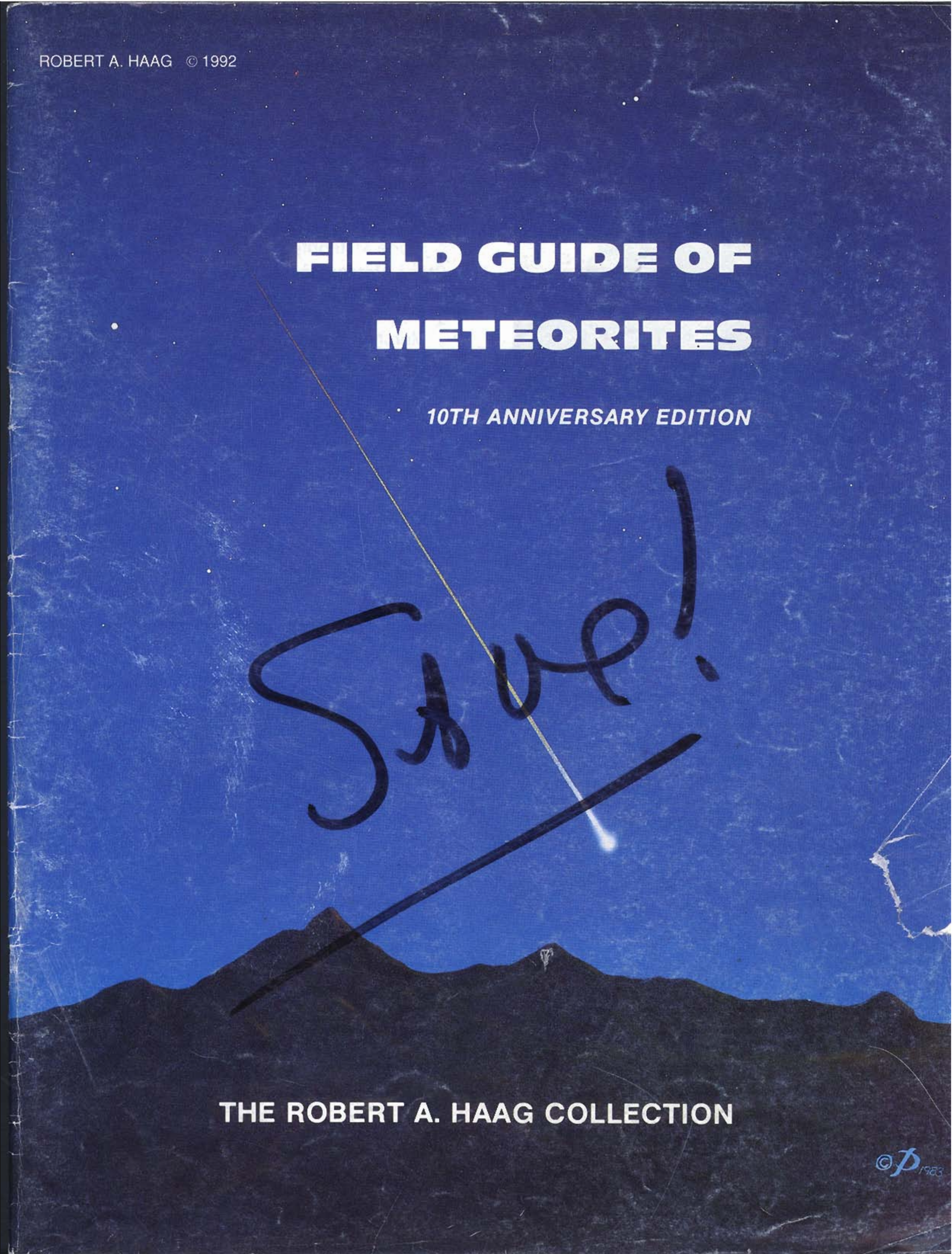
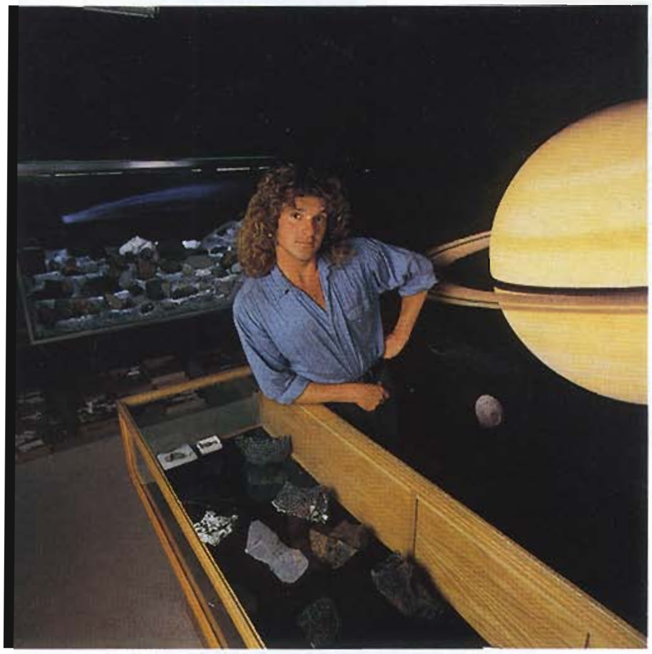


FIELD GUIDE OF METEORITES

10TH ANNIVERSARY EDITION

THE ROBERT A. HAAG COLLECTION



Author at home in Tucson, Arizona with his private collection.

About the author, Robert A. Haag** . . .explorer, rock and roller. Robert has been fortunate enough to spend his life pursuing meteorites, his true passion. His adventures have taken him from the jungles of Africa to the plains of Australia, the moon, Mars and beyond. This Field Guide is a compilation of the many meteorites Robert has been privileged to find or acquire during his many journeys around the solar system. Please enjoy this **10th Anniversary - Field Guide of Meteorites.

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Send meteorite orders and inquiries to:

Robert A. Haag
P.O. Box 27527
Tucson, AZ 85726
USA

Telephone 1 (602) 882-8804
FAX: 1 (602) 743-7225

***Meteorite Medallion.** This unique collector's item is made entirely from melted (3,400 degrees F!) Canyon Diablo nickel-iron meteorites. The front shows the space shuttle over Earth, and the back depicts Halley's Comet and the solar system. Limited edition of 1000 pieces. Each 360 grams, 5 cm. medallion comes with a signed, numbered certificate of authenticity.*

This was an experiment in itself. Here in Tucson, we will try just about anything to generate interest in meteorites. Besides the medallion, we've also made some fabulous jewelry.

Readily available, more common iron meteorites can be sacrificed to pay for the really exotic research specimens.

ISSN 1053-8267

This book is dedicated to
Mr. James DuPont
who always paid too much
but kept me going.
Thank You Jim!

NOTE:
2.5 cm. = 25 mm. = 1 in.
454 grams = 1 lb.
1 kilo = 2.2 lbs.

SUPPORT YOUR LOCAL MUSEUMS, SCHOOLS AND UNIVERSITIES

All THE Best

THE ROBERT A. HAAG COLLECTION

FIELD GUIDE OF METEORITES

10TH ANNIVERSARY EDITION

UPDATED JAN. '92
2nd printing

Cover: Commissioned oil painting by Kim Poor, 1983, showing an incoming fireball over Arizona's Sonoran Desert.

INTRODUCTION

Welcome to the Tenth Anniversary Edition of the *Robert A. Haag Collection Field Guide of Meteorites.* It shares10 years of buying, selling, swapping, collecting and studying meteorites. My meteorite scrapbook. In that time I've learned that 99% of all rocks that drop out of the sky will look like the samples photographed here. Meteorites have their own style. The rarest, most exotic meteorites found have been recognized because of remnants of the melted surface. That single factor plus the presence of iron and rust is the key to finding meteorites.

There are many different kinds, study this book. The potential for future discoveries staggers the imagination. And the best part about it is, that you can be part of the excitement of discovery. It may well be a piece that you find, that will blow the current theories all to Pluto.

This field guide is intended to sell meteorites, naturally, but it is also a beginning course in meteoritics. There are lots of great tips here for recognizing and recovering meteorites, pictures to help you pick the meteorite out from the shale and granite, and lots of, hopefully, inspiring stories of adventure to spur you on to momentous discoveries of your own. But it's only a small beginning to self-education. The best thing to do is to go and meet some aliens from outer space "up close and personal"... at your local university or museum. Or better yet, start a small (or large! large is better) *private* museum of your own by investing in some meteorites.

If you have thumbed through the catalogue already, you'll have noticed that there are no prices listed. This is because my inventory is constantly changing as certain types of material sell out and new types come in. (I can't manufacture these things, you know, and the delivery schedules are hopelessly erratic!) So the only thing to do is call, write or fax me, and *I can let you know the prices and availability of the meteorites you are looking for.* Incidentally, nearly all of the photographs refer to pieces in my private collection and are not for sale, which is a big tease, I know, but **I have material just as spectacular for sale**. So call, write and/or fax today, before someone else gets that last piece of whatever it was you've been longing for.

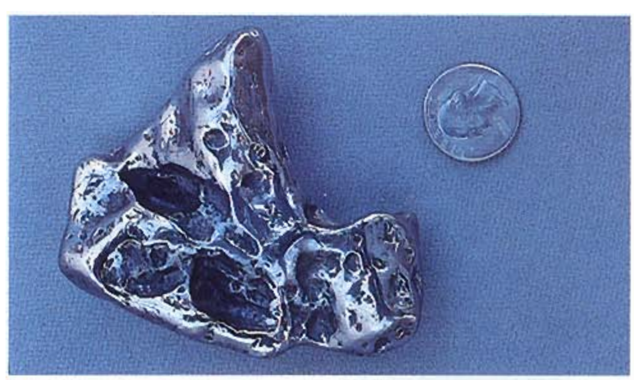
By selling the extra material, I can finance many a risky expedition to some forsaken place in order to find more. Sometimes I do, and sometimes... I don't. Many of the specimens shown in this field guide represent thousands of man hours of searching and thousands of real dollars out of my own pocket. New discoveries are made available for scientific study, museums, schools, and private collectors all over the world, and everyone benefits.

If you aren't in a position to purchase meteorites at the moment, you can always go out on your own expeditions. Again, the key word to remember about recognizing meteorites is *iron*, whether great lumps of it or microscopic bits of it, too small to see and discernable only with chemical tests. (Imagine throwing your steel car keys into a grinder, mixing them with a pound of hamburger and then alternately baking and freezing the mess into "metal meatloaf" -- you'd have a heck of a time seeing all the metal, but it would be there...) Iron however, in whatever form, is *always* present in meteorites, making them considerably heavier than most Earth rocks, as well as being susceptible to rust. This is why the most important tool of a meteorite hunter is a trusty magnet-on-a-string. A true meteorite will *always* draw the magnet, even if it's only a slight deflection, and will usually show some rust.

Shooting stars drop meteorites. The speed of the fireball, angle of entry, mass and makeup of the original *bolide*, or meteor, determine how much of it survives. Most meteors burn up entirely, especially stones, being made of softer material than irons. What survives will have a distinctive melted skin, called *fusion crust*. Fusion crust is very important to finding meteorites. Most fresh falls will have a thin black skin covering the rock. Inside, the rock remains untouched and pristine. Not effected at all from the heat of the fireball.

The stones are generally smooth. In time, the crust will dull and begin to rust but the shape of the stone remains. That's what you look for.

Tons of meteoritic material make it to Earth every year, and the vast majority is never found. It remains out there, waiting for someone motivated and knowledgeable to pick it up. Armed with a magnet, sharp eyes, a burning desire to find a space invader and a *Robert A. Haag Collection Field Guide Of Meteorites,* you can recover specimens that might otherwise be lost to the world. The key is to *look for them.* (As space invaders go, meteorites tend to be rather quiet...)

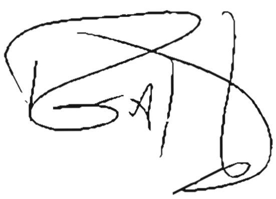


Odessa, Texas. *A tumble-polishing process turns old rusty irons into "like new" nuggets of the space metal.*

If I've convinced you, then read on, study the photos, visit a museum, and then go and search in places where meteorites have already been found. Usually, some pieces were missed in the initial search. Talk to the people there, be friendly, offer rewards. Start your own "Meteorite Recovery Team". (If you don't who will?) It's worth the energy and time. And when you find that exotic new meteorite, I want to buy it or trade for it.

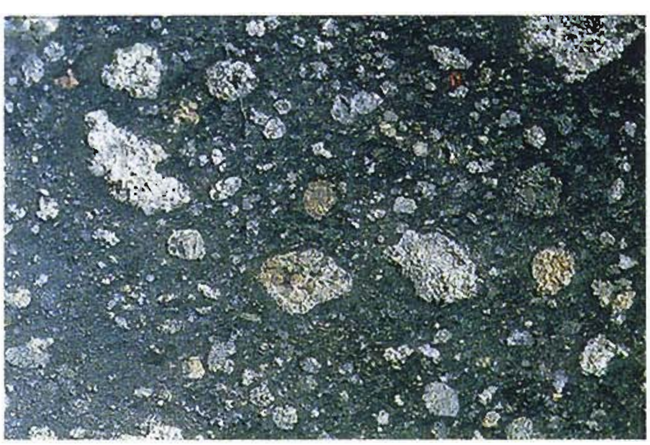
The last ten years have been action-packed and lots of fun. Spaceship Earth has been good to Robert Haag: I'm glad to call this planet home. It's been hard work, too, but it's all been worth it. Especially if, after you read and study the Tenth Anniversary Edition of the *Field Guide To Meteorites*, you go out and make some contributions to meteoritic science of your own. Look in your own back yard, or look on the other side of the world. One way or another, you'll find adventure!

Good hunting!



Robert A. Haag, the Meteorite Man

P.S. Before you buy or sell meteorites, contact me and check my prices, selection and quality. No one else even comes close. Not on *this* planet, anyway...



The Murchison stone meteorite. *Real stardust! It contains 12% water, various amino acids and other organic compounds. Shown at 10x magnification. (See story on page 36.)*

IRON METEORITES

Iron meteorites are one of the most durable and easiest to recognize of all meteorites, but only one in ten meteorites that fall from the sky is of the iron variety. The other 90% are stone meteorites. Iron meteorites are fragments of the once-molten metal core of an asteroid or demolished moon, probably from the asteroid belt. As these moons cooled, their cores crystallized and through later collisions, were destroyed. Chemically, they are an alloy, or combination, of iron (Fe) and nickel (Ni), of approximately the same density and hardness as a blacksmith's anvil. Unlike a common anvil, however, these originated, melted and crystallized in the vast, frigid (near absolute zero) expanses of outer space before arriving on Earth. Iron meteorites **always** contain some nickel.

It is the amount of nickel relative to the amount of iron that determines the type or classification of the iron meteorite and also creates the crystalline pattern seen after etching a cut surface with weak acid. This crystalline pattern is known as a Widmanstätten pattern, and is definitive of meteoritic metal. This pattern can appear very fine (small crystals) to coarse (large crystals).

Most iron meteorites show a Widmanstätten pattern of eight-sided crystals and are therefore known as *octahedrites*. (Fig. 4-A, below) Other varieties of irons show six-sided crystals, (cubes) or *hexahedrite* patterns when etched, known as *Newman lines*. Yet another type of iron meteorite, the very nickel-rich *ataxites*, shows virtually no Widmanstätten pattern when etched.

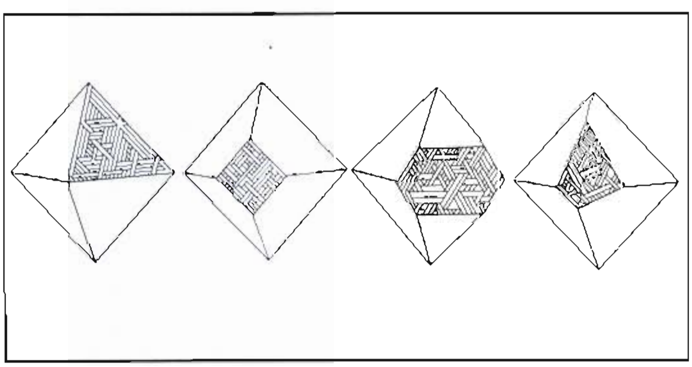


Fig. 4-A. Octahedrite crystal configuration in nickel-iron meteorites. (Picture two pyramids stuck base-to-base.)

Widmanstätten lines were named for one of the discoverers, Count Alois von Widmanstätten, who first described them in Vienna in 1804. This pattern appears when Ni-Fe meteorites are etched with a weak (about 10%) nitric acid solution, and is the result of the meteorite being made up of two different *polymorphs* of the Ni-Fe alloy. *Kamacite* (Fig. 4-B) contains 6% nickel in its molecular structure. *Taenite* (Fig. 4-C) contains 19% nickel in its molecular structure. These two phases of Ni-Fe alloy crystallize at separate temperatures and form different crystal structures, which etch at different rates.

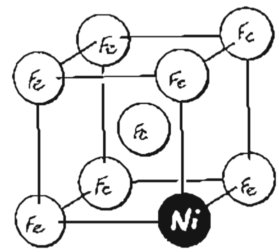


Fig. 4-B. *Kamacite, 6% Ni.*

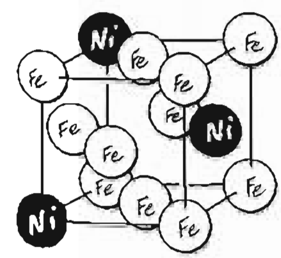
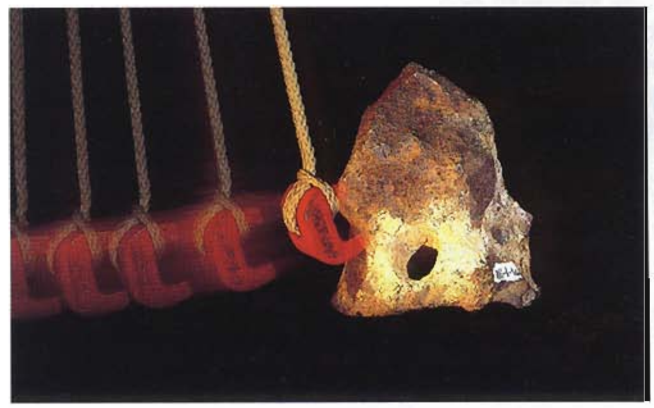
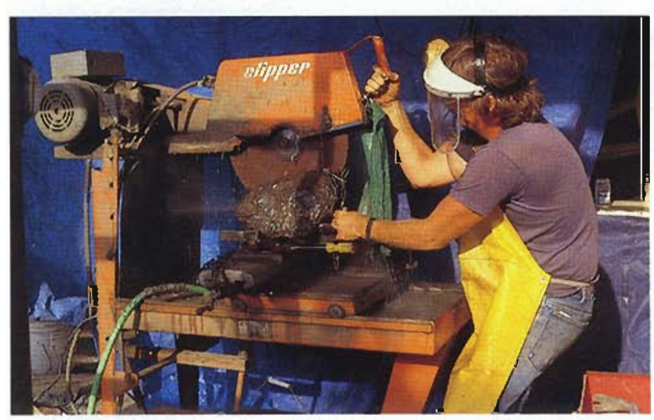


Fig. 4-B. *Taenite, 19% Ni.*



Strong magnet on a string test. *A strong magnet will swing towards ALL meteorites, whether stone, stony-iron or iron, making this one of the best preliminary tests for meteoritic material. Other excellent field tests for meteorites include checking for "fusion crust" and "rust" and filing off a tiny corner to look inside for bright metal or, in the case of stones, bright metal flakes. I can't say this enough times.*

In addition to the two main elements of iron and nickel, the so-called iron meteorites can also contain elements such as sulfur, silicon, phosphorus and carbon, among others. High percentage of these inclusions can reclassify a specimen.



Slices, dices, chops . . . *At the shop, Mark Carlton works on our most powerful cut-off saw. The crystallized texture of these things makes them incredibly difficult to cut, and we wear out scores of carborundum and diamond-coated blades every year.*

Just in! **A new water-soluable mineral was just discovered in several large gibeons. Scientists are studying it.**

Gibeon, Namibia, Africa. *This meteorite has a beautiful, fine-octahedrite Widmanstätten pattern when etched. Some of this meteorite was used by Masai warriors for spear points, since it was both highly malleable and easily worked and was the only source of metal known to them. Over the centuries, many cultures have used meteoric iron for weapons and tools. It's easy to see why this is one of the most popular meteorites among collectors.* *(See photo 9, next page.)*

IRON METEORITES

#1 **Atacama, North Chile Hexahedrite.** The low nickel content of this type of meteorite puts it in the hexahedrite category of irons. When etched, it shows a fine pattern of lines called *Newman lines*. This has lain in Chile's Atacama Desert for thousands of years.

#2 **Henbury, Central Australia, Australia.** These octahedrites have 7% to 9% nickel. This particular specimen is well-oriented, showing that it did not tumble as it passed through the atmosphere, but maintained a stable flight pattern.

#3 **Chinga, Turvinskaya, USSR.** An ataxite, these have the most nickel of all - 12% or more. This meteorite shows signs of heavy shock and deformation during break-up in the atmosphere.

#4 **Sikhote Alin, USSR.** This comes from one of the largest recorded falls in history. When this main mass exploded, it blasted twisted, jagged fragments in every direction; pieces were found embedded in nearby trees.

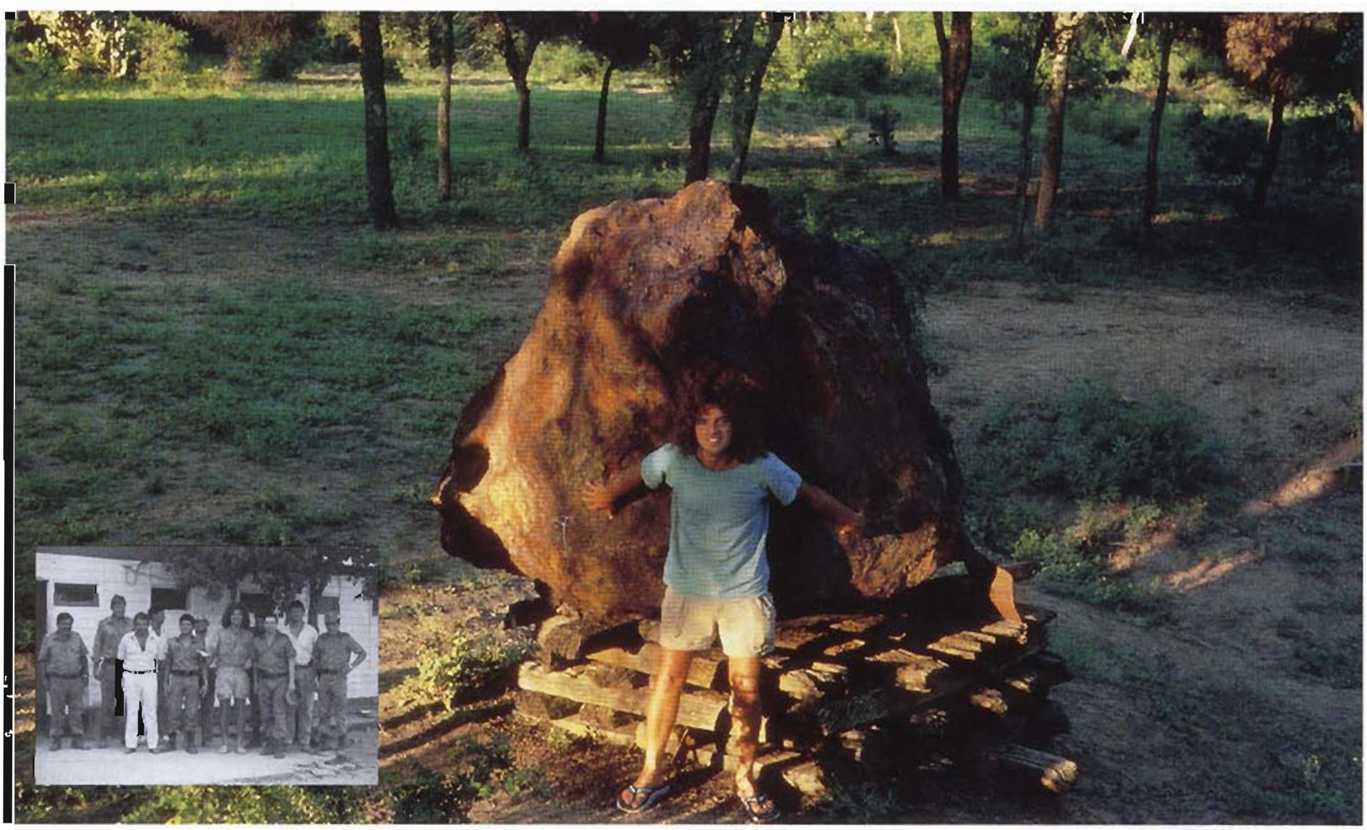
#5 **Toluca, Mexico.** This comes from a remote mountain location near Mexico City, where local farmers still occasionally run into these heavy "rocks" with their plows. Toluca might once have looked like Sikhote Alin, but many years of weathering have dulled the sharp edges and left a rusty shell.

