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CHECKLIST OF CUBAN METEOR-WRONGS

Listado de pseudometeoritos cubanos

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Abstract: *This research addresses the prevalent issue of misidentifying terrestrial rocks and man-made materials as meteorites in Cuba, a region with rich geological diversity that complicates such distinctions. The objective is to systematically differentiate true meteorites from pseudometeorites, or "meteor-wrongs", through an analysis of collected specimens across the island. Employing a multifaceted methodology, including macroscopic examination, basic magnetism testing, density measurement, and advanced analytical techniques like X-ray fluorescence (XRF) and Scanning Electron Microscopy/Energy Dispersive Spectroscopy (SEM/EDS), this study elucidates the distinguishing features of meteoritic versus non-meteoritic materials. Our findings reveal a predominance of igneous rocks, particularly basalt, and ferrosilicon alloys misidentified as meteorites. This work emphasizes the importance of curatorial documentation and accessibility of problematic specimens for scientific investigation, advocating for a culture of precision and curiosity in geoscientific research.*

Keywords: *Cuba, pseudometeorites*

Resumen: *Esta investigación aborda el problema de la identificación errónea de rocas terrestres y producidas por humanos como meteoritos en Cuba, una región con una rica diversidad geológica que complica tales distinciones. El objetivo es diferenciar sistemáticamente los verdaderos meteoritos de los pseudometeoritos, o "meteor-wrongs", a través de un análisis de ejemplares provenientes de la isla. Empleando una metodología que incluye examen macroscópico, pruebas básicas de magnetismo, medición de densidad y técnicas analíticas avanzadas como la fluorescencia de rayos X (XRF) y la microscopía electrónica de barrido/espectroscopía de energía dispersiva de rayos X (SEM/EDS), este estudio aclara las características distintivas de los materiales meteoríticos respecto de los no meteoríticos. Nuestros hallazgos revelan una predominancia de rocas ígneas, particularmente basalto, y aleaciones de ferrosilicio identificadas erróneamente como meteoritos. Este trabajo enfatiza la importancia de una documentación curatorial y la accesibilidad de ejemplares en discusión para la investigación científica, abogando por una cultura de precisión y curiosidad en la investigación geocientífica.*

Palabras clave: *Cuba, pseudometeoritos*

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Introduction

The study of meteorites offers a unique window into the cosmic processes that have shaped our solar system. However, amidst genuine meteoritic discoveries, a significant number of terrestrial rocks and man-made objects are often misidentified as meteorites. These are commonly referred to as pseudometeorites or "meteor-wrongs" (Ceballos-Izquierdo *et al.*, 2024; Notkin, 2011; Senesi *et al.*, 2018).

In Cuba, the task of distinguishing meteorites from meteor-wrongs has been a daunting one. Over the years, several terrestrial rocks or man-made objects have been repeatedly identified as meteorites, some of them lacking comprehensive analysis or were based on anecdotal evidence/historical records. This has led to a mix of confirmed meteorites and a larger number of questionable or unverified specimens (Ceballos-Izquierdo, 2019, 2022; Ceballos-Izquierdo *et al.*, 2021). This aspect reflects a broader pattern seen worldwide, where enthusiasm and public engagement often intersect with scientific research.

The purpose of this paper is to provide a checklist to the most significantly encountered pseudometeorites in Cuba. By examining the properties of these specimens, this paper seeks to elucidate some key differences between meteorites and their terrestrial counterparts, thereby aiding both amateur enthusiasts and professional geologists in accurate identification. The focus on Cuba is particularly pertinent due to its diverse geological landscape, which, due to the variety of rocks, can contribute to the misidentification of native rocks as extraterrestrial. The island comprises a series of tectonic terrains that include igneous, metamorphic, and sedimentary rocks dating from the Jurassic to the Quaternary. In western Cuba, limestone formations and carbonate rocks predominate, while in the central and eastern parts of the island, metamorphic and ultramafic complexes are found, along with basalts and other volcanic rocks. A synthesis of Cuban geology can be found in Iturralde-Vinent *et al.* (2016).

Materials and methods

A comprehensive collection of rock samples commonly mistaken for meteorites was gathered from literature and collections (Table 1), representing various regions across Cuba (Fig 1.). These samples were primarily sourced from locations with a history of reported meteorite finds or areas with geological features conducive to such misidentifications. Each sample, when available, underwent a detailed macroscopic examination for features typically associated with meteorites. This included assessments of physical characteristics such as size, weight, color, texture, and the presence of key features like fusion crusts or regmaglypts (Norton and Chitwood, 2008). Initial assessments of the specimens involved basic magnetism tests to check for the presence of magnetic minerals by attraction to a magnet, aiming to distinguish meteoritic material from terrestrial rocks at a preliminary stage (since most meteorites contain appreciable elemental iron) (Norton and Chitwood, 2008). The density values for the Mango Jobo and Cuba specimens were derived from existing literature, while the density for MNHNCu specimen was determined using the water displacement method. These measurements were systematically compared with established density ranges for both meteorites and common terrestrial rocks to assess their probable origins (Henderson and Perry, 1954; Britt and Consolmagno, 2003; Norton and Chitwood, 2008; Scott, 2020).

In more challenging cases, where the nature of the samples could not be determined through macroscopic examination alone, X-ray fluorescence (XRF) analysis and SEM/EDS (Scanning Electron Microscopy/Energy Dispersive Spectroscopy) was employed. For instance, the MNCN No. 17294 specimen was subjected to a comprehensive chemical and morphological examination using an FEI InspectTM SEM equipped with Secondary Electron (SE), Backscattered Electron (BSE), Cathodoluminescen-

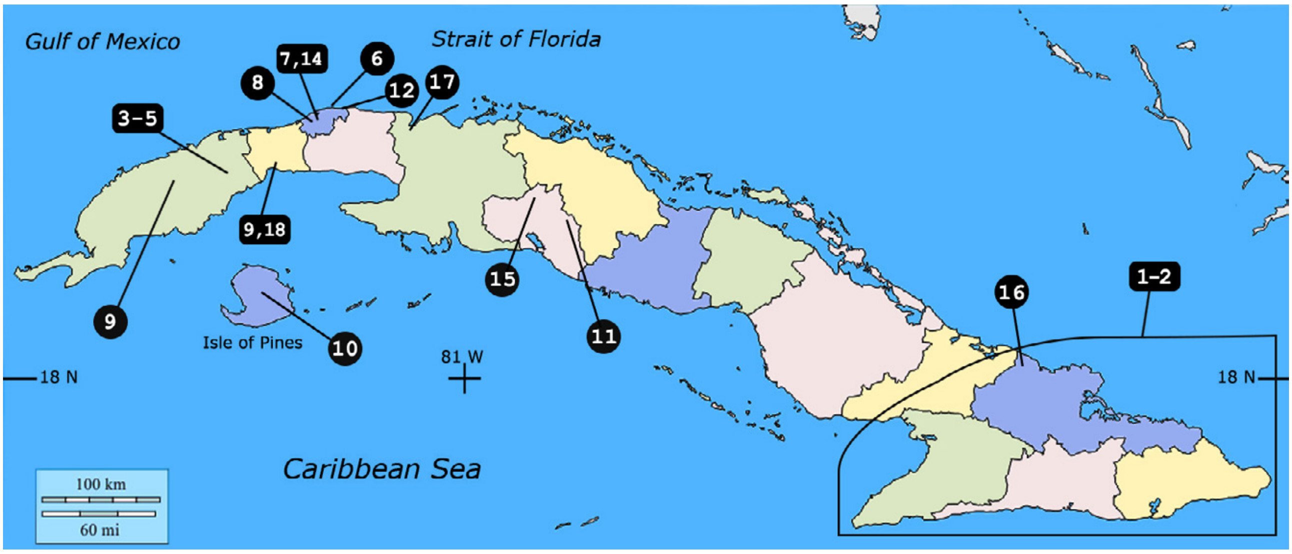

Fig. 1.- Generalized map with the location of the Cuban meteor-wrongs mentioned in this paper (the numbers correspond to those in Table 1). The locality of the "Cuba" meteor-wrong (1-2) is reported as the "Eastern Department" that includes the current provinces of Holguín, Guantánamo, Granma, and Santiago de Cuba. Scale = 100 km.

