METEORITES: A transition from geo-hazards loss to geo-tourism gains

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Doi: 10.21608/nujbas.2025.356317.1031
Article information: Submit Date 11 Feb. 2025; Revise Date 18 Mar. 2025; Accept Date 19 Mar. 2025

Abstract

Meteorites are extraterrestrial objects (rocks) that go towards the atmosphere and then strike the Earth and other planets. The origin is related to asteroid belts located between Jupiter and Mars Planets. Almost all meteorites have very high speed, according to the meteorite size and weight, when they come from outer orbitals to elsewhere (ranging from 4 to 40 km/second), therefore they carry powerful energy of pressure and temperature. Regarding the meteors striking the Earth, the geo-hazard loss has caused atmosphere combustion, forest burning (if falls on wood area), extreme damage to the entire area, and tsunami of variable intensity if slammed into the marine environment. On the contrary, geo-tourism gains include impact craters (if present) that are considered to be touristic and protected areas, valuable iron-nickel and gem types that have been sold in international meteorites trade and shops, meteorite museums and fairs as well as geo-parks. We conclude that the advantages of the meteorites are more valuable and constructive if compared with their disadvantages related to geo-hazards loss.

Keywords: Meteorites, Impact craters, Geo-hazards, Geo-tourism implications.

1. Introduction

Meteorites represent a source of extraterrestrial material naturally available on Earth, and their investigation provides valuable insights into the early stages of the solar system, the processes involved in planetary formation, and the origin of organic compounds [**1-6**]. All meteorites slammed into the Earth occurring in the form of observed falls (Fig. 1a-b) or finds (Fig. 2a-c). The tentative field classification of meteorites is Finds (most common) and observed Falls (less common) where the second type is more favorable for researchers. Meteorites are classified into three main groups based on their composition, structure, and origin: stony-iron meteorites (Pallasites), stony meteorites (Chondrites and Achondrites), and iron meteorites. The age of meteorites ranges from 1.85 billion years to the present, spanning all geologic eras. Meteorites and fragmented rocks have been found all over the world, particularly in the northern hemisphere. In addition, others have been reported in different Arab countries. Several remnants of ancient meteorite craters are believed to be remnants of the solar system. We note that almost all discovered impact craters are concentrated near the northern and southern parts of our planet [**6**], while very few craters are found in the equatorial region (Figs. 3). This is due to the intensive weathering processes and erosion factors that affect these features. This means that the meteorites slammed into the Earth with random orientation without any physical or astronomical factors such as the Earth's magnetic fields. It found large impact craters, about 190 in almost all world countries, particularly the northern hemisphere of the Earth (Fig. 3). About 13 impact structures were reported in the Arab World [**6-10**]. Most discovered meteorites in the Arab countries were in Morocco [**11**] (Fig. 4).

In this review article, we focus on the geohazard loss and geo-tourism gains to verify the main influences for both. We must also raise the positive side of the exploitation of meteoritic heritage [**12**] and impact craters in local development (Geo-tourism, Geopark, and meteorite jewelry), the popularization of scientific culture concerning astronomy and meteorites.

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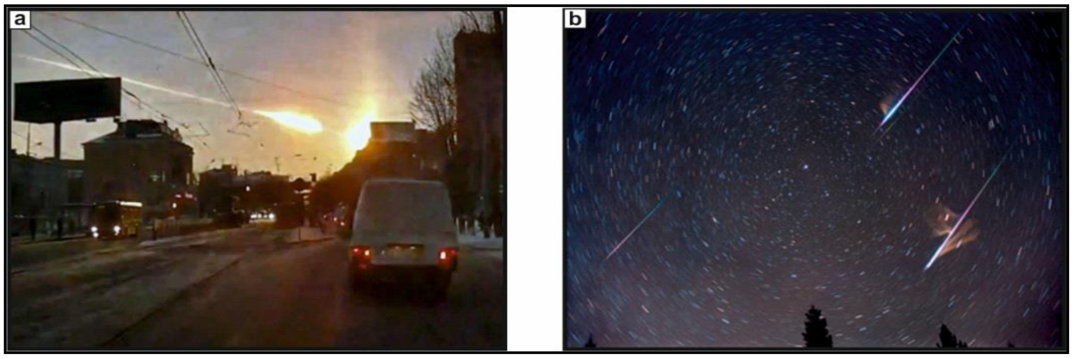


Fig.1: (a) Fireball falls in Russia and (b) observed falls in Jordan. Source [13]

Fig. 2: (a) Meteorite finds in Morocco desert, Photo permission from Prof. Hasnaa Chenawi (b) Meteorite fragment (black color) nearby Gabel Kamel Impact crater (Source [8]) and (c) Prof. El Sharkawy with meteorite finds of the iron-nickel meteorite near the impact crater of Gabel Kamel, Western Desert of Egypt (Source: [14]) and communicated permission with Prof. El Sharkawy).

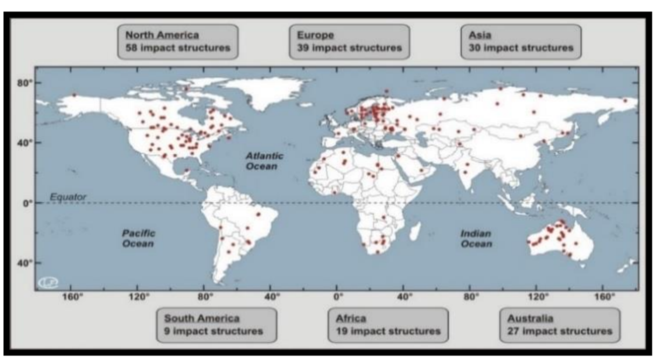


Fig.3: Distribution map of the 190 confirmed meteorite impact structures on Earth. Source: [15].

