Analysis of Alleged Fragments from an Exploding UFO near Ubatuba, Brazil: an introduction

by
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Abstract:

One of the rare alleged artifacts from a UFO, which was available for proper scientific study in laboratories, was the fall of magnesium metal fragments which apparently occurred on the coast of Brazil in the 1950's. These controversial materials have been looked at by several laboratories, but, until now, never properly reported upon in depth. The core of this review article is a paper, hitherto unpublished, written in 1969-70 by Drs. Walker and Johnson, which compares the studies available at that time, and adds significant new metallurgical analyses. While adding more descriptive information about the nature of the material, these tests do not allow a clear identification as either terrestrial or extraterrestrial materials.

Historical Introduction

In March of 1960, the APRO Bulletin produced a story of alleged UFO fragments bearing the banner headline, "PHYSICAL EVIDENCE." The report stated that in September of 1957 a reader o the Rio de Janeiro daily, O Globo, had sent a letter as follows:

> "Dear Mr. Ibrahim Sued. As a faithful reader of your column and your admirer, I wish to give you something of the highest interest to a newspaperman, about the 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 some 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 was almost striking the waters, it made a sharp turn upward and climbed rapidly on a fantastic impulse. We followed the spectacle with our eyes, startled, 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 these 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 as light as paper. I am enclosing a small sample of it. I don't know anyone that could be trusted to whom I might send it for analysis. I never read about a flying disc being found, or about fragments or parts of a saucer 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 not legible), together with the above letter, I received fragments of a strange metal...

The original witness/correspondent (to this writer's knowledge) remains unknown to this day. Local people remember some vacationers there at the time, but that is all. There has been one published statement that the event may have occurred as many as 20 years earlier (in the 1930s)(Pierre Kaufman in Sturrock: 1985 and Vallee: 1990), but as no proper documentation was given for that claim, and because it is at variance with the primary case investigator's (Dr. Olavo Fontes) findings in local interviews, it is best disregarded at this time. The event, if it happened at all, is probably a late summer 1957 phenomenon. (Fontes: 1962).

Olavo Fontes, the renown Brazilian investigator of UFOs, became involved with the case immediately, due to the fact that the sample fragments were sent to O Globo along with the correspondence. Fontes' description of the materials and the Brazilian testing of them are included in the formal paper by Drs. Walker and Johnson which

follows. Their report also discusses subsequent U.S. testing carried out largely in connection with the famous University of Colorado Project for the study of unidentified flying objects (the "Condon Project"). Since the writing of the Walker-Johnson study, the only other properly reported study of the Ubatuba fragments has been by Dr. Peter Sturrock of Stanford. Unfortunately, this report, though by a scientist of highest quality, is currently available only in the briefest form: that of an abstract for an oral presentation to the Society of Scientific Exploration in 1984. (Sturrock: 1985). The relevant results from the abstract are quoted below. The referred to tests on isotopic ratio do not seem to be available anywhere for "public" scientific perusal, nor does there seem to be paper publication of another claimed test by an Australian group (Walker: 1980). This laxity in proper publication may be forgiven by the lack of available publishing vehicles, due to editorial hostility to UFO-related research, but in 1992 with the existence of this present journal and its sister publication, the Journal of Scientific Exploration, one hopes that such covert results will rapidly become public.

Now, before we proceed with the major paper by Drs. Johnson and Walker, a few relevant quotes to aid the reader in the appreciation of the dimensions of testing thus for involved with these fragments. Here is the report by Dr. Sturrock:

> The "Brazil magnesium" first came to public attention in Rio de Janeiro in 1957. Its reputed place of origin was the Ubatuba area, but this purported origin has never been substantiated. As described in the Condon Report, the Colorado Project investigated this material to the extent of arranging for neutron-activation analysis. The samples are composed of magnesium, and are more pure than commercially produced magnesium but possibly not as pure as multiply sublimed magnesium.
>
> At various times, the samples have been analyzed for chemical composition, with the following results expressed, for brevity, as elements detected with abundance greater than 100 ppm; Brazil (three tests with emission spectrographs), none; Oak Ridge National Laboratory (emission spectrograph), Al, Fe, Si; Dow Chemical Company (emission spectrograph), Al, Ba, Ca, Cu, Fe, Pb, Sr; Bureau of Internal Revenue (neutron activation), Ba, Sr, Zn; MIT (electron microprobe), none; and Evans Associates (Camica ion microprobe), Al, Ca, Li, Mn, Sr.
>
> Through the courtesy of Mr. James Lorenzen of APRO, I have been able to arrange for further tests on these samples, with the following results; Stanford University (electron microprobe), none; NASA Johnson Space Flight Center (ARC ion microprobe) none; Evans Associates (Cameca ion microprobe), C, Ca, Cl, Fe, K, Li, Na, Sr, Ti. None of the positive detections can be securely attributed to the interior metal of the sample. Consequently, after all these years, we still do not have a single reliable measurement of the actual impurities and impurity level of the Brazil magnesium. By contrast, the isotopic ratio has been measured at the California Institute of Technology and at the University of Paris at Orsay with high accuracy and with consistent results. The ratios are the same as in normal terrestrial

magnesium. Measurements at Stanford with an electron microprobe show that the white material covering much of the magnesium is Mg(OH) with the following impurities each at about 2,000 ppm; Ca, Cl, Fe, Si, Ti.

Investigations by Dr. Pierre Kaufmann of Sao Paulo have shown that the only aerial event to occur at or near Ubatuba in 1957 was the crash of a DC3. However, In 1933 or 1934, a bolide passed over Ubatuba and crashed at a nearby beach. At approximately the same time, some unusually light material was captured in the nets of fishermen in the area. Sturrock: 1985.

During the initial studies by Dow Metal Products in 1961, the chief investigator, Dr. R. S. Busk, director of the metallurgical laboratory said this about the fragment:

We have also examined the piece metallographically and find that it is quite free of inclusions and has a columnar grain. A conclusion I would arrive at from these two sets of facts is that this is a very good sample of high purity magnesium. One element that is rather high is calcium at 0.01%. We have seen many samples of magnesium that are as clean and low in alloy content as this material. Busk: 1961

Writing for the University of Colorado during the Condon Project investigation, Dr. Roy Craig wrote the Lorenzens with the following news:

I promised you a copy of the analysis of Ubatuba magnesium. A copy of the neutron-activation analysis results is attached. While these results are in some ways surprising, they should be dependable. I deliberately took them to a laboratory where the personnel had no special interest in the UFO question (Alcohol and Tobacco Tax Division of the Bureau of Internal Revenue). I personally delivered the samples there, and watched the entire operation of sample irradiation and gamma-spectrometry. Thus I know there has been no hanky-panky involved in this analysis. I have all the original data--i.e. gamma-spectrometer read-out tapes and graphs, irradiation data, and exposure and counting times -- here in the office so they are available for re-checking.

We did not irradiate the entire Ubatuba sample, but used a sliver of it, which is adequate for neutron-activation analysis. I'll return the rest of your sample to you, as per our agreement, but would like to keep it until I confirm that the composition is or is not unique in any way. I may wish to have it examined metallographically before returning it.

Incidentally, neutron-activation also allows us to determine if the magnesium has an unusual isotope ratio. The reaction Mg^{26} (n,) Mg^{27} would produce more radioactive Mg^{27} if the magnesium originally was composed of unusually great amounts of the Mg^{26} isotope. Because of the letter to you from Frederic B. Jueneman, a copy of which you sent to me, we looked at this possibility in Washington. The concentration of Mg^{26} isotope was essentially the same as in terrestrial magnesium (11.2%).

Craig: 1968A

Finally, in the last "wave" of Ubatuba testing (in the seventies), an unnamed governmental laboratory (NASA) measured the isotopic ratios of the magnesium, and, when asked to publish the results, issued this strange (and anti-scientific) viewpoint:

> "We believe that the request to provide these analyses was reasonable; however, in view of the fact that this sample has normal terrestrial isotopic composition, we see no purpose in publishing this result. As I mentioned to you, we frequently receive requests from individuals to check whether a rock or a piece of metal is a meteorite. In most eases, it is either a terrestrial rock or a furnace slag. In none of these instances do we publish our finding. ....we believe that the magnesium results are of no scientific interest and should not be published. The owner of the material may be told informally that the magnesium is of terrestrial composition; however, without identifying the source of the information." Anon: 1976?

Drs. Walker and Johnson (as well as Dr. Sturrock and we at JUFOS) do believe in publishing testing and results, however, and so we are happy to present the complete text of the research paper by Drs. Walker and Johnson, ending a gap which has remained in this case for thirty years.

. WKJ paper(s) in Ubatuba Case file.

Anonymous
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FURTHER STUDIES ON THE

UBATUBA UFO MAGNESIUM SAMPLES

by

Walter W. Walker, Ph.D

and

Robert W. Johnson, Ph.D

(Winner of the 1970 Fontes

Memorial Scientific UFO Research Award)

CHAPTER I

INTRODUCTION

Sometime in 1957 a UFO is reported to have exploded in the air over the beach at Ubatuba, Saõ Paulo, Brazil. Several fragments of metal were subsequently recovered from the ocean. Chemical analysis showed that the metal was ultra-pure magnesium. These pieces of magnesium have since been subjected to repeated chemical analyses with conflicting results. These repeated chemical analyses have not led to any conclusive proof as to extraterrestrial origin but have resulted in the destruction of much valuable material.

The purpose of the present study is to look at these magnesium samples from a *structural* rather than the *compositional* viewpoint as has been done in the past.

The Twentieth Century has seen the rise of many new scientific disciplines, among which is Materials Science. Materials Science resulted from the realization within the past three decades that the properties of a material are a result of its structure (1). Chemical composition only affects the properties of materials to the extent that it affects the structure. Structural studies, not chemical composition, are therefore of paramount importance in the study of any material. From a brief review of all of the previous work which has been done on the Ubatuba magnesium samples, one is immediately struck by the fact that essentially all that has been accomplished to date has been in the realm of chemical analyses, not structural studies. The present study was undertaken in the hope that a look at the Ubatuba magnesium, from a fresh viewpoint (that of structure), might yield additional interesting information about this material.

CHAPTER II

LITERATURE REVIEW

As an initial step in the present study, the literature on the subject of the Ubatuba magnesium was critically reviewed. Three published sources: the Fontes account in Coral Lorenzen's book, Flying Saucers, The Startling Evidence of the Invasion from Outer Space (2), The Scientific Study of Unidentified Flying Objects (3), and Saunders and Harkins' UFO's? YES! (4), in addition to certain unpublished original material from the files of APRO.

Chronological Review

The initial and most thorough study of the Ubatuba magnesium to date is that of Fontes (5). Since the data in Coral Lorenzen's book (6) closely follows the original sources (7, 8), the published Fontes account (9) will be used as a basis for this part of the review.

The Ubatuba magnesium samples first came to light through the column of a well known Rio de Janeiro society columnist, Ibraham Sued, dated September 14, 1957. The column quoted a letter from an unknown correspondent which described an explosion of a UFO over the beach at Ubatuba, São Paulo, Brazil. Three samples of metal from "a large amount" which was collected, were forwarded with this letter. Mr. Sued kindly furnished the three metal fragments to the late Dr. Olavo T. Fontes, M.D., who was the Brazilian APRO Representative. For purposes of clarity, these samples will henceforth be referred to as Samples No. 1, 2, and 3, in accordance with Dr. Fontes' nomenclature.

Dr. Fontes describes the three samples as follows: "Three small pieces of dark-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. Their appearance suggested that they might be, if really metallic, pieces of fragments disintegrated from a larger metallic mass of object; in fact, the surface of one of the samples was shot through with microscopic cracks always longitudinal and even showed on one face a large longitudinal fissure running almost two-thirds of its length, as if that piece had been disrupted under the action of some force. The others did not show many cracks or fissures, but the surfaces of all samples were covered with scattered areas of 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. It also filled fissures and cracks of the first sample." Two of the samples were later photographed in their original form (Figure 1).

Dr. Fontes initially submitted his samples to the Mineral Production Laboratory, a division of the National Department of Mineral Production, of the Agriculture Ministry of Brazil. Dr. Feigl, the chief chemist, performed a phosphomolybdic acid spot test which confirmed that the substance was metallic.

Sample No. 1 was subsequently divided into several pieces, and two of these were submitted to the Spectrographic Section of the Mineral Production Laboratory, where they were analyzed by Dr. Luisa Maria A. Barbosa. Dr. Barbosa's report reads as follows:

> "The spectrographic analysis showed the presence of magnesium (Mg) of a high degree of purity and the absence of any other metallic element."

When questioned about these unusual results, Dr. Barbosa pointed out that the magnesium *could* still contain other possible constituents which would escape detection by

the spectrographic method. These would, for example, be elements which have too low a volatility or whose characteristic lines are obscured by background.

A second emission spectrographic examination was then made on the Hilger spectrograph by Mr. Elson Teixeira. He verified that Sample No. 1 was extremely pure magnesium. Even those elements which normally exist in the carbon electrode, and which sometimes appear as contaminants, were not detected.

Dr. Fontes next submitted some fragments of Sample No. 1 to Dr. Elysiario Tavera Filho at the Laboratory of Crystallography for X-ray analysis. Dr. Filho performed repeated X-ray spectrometric analyses which indicated the material was pure magnesium. He also prepared some filings and made a conventional X-ray diffraction powder pattern. His powder pattern results are given in detail in Mrs. Lorenzen's book.

The specific gravity of Sample No. 1 was determined by the classical Archimedes method on a Jolly balance. The density was found to be 1.866 instead of 1.74, which is the theoretical density of magnesium.

Faint Debye rings on the powder pattern indicated that some other crystalline contaminant was present. This was subsequently identified as $Mg(OH)_2$ and was attributed to oxidation and water quenching.

Two other spectrographic analyses were apparently run on Sample No. 1 in Brazil, by the Brazilian Army and Brazilian Navy. The results of these analyses are unknown. <u>All of Sample No. 1 was consumed in the tests discussed above</u>.

Aside from the X-ray diffraction study, the only structural investigation of Sample No. 1 was a cursory microscopic study by Dr. Batista of the Laboratory of Crystallography. Dr. Batista stated that the microstructure was that of a casting.

Samples No. 2 and 3 were sent to APRO Headquarters in the United States. Since all of Sample No. 1 was destroyed during testing in Brazil, none is available for further investigations.

The next attempt at analysis was made on Sample No. 2 by APRO (10). A portion of Sample No. 2 was submitted to an Air Force spectrographic laboratory for analysis. For unknown reasons, the entire sample was burned without exposing a film or plate, hence no record of the emission spectrum was made. The emission spectrograph operator requested another sample but APRO declined.

The next investigation was undertaken on Sample No. 2 by an Atomic Energy Commission (AEC) national laboratory, which prefers to remain anonymous. The original source (11) from APRO files is used as the basis for the following review. One of the authors (WWW) once worked at this particular AEC laboratory and is familiar with their capabilities. He also knows one of the investigators personally and will vouch for the technical competence of the personnel involved.

The specimen was first tested for specific gravity using the heavy media method. The specific gravity was found to be 1.7513. Since this density is only slightly greater than the theoretical value of 1.74, further mass spectrographic analyses to look for heavy magnesium isotopes was deemed unprofitable.

The Sample No. 2 fragments were next subjected to emission spectrography using an ARL 2-meter grating spectrograph with a dispersion of 5 Å/mm. Results of this analysis are given in Table I in the column marked, "AEC Laboratory." Results were reported in weight percent but were converted to ppm by the authors. As seen from Table I, Sample No. 2 was much less pure than Sample No. 1.

