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# Composition Analysis of the Brazil Magnesium

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**Abstract**—Some of the surviving fragments of the Brazil magnesium that purportedly had their origin in the explosion of a UFO have been subjected to surface, internal and isotopic analyses. The surface composition of four of the specimens has been determined to better than 1 part per million (ppm). There are some similarities, but also significant differences, so it is clear that the specimens were subjected to different influences. Some of the impurities (such as sodium and calcium) may be due to seawater or sand, but many of the impurities are incompatible with such contamination. Some of the impurities (titanium, chromium, iron, cobalt, selenium, strontium, yttrium, niobium, palladium and barium) may point toward an origin in a technological device or devices.

Two specimens of Brazil magnesium, together with four comparison specimens, have been subjected to internal analysis by a laser ablation inductively coupled plasma mass spectrograph (ICP-MS) instrument. This analysis shows that the Brazil specimens contain calcium at a few thousand ppm and (as found by the Colorado Project) both strontium and barium at a few hundred ppm. One specimen also contains titanium at a few hundred ppm. This analysis indicates that the existing Brazil samples are not as pure as magnesium specimens readily available in the 1950s.

Some of the specimens have been subjected to isotopic analysis. The only departures from normal isotopic ratios are small differences that may be attributed to fractionation as a result of heat treatment.

The origin of these fragments remains a mystery. There is no evidence that the specimens are of extraterrestrial origin.

## 1. Introduction

The material that is here referred to as the “Brazil magnesium” has an important place in UFO research. It was the only material specimen investigated by the Colorado Project, which is the only unclassified UFO research project funded by a United States government agency (Condon & Gillmor 1969).<sup>1</sup>

The Brazil magnesium was first mentioned in a short article published in the Rio de Janeiro newspaper *El Globo* on September 14, 1957, reproduced in its original Portuguese in Appendix 1. This article, headed “UM FRAGMENTO DE DISCO-VOADOR!” [A Fragment from a Flying Disk!] was written by the *El Globo* society columnist, Mr. Ibrahim Sued, who reported that he had just received an interesting letter which he reproduced in his column (Sued 1957). Professor Pierre Kaufmann of the Instituto Presbiteriano Mackenzie, Sao

Paulo, Brazil, has kindly reviewed this column and supplied the following translation:

Dear Mr. Ibrahim Sued. As a faithful reader of your column, and an admirer of yours, I wish to give you, as a newspaperman, a “scoop” concerning flying discs. If you believe that they are real, of course. I didn’t believe anything said or published about them. But just a few days ago I was forced to change my mind. I was fishing together with various friends, at a place close to the town of Ubatuba, Sao Paulo, when I sighted a flying disc! It approached the beach at unbelievable speed and an accident, i.e. a crash into the sea, seemed imminent. At the last moment, however, when it seemed it was almost striking the waters, it made a sharp turn upward and climbed rapidly on a fantastic impulse. Astonished, we followed the spectacle with our eyes, when we saw the disc explode in flames. It disintegrated into thousands of fiery fragments, which fell sparkling with magnificent brightness. They looked like fireworks, despite the time of the accident, at noon, i.e. at midday. Most of the fragments, almost all, fell into the sea. But a number of small pieces fell close to the beach and we picked up a large amount of this material—which was light as paper. I am enclosing a sample of it. I don’t know anyone that could be trusted to whom I could send it for analysis. I never read about a flying disk being found, or about fragments or parts of a disk that had been picked up. Unless the finding was made by military authorities and the whole thing kept as a top-secret subject. I am certain the matter will be of great interest to the brilliant columnist and I am sending two copies of this letter—to the newspaper and to your home address.

From the admirer (the signature was illegible), together with the above letter, I received fragments of a strange metal.

#### According to Professor Kaufmann:

The writer was definitely not a “local fisherman.” The letter was written in very good Portuguese, and we may infer that the writer was well educated, and that he and some friends were visiting Ubatuba for a fishing vacation. A “local fisherman” would never have read Sued’s social column in *O Globo*, and would probably not have read any newspaper. If he had, it would have been a Sao Paulo State newspaper.

Kaufmann also points out that the writer obviously knew Sued’s home address, suggesting that he may have been part of the society circle with whom Sued was associated.

The above letter was read by Dr. Olavo Fontes, a resident of Rio de Janeiro. Dr. Fontes (who passed away in 1968 at the early age of 44) was an M.D. and chief of the gastroenterology section of the National School of Medicine in Rio de Janeiro. He was also an investigator of UFO reports. Fontes telephoned Sued and arranged to visit Sued in his apartment that same day. Fontes asked if he could take possession of the samples, to which Sued readily agreed. Fontes has described the material shown him by Sued in his apartment as follows:

I saw the samples sent by the unidentified correspondent—three small pieces of a dull-gray solid substance that appeared to be a metal of some sort. Their surfaces were not smooth and polished, but quite irregular and apparently strongly oxidized... The surface of one of the samples was shot through with almost microscopic cracks... The sur-

faces of all samples were covered in scattered areas with a whitish material. These whitish smears of a powdered substance appeared as a thin layer. The fine, dry powder was adherent but could be displaced easily with the nail... Mr. Sued said the material appeared to be lead at first sight—because of the gray color—but I could see that it could not be lead ... the material was light ... almost as light as paper.

The above excerpt is taken from a report that Fontes sent to the Aerial Phenomenon Research Organization (APRO) in Tucson, Arizona, on November 30, 1957. This report was subsequently reproduced, with minor revisions and excisions, as an article (Fontes, 1962) in a book by Coral Lorenzen (1962). Fontes was affiliated with APRO, of which Coral Lorenzen and her husband Jim Lorenzen were the founders and directors. It appears, from his article and from APRO files, that Fontes took possession only of the material that had been sent to Sued's apartment. There is no indication that he took possession either of the letter Sued had received at his home or the duplicate letter with additional specimens that had been sent to Sued's office. This has proved to be an unfortunate oversight. From information provided by Fontes, there is no way to be sure that the specimens did originate near Ubatuba (which is why they are here referred to as the "Brazil magnesium"), no way to be sure that they originated in an aerial event, and no way to be sure that the event (if it occurred) happened in 1957. These questions have been pursued by Professor Kaufmann. The results of his investigations will be presented in a separate article. In the present article, we discuss the results of composition analyses of the specimens.

Fontes received from Sued three specimens that he refers to as "Samples 1, 2 and 3." Photographs of Samples 2 and 3 are reproduced as figure 1 of Fontes (1962). Their lengths were about 1/4 inch and 3/4 inch, respectively. Sample 1 was never photographed.

Fontes first took the specimens to the Mineral Production Laboratory in Rio de Janeiro, a Division of the National Department of Mineral Production in the Agriculture Ministry of Brazil, where they were delivered to Dr. Feigl, the Chief Chemist. Feigl's assistant, Dr. David Goldscheim, made a preliminary examination of a chip of Sample 1 and determined that it was a metal. Sample 1 was then divided into several pieces. Two were left with the laboratory, and Fontes retained the rest (together with Samples 2 and 3). Goldscheim sent one piece of Sample 1 to the Spectrographic Section of the Mineral Production Laboratory, where it was investigated by Dr. Luisa Maria A. Barbosa, a chemical technologist, using a Hilger mass spectrograph, model DMA 1-412 (a high-quality instrument). In her report dated September 24, 1957 (figure 2B of Fontes 1962), Barbosa states "The spectrographic analysis showed the presence of magnesium (Mg) of a high degree of purity and absence of any other metallic element."

Fontes asserts that the sensitivity of the spectrograph was 1 part per million (ppm), but it is not clear whether or not Fontes is quoting the analyst in making this statement. It is important to note that the Hilger mass spectrograph evapo-

rates the material in an arc discharge and is therefore destructive. Fontes received a copy of the spectrogram, which is reproduced as figure 2C of his article.

One of the pieces of Sample 1 was sent to the Laboratory of Crystallography of the Geology and Mineralogy Division of the National Department of Mineral Production. An X-ray diffraction analysis was carried out by Dr. Elysiario Tavora Filho (then a Professor of Mineralogy at the National Chemical School). The results of these tests are reported in Fontes' article. This test was presumably non-destructive.

At Fontes' request, a second spectrographic analysis of Sample 1 was carried out by Mr. Elson Texeira at the same laboratory, using the same Hilger spectrograph. The spectrogram from Texeira's analysis is reproduced as figure 3B of Fontes (1962). Texeira's report, reproduced as figure 3A of Fontes (1962), reads in part:

The spectrographic analysis identified the unknown metal as magnesium (Mg), and showed it to be absolutely pure—as it can be concluded from the study of the spectrographic plate taken with the Hilger spectrograph. No other metal or impurity was detected in the sample analyzed; even the so-called 'trace elements,' usually found with any metal, were not present... A comparison ... between the spectrum of the unknown metal and that of a chempur magnesium salt ... demonstrated the extreme purity of the metal in the sample ... Even impurities that might exist in the carbon rod used as electrode (i.e., traces of Mn, Fe, Si, and Ti), sometimes appearing as contaminants, were not detected in this case.

