Investigating planetary interiors with meteorites: the case of Mars

by Nicola Mari

September 2019
On the 455th birthday of William Shakespeare’s birth, a CM2 stony meteorite crashed into Costa Rica, a country one-seventh the size of my Montana and one-third the population. What that means is that I can imagine what it’s like there in terms of population density and size, but with less snow, fewer grizzly bears, and no ponderosa pine trees.
Murchison, a CM2 that fell in 1969, and Mighei, a CM2 that fell in 1889 are both fairly illusive specimens for collectors today. However I have good memories of both stone locations from a collection standpoint having multiple specimens of them move in and out of my hand. So when Blane Reed sent out a list of his latest offerings, I read a description of a complete oriented individual of Aquas Zacas that I couldn’t pass up because it reminded me of what I’d read in history.
Even with all the unknowns still surrounding the 23 April, 2019 fall, Aquas Zacas was a stone whose fall I wanted a part of. And seeing a list of meteorite friends in the Meteoritical Bulletin entry regarding Aquas Zacas just added icing on the carbonaceous cake. The likes Mike Farmer, Achim Karl, Robert Ward and Kevin Kichinka are all meteorite people with whom from I am no more that one degree of separation. Not that that’s much of reason, but enough given my desire for historically important specimens usually over shadows anything that might fall in the 21st century.
Anyway, back on topic, I found the Aquas Zacas to be an inspirational specimen from a collecting point of view. I was not an avid meteorite collector back in 1969 when Murchison fell so I didn’t want on Aguas Zacas from a collecting point of view. Reliving non-existent memories perhaps?
Murchison entered my collection back in the early 1990s, still over 20 years after it fell. But I only missed Aguas Zarcas by a couple months. Either way, I am enjoying my small complete oriented individual of Aguas Zarcas as if it was late in 1969. Not a bad way to celebrate the 50 year anniversary for that game changing stone smelly amino acid-filled meteorite that fell in Down Under just two months after the moon landing.

Until next time....
Moon Rocks and Moon Meteorites
James Tobin

On July 20th much of the world celebrated with the United States the 50th Anniversary of the first landing of men on The Moon. I went to Florida with my wife to Kennedy Space Center and was there on the actual anniversary day. It was a great experience. One thing that I noted, however, was the lack of moonrocks on display. I saw only three and I may have missed some others but I do not think so. I must say that the two I did see were quite interesting. They were very different from the samples of The Moon that I have seen as meteorites.
Lunar Sample 15058.187.023
Apollo 15 • July 26–August 7, 1971

This igneous rock, estimated to be 3.7 billion years old, was collected by astronaut Jim Irwin in the Palus Putredinus (Marsh of Decay) lunar region.

Weight • 4.5 ounces (129 g)
Lunar Sample 70035.40.020 Collected by Apollo 17 astronaut Harrison Schmitt near the Taurus-Littrow Valley region of The Moon. Weight 3.9 ounces (110 g)

There was one moon rock slice on display that you could touch.
Before the manned moon landings, we did not know what the rocks of The Moon were truly like. There were maps of what was believed to be the surface of our neighbor in space but it was based on remote studies from some probes and by observations from the ground. The lunar geologic maps of the Apollo era were very detailed and colorful but unlike geological maps of terrestrial areas, they showed mostly the type of terrain and the structural information about the areas. They might describe an area as a “plains” type region and assign it a color of dark salmon and a pLp label but say nothing of the rock types or mineralogy because that information did not exist yet. Phrases such as slightly hilly, hummocky, strongly steeped domes and a host of others described the places seen on the lunar surface. Only some general statements such as “likely volcanic rocks” were ever written in map publications. This changes and is still changing today from the study of the rocks returned by the astronauts. As a side benefit once scientists had actual moonrocks to study it was possible to identify some of the anomalous meteorites as actually originating on The Moon.
Just in the last few months, the archives of the Apollo moon rocks have been opened and some of the rocks stored untouched for fifty years have been brought out to be investigated. This is a tremendous development. Pristine rocks from the Moon can get studied with the latest equipment. It has been a best practice in archeology for a few decades to leave if possible some of a site untouched for future investigation as tools improve and focuses change. In the past, it was the wonderful sculptures, monuments, gold and silver objects and skeletal remains that were of great interest and now in many places, it is tiny fish bones and seeds and trade beads, small bits of textiles that are actually of more interest. These later items were often lost either entirely or at least their context by the bulldozer type archeology of two centuries ago. Hopefully, the refined techniques and better equipment of today will lead to many new discoveries from the Apollo returned rocks.