#6 **Boxhole, Northern Territory, Australia.** A medium octahedrite similar to Henbury. When it hit, it formed a small crater, from which some large masses were recovered, along with many smaller old, weathered-out meteorites, called "shale balls".

#7 **Aldama, Mexico.** This specimen is unusual because it shows signs of having gone through an extended and intense heating and re-crystallizing process, possibly as a result of passing too near the Sun. The Widmanstätten pattern was completely altered by this encounter, and there seem to have been some other strange consequences as well...

#8 **Wolf Creek, West Australia, Australia.** This shows the last stages of decay for an iron meteorite; all that's left is iron oxide -- rust. This is called "shale" or limonite. In this case, the process took a million years under dry desert conditions, but can very occur rapidly in a wet environment.

#9 **My daughter, Onnie**, age 4 and Barbie, age 31 with a monster Gibeon specimen. Here at the "Meteorite Ranch", rounding up specimens and sending them to market is all part of a day's work.



Chaco Province, Argentina. *Author with the 37 ton "alien" that tried to possess him.* ***Inset:*** *Author with the Argentine police. They did possess him . . . for awhile, anyway. (It was, however, all a big misunderstanding)*

1 NORTH CHILE
HEXAHEDRITE WITH NEWMAN LINES, IIA. SMALLER: 4.7 kg.: 230 x 80 x 70 mm. LARGER: 17.2 kg.: 230 x 150 x 100 mm.

2 HENBURY
MEDIUM OCTAHEDRITE, IIIA, WITH EXCELLENT SURFACE FEATURES. COMPLETE SPECIMEN. 30 kg.: 250 x 250 x 150 mm.

3 CHINGA
NICKEL-RICH IRON ATAXITE, IVB. COMPLETE SPECIMEN. 1,605 grams: 95 x 100 x 50 mm.

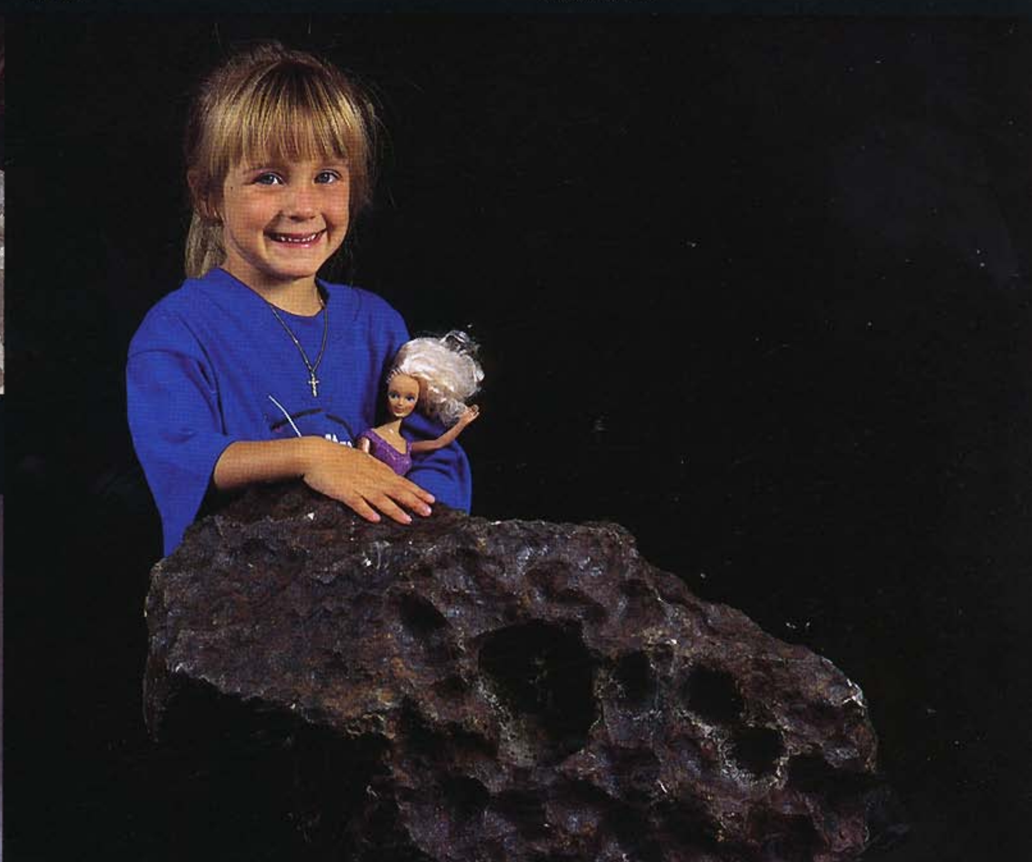
4 SIKHOTE-ALIN
JAGGED SPECIMEN WITH GOOD FLIGHT MARKINGS. COARSEST OCTAHEDRITE, IIB. 755 grams: 200 x 130 x 170 mm.

5 TOLUCA
COMPLETE SPECIMEN, IA. COARSE OCTAHEDRITE 3 kg.: 230 x 130 x 75 mm.

6 BOXHOLE
IIIA IRON. COMPLETE MEDIUM OCTAHEDRITE SPECIMEN. 4 kg.: 230 x 50 x 50 mm.

7 ALDAMA
COMPLETE SPECIMEN SHOWING NICE FLIGHT MARKINGS. MEDIUM OCTAHEDRITE, IIIAB. 7.2 kg.: 350 x 130 x 100 mm.

8 WOLF CREEK
FROM A VERY OLD IMPACT CRATER. IIIB. END PIECE. 1,227 grams: 120 x 110 x 40 mm.



9 ONNIE, BARBIE & GIBEON
GIBEON, NAMIBIA. LARGE COMPLETE SPECIMEN IVA. 190 kg.: 600 x 270 x 260 mm.

#10 **Cape York, Greenland.** A 3-ton specimen was found in 1982 by an Eskimo lucky enough to spot it laying in several feet of water at low tide. This 100 lb. slice is for sale. The dog "Poopers" is not.

#11 **Odessa, Texas, USA.** This is a coarse octahedrite, meaning it has the largest crystal size of all. Octahedrites can have coarse, medium or fine Widmanstätten patterns. Usually available.

#12 **Ocotillo, California, USA.** A new, coarse octahedrite find from California. Each octahedrite has its own individual pattern.

#13 **Uruachi, Chihuahua, Mexico.** Another new iron recently discovered by ranchers in Mexico. Coarse octahedrite. 13 kilograms total weight were recovered.

#14 **Wolsey, North Dakota, USA.** A South Dakota man discovered this 160 lb. specimen while plowing his field. He sold it after reading a notice in a local farm journal which offered a reward for such things.

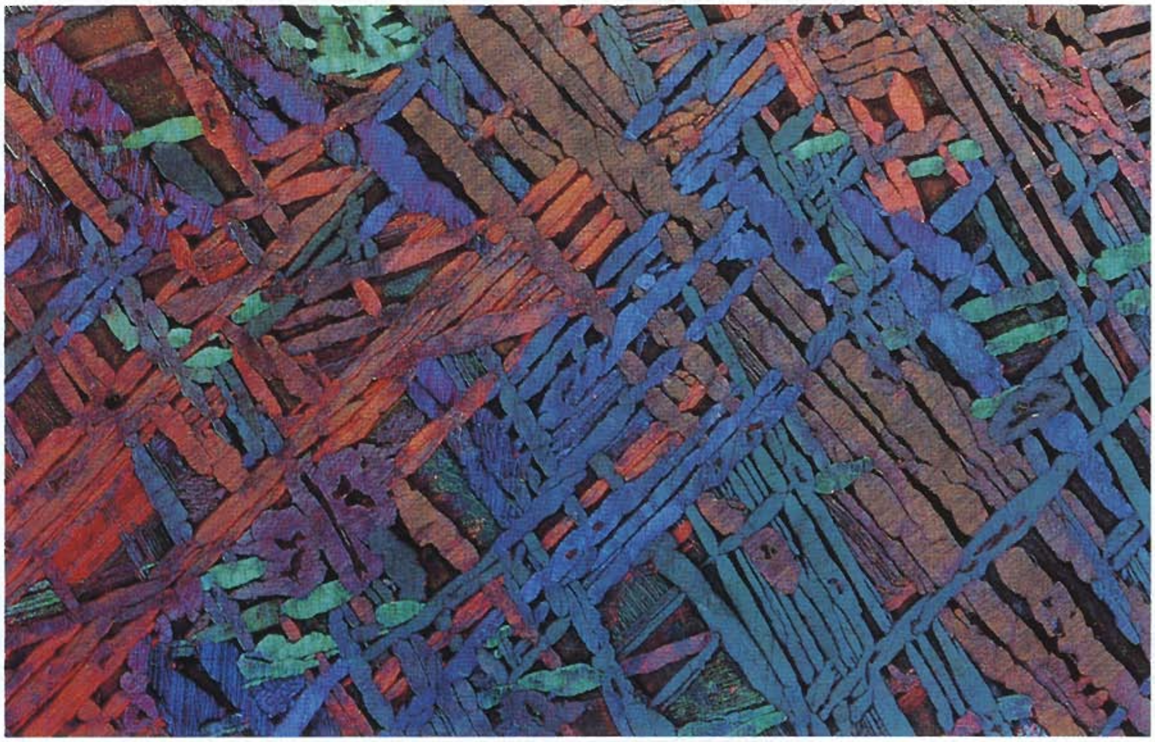
#15 **Fairview, Texas, USA.** Pappa Yeates, a Texan friend of mine and local authority on all things rock, fossil or meteorite-like, saved this specimen for me after a farmer brought it to him for sale.

#16 **Bear Creek, Colorado, USA.** A large 500 lb mass was discovered in 1866 in a deep gulch at nearly 8000 ft. elevation, on a slope in the Rocky Mountains. Meteorites were often turned up by prospectors who mistook them for silver nuggets, among other things.

***Etched Toluca** face in gold watch case; very expensive and very beautiful. The future for meteorites looks good.*

#17 **Arispe, Sonora, Mexico.** This is also a coarse octahedrite. This slice is almost free of inclusions. Note the obvious and clear crystal boundaries. When an iron meteorite hits the atmosphere, it usually breaks along these weaker boundary lines.

#18 **Seymour, Missouri, USA.** A mass of some 57 pounds was found in 1940 but it wasn't recognized as meteoritic until 1963. I received this specimen in trade with a major American museum.



*This amazing photo was taken by Mr. Ken Cooper of Vancouver, British Columbia. By using colored lights shining from different angles, he produced this unique Widmanstätten pattern. This was first published in **Omni** magazine.*

10 CAPE YORK
TROILITE (FeS) AND GRAPHITE (C). COARSE OCTAHEDRITE. IA. SLICE. 45.5 Kilos: 1287 x 630 x 25 mm.

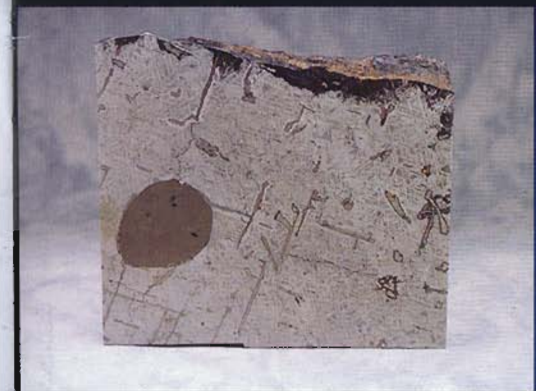
11 ODESSA
COARSE OCTAHEDRITE, IA. ETCHED SLICE. 2000 grams: 180 x 130 x 10 mm.

12 OCOTILLO
NEW DISCOVERY. COARSE OCTAHEDRITE W/GRAPHITE & TROILITE INCLUSIONS, IA. ETCHED SLICE. 738 grams: 180 x 120 x 5 mm.

13 URUACHI
NEW DISCOVERY. OCTAHEDRITE, IIIB. ETCHED END PIECE. 2,375 grams: 140 x 80 x 60 mm.

14 WOLSEY
COARSE OCTAHEDRITE, IA. SLICE. 3,009 grams: 270 x 220 x 10 mm.

15 FAIRVIEW
MEDIUM OCTAHEDRITE. ETCHED SLICE. 926 grams: 220 x 125 x 7 mm.



16 BEAR CREEK
MED. OCTAHEDRITE, IIIB. PARTIAL SLICE. LG. TROILITE NODULE. DIFFERENT KIND OF ETCHED PATTERN. 1.7 Kilos: 117 x 95 x 22 mm.

17 ARISPE
COARSE OCTAHEDRITE, IC. SLICE. 348 grams: 145 x 70 x 10 mm.

18 SEYMOUR
COARSE OCTAHEDRITE, IA. SLICE. 980 grams: 200 x 95 x 9 mm.

SILCATED IRONS

Silicated iron meteorites are sort of a group between groups. While considered irons, they nevertheless contain significant amounts of silicates and other inclusions. Occasionally, as in the case of the Caddo County specimen, two or three categories of meteorite are represented in the same piece at once. Because of their silicate content, silicated irons tend to be lighter than pure irons and have better surface features.

***Author with metal detector.** This is one of the best ways to look for meteorites, especially irons. I prefer White's Model 6000 or Eagle series. They are easy to use and stand up to lots of wear and tear.*

#28 **Georgetown, Queensland, Australia.** This brand new discovery was made by a gold prospector while metal-detecting in the rich Queensland goldfields. Of a very unusual type, it is unlike anything I've ever seen before. Only four small specimens have been found over a quarter mile area.

#29 **Mundrabilla, West Australia, Australia.** Ribbons and pockets of troilite inclusions create the distinctive Mundrabilla pattern. When this meteorite weathers, the troilite disappears, leaving deep pocks and holes.

#30 **Twannburg, Switzerland.** This beautiful meteorite is classified as an anomalous iron, meaning that it is unique. No others have ever been found. The unusual, scroll-like inclusions are of a phosphorus mineral called schreibersite, which does not occur in Earth rock.

#31 **Graphite Nodule. Canyon Diablo, Arizona, USA.** This excellent example of a graphite nodule is shocked through with metal, probably from the impact blast. The metal that once surrounded it either weathered away or was stripped off during entry and impact.

#32 **Odessa, Texas, USA.** This is a close-up of an interesting inclusion from an Odessa iron meteorite slice. There seems to be a little bit of everything: the dark material in the center is black graphite and troilite. The crystals around the rim are schreibersite. There is also a bright yellow olivine crystal near the center.

#33 **Canyon Diablo, Arizona, USA.** Diamond crystal (carbonado). When we cut this piece, the much harder diamond crystal actually *moved* the saw blade over and around it. The carbonado was probably formed when carbon, in the form of graphite within the meteorite, was subjected to an intense shock, either in a collision with another asteroid or with the surface of the Earth.

#34 **Toluca (b), Mexico.** This new silicated iron meteorite was picked up from within the Toluca strewnfield where it was found by one of the local people. The minute I held it, I realized that it was different from the other Toluca pieces; half as heavy, but obviously iron, with the typical, pitted surface of silicated irons.

#35 **Zagora, Morocco.** This piece was found in the desert near the Atlas Mountains by fossil hunters. Unfortunately, the locality is near a military zone. Not much chance of getting in there with my detector! Note how the many silicate inclusions disrupt the etched medium octahedrite pattern. (Also see photo below.)

#36 **Landes, West Virginia, USA.** This is a beautiful, unusual meteorite, with so many silicates that the pyroxene crystals seem to grow in the meteorite, rather than be simply mixed in, as with a mesosiderite.

#37 **Udei Station, Nigeria.** I got this cut fragment right off of the main mass while trading in Nigeria. Note the silicate inclusions inside, and the fresh fusion crust. This was a recent, witnessed fall, and this specimen was dug up from the impact hole.

#38 **Woodbine, Illinois, USA.** The silicates are obvious in this anomalous, 1B silicated, fine-octahedrite. It was discovered by a farmer in1953, when he plowed it up during spring planting. (Many meteorites have been found by farmers and ranchers. Keep it up, y'all.)

#39 **Caddo County, Oklahoma, USA.** This is an unusual piece in that one end section is highly silicated and the other end of the same specimen is very poorly silicated - nearly solid iron. The silicates and iron are very poorly mixed; sort of a borderline mesosiderite/ silicated iron. This is closely related to lodranites.

***Zagora, Morocco.** The softer silicate and sulfur inclusions melted out leaving holes in the iron. Note fusion crust.*

28 GEORGETOWN
ANOMALOUS IRON TROILITE INCLUSIONS NETWORK THE MATRIX. END PIECE. 397 grams: 850 x 500 x 230 mm.

29 MUNDRABILLA
MEDIUM OCTAHEDRITE, (IRANOM) SLICE. 1569 grams: 230 x 180 x 10 mm.

30 TWANNBURG
ANOMALOUS IRON. SLICE. 430 grams: 180 x 100 x 10 mm.

31 GRAPHITE NODULE
END PIECE FROM A SPHERE OF GRAPHITE. CANYON DIABLO. THE METAL HAS BEEN STRIPPED AWAY. 1000 grams: 110 x 80 x 30 mm.

32 ODESSA INCLUSION
GRAPHITE INCLUSION. SLIDE. CLOSE-UP. IMAGE AREA: 40 x 20 mm.

33 CANYON DIABLO
CARBONADO IN COARSE OCTAHEDRITE. IA. UNETCHED ROUGH SLICE. 26 grams: 5 x 5 x 2 mm.

34 TOLUCA (b)
SILICATED IRON. END PIECE. 943 grams: 110 x 110 x 30 mm.

35 ZAGORA (MOROCCAN IRON)
SILICATED IRON. END PIECE. 2,695 grams: 170 x 100 x 70 mm.

36 LANDES
SILICATED IRON. IA. SLICE. 206 grams: 100 x 90 x 100 mm.

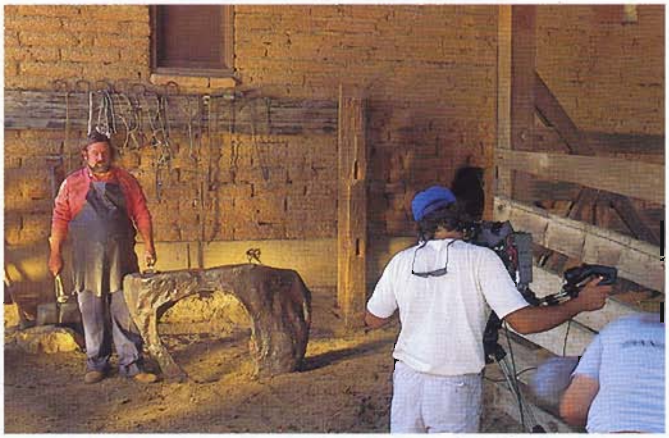
37 UDEI STATION
COARSE OCTAHEDRITE, IA. END PIECE. 855 grams: 100 x 80 x 40 mm.

38 WOODBINE
SILICATED IRON, ANOM. SLICE. 471 grams: 110 x 110 x 10 mm.

39 CADDO COUNTY
SILICATED IRON, IA. PARTIAL PIECE. 17 kg.: 280 x 150 x 80 mm.

THE TUCSON IRON METEORITES

The Tucson Iron meteorites are shrouded in mystery, even today. Known for centuries by the local Indians and later by ranchers in the area, only two masses were ever recovered. These came from somewhere in the Santa Rita Mountains, south of Tucson, Arizona. Legend says they fell near a pass known as Box Canyon, but this hasn't been proven. (See map, pg. 15.)



***Mike Barry** in a re-creation of the blacksmith's shop.*

Both pieces were eventually transported overland to the tiny frontier settlement of Tucson, where they ended up as working blacksmith's anvils. It wasn't until 1850 that a U.S. Cavalry officer recognized the huge chunks of iron as meteorites and contacted the National Museum in Washington. Both specimens were transported there and now reside in the Smithsonian, far from their secret landing spot in the Sonoran Desert. Unusual in more ways than a lost location, the larger, 688 kg. meteorite is shaped in a natural, perfect ring. They are both of a rare *anomalous* iron: uncategorizable, highly unusual and unique. For one thing, even though it is labeled an ataxite, it is full of nearly microscopic crystals of enstatite and olivine. Furthermore, it contains 9.45 % nickel and shows no crystalline Widmanstätten pattern.

Anomalous Iron. *This is a close-up of the internal structure of the Tucson Ring meteorite. Note the pin-point sized silicates throughout the metal. Area shown twice life-size.*

For me, this is the ultimate "lost treasure", far surpassing the (ho-hum) "Lost Dutchman Gold Mine". After all, gold is just gold, but more specimens of an anomalous iron like the Tucson would thrill scientists and have collectors panting at my door... In any case, I've been fascinated with the story and the mystery for years since I was a child and listened to my rock-hound parents and their rock-hound friends speak of it. When I saw a copy in the Flandrau Planetarium on the University of Arizona campus, something klunked into place in my head: " I'm going to find the *rest* of that sucker."

So, a bunch of crazy friends and I have been searching for years, up and down ravines, in and out of box canyons, over dozens of square miles, either freezing our rears off or broiling our brains, depending on the time of day or year that we can get away. We've had brushes with sticker bushes, near misses with rattlesnakes, dead hits from Spanish dagger plants that ram two inches of hardened spike into your shins and many a tumble down long slopes of loose shale, but all in all, it's a gas, and I wouldn't have missed those jaunts for the world, even though we still haven't found the strewnfield. (...Um, did you say there was beer back at camp...?)

***Author with paraplane in the Santa Ritas.** The search for the Tucson Iron meteorite strewnfield continues . . .*

Recently Four-Point Entertainment came out and filmed a segment for national broadcast on a program called "Missing: *Reward*", narrated by Stacy Keach. It is a show about various kinds of treasure that can be found by folks and about the people (other lunatics like myself) who will pay ridiculous amounts of money for it. I offered up to $100,000.00 for information about the exact location of the fall and recovery of more of the same meteorite. We had a blast filming it and I got a great deal of response from around the country, but so far, no one has come to collect a check. (We did, however, locate two *new* meteorites as a direct result of the program.)

We all had a blast working with a professional film crew in the beautiful Arizona countryside. The scene above was shot only a few miles from my parent's ranch in southern Arizona. I spent many hours in these hills myself, searching for the Tucson Iron strewnfield.

This scene is probably a fairly accurate reenactment of how the massive meteorites were moved the many miles from their landing spot in the Santa Ritas to the old presidio of Tucson. (And no, I didn't get to meet Stacy Keach during the filming...)