	Meteor-wrong	Date	Repository	Mass (g)	Reference
1	Cuba	1871	MNCN	~1327 g	Ceballos-Izquierdo *et al.* (2024)
2	Cuba (6 fragments)	?	FMNH	?	Ceballos-Izquierdo *et al.* (2024)
3	Mango Jobo	1938	IGA	1099	Pérez-Doval (1996)
4	Mango Jobo II	1938	IGA?	344	Pérez-Doval (1996)
5	Mango Jobo III	1938	IGA?	162	Pérez-Doval (1996)
6	Bacuranao	1974	?	?	Segura-Soto (1983)
7	Boyeros	1996	IGA?	117.5, 14.9	Jaimez-Salgado *et al.* (2001)
8	Balcón de La Lisa	2001	?	4.44	Jaimez-Salgado *et al.* (2007)
9	Guira de Melena	2001	**	194.9	Jaimez-Salgado *et al.* (2007)
10	Isla de la Juventud	?	?	?	CIPIMM (2003)
11	Cruces	?	?	?	CIPIMM (2003)
12	Guanabo	?	?	?	CIPIMM (2003)
13	Número 6	?	?	?	CIPIMM (2003)
14	Boyeros (CENHICA)	2006	IGA?	~200 g	Ceballos-Izquierdo (2016)
15	Rodas (Fca. Castellanos)	2011	**	?	This paper
16	Gibara	2013	?	114 g	This paper
17	Cueva del Gato Gíbaro	?	MNHNCu	40.6 g	Ceballos-Izquierdo *et al.* (2024)
18	Guira de Melena II	2023	**	?	This paper

Table 1.- List of Cuban specimens investigated in this paper. A (**) refers to material in private collections, (?) data is unknown. Acronyms of collections and institutions of specimens or material mentioned: Museum of Natural Sciences in Madrid, Spain (MNCN), Field Museum of Natural History, Chicago, United States (FMNH), Institute of Geophysics and Astronomy of Cuba (IGA), National Museum of Natural History of Cuba (MNHNCu), Centro de Investigaciones para la Industria Minero-Metalúrgica (CIPIMM).

ce (CL), and an Oxford Instruments INCA EDS system for elemental analysis. Given its historical significance, only non-destructive surface examinations were initially conducted under specific parameters (30 kV, 13.7 mm working distance, in a low vacuum environment). Oxalic acid was cautiously applied for surface cleaning, preserving the specimen's integrity. Subsequent investigations involved a detailed examination of a small fragment to unveil the

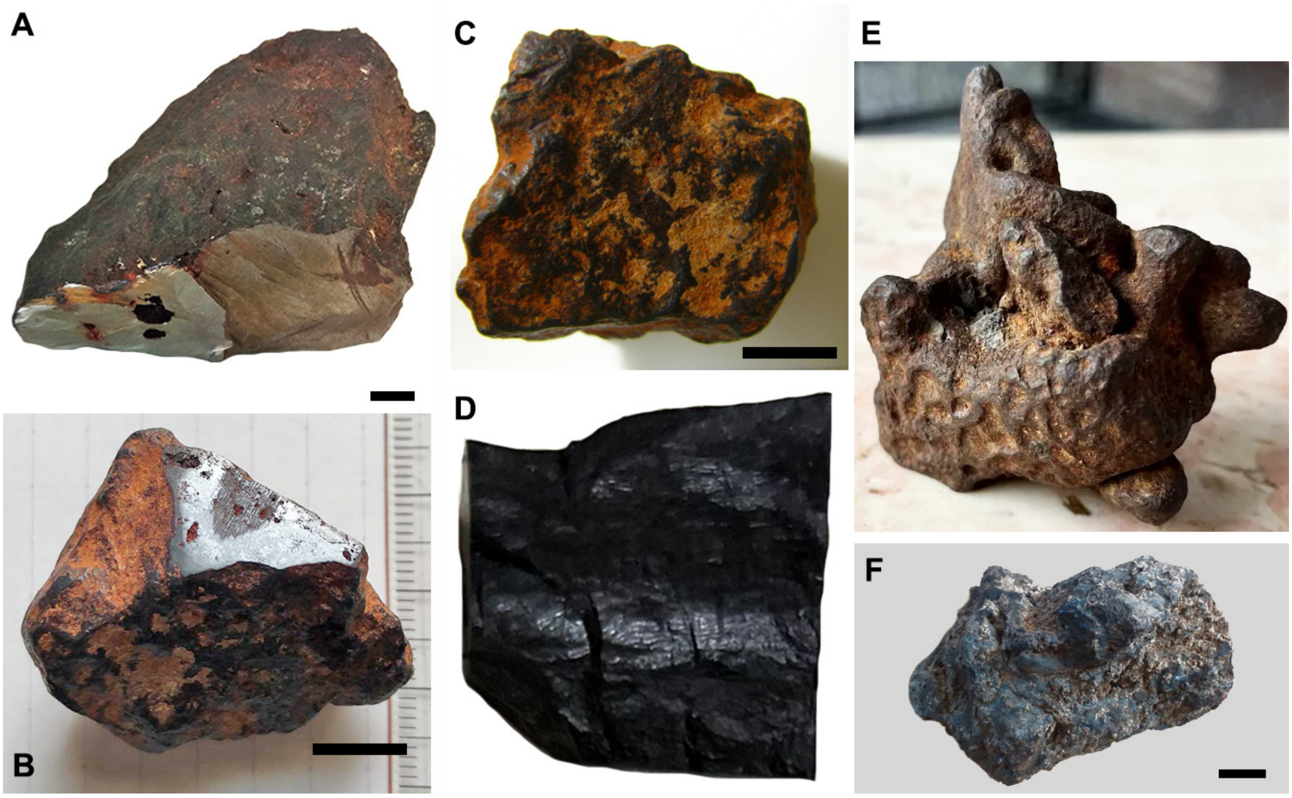

Fig. 2.- Some of the Cuban meteor-wrongs mentioned in this paper. A) Cuba (MNCN No.17294), B-C) Cueva del Gato Jíbaro, D) Bacuranao (modified from Rochette *et al.*, 2023), E) Mango Jobo II (modified from Rochette *et al.*, 2023), F) Guira de Melena II. Scale = 1 cm.

internal matrix structure. Moreover, the Metallurgy Department at the Technical School of Industrial Engineers in Madrid contributed to this analysis, employing nitric acid treatments and advanced microscopy techniques to further characterize the specimen. The MNHNCu specimen underwent SEM/EDS analysis at Florida International University, Miami. This was facilitated using a JEOL JSM 5900LV microscope, which provided high-resolution imaging capabilities (up to 3 nm) at selected focal points. XRF analysis of the specimens mentioned in Jaimez-Salgado *et al.* (2001, 2007) were evaluated from Test Certificate #2 (CIPIMM, 2003).

Results and discussion

Meteorites are characterized by distinctive features such as density ranges from 3.0 to 8.0 g/cm³, depending on type, and nickel content between 5-30%, rarely found in terrestrial rocks (Britt and Consolmagno, 2003; Norton and Chitwood, 2008). They typically lack quartz and have minerals like kamacite, schreibersite, olivine, pyroxene, and plagioclase feldspar, with chondrules being a hallmark in the case of chondritic meteorites. SEM and XRF analyses often reveal iron-nickel alloys and sulfides, distinct from terrestrial compositions. The frequent misidentification of terrestrial rocks as meteorites in Cuba underscores the need to employ these diagnostic features and conduct comprehensive testing for accurate identification. This approach fosters a culture of scientific curiosity and rigor.