This appears to be the origin of the assertion, frequently repeated, that Sample 1 was "absolutely pure." This statement has been repeated many times in the UFO literature, with the implication that the material was extraterrestrial in origin. Fontes (1962, p. 115) states: "On the basis of this evidence, it is highly probable the metallic chunks picked up on the beach near Ubatuba, in Sao Paulo, Brazil, are extraterrestrial in origin." However, the details of Texeira's report do not support his assertion that the specimen was "absolutely pure," since his report also contains the following statement:

A comparison was made between the spectrum of the unknown metal and that of a chempur [sic] magnesium salt. It showed clearly that they were identical—in fact, all their spectrum lines corresponded with each other. This demonstrated the extreme purity of the metal in the sample.

It appears, from this statement, that Texeira was claiming only that the specimen he analyzed was comparable in purity to a "chemically pure" specimen he had in his laboratory. Such a specimen is not 100% pure. As a gauge of the purity of magnesium specimens then available, we may refer to Fontes (1962, p. 115), who wrote, "The ASTM standard of purity for magnesium (ASTM 4-0770) shows in spectrographic analysis the following impurities: Ca 0.1%; and traces of Al, Cu, Fe and Si."

Here, as elsewhere in studying the Brazil magnesium, we are left with a puzzle: even if Texeira had used the ASTM standard for comparison, analysis by the Hilger spectrometer should have shown the presence of calcium, at least, since that spectrograph was certainly capable of detecting elements at the 0.1% (1,000 ppm) level.

Texeira's report raises another puzzle, when he states: "Even impurities that might exist in the carbon rod used as an electrode (i.e. traces of Mn, Fe, Si and Ti), sometimes appearing as contaminants, were not detected in this case." One would like to know *why* the Hilger spectrograph did not show the usual contaminants from the carbon rod. Clearly, there is the possibility that the Hilger spectrometer malfunctioned, but it would be surprising if a similar (presumably rare) malfunction had occurred for both the Barbosa and Texeira analyses.

On November 4, 1957, Fontes gave one of the remaining pieces of Sample 1 to Major Roberto Caminha of the Brazilian Army, who had the specimen analyzed at the Military Institute of Technology. A few months later, Fontes gave another piece of Sample 1 to Commander J. G. Brandao of the Brazilian Navy; this specimen is believed to have been analyzed at the Navy arsenal in Rio de Janeiro. Neither piece was returned, and Fontes received no information about any analyses that were made at either laboratory.

In her book (Lorenzen, 1962), Coral Lorenzen adds an interesting postscript to Fontes' report, dealing with his later attempts to track down the person who sent the material to Sued, and with evidence of military interest in the Brazil magnesium. Her postscript reads in part:

The identity of the witnesses to the original incident remains unknown. In an attempt to locate them, Dr. Fontes and Joao Martins canvassed the beach area in the neighborhood of Ubatuba. Eventually they located a fisherman who remembered a group of vacationers from an inland town who told of the incident and displayed pieces of gray substance to support their story. He could remember nothing else of value except that they were excited and talked eagerly of their experience. This information might only serve to deepen the mystery, except for this fact: during 1958 when Dr. Fontes was in the midst of his investigation of the strange metal he was visited by two members of a Brazilian intelligence agency. These two individuals at first made veiled threats of what might happen to him if he continued his inquiry into matters that "did not concern him." When it became apparent that Fontes could not be coerced into silence, they appealed to his "better judgement" to cooperate with them and turn all his notes and the strange metal over to them. [Fontes declined this request.]

In late 1957, Fontes conveyed the remaining piece of Sample 1, and also Samples 2 and 3, to the Lorenzens at APRO. If the piece from Sample 1 had been carefully identified and preserved, and subsequently tested non-destructively, this could have put an end to the speculation that Sample 1 differed from Samples 2 and 3 and that Sample 1 was "100% pure," in the sense that it contained absolutely no impurities. As it is, no specimen that was in APRO's possession was ever shown to be 100% pure.

Coral Lorenzen (1962) recounts their experience in trying to get part of the material analyzed by an U.S. Air Force laboratory:

Soon after receiving the samples from Dr. Fontes, APRO submitted a portion of a sample to an Air Force spectrographic lab for analysis. An "emission spec" was requested. The following day the emission spectrograph operator reported that he had accidentally burned the entire sample without obtaining an exposed plate. He requested another sample. APRO declined.

The Lorenzens were able to make an informal arrangement with an APRO member, who was a theoretical physicist at a national laboratory, for an analysis to be made at that laboratory. The physicist secured the assistance of a physical chemist, a chemist specializing in spectrographic analysis, and a metallographer. A spectrographic analysis of Sample 2 was carried out on September 18, 1958, by means of an Applied Research Laboratories two-meter spectrograph with a dispersion of 5 Angstrom per millimeter. The spectrographic analyst confirmed that magnesium was the major ingredient, but he detected aluminum, silicon and iron in the 100 to 1,000 ppm range (see Table 1). Lorenzen's colleague wrote that "as far as this writer has been able to ascertain, no commercial alloy of magnesium exists with a composition at all like that of the sample. The metal of the sample is of no conceivable use for mechanical purposes, or for the conduction of electricity."

Mrs. Coral Lorenzen also arranged for part of Sample 2 to be spectroscopically analyzed by the Dow Chemical Corporation. The results of their analysis were transmitted in a letter dated December 15, 1961, to Mrs. Lorenzen from Dr. R. S. Busk, Research Director of the Dow Metal Products Department of the Dow Chemical Company, Midland, Michigan. Busk's analysis (Table 1, Dow Sample 2) indicates that calcium is present at 100 ppm, and strontium and barium each at 30 ppm. It should be noted that these results have been misrepresented in the UFO literature. W. W. Walker and R. W. Johnson prepared a report for APRO in 1969–1970, but their report was not published until 1992 (Walker & Johnson, 1992), when it appeared in the *Journal of UFO Studies* with an introduction by Swords (1992). Unfortunately, Walker and Johnson misread Dr. Busk's table, so that entries in their version of the Dow analysis are all too high by a factor of 100.

In 1967, the Lorenzens contacted Dr. Edward U. Condon, who was serving as director of the Colorado Project, to examine UFO evidence under contract with the U.S. Air Force. Analysis of the Brazil magnesium specimen was assigned to Dr. Roy Craig, who has given a narrative account of his experiences with the Colorado Project (Craig, 1995). The results of his investigations into the Brazil magnesium are summarized in the Condon Report (Condon & Gillmor, 1969, pp. 94–97).

According to Craig, he contacted and visited Dr. Busk early in 1968. Busk informed Craig that Dow had, for about 25 years, produced a number of batches of very pure magnesium by the process of repeated sublimation, and he pro-

TABLE 1  
Early Composition Analysis of Brazil Magnesium Specimens

Element	At no	Group	National lab sample 2	Dow sample 2	Colorado SU-E	Paris SU-E	Colorado DOW
Magnesium	Mg	12	14	major	major	major	major
Aluminum	Al	13	13	100–1000	<20		<5
Silicon	Si	14	14	100–1000			
Calcium	Ca	20	2	1–10	100	8500	
Chromium	Cr	24	6	<1	32		5.9
Manganese	Mn	25	7	<40	35		4.8
Iron	Fe	26	8	100–1000	<2		
Copper	Cu	29	11	1–10	2		0.4
Zinc	Zn	30	12	<300	500		5.0
Strontium	Sr	38	2	<1200	30	500	700
Barium	Ba	56	2	<1200	30	160	
Mercury	Hg	80	13	<1200			2.6

Note: Abundances all in ppm. Blank entries indicate “not detected.”

vided him with a specimen of triply sublimed magnesium. Craig was advised that the most sensitive test for impurities would be neutron activation analysis. He therefore arranged to take a specimen of the Brazil magnesium and (for comparison) a specimen of the Dow triply sublimed magnesium to the Alcohol, Tobacco, and Firearms (ATF) Laboratory in Washington, D.C. This visit took place on February 5, 1968, and the specimen was analyzed by Mr. Maynard J. Pro, whose report on the analysis was mailed to Craig on February 29, 1968.