Fig. 4: Moroccan Italian- Teamwork in Morocco desert for searching the meteorites, Photo permission from Dr. Ouknine.

2. Data Background

2.1. Geo-hazards Loss

Geo-hazards loss represents the negative impacts of the meteorites, which include four major categories:

2.1.1. Atmosphere combustion

When meteors enter the Earth's atmosphere at a very high speed of about 60 km/second, they create big fiery white clouds around the meteors (Fig. 5) which cause air pollution, giving rise to the smell of sulfur.

Fig.5: Atmosphere combustion in Russia. Source: [16]

2.1.2. Forest (Woods) Fires

Sometimes meteorites strike the woody forests such as Canadian and Brazilian ones (very dense woods) (Fig. 6a-b) which cause heavy wood fires reflecting the worst environmental impacts.

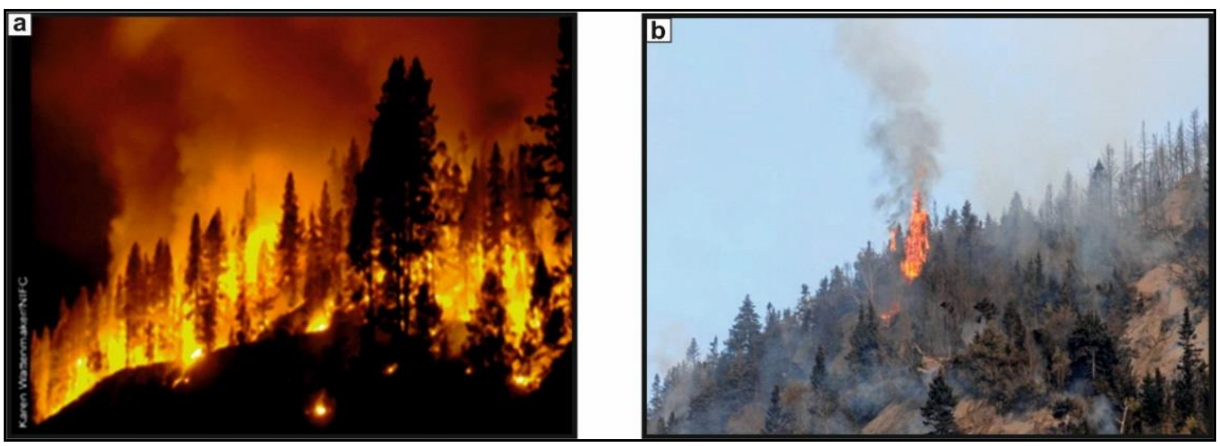


Fig.6: (a) Woods fire in north Canada, due to meteorite attack; Source: [17] and (b) Woods fire due to meteorite striking in Brazil forests; Source: [18]

2.1.3. Damage to population areas

Normally, meteors travel to various destinations, such as Earth, Moon, Mars, and other planets. They travel at awesome speed, about 60 km/sec. So, they carry very high amounts of energy in terms of pressure and temperature. The most entire energy includes shockwaves that are destructive carriers of population areas. For example, on 15 Feb 2013, very huge meteorites slammed into a population area called Chelyabinsk region in Russia causing awesome damage to buildings and resulting in many injuries (Fig. 7a-c).

2.1.4. Tsunami Disasters

Tsunamis start as large waves far out into the ocean and move at high speed towards the shore. As the wave reaches shallower water it is slowed, causing it to increase in height, creating a tsunami. Meteorite impacts don't cause tsunamis (in major), though asteroid impacts might. Meteorites are in general less than 10 cm (4 in) in diameter by the time they impact on the Earth's surface (or in an ocean). If the meteorites fall have big sizes and are heavy-weighted, some tens of tons would potentially create large waves, which seem to be tsunamis (Fig. 8).

Fig. 7: (a) Effects of building destruction as a result of meteorite fall, (b) One of the injuries as a result of meteorite fall in Russia; source of (a and b) [19], and (c) Impact crater within ice accumulated due to meteorite falls; Source:[20]

Fig.8: Sketch showing tsunami due to huge meteorite falls. Source:[21]

3. Geo-tourism

The link between meteorite occurrences, geo-tourism, and heritage was emphasized by Thomas Alfred Hose in 1995. Therefore, it is important to highlight this issue in the current discussion. We must also raise the positive side of the exploitation of meteoritic heritage and impact craters in local development (Geo-tourism, Geopark, meteorites jewelry), and the popularization of scientific culture concerning astronomy and meteorites. Geo-tourism includes four major categories as follows:

3.1. Impact Craters

The impacts of craters were reported in 190 localities of the world (Figs. 3, 9-13). The Earth? planet has been impacted even more heavily than the Moon and Mars planets [11, 22-24]. Furthermore, nearly all natural lakes in Canada, the

USA, Austria, and Africa were formed by impact craters subsequently filled with heavy ice accumulation and rainfall giving rise to popular resort sites for tourists in many countries of the world (Fig. 14).

We would like to specifically know what Gabel Kamel's impact crater could have had upon Ancient Egyptian civilization. There are clues: in 1295 BC a new hieroglyph appeared *ba-en-pet* (Iron from the Sky), implying that the Ancient Egyptians could have witnessed proof that their valuable meteoritic iron came from the sky ([**25**], further details at the Open University. Since the latest dating suggests that the meteorite impacted between 1600 BC - 400 BC [**26**], Gebel Kamel seems the most likely candidate for this realization. The theory here is that the meteorite could have been the progenitor for the first Ancient Egyptian empire, that of Ramesses II the Great (1303 BC -1213 BC) and the 19th Dynasty. The impact occurred 1600 - 400 BC according to [**26**].