Finally, certain samples were prepared for microscopic examination by the metallography section of the AEC laboratory. Microscopic examination showed that the

metal was shot through with cracks which were filled with a non-metallic material (Figure 2); the same material was observed as a scale on the surface (Figure 3). Considerable internal oxidation and subscale was also observed near the outer surface (Figure 4).

At approximately this same time, APRO also submitted a portion of Sample No. 2 to Dr. R. S. Busk, Director, Metallurgical Laboratory, the Dow Metal Products Co., Midland, Michigan. His report (12) is given in Table I also. Comparison of the AEC spectrographic data and that of Dow Metal Products Laboratory in Table I shows that there are significant variances in the amounts of barium, calcium, and strontium.

The most recent investigation of the Ubatuba magnesium was undertaken as part of the University of Colorado UFO Project (Condon Committee). The basis for this part of the review are the published sources (13, 14).

The investigator was Dr. Roy Craig, a physical chemist. The sample studied was Fontes Sample No. 3, which had not been previously investigated (15). In this investigation, a new analytical method was used. This method is neutron activation analysis. Results of this study are given in Table II. For comparison all other published analyses are also listed. As Saunders and Harkins (16) point out, the neutron activation results are quite noteworthy for the types of impurities (strontium, barium, and zinc) which were found. Microprobe analysis indicated that the impurities listed were in solid solution in the magnesium. Metallographic examination showed large, elongated metal grains typical of a casting. Based on this typical as-cast grain structure, the Condon Report states that "it therefore seems doubtful that this sample had been part of a fabricated metal object."

Apparently, to the Condon Committee, castings are not fabricated metal objects. The authors believe that the entire foundry industry in the United States might take exception to this conclusion.

Critical Evaluation of the Literature

Every investigator of the Ubatuba magnesium to date has either implicitly or explicitly made the assumption that all three Ubatuba samples have the same composition and density. For example, Fontes (17) states, ". . . Sample No. 2 was not analyzed in Brazil, but there is no logical reason to suspect it is less pure than the other . . . the material is similar in appearance and came from the same object."

The purpose of this portion of the review is to critically examine this assumption in the light of reported results.

Comparison of Analyses

Two hypotheses may be made concerning the different compositions reported in the literature: Either all samples had the same composition and the reported variations were due to differences in analytical techniques, or the samples varied in composition.

Comparison of Emission Spectrograph Results. The ultra-high purity of Ubatuba Sample No. 1 was determined in Brazil by emission spectrography. Both Busk (18) and the AEC laboratory (19), also using emission spectrography, found that Sample No. 2 was much less pure than Sample No. 1. The assumption was again made that Sample No. 2 must have the same composition as Sample No. 1. The fact that Sample No. 2 proved less pure than Sample No. 1, in fact, contributed to the AEC principal investigator giving up his belief in the extraterrestrial origin of UFOs! There is some doubt, however, that the AEC investigators were aware that their material was not part of Ubatuba No. 1 as described by Fontes (20).

If Sample No. 1 had the same composition as Sample No. 2, and if emission spectrography techniques were identical, then the reported analytical results should have

been identical. But they were not. The question, therefore, arises as to whether the discrepancy is in analytical techniques or in composition.

Duplicate emission spectrographic analyses of Sample No. 2 by the AEC laboratory and Busk did not give comparative results (Table I). If two qualified, reputable emission spectrographic laboratories such as the AEC laboratory and the Dow Metal Products laboratory cannot arrive at the same results on the same sample (Sample No. 2), then we have no cause to suggest that the Brazilian analyses of Sample No. 1 were any less precise than the North American analyses of Sample No. 2.

If it is accepted that Brazilian analyses of Sample No. 1 were as correct as those on Sample No. 2, then it can only be concluded that Sample No. 1 was much purer than Sample No. 2.

Comparison of Emission Spectrograph Results with Neutron Activation Analysis. The latest chemical analysis of the Ubatuba samples was performed on Sample No. 3 in the National Office Laboratory, Alcohol and Tobacco Tax Division, Bureau of Internal Revenue, as reported by Craig (21). The results of this analysis and all other published analyses are given in Table II.

Comparison of the Brazilian analysis of Sample No. 1 with IRS analysis of Sample No. 3 shows that Sample No. 3 was less pure than Sample No. 1. Comparison of the emission spectrographic results on Sample No. 2 (AEC laboratory and Dow) with the Neutron Activation Analysis (IRS) results of Sample No. 3 reveals markedly different composition in Samples No. 2 and 3. Both are much less pure than Sample No. 1, however. Again, if the assumption is made that Samples No. 1, 2, and 3 are of equal purity, then at least three of the four analyses in Table II must be in error. To the authors, this conclusion appears less likely than that all analyses are reasonably correct but that the samples vary in composition.

It is hoped that the above critical evaluation will demonstrate the futility of further chemical analyses. However, for completeness alone, it is suggested that a spark-source mass spectrometer analysis be performed on either Samples No. 2 or 3. This is the technique that Morrison (22) plans to use on returned lunar material. Such an analysis should finally settle any questions concerning unusual isotopic ratios in the Ubatuba material.

Comparison of Densities

The theoretical density of Sample No. 1 may be easily calculated from the X-ray diffraction data cited by Fontes (23). This was done by the authors and the result was 1.743, which agrees closely with values cited in the literature. The experimental density value Fontes reported was 1.866. Fontes also reported that Sample No. 1 was contaminated with $Mg(OH)_2$ (not MgO as suggested by the AEC laboratory). If the discrepancy in density is due to $Mg(OH)_2$ entrained in the sample, then the amount of $Mg(OH)_2$ present may be calculated from a linear equation, which gives the relationship between the fraction of magnesium (X) present in the mixture and the density of the mixture.

$$1.866 = X(1.74) + (1-X)(2.36)$$

X = 79 v/o magnesium metal

$(1-X)$ = 21 v/o magnesium hydroxide

Fontes' description of Sample No. 1 (which was quoted earlier) lends credence to the fact that this sample may have had as much as 21 v/o entrained $Mg(OH)_2$.

Similarly, inspection of Figure 2 from the AEC laboratory indicates that Sample No. 2 may contain at least 8.55 v/o $Mg(OH)_2$. Applying the same equation gives a density of 1.785 as compared to the experimental value of 1.7513.

It is therefore obvious that entrained $Mg(OH)_2$ could account for anomalous measured densities without invoking the abnormal isotopic experimental ratios suggested by Jueneman (24).

Structural Studies

Microstructure. Although Fontes (Sample No. 1), the AEC laboratory (Sample No. 2), and the Condon Committee (Sample No. 3) all reported that they performed microscopic studies on their respective samples, not one *single micrograph* of the structure of the Ubatuba magnesium has ever been published! This observation becomes almost incredible when it is considered that all accepted metallurgical journals are stuffed with beautiful photomicrographs illustrating microstructures. Lack of published photomicrographs only reinforces the authors' opinion that the structure of the Ubatuba magnesium has been sadly neglected.

Mechanical Tests. One of the first tests any metallurgist performs on a metallographically prepared sample is microhardness. Again, it is incredible to find that no one has yet performed any microhardness tests on the mounted Ubatuba samples available. As a result, we have no way of knowing if this material is anomalously hard, soft, or merely normal.

Defect Concentration Studies. The non-metallurgists who have investigated the Ubatuba material to date have ascribed ultra-high strength properties to this material due to its unusual purity (25) or due to the unusual impurities it contains. Actually, a high degree of purity does not increase strength.. Impurities (alloying elements) are added to pure metals

mainly to impart strength. Similarly, addition of HCP alloys such as strontium or zinc in solid solution in HCP magnesium does not necessarily impart strength or hardness to the magnesium, as suggested by Saunders and Harkins (26).

If mechanical testing reveals that the Ubatuba samples are in any way unique, this uniqueness will undoubtedly be connected with the number and distribution of dislocations. As yet, no one has attempted to determine the dislocation density and distribution in this material.

X-Ray Diffraction Studies. The only X-ray diffraction study in the literature is the powder pattern study on Sample No. 1 reported by Fontes. No X-ray diffraction studies have been performed on Samples No. 2 and 3. Even the X-ray powder pattern on Sample No. 1 was run for purposes of chemical analysis not elucidation of structure. Therefore, it may be concluded that no structurally oriented X-ray diffraction studies have been made to date.

Summary of the Literature Review

As a result of this literature review, it is apparent that little further study along the line of chemical analyses would be very fruitful. A possible exception to this is the use of mass spectrography on one sample.

It is also very apparent that the structural aspects of the Ubatuba samples have been ignored. These are the aspects which show most promise for further study.

CHAPTER III

EXPERIMENTAL STUDIES

Sample Description

The material studied in this investigation is described as follows.

1. A metallographic sample of Ubatuba No. 2 mounted in Hysol Epoxy at the AEC laboratory (27).
2. A metallographic sample of Ubatuba No. 3 mounted in green Bakelite as part of Condon Committee Study (28).
3. A sample of multiple sublimed DOW Magnesium which had previously been furnished to APRO by Dr. Busk. This was mounted in black Bakelite.

These three samples were approximately 30 mm^2 in area on the polished surface and were irregular in shape. For convenience in the balance of this section, they will be referred to respectively as Ubatuba No. 2, Ubatuba No. 3, and DOW.

All samples were first polished and examined for gross microstructural features. The Ubatuba samples were both shot full of fractures which were filled with a dove gray material (Figure 2). The DOW sample was relatively unfractured.

Experimental Procedures and Results

Microhardness Studies

Basic Microhardness. The Leitz Durimet Microhardness Tester was first calibrated as suggested by Mott (29). An optimum load was determined to be 100 grams. A series of ten measurements were then made on Ubatuba No. 2, Ubatuba No. 3, and DOW with the following results.

Sample Identity	Average Diamond Pyramid Hardness (Kg/mm^2)	Standard Deviation (σ)
DOW	32.8	± 2.6
Ubatuba No. 2	36.3	± 6.1
Ubatuba No. 3	38.2	± 3.3

1. Indentation Creep Studies. The relative indentation creep characteristics of Ubatuba No. 3 and DOW were next determined. These samples were selected for study since both were mounted in phenolic (Bakelite) which was assumed to introduce similar mount-creep to each sample. Indentation creep studies were made at 27°C, 100°C, and 200°C. Indentation creep was studied by indenting the specimen (under a 100-gram load) and systematically varying the indentation time from 10 to 1000 seconds. Results of these studies are shown in Figures 5 and 6. Note that the DOW sample exhibited marked indentation creep at 27°C whereas Ubatuba No. 3 exhibited no creep at the same temperature within 1000 seconds. Notice also that the shape of the creep curves is different for the two samples. It should also be noted that the residual apparent hardness of the DOW sample was about one-half that of the Ubatuba sample after 1000 seconds at

200°C. Finally, the general effect of temperature on hardness should also be noted. The initial (10-second) hardness decreased much more rapidly in the DOW sample with increasing temperature than it did in the Ubatuba No. 3 sample.

2. Knoop Hardness Studies. The variation of hardness with crystallographic direction on the polished surface was determined using the Knoop Indenter with a 100-gram load and 10-second indentation time. The sample was subsequently rotated through a 90° quadrant from an arbitrary baseline which was assigned the value of 0°. Knoop hardness readings were made at 15°, 30°, 45°, 60°, 75°, and 90° from the base orientation. Results are shown in Figure 7.

X-Ray Diffraction Analysis. All three mounted samples (Ubatuba No. 2, Ubatuba No. 3, and DOW) were next subjected to X-ray diffraction analysis using the Laué back reflection method. A General Electric XRD-5 machine with copper Ka radiation was used in this experiment. Results are shown in Figures 8-10.

Figure 8 is the Laué diffractogram of the DOW material. The Debye rings indicate that the material is polycrystalline, although the darkening of the rings in certain quadrants indicates a marked preferred orientation.

Figures 9 and 10 are diffractograms of Ubatuba No. 2 and Ubatuba No. 3, respectively. The discrete spots indicate that the Ubatuba samples approach monocrystallinity. All previous investigators concur that the Ubatuba samples are castings (see Literature Review). If these are castings and have such large grains as to approach monocrystallinity, then these samples must have been cooled very slowly and carefully from the liquid state. Such slow cooling is not normal in commercial magnesium ingots or shaped castings.

Microstructural Studies. The polished samples were etched in the picral-acetic solution recommended by Couling and Pearsall (30). The samples were then examined and photographed under reflected polarized light.

Microscopic examination of the Ubatuba samples revealed that the indicated "monocrystallinity" was actually due to an extremely large grain size (see Figure 11). The typical polycrystallinity of the DOW sample is shown for comparison in Figure 12. Figures 13 and 14 illustrate these typical microstructures at higher magnification. Typical {1012} twinning was observed in all samples (cf. Figures 12 and 13). The reason for this twinning is unknown but it was observed on all three samples, which indicates it may be the results of mechanical polishing. To determine if this was the cause, an attempt was made to electropolish all samples, but this was unsuccessful.

Dislocation Etch-Pit Studies. The samples were etched in aqueous 27% ammonium chloride to bring out etch-pits.

Figure 15 shows a subgrain in Ubatuba No. 3 and the etch-pit density typical of the Ubatuba material. Figure 16 shows a grain boundary and the etch-pit density typical of the DOW sample. If the assumption is made that these etch-pits represent emerging segments of dislocation loops, then it can be concluded that the Ubatuba material contains a lower defect concentration.

The 27% NH_4Cl etchant preferentially attacks {1012} twins and can, therefore, be used to orient crystals. Figure 17 is a macrograph of Ubatuba No. 2 after over-etching in 27% NH_4Cl. Note that the individual crystals vary somewhat in orientation.

CHAPTER IV

DISCUSSION

The Ubatuba magnesium has been widely acclaimed (31) as direct, physical evidence of the extraterrestrial nature of UFOs; however, as of the present, after more than a decade of investigation, the extraterrestrial nature of the Ubatuba material has yet to be conclusively proven or disproven.

A basic problem exists with using physical evidence for concluding extraterrestrial origin. Even if we possess a genuine article or material made by extraterrestrial technology, there still exists the following possible problems in investigating this material or article:

1. The extraterrestrials used methods within our technology and material available on Earth and, hence, their handiwork cannot be distinguished from our own.
2. The extraterrestrials used materials not available on Earth or methods beyond our technology, but the evidence of such cannot be detected by any means.
3. The extraterrestrials used methods beyond our technology or nonterrestrial materials, but we lack techniques to detect either.
4. The material is not available on Earth and/or the methods used are beyond our technology. The evidence for extraterrestrial origin exists in the sample and our techniques can detect it.

Obviously only articles in Category No. 4 above will be useful for proving extraterrestrial origin of any physical evidence. The ultra-high purity of the Ubatuba Sample No. 1 has been cited as an example of Category No. 4. Unfortunately this ultra-high purity could not be verified by any subsequent analysis of Samples No. 2 and 3. This lack of subsequent verification of the Ubatuba purity has been the reason that all investigations to date have discounted extraterrestrial origin. However, as pointed out in this chapter, if it is assumed that Ubatuba Samples No. 2 and 3 were actually less pure than No. 1, the case for extraterrestrial origin cannot be dismissed. Unfortunately, since all of Sample No. 1 was destroyed in tests in Brazil, the case *for* extraterrestrial origin is equally impossible to prove on the basis of purity.

In the present study, certain aspects of the structure of this material were investigated. Unfortunately no single result of this preliminary study was sufficiently unique to prove extraterrestrial origin. Nevertheless, the extremely large, oriented cast grains of the Ubatuba sample are rather unusual and could not be easily obtained by sampling a random stock of magnesium and its alloys.