The results of Pro’s analysis of the Brazil specimen and of the Dow specimen are included in the Condon Report (Condon & Gillmor, 1969, pp. 94–97). They are summarized in Table 1. Clearly, this specimen of the Brazil magnesium was not “100% pure.” Indeed, it was not as pure as the triply sublimed Dow specimen. In his report, Condon comments that:

[T]he magnesium metal was found to be much less pure than the regular commercial metal produced in 1957 by the Dow Chemical Company at Midland, Michigan. Therefore it need not have come from an extraterrestrial course, leaving us with no basis for rational belief that it did.

Like many of Condon’s statements in his report (see, for instance, Sturrock, 1987), this comment is not quite accurate: the specimen analyzed at the ATF Laboratory was a piece of triply sublimed magnesium, not a piece of “regular commercial metal.”

On the other hand, the results of the ATF analysis (see SU-E in Table 1) did seem somewhat unusual to the magnesium experts at the Dow Chemical laboratory. The Brazil magnesium contains significant amounts of both barium and strontium. As Craig reports:



The high content of Sr was particularly interesting, since Sr is not an expected impurity made by usual production methods, and Dr. Busk knew of no one who intentionally added strontium to commercial magnesium... In all probability, the strontium was added intentionally during manufacture of the material from which the sample came.

Craig learned that the Dow Metallurgical Laboratory had over the years produced a number of experimental batches of magnesium containing strontium. However, there is no indication that any of the batches contained exactly the same impurities as those found in the Brazil magnesium.

Dr. Donald Beaman and Dr. Laurence Solaski of the Dow Chemical Company, during a meeting with the author on January 17, 1983, also expressed surprise at the presence of strontium in the specimens. They pointed out that the strontium would have to have been added, since it is not a "natural" impurity in magnesium production. Dr. S. Lawrence Couling, of the Battelle Columbus Laboratories, expressed a similar opinion during a telephone conversation with the author on May 11, 1984. He remarked that the presence of strontium in magnesium metal is "very, very unusual." He did not know of any place in magnesium technology where strontium is used.

I became interested in the Condon Report in 1976 and prepared an evaluation of that report that was subsequently published in this journal (Sturrock, 1987). I thereby became interested in the only material that had been investigated by the Colorado Project, namely the Brazil magnesium specimens. With the kind cooperation of the Lorenzens, I was able to arrange for some analyses in California. The most useful of these was also the first. I was able to arrange for an isotopic analysis to be carried out at the Division of Geological and Planetary Sciences of the California Institute of Technology in Pasadena. In October 1976, Mr. Typhoon Lee and Dr. D. A. Papanastassiou performed a mass-spectrographic analysis aimed specifically at determining the isotopic composition of the magnesium (Lee & Papanastassiou, 1976). They were able to determine that, with an accuracy of 0.04% (400 ppm), there is no significant difference between the isotopic composition of the specimen I had provided and that of normal terrestrial magnesium that had been subjected to normal fractionation processes such as sublimation.

Through the kind cooperation of M. Jean-Jacques Velasco of the French space agency Centre National d'Etudes Spatiales (CNES) in Toulouse, I was able to arrange for an independent determination of the isotopic ratio. This was carried out in 1986 by Professor J. C. Lorin and Dr. A. Havette of the Laboratoire de Mineralogie-Cristallographie of the Pierre and Marie Curie University in Paris. Their report (Lorin & Havette, 1986) confirmed that the isotopic composition of the specimen they analyzed differs from the normal terrestrial composition by less than 0.2% (2,000 ppm). Lorin and Havette also determined that the specimen contained calcium at 8,500 ppm and strontium at 700 ppm.

The Lorenzens kindly transferred ownership of the remaining specimens to me in 1987. It should be noted that, by that time, the association of the remain-

ing specimens with the original three specimens had been completely lost. The specimens had not been carefully protected and tracked. In my discussions with the Lorenzens, I learned that two specimens were out on loan. One was in the possession of Mr. Robert Achzehn of Costa Mesa, California; I subsequently retrieved this specimen from Mr. Achzehn in 1986. The other has a more interesting history.

Mr. Harold Lebelson, a journalist, had expressed an interest in the Brazil magnesium in 1978. As a result, a specimen (the same specimen that had been analyzed by the Colorado Project) was given into his care by the Lorenzens. He took this specimen to Professor Robert E. Ogilvie of the Metallurgy Department at the Massachusetts Institute of Technology (MIT). The results of Ogilvie's analysis were reported by Lebelson in an article in OMNI magazine (Lebelson, 1979), which reads in part:

The specimen was examined by metallographic analysis to determine its mechanical and thermal history. Electron probe microanalysis was employed to determine the chemical composition and the distribution of elements within the specimen. Results of these tests showed the metal to be pure magnesium. No impurities or alloying elements, such as aluminum, zinc, manganese, or tin, were found. An oxygen x-ray map picked up magnesium and oxygen x-ray signals, thus confirming the network to be magnesium oxide.

"My conclusion," says Ogilvie, "is that the specimen from Brazil has a composition that would be found in magnesium weld material. However the structure is indeed unusual. In my opinion it could only have been formed by heating the magnesium very close to its melting point in air. It would be necessary to hold the temperature for only a minute or so. This would produce an oxide coating on the material, which is clearly visible. Also, oxygen would diffuse down the grain boundaries, thereby producing the oxide network. It is therefore quite possible that the specimen from Brazil was a piece of weld material from an exploding aircraft or a reentering satellite."

The first part of this report is not accurate. I visited Ogilvie and discussed his analysis with him in June 1982, when he informed me that he had in fact detected impurities in the Brazil specimen, including calcium at a few thousand ppm and strontium, iron and zinc at lower concentrations.

In 1986, with the agreement of the Lorenzens, I contacted Ogilvie to see if I could take possession of the specimen he had been analyzing. However, on telephoning him, I was dismayed to learn that he no longer had the specimen. According to Ogilvie, Lebelson had telephoned him in 1984 and advised him that someone would visit Ogilvie on Lebelson's behalf to retrieve the specimen. Soon thereafter, a gentleman turned up at Ogilvie's laboratory and took possession of the magnesium. Ogilvie did not recall the person's name, did not check his credentials, and did not ask for a receipt. All that Ogilvie could remember about the visitor was that he said he was from the IBM plant in Fishkill, New York. I telephoned Lebelson to ask what had happened to the magnesium as I wished to retrieve it, but Lebelson responded that he had never telephoned Ogilvie to authorize anyone to pick up the specimen. So, another piece of the Brazil magnesium was lost.

Ogilvie more than once recounted to me a conversation with Beaman who, according to Ogilvie, had told him that, in the late 1950s, an Air Force lieutenant brought a magnesium specimen from Ubatuba to his laboratory for analysis. Beaman had found calcium, strontium, and other elements in the specimen. The officer took away all records, putting them in a briefcase that was chained to his wrist. However, when I later asked Beaman about this episode, he stated that it had never happened.

During our conversations, Ogilvie made a very interesting suggestion. He pointed out that the Brazil magnesium seemed to originate in an event that occurred in September 1957, only one month before the Russians launched Sputnik One (October 4, 1957). Ogilvie hypothesized that the Russians had attempted to launch a Sputnik (that he referred to as "Sputnik Zero") in September but it did not make the required orbit and crashed near Ubatuba. This seemed a plausible hypothesis, since it would explain the apparent interest of military and intelligence agencies in this material. However, I addressed an inquiry to Dr. Vladimir Rubtsov of the Research Institute on Anomalous Phenomena in Kharkov, who replied as follows:

The "Sputnik Zero" hypothesis is, probably, worthy of examination, but I personally doubt it. The Sputnik One was made, as far as I know, of aluminum alloy. Magnesium alloys are used in space technology, but not pure magnesium. Now practically everything in the history of Soviet space explorations (including failures) seems to be revealed. If there had existed a "Sputnik Zero", it would have been a noticeable sensation in our mass media. I did not notice such a sensation and can therefore conclude the "Sputnik Zero" never existed.

In 1999, I finally acquired a sample of magnesium produced in Russia in the 1950s. The results of my comparison of the Russian magnesium and the Brazil magnesium are given in Section 3.

In 1977, there was an interesting exchange of correspondence between the President's Science Advisor, Dr. William Press, and the Administrator of NASA, Dr. Robert Frosch. This exchange was unusual in that it was released to the news media. In a letter dated September 14, 1977, Press advised Frosch that the White House was receiving inquiries about UFO reports and asked if NASA would be willing to investigate the subject.<sup>2</sup> As reported by Professor Richard C. Henry (1988) of Johns Hopkins University, who had been working temporarily at NASA Headquarters for the period in question, this request was duly considered at NASA Headquarters. On December 21, 1977, Frosch replied to Press declining to initiate a new study but stating, in part:

In response to your letter of September 14, 1977, regarding NASA's possible role in UFO matters, we are fully prepared at this time to continue responding to public inquiries along the same lines as we have in the past. If some new element of hard evidence is brought to our attention, in the future, it would be entirely appropriate for a NASA laboratory to analyze and report upon an otherwise unexplained organic or inor-

ganic sample; we stand ready to respond to any *bona fide* physical evidence from credible sources. We intend to leave the door clearly open for such a possibility.