Fig. 9: Sketch showing impact crater in Arizona, USA. Source [**26**]

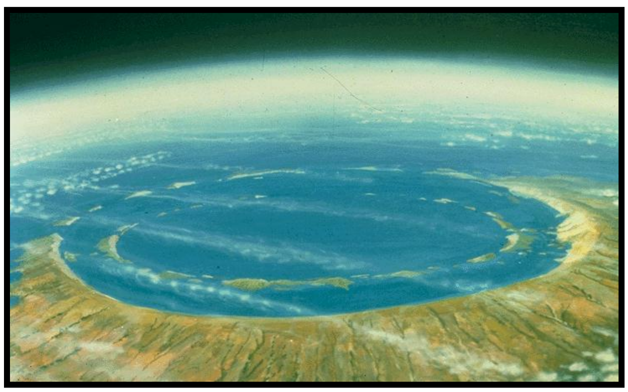


Fig. 10: The Chicxulub impact is widely believed to have led to the extinction of dinosaurs. Chicxulub Impact Crater, Mexico. Source [**27**]

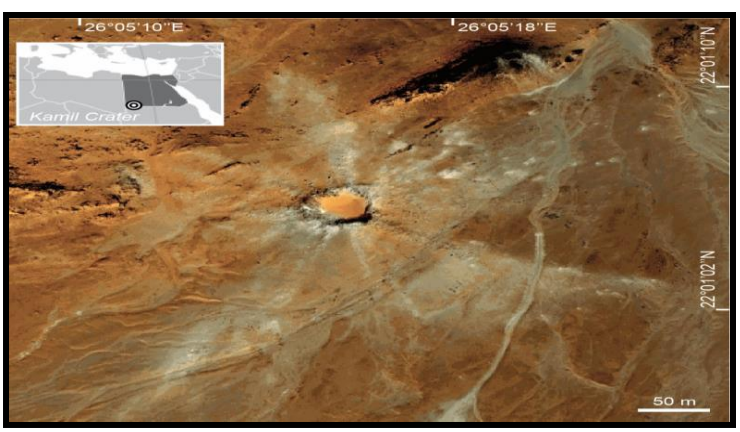


Fig. 11: Location of impact crater of Gabel Kamel as discovered by Google Earth. Source: [**8**].

Fig.12: Impact crater of Gabel Kamel, Egypt. Source:[8].

Fig. 13: Major Impact crater, Arizona, USA. Source: [28]

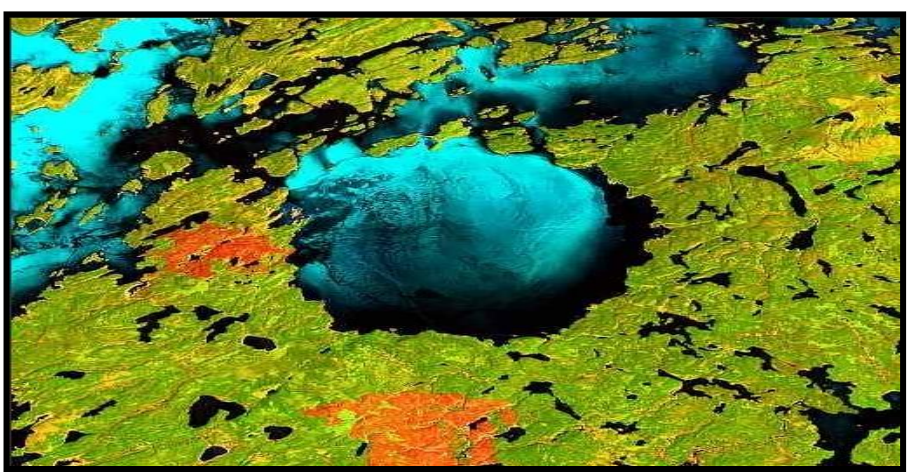


Fig. 14: Deep Bay Lake reflecting fantastic resort, Saskatchewan, Canada. Source [6]

3.2. Geologic Museum of Meteorites

Almost all collected samples of meteorites are sold to museums worldwide and/or meteorite trades in the USA, London, and Paris, Morocco, Egypt, Oman and Saudi Arabia. Morocco is a very rich owner of meteorite falls and finds. Ibn Zohr University in Agadir has a very exciting meteorite museum that contains fantastic pieces of meteorite. It is available to receive visitors and tourists (Fig. 15 a-d). Almost all international museums in the world include a respectable sector of meteorites (Fig. 16).

3.3. Geoparks

Recently, the term “Geopark” has been used to describe natural areas that include specific geological and geomorphological features, such as sites of meteorite falls and finds. These areas became protected sites, such as national parks and landscapes to enhance their many benefits for tourism. A lot of geoparks occur in several localities of the world reflecting geosites for visitor centers (Fig. 17a-c) [12]. In Egypt, there are many geoparks such as Gabel Kamel, Wadi El crystal, and most oasis's geomorphic features in the western desert.

Fig. 15: (a) Entrance of Aghadir Meteorites Museum, Ibn Zohr University, (b) Some tourists in a visit inside the museum, (c) Dr. Ouknine explains the meteorite types encountered in the showcase, and (d) tourists in a discussion concerning the meteorites types.

Fig.16: Meteorite (Willamette Meteorite**)** block up to tens of tons in weight. Oregon State Museum, USA. Source: [29]

Fig.17: (a) Geopark includes a big piece of meteorite, Paleorrota, in Brazil, (b) Meteorite block in Geopark, Nambiba. Dr. Enas stands as scale and (c) meteorite block (highly eroded) inside geopark in South Africa. Source: [**30**]

3.4. Gemstones, Meteorite shops, and Meteorites trade

We mentioned that the tentative meteorite classification is based on mineral composition into chondrite, achondrite, Iron stony meteorite, and Iron meteorites. Pallasite meteorites are named after the German scientist Peter Pallas (1741-1811) and peridot (olivine), embedded in an Iron-nickel matrix represent the best quality collected from the meteorite falls and finds, they are considered as gemstones (Figs. 18-19). In addition, many meteorite shops are spreading in almost European Union countries, USA and Canada (Figs. 20-21) The beautiful 'Meteorite Jewelry', rings, necklaces, earrings, and watches are available in these shops (Fig.22a-e).