The purposes for which this study was undertaken have been achieved, however. The authors were not so sanguine in their expectation as to believe that they could prove extraterrestriality. They did set out to acquire new information concerning the structure of this material, and in this respect they feel they have been successful. The results of this study will, therefore, be discussed next.

Discussion of Experimental Results

The major result of this study was the observation of the extremely large, columnar grains in the Ubatuba material. The large size, columnar nature, and few grain boundaries all suggest that the material was cooled slowly and directionally. Such slow, directional

cooling may have been purposely adopted to achieve certain physical or mechanical properties not normally encountered in random polycrystalline magnesium.

Directional solidification has only recently been developed in the casting industry as a means of producing desirable properties (32, 33); however, the properties which were desired in the present case are primarily a matter for speculation.

Initial Knoop hardness studies and Laué back-reflection X-ray analyses both indicated that the Ubatuba material was monocrystalline. Subsequent microscopic examination showed that this material had a somewhat randomly oriented columnar grain structure (Figure 17), however. The question immediately arises as to why structural members of a vehicle having the performance characteristics attributed to UFOs would be made from pure magnesium in the first place. Magnesium is never used for structural members in its pure state. As an indication of the relative importance of pure magnesium as compared to (impure) magnesium alloys, review of three definitive texts on magnesium (34-36) show less than 20 pages devoted to the pure metal. The primary reason is that pure, unalloyed magnesium is soft and weak. The microhardnesses reported in this chapter correspond to ultimate tensile strengths of only 14,000-16,000 P.S.I. A stress analysis by Peterson (37), on the other hand, shows that forces imposed by the tight radii turns and rapid accelerations reported for UFOs induce stresses at least ten times greater than these ultimate tensile strengths. Hence, pure magnesium would not be used for structural applications.

In addition, the peculiar columnar grains observed will tend to fracture at an even lower stress if the major stress direction is parallel to the grain boundary. Strength parameters other than fracture strength will be higher, however, due to fewer grain boundaries. All-in-all it can be concluded that, if this material came from a UFO, it was not part of the structure.

The next question is, of course, if this metal was not part of the structure, what purpose did it serve? If it is accepted that this magnesium came from a UFO, this cannot be answered. Nowhere in our present technology is there a use for oriented, cast, coarse-grained metals such as observed in this study. The possible uses for such materials in advanced control of propulsion systems, in turn, can only be speculated upon. In a rather oblique manner, this may be taken as an argument *for* extraterrestrial origin.

On the other hand, if the Ubatuba incident is a hoax and the material is terrestrial, the hoaxer went out of his way to select a most unsuitable material for a UFO. This in itself argues against invoking a hoax as the explanation.

The general low hardness of the DOW material is equivalent to the Ubatuba material. Both are very soft and weak; however, probably due to the lack of grain boundaries, the Ubatuba material possesses markedly better high temperature properties. The initial 10-second hardness for each material was converted into yield strength using Tabor's (38) formula. The comparative lowering of yield strengths with temperature is shown in Figure 18. Note that the Ubatuba material did not soften nearly as much with temperature as did the DOW material.

Comparison of the indentation creep characteristics of Ubatuba No. 3 with DOW (Figures 5 and 6) shows that (a) the creep mechanism is perhaps different in each material as suggested by different shape creep curves, and (b) the deterioration of hardness with time and temperature was much greater in the DOW material. The undulating nature of the creep curves for the polycrystalline material is thought to indicate a grain-boundary sliding mechanism (39).

In summary, this preliminary investigation has not proven the extraterrestrial hypothesis but has increased our knowledge about this material.

CHAPTER V

CLOSURE

Conclusions

This preliminary study of the structure of the Ubatuba magnesium has shown that:

1. Ubatuba No. 1 may be much purer than either Ubatuba No. 2 or Ubatuba No. 3.
2. Anomalously high density of Ubatuba No. 1 may be due to the entrainment of $Mg(OH)_2$ in the sample.
3. The structure of the Ubatuba No. 2 and Ubatuba No. 3 samples is typically a cast, columnar type.
4. The Ubatuba material is very soft--on the order of 32-38 Kg/mm^2.
5. Indentation creep in the Ubatuba sample was much less than in a terrestrial magnesium sample of equivalent purity.
6. The effect of elevated temperatures is much lower on Ubatuba material than on terrestrial polycrystalline material of equivalent purity.
7. The Ubatuba material may have had a lower dislocation density than terrestrial magnesium.

Suggestions for Further Research

Several lines of attack were indicated for further work on this material. A few of the areas which should receive further study are:

1. A more definitive study of the effect of temperature on hardness.
2. A more definitive study of the dislocation density and distribution using transmission electron microscopy.
3. A study of other physical properties such as resistivity, etc., to determine if some characteristic is unique to the Ubatuba samples as compared to those of known terrestrial origin.

CHAPTER VI

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TABLE I

COMPARISON OF EMISSION SPECTROGRAPHIC ANALYSIS OF SAMPLE NO. 2

BY DIFFERENT LABORATORIES

Element	AEC Laboratory (ppm)*	DOW Metals Products Laboratory (ppm)
Aluminum	100 - 1000	<2000
Barium	ND	3000 (est.)
Calcium	1 - 10	~10,000
Cobalt	ND	ND
Copper	1 - 10	<200
Chromium	ND	ND
Iron	100 - 1000	<200
Manganese	N.D.	<200
Silver	ND	ND
Nickel	ND	ND
Lead	ND	ND
Tin	ND	ND
Strontium	ND	3000
Titanium	ND	ND
Vandadium	ND	ND
Zinc	ND	ND

ND = Not detected or not reported

* Converted to ppm from w/o by authors

TABLE II

COMPARISON OF PUBLISHED ANALYSES

Element	Brazil (ES) Sample No. 1 Amount Reported	AEC Laboratory (ES) Sample No. 2 Amount Reported	AEC Laboratory (ES) Limit Of Detection (ppm)	DOW (ES) Sample No. 2 Amount Reported	DOW (ES) Limit Of Detection (ppm)	IRS Laboratory (NA) Sample No. 3 Amount Reported	IRS Laboratory (NA) Limit Of Detection (ppm)
Aluminum	ND	100-1000	NS	<200	<5	ND	<10
Barium	ND	ND	<1200	~3000	<1	160 ± 20	NS
Calcium	ND	1-10	NS	~10,000	NS	ND	NS
Cobalt	ND	ND	<10	ND	NS	ND	NS
Copper	ND	1-10	NS	200	<10	3.3 ± 1	NS
Chromium	ND	ND	<1	ND	NS	ND	NS
Iron	ND	100-1000	NS	<200	<4	ND	NS
Lead	ND	ND	<640	~200	<5	ND	NS
Magnesium	Present	100,000-1,000,000	NS	NS	NS	NS	NS
Manganese	ND	ND	<40	ND	NS	35 ± 3	NS
Mercury	ND	ND	<1200	ND	NS	ND	NS
Nickel	ND	ND	<10	ND	NS	4	NS
Silicon	ND	100-1000	NS	ND	<10	ND	NS
Silver	ND	ND	<1	ND	NS	ND	NS
Strontium	ND	ND	<1200	3000	5	500 ± 100	NS
Tin	ND	ND	<21	ND	<10	ND	NS
Titanium	ND	ND	<21	ND	NS	ND	NS
Vanadium	ND	ND	<10	ND	NS	ND	NS
Zinc	ND	ND	<300	ND	<NS	500 ± 10	NS

(ES) - Emission Spectrograph
(NA) - Neutron Activation
(ND) - Not Detected
(NS) - Not Specified

Figure 1. Enlargement of Ubatuba Samples No. 2 and 3.
(After Fontes (5))

Figure 2. Deposit in Cracks in Ubatuba Sample No. 2.
(From Ref. 11)

Figure 3. Surface Scale on Ubatuba Sample No. 2.
(From Ref. 11)

Figure 4. Internal Oxidation (Black Dots) on Ubatuba Sample No. 2.
(From Ref. 11)