The Apollo Program only visited six locations on the Moon and though hundreds of pounds of rocks and soil samples were returned to Earth it was still just material from six locations. Scientists developed new technology and advanced the methods already on hand to define characteristics that moonrocks possess. These were characteristics most meteorites do not have. Scientist used this elemental and isotope signature of rocks from the Moon and soon found it within a few meteorites. The first question I am always asked about lunar meteorites is “How do you know this rock is from the Moon?” Well, that is what the Apollo returned samples made clear. I try to explain to the individual asking the question that moonrocks come from a place in the solar system where they have developed in a particular elemental signature. I try to tell them about how Moon rocks have acquired amounts and kinds of isotopes unlike the signature of rocks from other places in the solar system. That this signature is the same as that found in the rocks returned by the Apollo Astronauts. I can not go into much more detail with them, I frankly do not know enough about the laboratory processes involved to tell them too much more. I do know that the gases, often noble gases are extracted from the rocks and meteorites and that the sample is sent to a mass spectrometer or similar instrument to determine the composition and the ratios of the gases and their families of isotopes.

Today there are according to one source on the internet 371 Lunar meteorites. Some meteorites of this number are paired. Multiple samples of the same meteorite were classified by different laboratories so the
actual sample of lunar material is from much fewer than 371 sites on The Moon. And many of the meteorites may have come from just a handful of huge events on our nearest neighbor. Still, the surface of The Moon is covered with thousands of craters, so it seems quite reasonable that the lunar meteorites represent samples from many locations distinct from the places the astronaut visited.

This is a whole individual of NWA 11273 that weighs 4.2 grams.

The actual mechanize for getting rocks off The Moon and to the Earth is giant impacts of asteroids into the lunar surface. During the cratering event, the material being blasted out of the forming crater needs to be accelerated to the escape velocity of The Moon. If this happens the boulders rocks and dust that make it off the surface will not fall back with the vast majority of the material thrown up from the impact. These escaping individuals will then travel around the sun in orbits until they fall to Earth to be found as meteorites. There has been much discussion about whether or not a particular type of impact is required to accelerate ejecta to escape velocity. One idea is that low angle impacts that plow masses of material in front of an impactor and which make elongated craters are the type with the possibility of accelerating the plowed material to escape velocity. The speed needed to leave The Moon is so much lower than what is required to leave a planet permanently, maybe more types of cratering events can create lunar meteorites. The great number of lunar meteorites, represents a tremendous opportunity to study The Moon since we are not going there presently to collect samples from additional locations.

I watched the Apollo 11 astronauts on The Moon and the other landings with great interest. I was already fascinated by meteorites and had been once to Meteor Crater and walked around its perimeter. I found a few pieces of iron shale, and cool rocks that day. I was reading all of H. H. Nininger’s books and had already sent him a piece of Mojave Desert basalt. I was disappointed that the missions stopped and remain
disappointed 50 years later that we have still not returned to The Moon.

It is the nature of mankind to explore and seek to understand what is over the next hill or across the ocean and yes, across the vastness of space. No explorers of the past went to a place and collected a handful of rocks and said “Ok we have been here, this is what it is all like. We can return home there is nothing else to do or learn here.” If the explorers of the new world had come and said, “The new world is a swampy bug-infested place without gold and riches which the rulers of Europe seek.” then there would not have been the development of Florida and no Space Center there today. To not continue and explore further is against the nature of our species. Maybe that is what bothers me most. Even though I can not go into space and travel to The Moon there is a part of me that wants to go. And even more desires for someone to go in my place and to continue what was begun by the Apollo Astronauts. Thousands of us who grew up during the 1960s and 1970s thought as excited space geeks that we would be on Mars in a decade or two and looked to see tremendous new space challenges met and overcome in our lifetime. But it was not to be.