It happened like this . . . *Actors on horseback are dragging a replica of the Tucson Ring for the televsion show "Missing Reward". Another excellent replica of this bizarre meteorite can be seen at the University of Arizona's Flandrau Planetarium. The original, of course, along with the other mass, known as the Carleton, (see photo at right) is still on display at the Smithsonian Institute.*

A piece of the ring. *This fragment of the original Tucson Ring meteorite now resides in the author's private collection as a result of a recent trade with Harvard University. 267 grams, shown 80% life-size.*

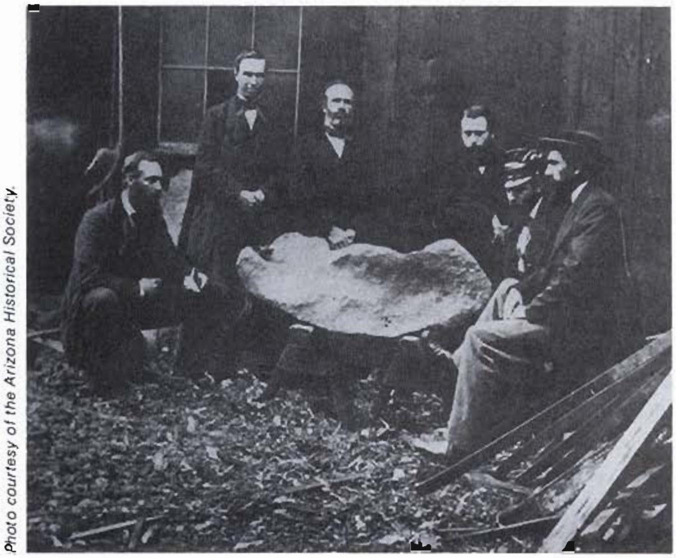
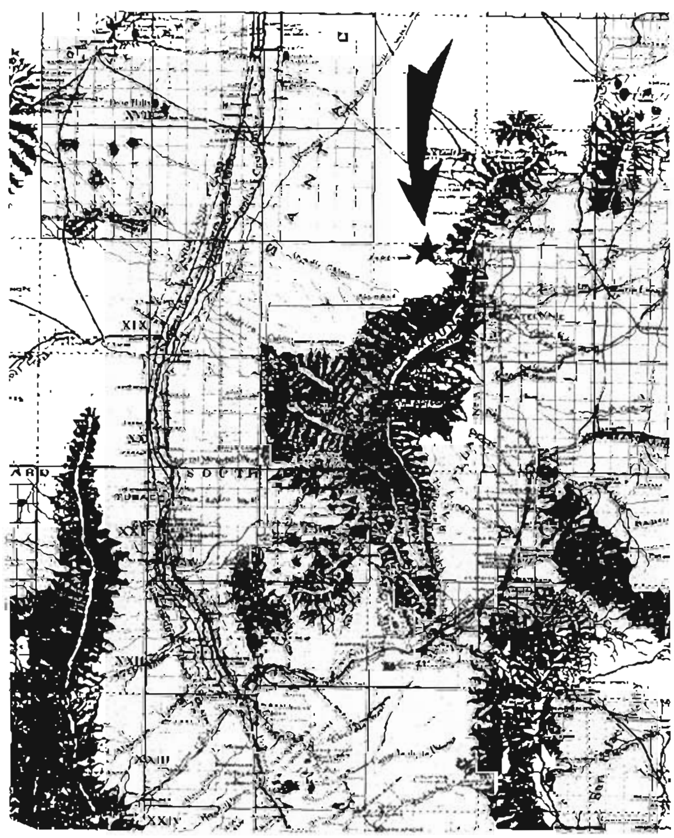


Photo courtesy of the Arizona Historical Society.

The Carleton Meteorite. *The Carleton Meteorite was the smaller and less famous of the two massive iron meteorites found in the Santa Rita Mountains, south of Tucson, Arizona. This photograph dates from around 1862 and shows the Carleton in San Francisco, just before its journey by sea (around the Cape of Tierra del Fuego) to the Smithsonian Institute in Washington, D.C., USA.*



This section of a 19th century map shows the purported location of the Tucson Iron strewnfield, somewhere near Box Canyon in the Santa Rita Mountains near Tucson. The actual location was apparently once called "Puerto de los Muchachos", but that name does not appear on this map of the area.

IMILAC PALLASITE

The Imilac pallasites were found high up in the Andes Mountains of Chile, in one of the most remote places on Earth. It's like no other place I've ever been before. It's a high, *dry* desert; there's virtually no annual rainfall, no plants to speak of and it is as barren a corner of the world as you're likely to see.

Several years ago, the "Meteorite Recovery Team", consisting of me, two of my good buddies and three Chilean friends, went on a joint Chilean/American expedition in search of more specimens. What a trip! Two trucks, six crazy guys and a lot of supplies all crawling up the side of the Andes to the Atacama Desert, setting out to search the high mountains for Imilac pallasites.

Among the light background rock of the desert, the rusty-looking pallasites with their bright yellow olivine crystals showed up clearly and seemed to jump out at us. In the strewnfield, most of the larger specimens were dumped high on the sides of a steep hill. Near the end of the strewnfield was an impact crater where a big one hit, blew up and scattered fragments for a kilometer or more.

At night, we gazed at the incredibly bright stars of the southern hemisphere from our camp at nearly 10,000 feet elevation. Without city lights, smog or dust to obscure their light, they were like a white blanket. The Milky Way, indeed. (Walk outside your door tonight, look up, and in your mind, multiply the number of stars you can see by about ten thousand: that's only a hint of what it was like.) Which is, of course, the reason that the Andes are one of the best locations in the world for astronomical observatories.

During the day, we searched the whole area with detectors, finding fragments and complete stones all along the sides of the peaks. The air was thin and cold, which wasn't so great for us, but sure seemed to suit the meteorites; they were perfectly preserved and are some of the most beautiful meteorites I've ever collected.

Imilac fragment, as found. *Most of the recovered pieces were right on the surface. You have to **tune** your eyes to see them.*

Several years ago, I was very lucky to be featured in *National Geographic* magazine holding a slice of this exotic pallasite. I hope to return to this locality soon. Chile is a terrific place to visit. It's got everything.

While scientists now agree that they do have extraterrestrial origins, they don't yet agree on how pallasites originally formed. It has been proposed that they represent the interface between the heavy, metal core and the lighter, stone mantle of an asteroid or planetoid. This isn't proven, however, and they remain a mystery.

Atacama Desert, Northern Chile. *Author parasailing over the Atacama Desert, looking for Imilac impact craters. (While an outrageous sense of adventure is not absolutely necessary to become a meteorite hunter, it sure doesn't hurt . . .)*

Imilac, Atacama, Chile. *This 17 kg. specimen was found in its own impact crater. The buried part retained some dark fusion crust, while the exposed section was sand-blasted for perhaps thousands of years, which kept it rust-free. When in doubt, flip the rock over!*

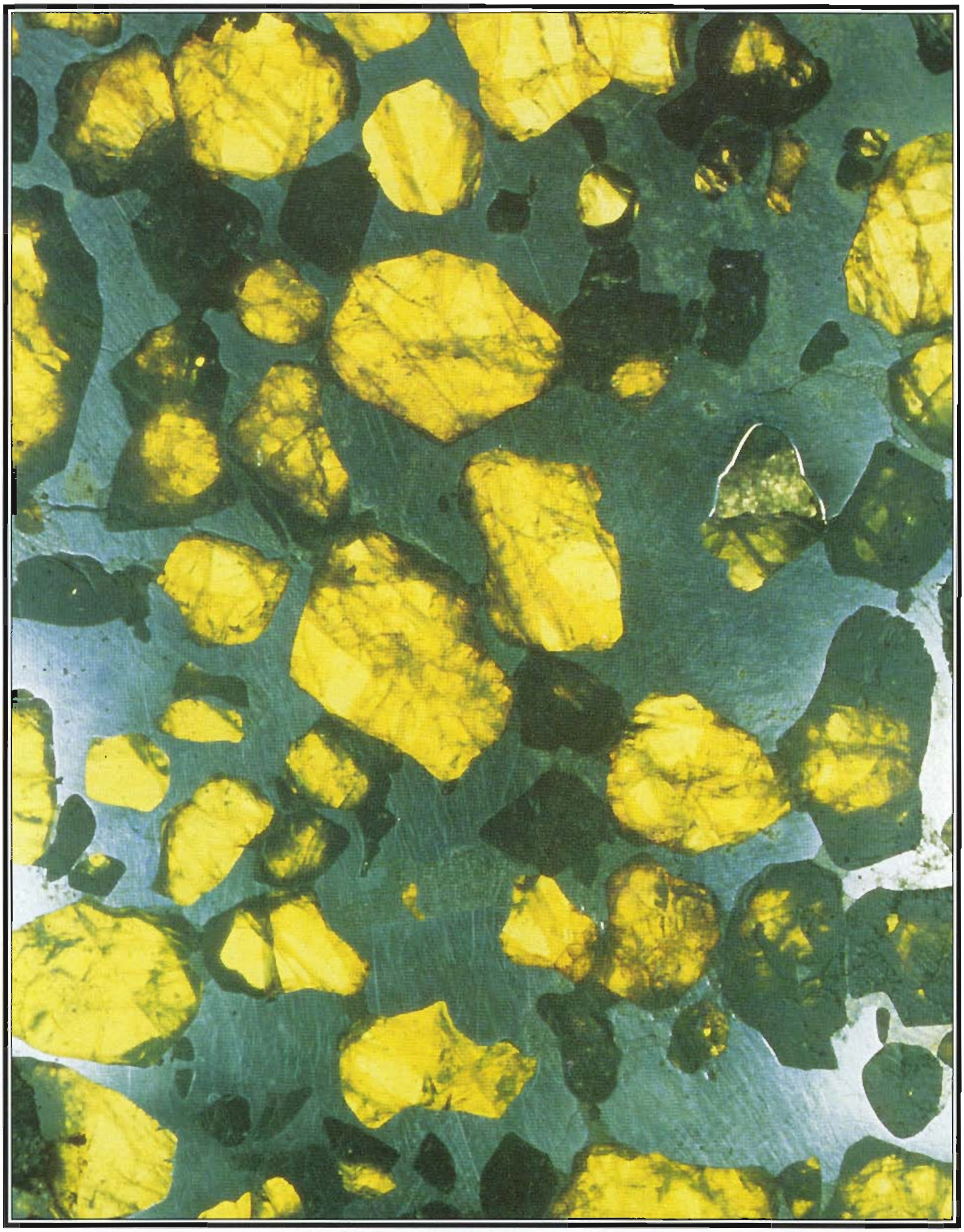


Photo by Andre Bagel - Tucson.

Imilac thin-section. *This meteorite is composed of approximately 50% nickel-iron alloy and 50% stone, in the form of beautiful olivine ((Mg, Fe)$_2$ SiO$_4$) crystals. Olivine is abundant in meteorites as well as in the Earth's magma; for instance, the so-called "black" volcanic sands (actually green sands) of Hawaii are composed of olivine. Sometimes called by the popular name of peridot, olivine constitutes a great deal of the "stone" in stone meteorites, along with other minerals, such as hypersthene, plagioclase, troilite and others. Imilac is the most popular selling stony-iron, for obvious reasons.*

STONY-IRON METEORITES - Mesosiderites

The stony-iron meteorites are quite rare. There are two kinds, pallasites and mesosiderites. Remember, these are a mix of stone and iron. In the mesosiderites the amount and extent of the mixing can vary a lot. Poor mixing can cause confusion in the classification of a meteorite. Scientists are realizing that much of the classification is arbitrary and that in fact, many meteorites cross categories.

#40 **Emery, South Dakota, USA.** The iron and stone portions of this meteorite are very well mixed, indicating that it was smashed together sometime during its formation. For instance, there is evidence of grinding and folding in its past. Meteorites like this give scientists an opportunity to study the composition of the universe and to understand more about the formation of planets and solar systems such as our own. It is important to remember that meteorites such as Emery come to us just the way they occurred in space. The deformation of the crystals is not a result of terrestrial impact.

#41 **Clover Springs, Arizona, USA.** This photo shows the nice mixing of the metals and silicates in this well-preserved meteorite. I searched among the pine trees for this one, and I'm sure there's more to be found.

#42 **Mt. Padbury, Western Australia, Australia.** This meteorite is quite old and weathered on the outside, making it hard to recognize. However, if you grind a corner of this rough, rusty rock, you'll see lots of metal. Then you can get excited!

#43 **Chinguetti, Mauritania.** According to legend, an iron meteorite mass as big as a two-story house was known to the Bedouins. One of them showed the location to two French Legionnaires, and was fatally poisoned a few days later for divulging the secret. The Legionnaires noted the episode in a journal, but when they went to find the "meteorite", it was lost under the constantly shifting sands of the Sahara, and was never seen again. Until recently, that is, when, sadly, the mystery was solved: the huge, long-lost "Chinguetti meteorite" turned out to be an enormous, natural bank of iron-bearing (Earth) rock called hematite. This meteorite specimen was an unrelated find from nearby.

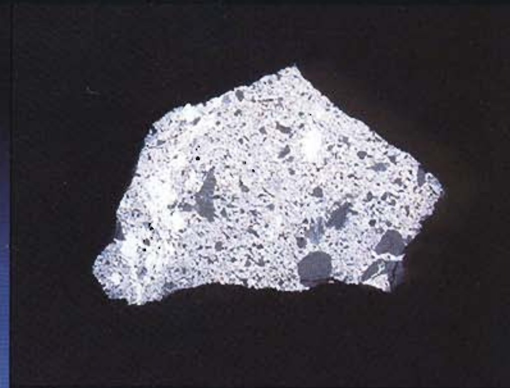
#44 **Budulan, Buryat National District, USSR.** This is a fragment from a single, 100 kilogram mass found in 1962. This is another trade specimen from the Moscow Academy of Sciences.

#45 **Esterville, Iowa, USA.** The iron and stone portions of this meteorite are poorly mixed together. It comes from the spectacular, witnessed fall of 1879, when a fireball exploded and sent thousands of fragments raining down onto the farms below.

***Lowicz, Poland.** Mesosiderite fall, March 12, 1935. 979 gram end piece. **Rare**, fresh metal and stone are mixed together in this ½ stone. Perhaps some lucky prospector will hit the mother-lode hunting in the strewfield. Poland's friendly!*

***Esterville, Iowa, USA.** The blue-black fusion crust is very important in the identification of meteorites and often gives clues as to the type of material within. Close examination of this photo reveals two different types of fusion crust. The softer, grainy stone material melted out faster and left a different fusion crust than the harder iron.* *(See photo 45, page 19.)*

40 EMERY
STONY-IRON MESOSIDERITE. SLICE. 211 grams: 150 x 80 x 5 mm.



41 CLOVER SPRINGS
MESOSIDERITE. SLICE. 90 grams: 100 x 70 x 5 mm.

42 MT. PADBURY
MESOSIDERITE. END PIECE. 564 grams: 80 x 70 x 50 mm.

43 CHINGUETTI
MESOSIDERITE. SLICE. 264 grams: 90 x 45 x 10 mm.

44 BUDULAN
78 grams: 25 x 25 x 25 mm.

45 ESTERVILLE
MESOSIDERITE. END PIECE. 818 grams: 100 x 70 x55 mm.

#46 **Bencubbin, Western Australia, Australia.** Occasionally a meteorite will occupy a class by itself. Bencubbin is one such specimen. A mesosiderite, it has enstatite and olivine crystals as well as clasts of chondritic material, mixed with troilite and finely laced silicates. It has a hexahedrite metal matrix (6.6% nickel), yet shows no Newman lines when etched. Very unusual.

#47 **Mincy, Missouri, USA.** Large stony chunks are mixed into the mesosiderite. More specimens of Mincy would certainly be welcome.

#48 **Vaca Muerta, Chile.** This is an example of stone meteorite material (pyroxene and plagioclase) being mixed in with a mesosiderite. Clasts, or inclusions, of this stone material, such as the large, dark rectangle at the top, are similar to the calcium-rich achondrites, (eucrites). From examples such as Vaca Muerta, scientists have concluded that both eucrites and mesosiderites may come from the same parent body.

#49 **Bondoc, Luzon, Philippines.** This mesosiderite had huge, baseball-sized spheres of iron set into a matrix of stony material, putting it on an entirely different scale than any other mesosiderite. (Giant size?) If that weren't unusual enough, when the spheres of iron were cut open, they revealed yet more inclusions of stony material within.

#50 **Crab Orchard, Tennessee, USA.** A beautiful, unusual mesosiderite. Note the big clasts of iron and stone. This probably fell in the late autumn of 1880, when a meteor passed over the area, leaving a dense, narrow trail of light-colored smoke. A loud report was heard by persons witnessing the meteor's passage. Seven years later, this meteorite was found by Mr. Elihu Humbree who knocked off several large chunks, looking for "native silver". Mr. Lenoir, the owner of the land on which it fell, and therefore the owner of the meteorite, suspected its true nature and sold the specimen.

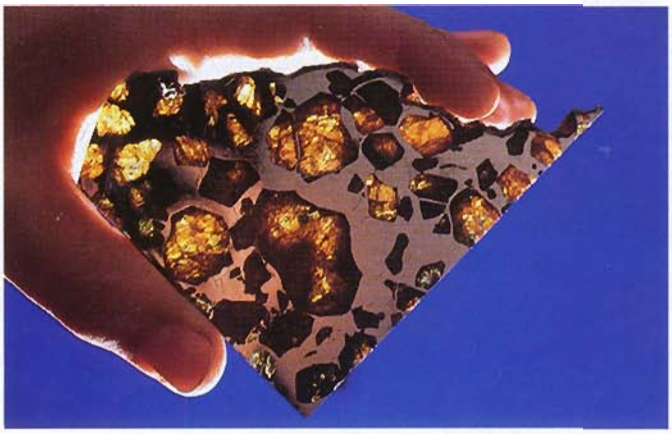
Now we will start on the second half of the stony-irons, Pallasites. As you look at the photos keep in mind the yellow olivine crystals. They can vary from nearly perfect spherules to broken up angular fragments.

#51 **Huckitta, Northern Territory, Australia.** The Huckita pallasite is a very old meteorite. A huge mass was found lying alone in the desert with nearly half of the rock completely rusted away. The iron has metamorphosed into its oxide, hematite. The olivine crystals are stained but intact.

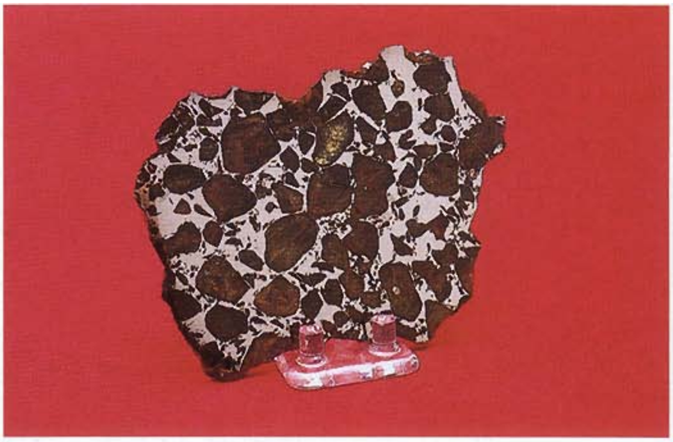
#52 **Admire, Kansas, USA.** Note the unusual surface features in this large, complete specimen; ie., plow scars! Fusion crust is still visible, but is very rusty. Like many meteorites found in the USA, this one comes from the Midwest. See also photo 56, next page.

#53 **Glorietta, New Mexico, USA.** This pallasite has small traces of fusion crust covering both the crystals and the metal, with bits of rust here and there. Some pieces of this meteorite have been found to contain alternating sections of pure nickel-iron and olivine-rich pallasite. This is a fun place to search.

#54 **Otinapa, Durango, Mexico.** The surface of this meteorite reveals what's to come on the inside: mixed metal and stone. I was extremely lucky to have acquired the only piece ever recovered of this meteorite, a beautiful 8 kilo mass. I have since traded slices of it for other terrific pallasite pieces. (I *love* pallasites.)



***Esquel, Chubut, Argentina.** This is a very thin slice of a rare pallasite. In this piece, the olivine crystals are average size, but I've seen them as large as footballs. Slice, 80 grams: 110 x 90 x 2 mm. (See inside back cover.)*



***Acomita, New Mexico, USA.** This was found by an elderly Indian man who saw it by the side of the road while changing a tire, and used it to prop up an axle of his truck. Instead of leaving it behind, he threw it in the back where it reportedly rolled around for several years before it was recognized as being a meteorite. Pallasite slice, 160 grams: 100 x 75 x 6 mm.*

46 BENCUBBIN
STONY-IRON MESOSIDERITE. SLICE 480 grams: 50 x 30 x 10 mm.

47 MINCY
MESOSIDERITE. NOTE INCOMPLETE MIXING OF STONE AND METAL. SLICE. 224 grams: 90 x 70 x 10 mm.

48 VACA MUERTA
UNUSUAL MESOSIDERITE. END PIECE. 2,306 grams: 250 x 230 x 80 mm.

49 BONDOC
STONY-IRON MESOSIDERITE. END PIECE. 1,454 grams: 85 x 85 x 50 mm. IRON NODULES LACED WITH SILICATES.

50 CRAB ORCHARD
MESOSIDERITE. SLICE. 181 grams: 60 x 50 x 20 mm.

51 HUCKITTA
PALLASITE. HIGHLY WEATHERED. END PIECE. 500 grams: 90 x 90 x 80 mm.

52 ADMIRE W/TRUCK
COMPLETE SPECIMEN. AT 220 POUNDS, THIS IS HARD TO MOVE AROUND THE YARD, MUCH LESS GET INTO THE SAW.

53 GLORIETTA
PALLASITE. COMPLETE SPECIMEN. 78 grams: 60 x 70 x 30 mm.

54 OTINAPA
PALLASITE. HALF-SPECIMEN. 3,700 grams: 180 x 80 x 80 mm.

Faceted olivine crystal. This beautiful faceted gem came from an imilac pallasite. It's rare to find such a large, unshocked inclusion. This is about a half carat stone.

#55 **Albin, Wyoming, USA.** This meteorite was found on a grassy, sod slope by a rancher who had seen a meteorite display in Denver and recognized this piece.

#56 **Admire, Kansas, USA.** This is a slice off a find from Kansas. This pallasite is difficult to maintain, as sulfides in the metal promote rust, and the crystals are often smashed and crumbling.

#57 Theil **Mountains, Antarctica.** This unusual specimen was found on a glacier in 1962. The single crystals of olivine appear as nearly perfect round "bubbles" in the iron matrix. Such perfect crystal structure indicates little change since the first crystallization in the parent body.

#58 **Dora, New Mexico, USA.** This would be a good pallasite to look for, as there may be more in the area that were missed on the first sweeps.

#59 **South Bend, Indiana, USA.** This specimen was found resting next to a fence. If you live nearby, it might be worth while to look for more of this nice pallasite.

#60 **Ahumada, Mexico.** This pallasite has unusually large olivine crystals. It comes from a vast mesquite desert, with only a few isolated farms scattered around.

#61 **Springwater, Saskatchewan, Canada.** The Springwater pallasite is very similar to the Brenham pallasite, but the crystals of olivine are approximately 30% smaller, nor is any troilite visible, as in Brenham.

#62 **Otinapa, Durango, Mexico.** This pallasite contains both large and small crystals of olivine, many are crushed. (See photo 142, pg. 19.)

#63 **Brahin, Minsk, Byelorussia, USSR.** This is the Soviet Union's answer to Brenham. An old discovery from 1810, I traded for this slice when I was in Moscow a few years ago. This would be a great area to search with a metal detector. (Wonder if I can get in...?)

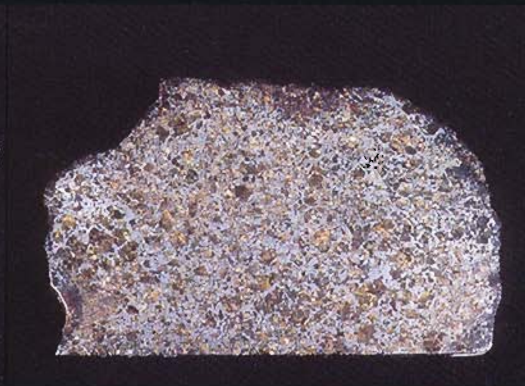
#64 **Mt. Vernon, Kentucky, USA.** This specimen is especially valuable because it was a witnessed fall. As with all pallasites, it's hard to imagine just how they formed. Did the two elements form together or were they mixed later? Perhaps pallasites represent a transition or contact zone deep in some asteroid where separation was taking place.

#65 **Mt. Dyrring, New South Wales, Australia.** This pallasite was found in 1903, when fragments totaling about 12 Kg. were picked up by local residents and brought to the museum as bits of unusual "rock". This has had a long Earth exposure time; all of the metal has weathered away, leaving behind only limonite, hematite and the olivine

#66 **Krasnojarsk, Siberia, USSR.** This is a piece of the first, historic pallasite, found by their namesake, the German-born naturalist, Peter Simon Pallas. He discovered the main 1,600 pound mass at a remote site in Siberia, some 45 miles south of Krasnojarsk, in 1749, years before the scientific world accepted meteorites as extra-terrestrial. Yet the native Tartars believed that it was a holy relic and that it had fallen from the sky.