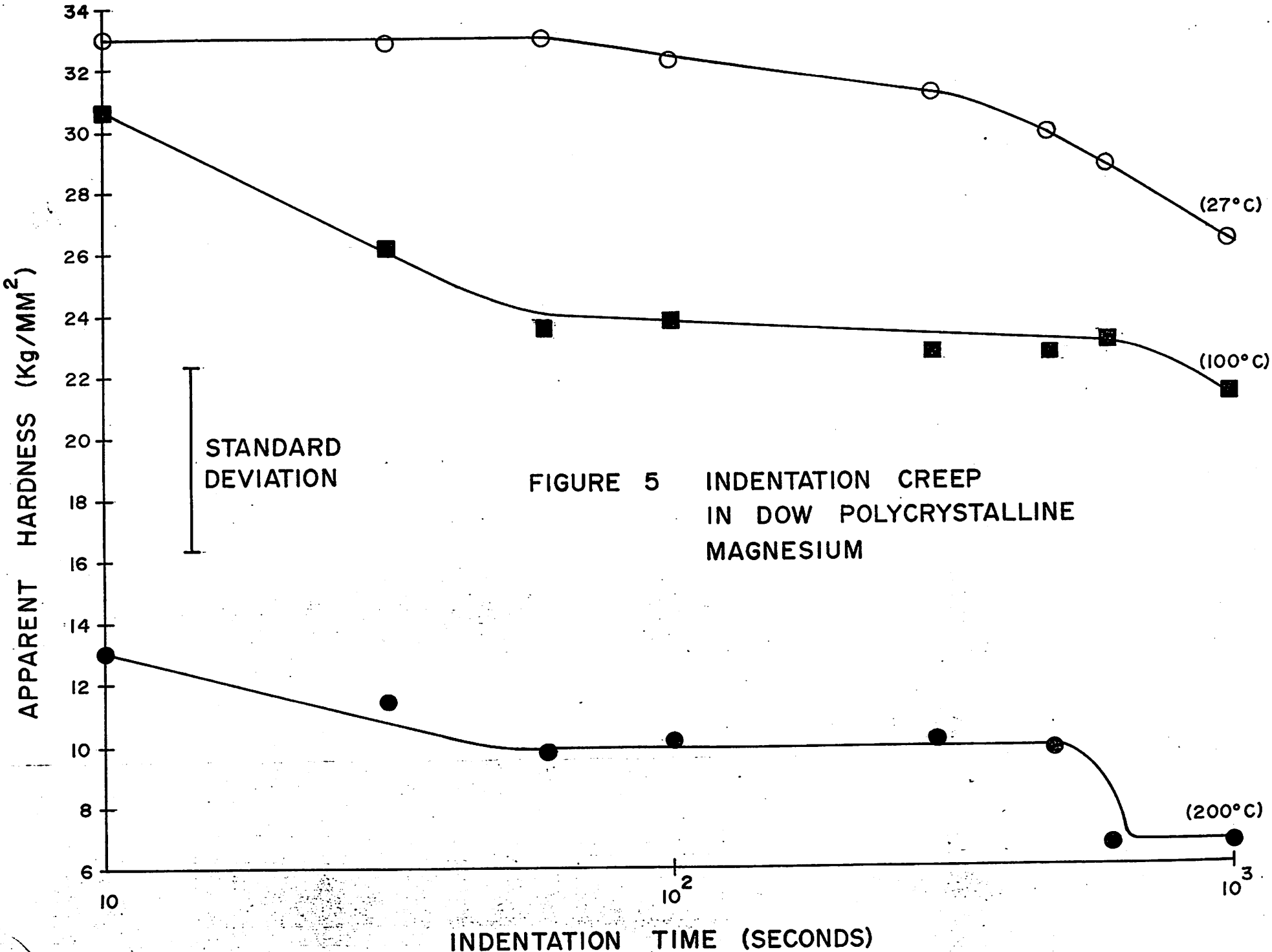


FIGURE 5 INDENTATION CREEP IN DOW POLYCRYSTALLINE MAGNESIUM

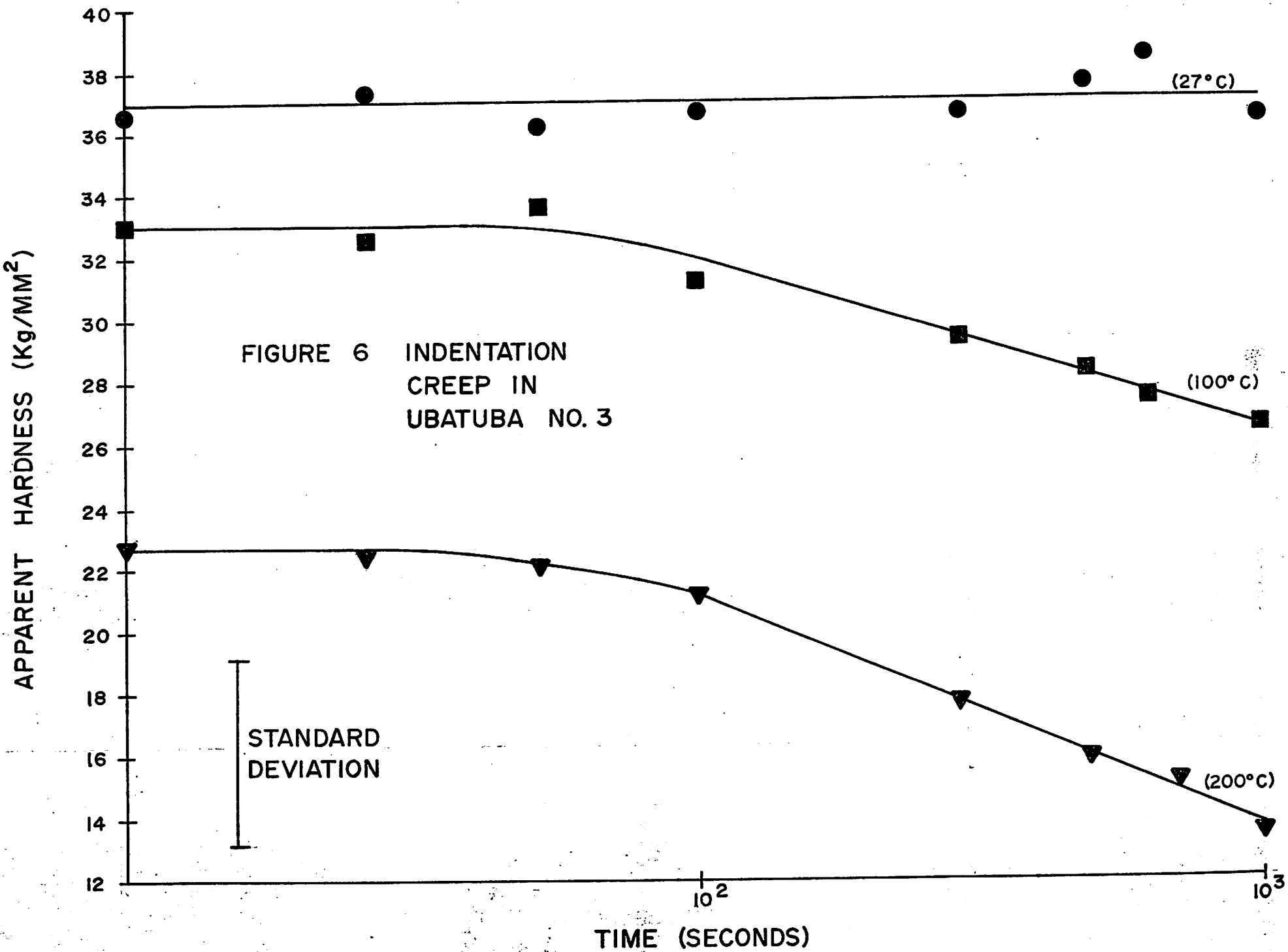


FIGURE 6 INDENTATION CREEP IN UBATUBA NO. 3

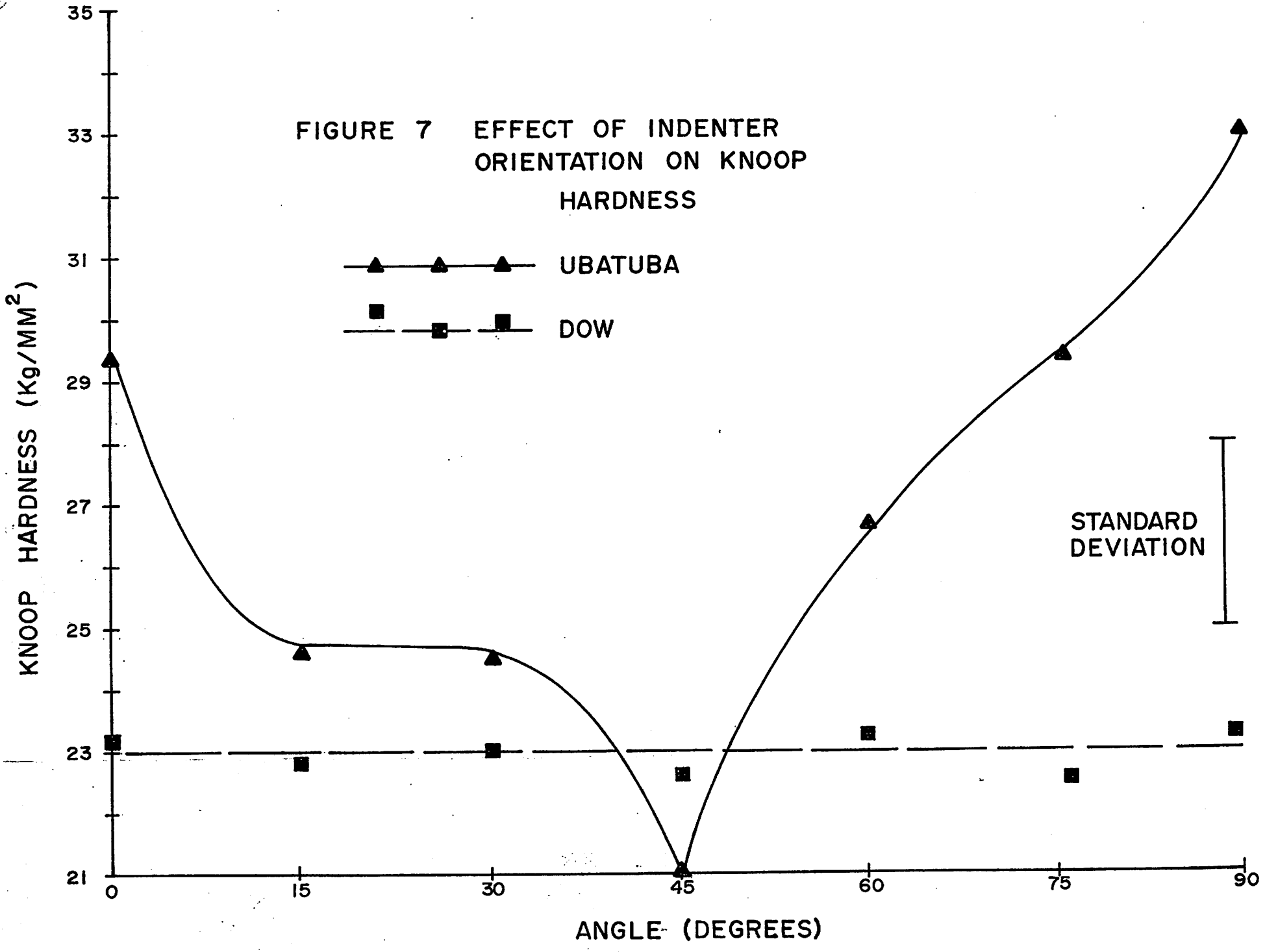


FIGURE 7 EFFECT OF INDENTER ORIENTATION ON KNOOP HARDNESS
UBATUBA
DOW
KNOOP HARDNESS (Kg/MM^2)
35
33
31
29
27
25
23
21
0
15
30
45
60
75
90
ANGLE (DEGREES)
STANDARD DEVIATION

Figure 8. Laué Diffractogram on DOW Magnesium.

Figure 9. Laué Diffractogram of Ubatuba Sample No. 2.

Figure 10. Laué Diffractogram of Ubatuba Sample No. 3.

25x Picral-Acetic Etch

(Polarized Light)

Figure 11. Structure of Ubatuba Sample No. 2.

Columnar Grains (0.3 to 0.7mm wide x ~6mm long)

25x Picral-Acetic Etch

(Polarized Light)

Figure 12. Structure of DOW Sample.

Duplex Grain Size (0.2 x 0.3mm to 0.5 x 1.1mm)

80x Picral-Acetic Etch

(Polarized Light)

Figure 13. Ubatuba Sample No. 2.

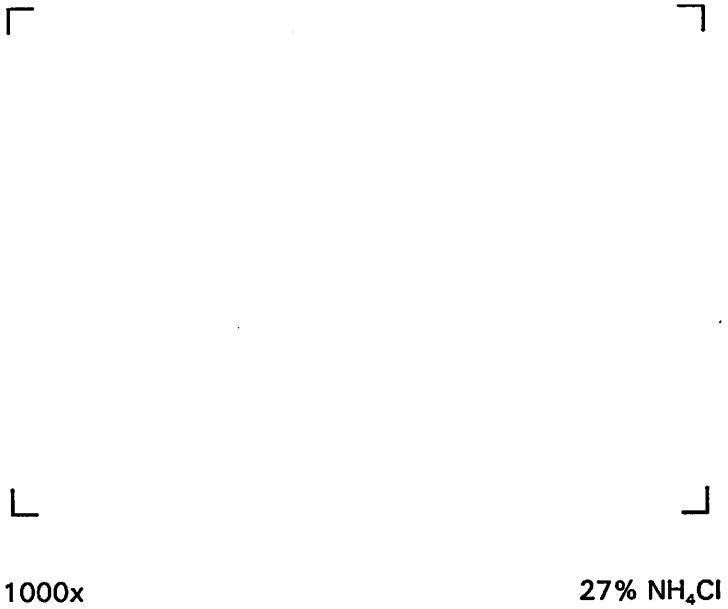
80x Picral-Acetic Etch

(Polarized Light)

Figure 14. Structure of DOW Sample.

1000x 27% NH_4Cl

Figure 15. Etch-pits and Subgrain Boundaries in Ubatuba Sample No. 3.



1000x 27% NH_4Cl

Figure 16. Etch-pits and Grain Boundaries in DOW Sample.

25x 27% NH_4Cl

(Macrophoto)

Figure 17. Over-Etched Ubatuba Sample No. 2.

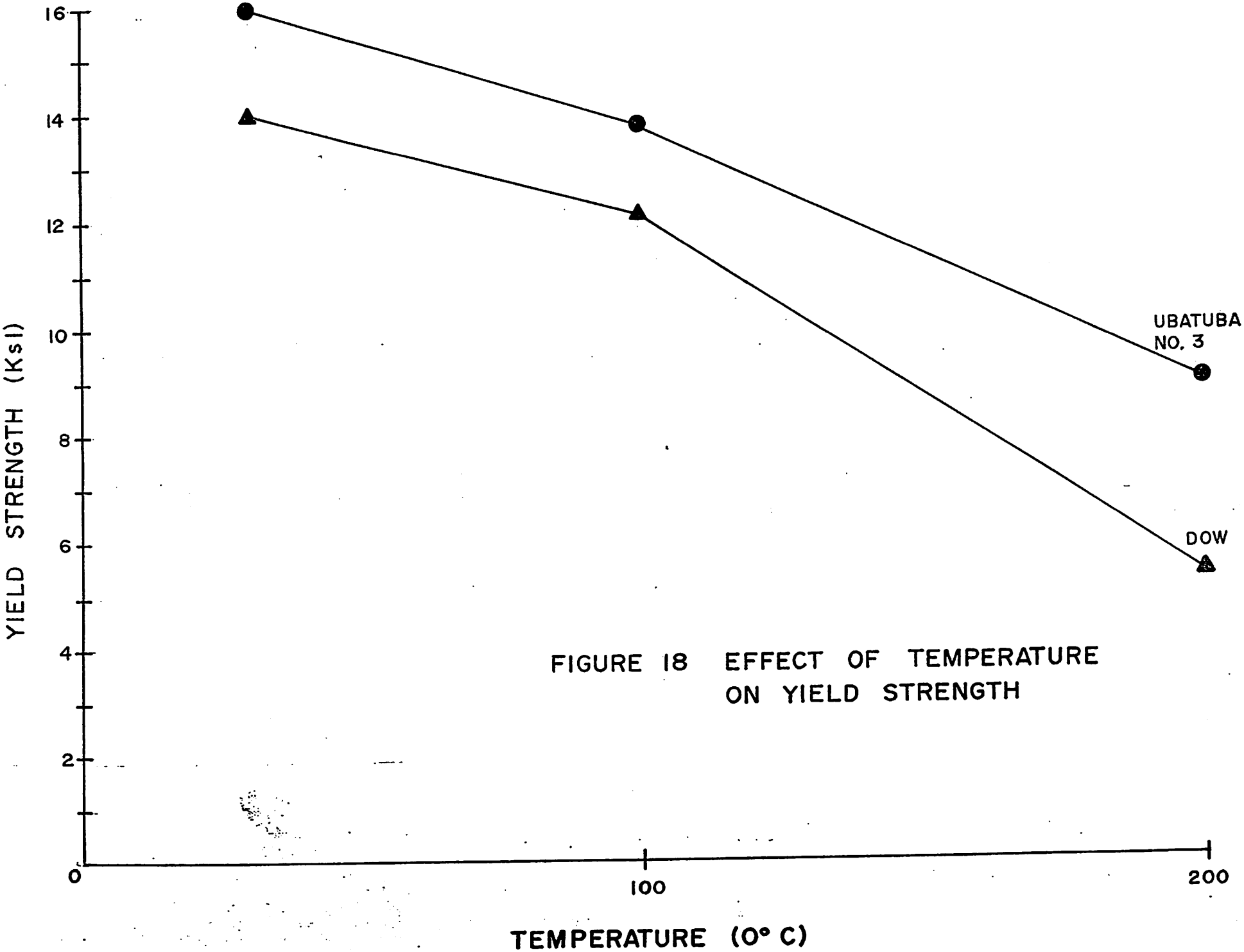


FIGURE 18 EFFECT OF TEMPERATURE ON YIELD STRENGTH

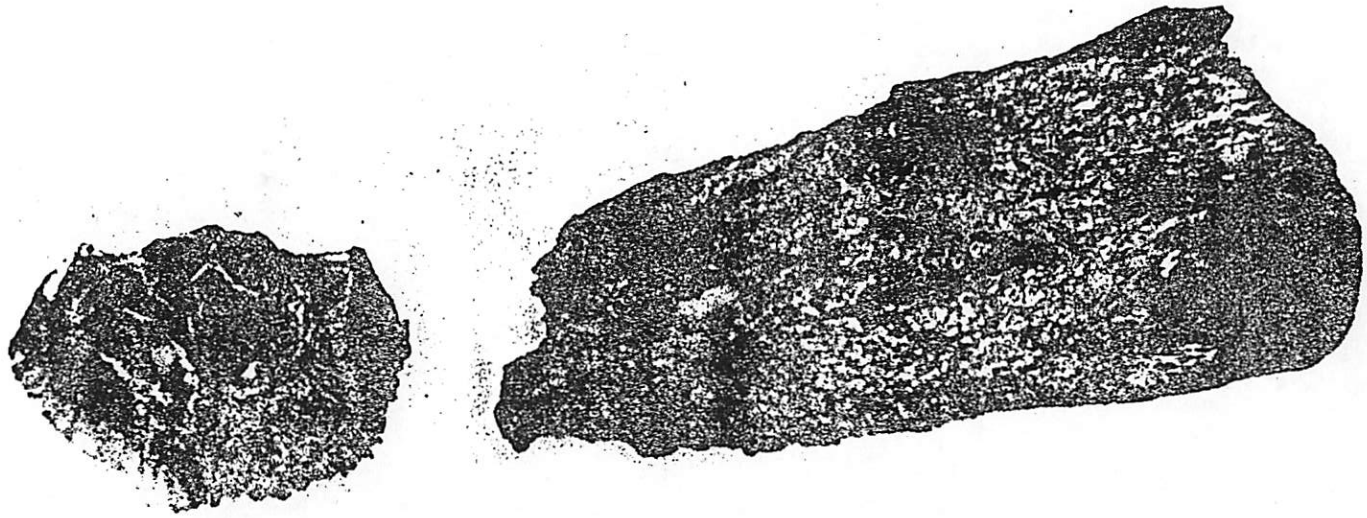


Figure 1
Enlargement of Ubatuba
Samples 2 and 3 (after Fontes[5])

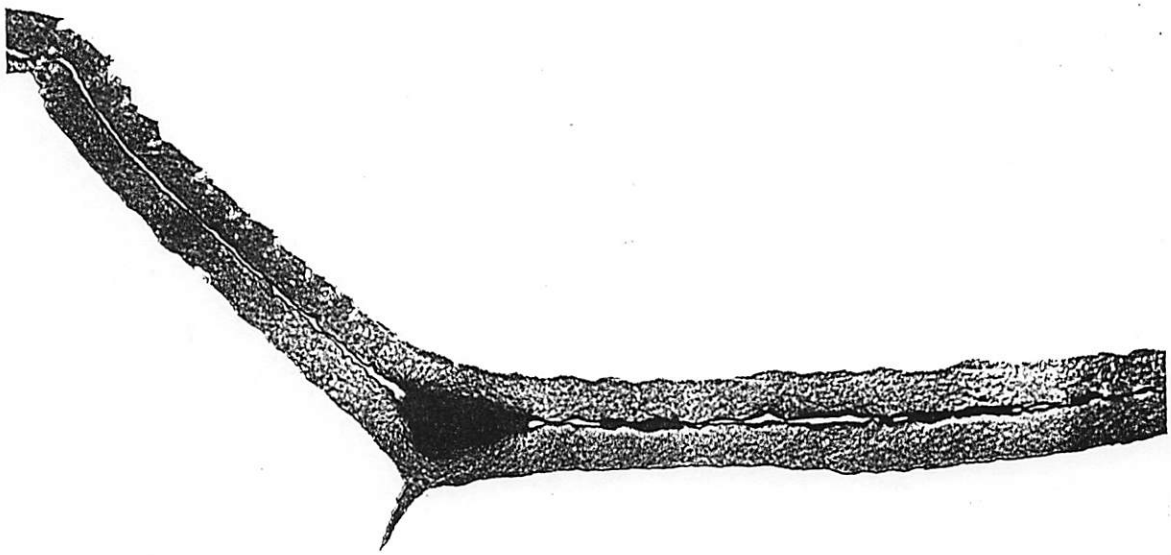


Figure 2
Deposit in Cracks in Ubatuba
~~Magnesium~~ Sample No. 2
(From Ref. #11)

