconclusive. Recommendations are made for improving the process of examining the trace elements.

KEYWORDS

Ubatuba, isotope, magnesium, HR-ICPMS, UFO

INTRODUCTION

The vast majority of UFO sightings involve only witness testimony, without physical evidence that can be examined in a laboratory. However, in a very small fraction of cases, there has been material available for later analysis. These include falls of angel hair (although these often evaporate rapidly), slag-like material, powdery deposits, or physical samples that appear manufactured. The Ubatuba, Brazil, samples, the subject of this paper, fall into this latter category. Other notable examples of physical traces include those in Campinas, Brazil (1954), Vaddo, Sweden (1954), Redding, CA (1969), Delphos, Kansas (1971), and Carlisle, NY (1975).

The ideal UFO artifact useful for isotope testing should 1) be something physical in a solid state, 2) have been witnessed or otherwise determined to be clearly involved with a UFO, and 3) have acceptable provenance and adequate data collection. These criteria are not easy to meet, first because the events themselves are rare (far less than 0.1% of UFO reports), and also because of the lack of investigative resources to meet points 2 and 3. Although the Ubatuba samples are not conclusively tied to a UFO event, the rarity of such a sample, the interesting circumstances of how it became available, and the long history of prior testing motivated this new analysis.

Sample History

The Ubatuba sample originated in Brazil in mid-1957. It was first mentioned in a Rio de Janeiro newspaper, *El Globo*, on September 14, 1957, with the title "A Fragment from a Flying Disk!" Pieces of a supposed flying disk were provided to the newspaper by a subscriber whose name was illegible but wrote in a very educated manner. The subscriber claimed that he had been fishing near the coastal town of Ubatuba when he saw a flying disk that was climbing rapidly just before it exploded into a shower of thousands of fiery fragments. Most of the fragments fell into the sea except for a few that fell on the beach and were collected. Three samples of a very light, dull, grayish metal that were received by the newspaper were turned over to Dr. Olavo Fontes. Fontes had the samples tested in Brazil before he turned the samples over to Coral Lorenzen of the Aerial Phenomenon Research Organization in late 1957. In 1987 Lorenzen turned the samples over to Dr. Peter Sturrock of Stanford University. The latter is the source of the sample tested by the authors of this paper (Sturrock, 2001).

It is not possible to know if these samples originated from an unknown aerial explosion or from the town of Ubatuba, Brazil. We can only be reasonably confident that the sample originated in Brazil sometime before September 1957 as that is when the samples first appeared at the Brazilian newspaper office of *El Globo* (Sturrock, 2001). This paper will examine the possibility of whether the material has a possible extraterrestrial origin based on an examination of the isotope ratios of the elements within the sample. Independent of the history of the samples, the isotope ratios of the elements within the sample should fall within the range of elements that originate on Earth. The isotope distribution of elements vary across the planet and those ranges have been established (CRC, 1998–1999).

Bulk Chemical Makeup

Close to a dozen different labs examined the elemental makeup of the Ubatuba sample from the 1950s through the 1990s. The surface chemical constituents will be ignored due to the lack of proper handling and contamination from contact with the ground. The bulk chemical makeup of the material from various labs will be reviewed as these tests involve removal of surface coatings prior to analysis, which eliminates the surface contamination issues.

Dr. Fontes arranged for the first testing of these samples, completed in Brazil in November 1957 by a Brazilian government lab, the Mineral Production Lab. Tests on the material using a Hilger Spectrograph detected no trace elements present, indicating 100% magnesium (Mg) as far as the equipment could determine (*APRO Bulletin*, 1960). This seems to be the origin of statements that the Ubatuba sample was extraterrestrial because it was 100% pure magnesium. This was an erroneous conclusion as the material was not truly pure Mg; the trace elements were not detectable with the equipment used in Brazil at the time (Sturrock, 2001).

The Ubatuba sample was next tested in September 1958 at Oak Ridge National Laboratories by chemists Dr. Ellison Taylor and Dr. Cyrus Feldman, physicist Dr. T. A. Welton, and metallurgist Dr. Robert Gray. The chemical analysis was made by burning a small amount of the sample with an arc and using an Applied Materials two-meter grating spectroscope to measure the elemental makeup. The results showed an overall purity of the Mg measured as 99.8%. Trace elements detected included iron (Fe), silicon (Si), and aluminum (Al) in the 100–1000 parts per million (ppm) range and calcium (Ca) and copper (Cu) in the 1–10 ppm range. (It is worthwhile to note that two elements that will be found in future tests, barium (Ba) and strontium (Sr), could not be measured if below 1200 ppm.) In their report, the scientists noted that the sample had fissures within the Mg crystalline lattice that indicated oxidation at high temperature, supportive of the story as to how it was found (ORNL report, 1958). Indications of high temperature oxidation based on lattice inspections were also noted in later examinations of the material by two metallurgists (Walker & Johnson, 1970; Walker, 1992). It was also noted that the form of the Mg ruled out pyrotechnics, and the properties of Mg ruled out this being any type of aircraft or missile that had burned up in the atmosphere. Oak Ridge National Labs believed it could still be man-made and that the sample was sufficiently interesting that it warranted further study (ORNL report, 1958).