At that time (in 1977), I had little understanding of the operation of government agencies. I took the offer at face value, and wrote to NASA to ask where such material should be submitted. These inquiries led me to meet with Mr. David Williamson, Jr., of "Code AX, Special Projects." After discussing two or three items that might be analyzed at NASA centers, Williamson agreed to arrange for the analysis of a specimen of the Brazil magnesium. This specimen was forwarded to Dr. Richard Williams at the Johnson Space Flight Center in Houston, Texas. I had several telephone conversations with Dr. Williams. I attempted to find out just what kind of machine he would be using and its sensitivity. He was not too precise in his answers. I learned that it was "an old ARC machine," and that the sensitivity was not very good, not as good as that of other machines then in existence. When pressed, Williams guessed that his instrument should be able to detect impurities with abundances of 100 ppm or more.

In due course, I received a letter dated December 15, 1981, from Williams, giving the results of his analysis. His letter reads, in part:

We have finally completed our look at the Brazil magnesium sample. The SEM [scanning electron microscope] with EDAX [electron-deposition analysis by X-rays] has proved to be the best way to examine the sample ... The metal ... is essentially pure magnesium. I have also enclosed a copy of the mass spectrum obtained on our ion microprobe mass analyzer (IMMA) ... When we drilled deeper into the sample than 1 micron, we saw only Mg and various interferences. The spectra, with the exception of the Fe and Ti near the surface, is [sic] the same as we obtain from commercial, high-purity magnesium wire which we use as a standard.

Our EDAX analysis should be sensitive at about the 0.1% (1,000 ppm) level; our IMMA analysis at the 100–1 ppm level depending on the mass. Our essential conclusion is that the specimen behaves like commercial, high-purity magnesium which has had its surface contaminated by handling and which has been exposed to a "plastic" potting compound which appears to be the source of the Ti, Si, and possibly the Fe.

When I reported these results to Ogilvie at a later date, he remarked laconically "I'm afraid their system isn't very good."

I made several other attempts to get accurate composition analysis of the Brazil specimens, without great success, until I was able to commission analyses at commercial laboratories. In subsequent sections, I report the results of analyses carried out at the laboratories of Elemental Research, Inc. in Vancouver, Canada.

Several other analyses of the Brazil magnesium have been carried out over the years, due to the generous cooperation of the Lorenzens. One notable analysis is the metallurgical investigation carried out in 1970 by Walter W. Walker, then Associate Professor of Metallurgical Engineering at the University of Arizona, Tucson, and Dr. Robert W. Johnson, then Development Metal-

lurgist in the Advanced Materials Division of the Materials Research Corporation in Orangeburg, New York. Their report was finally published in 1992 (Walker & Johnson, 1992) in the *Journal of UFO Studies*. The same issue of that journal also contains a valuable historical introduction to the Brazil magnesium by Michael D. Swords (1992), Professor in the General Studies Department at Western Michigan University in Kalamazoo, and a commentary by Walker (1992) reviewing the available information about the material.

## 2. Surface Analysis

Fontes (1962), in describing the specimens that he acquired from Sued, commented on their appearance as follows:

three small pieces of a dull gray solid substance... Their surfaces were not smooth and polished, but quite irregular and apparently strongly oxidized ... the surfaces of all samples were covered with a whitish material... The fine, dry powder filled the fissures and cracks on the surface of the first sample.

It is not easy to reconcile the gray appearance of the specimens with the writer's account of their origin. If a magnesium object were suddenly fragmented, the fragments would be shiny, not dull gray. Magnesium becomes dull only slowly. In a reasonably dry climate, it remains shiny for months and even years. In a damp climate, it will corrode more rapidly.

However, if a complex device were to explode, the metal parts may well be contaminated by material from parts that were not constructed of magnesium. Furthermore, the person who sent the letter and specimens to Sued had claimed that the event occurred near the water's edge (in or near Ubatuba). If this were the case, it is possible that magnesium fragments were heated to a high temperature and then dropped into seawater. They might then acquire a coating of minerals from the seawater and from the sand, and this could account for the whitish-gray surface material.

As a result of this speculation, it appeared that it would be worthwhile to determine the composition of material on the surface of the specimens. If it were found that the surface abundances were a good match to the element abundances of seawater and of the sand on one of the beaches in the Ubatuba area, that would tend to corroborate the writer's story, and it might even help identify the actual location, since different beaches in that area have different types of sand.

In April 1978, the surface composition of one of the specimens (SU-D) was determined by analyst Chris Zercher of the Center for Materials Research at Stanford University using a KEVEX electron microprobe.<sup>3</sup> Zercher found that the principal constituent was magnesium, but he detected calcium, chlorine, iron, silicon and titanium, each at about 2,000 ppm. The material was also analyzed by a Laue diffraction analysis and was found to be mainly  $\text{Mg}(\text{OH})_2$ .

More recently (January 1997), Professor Michael Kelley, also of the Center

for Materials Research at Stanford University, carried out a similar analysis using an XPS (X-ray Photoelectron Spectroscopy) instrument, but this proved to be much less sensitive than we required, and he was able to identify only a few elements. According to Kelley, the gray surface material contains the following elements: oxygen 22.9% (by number), magnesium 10.6%, carbon 66.1% and chlorine 0.4 %, indicating the presence of MgO and MgCl<sub>2</sub>. (Note that some elements—including oxygen, carbon and chlorine—do not show up in the positive-beam analyses that were used in the secondary mass ionization spectrometer [SIMS]—type instruments to be discussed later.)

On consulting Dr. Robert Odom, Manager of Contract Research at Charles Evans and Associates in Redwood City, California, in the spring of 1997, I was advised that the most sensitive surface analysis would be provided by a device developed in that laboratory that is referred to as ToF-SIMS (Time-of-Flight Secondary-Ion Mass Spectrometer). The top monolayer of the surface of the specimen is zapped with a beam that is pulsed, the pulse duration being of order one nanosecond. Ions produced in this way are accelerated by an electric field, travel some distance, and are analyzed by a mass spectrometer, taking into account the different flight times of ions of different mass. Information from the mass spectrometer, which yields the mass-to-charge ratio, is registered as a function of time. This procedure, which has a sensitivity of better than 1 ppm, is regarded by the analysts as a qualitative technique for determining the composition of the top one to four monolayers. By comparison the analysts regard inductively coupled plasma (ICP) instrumentation as capable of providing quantitative information about the bulk composition of specimens.

Of course, surface analysis can be carried out only on specimens that have not yet been mounted and polished, and several of the Brazil magnesium specimens have at various times been mounted and polished for analysis. This led me to select specimens SU-C and SU-D for ToF-SIMS analysis. The results are shown in Table 2. The instrument gives the “intensity” of measurements of the various elements relative to magnesium.

There are significant differences between the surfaces of SU-C and SU-D. For instance, the abundances of lithium, sodium and titanium in SU-C are about ten times the levels of the same elements in SU-D. Furthermore, SU-C shows a significant trace of palladium that was not detected in SU-D. It is clear that, judging from the surface composition, the specimens are not homogeneous.

With the kind cooperation of Professor Kaufmann, I was able to obtain samples of sands from two beaches in the neighborhood of Ubatuba: Praia Anchieta and Praia Enseada. These were analyzed by Dr. Hugh Gotts of the Materials Analysis Group at Philips Semiconductors in Sunnyvale, California, on March 28, 1997. The samples were dissolved in a mixture of aqua regia and hydrofluoric acid and analyzed for bulk elemental composition by means of a Thermo-Jarrell-Ash AtomScan 25 ICP Optical Emission Spectrometer (ICP-OES). The instrument was calibrated using standards containing 0, 1, 3 and 5 ppm of each element. The calibration was then verified by running quality-

control standard solutions containing 1 ppm of each element. In addition, to assure that there was no instrumental drift during the analysis, several standard zeroes and 1 ppm standards were interspersed with the extracts.

Table 2 shows the bulk abundances of elements in seawater and in sand from these beaches for the same elements that are found at a level of 10 ppm or more in the surface impurities of SU-C and SU-D. Although the sodium and calcium in SU-C and SU-D may have originated in seawater and sand, it is clear that most of the impurities in the surface material cannot be explained in that way. It is also notable that the sands in the Ubatuba area have a high iron content, but the iron content of SU-C is comparatively low, and the iron content of SU-D is undetectable.