***Brenham, Kansas, USA.** The photo on the left is of an etched slice of Brenham pallasite that is only iron with no stone inclusions at all. The olivine just "ran out" at the end of the specimen when the "normal" pallasite structure abruptly changed to iron. Compare the piece on the right with that on the left: they both came from the same meteorite! Examples like this sometimes create more questions for scientists than they answer.*

55 ALBIN
PALLASITE. SLICE. 740 grams: 190 x 140 x 10 mm.



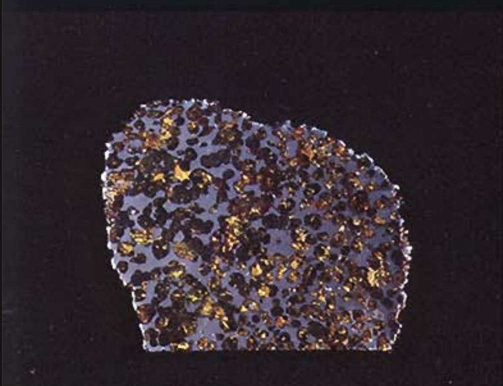
56 ADMIRE
PALLASITE. SLICE. 2 kg.: 220 x 150 x 20 mm.

57 THEIL MTS.
PALLASITE SLICE. 535 grams: 130 x 90 x 15 mm.

58 DORA
PALLASITE. COMPLETE SLICE. 162 grams: 110 x 90 x 10 mm.

59 SOUTH BEND
PALLASITE SLICE. 264 grams: 110 x 70 x 5 mm.

60 AHUMADA
PALLASITE SLICE. THE OLIVINE CRYSTALS ARE A DIFFERENT COLOR NEAR THE CRUST. 295 grams: 90 x 70 x 10 mm.



61 SPRINGWATER
PALLASITE SLICE. 357 grams: 110 x 100 x 10 mm.

62 OTINAPA
PALLASITE. 3,700 grams: 180 x 80 x 80 mm.

63 BRAHIN
PALLASITE. 163 grams: 75 x 55 x 18 mm.

64 MT. VERNON
WITNESSED FALL OF 1868. 11.5% Ni. SLICE. 6 kg: 340 x 230 x 26 mm.

65 MT. DYRRING
NICE OXIDE VEINS APPEAR TO OUTLINE THE OLIVINE IN THIS OLD METEORITE. 317 grams: 70 x 55 x 45 mm.

66 KRASNOJARSK
FOUND BY PETER PALLAS IN 1749! TROILITE CONNECTION BETWEEN OLIVINE CRYSTALS. 40 grams: 60 x 40 x 5 mm.

STONE METEORITES

Stones represent the third main group of meteorites, by far the most diverse group of the three. Nine out of ten meteorites that fall from the sky are stone meteorites. Fewer are found, however, primarily because they resemble Earth rocks, superficially, and are therefore harder to recognize. Stone meteorites also decompose more rapidly under terrestrial conditions than do irons.

Stone meteorites are divided into two main groups; those with chondrules, the *chondrites* and those without, the *achondrites*. Chondrules, from the Greek word for "seed", are the inclusions for which the two types are named. These round spheres of silicates range in size from the microscopic, to the size of marbles. Most, however, are the size of steel shot pellets. These chondrules are time-travelers, dating from the very beginnings of the solar system, some 4.6 billion years ago.

Formed as clouds of pre-solar dust began to condense, these tiny balls were packed into larger and larger masses, eventually forming small moons and asteroids. Some of these "parent bodies" were destroyed before they accumulated enough matter to cause remelting of their core material. Bits of this material usually contain chondrites in their earliest form.

Other parent bodies continued to accrete material until the mounting high-pressures within destroyed all evidence of the original chondritic structure. Bits of this material represent the achondrites, or those without chondrules. These are rarer than chondrites.

CHONDRITES

The group of stone meteorites known as chondrites is broken down into three classifications: *ordinary,* which includes the bronsite (H's), hypersthene (L's) and amphoterites (LLs), *enstatite* chondrites (E chondrites), and *carbonaceous* chondrites, (C chondrites).

"Ordinary" chondrites are classified from LL for "low-low" iron content, through L for "low" iron content, through H for "high" iron content. They are further classified by a numbering system of 3 through 6; where the *lower* the number the less the chondrules have changed and the *higher* the number, the more the chondrules have been changed. This alteration may have been caused by heat, pressure or shock prior to landing on Earth. An L3 for instance, would refer to a low iron, virtually untouched ordinary chondrite with perfect chondrules.

E chondrites, or enstatite chondrites are the most metal rich of all the chondrites, and are made up primarily of the mineral enstatite, or *magnesium silicate* ($Mg_2Si_2O_6$) one of the pyroxene group of minerals. In these meteorites, the metal is not tied up in the minerals, but is visible as free, metallic iron.

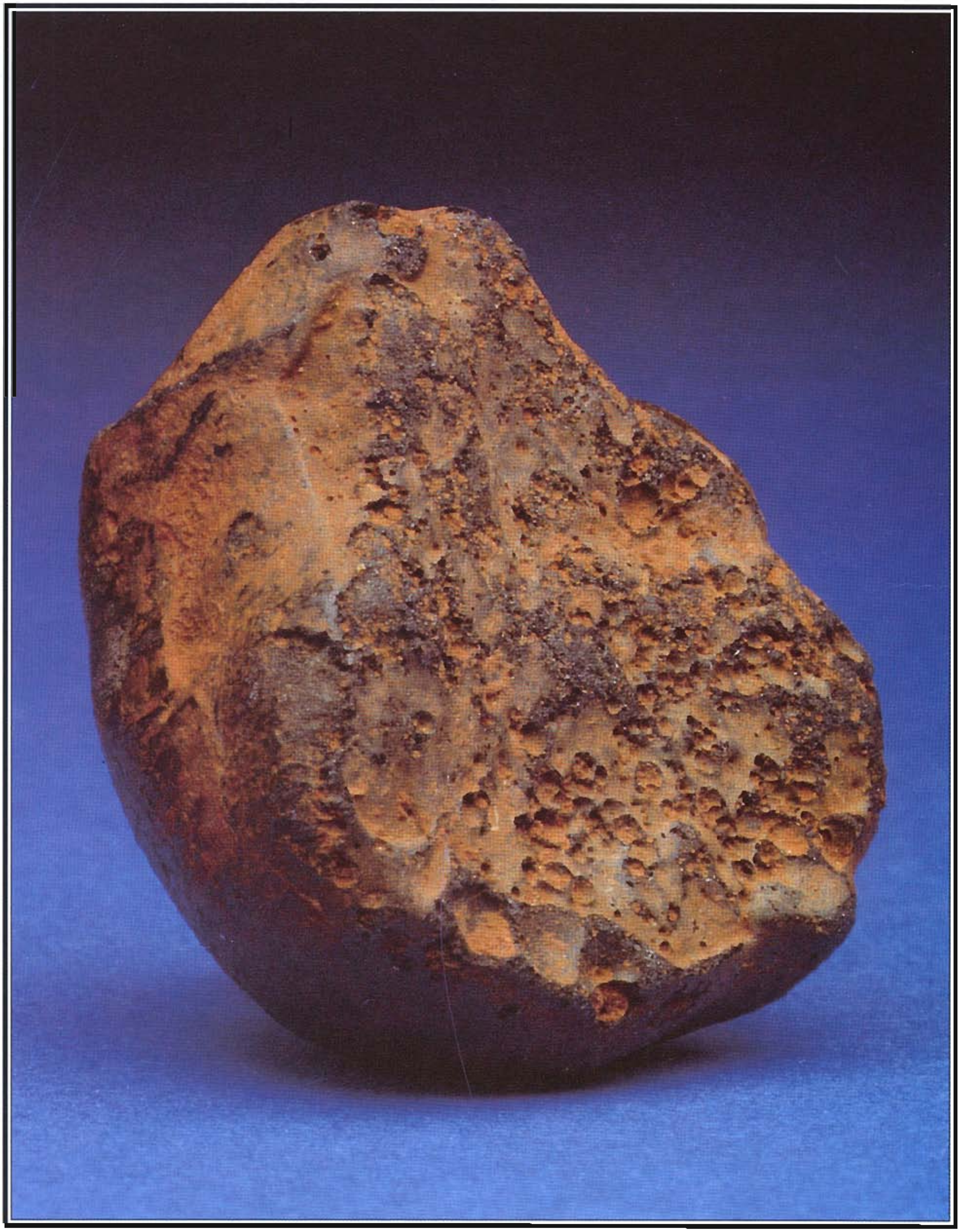
Carbonaceous chondrites are those that are enriched in the element carbon. These meteorites have stirred a great deal of scientific interest since the discovery that they contain amino acids, the building blocks of proteins, as well as diamonds and other complex and interesting organic compounds. (See table 36A, page 36.)

ACHONDRITES

Achondrite meteorites are stone meteorites which do not show any chondrules. They *may*, however, have round clasts or other spherical crystals that have grown out of re-melted, metamorphosed material. This can cause confusion. One clue is that achondrites very rarely contain any *visible* metal.

Millbillillie, West Australia, Australia. *Eucrite, achondrite. No sign of any chondrules. This material has been completely re-melted and then crystallized, resulting in two totally different textures in the same specimen. If you saw each part separately, it would be hard to believe that they came from the same piece. End piece, 31 grams. (Shown actual size.)*

Moorabie, New South Wales, Australia. *The L3 Moorabie chondrite has a matrix of thousands of pure chondrites of varying sizes and shapes, all virtually unchanged since the beginnings of the solar system. (Photo shows close-up. Chondrules enlarged 100%.)*



Millbillillie, West Australia, Australia. *This 17.8 gram, 25 x 24 x 15 mm stone shows evidence of bubbling, an unusual flight marking on meteorites. During entry, the melting skin of the rock flowed back and away from the front, (ablation) and accumulated in the rear, where it "boiled" in the low pressure area. This is a textbook example of an "oriented" meteorite and clearly shows the direction of flight of the stone as it passed through the atmosphere. Oriented pieces such as this one are highly prized by scientists and collectors. (Early designs for re-entry heat shields were taken from meteorites!)*

#67 **Peña Blanca Springs, Texas, USA.** This aubrite achondrite fell into a small spring, startling the dozen or so people nearby, who were just sitting down to lunch. Of a very rare type, it is composed mostly of enstatite, or magnesium silicate, has little visible metal and is difficult to recognize. I was fortunate to have been able to purchase this single specimen from the estate.

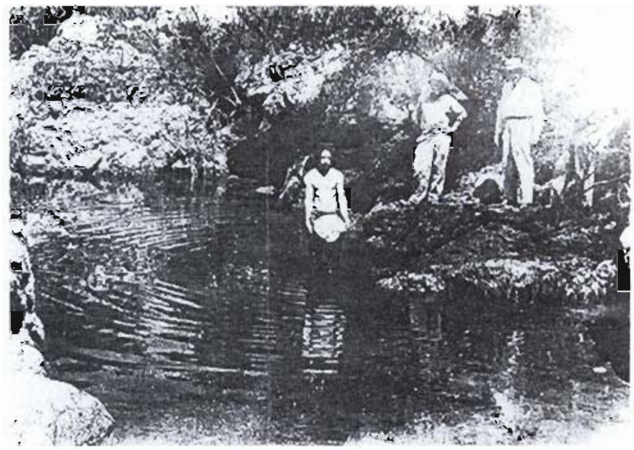
#68 **Mount Egarton, West Australia.** This is a metal rich type of aubrite. Very old and very weathered, most of the iron has rusted away, leaving only trace iron remnants and the brown-stained enstatite. It was found by an Australian prospector.

#69 **Peña Blanca Springs, Texas, USA.** During sawing at the shop, this meteorite was cut with kerosene as a lubricant, in order to preserve the rare, water-soluble minerals inside.

#70 **Cumberland Falls, Kentucky, USA.** Aubrite achondrite. The enstatite crystals in this specimen show signs of mixing. In fact, in some specimens, scientists have found small pieces of ordinary-type chondrite material mixed in with this achondrite material, making it very hard to categorize.

#71 **Norton County, Kansas, USA.** Note the light colored fusion crust on this piece, due to the calcium-poor composition and low iron. The inside is an unusual and beautiful milky white.

#72 **Mayo Belwa, Nigeria.** This is an aubrite achondrite with some very unusual surface features, such as little or no fusion crust and gas vesicles on the surface. This was seen to fall, or it would probably never have been recognized as a meteorite. Tiny rust stains help to identify this as a meteorite.



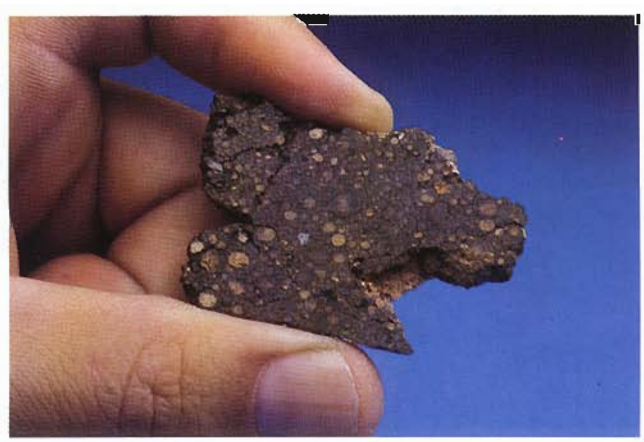
Peña Blanca Springs. *This old photograph was taken at the site of the Peña Blanca fall in 1946. The man in the water actually dove in to recover the pieces. Wouldn't you do the same?*

#73 **Johnstown, Colorado, USA.** Diogenite achondrite. Hypersthene crystals are smashed in this brecciated (mixed sizes and textures) specimen. Probably the diogenites settled out of the molten eucrite/diogenite parent body and were subjected to later stresses resulting in further mixing. This meteorite is calcium-poor and contains very little metal, making it hard to recognize.

#74 **Tatahouine, Tunisia.** This diogenite achondrite showered down from a daytime fireball over the Sahara Desert in 1931. The event was observed by local Bedouins who collected the few kilos that fell. Because the larger mass blew apart late in its entry, the hypersthene crystals were not melted, and fusion crust is completely lacking. This meteorite is extremely difficult to recognize.

#75 **Shalka, West Bengal, India.** This diogenite does not appear green like the others. Both diogenites and aubrites are calcium-poor (<3%) achondrites.

Millbillillie, West Australia, Australia. *This eucrite was a witnessed fall from the 1960's. It has a lovely, well-preserved, glossy black fusion crust, typical of Ca-rich stone meteorites, and is our most popular and available achondrite. Many of these specimens were recoverd by the local Aborigines, after a brief "training session" in meteorite recognition.*



Acfer, Sahara Desert, Algeria. *28 grams Renazzo-type Carbonaceous Chrondrite. This is a classical example of chrondrules. Think of them as tiny (micro!) size moons and planets. These are perfectly preserved. To be a meteorite-man you must know about chrondrules!! Achrondrites = melted down chrondrites.*

67 PEÑA BLANCA SPRINGS
PEÑA BLANCA SPRINGS (IN SAW). NOTE BEAUTIFUL LIGHT-COLORED FUSION CRUST.

68 MT. EGARTON
METAL-RICH AUBRITE. FRAGMENT. 52 grams: 40 x 30 x 20 mm.

69 PEÑA BLANCA SPRINGS
STONE ACHONDRITE. CA-POOR AUBRITE. WITNESSED FALL, AUG. 2, 1946, INTO A POND IN BREWSTER COUNTY, TEXAS. END PIECE. 22.5 kg.: 310 x 295 x 160 mm.

70 CUMBERLAND FALLS
AUBRITE ACHONDRITE. SLICE. 49 grams: 70 x 60 x 50 mm.

71 NORTON COUNTY
AUBRITE ACHONDRITE. FRAGMENT WITH CRUST. 894 grams: 100 x 90 x 80 mm.

72 MAYO BELWA
AUBRITE. SLICE. 84 grams: 50 x 40 x 35 mm.

73 JOHNSTOWN
DIOGENITE ACHONDRITE. PARTIAL STONE. 762 grams: 90 x 90 x 50 mm.

74 TATAHOUINE
STONE ACHONDRITE. COMPLETE STONE FRAGMENT. 12 grams: CLOSE-UP IMAGE AREA: 20 x 20 mm.

75 SHALKA
STONE ACHONDRITE. CA-POOR DIOGENITE. WITNESSED FALL. CRUSTED FRAGMENT. 40 grams: 33 x 40 x 22 mm.

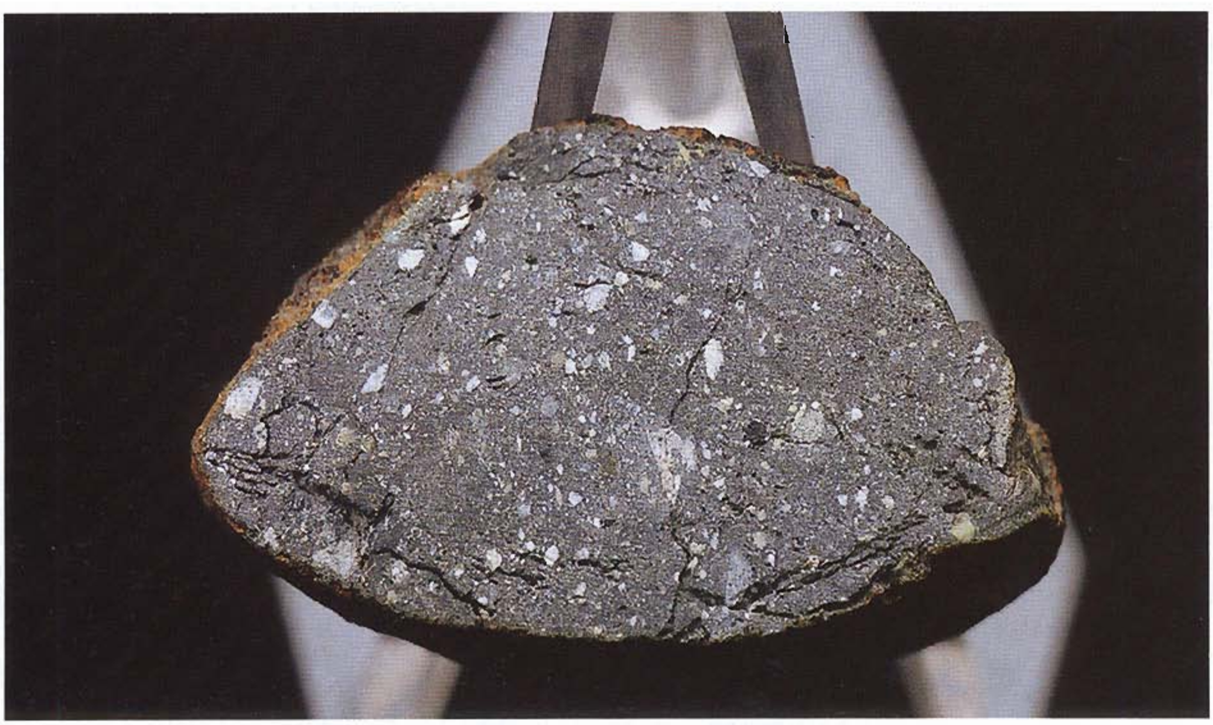
CALCALONG CREEK - THE LUNAR METEORITE STORY

The town of Wiluna, Western Australia was a pretty high-flying gold town in its heyday, boasting among other things the longest bar in the western world and the site of the Wiluna olivine-bronzite chondrite meteorite strewnfield. This September 2, 1967 fall was witnessed by no less than the entire town who'd turned out for an outdoor movie, and was accompanied by sonic booms, a huge fireball and highly peculiar electrical phenomenon: electrical power went out all over town and even the car batteries were powerless. The local constable, for instance, jumped into his Landrover to chase down the meteor, but his vehicle wouldn't start! (All in all, a pretty entertaining evening...)

Seven years earlier, another fireball had startled sheep ranchers on the Millbillillie Station Homestead only about 12 kilometers from Wiluna, just about lunch hour sometime in October, 1960. The locals found a few shiny, black rocks afterwards, and they were eventually given to the museum folks after being identified as Ca- rich eucrites; rare stone achondrite meteorites.

This was a boon for the free-drifting gold prospectors who regularly combed the desert for nuggets, opals and even tektites of the kind known as "australites", all of which could be sold to either tourists or museum people for tidy profits. A fellow of this persuasion, Mr. Harry Redford, one of the *real* "Crocodile Dundee" types, happened to hear of this money from heaven, and decided to have a go at looking for the shiny black rocks himself. After getting permission from the manager of the Millbillillie sheep station, Mr. Redford camped for a few nights in the bush, and spent the days fighting prickly spinifex grass and the death adders for possession of the eucrites. When he left, he had several pockets full and he'd been converted into a meteorite hunter. Before long came the idea that if he'd found these just kicking through the bush, there were probably more to be had. He decided to offer a reward - get everybody hunting. Which, considering how much area there was to search, was a pretty good idea.

Soon, a few of the Aborigines came in with the black, shiny rocks. These were purchased for enormous sums, compared to their usual daily wages. When the word got out that the whites were paying so much for rocks, more Aborigine meteorite hunters showed up to look. They, too, were paid "exorbitant" sums for the black stones. Within a few days, hundreds of people were leaving their government jobs in the citrus groves; the fruit was left on the trees to rot, while the workers scoured the outback to find stones. Another 300 kg. were collected in this way, more than ten times what had been found previously. These meteorites eventually found their way



Calcalong Creek, Western Australia, Australia. *In this close-up, the tell-tale white anorthosite clasts can be seen. The crust also has unusual gas vesicles present. Compared to the other Millbillillie eucrites, this little lunar specimen has a distinctive greenish tinge.*

Millbillillie/Wiluna Strewnfield, West Australia, Australia. *On location in the general area of the lunar meteorite discovery site. Note the sandy soil with few rocks - perfect for searching.*

around the world in general and to Tucson in particular. I personally purchased hundreds of the Millbillillie stones for distribution to foundations, museums and collectors. I've sold a lot of them.

One afternoon, I was going over some of the Millbillillie meteorites when I picked up one small, 19 gram complete stone that felt "different". It looked virtually identical to the others, but some small, very subtle differences in color and texture made me put it aside for more careful examination later. When I looked at the stone again, I was able to see that this specimen had tiny gas vesicles on the fusion crust, something so rare that I've only seen it in a few other meteorites. Furthermore, the crust had a slight greenish tinge, unlike the Millbillillies. I ground off a tiny corner to look inside, and again, it was different from the Millbillillie eucrites, and contained the same tiny white clasts I'd seen in high-definition photos of moon rocks. Slowly, the realization was dawning on me that this little stone looked a whole lot like a sample of lunar rock I had once had the opportunity to examine in Tokyo, at the Japanese Institute of Polar Research.

It was difficult to keep my excitement in check, to say the least. I called the experts, my friends and colleagues, Dr. William V. Boynton and Dolores Hill at the University of Arizona Lunar and Planetary Laboratory and told them of my discovery. They got quietly and scientifically excited and said they would have it analyzed. Since the Lunar and Planetary Lab received the first lunar meteorite from Antarctica, as well as many of the moon rocks returned by the Apollo moon landers for analysis, there was hardly a place in the world better equipped with either instruments or experience, to handle the job.

Then we all waited for the results. I ate several centimeters of fingernail before the official word came back from the lab:

"We have analyzed the new meteorite by neutron activation analysis and believe it to be of lunar origin based on comparison with other meteorites and samples returned from Apollo landing sites..."
Hill, Boynton

Other than the Antarctica specimens, we had discovered the *only known lunar meteorite* in the world... If you can find moon rock on Earth, I'll bet you can find Mars rock too! See page 53.

Calcalong Creek, Western Australia, Australia. *Lunar meteorite specimen as seen from the back side. (Actual size.)*

At this time, Hill, Boynton and I are in the process of co-authoring a scientific paper describing the lunar specimen and the conditions of its discovery, which will be public in *Nature Magazine* soon.