Dow Chemical was the next laboratory to test the samples, in December 1961. They used an electron beam that sputtered into the sample to a distance of 1-4 microns. The system's sensitivity was generally 1000 ppm but with lower levels of detection for certain elements. Results indicated the purity of the Mg at 99.98% with traces of Sr and Ba at 30 ppm and Ca at 100 ppm (Sturrock, 2001).

February 1968 was the year that the University of Colorado UFO Study (Condon Committee) under the supervision of Dr. Roy Craig evaluated the Ubatuba samples. Craig used the government's Alcohol & Tobacco Laboratory to complete the testing. The lab removed the surface areas of the sample with hydrochloric acid and then rinsed it in distilled water before they utilized neutron activation followed by measurement of gamma ray activity using gamma-ray spectroscopy to measure the sample's elemental makeup. The purity of the Mg was 99.9% with Sr at 500 ppm, Ba at 160 ppm, zinc (Zn) at 500 ppm, manganese (Mn) at 35 ppm, chromium (Cr) at 32 ppm, and copper (Cu) at 3 ppm. The lab's published measurement errors varied by element but they were all roughly +/–20% of the measured value. (NOLAT Report, 1968). Craig noted in the Condon report that the traces of Sr were not known to be added to commercial Mg (Condon Committee, 1968). This lab also measured the Mg isotope ratios, which will be discussed later in this paper.

The capability to test <100 ppm and parts per billion (ppb) levels of trace elements advanced considerably in the 1990s with the advent of the inductively coupled plasma mass spectrometer (ICP-MS). For background,

> ICP-MS is a type of mass spectrometry that uses an inductively coupled plasma to ionize the sample. It atomizes the sample and creates atomic and small polyatomic ions, which are then detected . . . It can detect different isotopes of the same element, which makes it a versatile tool in isotopic labeling. (Wikipedia, 2022)

Sturrock had two samples tested in March 1997 by Elemental Research in Vancouver using a laser ablation ICP-MS. With this new technique 37 trace elements were detected. This is not unexpected as many of these elements were in the ppb range and almost any metal tested with such a system will have many trace contaminants. Only the significant trace elements will be discussed. Calcium was detected at 4600 ppm and 3230 ppm and titanium (Ti) at 283 ppm in one sample. The Ca is much higher than ever reported previously. It is likely that this is due to surface contamination as laser ablation vaporizes the sample from the surface downward. Surface analysis tests had shown large amounts of sodium (Na), Ca, Mn, and Ti all present in seawater, which was near where the samples were claimed to have been found. The more interesting trace contaminants in order of amount were as follows: Sr (916 ppm and 568 ppm), Ba (301 ppm and 248 ppm), Zn (27.8 ppm and 17.5 ppm), Cu (3.0 ppm and 16.6 ppm), tin (Sn) (7.7 ppm and 11.3 ppm), and lead (Pb) (7.1 ppm and 10.5 ppm) (Sturrock, 2001).

In summary, the Ubatuba sample's bulk constituents were approximately 99.8% Mg with the main two trace metals being Sr (500–000 ppm) and Ba (150-300 ppm). Present in smaller amounts were Zn (<100 ppm), Cu (3–20 ppm), and both Pb & Sn (7–11 ppm). The use of Sr as a trace element in Mg had been done by Dow Chemical but was not considered a normal practice during the time this sample was first obtained (Sturrock, 2001). Although finding such a pure form of Mg with trace levels of Sr in Brazil in 1957 was very unusual and difficult to explain, this was not sufficient evidence to establish a non-terrestrial origin for the sample. The next tests discussed attempted to do that by examining the isotope ratios of the Mg in the Ubatuba sample.

Isotopic Analysis of Mg

The value of isotopic analysis rests with the unique isotope ratios of elements that originate in different locations on earth, different time periods, other areas of our solar system, or in other star systems. We know the range of isotopes that can occur naturally on Earth, so unless a material is treated in such a way as to shift the isotope ratios of a given element, we expect it to fall within the normal terrestrial range. Elements that originate in meteorites, on the Moon, Mars, etc., will have slightly different isotope ratios for some of the elements such as Mg, Cr, Sr, Ba, Ti, and Ni due to the inhomogeneous development of the solar system's protoplanetary disk as well as the decay of ^{26}Al (Paton et al., 2013; Young & Galy, 2004; Lugaro et al., 2018). A material from outside of our solar system would be expected to have even more variation in isotope ratios (Lugaro et al., 2018; Vangioni & Olive, 2019). The isotope ratio in and of itself cannot prove that an object has an extraterrestrial origin but it is a clue as to a material's origin.