Later in 1997, I became aware of the capabilities of the Elemental Research laboratories in Vancouver, British Columbia, Canada, including a laser-ablation ICP-MS that can give abundances with high sensitivity and consumes only amounts of order 1 micrometer<sup>3</sup> ( $10^{-12}$  cm<sup>3</sup>). I originally planned to use their services for internal analysis, but I learned that their instrument could be used also for analysis of the top few micrometers of a surface. I therefore arranged for them to carry out these surface analyses of two specimens that had been sent to them for internal analysis: SU-Ib and SU-Ja. The results of their analysis are also given in Table 2. We see that these two specimens differ from each other and also from SU-C and SU-D.

On comparing SU-Ib and SU-Ja, we see that, except for silicon, calcium, chromium, zinc and selenium, SU-Ja has lower impurity levels than SU-Ib; of these elements, silicon and calcium could have been derived from sand.

Comparing SU-Ib and SU-Ja with SU-C and SU-D, we see that boron, phosphorus, and zinc are present at a higher level in SU-Ib and SU-Ja than in SU-C or SU-D; on the other hand, lithium, strontium, and niobium are present at lower levels in SU-Ib than in SU-C and SU-D. This suggests that different specimens have experienced different environmental conditions, either in their original setting or in subsequent handling and storage. Although some of the surface impurities (such as sodium and calcium) may have been derived from seawater or sand, other elements (such as titanium, chromium, iron, cobalt, selenium, strontium, yttrium, niobium, palladium and barium) are more likely to have had a technological origin.

### 3. Bulk Analysis

In the early 20th century, magnesium was produced commercially in Austria by the carbothermic reduction of magnesium oxide that was obtained from calcined magnesite, and in Germany by the electrolysis of magnesium chloride, obtained from potash and from carnalite. The Pidgeon ferrosilicate thermal technique, developed in Canada in 1941, uses ferrosilicon and calcined dolomite. The electrolytic process that is now generally used produces magnesium that is typically 99.9% pure. In the United States in the 1950s, most mag-

TABLE 2  
Surface Analysis and Comparison Data

Element	Charles Evans		Charles Evans		Elemental analysis		Philips	
	At No	Group	SU-C ratios	SU-D ratios	SU-lb (ppm)	SU-Ja (ppm)	Seawater (mg/liter)	Anchiete ratios
Lithium (Li)	3	1	9500	600	42	1	0.18	46
Boron (B)	5	13			610	15		163
Sodium (Na)	11	1	44000	6000	1150	78	10800	49581
Magnesium (Mg)	12	14	major	major	major	182	0.1296	14999
Aluminum (Al)	13	13			750	15	0.002	32001
Silicon (Si)	14	14			73	347	0.1512	5404
Phosphorus (P)	15	15			121	32		65211
Sulphur (S)	16	16			15	8		
Calcium (Ca)	20	2	41000	9900	1060	1250	412	1000000
Titanium (Ti)	22	4	47300	4000	1630	8	0.001	1000000
Vanadium (V)	23	5				1		
Chromium (Cr)	24	6	100		4	176	0.0003	15
Manganese (Mn)	25	7			9	2		54
Iron (Fe)	26	8	1000		4	3	0.002	30499
Cobalt (Co)	27	9	100				0.00002	15
Nickel (Ni)	28	10	200				0.00056	30
Copper (Cu)	29	11			5			109
Zinc (Zn)	30	12			13	52		
Germanium (Ge)	32	14				3		
Arsenic (As)	33	15			1			
Selenium (Se)	34	16				71		
Strontium (Sr)	38	2	2100	1600	196	2	7.9	
Yttrium (Y)	39	3	100				0.000013	
Niobium (Nb)	41	5	700	900	9		0.00001	
Palladium (Pd)	46	10	1200					
Tin (Sn)	50	14			6			
Barium (Ba)	56	2		100	49		0.013	46

Note: The ICP-MS and ICP-OES analyses are quantitative, but the ToF-SIMS analysis is qualitative. For ICP-MS and ICP-OES, abundances are in ppm. ToF-SIMS = time-of-flight secondary-ion mass spectrometer; ICP-MS = inductively coupled plasma mass spectrometer; ICP-OES = inductively coupled plasma optical emission spectrometer.

nesium was produced by the electrolysis of magnesium chloride prepared from seawater off the coast of Texas (Krenzke et al., 1958).

With the kind cooperation of M. Jean-Jacques Velasco of the French space agency CNES, I arranged in 1986 for a specimen of the Brazil magnesium, then in my possession, to be analyzed by Professor J. C. Lorin and Mme. A. Havette of the University of Paris. Lorin and Havette used a Cameca SIMS instrument. They detected calcium at the 8,500 ppm level, substantially higher than levels previously quoted. They also detected strontium at 700 ppm, similar to the level found by the Colorado Project (see Table 1).



In 1997, I arranged for new analyses of some of the specimens then in my possession. I began with SIMS analysis at a local laboratory, but the analyst found that the results were erratic. He ascribed this to the fact that the samples had not been properly mounted. He advised me that to get meaningful results from SIMS analysis, it would be necessary not only to mount and polish the specimens and cover them with conductors such as carbon or gold, but also to have some independent information as to the likely impurities. It therefore became clear that SIMS analysis was not the optimum search procedure.

I learned that Elemental Research Inc., in Vancouver, Canada, is one of the few laboratories in the world that have a laser ablation ICP-MS instrument. I was advised that this instrument can provide measurements at the 1 ppm level or better using only a micron-cube of a specimen, over the complete range of atomic numbers.

In September 1997, I arranged for Elemental Research to analyze two samples, SU-Ia (part of my sample SU-I) and SU-H. They also analyzed, at the same time, the following comparison samples: Dow CP-d, part of the Dow sample provided to and analyzed by the Colorado Project; ALFA-a and ALFA-2a, two samples of very pure magnesium purchased from the ALFA Corporation; and ISO-A, a sample of isotopically certified magnesium purchased from National Institute of Standards and Technology. The Dow specimen was generously made available to me by Dr. Roy Craig, who had been responsible for the analysis of the Brazil magnesium on behalf of the Colorado Project. The results of these analyses are shown in Table 3, where I display all elements for which there was a non-zero measurement for any one of those six specimens.

There is good agreement between the measurement of the composition of SU-Ia and SU-H, except that silicon shows up in SU-H and not in SU-Ia, and titanium appears to be more abundant in SU-Ia than in SU-H. Calcium was detected at the 3,000–5,000 ppm level, which is similar to the estimate made by the analysts at the University of Paris. Strontium was found to be present at the 600–900 ppm level, and barium at about the 300 ppm level; this result is approximately consistent with the results of the Colorado Project analysis. Ignoring estimates below 1 ppm, we see that barium appears (at 15 ppm) in only one of the comparison specimens and strontium in none of the comparison specimens.

As in our analysis of the surface composition, we note that the major impurities are calcium, strontium and barium, in that order. These all belong in the same column (column 2) of the Periodic Table, as does magnesium. This suggests that the Brazil magnesium was produced from material that contained not only magnesium but also calcium, strontium and barium.

As mentioned in Section 1, Professor Robert Ogilvie of MIT suggested to me that the Brazil magnesium may have come from the crash of an attempted launch of a Sputnik by the U.S.S.R. before the first successful launch of Sputnik One in October 1957. Ogilvie referred to this hypothetical spacecraft as “Sputnik Zero.” I have made inquiries into this possibility, and I have been ad-