To own this piece of Moon Rock is a dream come true for me. I remember watching the astronauts exploring the moon. I wanted a piece in the worst way. This moon rock represents my space mission. Someday I will go to space, somehow. I'm glad I can do something while I'm still on this planet.

#76 **Pasamonte, New Mexico, USA.** The Pasamonte fireball was one of the largest and most brilliant ever seen in recent times. It was said to have been brighter than the sun. Based on the amount of dust in the air after the event, the original mass was estimated at over a million tons, but all that was recovered were a few small stones. (There must be more out there *somewhere.)* This is a very fragile meteorite.

#77 **Stannern, Czechoslovakia.** This calcium-rich eucrite achondrite fell on May 22, 1808, following loud detonations. Some 52 kgs were recovered at the time.

#78 **Caldera, Chile.** This beautifully oriented large stone and others were found by a geologist in the vast interior desert of Chile. Note the fine flow-lines.

#79 **Bouvante, Drome, France.** This is a new find from France. It is still very fresh-looking. France is the most meteorite-concious country on Earth and seems to recover the most meteorites, per capita.

#80 **Juvinas, Libonnes, France.** This eucrite has a very coarse texture, with lumps of plagioclase and pyroxene, which grew as the basaltic materials cooled from a liquid state.

#81 **Rancho Blanco, Mexico.** I was in Mexico buying meteorites at the Nuevo Mercurio fall site, when this different specimen was brought in by one of the locals who recognized it by the small amount of fusion crust. (See photo 172, pg. 33.)

#82 **Kapoeta, Sudán.** This is another type of achondrite called a howardite. Howardites are basically surface substrate or "soil" from a moon or asteroid, and are made up of different types of meteorites that have plowed into the surface over the millennia and resolidified under pressure. Howardites such as this one are composed mainly of eucrite and diogenite.

***Palo Blanco Creek, New Mexico, USA.** Found in 1954, this Ca-rich eucrite achondrite has a nice, well-preserved fusion crust and the clasts are surrounded and cut by dark, glassy shock veins.*

#83 **New Discovery, West Australia, Australia.** I'm unsure of exactly what this is, but it's currently being studied and classified by the University of Arizona. I suspect that it is a eucrite.

#84 **Camel Donga, West Australia, Australia.** Eucrite achondrite (metal rich). This very unusual achondrite has big lumps of iron in it. The shiny black fusion crust indicates a calcium-rich specimen. Note rust stains.

The Demise of the Dinosaurs

Approximately 65 million years ago, 70% of the Earth's plant and animal species were mysteriously wiped off the face of the Earth. This event occurred at what's called the Cretaceous - Tertiary (or K-T) boundary, and marks the end of the age of dinosaurs.

For centuries, debate has raged over what mechanism could possibly account for such widespread and virtually instantaneous (by geologic standards) extinction of species ranging from the largest land animals that ever lived, to tiny, one-celled sea creatures. Recent evidence, however, points more and more toward the catastrophic impact of a massive, mountain-sized asteroid with Earth.

The theory began to gain credence when researchers found an anomalous layer of the element *iridium* all over the world at the clay layer associated with the K-T boundary. This iridium-rich clay is compelling evidence because iridium is extremely rare on Earth, but abundant in meteorites. Further investigation showed that there was also a global distribution of shocked quartz grains, soot, pyroxene spherules and *stishovite,* a mineral formed only under tremendous pressure, such as generated by atomic bombs or meteorite impacts. Other puzzling evidence came from both land and marine sediments which strong-ly suggested that a mega-tsunami (tidal wave) several kilometers high had crashed over most of North America and northern South America at about the same time.

The next step was locating a probable impact site large enough to account for the release of such massive quantities of rock and iridium. After examining several sites, the University of Arizona's Alan Hildebrand and William Boynton have come up with two likely candidates in the Caribbean Ocean, between Columbia and Cuba. One of these sites is an undersea depression some *300 kilometers* across.

76 PASAMONTE
EUCRITE ACHONDRITE. COMPLETE STONE. 67 grams: 50 x 35 x 25 mm.

77 STANNERN
EUCRITE ACHONDRITE. END PIECE. 396 grams: 100 x 75 x 50 mm.

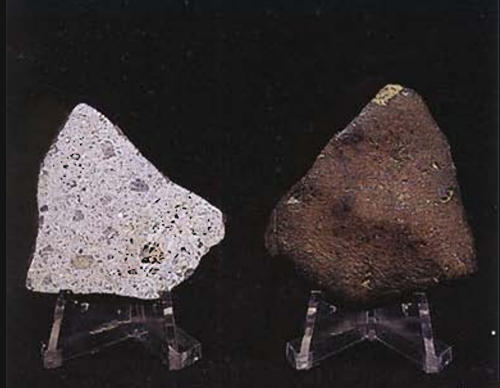
78 CALDERA, CHILE
EUCRITE ACHONDRITE. 90% COMPLETE STONE. 500 grams: TOTAL PICTURED WEIGHT.

79 BOUVANTE
STONE ACHONDRITE. CA-RICH EUCRITE. FOUND JULY 30, 1978. CRUSTED END PIECE. 201 grams: 85 x 65 x 30 mm.

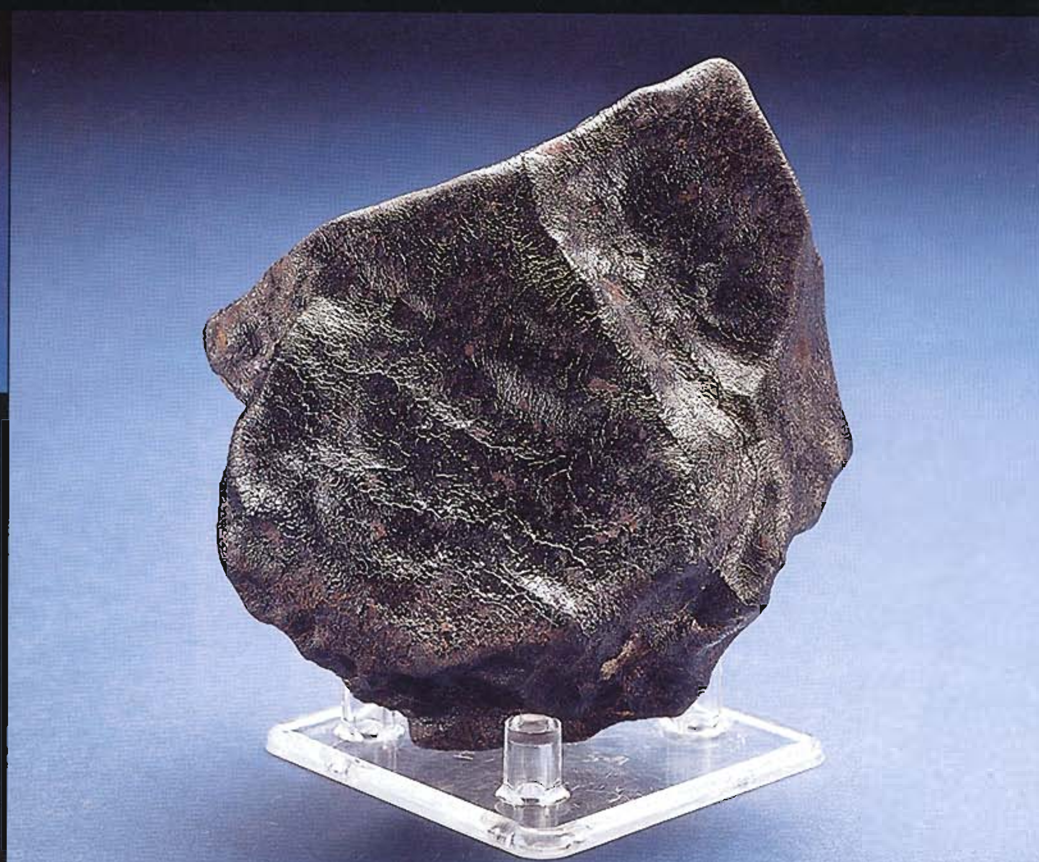
80 JUVINAS
STONE ACHONDRITE, CA-RICH. (EUC.) WITNESSED FALL, JUNE 15, 1821. END PIECE. 367 grams: 95 x 70 x 50 mm.

81 RANCHO BLANCO
EUCRITE ACHONDRITE. 80% OF STONE. 123 grams: 60 x 40 x 40 mm.

82 KAPOETA
HOWARDITE ACHONDRITE. FRAGMENT. 129 grams: 50 x 35 x 30 mm.



83 NEW DISCOVERY
NEW DISCOVERY. AUGUST, 1990. MUNDRABILLA STREWNFIELD, WEST AUSTRALIA. 24 grams: 45 x 37 x 10 mm.



84 CAMEL DONGA
EUCRITE ACHONDRITE. COMPLETE STONE. 1133 grams: 110 x 100 x 70 mm.

#85 **Camel Donga, West Australia.** This is a very unusual metal rich eucrite. The metal iron is mixed with sulfur to form trolite. This is now beginning to rust and stain the matrix material. Look at photo #84 on page 31 and you can see the rust coming through the fusion crust.

#86 **Kenna, New Mexico, USA.** A rare meteorite of the ureilite type. Ureilites are composed primarily of olivine and clinopyroxene in a black, carbon-rich matrix. Tiny diamonds are occasionally found in these meteorites. They may be related to carbonaceous chondrites.

Nullarbor Plain, West Australia, Australia. *Oops, I thought I found a new urelite here but later tests proved me wrong. I've seen thousands of different meteorites and believe me, some look so similar to earth rocks even I can be fooled, especially achondrites.*

#87 **Eagle's Nest, N.S.W. Australia.** This is a brand new discovery, something like a bracinite, olivine-achondrite, but unique. The University of Arizona Lunar and Planetary Lab is currently doing analysis and classification of this specimen. This specimen shows terrific flow lines: a fine example of orientation.

#88 **Eagle, Nebraska, USA.** This is classified as an EL6, meaning that it is a lower-metal type of enstatite chondrite, with highly metamorphosed chondrules. Enstatite chondrites are quite rare, and consist of crystalline orthopyroxene and magnesian pyroxene.

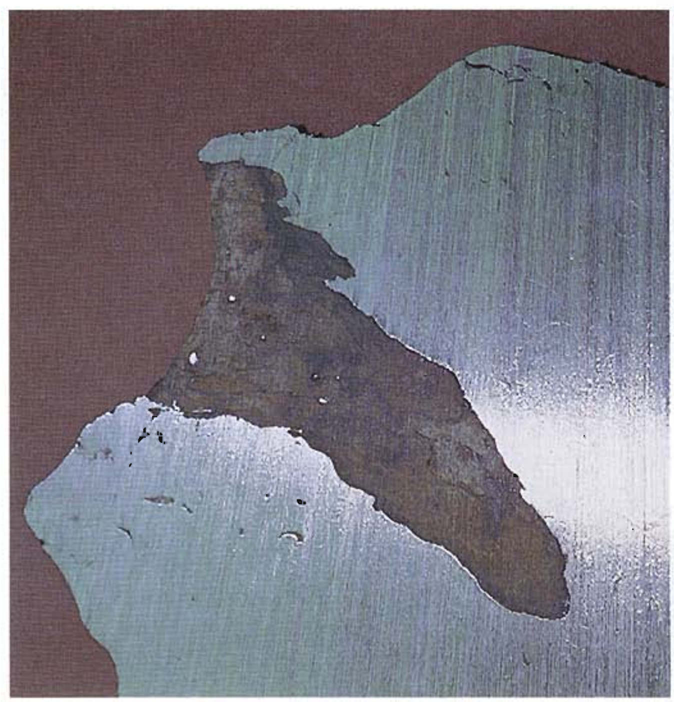
#89 **Abee, Alberta, Canada.** This was a witnessed fall in 1952. A 107 kg stone was recovered from a hole 6 feet deep. It is of a very rare type, EH4, meaning it is an enstatite, high-metal chondrite. Note the way in which the enstatite crystals formed in this unusual specimen.

#90 **Hvittis, Abo, Finland.** Total iron: 22%. This fell in 1901. I received it in trade after I stopped at the University of Helsinki on my way back from Moscow and found out that they didn't have any Mars rock. Now they have Mars rock and I have Hvittis. We're all happy.

#91 **Happy Canyon, Texas, USA.** Even with all of my meteorite experience, I would never have recognized this in the field. It's extremely weathered; very old, with no visible metal grains. Luckily, it still had a bit of crust and came from an area of few rocks, so it stood out. It seems to be highly shocked.

#92 **Nuevo Mercurio "B", Zaletecas, Mexico.** A single 349 gram fusion crusted stone was found May, 1990 by a young girl hunting meteorites. Urelites are rare. This one is shocked olivine, pigeonite and graphite. Possibly from Venus.

#93 **G'Day, Australia** This new achondrite was just classified as a Howardite by Johnson Space Center. It closely resembles Rancho Blanco in color and texture (See photo 81, page 30.) These also can look like eucrites, and for this reason, classification of achondrites by physical properties alone is difficult.



Watson, South Australia. *This is a highly unusual meteorite. Within this otherwise ordinary iron meteorite is a large intrusion of H chondrite stone. It is as though the metal flowed around the existing stone, or perhaps the stone was injected in a molten state into a seam in the metal. Interestingly, there doesn't seem to be any heat alteration of either material at their interface. Not much is known about this piece yet, and it is currently being studied and classified by Dr. Edward Olsen of Chicago's Field Museum. This is a 2 kilogram slice.*

85 CAMEL DONGA
EUCRITE CUT, POLISHED FACE. 83 grams, 65 x 4 x 35 mm.

86 KENNA
UREILITE ACHONDRITE. SLICE. 22 grams: IMAGE AREA: 5 x 50 mm.

87 EAGLE'S NEST
135 gram, COMPLETE STONE. THIS IS A NEW CHASSIGNITE, ANOTHER MARS ROCK.

88 EAGLE
ENSTATITE CHONDRITE. EL6. END PIECE. 396 grams: 130 x 60 x 30 mm.

89 ABEE
ENSTATITE CHONDRITE. EH4. SLICE WITH CRUST. 156 grams: 90 x 50 x 40 mm.

90 HVITTIS
ENSTATITE CHONDRITE. E6. VERY RARE. WITNESSED FALL, 1901. END PIECE. 694 grams: 80 x 75 x 40 mm.

91 HAPPY CANYON
ENSTATITE CHONDRITE. E6. SLICE. 172 grams: 155 x 70 x 6 mm.

92 NUEVO MERCURIO B
SLICE WITH CRUST URELITE. 56.6 grams: 62 x 37 x 10 mm.

93 G'DAY
HOWARDITE. COMPLETE STONE WITH CRUST. 65 grams: 37 x 35 x 26 mm.

Carbonaceous chondrites, as the name implies, contain both chondrules, and a high carbon content, (up to 3.4%) and represent the most primitive of the meteorite types known. *Calcium aluminum inclusions*, or CAI's, for instance, are found in certain carbonaceous chondrites such as the Allende. These enigmatic spherules possibly *pre-date the solar system*, with a crystallization age of approximately 4.6 *billion* years. Spectrographic analysis shows that these CAI's are, in fact, very close in composition to our sun, less the gases of course!

The carbonaceous chondrites on this page, such as Orguiel, Murchison, and others having designations of C1 or CM2, are thought to be cometary in origin, and show evidence of liquid water having been present during their crystal formation. C1 types are the most water-altered and the least heat-altered. C1's also contain carbonate and sulfate silicaceous minerals, indicating that they formed in a warm, wet environment. C2's are somewhat altered from their original condition. C3's have been altered very little.

The letter designation after the "C" for carbonaceous, refers to a particular meteorite that acts as a standard reference for others. For instance, the "M" means that it is similar to the Mighei, Russia carbonaceous chondrite. An "O" indicates a similarity to the Ornans, France, meteorite, while a designation of "V" following a C, indicates that the specimen is like the one from Vigarano, Italy. (See photo 97, facing page.) Carbonaceous chondrites are very important. Other collectors like myself will pay almost anything to get hold of some. Keep searching!

Orguiel, France. *This 20 gram fragment represents the most primitive of all, a C1. Unless you see it fall, this type of meteorite is nearly impossible to recognize in the field: it look like a lump of charcoal. Almost 20% carbon, C1s such as Orguiel (pronounced "OR-gay") show no evidence of chondrules or metal grains even though the metal content is about 19.5%. Furthermore, these meteorites are considered to be of cometary origin because of evidence of alteration by liquid water. Orguiel, and other meteorites like it, are highly sought after for scientific study.*

#94 **Kainsaz, Tartar Republic, USSR.** C03. This very rare carbonaceous chondrite was a witnessed fall from 1937. It is my prize specimen received in trade when I was invited to Russia by the Moscow Academy of Sciences. I was very honored and hope to return soon.

#95 **Colony, Oklahoma, USA.** CO3. This is a very old carbonaceous chondrite. The chondrules are small but still visible to a trained eye. Found in the tines of a cotton cultivator. Years of rain and ground water have rusted out the metal in this piece, making it hard to recognize.

#96 **New Discovery, Nullarbor, West Australia.** This specimen looks almost exactly like the specimen from Vigarano, although it has a slightly greener cast. I think it is safe to say that this is another CV3 carbonaceous meteorite.

#97 **Vigarano, Italy.** CV3. Vigarano is the classic standard of the "V" designation of carbonaceous chondrites. (Allende is another example of the "V" designation.) The matrix of this piece is a darker grey and is a bit more fragile than Allende. (See page 37.)

#98 **Maralinga, South Australia, Australia.** C4. The chondrules in this C4 are still intact, but very compacted and weathered. It has had a long Earth exposure, as evidenced by the extreme weathering of the piece.

#99 **Karoonda, South Australia, Australia.** C5. This carbonaceous chondrite is very different from the preceding meteorites, in that the petrologic end number is 5, meaning that it has been subjected to high pressures and temperatures. These influences have changed the structure of the minerals, creating glasses in some crystals, as well as bending, breaking and crushing in others. The chondrules in this piece have been smashed to powder. This was an American Museum of Natural History trade specimen.

Nogoya, Entra Rios, Argentina. *This 124 gram end piece of a CM2 carbonaceous chondrite was seen to fall after the appearance of a fireball on June 30, 1879.*

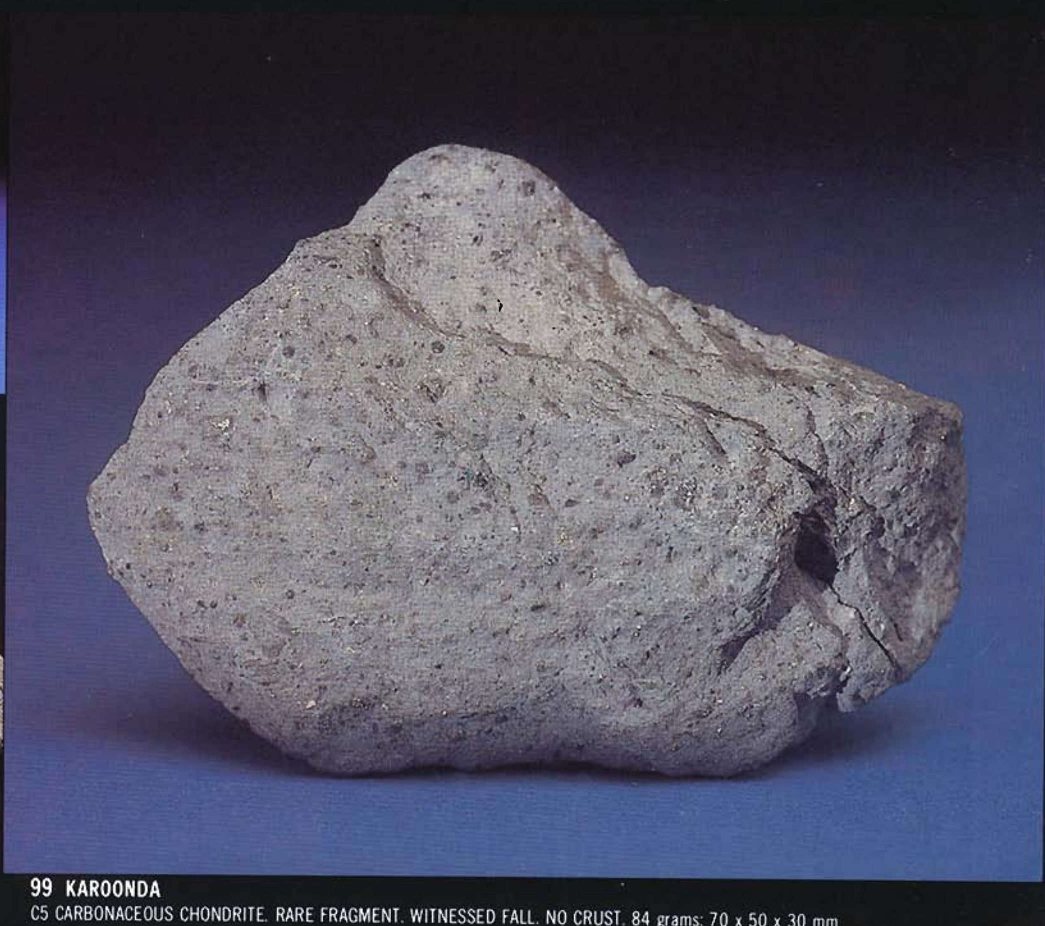
94 KAINSAZ
CARBONACEOUS CHRONDRITE. TYPE III (CO3). VERY RARE. WITNESSED FALL, 1937. HALF-STONE. 943 grams: 80 x 80 x 80 mm.

95 COLONY
CO3 CARBONACEOUS CHONDRITE. SLICE. 165 grams: 90 x 70 x 10 mm.

96 NULLARBOR
CV3 SMALL FRAGMENT. 30 grams: 50 x 25 x 10 mm.

97 VIGARANO
CARBONACEOUS CHONDRITE, TYPE III (CV3). WITNESSED FALL, 1910. SLICE. 71 grams. 90 x 65 x 4 mm.

98 MARALINGA
C4 CARBONACEOUS CHONDRITE. VERY OLD EARTH AGE. FRAGMENT. 25 grams: 60 x 24 x 8 mm.



99 KAROONDA
C5 CARBONACEOUS CHONDRITE. RARE FRAGMENT. WITNESSED FALL. NO CRUST. 84 grams: 70 x 50 x 30 mm.

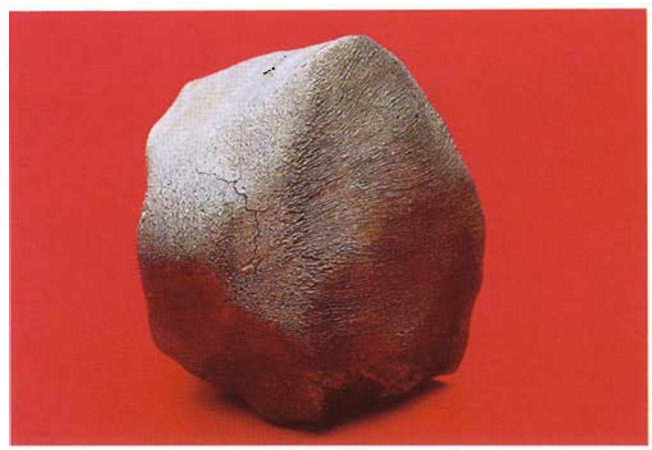
Murchison carbonaceous chondrite

Betty Maslin, a Murchison, Australia resident, *shows off some of the smelly rocks that landed on the outskirts of town one Sunday morning in September, 1969. When the fireball exploded, loud detonations and "hissing" noises were heard, and smoke rings were seen hanging in the air. Some 700 kilos of stones rained down out of the sky, covering 33 square kilometers and stinking up the whole town with the smell of methylated spirits and dust. (Betty and her father found the two largest pieces by the side of the road.)*

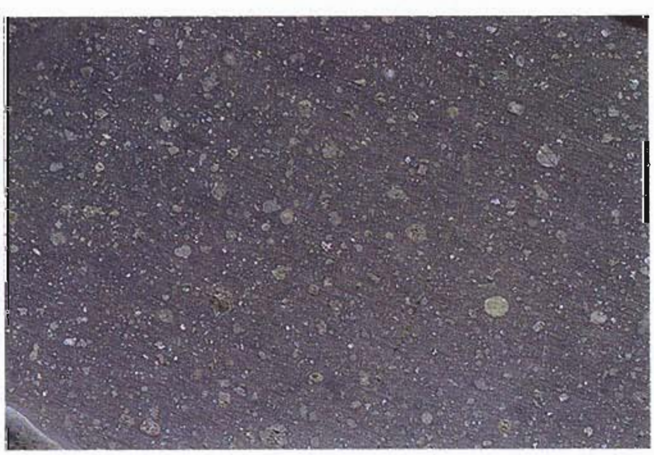
Mrs. Maslin is holding a jar of meteorites that had been sealed for ten years and when I opened it, the smell of rubbing alcohol and ether was still strong enough to nearly put me under. This jar was my first "score." These first specimens put me on the map as an official (?) meteorite dealer. They all sold fast.