The first analysis of Mg isotopes in the Ubatuba sample was done in February of 1968 by Craig as part of the Condon Committee and was performed using neutron activation by the National Office Laboratory of the Alcohol and Tobacco Division (NOLAT, 1968). The analysis looked at only one of the three isotopes of Mg, ^{26}Mg. As reference, the nominal terrestrial abundance values for these isotopes are: ^{24}Mg = 78.99%, ^{25}Mg = 10.00%, ^{26}Mg = 11.01% (the abundances of the common isotopes of an element in a sample should add to 100.0%, so in the Ubatuba sample, ^{24}Mg + ^{25}Mg + ^{26}Mg =100.0% within measurement error). The report indicated that the isotope abundance of ^{26}Mg was 14.3% with an error of 0.7% and noted that the value "is in reasonable agreement with ^{26}Mg in the literature." (NOLAT, 1968) This statement is incorrect, and to further compound the error, Craig, in the Condon Committee report, left out the value obtained by the lab and simply stated (Condon Report, 1968), ". . . the Brazil sample did not differ significantly in ^{26}Mg isotope content from other magnesium samples (p. 142)." It is difficult to understand how Craig, with a PhD in chemistry, could have made this error, but he did. A chemist's bible, *The Handbook of Chemistry and Physics*, lists the nominal abundance of ^{26}Mg as 11.01% (CRC, 1998–1999). The terrestrial range of this magnesium isotope is 10.99% to 11.03% (USGS, 2006). This gross error was not known until Dr. Michael Swords obtained and then reviewed the actual papers of Craig from the Texas A&M Cushing Library in 2008. A further error was found by Brad Sparks in 2018 when he noted that the lab calculations used the weight of the wrong Ubatuba sample (there were two samples prepared) and if the correct weight had been used then the ^{26}Mg value would be 23.1% (Sparks, 2019). It is clear that whether the ^{26}Mg was 14.3% or 23.1%, this first attempt at measuring the isotope ratio was a failure.

The second analysis of Mg isotopes was done by Sturrock in the spring of 1997 and the testing was completed by Charles Evans and Associates using SIMS (Secondary Ion Mass Spectrometry) instrumentation. This analysis evaluated all three common magnesium isotopes. The exact values for each isotope obtained were not provided but instead the ratios of the isotopes were displayed in a chart that compared the ratio of ^{26}Mg/^{24}Mg to ^{25}Mg/^{24}Mg. Figure 1 (from Sturrock, 2001) shows these ratios for an Ubatuba sample as well as four different samples provided by DOW Chemical. Also plotted is the point corresponding to the ratios for the nominal values of the Mg isotopes: ^{26}Mg/^{24}Mg = 0.1394 and ^{25}Mg/^{24}Mg = 0.1266.

The last attempt to measure the magnesium isotopes was made later in 1997 by Sturrock using Elemental Research in Vancouver, Canada. They used a laser ablation ICP-MS. Sturrock indicated that there were results for two Ubatuba samples and two magnesium standards, one of which came from the National Institute of Standards and Technology (NIST). However, his paper displays results from only one of the Ubatuba samples, the two standard samples, and states the other Ubatuba results "looks" just like the other one. The three displayed magnesium isotope distributions look similar, indicating a terrestrial origin for the Ubatuba sample as shown in Figure 2 (from Sturrock, 2001). The data counts for the graphs are supplied in the paper but not the actual magnesium isotope percentages.

The authors have converted the data counts in Figure 2 into percentage values, which are shown in Table 1. Uncertainties for these ratios are not available as errors were not published with figure 2 in Sturrock (2001). Even so, the deviations of the values of the Ubatuba sample from the terrestrial norms are very small in magnitude and not inconsistent with a terrestrial source (differences could be due to the capability of the equipment used).

In summary, the three past attempts to measure magnesium isotopes in the Ubatuba samples have been inconclusive. We next report on more recent results using modern equipment that allows measurement of not only the magnesium isotopic distribution but the isotopic components of the trace metals in the sample that are in the 10–100 ppm range. This will allow for examination of more metals than just the magnesium which makes up 99.88% of the sample with trace metals accounting for the remaining 1200 ppm.