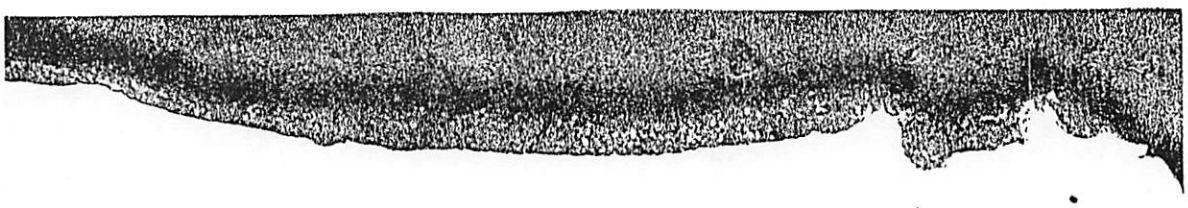


Figure 3
Surface Scale on Ubatuba
No. 2 [redacted] Sample
(From Ref. [redacted]11)

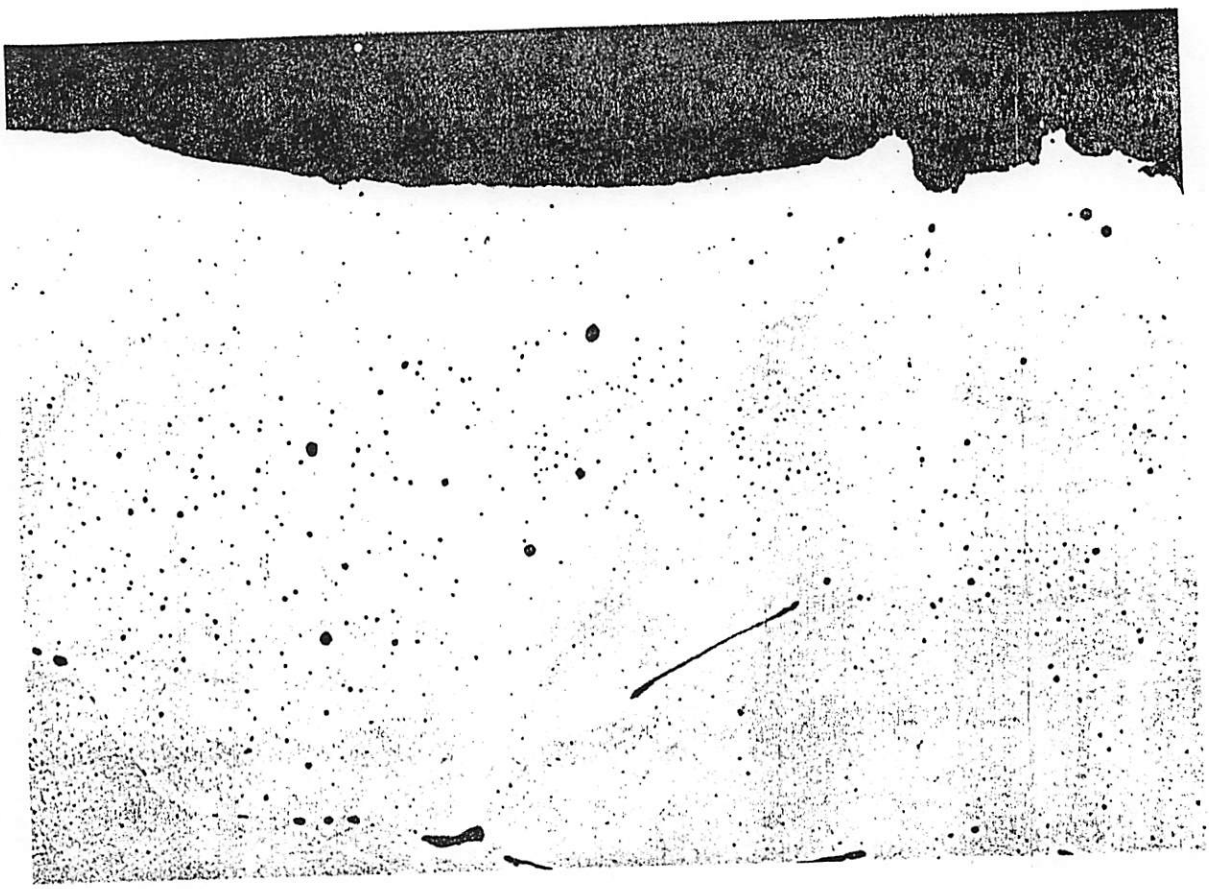


Figure 4
Internal Oxidation — (Black dots) on
Ubatuba [redacted] Sample No. 2
(From Ref. #11)

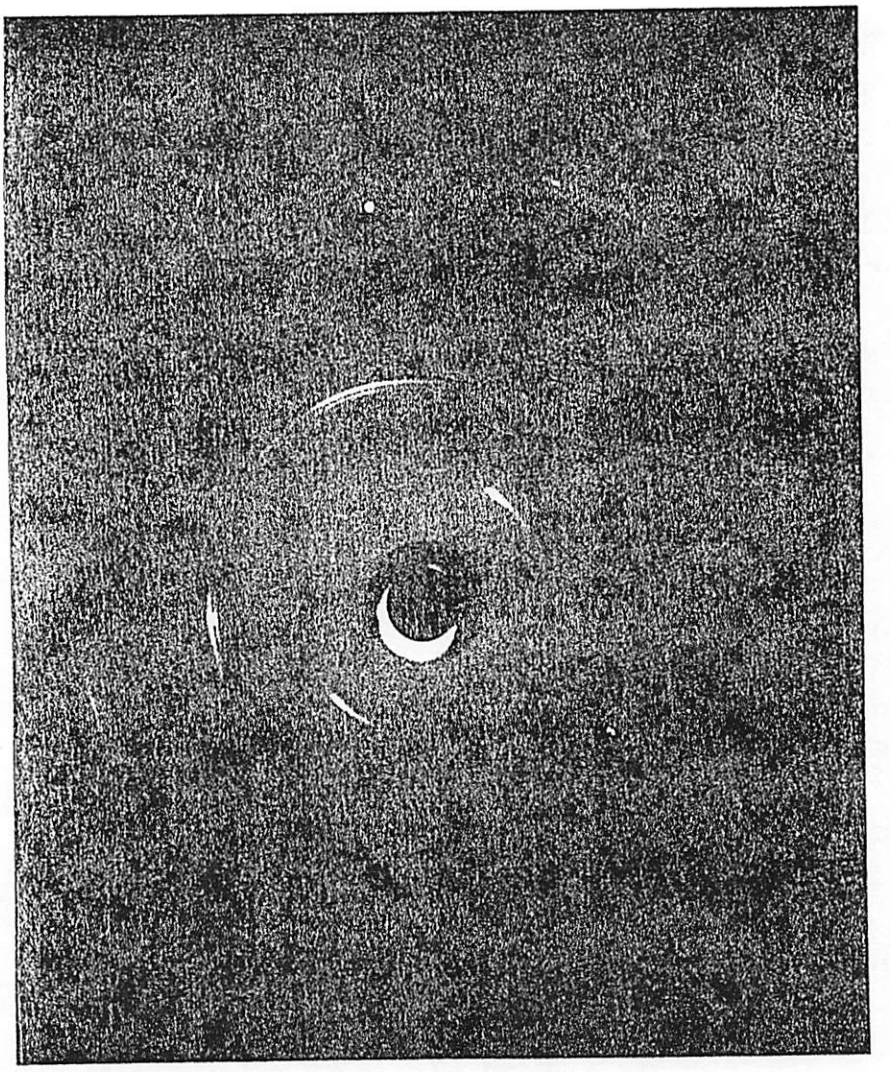


Figure 8
Laue Diffractogram on
DOW ~~Extruded~~ Magnesium

Figure 9
Laüé Diffractogram of
Ubatuba No. 2

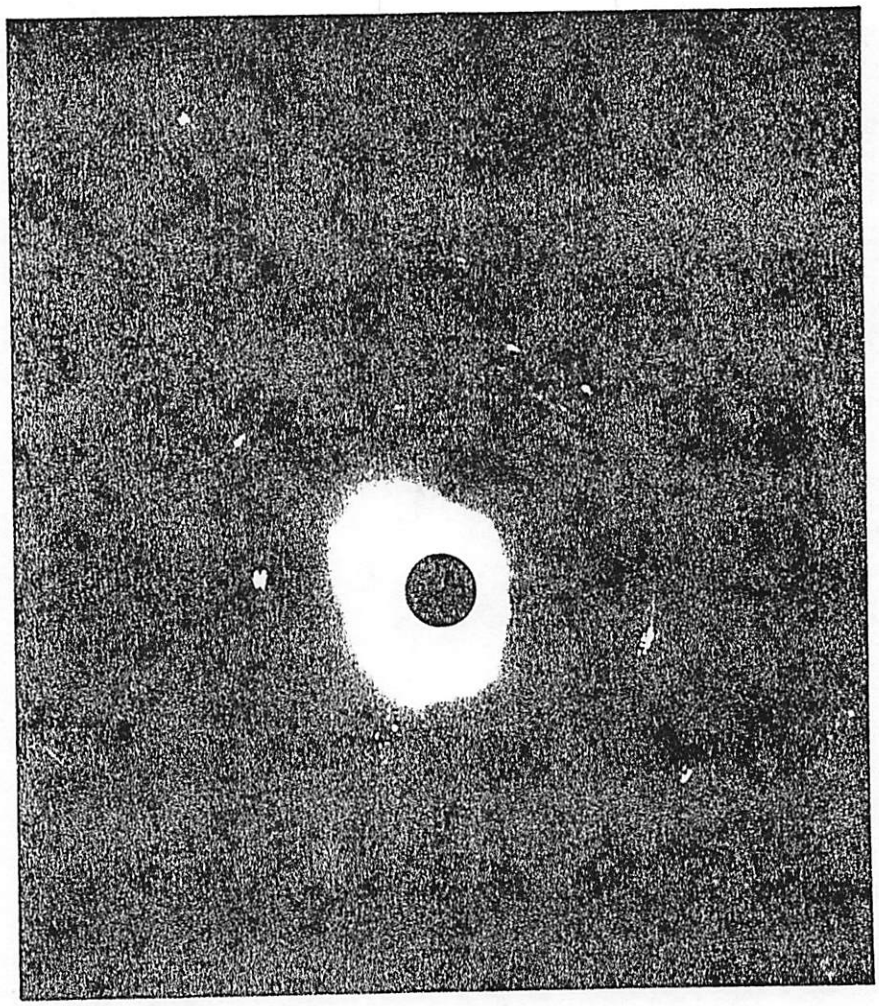
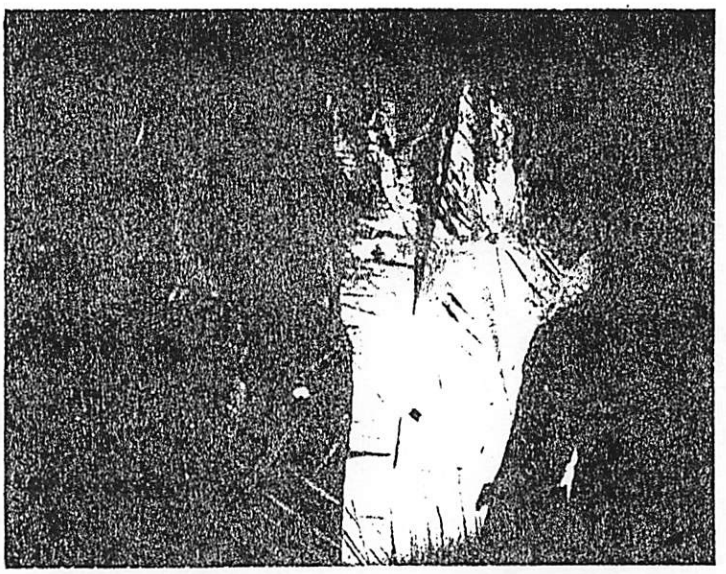


Figure 10

Laué Diffractogram

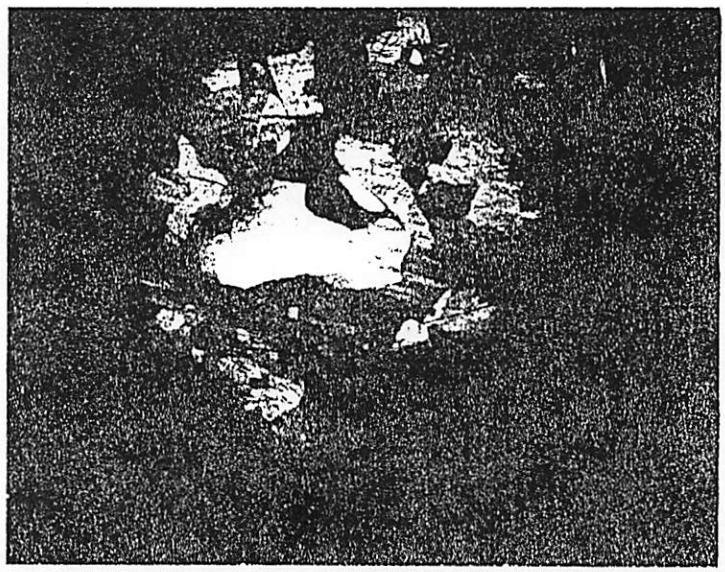
of Ubatuba No, 3



25x Picral-Acetic Etch

Figure II
(Polarized Light)

Structure of Ubatuba No. 2
(Columnar Grains 0.3 to 0.7mm wide x ~ 6mm long)

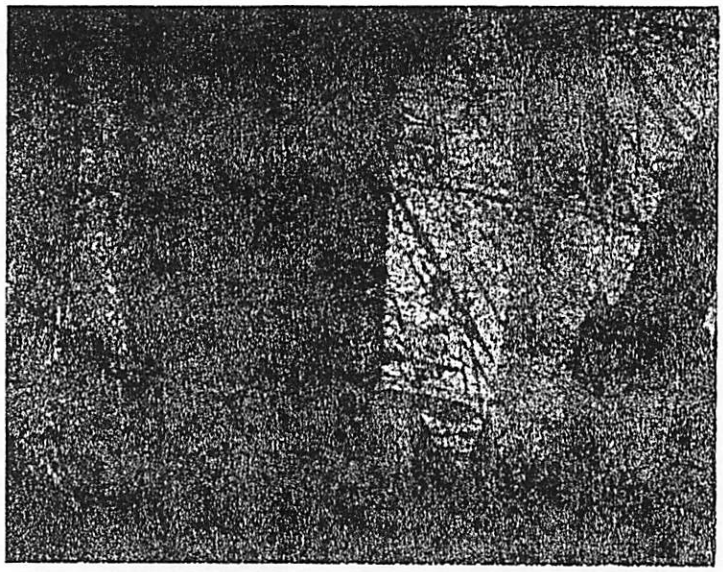


25x Picral-Acetic Etch

Figure 12
(Polarized Light)

Structure of DOW Sample

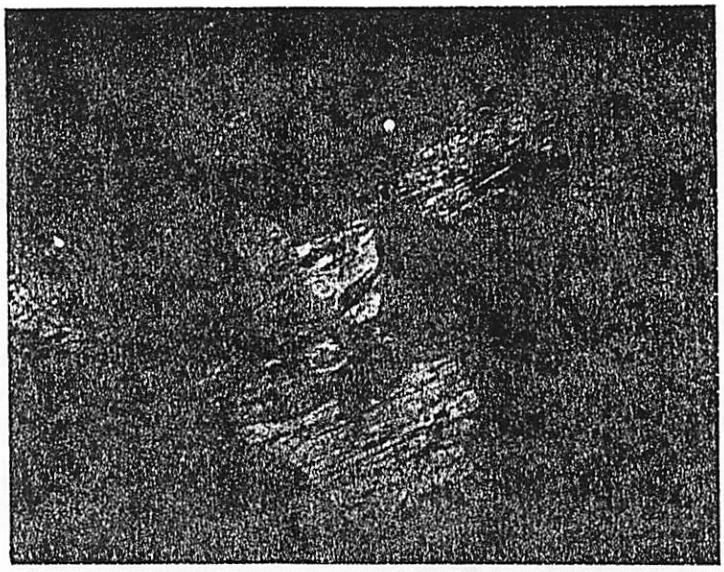
Duplex Grain Size (0.2 x 0.3mm to 0.5 x 1.1mm)