Murchison is one of the most primitive meteorites known, and is believed to be virtually unchanged since the formation of the solar system, some 4.6 billion years ago. Besides being carbon-rich, the Murchison meteorite contains 12% water, and is considered to be cometary...

There are, in fact, some scientists who believe that all water on Earth originally came from the stars, in the form of cometary ice and in meteorites such as the Murchison. Before Earth developed a heavy shielding atmosphere, many times more meteorite impacts would have occurred. Of course, there were more "loose parts" floating around then; now most have hit or have found a stable orbit. The same line of reasoning has been applied to the appearance on Earth of basic pre-life compounds, such as amino acids and polymerized molecules, also present in Murchison. (Perhaps all life on Earth was "seeded" from the stars...)



Murchison, Victoria, Australia. *This beautiful oriented specimen of Murchison weighs nearly one kilo and shows classic, textbook qulaity "thread lines." This fine new acquisition was purchased from an old geologist who visited the fall site a few years after the event. He said he paid "a hundred dollars" for this specimen. I paid ten thousand - still a good deal.*



Murchison, Victoria, Australia. *Tiny round chondrules can be seen in this close-up of a polished face of the Murchison meteorite. Learn to identify chondrules!*

Partial List of Organic Molecules Found in Space

Acetaldehyde	CH_3CHO
Acetonitrile	CH_3CN
Acetylene	HC=CH
Ammonia	NH_3
Carbon monosulfide	CS
Carbon monoxide	CO
Carbonyl sulfide	O=C=S
Cyanamide	NH_2CN
Cyanoacetylene	HC=C-C-C-N
Cyanotetra acetylene	HC_9N
*Dimethyl ether	H_3C-0-CH_3
*Ethanol	C_2H_5OH
Ethyl cyanide	CH_3CH_2CN
Formaldehyde	H_2CO

*Possible chemical candidates for the smell in Murchison

Table 36A. *Many of these molecules have shown up in meteorites such as Murchison, Allende and others.*

Allende carbonaceous chondrite

Allende, Chihuahua, Mexico. *Several thousand kilograms of this rare type of meteorite fell in 1969. It made one of the largest stone strewnfields in recorded history. This particular specimen was used at a garage to block the wheels of cars when they changed tires. If you look closely, you can see the dent in the right side from the weight of the axles.*

The Allende carbonaceous chondrite is one of the most important falls from a scientific standpoint, primarily because it contains pristine chondrules and calcium-aluminum inclusions, or CAI's. These inclusions are considered to be some of the oldest matter ever known, possibly dating from before our solar system began to condense into a star and planets, some 4.6 billion years ago. To hold a piece of Allende in your hand is to hold the most ancient thing known in the universe, currently available on Earth.

Both the Allende and the Murchison meteorites arrived on our planet in 1969. (This was also the year that the Apollo Moon landings brought back lunar samples.) It wasn't until 1980, however, that I was able to go to Allende to hunt for additional meteorites. Working with some of the ranchers, I scoured the territory, offered rewards, went ranch to ranch, and eventually came up with over 100 pounds of material that had previously been found, but was never collected. The ranchers continue to hunt.

A tremendous amount -- at least 3 tons! -- of this important, exotic meteorite fell. It has since been widely distributed to universities and other scientific institutions and collectors around the world, and its value continues to appreciate...

Allende Strewnfield. *Covering an area of over 150 square kilometers, the Allende Strewnfield is one of the largest known in history.*

The Allende Strewnfield...

This place is like Brigadoon. It seems far more natural to go about on horseback than in an automobile. The people of Allende are just tremendous; they took me in, fed me and encouraged me. I loved it there. (It seems that if ever a place deserved to be "blessed by heaven", Allende is that place.)

Interestingly, this area of Chihuahua, Mexico mysteriously collects large meteorites. Two of the largest iron meteorites in the world, the Morito and the Chupadero, fell on either side of the enormous Allende strewnfield. This region has been called the "*Zona de Silencio*", or "Zone of Silence", for the unexplained radio silences that occur there, and has even been compared to the "Bermuda Triangle".

The following meteorites are representative of the type of stones known as *ordinary chondrites.* Ordinary chondrites are believed to have crystallized in outer space at fairly low temperatures and pressures relative to other stone meteorites, such as achondrites.

In these meteorites, the relative amounts of oxidized iron and metallic iron are *inversely proportional*; in other words, if the amount of *metallic* iron is high, then the amount of *oxidized* iron will be low. This is the case with H chondrites (H= high metallic iron). The so-called L chondrites (L= low metalic iron) have lower concentrations of metallic iron and higher concentrations of oxidized iron present, while the LL chondrites (LL= low-low metallic iron), have the lowest concentrations of metallic iron and the highest concentrations of oxidized iron. There is no HH designation. (Of the three, the LL's, or amphoterites, are the rarest, especially those with low numbers.)

#100 **Ragland, New Mexico, USA.** This LL3 olivine-hypersthene chondrite was found in 1982 in Quay County, New Mexico. It shows superb chondrules and is in terrific condition. Terrestrial weathering has oxidized out the metal grains and made it an overall rusty color.

#101 **Parnalee, Tamil Nadu, India.** This is an extremely primitive, LL3 stone amphoterite meteorite, full of slightly compacted chondrules. It was a witnessed fall from February 28, 1857. Two stones of approximately 134 pounds and approximately 37 pounds, respectively, were seen to fall after loud detonations were heard. This was a trade with Arizona State University, Tempe, AZ.

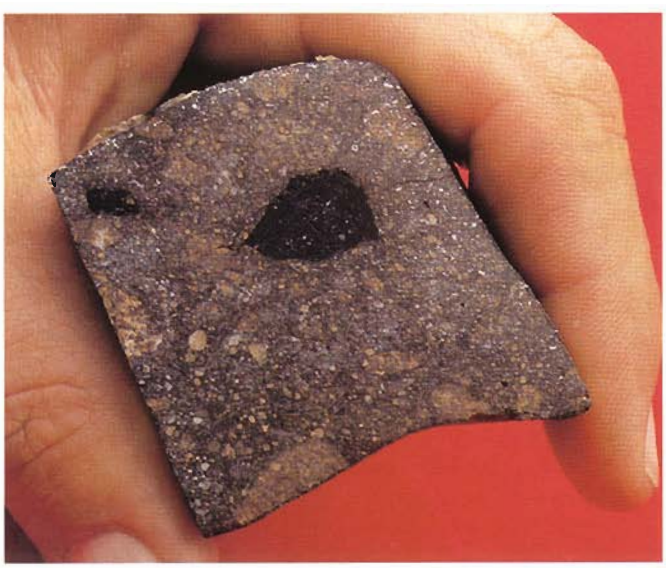
#102 **Greenwell Springs, Louisiana, USA.** This in an LL4 amphoterite, indicating that it has a very low iron content and has been moderately metamorphosed. This meteorite fell on a fireman's lawn in 1988. Since I had an exact location from which to start, I went to Greenwell Springs and passed out flyers, showed similar stones to lots of people, offered a reward and generally hit the pavement. We searched and searched in that small rural town, but no more was to be found. This is somewhat odd, because by looking at this piece, one can see that it is a fragment of a larger mass that blew completely apart. So... where's the rest of it ?

#103 **Ensisheim, France.** This meteorite fell in 1492 and is one of the oldest known falls from which there is recovered material. For hundreds of years, a large stone was kept chained in the local church, to prevent it from wandering off in the same manner in which it arrived! Metal is visible, but there's almost no visible evidence of chondrules. The high petrologic end-number, 6, means it was highly metamorphosed inside of the parent body.

#104 **Naryilco, Queensland, Australia.** This is the best example of a brecciated chondrite I have ever seen. The original material has been broken up and then re-cemented to form a wonderful mosaic pattern, and many different clasts of light and dark stone have been melded together. An LL6 amphoterite, this single stone was found in 1975 by an Australian rabbit trapper.

#105 **Tuxtuac, Zacatecas, Mexico.** This LL5 chondrite amphoterite was a witnessed fall on October 16, 1975, but it took 14 more years before this main mass was found, when it was stumbled upon by ranchers. There were bits of grass growing out of the holes and cracks, but otherwise, it appeared as though it had fallen yesterday. The surface details show the classic " thumbprint", or *regmaglypt* pattern associated with melting during entry.

#106 **Beeler, Kansas, USA.** This LL6 amphoterite chondrite was a 1924 find from Kansas. This is also brecciated like the Naryilco (#104) but is a bit more weathered. In weathered meteorites such as this one, it is difficult to distinguish type without chemical tests.



Butha Qi, Nei Mongol, China. *LL Amphoterite. 206.5 grams: 45 x 45 x 35 mm. Currently being studied.*

Butha Qi, Nei Mongol, China. (Left) This highly unusual little meteorite is a 1980 fall from a remote area of China. As far as I know, it is undescribed, but it appears to be an amphoterite.
The round, dark inclusion looks highly carbonaceous. (CM2?) Only 3 kgs of this material are known, and reportedly, this is the only fragment to have been released from the country. It was originally received in trade for 300 tons of agate for carving!

100 RAGLAND
LL3 AMPHOTERITE. PARTIAL STONE. TRADE WITH VIENNA. 186 grams: 80 x 60 x 30 mm.

101 PARNALEE
LL3 AMPHOTERITE. FRAGMENT. 332 grams: 60 x 50 x 40 mm.

102 GREENWELL SPRINGS
LL4 AMPHOTERITE. SLICE. 68 grams: 75 x 55 x 8 mm.

103 ENSISHEIM
LL6 AMPHOTERITE. SLICE. 176 grams: 70 x 60 x 40 mm.

104 NARYILCO
LL6 AMPHOTERITE. END PIECE. 5 kg.: 230 x 160 x 70 mm.

105 TUXTUAC
LL5 AMPHOTERITE. HALF-STONE. 11.8 kg.: 270 x 210 x 170 mm.

106 BEELER
LL6 AMPHOTERITE. SLICE. 700 grams: 120 x 65 x 30 mm.

STONE METEORITES - L Chondrites

The most plentiful of all the stone meteorite types are the L's, or olivine hypersthene chondrites. Of these, the most plentiful group is the L6. These are low-iron, highly metamorphosed stone meteorites. Keep in mind that the petrologic numbers at the end refer to the degree of metamorphosis, or change, from the original, round, chondrite crystal structure. An L3 or L4 has a low number and is therefore only slightly changed or metamorphosed, while an L5 or L6 has virtually no undamaged chondrules; most have been heat altered.

#107 **Bjurböle, Finland.** This *extremely* fragile, chondritic meteorite fell on sea ice and somehow both the ice and the meteorite survived the impact. This is especially surprising because Bjurböle will literally crumble to pieces in your hand. An L4, one can see that these multi-sized chondrules have been only slightly pressure changed. This was a trade piece from Helsinki.

#108 **Ioka, Utah, USA.** I received this piece in a museum trade in exchange for some of the Moorabie. Ioka, a weathered L3, was plowed up in Duchesne County, Utah in 1931 but wasn't recognized as being meteoritic until 1956.

#109 **Gunlock, Colorado, USA.** This is another L3, although in this case, that classification seems difficult to understand, as the minerals seem more blended together than those of say, Moorabie.

#110 **Barratta, New South Wales, Australia.** In this L4 olivine-hypersthene chondrite meteorite, the spheres are tightly compressed and on broken edges this structure can be seen. Note the remnants of old fusion crust.

#111 **Moorabie, New South Wales, Australia.** This is an L3 stone and is entirely made up of chondrules of all sizes. L3's are hard to find. They are also more interesting to science than a highly changed stone, such as an L6, for instance. Only a 17 kg. specimen was found.

#112 **Tsarev, Volgograd District, USSR.** This stone was found in 1968 and was saved, for some reason, though it was not recognized as a meteorite until 9 years later, in 1979. An L5, it shows signs of pressure change.

#113 **Beaver, Oklahoma, USA.** This L5 olivine-hypersthene chondrite was used for 40 years as a door stop in the local jail! It was finally recognized in 1981, some 41 years after it was found.

#114 **Knyahinya, Ukraine, USSR.** This meteorite fell in June of 1866 amid detonations and a shower of stones. The estimated total weight was 500 Kg. Look at the delicate crust on this meteorite. Would you have recognized this if it had fallen in your back yard?

#115 **Bovedy, Northern Ireland.** This fall of 1969 has classic chondrules, typical of L3's.

STAR JELLY??

Where the citizens of Rahway, New Jersey, saw "firey rain" fall to the ground on November 13, 1833, they found "lumps of jelly". And a woman milking a cow at West Point, New York, on the same day saw something land "with a splosh" beside her. It was a round, flattened mass the size of a teacup and perfectly transparent. This occurred at sunrise. At 10:00 am, she went out to show some people the jelly, but found it had disappeared. In its place, a boy found some white particles the size of a pinhead, but they disintegrated into powder and disappeared when he tried to pick them up. (Letter from Alexander Twining to Prof. Denison Olmsted of Yale College).*(The American Journal of Science and Arts* 1: 363-411, Jan 1834.)

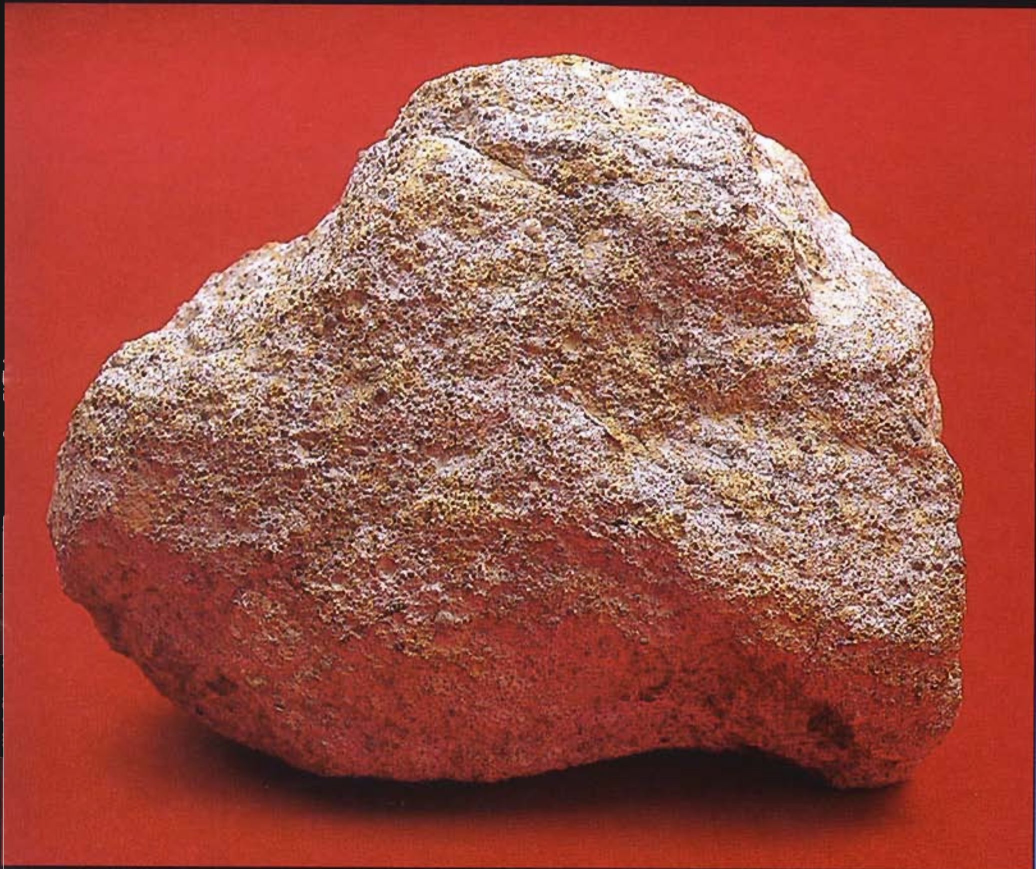
A foul-smelling substance, the consistency of butter, fell over large areas of southern Ireland in the winter and spring of 1696. According to the Bishop of Cloyne, this "stinking dew" fell in "lumps, often as big as the end of one's finger"; it was "soft, clammy, and of a dark yellow color"; the cattle in fields where it fell continued to feed as usual According to Mr. Robert Vans of Kilkenny, the local people believed the "butter" was a useful medicine and collected it in pots and pans. *(Philosophical Transactions of the Royal Society of London,* 19:224-25, March-May, 1696.)

Nut-sized lumps of odorless, grey resinous matter fell on Vilna, Lithuania, during a rainstorm on April 4, 1846. When the material was burned, it released a pervasive sweet smell. After being soaked in water for 24 hours, it swelled and seemed completely gelatinous. (*Compres Rendus hebdomadaires des seances de l'academie des sciences, 23:542.)*

On January 21, 1803, a shooting star fell to Earth in Silesia between Barsdorf and Freiburg (now Swiebodzice); its trajectory was low, and witnesses heard a whizzing sound as it went by. For some time, the meteorie seemed to lie burning on the ground, and its point of impact was therefore easily observed. In the morning, a mass of jelly-like material was found on the snow at the landing place. (*Report of the Thirteenth Meeting of the British Association for the Advancement of Science, 30:62-63, 1860)*

From Reader's Digest, *Mysteries of the Unexplained*

("Butter"? "Stinking dew"? ....What is this stuff...? Find some, quickly seal it in a jar and I'll definitely buy it!)



107 BJURBÖLE
FRAGMENT. 3.3 kg.: 155 x 110 x 105 mm.

108 IOKA
L3 OLIVINE-HYPERSTHENE CHONDRITE. SLICE. 136 grams: 105 x 35 x 15 mm.

109 GUNLOCK
L3 OLIVINE-HYPERSTHENE CHONDRITE. COMPLETE SLICE. 237 grams: 125 x 85 x 10 mm.

110 BARRATTA
L4 OLIVINE-HYPERSTHENE CHONDRITE. CRUSTED FRAGMENT. 995 grams: 130 x 70 x 50 mm.

111 MOORABIE
L3 OLIVINE-HYPERSTHENE CHONDRITE. END PIECE. 5 kg.: 220 x 190 x 90 mm.

112 TSAREV
L5 OLIVINE-HYPERSTHENE CHONDRITE. SLICE. 1071 grams: 110 x 90 x 40 mm.

113 BEAVER
STONE. L5 OLIVINE-HYPERSTHENE CHONDRITE. COMPLETE SLICE. 574 grams: 235 x 180 x 6 mm.

114 KNYAHINYA
STONE. L5 OLIVINE-HYPERSTHENE CHONDRITE. COMPLETE STONE. 434 grams: 80 x 60 x 50 mm.

115 BOVEDY
L3 OLIVINE-HYPERSTHENE CHONDRITE. COMPLETE SLICE. 105 grams: 100 x 70 x 5 mm.

#116 **Antarctica 76009.** This specimen was spotted from a helicopter, unlike most of the Antarctic meteorites, which were found by snowmobile. In a blue and white landscape, the dark meteorites are highly visible. While the climate of Antarctica is inclement to humans, it suits meteorites rather well, as there is little weathering from liquid water -- it's almost all bound up in ice crystals. (Ice crystals, carried by strong winds, can cause the same scouring effect as blowing sand, however.)

#117 **Alfianello, Lombardy, Italy.** This fine-grained L6 olivine-hypersthene chondrite was a witnessed fall from February 16, 1883. This piece was buried deeply enough within the parent body to begin altering the integrity of the chondrules and blurring the chondrule boundaries, thus creating a new texture. I acquired it in trade from a museum in East Berlin last year.

#118 **Holbrook, Arizona, USA.** Thousands of these L6 olivine-hypersthene chondrites showered down into the desert sand dunes near Holbrook, AZ on July 19, 1912. It remains in excellent condition due to the dry climate. Since the sands continually shift, more may surface from time to time. This would be a very good place to search in the future.

#119 **Etter, Texas, USA.** Note the way the metal flakes in this meteorite were squeezed into long veins. For this reason, it is called an L6 *veined* chondrite. As these meteorites weather, the metal veins rust more quickly than the silicates, and speed up breakage.

#120 **Tenham, Queensland, Australia.** This meteorite fell during the night in the spring of 1879, showering the countryside with stones. Some 350 pounds were recovered. This too is an olivine-hypersthene chondrite. Recently, meteorite hunters camped out in the bush for months and recovered 100 more specimens. (Good job!)

#121 **Bruderheim, Alberta, Canada.** These are all beautiful specimens with intact fusion crusts because they fell in soft snow after the appearance of a wild, midnight fireball. The next day the locals found these shiny black rocks contrasted against the white background. This fall proved to literally be "pennies from heaven", as one farmer discovered, when one meteorite sold for enough money to almost pay off his farm.

#122 **Pervomaisky, Ivanovo-Vosnesenk, USSR.** This L6 olivine-hypersthene chondrite was a witnessed fall on December 26th, 1933. I received it in trade from the Moscow Academy of Sciences. (Everywhere one goes in Moscow, there are monuments to space exploration and the stars, and their astronauts are heros...)

#123 **Forrest (b), Western Australia, Australia.** This olivine-hypersthene chondrite was found in 1980. Another meteorite, the Forrest (a), an olivine-*bronzite* chondrite, was found in the same area in 1967. When two or more *different* meteorites are found in the same general area, an alphabetical designation is usually added to the locality name, to distinguish between them.

#124 **Nakon Pathom, Thailand.** A highly unusual meteorite, its history can be read in the stone. At some time in its past, the parent body was crushed by intense pressure, and the minerals then re-solidified into a conglomerate rock, called a *breccia* (pronounced BREK- ia).

Bluebush Ridge, Australia. *This is another new, undescribed specimen from Australia. Tiny chondrules and unusual clasts make up this nicely weathered meteorite fragment. It was found in the desert within a few kilometers of a natural rock cistern used by the Aborigine people for watering places. Roughly half of all the meteorites that fall to Earth would resemble this specimen if cut and polished. This small slice weighs 27 grams and is shown slightly larger than actual size.*

Marlow, Oklahoma, USA. *This 150 pound stone meteorite specimen was dug up by ranchers while making a stock pond. Note flight markings and intact fusion crust. Large, oriented stones like this are rare.*

116 ANTARCTICA
L6 STONE METEORITE. FRAGMENT. 200 grams: 80 x 60 x 20 mm.

117 ALFIANELLO
OLIVINE-HYPERSTHENE CHONDRITE. SLICE. 1,421 grams: 150 x 120 x 33 mm.

118 HOLBROOK
L6 STONE. COMPLETE STONE. 1550 grams: 160 x 100 70 mm.

119 ETTER
L6 SLICE. 1000 grams: 280 x 140 x 10 mm.

120 TENHAM
L6 VARIOUS STONES. LARGEST PICTURED WEIGHS 1400 grams.

121 BRUDERHEIM
L6 COMPLETE STONE. 830 grams: 100 x 90 x 70 mm.

122 PERVOMAISKY
L6 OLIVINE-HYPERSTHENE CHONDRITE. FALL. COMPLETE STONE. 566 grams: 70 x 70 x 55 mm.

123 FORREST (b)
L6 OLIVINE-HYPERSTHENE CHONDRITE. FIND. END PIECE. 1,262 grams: 120 x 115 x 50 mm.

124 NAKHON PATHOM
L6 OLIVINE-HYPERSTHENE CHONDRITE. SLICE. 96 grams: 120 x 60 x 5 mm.

#125 **Macy, New Mexico, USA.** In this extensively weathered meteorite only a few un-oxidized chondrules and metal flakes can be seen.