The most important hints to meteorite economics are said to be meteorite trade that is entirely located in the USA, and almost all European countries as given in the Tables below.

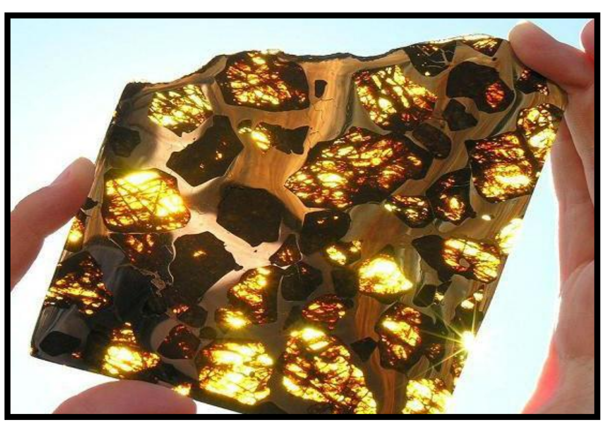


Fig.18: Polished slab of Pallasites meteorite embedded with beautiful gem-quality olivine crystals. This is a slice of the meteorite which was found in Argentina in 1951. Source: [**31**]

Fig. 19: Peridot as a gemstone.: Source: [31]

Fig. 20: Meteorite shop in Paris. Source: [32]

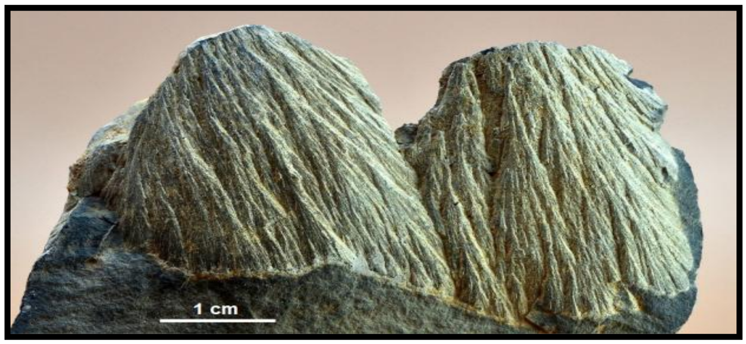
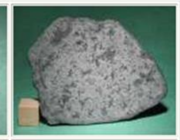


Fig. 21: Shatter cones in limestone from the Steinheim structure, Germany (Natural History Museum, Vienna). Source [33]

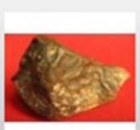
Fig.22: (a) A watch as a part of holdings of a meteorite shop, (b) Meteorite Pendants. Approximately 3/4" to 1" in length. Price ONLY $69.95 Each!, (c) Seamless Meteorite Ring, (d) Meteorite Necklace, and (e) Meteorite Earrings. Source: [34]

Tables of Price List of Meteorite Samples

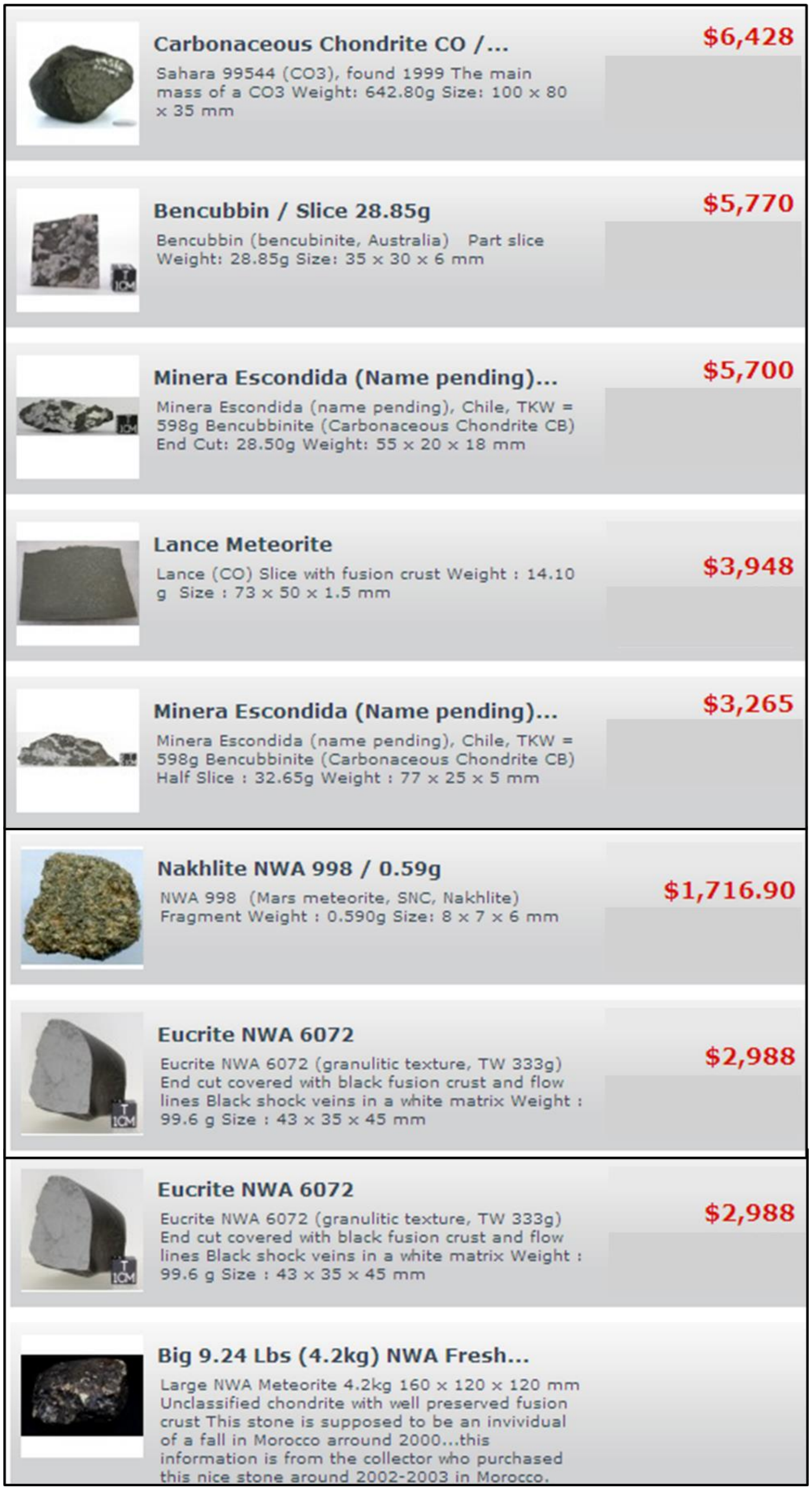
Sources: [32,35]