80x Picral-Acetic Etch

Figure 13
(Polarized Light)

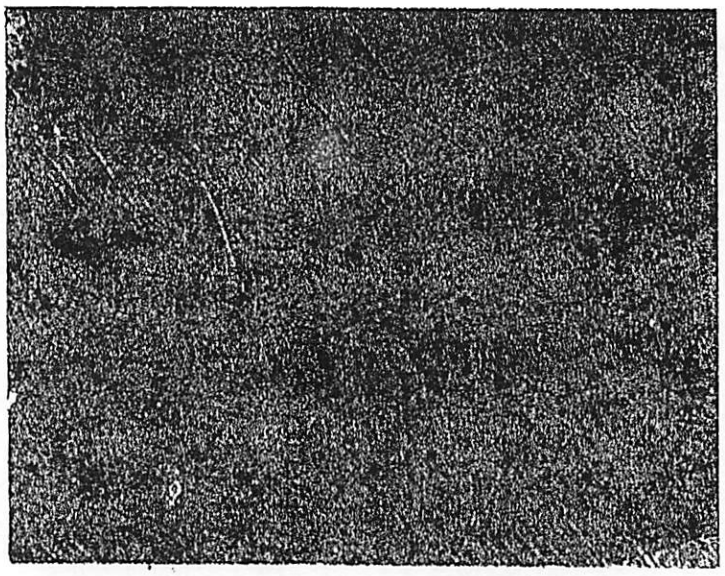
Ubatuba No. 2 Sample



80x Picral-Acetic Etch

Figure 14
(Polarized Light)

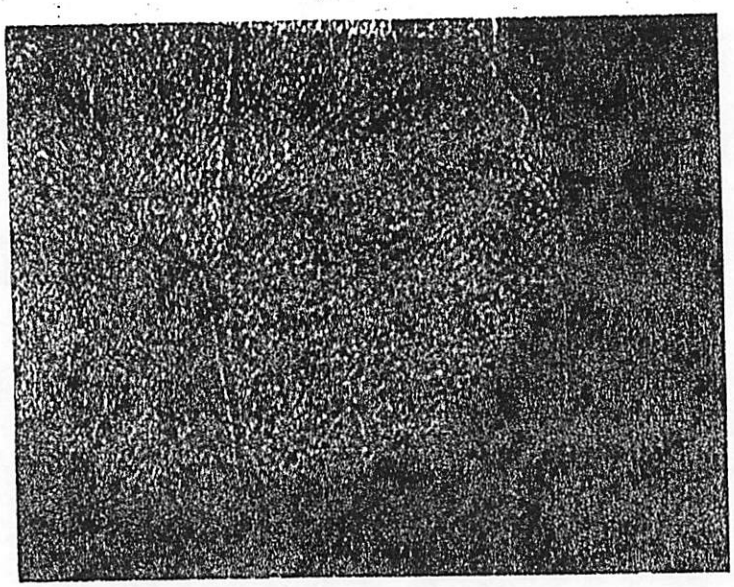
Structure of DOW Sample



27% NH_4Cl 1000x

Figure 15

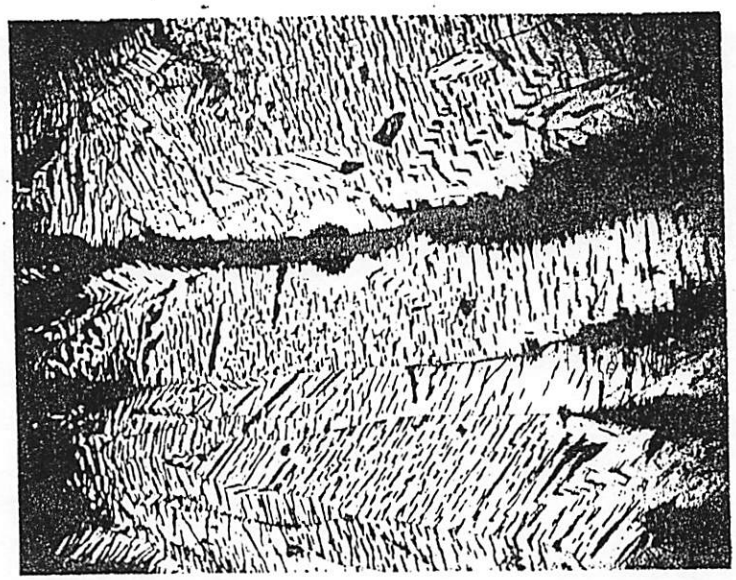
Etch-pits and Subgrain
Boundaries in Ubatuba No. 3



27% NH_4Cl 1000x

Figure 16

Etch-pits and Grain
Boundaries in DOW Sample

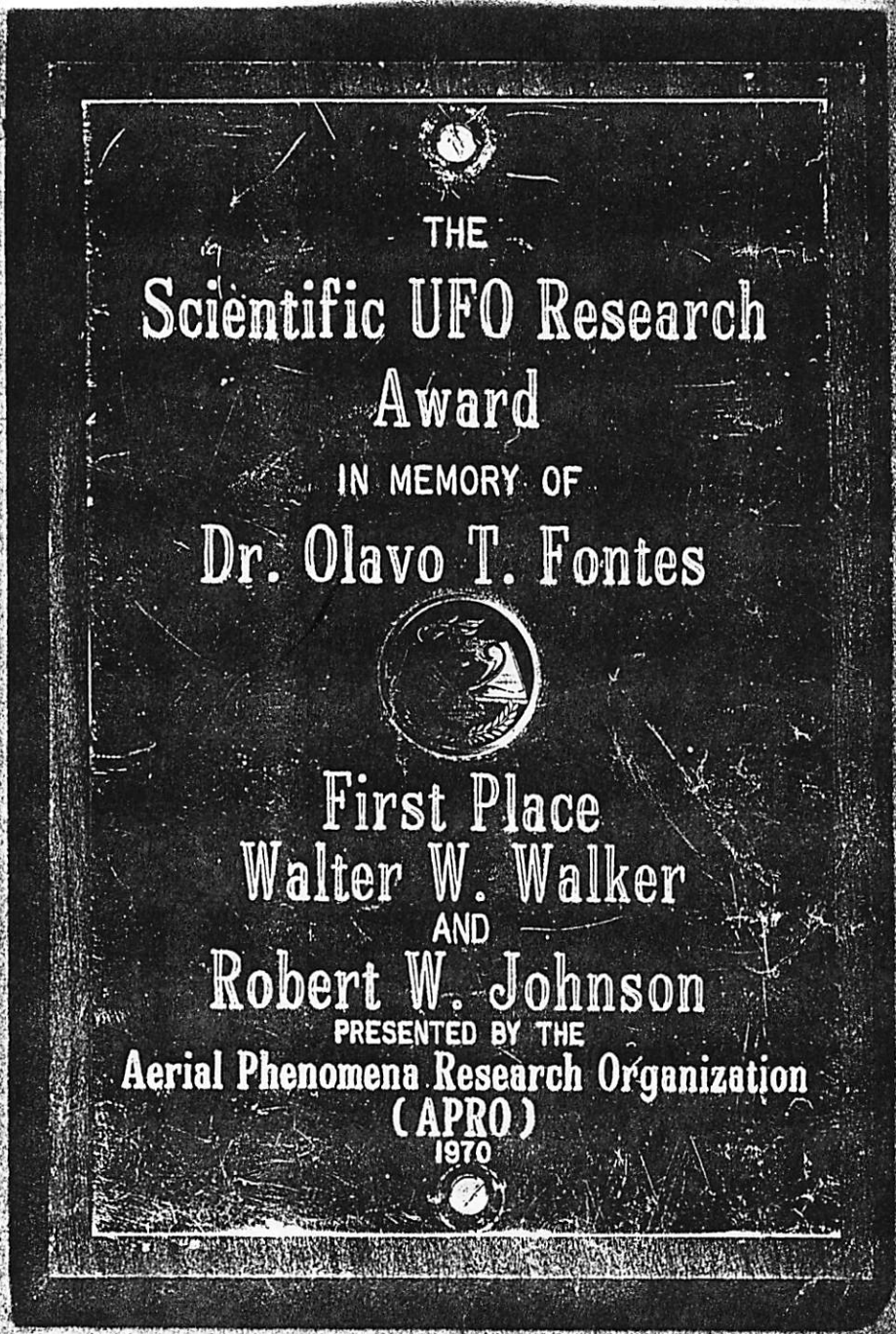


Macrophoto 25x

Figure 17

Over-Etched in 27% NH_4Cl

Ubatuba No. 2 4


THE
Scientific UFO Research
Award
IN MEMORY OF
Dr. Olavo T. Fontes
First Place
Walter W. Walker
AND
Robert W. Johnson
PRESENTED BY THE
Aerial Phenomena Research Organization
(APRO)
1970

SCIENTIFIC STUDIES OF THE UBATUBA MAGNESIUM FRAGMENTS

A 1992 RETROSPECTIVE

by

Walter W. Walker, Ph.D., P.E.
Retired Metallurgist

In 1957 a UFO allegedly exploded over the beach at Ubatuba, São Paulo, Brazil. Several fragments of burning debris reportedly fell into the ocean and were recovered. Two of the debris fragments eventually found their way to the Aerial Phenomena Research Organization, Inc. (A.P.R.O.), of Tucson, Arizona.

In 1970 the writer was one of two metallurgical consultants to A.P.R.O. In this capacity I undertook a metallurgical study of the two fragments. The other metallurgical consultant collaborated on this study. This study resulted in a paper: "Further Studies on the Ubatuba UFO Magnesium Samples," by Walter W. Walker and Robert W. Johnson. Although Walker and Johnson received the 1970 Fontes Memorial Scientific UFO Research Award for the best scientific paper published on UFOs in 1970, the paper itself has never been previously published.

The purpose of this review is to retrospectively examine some of the scientific studies which have been made on the Ubatuba material and to discuss the general difficulties of proving extraterrestriality from physical evidence.

The Source of the Material

The source of the Ubatuba magnesium samples is described by the late Dr. Olavo Fontes (Ref. 1) as follows:

> "On September 14, 1957, Ibrahim Sued, a well-known Rio de Janeiro society columnist, reported a strange story which startled the readers of his column in the newspaper *O Globo*. Under the heading, "A Fragment From a Flying Disc," he wrote:
>
> > We received the letter: "Dear Mr. Ibrahim Sued. As a faithful reader of your column and your admirer, I wish to give you something of the highest interest to a newspaperman, about the 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 some friends, at a place close to the town of Ubatuba, São 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 was almost striking the waters, it made a sharp turn upward and climbed rapidly on a fantastic impulse. We followed the spectacle with our eyes, startled, 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 these 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 as light as paper. I am enclosing a small sample of it. I don't know anyone that could be trusted to whom I might send it for analysis. I never read about a flying disc being 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 writer (the signature was not legible), together with the above letter, I received fragments of a strange metal . . ."

Accompanying the letter were three small metal fragments, each about the size of an ordinary pencil eraser. This anonymous letter and the small fragments of metal are the only link to the events reported in the letter. No one has ever verified that the events

described in the letter actually took place or that the metal was the result of the incident described.

This break in the chain of evidence severely compromises all subsequent scientific studies of the metal fragments themselves. Even if the two surviving metal fragments were unequivocally proven to be of extraterrestrial manufacture, there is no way, now, of proving they came from a UFO which exploded over the beach at Ubatuba, São Paulo, Brazil, in 1957.

The Chemical Composition

The largest portion of the scientific investigation of the Ubatuba metal fragments has involved chemical analysis of the composition using a variety of advanced, sophisticated techniques. These techniques included: a) emission spectrography, b) neutron activation analysis, c) electron microprobe analysis, and d) ion microprobe analysis. Each of these techniques analyzes only a small area of the surface, not the interior metal of the sample. Concerning the *interior* composition of the fragments, Sturrock notes: "Consequently, after all these years, we still do not have a single reliable measurement of the actual impurities and impurity level of the Brazil magnesium" (Ref. 2).

Analytical Results. Walker and Johnson reviewed the chemical analyses results up to the time of their investigation (1970) and these are summarized in Table I.

Chemical analyses results since 1970 have been published by Sturrock (Ref. 3) and are summarized in Table II for the bulk material and in Table III for the white surface coating. With respect to Table II, two problems exist: 1) The material is only generically

identified as Brazil Magnesium and no information is given as to whether Ubatuba Sample Nos. 2 or 3 was analyzed. Since Table I indicates these two fragments are not of identical composition, this oversight compounds the confusion. 2) Limiting the impurity detection levels to greater than 100 ppm makes it difficult to correlate the data with Table I, which reports lower impurity levels.

Discussion of Analytical Results. No metal on earth can exist in the absolutely pure state. To achieve even commercial grades of purity (99.999+%) takes a great deal of care and energy. Therefore, if Ubatuba Sample No. 1 was as pure as reported in Brazil (Table I, column 2), it could be considered extraterrestrial. As Erdmann (Ref. 4) points out, however, the reported degree of purity depends critically on the skill of the analyst, the care the analyst takes in his procedure, and the limits of detection of the analytical method. We have no way, now, of determining if the Brazilian spectrographic analyses of Sample No. 1 was as accurate as those analyses performed on Sample No. 2 by either the AEC Laboratory or Dow Magnesium Products Co. (Table I, columns 3 and 4). Similarly, all of Sample No. 1 was destroyed in testing in Brazil and, hence, the reported degree of purity cannot now be verified by another laboratory. All we have left are Sample Nos. 2 and 3, which are apparently less pure than Sample No. 1.

Concerning Sample Nos. 2 and 3, the next question, again posed by Erdmann (Ref. 5), is: are the surviving Ubatuba Samples 2 and 3 purer than magnesium existing on Earth in 1957? Table IV from an Ubatuba era text on magnesium (Ref. 6) gives the typical analyses of terrestrial unalloyed magnesium. Comparison of Tables I and II to

Table IV shows that both Sample Nos. 2 and 3 are less pure than terrestrial triple sublimed magnesium. Therefore, based on these published analyses, Sample Nos. 2 and 3 cannot be considered to be purer than terrestrial magnesium and, therefore, extraterrestrial.

Review of Table I yields a very striking observation: If equal analytical accuracy and limits of detectability are assumed for each of the different analyses, then the compositions of all three Ubatuba magnesium samples are markedly different.

Moreover, two different emission spectrographic analyses of Sample No. 2 showed markedly different results (Table I, columns 2 and 3). From this it may be concluded that if the three Ubatuba fragments are from the same metal object they are from three different locations, each with a different composition.

This variation in composition in different locations of a metal object is called segregation. It is an inherent condition in cast metals such as shaped castings, ingots, and welds. This compositional variation is consistent with the metallurgical observation that the Ubatuba metal exhibited a cast microstructure.