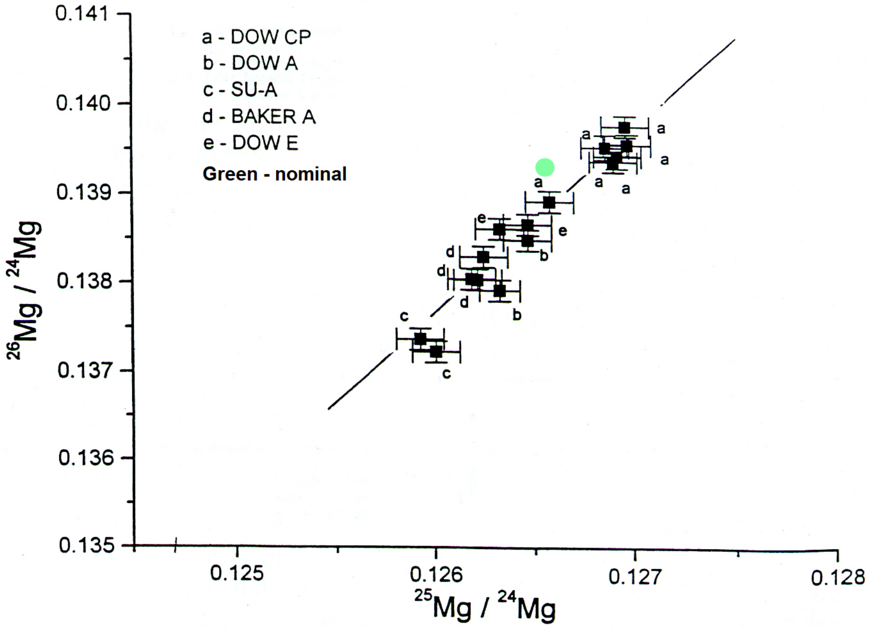

Figure 1. Plot of the determination of the isotope ratios ^{25}Mg/^{24}Mg and ^{26}Mg/^{24}Mg. From figure 1 from Sturrock (2001). (a) DOW CP is the DOW sample of triply sublimed magnesium used in the Colorado Project; (b) DOW A is a sample of triply sublimed magnesium supplied by DOW Chemical to Peter Sturrock; (c) SU-A is one of the Ubatuba samples; (d) Baker A is a magnesium standard used by the Johnson Space Flight Center; (e) DOW E is another sample of triply sublimed magnesium supplied by DOW Chemical to Peter Sturrock; and (f) the added green circle is the calculated nominal value based on the established nominal values for the 3 magnesium isotopes.