				
#SAU005-1-642	**#SAU005-1-870**	**#SAU005-3-334**	**#SAU005-5-892**	**#SAU005-15-1**
Weight: 1.642 **gm**	Weight: 1.870 **gm**	Weight: **3-334 gm**	Weight: **5.892 gm**	Weight: **15.1 gm**
Features: **Part slice**	Features: **End**	Features: **Part slice**	Features: **End**	Features: **Full slice**
Price: $1067	Price: $1100	Price: $1900	Price: $2800	Price: $7500

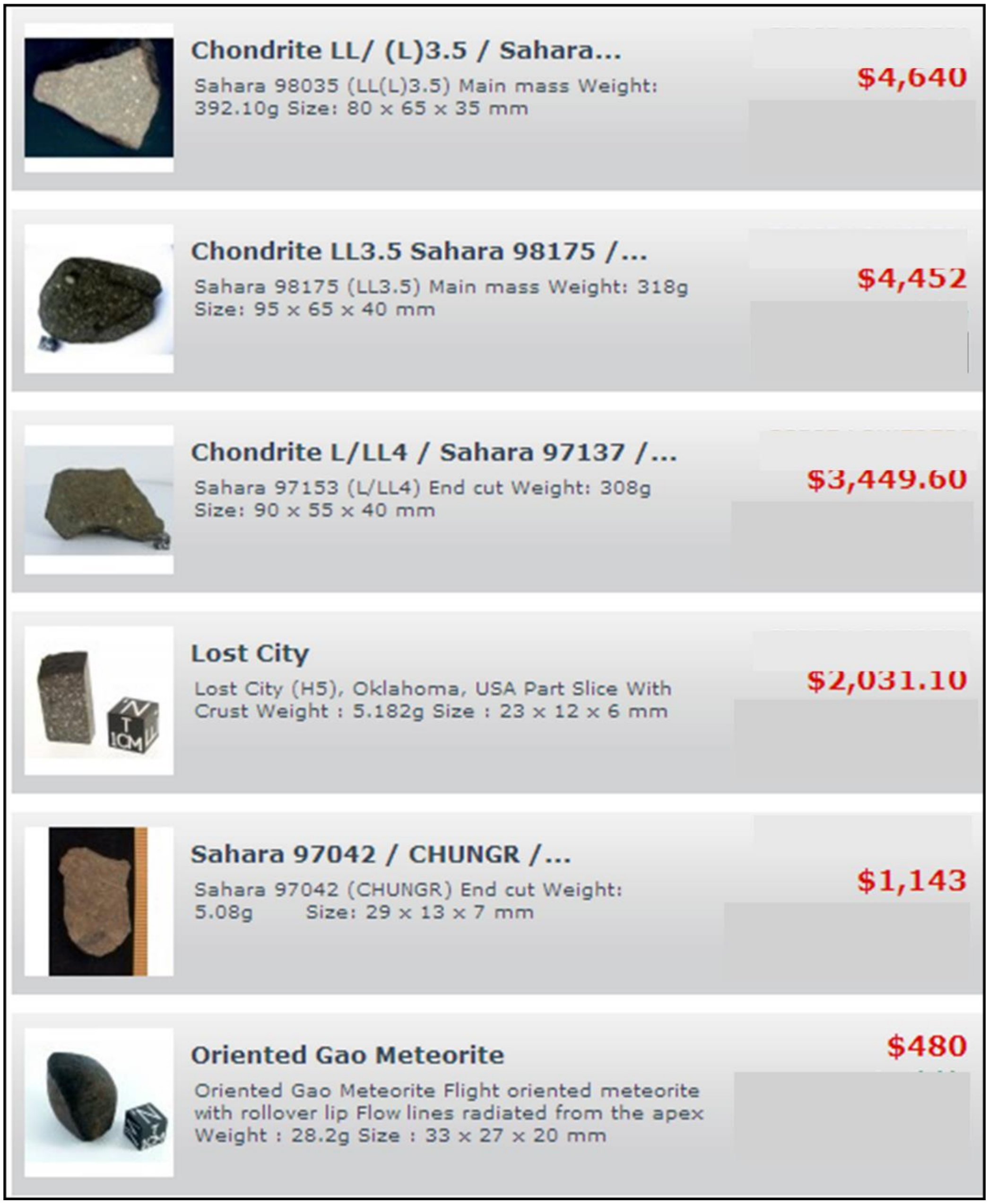

#SAU005-32-4
Weight: **32.4 gm**
Features: **Full slice**
Price: $14500

	**Oriented Iron Meteorite** Oriented Meteorite Campo del cielo (IA), Argentina Weight: (106 kg/233 lbs) Size: 400 x 400 x 250 mm	**$95,400**
	**Martian Meteorite NWA 2975** Martian Meteorite NWA 2975 (paired) Whole uncut martian meteorite Covered with fusion crust Weight : 48 g Size : ~50 x 30 x 28 mm	**$24,000**
	**Martian Meteorite NWA 4880** Martian Meteorite NWA 4880 Whole uncut martian meteorite Covered with fusion crust Weight : 32.24 g Size : ~33 x 28 x 25 mm (1.25 x 1.0 x 1.0 inches)	**$16,000**
	**Sahara 97161 / EH3 / 140g** Sahara 97161 (EH3) Whole Individual Paired with the Sahara 97072, EH3 Weight : 140 g Size : 70 x 45 x 40 mm	**$4,900**
	**Lunar meteorite DAG 262 / 2.1g** Lunar Meteorite DAG 262 (Lunar A) Part slice Weight : 2.01g Size: 20 x 14 x 4.5 mm	**$4,200**