#126 **Salla, Lappi, Finland.** L6 olivine-hypersthene chondrite. Found in 1963. This was a trade with the University of Helsinki Museum.

#127 **Tulia (a), Texas, USA.** H3-4, olivine-bronzite chondrite, brecciated meteorite. This was a 1917 find, when two specimens were plowed up.

#128 **Neenach, California, USA.** This L6 olivine-hypersthene chondrite was plowed up right outside of Los Angeles in 1948. (Try plowing up something there today... other than power lines.)

The Age of Meteorites

Meteorites are considered to have at least three different "ages". The first age has to do with how long ago the elements and minerals of the piece last crystallized. This "actual" age is commonly determined by radiometric dating. This process measures the total amount of one radioactive* particle, or isotope, which stays the same over the course of time, against the amount of another radioactive isotope which changes at a steady rate over time. By measuring the difference between the two, scientists can estimate the age of the specimen to within several million years - a mere snap of the fingers, cosmic time-wise.

The second age is the so-called exposure age. This refers to the amount of time elapsed since the meteorite has been separated from the parent body and out in space. This "age" can be estimated by looking at the amount of isotopes such as neon-21 present in the meteorite's surface, since this isotope only happens when the meteoroid is exposed to high-energy rays (cosmic rays) from the sun.

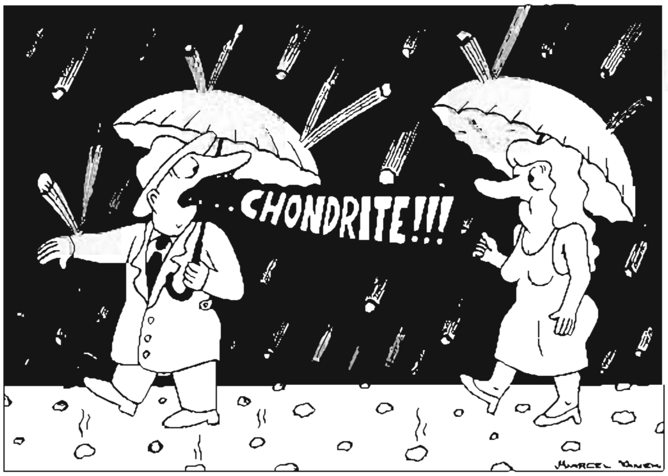
The third "age" is the Earth age, which is determined by examining the piece for weathering; rust, decomposition of silicates, presence and condition of fusion crust, etc., and usually constitutes an "educated guess" on the part of scientists. (This is especially tricky because meteorites from the same fall can and do, weather differently!)

** Note: Meteorites themselves are NOT radioactive!*

#129 **Harrisonville, Missouri, USA.** This veined L6 olivine-hypersthene chondrite was found, along with some 12.9 kg. of other stones, by another "meteorite man", the great H. H. Nininger on April 9, 1933. (Dr. Nininger's books about his adventures in the early days of the meteorite biz make fascinating and entertaining reading! Check them out at the library.)

#130 **Valkeala, Kymi, Finland.** This L6 olivine-hypersthene chondrite was found in Finland in May, 1962. Note weathered fusion crust on this complete stone.

Julesburg, Colorado, USA. *This is a portion of a stone chondrite that was found in 1983 in the town dump! Originally a 56.6 kg. specimen, it apparently had been discarded along with other rock and debris when someone cleaned up their property. (If only they had read the "Robert A. Haag Collection -* ***Field Guide of Meteorites****" first . . .)*



Many thanks to my friend, Marcel Vanek for this cartoon.

125 **MACY**
L6 STONE. SLICE. 176 grams: 50 x 40 x 30 mm.

126 **SALLA**
L6 OLIVINE-HYPERSTHENE CHONDRITE. FRAGMENT. 618 grams: 65 x 65 x 60 mm.

127 **TULIA (a)**
L6 OLIVINE-HYPERSTHENE CHONDRITE. SLICE. 305 grams: 145 x 120 x 6 mm.

128 **NEENACH**
L6 SLICE. 449 grams: 140 x 110 x 15 mm.

129 **HARRISONVILLE**
L6 OLIVINE-HYPERSTHENE CHONDRITE. HALF-STONE. 314 grams: 60 x 60 x 44 mm.

130 **VALKEALA**
L6 OLIVINE-HYPERSTHENE CHONDRITE. COMPLETE STONE. 309 grams: 70 x 52 x 40 mm.

#131 **Nuevo Mercurio, Zacatecas, Mexico.** Thousands of various-sized, well-oriented stones peppered the desert after the inhabintants were awakened one night in 1978 by noises decribed as being like "dynamite" going off and "freight trains" going through. The whole town turned out to search and some 40 kilos were recovered. This is an H5 olivine-bronzite chondrite.

#132 **Pultusk, Poland.** This shower of stones rained down over Pultusk on January 30, 1868, after a fireball appeared and detonations were heard. It was estimated that more than 100,000 stones must have fallen, yet nowhere near that amount has been recovered, so many more must still be there. (By now they would be rusty-looking.) This brecciated H5 olivine-bronzite chondrite was a trade specimen.

#133 **Chaing Khan, Thailand.** This H6 meteorite fell in 1982 near the so-called "Golden Triangle" region of northern Thailand, making it an interesting time and place for a meteorite hunt. (...*sure* you're looking for rocks from the sky. Now up against the wall, Yankee...) Notice how the iron in the crust has started to stain through into the interior of the piece.

#134 **Zhovtnevyi, Ukraine, USSR.** Six large and several small stones were recovered after a witnessed fall on the night of October 10, 1938. This is an H5 olivine-bronzite chondrite.

#135 **Ochansk, Federated SSR, USSR.** This brecciated H4 olivine-bronzite chondrite fell after a luminous meteor appeared and detonations were heard on August 30, 1887.

#136 **Weston, Connecticut, USA.** This was a witnessed fall from December 14, 1807. The strewnfield for this H4 olivine-bronzite chondrite was 10 miles long. There has been speculation that news of this fall once prompted Thomas Jefferson to make his famous, but probably apocryphal, remark that he'd "rather believe that two Yankee professors would lie, than that stones could fall from heaven."

#137 **Beardsley, Kansas, USA.** This H5 olivine-bronzite chondrite was a witnessed fall in October, 1929. More than 60 stones fell, with not an oriented specimen among them.

#138 **Big Rock Donga, South Australia, Australia.** This H5 olivine-bronzite chondrite was found by an old rabbit trapper who picked it up to stuff into a rabbit burrow to prevent the rabbits from escaping. It remained on a sheep station for years before being recognized.

#139 **Conquista, Minas Gerais, Brazil.** This H4 olivine-bronzite chondrite fell in the early morning hours sometime in December, 1965. Many fragments were collected, but only one main mass remained intact.

Tunguska Blast

On the morning of June 30, 1908, something exploded over a densely forested region of central Siberia. Seismometers as far as Tiblisi, some 2000 miles away, recorded an enormous earthquake and microbarograph readings in England showed simultaneous, anomalous fluctuations. For weeks afterwards, the night sky over northern Europe and Asia was strangely luminous, due to suspended vapor and particulates in the upper atmosphere. Whatever it was that violently detonated in Earth's atmosphere that morning created an explosion "brighter than the sun", with a force equivalent to 30*million* tons of TNT (as opposed to Hiroshima's 20 thousand tons) and an estimated temperature at the center of over 30 million degrees F. "Tongues of flame" shot up thousands of feet into the air, flash-scorching everything for 30 miles and leveling 2000 square kilometers of trees in all directions. Nomadic tribes people 40 miles away were seared by the hot, hurricane-strength winds, which blew away their tents and killed and injured their animals.

The mysterious entity that caused the destruction is still unidentified; no impact craters or meteorite fragments were ever found. Only one clue was ever unearthed: billions of nearly microscopic, black, metallic and glassy micro-spherules of only 0.10 mm in diameter were later discovered in the soil.

Various hypotheses about the object in question include things such as a collision with a microscopic "black hole", or ball of "anti-matter". Even more fancifully, it has been attributed to the explosion of an alien space ship. The most likely answer, however is that an ice-bearing comet impacted with the atmosphere and its kinetic and potential energy was instantly converted to heat... and devastation.

131 NUEVO MERCURIO
H5 STONE. VARIOUS STONES. LARGEST SPECIMEN SHOWN IS ABOUT 950 grams.

132 PULTUSK
H5 STONE. COMPLETE STONE. 224 grams: 60 x 50 x 30 mm.

133 CHIANG KHAN
H6 STONE METEORITE. COMPLETE STONE. 682 grams: 90 x 60 x 80 mm.

134 ZHOVTNEVYI
H5 OLIVINE-BRONZITE CHONDRITE. END PIECE. 241 grams: 60 x 45 x 45 mm.

135 OCHANSK
H4 BRECCIATED. OLIVINE-BRONZITE CHONDRITE. FRAGMENT. 100 grams: 45 x 45 x 35 mm.

136 WESTON
H4 OLIVINE-BRONZITE CHONDRITE. FRAGMENT WITH CRUST. 63 grams: 40 x 30 x 30 mm.

137 BEARDSLEY
H5 OLIVINE-BRONZITE CHONDRITE. END PIECE. 422 grams: 92 x 70 x 35 mm.

138 BIG ROCK DONGA
H5 OLIVINE-BRONZITE CHONDRITE. END PIECE. 7 kg.: 245 x 190 x 60 mm.

139 CONQUISTA
H4 STONE. SLICE. 408 grams: 90 x 80 x 250 mm.

#140 **New Stone, Iowa, USA.** This interesting specimen was given to a school teacher after a witnessed fall, (year and location unknown, but possibly Homestead, Iowa, a witnessed fall from1875) and was sent to my office with very little background information. It has a very obvious fusion crust, which, together with the trusty magnet-on-a-string, is one of the strongest clues in identifiying stone meteorites.

#141 **Plainview, Texas, USA.** Over 1000 stones were found on prime Texas farmland otherwise devoid of rocks. When local residents learned that these stones were worth a lot of money, they kept their eyes open for them, and many were recovered in this way. This specimen is beginning to stain on the outside from rust.

#142 **Hammond Downs, Queensland, Australia.** This H4 olivine-bronzite chondrite was found in 1986 by Mr. Joe Geiger, not far from Ingella Station and the Tenham strewnfield, both sites of other meteorite falls.

#143 **Faucett, Missouri, USA.** This H5 olivine-bronzite chondrite was found in 1966 in Buchanan County, Missouri, but may have fallen in the summer of 1907. Over 100 kg. of this material have been found.

#144 **Melvern Lake, Kansas, USA.** Mr. David Baker, a fellow meteorite hunter and friend, was going house-to-house in the area of the Admire pallasite strewnfield, when a farmer brought out this specimen. He had recognized the stone meteorite by its unusual weight and by its distinctive "thumbprint" surface pattern. (H5)

#145 **Wellman (c), Texas, USA.** This fine H4 olivine-bronzite chondrite shows beautiful flight markings, even though it has begun to weather slightly. Two previous, different types of stone meteorites have come from this same area, the Wellman (a) and Wellman (b).

Tenham, Queensland, Australia. *This 500 gram specimen of Tenham meteorite was photographed where it was found, in the cracked, dry mud of the blacksoil plains in Queensland, Australia. It had lain in this spot since it fell in 1879.*

The Twelve Largest Asteroids

Name	Diameter (Kilometers)	Surface Type
Ceres	1000	carbonaceous
Pallas	605	peculiar carbon
Vesta	530	eucritic
Hygeia	450	peculiar carbon
Euphrosyne	370	carbonaceous
Interamnia	345	carbonaceous
Davida	320	carbonaceous
Cybele	305	carbonaceous
Europa	290	carbonaceous
Patientia	275	carbonaceous
Eunomia	275	siliceous
Psyche	250	metallic iron

#146 **Faith, South Dakota, USA.** This is also a very nice stone specimen with good surface features. Recognition of such surface features as "thumbprints", flow lines, obvious orientation, etc.,is one of the best "tools" in a meteorite hunter's "kit". This specimen also is showing signs of contact with terrestrial water by rusting.

#147 **Ransom, Kansas, USA.** This H4 olivine-bronzite chondrite was a 1938 find.

#148 **Djerj, Algeria.** This specimen was found, along with several others, near an oil drilling rig in Algeria. It is an H5 ordinary chondrite. No doubt many more meteorites will eventually be found in Africa's Sahara Desert.

#149 **Correo, New Mexico, USA.** This small, complete stone was found by the author in a small blow-out on the sand dunes west of Albuquerque, NM. Sand dunes can be excellent places to look for meteorites, both because of high color contrast and generally excellent preservation conditions.

#150 **Lake Machattie, Queensland, Australia.** This weathered H5 chondrite is a relatively new find from Queensland. A single, 2.6 kg stone was recovered from near Lake Machattie in Queensland by an anonymous finder who spotted it from a moving vehicle. No more has been found. No fusion crust remains on this piece.

#151 **Ingella Station, Queensland, Australia.** This meteorite has a very old "Earth age", and is beginning to break apart along the once metal-rich, but now rusty, veins. Remains of the fusion crust can still be seen. This meteorite was found inside the large Tenham strewnfield, as was the Hammond Downs piece.

140 NEW STONE, IOWA
COMPLETE STONE. 134 grams: 60 x 50 x 30 mm.

141 PLAINVIEW
H5 ORDINARY CHONDRITE. COMPLETE STONE. 2,846 grams: 140 x 70 x 40 mm.

142 HAMMOND DOWNS
H4 ORDINARY CHONDRITE. END PIECE. 211 grams: 70 x 70 x 250 mm.

143 FAUCETT
H5 OLIVINE-BRONZITE CHONDRITE. END PIECE. 4.5 kg.: 175 x 130 x 90 mm.

144 MELVERN LAKE
HALF-STONE. 4.5 kg.: 200 x 130 x 110 mm.

145 WELLMAN (c)
H4 OLIVINE-BRONZITE CHONDRITE. COMPLETE STONE. 3,378 grams: 160 x 130 x 110 mm.

146 FAITH
H5 WEATHERED STONE. END PIECE. 7 kg.: 200 x 180 x 120 mm.

147 RANSOM
H4 OLIVINE-BRONZITE CHONDRITE. HALF-STONE. 800 grams: 70 x 65 x 60 mm.

148 DJERJ
H5 CHONDRITE. STONE. 419 grams: 90 x 70 x 30 mm.

149 CORREO
H4 ORDINARY CHONDRITE. COMPLETE STONE. 176 grams: 50 x 40 x 30 mm.

150 LAKE MACHATTIE
H5 OLIVINE-BRONZITE CHONDRITE. COMPLETE STONE. 2.5 kg.: 110 x 100 x 100 mm.

151 INGELLA STATION
WEATHERED COMPLETE STONE. 10 kg.: 300 x 200 x 200 mm.

#152 **Wiluna, West Australia, Australia.** This H5 olivine-bronzite chondrite fell in front of hundreds of witnesses on September 2, 1967, near the Wiluna Township. An estimated 1000 plus stones rained over an elliptical area. Interestingly, the Wiluna strewnfield overlaps that of Millbillillie. (See page 30.)

#153 **Vulcan, Alberta, Canada.** A single stone of this H6 olivine-bronzite chondrite was found in April, 1962. Note all the obvious metal flakes present in this nice, polished slice. Metal flakes are one of the key indicators of meteoritic origins for stones.

#154 **Musiyumovo, USSR.** You can see how the metal is beginning to stain the matrix as it oxidizes. This weakens the crystals and speeds its breakdown.

#155 **Selma, Alabama, USA.** This H4 olivine-bronzite chondrite was found in 1906. It is a fairly weathered specimen with a total iron content of over 22%!

#156 **Ybbsitz, Austria.** This meteorite was collected in the field as an "interesting rock" in 1977, but wasn't identified as being a meteorite until 1980.

#157 **Markovka, Altay Region, USSR.** This H4 olivine-bronzite chondrite was plowed up from a field in 1967, and is thought to have fallen in the autumn of 1966. Based on the amount of staining and weathering, however, I question this date.

#158 **Gladstone, New Mexico, USA.** This black-veined H6 olivine-bronzite chondrite was found by Nininger in Union County, New Mexico in 1936. Three more of the same stones were found just over the county line in Colfax County.

Roman coin. This ancient Roman coin dates from the first century AD and celebrates sacred stones, or *omphaloi,* which were considered to have fallen from heaven. The goddess Aphrodite was worshipped at three shrines connected with omphaloi or meteorites: two near Byblos and one on Cyprus.

The ancient temple at Delphi was built around a sacred stone reputed to have fallen from heaven after it was disgorged by Chronos, the father of the gods. The stone was anointed daily and covered with newly-shorn wool during festivals.

Hand carved gibeon iron meteorite jewelry box with trapieche emerald inside

Some people make knives with meteorites, some make jewelry, what will you make with your meteorites?

#159 **Edmonds, Kansas, USA.** It pays to advertise! I was trying to buy one meteorite (Norton County, photo 71, page 27) and just by luck another new specimen was located. A simple ad in the local paper did the trick.

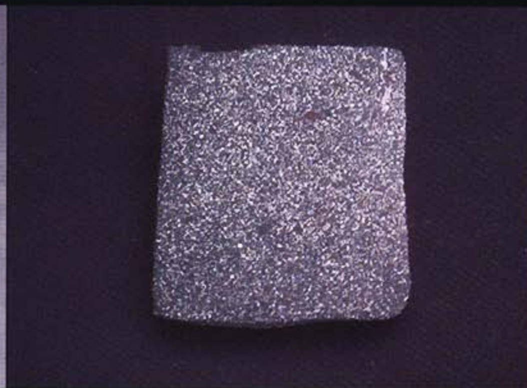
#160 **Owasco, Texas, USA.** Stone meteorite. In this piece, large patches of fresh, unweathered areas with good chondrules are separated by fractures and metal veins from more weathered areas.

#161 **Ozona, Texas, USA.** This H6 olivine-bronzite chondrite was found in Crockett County, Texas in 1929. Notice the extreme degree of weathering in this specimen. All the metal grains have disappeared out of this piece, making it very hard to recognize.

#162 **Pampa (c), Chile.** This is the oldest and most weathered stone meteorite in my collection, with an estimated Earth age of over 1 million years. There is virtually no metal left, the fusion crust is entirely gone and the remaining chondrules are hardly visible. It was found purely by accident when a friend of the author picked it up by the roadside to use as a support for his car jack, while fixing a flat! This specimen is of more interest as a curiosity than for scientific study.

#163 **Mills, New Mexico, USA.** This H6, olivine-bronzite chondrite stone meteorite was found on a ranch in Harding County, New Mexico in 1970. Although 6 pieces were found in all, none of the fragments could be fitted together. This is very weathered -- a ball of rust.

152. WILUNA
H5 OLIVINE-BRONZITE CHONDRITE. HALF-STONE. 79 grams: 52 x 40 x 20 mm.



153 VULCAN
H CHONDRITE. SLICE. 117 grams: 95 x 80 x 4 mm.

154 MUSIYUMOVO
END PIECE. 757 grams: 90 x 80 x 45 mm.

155 SELMA
WEATHERED SLICE. 240 grams: 120 x 90 x 10 mm.

156 YBBSITZ
NIEDER OSTTERREICH, AUSTRIA. FRAGMENT. 287 grams: 80 x 70 x 35 mm.

157 MARKOVKA
PARTIAL STONE. 337 grams: 80 x 52 x 45 mm.

158 GLADSTONE
SLICE. 2.56 kg.: 280 x 250 x 15 mm.

159 EDMONDS
STONE. 454 grams: 100 x 70 x 35 mm.

160 OWASCO
FRAGMENT. 682 grams: 141 x 90 x 35 mm.

161 OZONA
END PIECE. 1,281 grams: 170 x 65 x 40 mm.

162 PAMPA (c)
VERY OLD, WEATHERED HALF-STONE. 3.16 kg.: 160 x 130 x 90 mm.

163 MILLS
H6 OLIVINE-BRONZITE CHONDRITE. FRAGMENT. 1,239 grams: 170 x 110 x 60 mm.

LA CRIOLLA, ARGENTINA

Late in the day on January 6th,1985, Mrs. Rios of La Criolla, Argentina, had just finished supper with her family and was clearing the table, when a 750 gram stone crashed through her roof, destroyed her front door and ricocheted around the small room, terrorizing her and her children. Mrs. Rios grabbed her children and fled. She had heard loud detonations and was convinced that a passing airplane had dropped bombs onto her home. It was a long time before Mrs. Rios would even enter her house again.

Soon a representative of the University of Salta arrived in La Criolla to investigate. He was able to recover a few specimens and not long afterward, a slice made its way to Brian Mason, then curator of the Smithsonian Institute's meteorite collection. He determined that the visitor from space was an L6 olivine-hypersthene chondrite stony meteorite.

Back in Tucson, Arizona, I was reading a report of the new fall at La Criolla in a *Geophysical* newsletter. I was interested, but didn't think much about it until a month later, when I read a second report saying that "tens" of stones had been found in the area. A bulb lit up over my head: if there were "tens" of stones, there were just as probably hundreds of stones, and my chances of finding some were good. I made immediate preparations to go.

In Buenos Aires, I showed a map of the area to someone in a local travel agency and they got me on a flight to a town called Concordia, which was within 10 kilometers of La Criolla. Once in Concordia, I chose the most honest-looking of the town's two taxi drivers, showed him pictures and maps, and asked if he knew anyone who might have some of those stones. Luckily, he had some relatives in La Criolla, and said he'd take me there the next day.

True to his word, my driver showed up and off we went. In La Criolla, we stopped at a small *bodega*, or grocery store and started asking questions. The store keeper remembered the fall in vivid detail. Over big cups of maté, a thick, herbal tea drink, I mentioned purchasing some of the meteorites. She went into her back room and returned with a 50 gram stone. I bought it from her on the spot and asked if she knew where I might find more. She said to try "*El Policía...*"

La Criolla. The 6,100 gram specimen. Note "thumbprints."

"*El Policía*" turned out to be the town's only constable, a very friendly man who knew the community well -- the perfect contact. When I explained what I wanted, he asked to go along on the quest. But first we stopped at the home of the Mayor, a Mr. Silva. I asked him, too, if he knew where I could find more stones. He too excused himself and came back with the most beautiful, fresh meteorite I had ever seen. It was a 6,100 gram stone with scalloping over two sides and a clean break showing the interior. I was ecstatic. I offered him the equivalent of a year's wages which he accepted. Furthermore, he knew of many others! So we all piled into the taxi; the driver, the long-haired gringo, the policeman and the mayor, and went in search of treasure from heaven. We must have made a funny sight.

Just up the road, we stopped at a small farm house. Over more maté, I asked the woman there all the same questions and she told me that there was a piece in the barn, right beside the oil and tools! It turned out to be a 7,000 gram, complete specimen. Then, as if that weren't enough, her husband brought out another 2,600 gram specimen from his father's house.

The news of the crazy man buying rocks spread like wildfire, and soon people were coming from all over carrying black stones. After eight days, I had recovered 54 stones with a combined weight of some 30 kg. I promised to return in two months to get more, which I did, buying ten more kilos. Then, six months later, I made a final visit to La Criolla, and on that trip I recovered another 2 kg.

Back home, I distributed most of the meteorites among institutions, museums and collectors, but I will always keep the 6,100 gram stone in my personal collection as a remembrance of some wonderful people and a rewarding trip in search of the La Criolla meteorites.

***Zagami, Nigeria.** Stone. Achondrite, calcium-rich shergottite. 2,794 grams: 158 x 165 x 70 mm.*

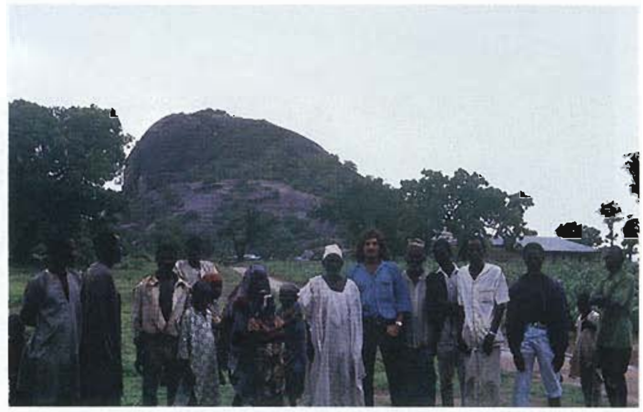
This extremely rare meteorite is classified as one of the SNC group (pronounced "snick") of achondrite meteorites, probably from the surface of Mars. The acronym stands for the initials of the first three known falls of Martian material, namely Shergotty (India), Nakhla (Egypt) and Chassigny (France).