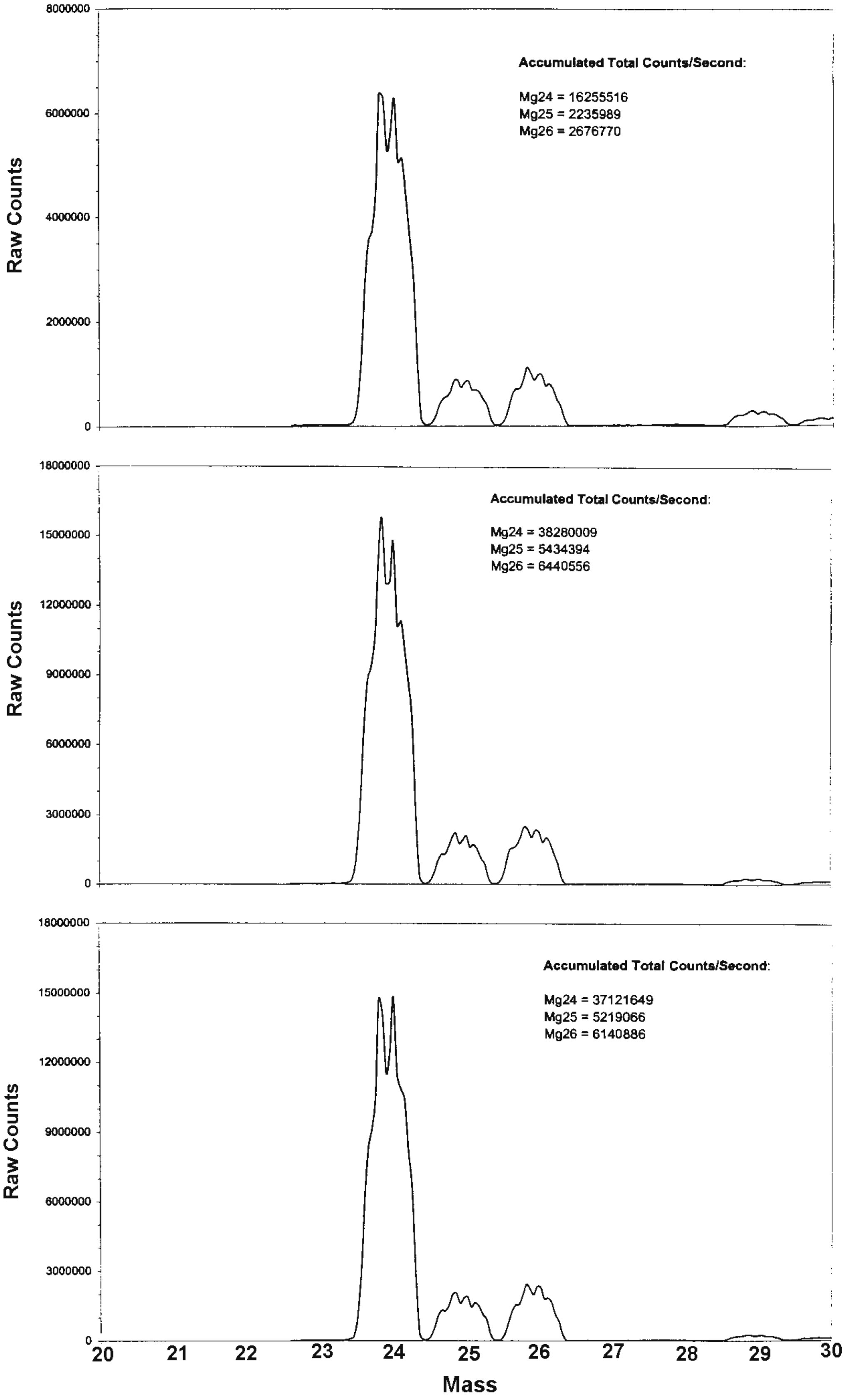

Figure 2. Isotope composition as determined by Elemental Research using ICP-MS (from figure 2 in Sturrock, 2001). Top display is of the Ubatuba Mg sample SU-H; center display is Mg sample ALFA-a; and bottom display is NIST sample ISO-A.

TABLE 1. Mg isotope abundance for distributions shown in Figure 2.

Isotope	NIST Standard ISO-A (%)	Ubatuba SU-H (%)	Standard Sample ALFA-a (%)
^{24}Mg	78.99	79.25	78.76
^{25}Mg	10.00	9.81	10.07
^{26}Mg	11.01	10.99	11.16

2017–2018 ISOTOPIC ANALYSIS OF MG, SR, BA, ZN, AND CU

During the twenty years since the Ubatuba sample was last studied, the ability to analyze isotope ratios has improved significantly. Not only can the isotopes of Mg be analyzed, but so can the minor constituents that are in the 100–1000 ppm range. Based on the previous analysis of the chemical constituents of the Ubatuba sample, we identified the trace elements of Sr, Ba, Zn, and Cu as targets for isotope analysis.

Michael Swords obtained from Peter Sturrock a small piece from an original Ubatuba sample. Cerium Laboratories in Austin, Texas, was identified as the lab of choice to do the isotope analysis. Cerium has an ISO 17025 accredited laboratory for testing and calibration and is well-known in the nanotechnology field. The instrument used for isotope analysis was their High Resolution Inductively Coupled Plasma Mass Spectrometer (HR-ICPMS) manufactured by Thermo Finnigan and known as the Finnigan Element2. The equipment is capable of measuring below parts per trillion levels of trace elements. This same system has been used to measure Pb isotopes in peat bogs (Krachler et al., 2004), Sr isotopes in sediments (Hulme et al., 2008), and is capable of separating most of the elemental isotopes (Element Series, 2020).

Two of us (MS and RP) met with Dr. Tim Hossain, the chief scientist at Cerium, along with the director of their lab and the chemist who would be running the HR-ICPMS. The sample and testing procedures were discussed and agreed upon. The sample was prepared in a Class-1 clean area, which means there is no more than one particle larger than 0.5 microns in size per cubic meter of air. It was agreed that 50 angstroms (5×10^{-7} cm) of the sample's outside surface would be removed in order to eliminate contaminates introduced from handling. From the cleaned sample 0.00570 grams was dissolved in 1% ultra-pure nitric acid at 22 °C for 30 minutes. The Sr, Cu, Zn, and Ba were diluted 100:1 while a solution to test the Mg was diluted 10,000:1. The latter was required due to the large amount of Mg making up the sample. Calibration of the HR-ICPMS was done using NIST traceable standards.

The more highly diluted Mg sample was tested first on July 28, 2017. The results are shown in Table 2. The ^{26}Mg abundance of 10.58% in the Ubatuba sample was substantively different from the nominal abundance of 11.01%. No standard error was provided by Cerium so we cannot conclude that the ^{26}Mg abundance was outside of the terrestrial norm.

TABLE 2. Ubatuba sample Magnesium isotopes abundances from a 10,000:1 sample dilution from Cerium Labs with nominal abundance for comparison.

Isotope	Nominal Abundance (%)	Ubatuba Unknown (%)
^{24}Mg	78.99	79.31
^{25}Mg	10.00	10.10
^{26}Mg	11.01	10.58

The results of the isotope analysis on the lower concentration elements were received on September 8, 2017, and are shown in Table 3. Unfortunately, again no standard deviation error was provided by the lab.