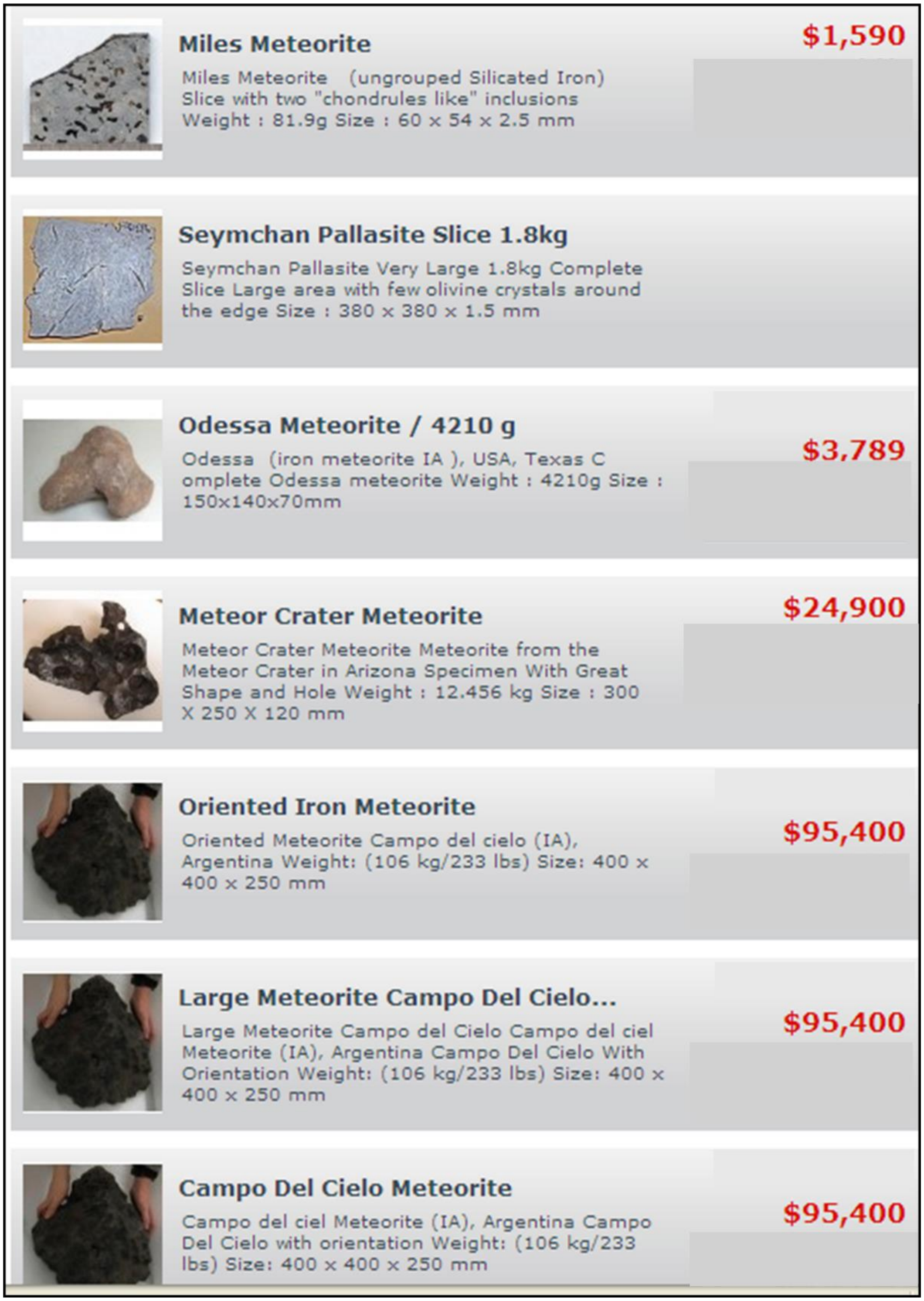
Carbonaceous chondrites

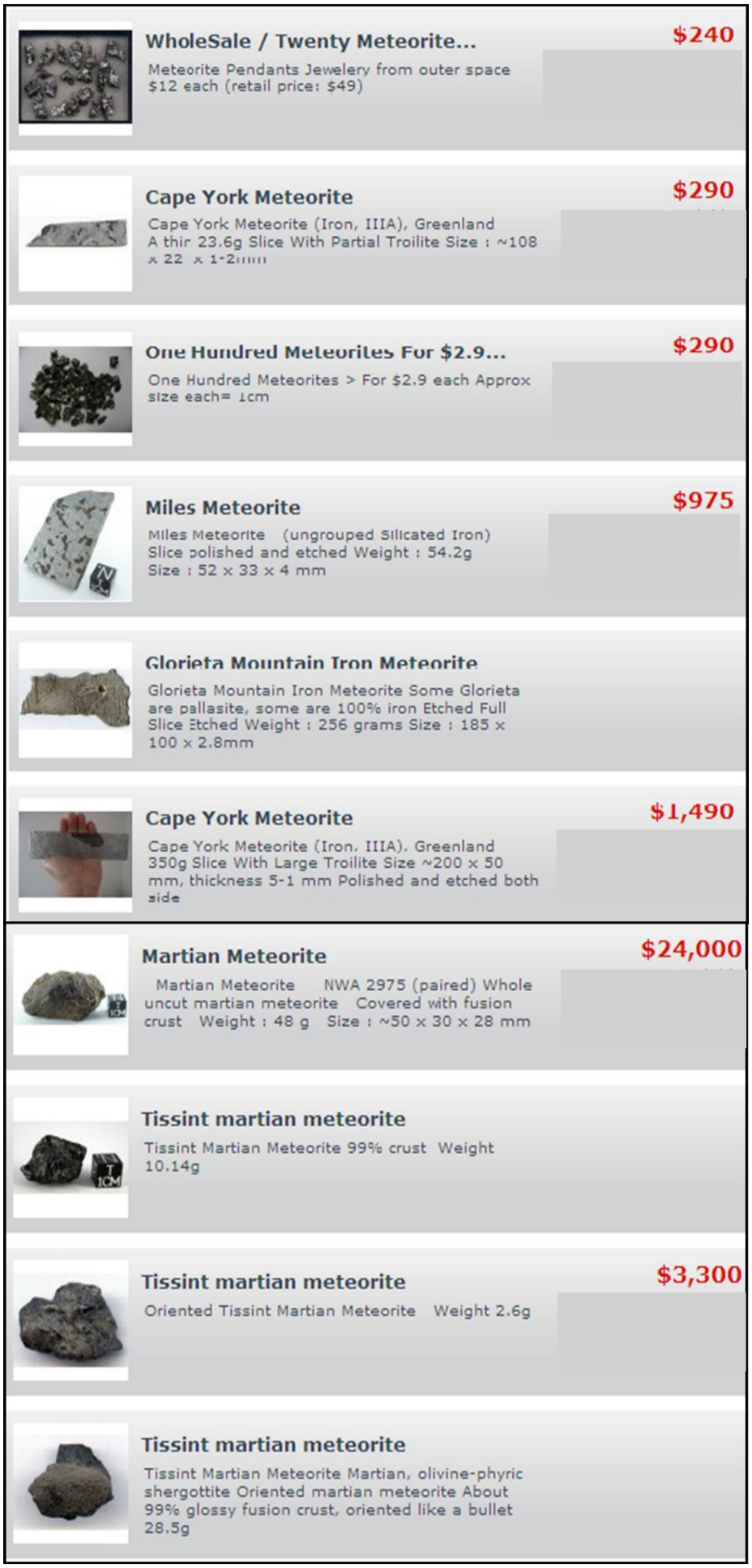


Chondrites


Chondrite LL/ (L)3.5 / Sahara...
Sahara 98035 (LL(L)3.5) Main mass Weight: 392.10g Size: 80 x 65 x 35 mm
$4,640
Chondrite LL3.5 Sahara 98175 /...
Sahara 98175 (LL3.5) Main mass Weight: 318g Size: 95 x 65 x 40 mm
$4,452
Chondrite L/LL4 / Sahara 97137 /...
Sahara 97153 (L/LL4) End cut Weight: 308g Size: 90 x 55 x 40 mm
$3,449.60
Lost City
Lost City (H5), Oklahoma, USA Part Slice With Crust Weight : 5.182g Size : 23 x 12 x 6 mm
$2,031.10
Sahara 97042 / CHUNGR /...
Sahara 97042 (CHUNGR) End cut Weight: 5.08g Size: 29 x 13 x 7 mm
$1,143
Oriented Gao Meteorite
Oriented Gao Meteorite Flight oriented meteorite with rollover lip Flow lines radiated from the apex Weight : 28.2g Size : 33 x 27 x 20 mm
$480