Analysis of these meteorites reveals them to have a very young crystallization age, (about 1.3 billion years) relative to other meteorites. This, along with their unusual chemical make-up, which is similar to volcanic rock found on Earth, indicates that these meteorites came from volcanos. Since they are so young, however, the moon and asteroids can be ruled out as possible parent bodies.

These meteorites also contain iron-rich silicates and iron oxides, which can only form in a relatively oxygen-rich environment. Additionally, SNC meteorites contain water-bearing minerals and evidence of weak gravity on the crystals as they cooled.

***Zagami.** 200% magnification of augite crystals. Zagami also contains a **lot** of glass fragments.*

In this solar system, only Mars fits all the necessary criteria for atmosphere, low gravity, spectral analysis and other factors, making it nearly certain that Zagami, like Nakhla and the others in the SNC group, come from Mars. Confirmation for this theory was received when the Viking lander radioed back soil and atmospheric analyses.



***Zagami Rock, Nigeria.** Author and friends standing on the exact site of the Zagami fall, where, on October 3rd, 1962, the man in the white hat was nearly brained by a passing piece of Mars. He was trying to chase the cows out of his corn field when he heard a tremendous explosion and was buffeted by a pressure wave. Seconds later, there was a puff of smoke and a thud, as something buried itself in the soft dirt only ten feet away. Terrified that it was an artillery shell or bomb, the man waited for a few minutes before going to investigate. What he saw was a black rock at the bottom of a two-foot hole. The local commissioner was summoned and the specimen was recovered and sent to the provincial capital, where it was placed in the museum. I was fortunate to have been able to trade a complete meteorite collection for a sizeable portion of the Zagami stone.*

***Nakhla, Abut Hommos, Egypt.** Stone. Achondrite: calcium-rich nakhlite. Complete specimen, 120 grams: 57 x 50 x 35 mm. Fell in 1911 in Abut Hommos, Egypt. This type of Mars rock is made up of fine green augite crystals. One stone of Nakhla is said to have hit and killed a dog. (Bow, wow, Ow! ...Gaaack.)*

The Great Jackson Lake Fireball. James M. Baker, an incredibly lucky photographer, captured this amazing photo of the great daytime fireball of 1972 that appeared over the Teton Mountains at Jackson Hole, Wyoming. Due to the angle of entry, this huge meteor skipped across the upper atmosphere and went back out into space. (Dang! That one got away!)

Look, up in the sky! It's a bird, no it's a plane, no it's . . . $ $. Most of us have seen them. Do you make a wish? I do. I wish they would land next to me!

Shooting stars or fireballs can occur at anytime, day or night. It's a lot harder to see them in the day of course, but if it's large enough, it can be brighter than the sun! Many U.F.O. sightings have turned out to be meteors. Picture this . . . if a meteor is coming straight at you, it would appear as a bright "flashbulb" in the sky. If that occurs close to the ground (a late break up), the heat and shock wave could flatten you. No wonder eye witnesses saw "little green men" (more likely, green crystals). Some fireballs have been seen to completely change direction in flight 180°. The hot air surrounding the meteor easily melts away the frozen rock. The deceleration is such that the meteor breaks apart from the stress. Each fragment is still traveling so fast that its surface will quickly melt smooth. A late break in the fireball (after it has slowed) will produce a rough surface. This means there are more pieces nearby. Violently twisted and jagged shapes mean the break up was just above ground level.

The incoming meteorite usually starts to burn up at high altitudes; 20 miles above the ground, or so, and is traveling at tremendous rates of speed; in excess of 10 miles per second. At that rate, in ten seconds it can literally be over the next state, yet still appear to be directly overhead.

Another important point to remember is that meteorites have been "cold-soaked" at temperatures approaching absolute zero in deep space. The 15 seconds or so of entry heat is only enough to flash-fry the skin and is rarely enough to penetrate to the interior of the piece, particularly if it is large. The melting meteoritic material carries away a great deal of the heat with it as it flows back and off, a process known as "ablation". Therefore, reports of "burning hot" meteorites or black, melted pits in association with meteorites are improbable. If the ground is burned, it is probably either an old campfire or an old slag smelting pile.

You need to gather sightings from many miles around to even begin to tell the true direction it was going, let alone where or if it fell. Remember, these rocks are traveling at cosmic velocities, at least 10 miles per second. At twenty miles high, the stones can travel a long way fast. Sometimes an incoming meteor will leave a huge dust trail in the sky. This is wonderful because it points to the place where the meteor fell. Trying to track down where a shooting star fell is **extremely** difficult.

If you see a large fireball, contact the **Smithsonian Institute**, **Fireball Network** at (202) 357-1511 or FAX: (202) 357-2476.

Flanged Button Tektites, (australites), Australia. *It is obvious from the shape of these incredibly perfect button tektites, that molten glass peeled back and melted away as they entered Earth's atmosphere at super-high speeds - in excess of 10 km per second. Only about 25 mm in diameter, they resemble the shape of a nose-cone.*

TEKTITES

After several hundred years of scientific study and debate, no one can say with certainty exactly where tektites originate or how they occur. Over the years they have been variously thought to be:

1. *man-made artifacts from primitive cultures*
2. *silica colloids that formed by "electrolytic action" in granite-rich Earth terrain.*
3. *the result of lightning striking the Earth*
4. *terrestrial volcanic ejecta*
5. *lunar volcanic ejecta*
6. *impact phenomenon whereby melted, silica-rich, melted Earth rock is thrown into the high upper atmosphere after a meteorite impact. Molten glass then falls back down, acquiring flight markings*
7. *an actual "glass" meteorite composed of pure silica (P.S.—my theory)*

On the *pro* side of the *lunar volcano theory*, are the following facts: 1.) tektites contain virtually no water, 2.) they are low in the volatile elements lead, thallium, copper and zinc found in Earth sediment, and 3.) they are oxygen-poor compared to Earth rock. On the *con* side of the *lunar volcano argument* lie these facts: 1.) they don't match up well with the lunar basalts brought by the Apollo missions, 2.) they don't show any trace of cosmic-ray exposure (tracks left by high-energy particles) and 3.) the escape velocity required to launch volcanic glass out of even the moon's gravitational field is improbably high for a volcano model.

On the *pro* side for the *meteorite-impact-on-Earth* theory are the facts that: 1.) several impact craters have been found that account for various tektite strewnfields in terms of chemical composition, age and distance such as the Ries Valley, Germany impact crater / Moldavite strewnfield, the Lake Bosumtwi crater / Ivory Coast tektite strewnfield, and the Elegygytgyn, Siberia crater / australite and indochinite strewnfields, 2.) tektites should be distributed over larger geographical areas if they came from the moon, and 3.) the chemical composition of tektites closely matches a type of Earth sediment called "subgraywackes". On the *con* side, however, is the fact that tektites are very dry; they contain virtually *no* water, compared to Earth rock, and the largest meteorite craters known have spawned no associated tektites.

The *silica meteorite* theory is weak because of, again, an absence of cosmic-ray tracks indicating time spent in space and the fact that no one in recorded history has ever witnessed a fall of tektites!

Tektites have been objects of wonder and veneration for centuries in many different cultures. The oldest association between man and tektite was found in an archeological dig in Willendorf, Austria, where researchers found tektite splinters worked into knives by the Cro-Magnon people who once lived there — some 29,000 years B.C.

Pre-neolithic peoples in the Philippines also used tektites for tools, 6,000 to 8,000 years ago. In Australia today, Aborigines still sometimes carry australite tektites around with them as "protection" pieces.

#164 **Indochinites, Thailand.** Indochinites are widely distributed throughout Thailand, where they are often picked up out of rice paddies and fields. Most Indochinites have very distinctive tear-drop, wand or even dumb-bell shapes. These tektites very popular.

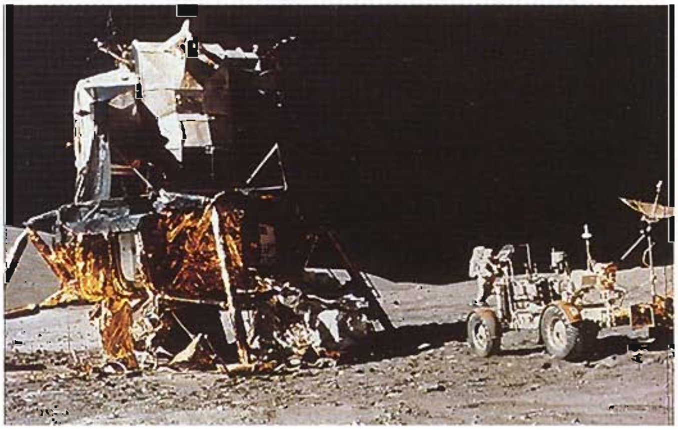
#165 **Moldavites, Czechoslovakia.** These tektites are unusual for their clarity and tourmaline-green color. Moldavites can be faceted into beautiful gem stones from space, and some people believe that they possess metaphysical powers for healing...

#166 **Libyan Desert Glass.** Found in the sand sea on the Libya/Egypt border, this beautiful golden tektite shows clear ablation markings on one side, where it was buried, and is sand-scoured where it was exposed.

#167 **Yellow Moldavite, Moldau, Czechoslovakia.** This exceptionally beautiful tektite is a lovely golden-yellow, and has an "oily" surface patina. I've never seen another one like it.

#168 **Columbite, Colombia.** Also called americanite, it's possible that this is not a tektite, but is a terrestrial volcanic glass, similar to obsidian. *In the case of tektites, origin can be difficult to prove or disprove.*

#169 **Rizal Province, Luzon Island, Philippines.** This and others from this locality have very unusual surface features, such as these deep grooves.



***The lunar origin theory for tektites** has been virtually abandoned, since the Apollo missions returned with actual lunar samples and none bore any resemblance, chemically or isotopically, to tektites.*

164 INDOCHINITES
INDOCHINITES ARE EASY TO RECOGNIZE BECAUSE OF THEIR DISTINCTIVE BLACK COLOR AND UNUSUAL SHAPES. BASIC SILICON DIOXIDE TRACE MINERALS.

165 MOLDAVITES
FACETED AND NATURAL SPECIMENS LIT FROM BENEATH.

166 LIBYAN DESERT GLASS
COMPLETE STONE. 2,079 grams: 155 x 150 x 87 mm.

167 YELLOW MOLDAVITE
POSSIBLY THE ONLY ONE EVER FOUND. CURRENTLY BEING ANALYZED AND STUDIED.

168 COLUMBITE
ALSO CALLED AMERICANITE, IT MAY NOT BE A TEKTITE AT ALL.

169 RIZAL PROVINCE, PHILLIPINES
163.5 grams: 60 mm diameter.

NULLARBOR ADVENTURE - The Promised Land

As every meteorite afficionado knows, besides Antarctica, Australia's Nullarbor Plain is the granddaddy meteorite hunting ground of them all; an area of some of the oldest, undisturbed ground on Earth, the site of the great Mundrabilla iron strewnfield and a bunch of others. Unfortunately, or fortunately, I suppose, it is at the ends of the Earth - right in the middle of the tremendous interior desert of Australia known as the outback.

I had been planning an expedition there for years, and with the help of my good Australian friends, Harry and Judy, it was coming together. We discussed the possibility of buying a paraplane, a small, gasoline powered parachute; a strange machine, like a soapbox derby with a giant fan on the back and a billowy, square parachute above. I found one in Phoenix, and after some "entertaining" test flights in this contraption, boxed it up and sent it off to Australia. I didn't need much; just lots of warm clothes and a sleeping bag. It was the end of winter when I was going, and cold in Australia.

We made final preparations in Perth, such as buying everything we intended to eat, drink, read or otherwise use for the next few weeks. (There aren't any convenience marts on the Nullarbor.) Finally, we headed out, saying goodbye to civilization for awhile. And I mean goodbye not only to civilization, but to the world as most of us know it. Entering the Nullarbor Plain was like leaving planet Earth entirely. There is NOTHING on the Nullarbor Plain: no mountains, no trees, no rivers, no man-made structures, no nothing. It is as featureless as the ocean. Which is why we literally had to "navigate" our way with compasses and the odometer. It's an odd place, where every mile traveled looks identical to the last, and it feels like some kind of time and space warp.

Camp at Alpha Centauri base.

Finally, after some expert tracking by my friends, we lurched across the Mundrabilla railway "station". (This consisted of some tracks and a radio tower.) It was only another 50 kilometers from there that we finally found the site where the 8 and 11 ton Mundrabilla irons had been recovered. (There is a little metal plaque that says so, out in the middle of absolute *nowhere*...)

That first night was incredible - the air clean and cold, no city lights and the whole Southern sky ablaze with stars, especially Alpha Centauri. A mere 4 light years away, Alpha Centauri was so beautiful and bright that we named our camp Alpha Centauri Base. It was an inspiring way to begin our search, under the Southern Cross with the Comet Levy making a command appearance overhead.

The next day was less poetic: the realities of the Nullarbor Plain include some of the most vicious rocks on the planet. The whole area was an ancient sea bottom and the sharp limestone shards it left behind are called "razorbacks"... for good reason. They can slice a tire to shreds if you are hasty or unwary. We had to maneuver slowly and carefully, but incredibly, we went the whole 30 days without a blow-out. Don't try that with radials...

This far into the Nullarbor, the horizon seems to recede from you in every direction. It's sky, sky, sky and miles of absolutely flat desert floor, covered with white limestone. After awhile, your eyes adjust, and begin to cancel out the limestone, focusing instantly on a black fusion crust or the weathered brown of a Mundrabilla! (I found one the first day, while looking for firewood!)

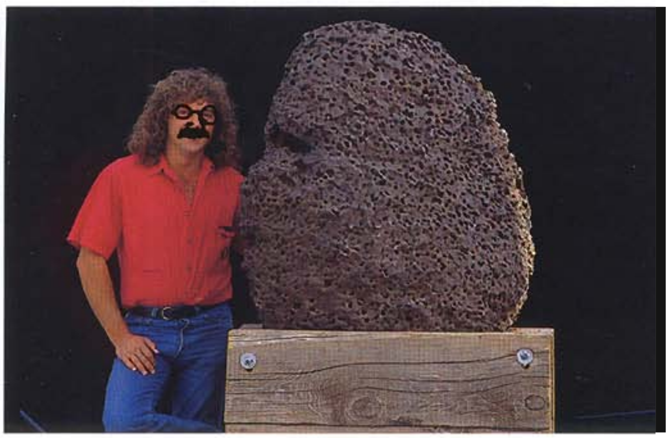
Just a few seconds after I found that first, one pound Mundrabilla, I looked down again and saw another brown rock, about 6 feet in front of me. It had some kind of white inclusions in it and I knew immediately that it was a meteorite, something unusual, some kind of achondrite. When I got back to camp, we ground off a corner and I saw that what I'd found was a ureilite, an extremely rare achondrite stone meteorite! What a thrill.

The next day, Judy found another 12 gram piece, and we realized that we were in a ureilite strewnfield, *within* the Mundrabilla strewnfield. During the next few days we found another achondrite, some chondrite fragments, several australites and Mundrabillas. Judy had some extravagant luck when she saw a small brown spot on the ground, no bigger than a quarter. It turned out to be a tiny tip of a buried,1 kilo, new stone meteorite! Overall, however, it was uneven pickings; we might find a bonanza of several pieces with-in a few feet of each other, then go the entire rest of the week without finding another scrap. But such is the nature of the meteorite hunt - it just keeps you tantalized!

We really had to train our eyes. The rocks seemed to come in waves, and after hours of scanning, just the eye strain caused problems. If you tried too hard to look, you would see nothing, but just about the time you gave up and relaxed your gaze, bingo, something brown would just seem to leap out. Zen and the art of meteorite hunting, I guess. We all carried magnets on strings for testing our specimens, and sometimes a small, nondescript "rock" would cause the magnet to practically jump out of our hands.

One had to be very careful while searching on foot away from the caravan, because there are no landmarks whatsoever. One day, I donned my Walkman, dropped in some raging rock 'n roll and went out, searching for the "big one". I was really rocking out, searching and not paying much attention to where I was, when I suddenly realized that I'd *no idea* where I was. I thought I knew where camp was but after 4 hours of wandering alone in the void of the outback, I figured I was in a bit of a mess. It was only when I sat down and figured out how the sun moved in relation to me, that I oriented myself. The only way out of it, I decided, was to walk straight towards the sun. As it turned out, my calculations were correct, and I found camp again. Whew.

We also had a sort of crows-nest arrangement on top of one of the Land Rovers. We'd take turns spotting with binoculars from up there while going slowly. If you saw something, you banged on the roof and someone would get out and investigate, while you shouted directions from above - "a little more to the left.. now forward. No, go more left! There! Right by your foot!". This is how Judy spotted a magnificent 110 pound Mundrabilla sitting regally in a patch of grass.



Some guy with a really big Mundrabilla.

In addition to foot prospecting and riding on top of the Land Rovers, we used the parasail for a lot of aerial reconnaissance. We flew mostly in the mornings, when there was little or no wind (the only real hazard to these flying go-carts) and endured some bitter cold. I wore 2 pairs of pants, a couple shirts, a coat, ear muffs, gloves, and a helmet, and I still froze my, er, nose off. Once airborne, though, this machine was incredible.

I'd be cruising along up there with the engine howling in my ears and look over to see eagles flying along beside me! Below, I could see everything for miles, including rabbits scurrying into their holes and kangaroos hopping along below me. Once I flew rather low over a mob of 'roos, ("herd" of kangaroos, for you non-Aussies...) and a big male tried to jump up and bite me! Twice I came upon circles in the desert piled about a meter high with white rocks - these were 10 to 12 thousand year old Aboriginal burial mounds. It was a very spiritual experience - at times I almost felt that the ancient Aborigine spirits were there with me...

Occasionally, a "willie-willie", (what we call a "dust devil") would blow up from the desert floor, tossing me violently around and threatening to collapse my chute. These scared the daylights out of me, but luckily I was never downed by one. I did, however, go down once. I had to make an emergency landing when my fuel line clogged. I just drifted down into some bushes, unscathed. The real problem at that point was being found. My friends knew to come looking if I didn't appear within the hour and a half fuel running time, and they knew my general direction, but without some way to signal, it would be like looking for the proverbial needle in the haystack. While I waited, I fixed the clogged line enough to send the chute billowing up into the air every half hour. Finally, after several tense hours, they spotted my chute, and arrived to collect me. I was glad to see them. Again.

Occasionally we came across "blow holes" - a peculiar phenomena where variations in pressure cause wind to roar into or out of the mouth of a small hole in the ground. They were the vent holes for extensive limestone caves, and often the volume of air escaping was so huge that large rocks thrown down the hole would come sailing back at you like they were made of styrofoam. At other times, the air would be turbulently rushing *into* the ground.

I enlarged the opening of one and by fastening a chain to the jeep, I was able to lower myself down into one of the monsters, with the understanding that if I wasn't back in an hour, the crew would come looking for me. It was a steep climb in and I had no idea of what to expect. The only thing I'd ever heard about a blow-hole was that a man had found an entire fossilized bass in one a few years ago. But not just fossilized: it had *opalized* as well! Incredible. All I found, however, were spiders and adventure.

After a hard day of flying and meteorite hunting, we'd relax around the fire and have dinner. Luckily, Judy is a great cook and she knew 50 ways to prepare kangaroo meat. We had kangaroo stew, kangaroo chops, and a great apricot rabbit dish. We even tried boxtail lizard, Aborigine style. Some Aborigines had told us how to cook it. (It's awful, by the way: not a bit like chicken!)

Sometimes, we had the luxury of a hot shower - a billy can full of heated water that ran out fast. Then, a bit of time for tea and battening down the hatches, because every evening, about 2 hours after sundown, the wind came lashing over the plains from the south at about 30 miles an hour. We could hear it roaring as it came. It was a solid front of extremely cold, moving air, and if you didn't have everything already stowed or tied down, it would go off in a northerly direction without you. It was a good time to be snug in your bag and swag. (A swag is a kind of mini-tent for your sleeping bag.) I had brought a guitar and a couple of harmonicas, so we'd sing and play music under that fabulous sky, while we looked out the windshield of Spaceship Earth... all in all, an incredible experience.

In the final analysis, we found some great meteorites, known varieties as well as unknown; some of which are extremely rare, and at least one of which is a complete puzzler that needs further study, but just may be a brand new type of stone, never seen before. And of course, we found adventure, which, as I've said before, is its own reward.

IF YOU THINK YOU HAVE FOUND A METEORITE, please send a small, *dime-sized* piece for me to examine along with a description and photograph of the entire specimen. ***If you wish to have the sample returned to you, you must enclose return postage***. All non-meteorite samples without return postage are added to the pile outside the back door. If I suspect that your sample *is* a meteorite, I will contact you by letter and phone, **so be sure to enclose your name, address and phone number along with all samples.**

GLOSSARY

Achondrites	Stone meteorites that do not contain chondrules
Amino acid	Large organic molecule; building block of protein
Amphoterite	Obsolete name for LL (low-low iron content) chondrites
Anomalous	Highly unusual, unique, uncategorized
Asteroid	An interplanetary body, of varying size; most are found between Mars and Jupiter
Ataxite	High-nickel content iron meteorite showing no Widmanstätten pattern when etched
Bronzite	A silicate mineral with associated iron content of between 10% and 20% - $(Mg,Fe)_2Si_20_6$
Carbonado	Carbon that has metamorphosed into its diamond phase but remains black
Chondrites	Stone meteorites that contain chondrules
Chondrules	Small spheres of silicaceous minerals associated with early formation of solar system
Enstatite	Silicate mineral with an associated iron content of 10% or less. $Mg_2Si_20_6$
Eucrite	Class of stone meteorite consisting of Ca-pyroxene and plagioclase achondrite
Fall	Witnessed event of meteorite-dropping fireball
Find	A found piece without associated witnessing of event
Hematite	Oxidized iron ore
Hexahedrite	Six-sided crystal structure found in low nickel-iron meteorites
Hypersthene	A silica mineral with associated iron content of between 20% and 30% $(Mg,Fe)Si0_3$
Inclusions	Mineral grains that once existed separately but now form an aggregate
Kamacite	Nickel-iron alloy (7wt %) phase with body-centered cubic structure
Limonite	Oxidized iron; rust
Lodranite	Refers to only the silicated portions of silicated irons - archaic term
Matrix	Base material, surrounding material
Mesosiderite	A class of meteorite; partly stone, partly nickel iron in a melded mixture
Meteor	A meteoroid that has entered Earth's atmosphere
Meteorite	The remnants of a meteor after it has actually impacted the Earth
Meteoroid	An object in space; similar to but smaller than an asteroid
Newman lines	Fine striations seen in some low nickel-iron meteorites
Octahedrite	Eight-sided crystal structure found in nickel-iron meteorites
Olivine	A silicate mineral with the general formula $(Mg,Fe)_2Si0_4$
Pallasite	Class of stony-iron meteorites containing crystals of olivine
Plagioclase	A triclinic mineral with the general chemical composition of $Al_2Si_2O_8$ +sodium and/or calcium
Pyroxene	One of a number of $Si0_4$ silicate minerals common in meteorites
Schreibersite	A phosphide mineral with the formula $(Fe,Ni)_3P$
Silicate	One of a great number of compounds containing silica
Strewnfield	The boundary area of a meteorite fall.
Sulfide	Sulfur-containing
Taenite	Iron alloy with a face-centered crystalline orientation
Troilite	Stoichiometric iron sulfide, FeS
Ureilite	Carbon-rich achondrite meteorites with olivine and pigeonite
Widmanstätten pattern	A crystalline pattern seen in iron meteorites after acid etching

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–FLASH–

***October 29, 1991**–Galileo spacecraft flies by and photographs stony-iron astroid Gaspra.*

***Esquel, Patagonia, Argentina.** Pallasite, 571 kilograms. Main mass - Robert Haag collection. This is the largest pallasite in the world. Can you imagine the treasures we will find in space?*

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