Strontium had the most unusual variations with the Ubatuba ^{84}Sr abundance at 0.74% compared to the nominal value of 0.56% and the ^{86}Sr at 9.10% compared to the nominal value of 9.86%.

Once these results were reviewed, we planned a second lab analysis of the same dissolved samples that had been originally prepared by Cerium Labs. This would provide independent verification of the Cerium results. We had hoped to use a university laboratory for the second analysis. Among the labs contacted were the University of Texas, Rice University, University of Maryland, and the University of Houston. We were unsuccessful in getting any university lab to commit to analyzing our sample once they asked about the source of the sample and were told it was of an unknown source of almost pure magnesium that had supposedly burned up in the atmosphere. Unsuccessful in the university arena, another commercial laboratory was chosen: ICP and ICP-MS Services in Cleveland, Ohio. The lab was run by Dr. Arthur Varnes and used a Thermo Scientific iCAP-Q inductively coupled plasma mass spectrometer.

TABLE 3. Ubatuba sample Strontium, Copper, Zinc and Barium Isotopes abundances from a 100:1 sample dilution from Cerium Labs with nominal abundances for comparison.

	Isotope	Nominal Abundance (%)	Ubatuba Unknown (%)	Absolute Percent Difference*
Strontium	^{84}Sr	0.56	0.74	32%
	^{86}Sr	9.86	9.10	8%
	^{87}Sr	7.00	7.03	0%
	^{88}Sr	82.58	83.12	1%
Copper	^{63}Cu	69.17	70.26	2%
	^{65}Cu	30.83	29.74	4%
Zinc	^{64}Zn	48.6	49.41	2%
	^{66}Zn	27.9	27.73	1%
	^{67}Zn	4.1	4.09	0%
	^{68}Zn	18.8	18.77	0%
Barium	^{134}Ba	2.42	2.28	6%
	^{135}Ba	6.59	6.27	5%
	^{136}Ba	7.85	7.55	4%
	^{137}Ba	11.23	10.85	3%
	^{138}Ba	71.7	73.05	2%

* Absolute percent difference = (Abs(Unknown – Nominal)/Nominal)*100

The ICP-MS used was calibrated based on NIST traceable reference solutions with concentrations of Ba, Cu, Mg, Sr, and Zn in the 1000 ppm range. The lab report from ICP-MS Services was received on July 3, 2018.

The results of the Mg isotopic abundances will be examined first. Table 4 shows for comparison the same information as Table 2 plus the addition of the results from ICP-MS Services in Cleveland, which included information on error of measurement allowing us to calculate a 95% confidence interval. The Cleveland results are consistent with terrestrial abundances for ^{26}Mg and ^{25}Mg, although not quite for ^{24}Mg. As noted earlier, non-terrestrial sources can lead to different abundances. For example, from results of models reported in Vangioni and Olive (2019), we calculate the abundances produced by a star with 15 solar masses (only stars with 2 or more solar masses produce magnesium) as ^{24}Mg = 82.4%, ^{25}Mg = 8.7%, ^{26}Mg = 8.91%, quite different from terrestrial values. Conversely, abundances for stars in the Hyades cluster are very close to terrestrial values because these stars are in the Local Group with the Sun (Yong et al., 2004).

It is most useful to look at the ratio of ^{26}Mg and ^{25}Mg to the dominant form ^{24}Mg to determine possible origin. This was first examined by Sturrock as shown in Figure 1. Figure 3 includes this same information, with additional data for Mg isotopes from a meteorite, Dead Sea Mg, Amazon River Mg, and the North Atlantic as well as the values obtained on the Ubatuba sample from the Austin and Cleveland labs. The results from the Cleveland lab fall on the same diagonal line as other terrestrial samples while the Austin lab falls well off the line. Since both of these labs are measuring the same sample solute, it is most likely that some error occurred in the measurement of the Mg isotopes by the Austin lab. (As comparison to a potential non-terrestrial source, the point corresponding to the two ratios derived from the abundances reported above for a 15 solar mass star falls well outside the plot area.)

TABLE 4. Ubatuba sample Magnesium isotopes abundances in 10,000:1 sample dilution from Austin and Cleveland labs with nominal abundances for comparison.