The present study identified a wide range of pseudometeorites across Cuba (Table 1). Many of the investigated samples comprised igneous rocks, predominantly basalt and similar types. Other specimens (e.g. 7-9 in Table 1), likely ferrosilicons, were also misidentified, despite their typically non-meteoritic composition. Basic magnetic testing revealed that a significant portion of the samples exhibited magnetic attraction, but it is not a distinctive feature of meteorites (Norton and Chitwood, 2008). Density measurements further aided in distinguishing pseudometeorites, with samples (e.g. 3-5 and 17 in Table 1) falling outside

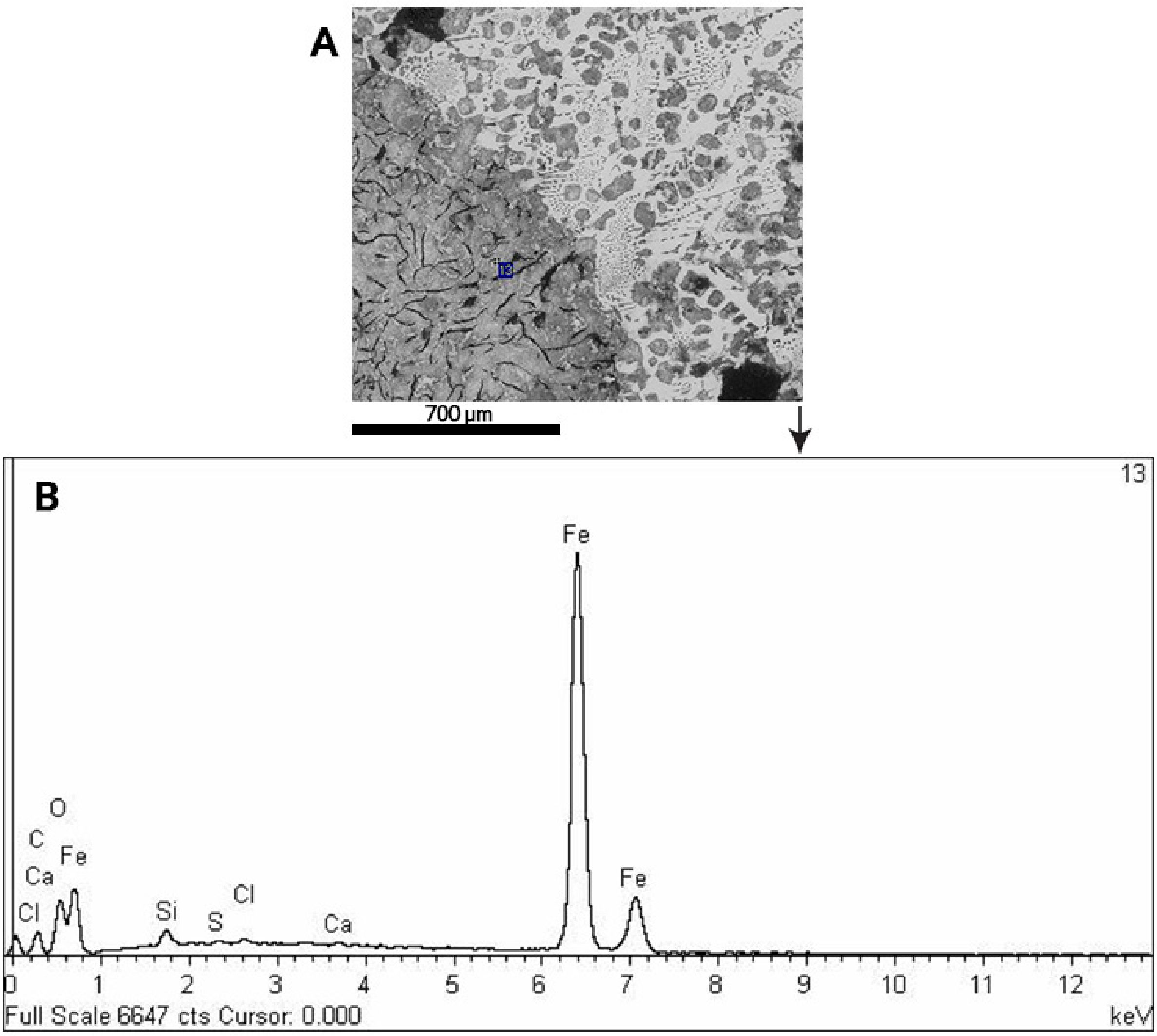

Fig. 3.- A) Backscattered electron image of one of the investigated areas of MNCN No.17294. B) EDS spectrum corresponding to the sample's area showing no detectable amounts of Ni.

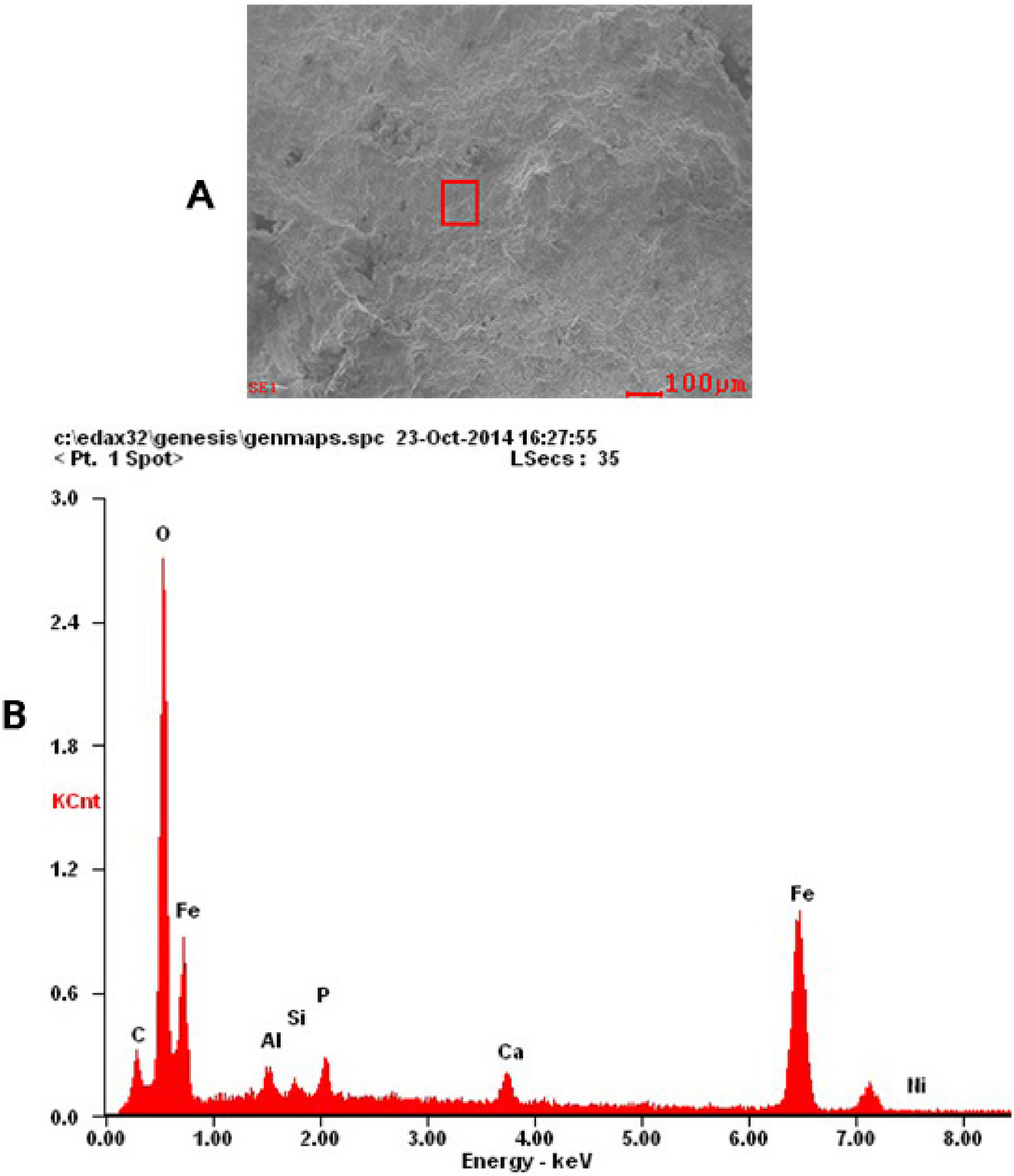

Fig. 4.- A) Backscattered electron image and B) EDS analysis spectra of the corresponding area in the MNHNCu specimen from Cueva del Gato Jíbaro, Matanzas, western Cuba. The EDS spectra show peaks for iron (Fe) with lower nickel (Ni) and aluminum (Al) contents. Note the incidence of phosphate-calcium peaks, both common aggregates of sedimentary rocks.

the typical density range of known meteorites (Henderson and Perry, 1954; Britt and Consolmagno, 2003; Norton and Chitwood, 2008). In some problematic cases, XRF and/or SEM analysis further confirmed the terrestrial origin, showing a composition inconsistent with meteoritic material (e.g., absence of Nickel, lack of meteoritic minerals, presence of quartz) (Ceballos-Izquierdo *et al.* 2024; Solano y Eulate, 1872). Microscopic examination provided additional insights, revealing mineralogical structures and textures not found in meteorites (e.g., quartz, high concentrations of metallic silicon). These results were instrumental in confirming the terrestrial origin of the samples, which are discussed in the following paragraphs.