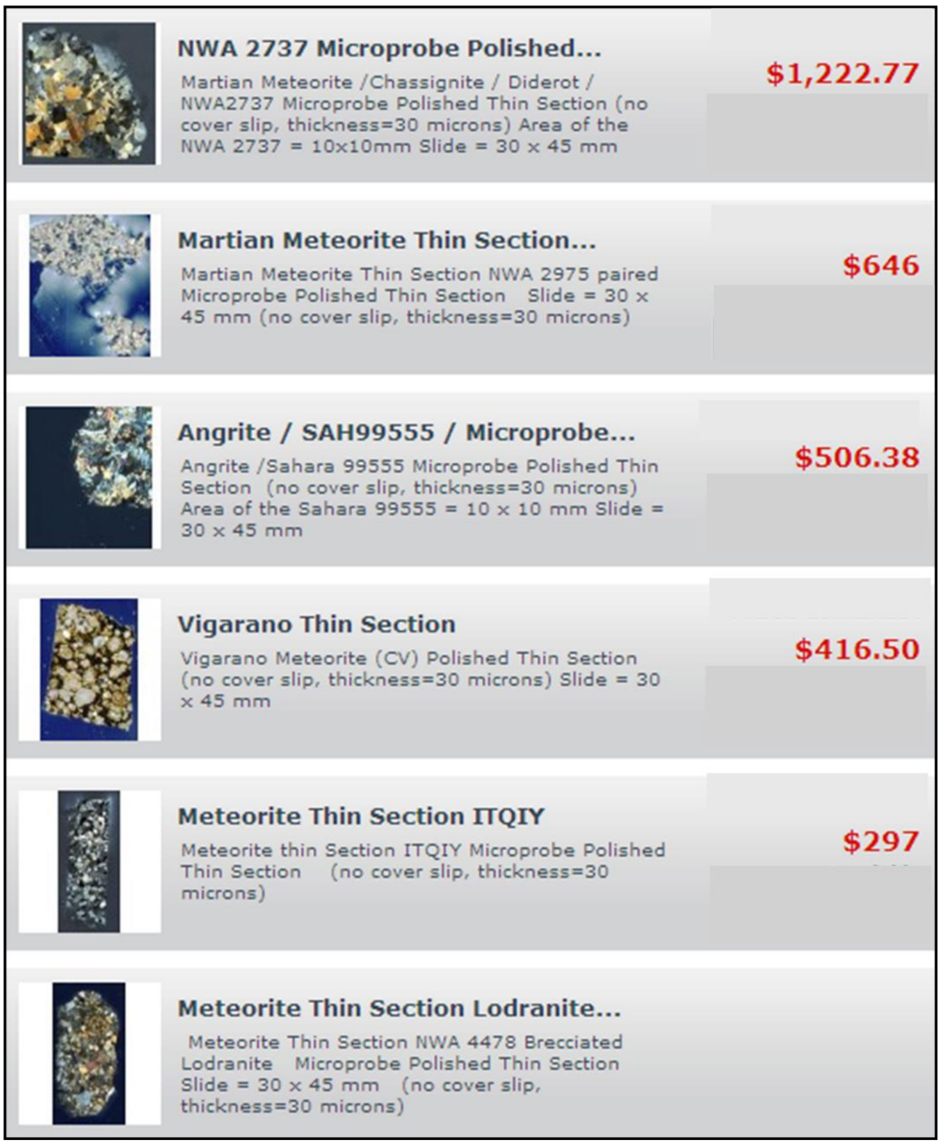
Iron Meteorites




WholeSale / Twenty Meteorite...
$240
Meteorite Pendants Jewelery from outer space $12 each (retail price: $49)
Cape York Meteorite
$290
Cape York Meteorite (Iron, IIIA), Greenland A thin 23.6g Slice With Partial Troilite Size : ~108 x 22 x 1-2mm
One Hundred Meteorites For $2.9...
$290
One Hundred Meteorites > For $2.9 each Approx size each= 1cm
Miles Meteorite
$975
Miles Meteorite (ungrouped Silicated Iron) Slice polished and etched Weight : 54.2g Size : 52 x 33 x 4 mm
Glorieta Mountain Iron Meteorite
Glorieta Mountain Iron Meteorite Some Glorieta are pallasite, some are 100% iron Etched Full Slice Etched Weight : 256 grams Size : 185 x 100 x 2.8mm
Cape York Meteorite
$1,490
Cape York Meteorite (Iron, IIIA), Greenland 350g Slice With Large Troilite Size ~200 x 50 mm, thickness 5-1 mm Polished and etched both side
Martian Meteorite
$24,000
Martian Meteorite NWA 2975 (paired) Whole uncut martian meteorite Covered with fusion crust Weight : 48 g Size : ~50 x 30 x 28 mm
Tissint martian meteorite
Tissint Martian Meteorite 99% crust Weight 10.14g
Tissint martian meteorite
$3,300
Oriented Tissint Martian Meteorite Weight 2.6g
Tissint martian meteorite
Tissint Martian Meteorite Martian, olivine-phyric shergottite Oriented martian meteorite About 99% glossy fusion crust, oriented like a bullet 28.5g

Stony-Iron Meteorites

Meteorite Thin Sections.



4. Other Benefits

There are other benefits related to advantages of the meteorites falls, the most economic benefits refer to mining discovering and indicators (in minor) such as Sudbury Nickel-Copper-Cobalt mine in Canada and Aumuelhe quarry in Germany (Figs.23, 24). In addition, tens of tons of iron-nickel meteorites are used as ore deposits.

Fig. 23: Sudbury mine (open cast), Northern mine in Canada. Source: [36]

Fig. 24: Aumuelha quarry containing precious nickel-copper-cobalt. Source: [37]

5. Conclusions

Meteorites are fascinating rocks that come from space. They provide essential information that helps us understanding the nature and origin of the solar system and thus the formation of the Earth. In the present work, we examine the most prevalent geo-hazard losses, including their negative impacts on the Earth such as fires, severe damage, and climate change. We also highlighted the positive gains of geo-tourism, which includes geoparks, meteorites museums and fairs, meteorite trades, and shops which indicate more favorable than the geohazards loss. Finally, interest in meteorites has grown significantly over the years due to advancements in planetary science, and space exploration.

Acknowledgments

The authors express their gratitude to Dr. Enas Abdel Dayam, Faculty of Petroleum and Mining Sciences, Matrouh University, Egypt, and Dr. Lahcen Ouknine, Ben Zohr University, Morocco for providing some photos that improved the present article.

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[19] https://www.buzzfeednews.com/article/ryanhatesthis/photos-of-the-destructive-aftermath-of-the-russian-meteor
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[29]https://geologyscience.com/gallery/geological-wonders/the-willamette-meteorite-largest- meteorites-ever-found-in-usa/
[30] Image courtesy of Damien du Toit
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