TABLE 3  
Bulk Composition Analysis

Specimen			SU-1a	SU-H	DOW-CP-d	ALFA-a	ALFA 2a	ISO-A
Element	At No	Group						
Lithium (Li)	3	1	66.2	26.3		2.7	0.5	0.9
Beryllium (Be)	4	2		0.2				
Boron (B)	5	13	55.3	49.8	0.2	5.0	2.7	20.4
Magnesium (Mg)	12	14	major	major	major	major	major	major
Aluminum (Al)	13	13	27.0	56.7	12.0	10.0	33.0	14.1
Silicon (Si)	14	14		156.0	42.7		10.0	5.0
Phosphorus (P)	15	15						
Calcium (Ca)	20	2	4600.0	3230.0				911.0
Scandium (Sc)	21	3	0.4					0.3
Titanium (Ti)	22	4	283.0	37.4	0.7	7.6	0.7	2.0
Chromium (Cr)	24	6	0.7	3.1	0.8	4.5		13.3
Manganese (Mn)	25	7	54.6	59.3	7.0	35.4	175.0	8.3
Iron (Fe)	26	8					243.0	
Cobalt (Co)	27	9		0.2	0.5		0.4	
Nickel (Ni)	28	10	2.6	1.3	6.5	1.5	1.5	4.8
Copper (Cu)	29	11	3.0	16.6	411.0	2.0	5.3	3.0
Zinc (Zn)	30	12	27.8	17.5	2.4	1.3	0.4	9.0
Gallium (Ga)	31	13	0.8	1.4			0.2	0.1
Arsenic (As)	33	15	0.3					
Rubidium (Rb)	37	1		1.3				0.3
Strontium (Sr)	38	2	916.0	568.0				0.3
Zirconium (Zr)	40	4		0.3			0.1	
Molybdenum (Mo)	42	6	0.3	0.2				0.1
Rhodium (Rh)	45	9			0.4			
Palladium (Pd)	46	10	0.2	1.3				
Silver (Ag)	47	11	3.2					9.5
Cadmium (Cd)	48	12	0.4	3.4	0.2			2.0
Indium (In)	49	13						
Tin (Sn)	50	14	7.7	11.3	0.3	0.1	0.1	0.7
Antimony (Sb)	51	15	0.1	0.3				0.1
Tellurium (Te)	52	16		0.4				
Iodine (I)	53	17	0.1				0.1	0.1
Barium (Ba)	56	2	301.0	248.0	0.6	0.1	0.1	14.7
Lanthanum (La)	57	3		1.8			0.7	
Cerium (Ce)	58	3		0.6			2.7	
Praseodymium (Pr)	59	4					0.3	
Neodymium (Nd)	60	5					1.1	
Samarium (Sm)	62	7	0.3	0.2				
Europium (Eu)	63	8		0.1				
Gadolinium (Gd)	64	9		0.5			0.7	
Gold (Au)	79	11		0.2				
Mercury (Hg)	80	13	0.3	0.3	1.5		0.1	0.2
Thallium (Tl)	81	13						0.1
Lead (Pb)	82	14	7.1	10.5	15.8	0.8	3.0	1.8
Bismuth (Bi)	83	15		8.5			0.3	

Note: Abundances all in ppm.

vised by contacts in Russia that no such event occurred. However, I decided to compare the composition of the Brazil specimens with magnesium produced in the Soviet Union. Through the kind cooperation of Dr. Pavel Detkov of the Solikamsk Magnesium Works in Solikamsk, in the Perm region of Russia, I obtained information concerning the primary impurities of high-quality magnesium produced in the Soviet Union in the 1950s. Another correspondent in Russia kindly obtained for my analysis a small sample of magnesium alloy used in 1950-era MIG aircraft. Table 4 shows impurities in SU-H, ALFA-2a, ISO-A, a Solikamsk specimen, and the MIG specimen, as determined by analysis at Elemental Research. We see that SU-H has much higher levels of boron, calcium, titanium, strontium, and barium than the other four specimens.

It appears that the Solikamsk magnesium has very low impurity levels, comparable with those of the ALFA specimen. It is notable that there is no trace of either strontium or barium in the Solikamsk magnesium. The MIG material is basically a magnesium–aluminum alloy and is therefore quite different from the Brazil magnesium. The MIG material contains only traces of strontium and barium. Clearly, the composition of the Solikamsk magnesium and of the MIG magnesium–aluminum alloy provides no support for Ogilvie's interesting hypothesis that the Brazil magnesium came from the crash of a Russian spacecraft that preceded Sputnik One.

#### 4. Isotopic Analysis

There has been sustained interest in the isotopic composition of the Brazil magnesium. An anomalous isotopic composition would be strong evidence for an extraterrestrial origin. This possibility was of interest to Roy Craig, who arranged for the neutron activation analysis carried out at the National Office Laboratory, Alcohol and Tobacco Tax Division, Bureau of Internal Revenue, on behalf of the Colorado Project (Condon & Gillmor, 1969). The neutron activation analysis could be used to make an estimate of the percentage composition of  $^{26}\text{Mg}$  and it was found that the abundance of this isotope did not differ significantly from other magnesium specimens (Craig, 1969).

As mentioned in Section 1, in December 1975 I arranged to have a specimen of the Brazil magnesium analyzed at the Meteoritic Laboratory of Professor Gerald Wasserberg of the California Institute of Technology. I received a report from Dr. Typhoon Lee and Dr. D. A. Papanastassiou in October 1976. Lee and Papanastassiou did not provide me with their raw data, nor with separate estimates of the abundances of the three isotopes ( $^{24}\text{Mg}$ ,  $^{25}\text{Mg}$ , and  $^{26}\text{Mg}$ ), but they did present an analysis of their data indicating that the measurements were consistent with fractionation of normal magnesium. When magnesium is heated, it tends to lose the lighter isotopes preferentially: the change in the abundance ratio  $^{26}\text{Mg}/^{24}\text{Mg}$  should be twice the change in  $^{25}\text{Mg}/^{24}\text{Mg}$ . Lee and Papanastassiou informed me that their measurements were a close fit to this expectation.

More recently, I have attempted to obtain precise measurements of the iso-

TABLE 4  
Comparison of Brazil Specimen With US and USSR High-Purity Specimens  
and With Specimens From 1950-Era MIG Aircraft

Specimen				SU-H	ALFA 2a	ISO-A	Solikamsk	MG
Element		At No	Group					
Lithium	Li	3	1	26.3	0.5	0.9		1.0
Beryllium	Be	4	2	0.2				
Boron	B	5	13	49.8	2.7	20.4		27.0
Sodium							20.0	
Magnesium	Mg	12	14	major	major	major	major	major
Aluminum	Al	13	13	56.7	33.0	14.1	70.0	major
Silicon	Si	14	14	156.0	10.0	5.0	60.0	260.0
Phosphorus	P	15	15					11.0
Calcium	Ca	20	2	3230.0		911.0	3.0	1000.0
Scandium	Sc	21	3			0.3		
Titanium	Ti	22	4	37.4	0.7	2.0		40.0
Vanadium	V	23	5					3.6
Chromium	Cr	24	6	3.1		13.3		
Manganese	Mn	25	7	59.3	175.0	8.3	50.0	1510.0
Iron	Fe	26	8		243.0			
Cobalt	Co	27	9	0.2	0.4		60.0	0.3
Nickel	Ni	28	10	1.3	1.5	4.8	8.0	9.0
Copper	Cu	29	11	16.6	5.3	3.0	8.0	60.0
Zinc	Zn	30	12	17.5	0.4	9.0	30.0	79.0
Gallium	Ga	31	13	1.4	0.2	0.1		13.0
Arsenic	As	33	15					2.9
Rubidium	Rb	37	1	1.3				2.6
Strontium	Sr	38	2	568.0		0.3		3.5
Zirconium	Zr	40	4	0.3	0.1			0.2
Molybdenum	Mo	42	6	0.2		0.1		1.8
Ruthenium	Ru	44	8					0.4
Rhodium	Rh	45	9					0.3
Palladium	Pd	46	10	1.3				2.1
Silver	Ag	47	11			9.5		0.6
Cadmium	Cd	48	12	3.4		2.0	3.0	10.0
Indium	In	49	13					0.2
Tin	Sn	50	14	11.3	0.1	0.7	30.0	37.0
Antimony	Sb	51	15	0.3		0.1		8.9
Tellurium	Te	52	16	0.4				1.0
Iodine	I	53	17		0.1	0.1		
Barium	Ba	56	2	248.0	0.1	14.7		19.9
Lanthanum	La	57	3	1.8	0.7			2.8
Cerium	Ce	58	3	0.6	2.7			11.4
Praseodymium	Pr	59	4		0.3			1.6
Neodymium	Nd	60	5		1.1			4.0
Samarium	Sm	62	7	0.2				
Europium	Eu	68	8	0.1				
Gadolinium	Gd	64	9	0.5	0.7			2.9
Gold	Au	79	11	0.2				
Mercury	Hg	80	13	0.3	0.1	0.2		
Thallium	Tl	81	13			0.1		0.6
Lead	Pb	82	14	10.5	3.0	1.8	30.0	80.9
Bismuth	Bi	83	15	8.5	0.3			0.3

Note: Abundances all in ppm.

topic composition of the Brazil magnesium, but this has not been easy. The first laboratory that I approached led me to believe that they could make accurate measurements by means of SIMS analysis, but they did not deliver on this promise.

I next turned to Charles Evans and Associates in Redwood City, California. They first attempted to measure the isotopic ratio using an unmounted specimen, but the results were very erratic, and they decided that it would be essential to mount the specimen, polish it, and then gold-coat it. Charles Evans and Associates also advised me that it is essential to have comparison specimens. I therefore supplied their analyst, Dr. Jack Cheng, with one specimen of the Brazil magnesium (SU-A); two specimens of triply sublimed Dow magnesium that had been provided to me in the 1970s (Dow A and Dow E); a specimen that had been used at Johnson Space Center for comparison, derived originally from the Baker Company (Baker A); and part of the triply sublimed magnesium that the Dow Chemical Company had provided to the Colorado Project in the 1960s (Dow CP). The Baker specimen was kindly provided by Dr. Richard Williams of Johnson Space Center, and the Dow CP specimen was kindly provided by Dr. Roy Craig of Durango, Colorado (formerly at the University of Colorado).