I loved the Space Shuttle. There is nothing more exciting than seeing a really enormous rocket burn thousands of pounds of propellant every few seconds and produce prodigious quantities of fire and smoke. But it is not the same (even with all the good work and knowledge it gave us) as going to The Moon or Mars or the asteroids. I still feel let down and I still yearn before the end of my life to see men and women walking on Mars and other places in our solar system. And I guess that should be enough soapbox preaching for one article.

I have had the pleasure to cut some massive lunar meteorites into slices and see more of the material from our natural satellite than most other people on Earth ever will. If the number of meteorite collectors in the world is a small number then the number of professional meteorite preparers is a vastly smaller number still. I have been thrilled with every tiny bit of metal that I have exposed with the blade in my slicing. Each just as exciting as the first. That tiny little flash of sparkle reminding me that asteroids and meteorites with nickel-iron have been incorporated into the moonrocks. I have been surprised by how solid and tough some of the lunar meteorites have been in the saw. Originally I thought that their pounded and crushed beginnings would leave them still somewhat friable but that was usually not the case.
This image is a table covered with slices from one of the smaller lunar meteorites (just 1.1 kilograms) I have been privileged to prepare in the last couple of years.
This is a full slice of the lunar meteorite NWA 11303. The slice weighs 9.047 grams.
The white spot is the brightly reflecting metal grain exposed by cutting in a lunar meteorite.

Back not too many years ago meteorite collectors bought lunar meteorites by the milligram. And we were thrilled to get a tiny piece of the newest small stone proven to be from The Moon. Things have changed somewhat. Several large finds of lunar meteorites have made it possible for collectors to acquire whole stones, endpieces, and slices weighing many grams. I posted to Facebook from the Kennedy Space Center images of the lunar rocks that I saw on the trip and was amazed at that moment by the fact that they were but 110-129 grams. I forgot for a second in the world of today with so many wonderful lunar meteorites how difficult it was to get the actual moon rocks the astronauts returned. Those astronauts may have been asked to look for diversity in the rocks they returned and diversity does not always come in big sizes. We experience this when hunting for meteorites here on Earth. Had those Apollo astronauts never accepted the danger and the challenge of the journey to The Moon we may never have been able to confirm with certainty that the lunar meteorites we love are from there as well.
This is an endpiece of the first lunar meteorite that I cut for the business. It turned out so nice and the 20 or so slices were so thin and polished so nice that Paul Harris and I decided that we would keep the endpieces for ourselves. Little did we know that in just a few months much larger stones would be found and the price would fall even farther. I like this 25.4-gram specimen.

In archeology, which with just a few different choices in life might have been my career, situation and context are everything for specimens. A specimen without context bought in an antique store reveals very little compared to a similar specimen recovered from a layer of dirt in the ground. As much as scientists can learn from lunar meteorites about the history of The Moon the returned moonrocks have whole added dimensions of knowledge to offer. Partly because they are uncontaminated, unweathered from exposure to the conditions here on Earth but in a bigger way because we know the exact location where they were picked up. When we hunt for meteorites in the desert we have two modes in which we often operate. One is we are looking for additional pieces of space rock where many have been found before. If that was a fall that was witnessed then there is just the one type stone and if it is a common type then the location of a piece I find is not so important and we may never share to the world all the collection information. A Holbrook found today is after all just one more of 20,000+ Holbrooks found. The other mode we operate in is cold hunting a spot where meteorites have never been found. Any find there is new and needs precise documentation for many reasons. Among these reasons are so the distribution of other pieces as they are found can be plotted to determine the rough confines of the strewnfield. Also, it is required that the location be provided if the newly discovered meteorite is to be classified and made official within the scientific community. Knowing just exactly where lunar rock specimens were collected provides many benefits to scientists studying the geology of The Moon.
This is a whole specimen of NWA 10203 a nice lunar meteorite of a paired group. It has relic fusion crust and just the beginning hints of the inside where it has eroded some. It weighs 1.5 grams. The availability of meteorites from The Moon has offered me one other enjoyment that was impossible a few years ago. As I cut lunar meteorites I have the option to make some ridiculously thin slices that I can later make into thin sections. I enjoy grinding down and polishing meteorites until they are transparent and then photographing the structure of the stone under polarized light. Lunar meteorites are not very colorful as is often the case with other classifications of meteorites. Yet, even without the bright interference colors, they are fascinating in their own ways. The following is just one image of lunar meteorite NWA 11273 with polarized light.
I love just about everything about The Moon. I love to image it with my telescopes and cameras. I love the meteorites I have from there. I hope that I will see new astronauts return to The Moon and watch them learn to dwell there and then press on from The Moon to Mars.
Whatever Happened To The Squaw Tom “Meteorite”  
Robert Verish

The mystery of the location of a 5-ton mass of iron, suspected of being a meteorite, after being found in the California Mojave Desert, but was never recovered.