The first specimen of concern is the object known as the “Cuba” meteorite, cataloged under MNCN No. 17294 in the Museum of Natural Sciences in Madrid, Spain (Fig. 2A). It has been historically recognized as an official meteorite in the Meteoritical Society’s online database. However, inconsistencies, particularly in historical records, density, anomalous composition, and the notable absence of Widmanstätten patterns, collectively provide evidence that casts doubt on this specimen. These factors led Ceballos-Izquierdo *et al.* (2024) to reevaluate it as a non-meteorite. Advanced analytical methods, such as SEM-EDS, were instrumental in proving the absence of detectable amounts of nickel (Ni) which confirmed the specimen's terrestrial origin (Fig. 3). Another problematic iron-like metallic object (MNHNCu specimen) of 40.6 g was also subjected to SEM-EDS analysis. This suspected meteorite was found within an archaeological site from Cueva del Gato Jíbaro, Matanzas province, western Cuba (Fig. 2B-C). The specimen was directly associated with an indigenous female burial (Mesolithic-hunter-gathered cultural affiliation) at this location (Arencibia and Delgado, 1984; Villegas, 1984), now dated to 1255-984 14C cal BP (Orihuela *et al.*, 2020). Initially, based only on visual inspection, the fragment was believed to be an iron meteorite, but its composition was unknown. However, the test results revealed a remarkably low nickel content of about 0.031 wt% (Fig. 4). Additionally, a cut made on the object surface failed to unveil the Widmanstätten pattern and instead displayed visible cavities within the polished section (Fig. 2B). Based on its EDS spectra, thin-section, low density (4.06 g/cm^3) and other analyses, the Cueva del Gato Gíbaro specimen is now considered a meteor-wrong.

The three pieces of Mango Jobo (Fig. 5) originally belonged to the collection of the renowned Cuban naturalist Dr. René Herrera Fritot, who was not only an archaeologist but also a mineralogist. Therefore, it is strange that he did not analyze them. The fragments (1099, 344, and 162 grams, respectively) were in the Department of Archaeology of the former Academy of Sciences of Cuba and later became part of the collection of the Institute of Geophysics and Astronomy since June 1987. Notably, two fragments were displayed at the Havana Planetarium until their removal during the preparation of the publication by Ceballos-Izquierdo *et al.* (2021) that declared it a non-meteorite. It is unclear how one of these fragments was facilitated to the National Museum of Natural History of Havana for exhibition and study (Rochette *et al.*, 2023). Currently, the repository of the three fragments is unclear, and whether they are available for new research.

The initial report on the Mango Jobo specimen by Pérez-Doval (1996, p. 101) suggested that it might have fallen in 1938 near Mango Jobo, in the province of Pinar del Río, and mentioned that one of the fragments was sliced to examine for Widmanstätten patterns. However, as first noted by Ceballos-Izquierdo (2022), this account lacks clarity regar-

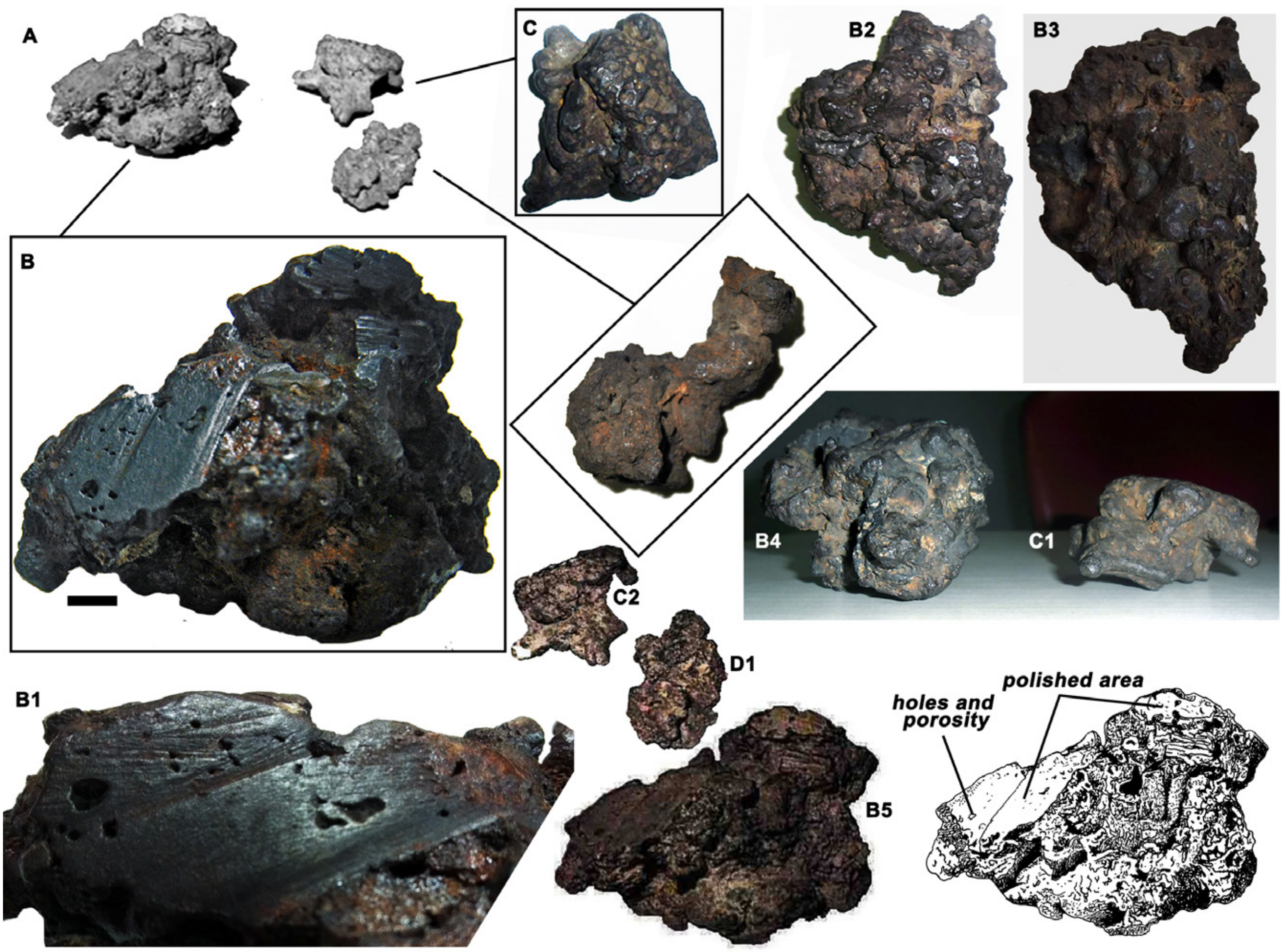

Fig. 5.- A) The three fragments of Mango Jobo, B) Major fragment, C) Medium fragment, D) Minor fragment. B2-B3-B4) Different views of the main fragment, B1) "polished" surface in an enlarged view, B5) comparison with line drawing. C-C1-C2) Different views of the median fragment. D-D1) Different views of the smaller fragment. Scale = 1 cm.