Charles Evans and Associates took great care in the mounting, polishing and coating of the specimens and they made a number of runs with SIMS instrumentation. The results are shown in Figure 1. The measured isotopic ratio for Dow CP is very close to that expected of normal terrestrial magnesium, for which  $^{25}\text{Mg}/^{24}\text{Mg} = 0.127$  and  $^{26}\text{Mg}/^{24}\text{Mg} = 0.139$ . The solid line in Figure 1 is the track to be expected if fractionation occurs due to heating. We see that all specimens lie on that track. It is curious that the isotopic ratios for the Dow CP specimen are quite close to the values for normal magnesium, since this specimen and also the specimens Dow A and Dow E were all produced by triple sublimation. The mechanism for the production of the Baker specimen is unknown, but it may well have been sublimation since that is the normal procedure used to purify magnesium.

We see that the Brazil specimen SU-A is the furthest from normal composition. However, it is on the same track as the other specimens. One may therefore infer that a specimen with the same isotopic composition as SU-A could be produced from normal magnesium by multiple sublimation. Hence this analysis does not point toward a non-terrestrial origin for the specimen SU-A.

However, these results are somewhat surprising. Sublimation (or any other form of fractionation) moves the isotopic composition away from the normal ratios ( $^{25}\text{Mg}/^{24}\text{Mg} = 0.127$  and  $^{26}\text{Mg}/^{24}\text{Mg} = 0.139$ ), along the track shown in Figure 1. However, it also tends to purify the magnesium, although this tendency is contingent upon the sublimation thermodynamics of the ensemble of elements. One therefore tends to expect that the specimen with the most deviant isotopic composition will also be the purest specimen. However, we see that SU-A is the furthest from normal composition, but it is less pure than the

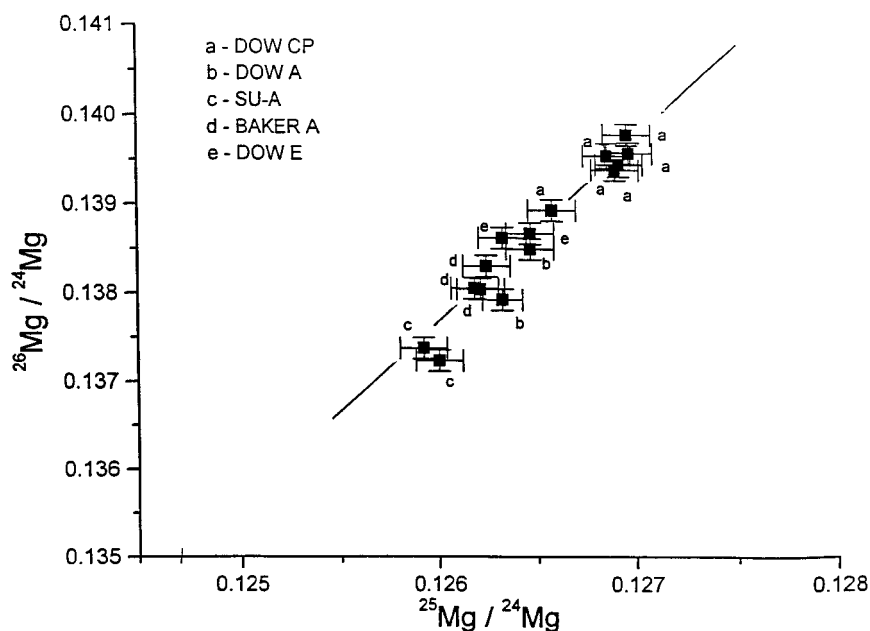


Fig. 1. Plot of the determination of the isotopic ratios  $^{25}\text{Mg}/^{24}\text{Mg}$  and  $^{26}\text{Mg}/^{24}\text{Mg}$ , as measured by Charles Evans and Associates by SIMS (secondary ion mass spectrometry) analysis, for the following specimens: (a) DOW CP, the Dow sample of triply sublimed magnesium used by the Colorado Project; (b) DOW A, a sample of triply sublimed magnesium supplied to me by Dow Chemical Company; SU-A, one of the Brazil magnesium specimens; Baker A, a magnesium standard used by Johnson Space Flight Center; and DOW E, another sample of triply sublimed magnesium supplied to me by Dow Chemical Company; Specimen (a) is located closest to the ideal ratios  $^{25}\text{Mg}/^{24}\text{Mg} = 0.127$  and  $^{26}\text{Mg}/^{24}\text{Mg} = 0.139$ .

DOW-CP specimen, for example. The former has high abundance of Ca, Sr and Ba, whereas the latter is almost free of these three impurities.

In addition to the abundance analyses reported in Sections 2 and 3, Elemental Research also analyzed certain specimens with greatly increased mass-to-charge resolution in the neighborhood of the values appropriate for the magnesium isotopes. The results are shown in the four panels of Figure 2. Panels a and b show the scans obtained for two specimens of the Brazil magnesium, SU-Ia and SU-H. Panel c shows the scan obtained for specimen ALFA-a, one of the standards used in this work. Panel d shows the scan obtained for specimen Iso-A, part of the magnesium isotopic standard obtained from the National Institute of Standards and Technology. We see that the isotopic compositions of these four specimens are indistinguishable: the isotopic composition of the Brazil magnesium is clearly compatible with terrestrial origin.

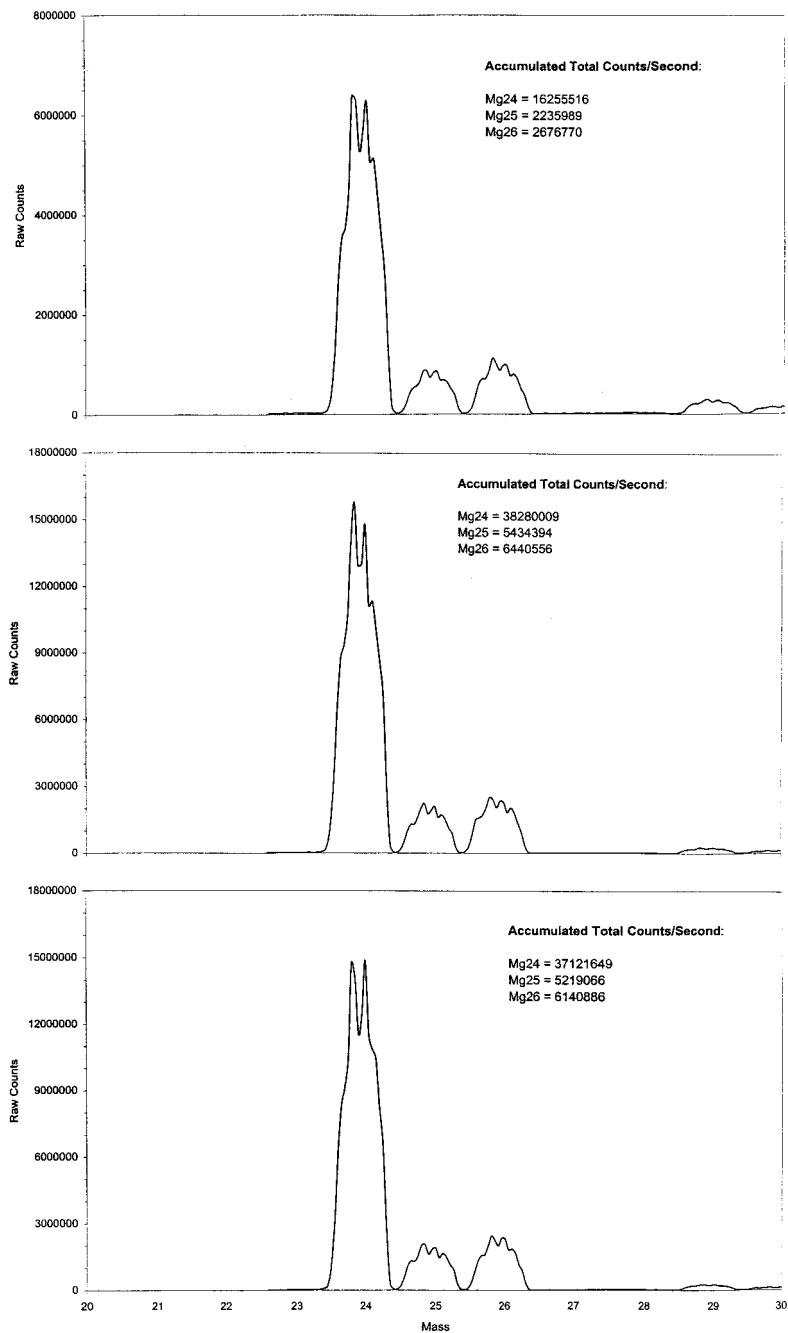


Fig. 2. Isotopic composition as determined by Elemental Research, Inc., using high-resolution mass scans of ICP-MS (inductively coupled plasma mass spectrometer): (a) Brazil magnesium specimen SU-H; (b) magnesium standard ALFA-a; (c) magnesium isotopic standard ISO-A. (The mass scan of specimen SU-Ia is indistinguishable from that of SU-H.)