There is no doubt that the Ubatuba magnesium has been contaminated. The photomicrographs presented by Walker and Johnson's Figure 2, which shows intrusion of oxidation into a grain boundary or crack; the surface scale, Figure 3; and the subscale caused by internal oxidation, Figure 4, all indicate a high temperature reaction of the solid magnesium with an oxygen-containing atmosphere. The white, powdery surface layer of $Mg(OH)_2$, containing a high level of impurities (Table III) may have been caused by a chemical reaction with terrestrial sea water. Although such contamination is consistent

with the account of the Ubatuba incident, it makes all subsequent chemical analyses suspect.

The suspected chemical segregation and terrestrial contamination makes the surviving Ubatuba Sample Nos. 2 and 3 appear much less pure than purified triple sublimed terrestrial magnesium (Table IV). The interior metal of Sample Nos. 2 and 3 may be as pure as that reported in Brazil for Sample No. 1, but repeated chemical analyses to date have not verified this supposition. Since all of Sample No. 1 was destroyed in testing in Brazil and Sample Nos. 2 and 3 appear less pure than Sample No. 1, it can be concluded that all chemical analyses to date have not verified the extraterrestriality of the Ubatuba magnesium.

The Density Anomaly

During the initial investigation of Sample No. 1 in Brazil, the relative density (i.e., specific gravity) was determined by a Laboratory of Crystallography chemist, A. Batista (Ref. 7). In order to eliminate the possibility of error due to contamination of the sample, Batista selected a small metallic chip from the center of Sample No. 1 and carefully polished it to remove all traces of contamination. The density was repeatedly found to be 1.866 gr/cc versus 1.741 gr/cc for terrestrial magnesium. This led Fontes to suggest that the Ubatuba magnesium had a higher concentration of heavier magnesium isotopes than does terrestrial magnesium. This, of course, would indicate an extraterrestrial origin for the Ubatuba material.

Table V shows the relative abundance of the isotopes of terrestrial magnesium. Jueneman (Ref. 8) has noted that if the Ubatuba magnesium was composed entirely of Mg^{26} the density would be 1.862, which is in good agreement with the density reported for Sample No. 1. No other density measurements were made of Sample No. 1. Similarly no isotopic analysis was performed to determine unusual isotope ratios. All of Sample No. 1 was destroyed in Brazil, hence no further testing of Sample No. 1 is possible.

As in the case of the chemical composition, density measurements of Sample No. 2 were different than that reported for Sample No. 1 in Brazil. An AEC laboratory found the density of Sample No. 2 was 1.7513 gr/cc (Ref. 9). Similarly isotopic analysis of Sample No. 3 (Ref. 10) indicated the Mg^{26} content was normal, (11.2%). Hence, the highly unusual Brazilian results on Sample No. 1 could not be verified by subsequent studies on Sample Nos. 2 and 3.

Walker and Johnson point out that anomalously high density results could be caused by internal contamination with $Mg(OH)_2$. Using the x-ray powder pattern from Fontes (Table VI), they also determined that the theoretical density of Sample No. 1 was 1.743, which is in good agreement with the usually accepted value of 1.741 gr/cc for terrestrial magnesium.

Based on the above discussion, it is concluded that the anomalously high density of Ubatuba magnesium Sample No. 1 was probably due to internal contamination, not an unusual isotope ratio.

Microstructure. As far as the writer knows, Walker and Johnson are the only investigators who have published any photomicrographs of the Ubatuba grain structures. Other metallurgists, notably the AEC Laboratory (Ref. 11) and Professor Ogilvie of MIT (Ref. 12) have examined the surviving Ubatuba fragments, but no photomicrographs have been published. Everyone agrees that the Ubatuba magnesium possesses a cast microstructure.

Cast microstructures result from the solidification of a molten metal without subsequent grain refinement by mechanical deformation. Cast microstructures are found terrestrially in as-cast ingots, shaped castings, and welds.

Figure 1 (which appears as Figure 17 in Walker and Johnson's paper) illustrates the typical microstructure of Ubatuba Sample No. 2. The grains are elongated and average about 6-7 mm x 1 mm in size. Extensive $\{10\bar{1}2\}$ twinning is noted on all grains. This twinning, which is also often observed in terrestrial magnesium microstructures, may have been induced by mechanical polishing. The transverse direction of the $\{10\bar{1}2\}$ twins is similar on all grains, which indicates a high degree of directional crystal growth.

Directional crystal growth is terrestrially observed in fusion welds and in small zones of large castings. Large terrestrial castings generally have randomly oriented grains with directional orientation only found near a mold wall where a temperature gradient can occur. It was initially assumed that the grain directionality in the small Ubatuba samples indicated that the fragments had come from a large, directionally solidified casting. Since large, directionally solidified, unalloyed magnesium castings were not being used terrestrially in 1957, it was prematurely and erroneously reported (Ref. 13) that this

indicated extraterrestrial manufacture. One of the early reviewers of the Walker and Johnson paper, however, pointed out, quite correctly, that small zones of directional grains are found in all castings, hence extrapolation of the small Ubatuba fragment to large castings is not warranted. Unfortunately the directionally solidified castings hypothesis for extraterrestrial origin is still being quoted in the UFO literature (Ref. 14).

Mechanical Properties. The only mechanical property test performed on the Ubatuba fragments are the microindentation hardness test of Walker and Johnson. Although the Ubatuba material exhibited an improved elevated temperature (up to 200°C) indentation creep properties, as compared to terrestrial unalloyed magnesium, Ubatuba and terrestrial unalloyed magnesium are both far too soft and weak to be used in any structural application. Therefore, better mechanical properties do not necessarily imply extraterrestriality.

The Nature and Uses of Unalloyed Magnesium

A standard metallurgical handbook from the Ubatuba era (Ref. 15) states, "Pure magnesium has only moderate strength (27,000 psi in the annealed condition); consequently, where structural stresses are involved, magnesium rich alloys are used." To the present, unalloyed magnesium has never been used as a structural material on any aircraft, missile, or spacecraft, only magnesium *alloys* have. The same handbook also states, "Pure magnesium is produced in the form of ingots, powder, ribbon, wire and extruded and rolled strip" (Ref. 16). Thus, if the cast Ubatuba material is terrestrial, it can only come from an ingot, not a shaped casting. Erdmann (Ref. 17) asks the question " . . .

"Has non-alloyed, technically pure, magnesium ever been used in a missile or aircraft?" He answers this question in the negative and documents his answer with 15 references. Later Walker and Johnson made the same point. This established fact has been ignored by all detractors who explain the Ubatuba incident as being due to the crash of a terrestrial aircraft, missile, or spacecraft.

Ogilvie (Ref. 18), for example, concluded that ". . . the specimen from Brazil was a piece of weld metal from an exploding aircraft or reentering satellite." In the 1950's magnesium alloys were welded together by gas welding, shielded arc welding, resistance welding, and flash welding (Ref. 19). In processes using welding filler metal, the filler rod was either of the same composition as the alloy being welded or had a *lower* melting point than the parent metal. Since unalloyed metals always have a *higher* melting point than their alloys, the welding rod could not have been unalloyed magnesium.

The fact that unalloyed magnesium is not used as a structural metal in any terrestrial vehicle and, hence, cannot be invoked to explain the Ubatuba incident, should give scant comfort to those who believe that UFOs are extraterrestrial vehicles. *If* unalloyed magnesium is too soft and weak to be used in relatively low stressed terrestrial vehicles, how could it possibly be used in a vehicle exhibiting the extremely high stress maneuvers of UFOs? The answer is that it could not be used for the vehicle's structure if the UFO obeys the physical laws of our universe.

It has been suggested that the Ubatuba magnesium did not come from the structure of the UFO. If it had come from the pots and pans in the galley, for example, why was only

unalloyed magnesium recovered, not a high strength alloy from the structure? This question cannot be answered from our limited knowledge of the Ubatuba incident.

Another intriguing hypothesis is that, in a limited space envelope around a UFO, the physical laws of our universe do not operate. This hypothesis has been put forward by Harris (Ref. 20), who also formulated the mathematical laws for the conditions that prevail inside the space envelope.

Physical Evidence and Extraterrestriality

Although Ubatuba has often been cited as one of the better UFO physical evidence cases, extensive scientific investigations of the magnesium fragments has yet to establish extraterrestriality. The Ubatuba case, however, serves as a classic example of the general difficulty of proving the extraterrestrial origin of physical evidence.

Pritchard (Ref. 21) has recently discussed the application of physical evidence to the hypothesis that extraterrestrial intelligence is present on Earth. The results of the scientific studies on the Ubatuba magnesium will next be discussed in terms of Pritchard's analysis.

(A) Pedigree. Pritchard defines the pedigree of an alleged alien artifact as "... the testimony of people concerning its origin, the circumstances of its recovery, any prior descriptions of the artifact or descriptions of similar (unrecovered) artifacts in independently investigated cases, etc." (Ref. 22).

Based on this criterion, the Ubatuba magnesium fragments have a very poor pedigree. The only documentation is a letter bearing an illegible signature which accompanied the fragments. Although Dr. Fontes conducted an extensive investigation, the writer of the

letter was never identified nor were any other witnesses to the incident described in the letter ever found.

(B) Other Criteria. Pritchard next asks what alleged alien artifacts must be like in order to convince a jury of skeptical scientists that they are of extraterrestrial origin. He categorizes his answer in terms of: 1) performance, 2) composition, 3) structure, and d) reproducibility.

1) ***Performance.*** Pritchard believes that performance should provide the strongest source of evidence in favor of extraterrestrial origin. He makes the point that alien engineers might very well use common materials but cause them to perform in an unusual manner. Hence, unusual performance might be considered as evidence of extra-terrestriality. In the present case soft, weak, technically pure, unalloyed magnesium being used as a structural material for a highly stressed vehicle could be considered as unusual performance. Unfortunately we have no valid evidence, other than a letter bearing an illegible signature, that the magnesium fragments came from a UFO and have no evidence whatever that they came from the craft's structure.

2) ***Composition.*** Pritchard considers composition in terms of unusual isotope ratios and unusual molecular arrangements. Although Ubatuba Sample No. 1 may have been composed entirely of Mg^{26} isotope as indicated by the 1.866 gr/cc density, no isotopic analysis was made to confirm this supposition. Ubatuba Sample No. 2 exhibited a nearly normal density, and Ubatuba Sample No. 3 had a normal Mg^{26} composition. Hence,

although Ubatuba Sample No. 1 may have been composed of unusual magnesium isotopes, this cannot be verified now.

Unusual molecular arrangements do not occur in metals, but all metals crystallize in characteristic atomic configurations. Magnesium always crystallizes in the close-packed hexagonal (HCP) crystal structure. If the Ubatuba magnesium had been found to be body-centered cubic (BCC), it could be assumed to be extraterrestrial. As shown by Table VI, Ubatuba Sample No. 1 was not only close-packed hexagonal but also the interatomic spacings were nearly identical to that given by the ASTM 4-0770 card for triple sublimed terrestrial magnesium. Hence, no out of this world compositional differences were observed.

3) ***Structure.*** At the atomic level, the HCP unit cell is characterized by what is called the C/A ratio. From Table VI the C/A ratios were computed, with results shown in Table VII. As shown by Table VII the C/A ratio of Ubatuba Sample No. 1 is nearly identical to cited values for terrestrial magnesium.

At the microstructural level, the elongated, directionally solidified grain structure shown in Figure 1 could be reproduced terrestrially by any competent magnesium foundry. So, the structure criterion fails also.

4) ***Reproducibility.*** Pritchard's final criterion, reproducibility, is generally not applicable to UFO sightings. UFO sightings and reported crashes, etc., are one-time experiences of the observers and have not been reproduced in the laboratory.

Moreover, the Ubatuba physical evidence is unique in that it is the only technically pure, unalloyed magnesium crash debris ever found. Descriptions of material allegedly recovered from the Roswell, New Mexico, crash (Ref. 24) do not resemble the Ubatuba magnesium fragments.

Finally, Pritchard makes the point that for the UFO phenomenon to be seriously considered by mainstream science, the relevant research must be performed and funded by the usual cast of characters (government agencies and university researchers, respectively) and presented in widely circulated, refereed journals. From personal experience I can verify that government agencies do not fund this type of research and university Deans frown on their faculty members engaging in such research. Moreover, I would not dream of submitting the Walker and Johnson paper to a mainstream metallurgical journal.

In every respect, the Ubatuba magnesium fragments fail to meet Pritchard's criteria. This only serves to emphasize the difficulty of proving extraterrestrial origins of physical evidence.

My Personal Views

Several years ago I published a position statement on UFOs (Ref. 25) which still generally reflects my views:

> "POSITION STATEMENT: The worldwide occurrence of nearly identical sightings, by persons who could have no knowledge of similar sightings on other continents, convinces me that the phenomena are real. The wide diversity in appearance, i.e., saucers,

cylinders, flying wings, mysterious lights, odd-shaped clouds, et cetera, argues that more than one phenomenon is being seen and that multiple explanations are possible. The arguments that all sightings can be explained in the same way as extraterrestrial vehicles, ball lightning, unrecognized astronomical objects, or airborne fauna is therefore not valid.

In talks to different audiences on the phenomena, I am always asked: "Do you believe in UFOs?" This question is generally asked in a manner implying an act of religious faith on my part, rather as if I were "Born Again." My answer is that to be a true believer in any one UFO theory, whether it be extraterrestriality or ball lightning, would require an act of faith not supportable by observational data. I am therefore not a true believer in any one UFO theory. I truly believe, however, that "something is flying around up there," in our airspace, which cries out for good scientific study, but at this time I do not know what these phenomena are."

Three general approaches can be hypothesized to explain the Ubatuba case: 1) a natural object or terrestrial vehicle which exploded over the beach at Ubatuba, São Paulo, Brazil, in 1957 and was misidentified as a flying saucer; 2) the incident as described in the letter to Ibrahim Sued never occurred and the entire episode is a hoax; and

3) the incident described in the letter actually took place and the magnesium fragments came from a flying saucer.

In my personal opinion, misidentification can be dismissed. Explanations on this category range from Menzel's metallic magnesium meteorite to Ogilvie's weld metal. Magnesium is so chemically reactive that it never naturally occurs on Earth in the metallic state. There is no reason to believe that it would occur in the metallic state in the asteroid belt, on other planets in the solar system, or in a comet either. Hence, metallic magnesium meteorites are geochemically impossible. Similarly, for reasons cite in this review, unalloyed magnesium castings and welds are not used on aircraft, missiles, satellites, or other spacecraft. This leaves only 2) a hoax or 3) the real thing as a satisfactory explanation. I believe that both hypotheses have an equal probability of being correct and am baffled as to which is the true one.

Hoax. Considering the poor pedigree of the Ubatuba physical evidence, a hoax cannot be ruled out. Although nothing proving extraterrestriality was observed in the scientific studies, nothing unequivocally identifying the material as terrestrial was found either. The hoax explanation therefore is possible but unproven.

Extraterrestrial Vehicle. If one accepts that it is possible that a flying saucer has a soft, weak, technically pure, unalloyed, cast magnesium fuselage, then the metallographic evidence is consistent. The surface scale, the oxide intrusion into the grain boundaries and, particularly, the subscale from internal oxidation all suggest that the

magnesium was exposed to the Earth's atmosphere at elevated temperatures. The white $Mg(OH)_2$ coating is consistent with the burning fragments falling into the ocean.

To accept that observed UFO phenomena are necessarily extraterrestrial vehicles requires a degree of faith that I presently don't possess. At best I can only say the extraterrestrial vehicle hypothesis is possible but unproven in this case.

In summary, after all these years, I consider the Ubatuba magnesium fragment as unusual material of still unknown origin.