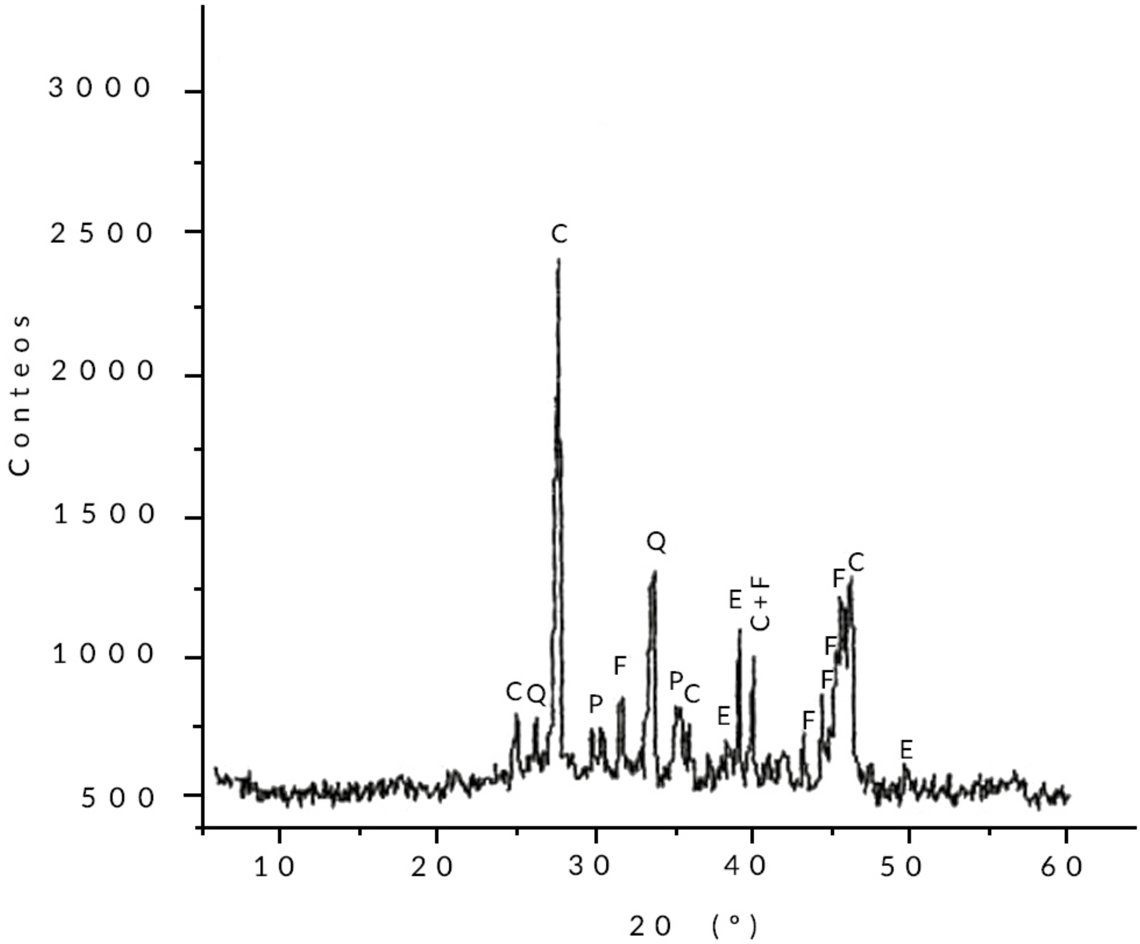

Fig. 6.- X-ray diffraction pattern of Mango Jobo III specimen (minor fragment) displaying prominent peaks corresponding to various minerals. The highest peak, denoted as 'C', is indicative of a significant cristobalite presence, while the other labeled peaks represent different minerals, such as quartz ('Q') and feldspar ('F'). Peaks labeled 'E', 'P', and 'L' correspond to other minerals that are present in smaller quantities.

ding the actual observation of these patterns, highlighting a need for further investigation and verification of these critical diagnostic features in the specimen. The surface that appears to have been polished is on the larger fragment and on it, porosity and internal voids can be seen (Fig. 5B). Meteorites are solid rocks that have regmaglypts on their surface, but not empty spaces inside, which is an important clue that the Mango Jobo rock is not of spatial origin. Moreover, a recent test with nitric acid did not reveal Widmanstätten patterns and its density (5.4 g/cm^3) is very low for an iron meteorite. The holes in the polished surface, lack of fusion crust or regmaglypts, and the general appearance of this specimen are consistent with a "mocarrero" formed by the agglutination or cementation of sandy particles and ferruginous material, leaving cavernous spaces inside.

The medium-sized fragment (Fig. 5C) lacks both a fusion crust and regmaglypts, but there are abundant cavities on one of the planes of its surface. Towards its ends, subrounded protrusions stand out that are uncommon for a meteorite and resemble a viscous flow that cooled (Ceballos-Izquierdo, 2022). Rochette *et al.* (2023) classified this specimen –an iron-rich fragment with traces of chromium (Cr) and nickel (Ni), consisting of metallic globules and silicate slag bubbles, and previously displayed at the National Museum of Natural History of Havana– as a man-made object. According to Iturralde-Vinent (2023), this sample was not found in the museum after the study by Rochette *et al.* (2023).

The smaller fragment (~6.5 x 3 x 2 cm) is very irregularly shaped, arched, appears deeply oxidized, and lacks a fusion crust and regmaglypts (Ceballos-Izquierdo, 2022) (Fig. 5D). The outer surface is reddish-brown. The diffractogram of the specimen revealed prominent peaks of cristobalite and quartz, and it notably lacked meteoritic minerals, regmaglypts, and a fusion crust (Fig. 6). Additionally, its irregular appearance and internal cavities are inconsistent with characteristics typically associated with extraterrestrial objects (Norton and Chitwood, 2008). This evidence collectively suggests a terrestrial origin for the specimen. On the other hand, Jaimez-Salgado (2023) expressed reservations about its cosmic origin (p. 25) and speculated that it might be a stony meteorite from the H-type chondrite class, citing its high magnetism (p. 22). However, given that magnetism is not an exclusive feature of meteorites, such a classification should be approached with caution. Jaimez Salgado's (2023) article acknowledges the exis-