It came as a surprise to me when I received a large manilla envelope in the mail, containing photo-copies of newspaper clippings and photos of what was described as being “Another Large Iron Meteorite”. The envelope showed that it had been sent by a Pat Schoffstall, a curator from the Mojave River Valley Museum (MRVM) in Barstow, California. Actually, getting an envelope from this museum wasn’t all that much of a surprise to me, because I knew some of the curators there, and not long before, I had paid a visit to ask the staff if they had any meteorites in their collection. (They didn’t have any, so I gave them a couple of small chondrites, and gave them my contact information, in case anyone else would bring them a meteorite – such as, for identification.)

But like I said, the newspaper clippings were about an “iron meteorite”, and when I talked to the staff at the museum our discussion centered on small stony meteorites. Other than a brief mention about the Old Woman Meteorite, which was on display only 2 blocks away at the Desert Discovery Center, there was no mention of any iron meteorites, let alone a “LARGE” one. The photos were not dated, but the newspaper clippings definitely were dated — all of them were from “1977”. It turns out that Pat had heard about my visit and request about meteorites, so she volunteered to take on the task of going through all the records at the museum regarding “meteorites”, and she is the one that pulled-up an entire folder of information labeled as “Squaw Tom Meteorite”! So, she is the one responsible for resurrecting this rare piece of history, and without request, was kind enough to make photo-copies for me of all the information that she discovered. NOTE: I received this envelope in August of 2017, so these newspaper clippings were very nearly 40 years old! This would be back in the time-period soon after the Old Woman Meteorite was brought to the
Having written an article about the Old Woman Meteorite earlier in 2017, I was very intrigued about the existence of this ferrous doppelgänger, which by all accounts had been lost to history. In any case, I had never heard about this ~5-ton "find".

But, here in my hands was all the evidence I would ever need to be convinced of its existence. And it wasn’t as if it was a kept-secret. After all, it isn’t very often that a “meteorite” lands on the headlines of a newspaper. But what was being kept secret was the exact location of this iron-mass. What was divulged, is that it still remained where it was found, in a very remote location (in the Avawatz Mountains NE of Barstow), and coupled with it being so massive, it wasn’t going anywhere soon.

There were newspaper clippings from four separate daily papers. The first three articles were curious press announcements given by a spokes-person for the two finders, a representative of the local mining council, a Mr. William E. Smith. better known locally as, Bill Smith. The gist of these articles was that “the two prospectors” were not going to divulge the location of their find until they were assured a “finder’s fee”, all because of the controversy surrounding the Old Woman Meteorite (OWM). But one good tidbit was that the dimensions were given for this "Squaw Tom" iron. This was divulged in order to compare the dimensions to the OWM in order to show that the OWM was actually smaller. Now that we know these dimensions, it will help identify the “Squaw Tom” should it ever be relocated. Another tidbit from the article was the fact that a sample was extracted from the main-mass. The location of that sample is also unknown, and probably will be less likely to be found than the main-mass.

One last “tidbit” mentioned in these articles was that there were originally four photos taken of the iron-mass (in-situ). These same photos are called-out as “4 pictures (various angles) of Squaw Tom’s meteorite” in museum paperwork called "RECORD OF LOAN", an agreement signed by William E. Smith. Two of those “pictures” appear in this article. Unfortunately, there is no record of what happened to the other two pictures. It also raises the question of who took the pictures, because there is no mention of who is the photographer. It doesn’t exclude the possibility that the photos were taken by Mr. Smith, because it is only an assumption that the cameraman was Sander’s partner, Art Wilson. If it is the former, then it raises the possibility that Bill Smith is more than a spokesman, but knows first-hand the location of this find, and that there were at least 3 people with that knowledge.