## 5. Discussion

The Brazil magnesium has attracted great interest from the UFO research community for a variety of reasons that were reviewed briefly in Section 1.

- It was the only material specimen investigated by the Colorado Project. The Colorado Project staff conducted a good analysis, as far as it went. However, it is regrettable that the Project did not send an investigator to Brazil. The investigator may or may not have been able to obtain more information from inquiries in the Ubatuba area. However, he could have consulted with Brazilian authorities. Such inquiries might have turned up more information about the event (if real), and the investigator would have been able to address some serious questions to the analysts at the National Department of Mineral Production. It is also likely that, even without sending an investigator to Brazil, the Project might have been able to send an inquiry through official channels and so obtain the results of tests carried out by the Brazilian Army and Navy.
- From the very beginning, there have been claims that some of the specimens were “ultra-pure,” more pure than magnesium produced on Earth at that time, with the implication that the magnesium was of extraterrestrial origin. These claims are very suspect. Analysis of the material that was in APRO possession was by no means ultra-pure—it contains calcium at the 1,000 ppm level. Hence the claim of ultra-purity has rested on the possibility that Sample 1 (the subject of the original analysis in Rio de Janeiro) was significantly different from Samples 2 and 3, which were sent to APRO. However, in his letter transmitting these samples, Fontes mentions that he is also enclosing a small remaining piece of Sample 1. Unfortunately, the Lorenzens did not keep a careful log of the specimens, so it is not possible at this time to identify that piece, or even to be sure that it is still part of the remaining specimens.

Furthermore, looking back on the reports prepared by the analysts at the Mineral Production Laboratory, it is clear that they did not justify Fontes' claim that Sample 1 had been found to be ultra-pure. The analysts stated that they found no impurities in the sample, *but* they added that neither did they find impurities in a comparison specimen, and neither did they detect the usual impurities attributable to the carbon rods. Perhaps their equipment was not working properly. Perhaps the analysts were having a bad day. Or perhaps the laboratory was deliberately withholding information. Government agencies, both in Brazil and in the United States, seem to have been either incompetent or uncommunicative with respect to the Brazil magnesium. The Brazilian Army and Navy both withheld from Fontes the results of their tests. The U.S. Air Force either destroyed a specimen or withheld information from the Lorenzens. An analyst at a NASA laboratory claimed that he was unable to detect any impurities either in the Brazil specimen or in a comparison specimen.

Investigators with the Colorado Project did draw attention to the presence of



strontium and barium in the Brazil magnesium. According to experts at the Dow Chemical Company, no one knew of any production procedure that would lead to these impurities, and no one knew of any producer who deliberately added these elements to magnesium. It may or may not be significant that magnesium, strontium and barium all belong to the same chemical group (group 2).

Analysis of the surface material yields a rich mixture of elements, and this fact deserves further investigation. It would be helpful to get expert advice on whether these elements could arise from contamination in a natural setting (air, water, sand, etc.) or whether they indicate that the specimens were at one time associated with materials usually found in a technological setting.

As far as one can tell from analyses carried out to date, there is no case for believing that the Brazil magnesium specimens had an extraterrestrial origin. On the other hand, it has not proved possible to identify where the material was produced.

However, composition analysis covers only one area of questioning concerning the Brazil magnesium. Inquiry into a UFO case normally involves investigation of the witness or witnesses. Unfortunately, the identity of the person who sent the material to Sued remains a mystery. At my instigation, Sued published a request for further information in his column dated August 21, 1985, but there was no response.

In an attempt to gain some information relative to the origin of the Brazil magnesium, Professor Pierre Kaufmann of Sao Paulo has carried out some inquiries in the Ubatuba area, with interesting but by no means conclusive results. These investigations will be reported in a separate article.

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### Notes

<sup>1</sup> There have been classified studies. For instance, it is known that the Air Force commissioned classified research by the Battelle Memorial Institute in Columbus, Ohio, in the early 1950s and that the Central Intelligence Agency commissioned a classified review by the Robertson Panel in 1953. For more on this point, or for a more general introduction to UFO history, see, for instance, Clark (1998) or Jacobs (1975).

<sup>2</sup> This may have been viewed as a way for President Jimmy Carter to deliver on his campaign promise that, if elected, he would find out the truth about UFO reports and release the information to the public.

<sup>3</sup> Since there had been no systematic tracking of specimens in the APRO files, it was convenient to adopt a new system of coding the various specimens when they were transferred from APRO to Stanford University. Specimens received from APRO were numbered SU-A, SU-B, etc. If a specimen was subdivided, its parts were coded SU-Ia, SU-Ib, etc.

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## **Appendix 1. Transcription from O Globo, Rio de Janeiro, September 14, 1957**

### **REPORTAGE SOCIAL DE IBRAHIM SUED**

#### **UM FRAGMENTO DE DISCO-VOADOR!**

RECEBEMOS: “Prezado Sr. Ibrahim Sued. Leitor assíduo de sua coluna e seu admirador, quero proporcionar-lhe um verdadeiro furo jornalístico a respeito dos discos voadores, se e que acredita nos mesmos. Eu também não acreditava no que ouvia falar e somente lia, áte que, alguns dias atras, perto de Ubatuba, em pescaria com vários amigos, vi um disco-voador! Aproximou-se da praia em incrível velocidade, parecendo prestes a abater-se sobre as aguas, quando, a um impulso fantástico, elevou-se rapidamente. Atônitos, seguíamos com os olhos êsse espetáculo, quando vimos o disco explodir em chamas, saindo em milhares de pedaços que pareciam fogos de artifício—apesar de ser doze horas, ou seja, meio-dia—com um brilho fortissimo. Êsses pedaços caíram quase todos no mar, mas muitos pequenos pedaços caíram perto da praia, tendo nos recolhido um bom numero dêsse material, tão leve que parecia papel. Aqui junto uma pequena amostra dêsse material, que não sei a quem devo confiar para analisar. Nunca li que houvesse sido recolhido um disco-voador ou que se tivessem recolhido pedaços de um disco, a não ser que as autoridades militares o tenham feito e usado de sigilo. Estou certo de que êste assunto bastante interessará ao brilhante cronista, e mando-lhe esta em duplicata, para o jornal e para a sua residência...” Do admirador, (assinatura ilegível), junto, recebi detritos de um metal estranho.

## **Appendix 2. Isotopic Fractionation**

Processing, such as sublimation, that involves heating the material, will lead to changes in the ratio of the abundances of the various isotopes. The lighter isotopes “boil off” more readily, so that the mixture changes in favor of the heavier isotopes. Magnesium has three stable isotopes, with atomic weights 24, 25 and 26. The evaporation rate is inversely proportional to the atomic weight, and this leads to a relationship between the three rates of change of the abundances.

If we write the fractional abundances of the three isotopes as  $F_{24}$ ,  $F_{25}$  and  $F_{26}$ , and if the abundances change by  $\delta F_{24}$ ,  $\delta F_{25}$  and  $\delta F_{26}$ , these changes will be related by

$$\frac{\delta F_{24}}{F_{24}} : \frac{\delta F_{25}}{F_{25}} : \frac{\delta F_{26}}{F_{26}} = \frac{1}{24} : \frac{1}{25} : \frac{1}{26} . \quad (\text{B.1})$$

The normal ratios are conventionally expressed in the form

$$\frac{F_{25}}{F_{24}} = 0.127, \quad \frac{F_{26}}{F_{24}} = 0.140. \quad (\text{B.2})$$

By manipulating these two equations, we find that the fractional changes in these two ratios are related by

$$\frac{\delta(F_{26}/F_{24})}{\delta(F_{25}/F_{24})} = \frac{(1/26 - 1/24)}{(1/25 - 1/24)} \frac{F_{26}}{F_{25}}, \quad (\text{B.3})$$

i.e., by

$$\frac{\delta(F_{26}/F_{24})}{\delta(F_{25}/F_{24})} = 2.12. \quad (\text{B.4})$$

This is the track shown in Figure 1.