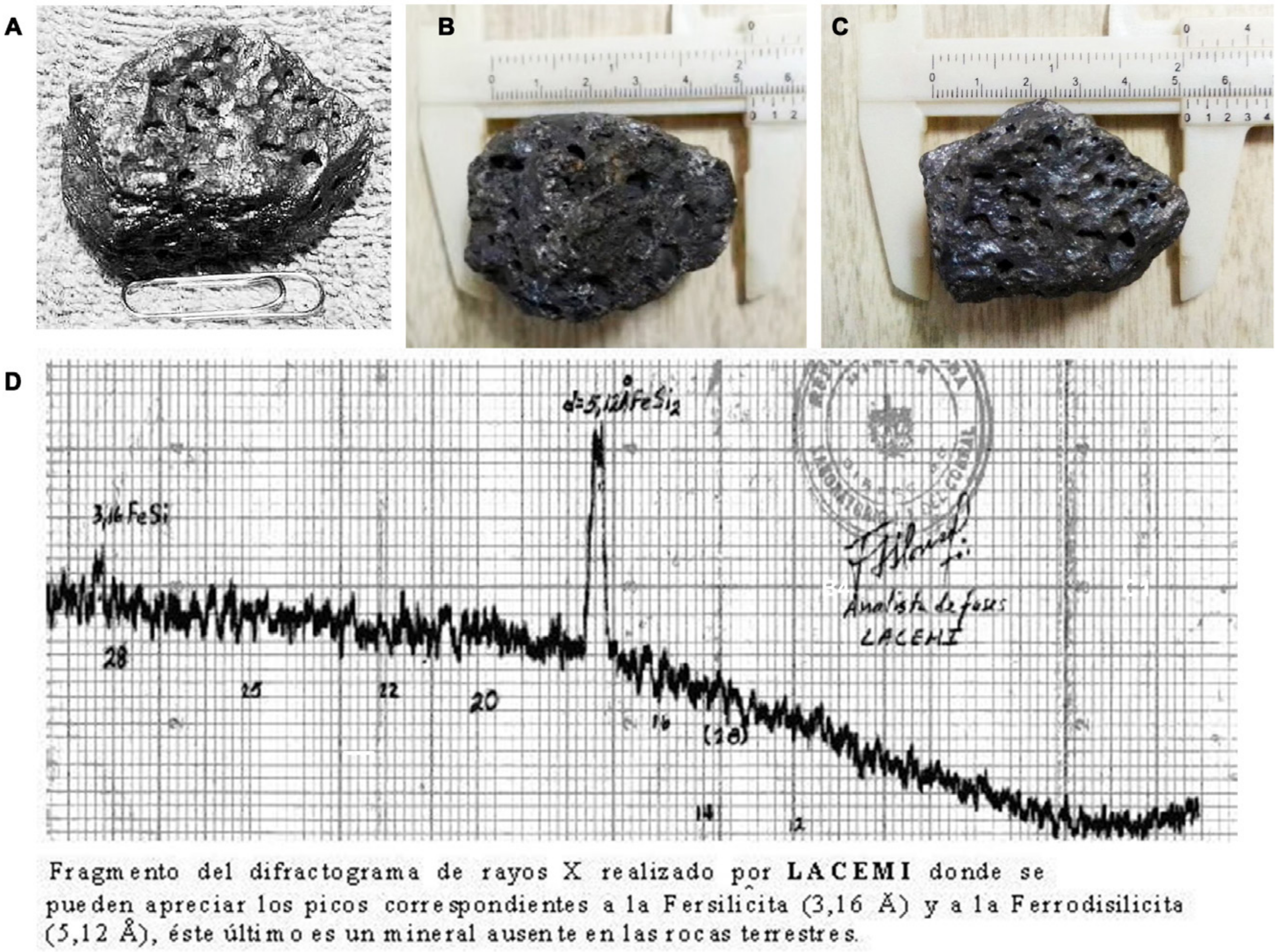

Fig. 7.- A) Old photo available of the Boyeros specimen. B-C) Recent photos of the Boyeros specimen. D) Diffractogram with the peaks of the terrestrial minerals $FeSi_2$ and FeSi. Although in the diffractogram it was written that Ferdisilicite is absent in terrestrial rocks, this mineral was discovered in 1960 in Donetsk Oblast, in the Soviet Union, and later found in Tibet.

tence of three fragments but only provides details on two. Further, the article lacks information regarding the status or custodianship of these objects, a detail that is crucial for the continuity and transparency of scientific research.

Visually, this pseudometeorite closely resembles an aggregate of iron pellets (mocarrero) or iron slag. The most plausible explanation for the Mango Jobo fragments is that they are mocarreros. This interpretation is in accordance with Iturralde-Vinent (2023), who stated that he examined in the sixties the sample designated as Mango Jobo in the collection of René Herrera Fritot at the Department of Archaeology of the former Academy of Sciences in the National Capitol. Since then, he had determined that, due to its yellowish-earthy coloration and nodular texture, it was a ferruginous concretion, typical of many Cuban soils and lateritic weathering crusts. Finally, if the three fragments mentioned truly originate from Mango Jobo, their presence there should not be considered exotic or out of place. The 1965 genetic soil map (ACC, 1965) indicates that the area around Mango Jobo and south of Pinar del Río province contains soils with mocarreros, supporting this interpretation. This area is characterized by Quaternary geological formations with weathering crusts, including ferritic crusts, nodules, and ferruginous concretions.

The Bacuranao specimen, which was previously unaccounted for in the collections of the MNHNCu, resurfaced and underwent a brief examination by Rochette *et al.* (2023). They identified it as slag, a finding supported by an unscaled photograph (Fig. 2D). For the sake of scientific transparency and ethical research practices, the provenance and chain of custody of the specimen, as it came into the possession of Rochette *et al.* for their in-situ study, warrant further clarification. Additionally, their dismissal of the specimen as a non-essential part of museum heritage is regrettable, casting doubt on its availability for future research. Adding to the confusion, Jaimez-Salgado (2023) first considered it as either an iron meteorite or a stony-iron (p. 22), later specifying it as a stony-iron (mesosiderite) (p. 24). This latter classification was based on the interpretation of the presence of both chondrules and Widmanstätten patterns in the same specimen (Jaimez-Salgado *et al.*, 2023, p. 31), which is highly unusual and warrants skepticism. Conveniently, the latter author omitted any discussion of the finding of Rochette *et al.* (2023) in his account.

The Bacuranao specimen was reported by Segura-Soto (1983) as found in a sandy seabed, on the beach of Bacuranao, Havana, in 1974. Under such conditions, an iron meteorite would be subject to corrosion, sedimentation, and possible interactions with bacteria that could affect its integrity and composition over time (i.e., Buchwald, 1977; Buchwald and Clarke, 1989; González-Toril *et al.*, 2005; Gronstal *et al.*, 2009). Despite these potential alterations, Segura-Soto (1983) did not report any alteration processes or corrosion products. The specimen was described as black in color with a submetallic luster. Regarding the Widmanstätten figures, Segura-Soto (1983) stated: "the internal mass of the sample is entirely composed of metallic minerals that in the polished section are revealed as kamacite, which, when arranged in lamellar bands, recalls the Widmanstätten figures". Yet, the published photographs by Segura-Soto (1983) do not conclusively show such figures. Furthermore, Segura-Soto (1983) reported the presence of a few lithic chondrules containing well-defined quartz and ferromagnesian minerals (breunnerite), which are atypical in iron meteorites (Ceballos-Izquierdo *et al.*, 2021; Scott, 2020). No information on the specimen's mass, density, or current repository was provided, leaving its existence uncertain.

Regarding the other three rocks that have traditionally been considered meteorites, namely Boyeros, Güira de Melena (Gámez), and Balcón de La Lisa, they have the appearance of a metallic silicon alloy (ferrosilicon) with a surface with small holes or depressions and no regmaglypts, nor any trace of a fusion crust. The diffractograms of these specimens show pronounced peaks of the minerals Ferdisilicite ($FeSi_2$) and Fersilicite (FeSi), suggesting their origin from industrial materials (Fig. 7D, 8-9). High concentrations of metallic silicon are typically not observed in meteorites. While both $FeSi_2$ and FeSi have been identified within meteoritic compositions, they are considered to be accessory phases, existing predominantly in the form of small grains (Rubin and Ma, 2017). Metallic silicon alloys are produced industrially on a large scale due to their numerous applications and their luster, color, and resistance to weathering often lead to them being mistaken for meteorites. It also is interesting to note that at the time when the diffractograms were performed, the names Ferdisilicite and Fersilicite were not internationally approved. These minerals were recognized later in 2012 as Linzhiite and Naquite (Li *et al.*, 2012; Nicheng *et al.*, 2012). Even, the first publications that reported Linzhiite and Naquite as accessory minerals in meteorites were from 2015 (Ma *et al.*, 2016; Nazarov *et al.*, 2015; Rappenglück, 2022). Another element to consider is that these three objects were originally reported as stony irons, and this classification in turn is divided into two subgroups. The first subgroup is