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TABLE I

COMPARISON OF PUBLISHED ANALYSES

(PRIOR TO 1970)

Element	Brazil (ES) Sample No. 1 Amount Reported	AEC Laboratory (ES) Sample No. 2 Amount Reported	AEC Laboratory (ES) Limit Of Detection (ppm)	DOW (ES) Sample No. 2 Amount Reported	DOW (ES) Limit Of Detection (ppm)	IRS Laboratory (NA) Sample No. 3 Amount Reported	IRS Laboratory (NA) Limit Of Detection (ppm)
Aluminum	ND	100-1,000	NS	<200	<5	ND	<10
Barium	ND	ND	<1,200	~3,000	<1	160 ± 20	NS
Calcium	ND	1-10	NS	~10,000	NS	ND	NS
Cobalt	ND	ND	<10	ND	NS	ND	NS
Copper	ND	1-10	NS	200	<10	3.3 ± 1	NS
Chromium	ND	ND	<1	ND	NS	ND	NS
Iron	ND	100-1,000	NS	<200	<4	ND	NS
Lead	ND	ND	<640	~200	<5	ND	NS
Magnesium	Present	100,000-1,000,000	NS	NS	NS	NS	NS
Manganese	ND	ND	<40	ND	NS	35 ± 3	NS
Mercury	ND	ND	<1,200	ND	NS	ND	NS
Nickel	ND	ND	<10	ND	NS	4	NS
Silicon	ND	100-1,000	NS	ND	<10	ND	NS
Silver	ND	ND	<1	ND	NS	ND	NS
Strontium	ND	ND	<1,200	3,000	5	500 ± 100	NS
Tin	ND	ND	<21	ND	<10	ND	NS
Titanium	ND	ND	<21	ND	NS	ND	NS
Vanadium	ND	ND	<10	ND	NS	ND	NS
Zinc	ND	ND	<300	ND	NS	500 ± 10	NS

(ES) - Emission Spectrograph
(NA)- Neutron Activation
(ND)- Not Detected
(NS) - Not Specified

TABLE II

COMPARISON OF PUBLISHED ANALYSES

(SINCE 1970)

LABORATORY	ANALYTICAL METHOD	ELEMENTS DETECTED WITH ABUNDANCE GREATER THAN 100 PPM
EVANS ASSOCIATES	CAMECA ION MICROPROBE	Al, Ca, Li, Mn, Sr
STANFORD	ELECTRON MICROPROBE	NONE
NASA JOHNSON SPACEFLIGHT CENTER	ARC ION MICROPROBE	NONE
EVANS ASSOCIATES	CAMECA ION MICROPROBE	C, Ca, Cl, Fc, K, Li, Na, Sr, Ti

TABLE III

SURFACE DEPOSIT COMPOSITION*

IDENTIFICATION OF SURFACE COATING	IMPURITIES (EACH ABOUT 2000 PPM)
$Mg(OH)_2$	Ca, Cl, Fe, Si, Ti

*Electron Microprobe at Stanford.

TABLE IV

TYPICAL ANALYSES OF MAGNESIUM

(PPM)*

ELEMENT	AS REDUCED METAL		AS PURIFIED METAL
	Electrolytic	Silicothermic	Triple Sublimed
Aluminim	50	70	4
Calcium	14	40	10
Copper	14	< 10	2
Iron	290	10	7
Manganese	60	20	< 10
Nickel	< 15	< 5	5
Lead	7	10	5
Silicon	1.5	60	< 10
Zinc	3	100	5
Other Impurities	< 300**	< 100***	< 100***
Total Impurities	< 1,300	< 400	< 200

* Converted from 0/0 by writer.

** B, C, Cl, K, Na, P, Sn-100 total; H-6, N-2.5, 0-2.2; Ag, As, Bn, Bc, Cc, Cd, Cs, Cr, Co, Hf, La, Li, Mo, P6, Sr, Ti, W, Zr-< 10 each.

***Ag, B, Bc, Co, Cr, K, La, Na, Sn, Sr, Ti, Zr-< 10 each; O, N, H not reported.

TABLE V*

ISOTOPICS OF MAGNESIUM

ISOTOPE	0/0 NATURAL ABUNDANCE	HALF-LIFE	ATOMIC MASS
Mg^{23}	--	11.9 sec	--
Mg^{24}	78.6	--	23.99189
Mg^{25}	10.1	--	24.99277
Mg^{26}	11.3	--	25.99062
Mg^{27}	--	9.6 min	--

*From Fontes (Ref. 1)

TABLE VI

X-RAY STUDY OF DR. OLAVO FONTES' SAMPLE

METALLIC CORE (Mg)					PULVAROUS CRUST $Mg(OH)_2$				
Sample		ASTM 4-0770 Card			Sample		ASTM 1-1169 Card		
d(A)	I	hkil	d(A)	I	d(A)	I	hkil	d(A)	I
§	VVW				4.79	VVS	0001	4.75	53
2.78	VVS	1010	2.780	35	2.78§§				6
2.607					2.71	VVW	1010	2.72	
2.458	VS	0002	2.606	41	2.61§§	VW			100
2.380§	VVS	1011	2.453	100	2.46§§	VW			40
1.900	VVW				2.36	VVS	0002	2.35	33
1.800§	S	1012	1.901	20	1.90§§	VVW			17
1.603	VVW				1.798	MD	1012	1.79	
1.572§	MD	1120	1.605	18	1.60§§	VVW			13
	VVW				1.574	S	0003	1.57	
1.473					1.495	MD	1121	1.49	9
1.389	S	1013	1.473	18					
	W	2020	1.389	2					7
1.367					1.372	DIF	2020	1.37	
1.342	MD	1120	1.366	16					
	MD	2021	1.343	9					3
1.304					1.310	DIF	2021	1.31	
1.225	MD	0004	1.303	2					4
	W	2022	1.227	2					4
1.179					1.184	DIF	0004	1.18	
1.085	W	1014	1.179	2					
1.050	MD	2025	1.085	2					
	VW	2130	1.051	1					
1.029					1.031	DIF	2130	1.03	
1.011	W	2131	1.029	7					
	W	1124	1.011	3					
0.975					1.007	DIF	2131	1.01	
	MD	1015	0.976	2					
0.926					0.947	DIF	0005	0.95	
	VW	3030	0.926	1					
0.889					0.909	DIF	5030		
	MD	2133	0.899	4					
0.874					0.893	DIF			
	W	3032	0.873	2					
0.834					0.866	DIF			
0.828	VW	2025	0.834	2					
	DIF	1010	0.826	1					
0.817					0.818	DIF			
0.811	DIF	2134	0.818	1					
	DIF	3033							
					0.786	DIF			

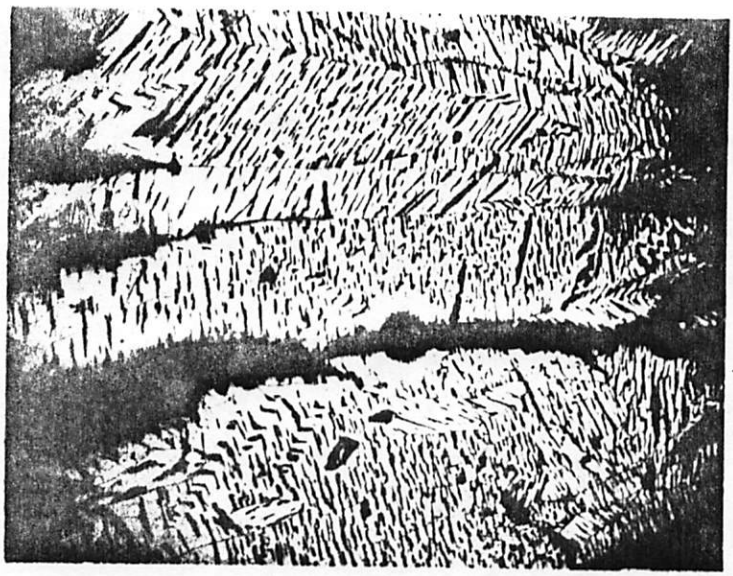
REMARKS:

§ - Reflection Due to $Mg(OH)_2$
§§ - Reflection Due to Mg
VVS - Very Very Strong
VS - Very Strong
S - Strong
MD - Medium
VVW - Very Very Weak
VW - Very Weak
W - Weak
DIF - Diffuse

TABLE VII

C/A RATIOS

	C/A	
UBATUBA	1.62633	CALCULATED FROM TABLE VI
ASTM 4-0770	1.62368	CALCULATED FROM TABLE VI
LITERATURE	1.62354	REFERENCE 23



25x NH_4Cl

(Macrophoto)

Figure 1. Overetched Ubatuba Sample No. 2.

Resume of Dr. Robert W. Johnson

EMPLOYMENT

June 1962 - Present

James Franck Institute, University of Chicago.

Responsibilities: Initially, had to start a laboratory for Materials Preparation starting with almost no suitable equipment on hand. Designed layout in space occupied by new lab. In charge of ordering equipment, and later, when funds became available, hiring technical and scientific men to work in it. In 1964, designated the purchase of a solids mass spectrograph and assumed responsibility for its operation and interpretation of results. In 1966 we were granted a three year contract with the Advanced Research Projects Agency with a total budget of $110,000 per year. Was responsible for $33,000 of that budget. The maximum staff was four people and myself. Of the four, two are scientific, two technical. In addition to directing this staff, have directed the work of many graduate students in matters related to crystal growth, purification, and physical and chemical characterization.

Results: The following materials were prepared in the Materials Preparation Laboratory. Each required techniques at or above the current state-of-the-art in material preparation.

Magnesium single crystals ($\rho\ 300^{\circ}/\rho\ 4.2^{\circ} > 100{,}000$)
Nickel fluoride (large single crystals)
Gadolinium (higher purity)
Palladium (higher purity)
Platinum (higher purity)
Zinc
Cadmium vapor growth single crystals of good purity
Antimony
Tin (maintained 99.9999% purity while growing large crystals)
Thallium (single crystals of alpha phase)
Tungsten (good resistance ratio)
Ferrites (single crystals)
Niobium (low O and N: moderately good resistance ratio)

Silver mass spectrographic standard with known isotopic concentrations from one part per billion to 25 parts per million.

Chromium: We have concentrated on this for about two years, the goal being samples having the resistance ratio $> 300^{\circ}/> 4.2^{\circ} \geq 10^{4}$. Best results so far are near 10^{3} which is the resistance ratio of the best chromium available elsewhere. In the course of this project we have developed techniques for purifying various chromium compounds and for reducing the O and N levels of the metal to a point that 3/16" rods of it are ductile enough at room temperature to be bent almost double without cracking.

Publications: The kind of research that is publishable has been possible only in the past two years. Prior to that, the job contained too much of an administrative and advisory nature to permit completion of publications. The work on chromium w ll be published at the end of this project. Other projects completed before then are being prepared for publication. A magazine article on material preparation facilities in general is being prepared.

Synopsis resume of
Dr. Robert W Johnson

5132 S. Ellis Avenue
Chicago, Illinois 60615
Phone: 312-493-7043

JOB OBJECTIVE

Any challenging position related to my experience.

EMPLOYMENT

June 1962 - present	James Franck Institute (formerly Institute for the Study of Metals) 5640 S. Ellis Avenue Chicago, Illinois Head, Materials Preparation Laboratory
Sept. 1959 - June 1962	Ames Laboratory of the Atomic Energy Commissic Iowa State University Ames, Iowa Student: 1/2 time work while working for Ph.D.
Sept. 1954 - Sept 1959	Ames Laboratory of the Atomic Energy Commissic Iowa State University Ames, Iowa Junior Scientist

Miscellaneous Employment

While an undergraduate, worked during school year and during summers when not taking summer courses.

EDUCATION

Sept. 1950 - Sept. 1954	St. Louis University, St. Louis, Missouri B.S., Chemistry (ACS approved curriculum)
Sept. 1956 - Sept. 1959	Iowa State University, Ames, Iowa M.S., Metallurgy. Obtained while working full time (44 hours per week) Thesis Title: The Lanthanum-Boron System
Sept. 1959 - June 1962	Iowa State University, Ames, Iowa Ph.D., Metallurgy - Minors: Physics, Mathematics. Obtained while working 1/2 time (assistantship) Thesis Title: Electron Requirements of Bonds in Metal Borides

PERSONAL

Age:	Born May 20, 1933 in St. Louis, Missouri
Appearance:	Height 6'4" - Weight 165 lbs.
Married:	Wife's maiden name: Joann Goebel. Education: two years college.
Children:	Six: ages 11, 9, 8, 7, 3, 2.
Health:	Good. No present physical limitations.
Residence:	Renting in neighborhood close to University.
Professional Societies:	American Chemical Society American Society for Metals
Military service:	None. When 18, was classified 4F because of history of rheumatic fever in childhood.

(for amplification please see following)

Reason for leaving: Government support of the Materials Preparation Laboratory is not being renewed after June 30, 1969. Other reductions in funds given to the James Franck Institute lead to the conclusion that this activity cannot be supported after the above date.

Present fields of knowledge: I have experience with the fields listed below, starting with those of greatest competence.

Purification and crystal growth methods.
Mass spectrographic techniques for trace analysis
Refractory intermetallic compounds, especially borides
Induction heating
Chemistry and Metallurgy of less common metals, especially rare earths, chromium, niobium and tantalum.
X-ray methods (powder, Laue, high temperature diffractometer)
High and ultrahigh vacuum techniques, including use of mass spectrometers as partial pressure analysers
Temperature measurement and control
Construction of vacuum resistance furnaces
General inorganic and physical chemistry
Analytical chemistry
Metallography

Scientific Societies:

American Chemical Society
American Society for Metals

Although not a member of the American Society for Testing Materials, I am working with one of its subgroups on standards for mass spectrographic analysis.

Sept. 1959 - June 1962
Iowa State University - Ames, Iowa

Responsibilities: Was a graduate student working on Ph.D. in Metallurgy. The thesis project was aimed at providing an experimental check of theoretical models for the electronic structures of the borides of the type MB_2, MB_4, MB_6 and MB_{12}. The check was to measure the number of "free" electrons in Yttrium borides via a measurement of the Hall coefficient. The task fell into two main categories. 1) Improvement of an existing system to allow sufficiently sensitive measurements. 2) Preparation of the compounds. A method was developed for obtaining single crystals of each compound. All have melting points above 2000°C, and two of them melt incongruently. A supporting experiment consisted of preparing single crystals of CaB_6, SrB_6 and BaB_6, and establishing their semiconducting nature by measurements of electrical resistance vs. temperature.

Results: The work was published in two parts:

Electron Requirements of Bonds in Metal Borides. R. W. Johnson and A. H. Daane. J. Chem. Phys. 38, 425 (1963).

Use of Induction Heating for Floating Zone Melting above 2000°C. R. W. Johnson. J Appl. Phys. 34, 352 (1963).

Sept. 1954 - Sept. 1959
Ames Laboratory of the Atomic Energy Commission
Iowa State University
Ames, Iowa

Responsibilities: At first, was mainly occupied with preparation of rare earth metals from their oxides. In 1956 started graduate school part time (5 hours per quarter) toward Masters degree, while continuing to work full time. Around 1957 was assigned thesis project, the determination of the phase diagram of Lanthanum and Boron. In the course of this work I established that a compound previously reported to be a boride of lanthanum could not be a phase in the binary system, but was at least a ternary compound. Developed a way to prepare lanthanum metal of improved purity, but this was not published.

Results: The thesis work was published in the following paper:

The Lanthanum-Boron System. Robert W Johnson and A H. Doane. J Phys. Chem. 65, 909 (1961).