Isotope	Nominal Abundance (%)	Ubatuba Unknown Austin (%)	Ubatuba Unknown Cleveland (%)	Cleveland 95% Confidence Interval
^{24}Mg	78.99	79.31	79.28	79.16 – 79.40
^{25}Mg	10.00	10.10	9.94	9.64 – 10.24
^{26}Mg	11.01	10.58	10.85	10.70 – 11.00

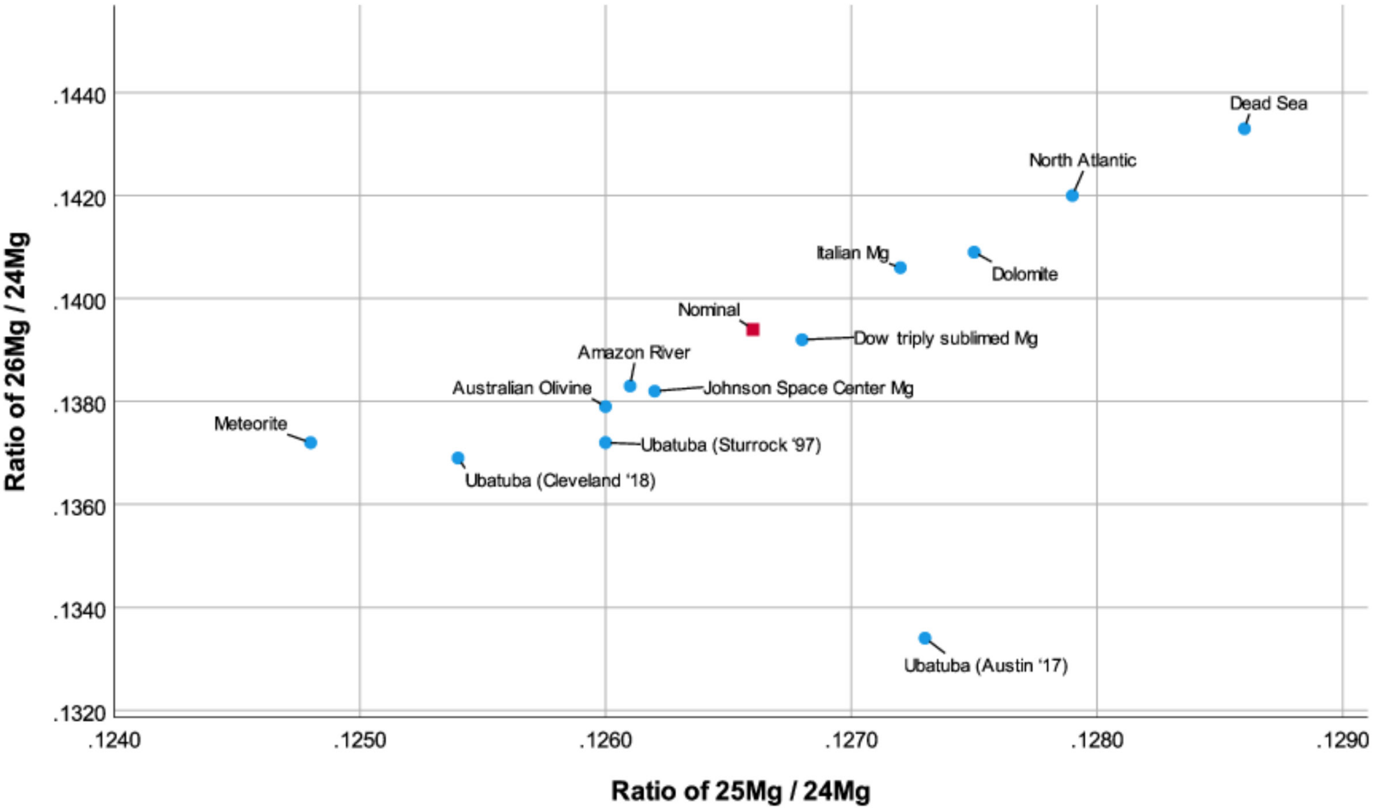

Figure 3. Magnesium isotope fractionation, plot of ratio of ^{26}Mg/^{24}Mg with ratio of ^{25}Mg/^{24}Mg from a variety of samples.

The other trace isotopes measured by ICP-MS Services are listed along with the results from Cerium Labs in Table 5. Given the results for Mg we place more weight on the ICP-MS Services analysis. There is no consistent variation between the two labs as compared to the nominal terrestrial isotope abundance measured for the various elements. ^{84}Sr and ^{87}Sr were below nominally measured terrestrial values as measured by ICP-MS Services yet the Cerium Lab value for those isotopes were above the nominal terrestrial values. The same can be seen with some of the Zn isotopes. ICP-MS Services measured ^{64}Zn as below the nominal value for the Ubatuba sample and measured ^{67}Zn and ^{68}Zn above the nominal values while Cerium Labs measured ^{64}Zn above the nominal value and the rest of the Zn isotopes as meeting the nominal terrestrial values.

DISCUSSION AND CONCLUSIONS

One of the key lessons from this paper are the difficulties inherent in identifying whether the elements in a

TABLE 5. Ubatuba sample Sr, Cu, Zn, Ba Isotopes abundance in 100:1 sample dilution from Austin & Cleveland labs with nominal abundances for comparison. Standard deviation included for Cleveland data.