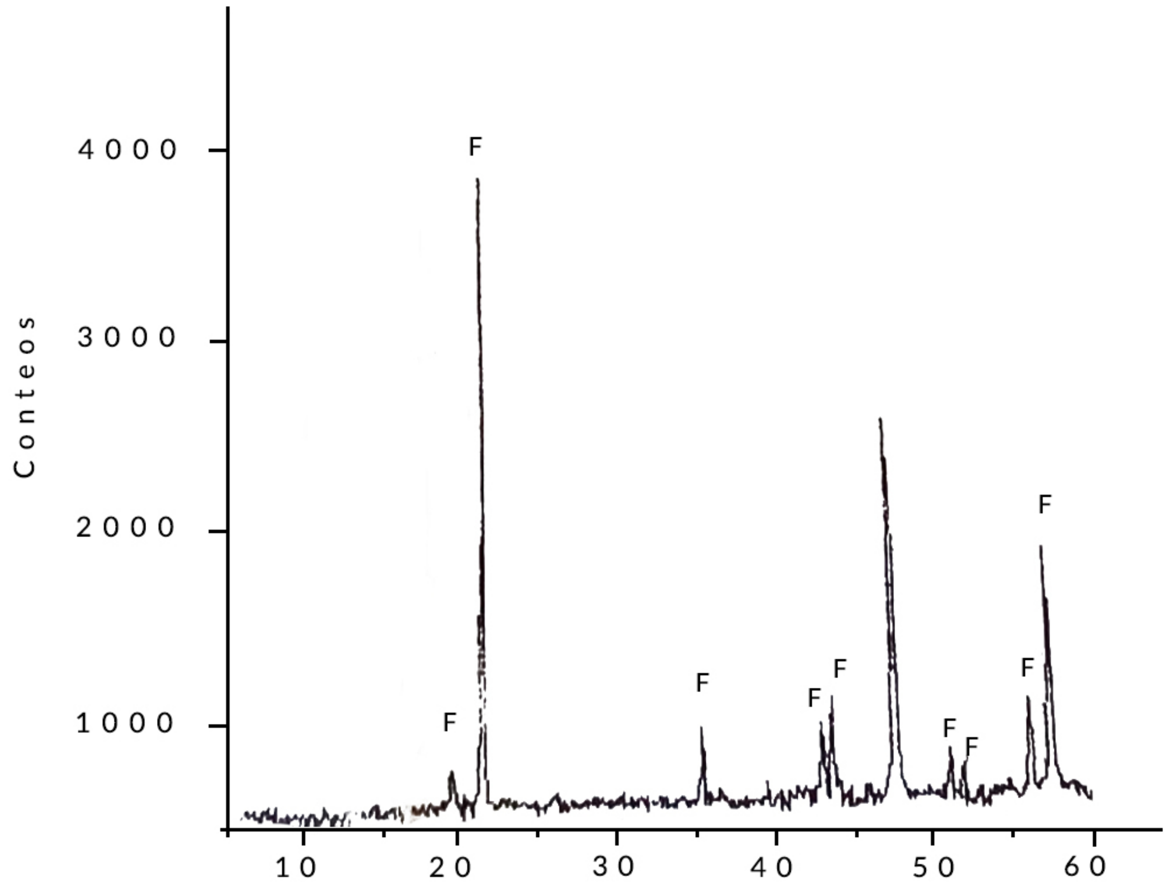

Fig. 8.- X-ray diffraction pattern highlighting the mineralogical composition of the Guira de Melena specimen. Labels 'F' correspond to the terrestrial minerals $FeSi_2$ and FeSi. Multiple smaller peaks are also present, which may correspond to various other minerals within the sample matrix.

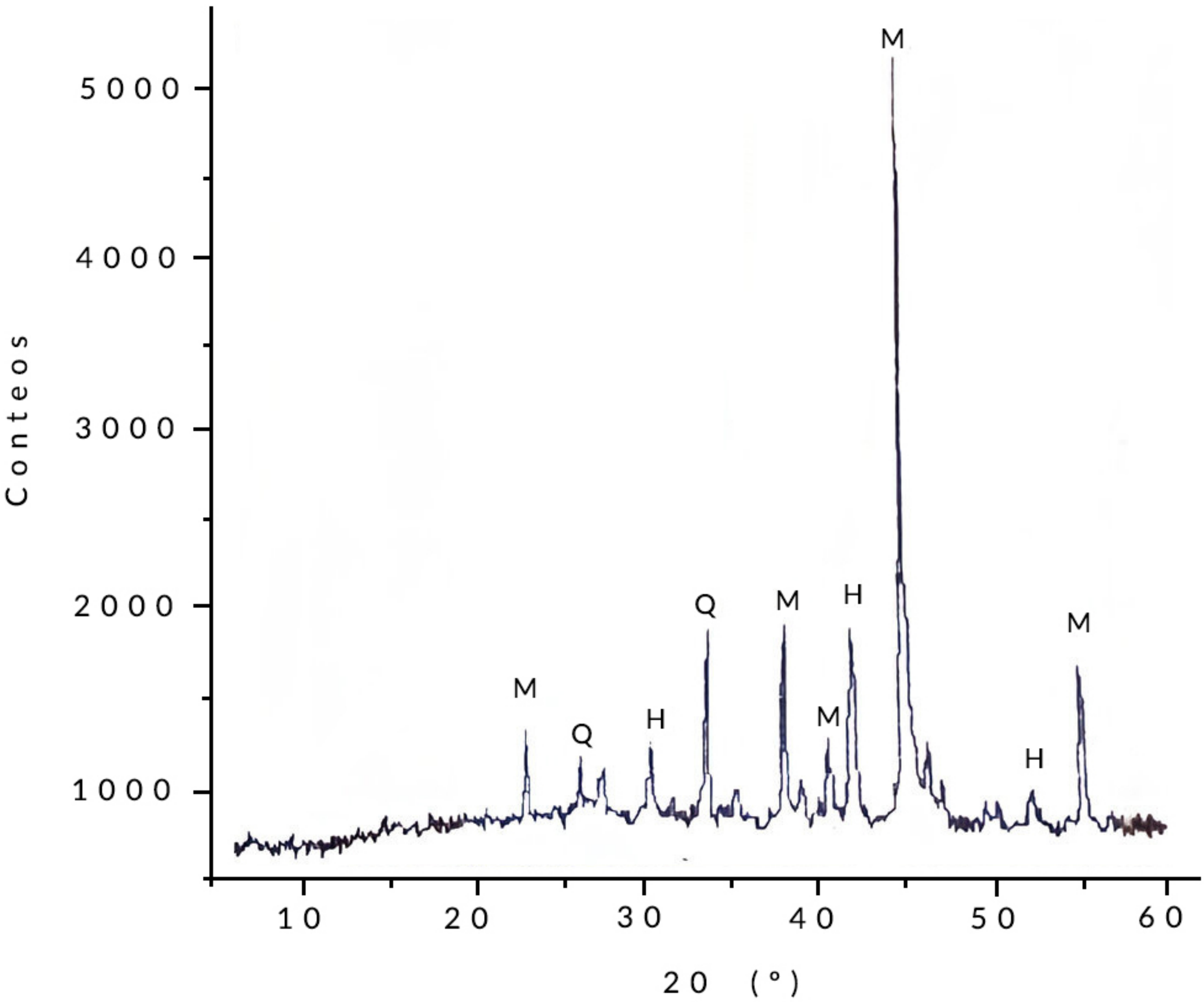

Fig. 9.- X-ray diffraction pattern highlighting the mineralogical composition of the Número 6 specimen. Labels correspond to Q: Quartz (SiO_2), H: Hematite (Fe_2O_3), M: Magnetite (FeO). Multiple smaller peaks are also present, which may correspond to various other minerals within the sample matrix.

called pallasites, considered the most beautiful meteorites because they have olivine crystals, thus in a pallasite a diffractogram should show minerals typical of a meteorite and high peaks of olivine, but the specimens we are analyzing do not belong to this classification. The second subgroup is called mesosiderites, because they present a metallic phase and a rocky/brecciated phase. These differ from Boyeros, Güira de Melena (Gámez), and Balcón de La Lisa, which have a very shiny metallic appearance. To validate them with a diffractogram, it should present high peaks of pyroxene and Ca-rich plagioclase, combined with peaks of kamacite and taenite. Visually, both Güira de Melena (Gámez) and Balcón de La Lisa specimens have tabular cuts that are improper for meteorites (Fig. 10). Specifically, one of the cuts in Balcón de La Lisa reveals the inner matrix, which markedly differs from a pallasite or a mesosiderite.

In the specific case of the Boyeros specimen, it was initially identified as an iron meteorite, with a reported global chemical composition as follows: Fe (53.7%), Ni (7.03%), Co (0.19%), and Si (39.08%) (Jaimez-Salgado *et al.*, 2001). Surprisingly, it was later reclassified as a stony-iron meteorite (Jaimez-Salgado *et al.*, 2007). On the other hand, Jaimez-Salgado (2023) presented two different compositions and a lower mass than initially reported, raising questions about the specimen's handling, storage, and the accuracy of the analyses. In all instances, the composition does not align with that of an iron meteorite due to the low iron content (Krot et al., 2014; Scott, 2020). However, it also does not correspond to a stony-iron meteorite, as these typically contain approximately even amounts of silicates and nickel-iron alloy (Norton and Chitwood, 2008).

According to an unpublished report from the Test Certificate #2 (CIPIMM, 2003), other pseudometeorites namely Isla de la Juventud, Cruces, Guanabo, and Número 6, were analyzed under the assumption that they might be meteorites. However, their diffraction patterns revealed that these samples are, in fact, meteor-wrongs, as the mineralogical composition is inconsistent with that of extraterrestrial meteoritic material. The diffractograms of these specimens revealed the presence of terrestrial minerals, predominantly quartz, which is a common mineral found in Earth's crust (Buchwald, 1977; Senesi *et al.*, 2018).