In this photo (reportedly taken in 1977) is the subject “meteorite” (in-situ) along with its namesake finder, “Squaw Tom” Sanders.

Not knowing the height of Mr. Sanders, or having anything else to use as a scale, it is hard to judge the size of the “Squaw Tom” iron-mass. As a side note, it wasn't until I enlarged this image that I noticed something
in Mr. Sanders hand. At first, I thought it was a thin magnet stick, but later I decided that it probably was a magnet on the end of a string. Apparently, this object attracts a magnet. In the image below the finder, “Squaw Tom” Sanders, is kneeling next to his “meteorite” (in-situ). The shadow of the photographer (supposedly, Sanders partner, Art Wilson) can be seen falling upon the iron-mass.

Depicted below is another photo taken on the same day as the image above.

Depicted below is a black & white version of the above image. This was done in order to increase contrast.

Mojave River Valley Museum paperwork, an agreement called “RECORD OF LOAN”.
Were there others? Are there any other people still living that would know the location, or whatever happened to this mystery iron-mass?

Below is headline from the 1977 Oct. 8th Desert Dispatch, the newspaper that broke the news of a “2nd Meteorite Reported”!

The existence of ANOTHER large meteorite comes across the newswires. It’s not every day that a meteorite makes the headlines of a newspaper! This gives some indication of the impact on the psyche of the residents of San Bernardino County after the saga of the prior “recovery” of the Old Woman iron meteorite was published in all of the local newspapers.

Here is the article that goes with that “headline”:
Prospector Claims Find Is Bigger Than ‘Old Woman’

By JACK SHINAR

BARSTOW—Proof of the second meteorite find reported in the last year and a half near Barstow has been provided to the Bureau of Land Management by local prospectors, but they aren’t saying exactly where the meteorite is.

Two miners who have seen the “new” meteorite, located somewhere in the Avawatz Mountain range north of Barstow, claim it dwarfs the “Old Woman” meteorite which is now on display in the Barstow office of the federal Bureau of Land Management.

Bill Smith, president of the Barstow Council of the United Mining Councils, said the location of the second meteorite won’t be disclosed until the government assures the miners of a finder’s fee.

The prospectors said they have shown a piece of the meteorite to Wilson to examine the rock, and Wilson, who had seen the first meteorite in the BLM office, told him what it was.

Sanders said he doesn’t have any plans for the meteorite himself, but he does expect to receive a finder’s fee before he gives it up.

The “Old Woman” meteorite is believed to be the second largest iron meteorite known in the world.
In the above article, it states that “Sanders said he first discovered the rock about 50 years ago, but thought it was ‘just a piece of iron.’ He said that he took his friend, Wilson, to examine the rock, and Wilson, who had seen the first meteorite [OWM] in the BLM office, told him what it was.”

“Bill Smith, president of the Barstow Council of the United Mining Council, said the location of the second meteorite won’t be disclosed until the government assures the miner of a finder’s fee. The prospectors said they have shown a piece of the meteorite [sic] to BLM officials, and one the miners, Art Wilson, showed a piece of the meteorite to the Desert Dispatch.”

Three days later, this headline becomes a by-line picked-up by other newspapers!
BARSTOW (AP) — Two miners say they've discovered a meteorite even bigger than the “Old Woman Meteor” that touched off a tug-of-war between state and federal officials and the men who found it.

But the miners aren't saying just where their treasure trove is, except that it's allegedly somewhere in the Avawatz Mountains about 60 miles northeast of Barstow.

The new specimen was dubbed the “Squaw Tom Meteorite” after one of the men who says he found it: "Squaw Tom" Sanders.

The miners claim an assayer has certified the authenticity of the rock as an iron and nickel meteor, the same as the "Old Woman." Sanders said he discovered "Squaw Tom" in 1927, but did nothing about it. "I thought it was just a piece of iron," he explained.

However, after he and his partner, Art Wilson, viewed the "Old Woman" in Barstow recently, Sanders said he decided to take another look at the specimen he had found in the desert five decades earlier.

Sanders claims "Squaw Tom" weighs more than three tons, while "Old Woman" weighs 2½ tons. The "Squaw Tom" specimen is also 26 inches longer, 11 inches wider and six inches higher, Sanders claims.