Element	Isotope	Nominal Abundance (%)	Ubatuba Unknown Austin (%)	Ubatuba Unknown Cleveland (%)
Strontium	^{84}Sr	0.56	0.74	0.53 +/−0.01
	^{86}Sr	9.86	9.10	9.85 +/− 0.31
	^{87}Sr	7.00	7.03	6.83 +/− 0.05
	^{88}Sr	82.58	83.12	82.77 +/− 0.32
Copper	^{63}Cu	69.17	70.26	69.14 +/−0.47
	^{65}Cu	30.83	29.74	30.86 +/−0.42
Zinc	^{64}Zn	48.6	49.41	46.99 +/− .024
	^{66}Zn	27.9	27.73	28.00 +/− 0.13
	^{67}Zn	4.1	4.09	4.37 +/− 0.04
	^{68}Zn	18.8	18.77	19.70 +/− 0.20
Barium	^{134}Ba	2.42	2.28	2.41 +/− 0.01
	^{135}Ba	6.59	6.27	6.65 +/− 0.03
	^{136}Ba	7.85	7.55	7.85 +/− 0.04
	^{137}Ba	11.23	10.85	11.21 +/− 0.08
	^{138}Ba	71.7	73.05	71.67 +/− 0.10

material are composed of isotopes that match the nominal terrestrial isotope values. One of the primary challenges is identifying two labs with sufficient experience in measuring specific isotopes so that duplicate results can be verified. Although both labs were very experienced in the use of HR-ICPMS and ICPMS systems, neither were experts in the specific isotopes being measured. This is a real challenge as most labs with experience in isotopic analysis of specific elements are at universities. Most of these labs have their own projects and it is difficult to get a university lab to do an analysis on an outside project especially if the sample source is tied to a subject that is not of interest to the university, and perhaps as controversial as the UFO phenomenon. As the demand for isotopic analysis increases, hopefully there will be an increase in the expertise at commercial labs as these are less concerned with sample origin.

The difficulty in obtaining consistent isotope values in the trace metals between the two labs may be related to the high concentration of Mg in the samples which was three orders of magnitude greater than the trace metals. This can lead to swamping of the HR-ICPMS detector sensitivity at the expense of the trace metal isotopic analysis. Should the Ubatuba samples be tested again, it would be advisable to chemically separate the heavier trace isotopes from the Mg so that all elements in the sample tested are in the same concentration range. Low ppm levels of trace elements can be tested effectively once separated and there now exist even more accurate testing capability with multiple collectors on a HR-ICPMS. These systems are known as Multicollector Inductively Coupled Plasma Mass Spectrometers (MC-ICPMS) and most exist at universities that do isotope analysis.

No conclusion can be drawn from the data obtained from Cerium Labs and ICPMS-Services as to whether the Ubatuba sample consists of trace elements whose isotopes do not match the normal range of terrestrial isotopic ratios. Although both labs found isotope distributions outside of normal terrestrial values, the lab values were not consistent with each other.

One definite strangeness with the Ubatuba sample does remain. All testing consistently indicates that the Ubatuba sample is 99.88% pure magnesium with traces of Sr, Ba, Zn, and Cu. The strontium impurity is not a normal by-product in the manufacture of magnesium and would have been intentionally added. Dr. Beaman and Dr. Solaski of DOW Chemical were surprised by the presence of strontium as was Dr. Couling of Battelle Labs (Sturrock, 2001). It is still a mystery as to how high purity magnesium with the addition of strontium impurities showed up at a Brazilian newspaper office in 1957.

IMPLICATIONS AND APPLICATIONS

The current study illustrates both the promise, and difficulties, of doing elemental analysis on samples from anomalous events, whether UFO-related or otherwise. The study aims to distinguish a possible extraterrestrial artifact from terrestrial ones, but this is not a straightforward exercise. Limitations of instrument precision and the cost of testing make definitive results difficult to achieve, even with the improvements in analytical technology (unless a sample has isotope ratios far outside normal abundances). So too do developments in materials science, which construct ever-more esoteric materials (although this is less of a complication with a sample from an earlier era, as with Ubatuba).

The use of isotope analysis within the field of ufology should be expanded to analyze landing traces, and close encounter cases generally, where odd substances or extreme effects are seen. Such cases could conceivably have remnant materials of abnormal isotope ratios. A concerted focus on this type of evidence by investigators and UFO organizations is an essential strategy.

Thinking beyond the UFO box, if any researcher obtains unusual seeming material from incidents like cryptozoological encounters, strange falls from the sky, or paranormal objects such as apports, this approach can be employed. We need more reliable, physical data on all types of paranormal events, and purported physical samples allow the most in-depth studies. However, this is limited by the serious expense of these tests. They cannot be casually applied.

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