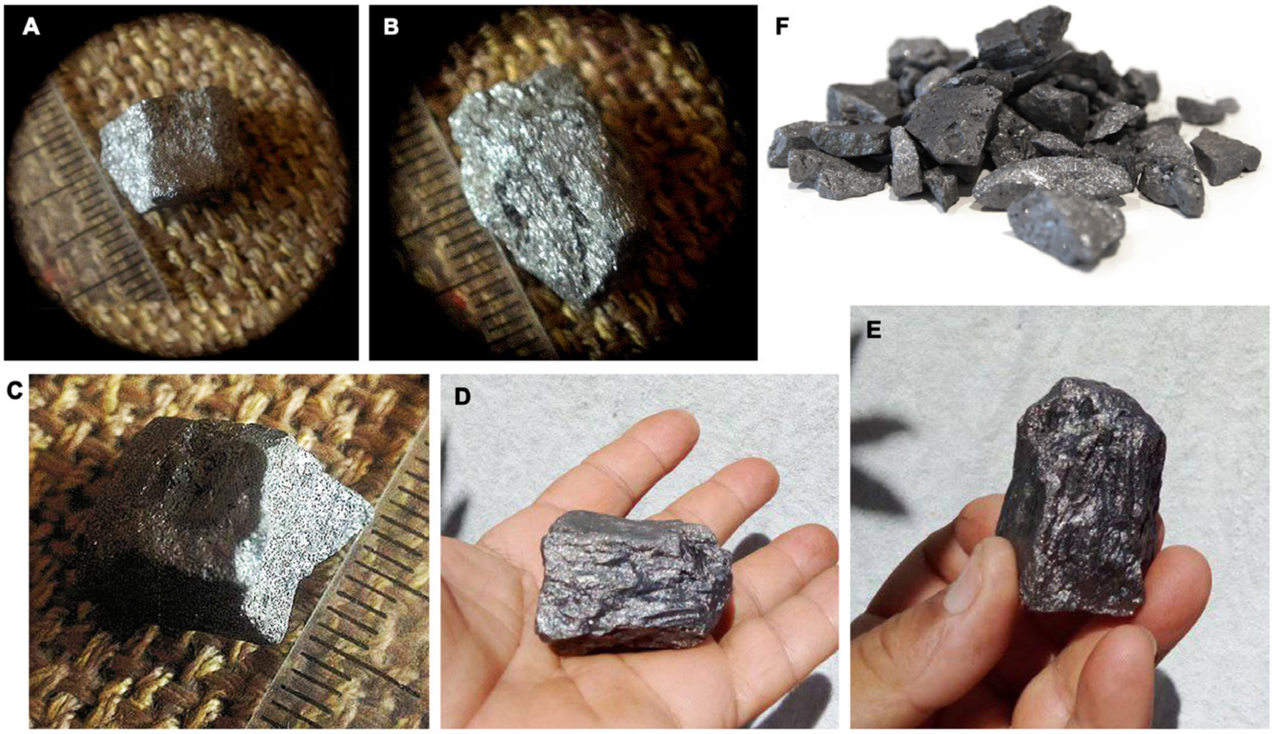

Fig. 10.- Cuban meteor-wrongs: A-C) Balcón de La Lisa specimen, D-E) Güira de Melena (Gámez) specimen, F) Ferrosilicon fragments for comparison.

Another unpublished specimen (14 in Table 1) was discovered in 2006 on the site formerly occupied by the National Center for Hydrology and Water Quality (CENHICA) in the Boyeros municipality, Havana, western Cuba. This specimen consisted of several small, highly magnetic metallic fragments with a total weight of approximately 200 g. One of the fragments, treated with concentrated nitric acid on a polished surface, was subsequently examined under an optical microscope. The result revealed a mosaic of highly oxidized ferruginous elements interspersed with very bright spots. These spots starkly contrasted with the ferruginous stains, yet there were no Widmanstätten patterns or Neumann lines observed (Jaimez-Salgado, pers. comm., 2016). According to Jaimez-Salgado (pers. comm., 2019), part of this material was sent to the CEAC laboratory in Cienfuegos (central Cuba) in 2019 for further investigation, but no results or even photographs of the material have been published to date.

One more rock (16 in Table 1) was reported to have impacted the roof of a house in the Las 79 Viviendas del Güirito neighborhood, located in the city of Gibara, Holguín province, at approximately 2:45 a.m. on March 31, 2013. This specimen, characterized by an oval shape and reddish-black color, featured a porous surface and the appearance of a water-worn pebble. It was transferred to the Center for Environmental and Technological Research and Services (CISAT) of the Ministry of Science, Technology, and Environment's delegation in Holguín, eastern Cuba. The object weighed 114 g and measured 5.5 cm in length, 3.6 cm in maximum width, and 3.3 cm in thickness, according to Juan José Guarch Rodríguez (Cuban Speleological Society) and Gibara researcher José (Joselín) Corella (Fig. 11A). However, the rock does not exhibit the typical characteristics of a meteorite; a fresh meteoritic fall would typically show a fusion crust and regmaglypts. Similarly, the specimens (15 and 18 in Table 1) known as Rodas (Fca. Castellanos) (Fig. 11B) and Guira de Melena II (Fig. 2F), which were examined by the authors, do not exhibit the typical characteristics of meteorites and present voids inside (Fig. 11).

A final comment is directed towards the better scientific documentation and curatorial process of several samples in

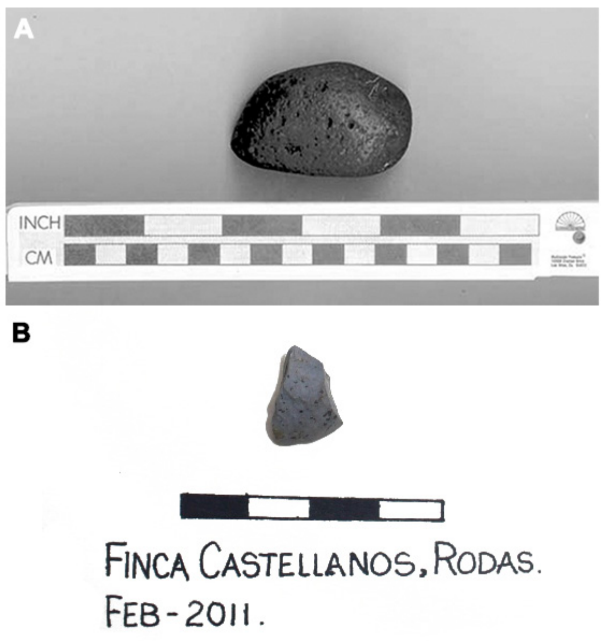

Fig. 11.- Cuban meteor-wrongs: A) Gibara specimen, B) Rodas specimen. Scale = 1 cm.

institutions or private collections in Cuba (e.g. 3-8 in Table 1), which often lack catalog numbers or unique identifiers. Even if they are not meteorites, their significance in scientific research cannot be understated, and these samples should be readily available for scientific examination. This accessibility not only assists in refining identification techniques but also contributes to a broader understanding of meteoritic versus terrestrial materials, thereby enhancing the overall knowledge in the field of meteoritics. Recently, Jaimez-Salgado (2023) and Jaimez-Salgado *et al.* (2023) briefly discussed some of these objects, however both articles fail to clarify their status or loan history.

Conclusions

This checklist not only clarifies the non-meteoritic nature of several misidentified specimens but also emphasizes the importance of meticulous and comprehensive testing in meteorite identification, particularly in the context of frequent misidentifications in Cuba. It contributes to a deeper understanding of meteoritic versus non-meteoritic materials, enhancing knowledge in the field of meteoritics and promoting a culture of scientific rigor and curiosity on the island. The list includes 18 specimens, some previously discussed by other researchers, and others never published before, included here to serve as references for future studies.

The case of the "Cuba" specimen, Bacuranao and the Mango Jobo fragments particularly exemplify the complexities involved in meteorite identification and handling of specimens. However, some specific traits were crucial in debunking the meteoritic nature of these specimens, revealing their terrestrial origins instead. The Mango Jobo fragments, initially part of Dr. René Herrera Fritot's collection, displayed characteristics more closely aligned with terrestrial formations, particularly mocarreros, which is consistent with the geological context of the area (ACC, 1965).

Our findings also draw attention to the need for better scientific documentation and curatorial processes in Cuba. Many samples in institutions or private collections lack proper cataloging, which hinders scientific research. Despite their non-meteoritic nature, some of these samples hold significant scientific value and should be readily available for examination.

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Author contributions

Work development, Y.C. and J.O.; methodology, Y.C and J.O., data collection, Y.C., J.O. and C.B.S.; figures, Y.C.; research/analysis, Y.C. and J.O.; manuscript review, Y.C and J.O.

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