The discovery of the "Old Woman," found in the Old Woman Mountains southwest of Needles, touched off a battle between state officials who wanted the rock to remain here and federal officials who wanted to take it to the Smithsonian Institution in Washington, D.C. Little attention was paid during the struggle to the claims of the miners who found the rock. They said they wanted to keep it for themselves and make jewelry out of it. California eventually won out in the battle, when the Bureau of Land Management decided to let the meteor remain on display at various museums in the state.

The article in the Independent (Long Beach, California), dated Tue, Oct 11th 1977 – titled, “Meteorite found in '27 bared”.
Meteorite found in '27 bared

BARSTOW (AP) — Two miners say they've discovered a meteorite larger than the recently discovered "Old Woman" meteorite, but were keeping its exact location secret Monday because of controversy over the ownership of its authenticated predecessor.

The miners claim an assayer has certified the authenticity of the purported outer space rock, but due to Monday's federal holiday, no immediate confirmation was available from Bureau of Land Management personnel or other officials.

The newly reported specimen, which lies somewhere in the Avawatz Mountains about 80 miles northeast of Barstow, has been dubbed the "Squaw Tom" meteorite after one of the two miners who claim it, Squaw Tom Sanders.
BARSTOW (AP) — Two miners say they’ve discovered a meteorite larger than the recently discovered “Old Woman” meteorite, but were keeping its exact location secret Monday [sic] because of controversy over the ownership of its authenticated predecessor.
The miners claim an assayer has certified the authenticity of the purported outer space rock, but due to Monday’s federal holiday, no immediate confirmation was available from BLM personnel or other officials. The newly reported specimen, which lies somewhere in the Avawatz Mountains about 60 miles northeast of Barstow, has been dubbed the “Squaw Tom Meteorite” after one of the two miners who claimed it: Squaw Tom Sanders.

Sanders said he discovered “Squaw Tom” in 1927, but did nothing about it. ‘I thought it was just a piece of iron,’ he explained.

However, after he and his partner, Art Wilson, viewed the “Old Woman” in Barstow recently, Sanders noticed the resemblance and decided to take another look at the specimen he had found in the desert decades earlier.

Chemical tests were done by an assayer, who certified that it was a genuine meteorite, with a nickel iron composition similar to that of the “Old Woman”, Sanders said. The alleged authentication was disclosed Saturday.

The specimen weighs more than three tons, while the “Old Woman: weighs two-and-a-half tons, Sanders said. The “Squaw Tom” specimen is also 28 inches longer, 11 inches wider, and 6 inches higher…”

Finally, there were two more newspaper clippings, but these were follow-up articles. They primarily focused on the disconcerting update that UCLA had tested a sample and deemed it man-made. They determined that [the sample they were given] didn’t have the internal structure of an iron meteorite, nor could they find any nickel (Ni) in the alloy. Regrettably, no record of this sample [from 1977] could be found at UCLA.
Make no mistake, there is little doubt in the minds of the meteorite scientists (although none were metallurgists) who have examined samples from this ~5-ton mass of iron, that it is nothing more than man-made foundry iron, an “artifact-iron”. But the discrepancy in the test results between the researchers and the assayer were never reconciled. So, questions still remain. “Where is the sample?”, and “Where is this main-mass currently located?”, and “Is it still sitting in the Mojave Desert?”. That is the mystery that historians would like to get answered. So far, none of the principle characters involved with the “Squaw Tom” saga can be located, or have passed away. If you have any information regarding this ~5-ton enigma, then please contact this author, or the Mojave River Valley Museum.
Post Script: Earlier in 2019, another multi-ton mass of iron was found (but in Riverside County), and it is tantalizing how similar it is in gross appearance to “Squaw Tom”. Could it be possible that the “Squaw Tom” was relocated (then abandoned) and now “found” again. Research and testing of this “3rd” iron-mass is on-going.

This article has been abbreviated in order for it to be included in this September issue of Meteorite-Times Magazine. The second part of this article will appear in a future edition.

References:

[1] Mojave River Valley Museum — on Barstow Road in Barstow, California, is two blocks away from the Desert Discovery Center where the “Old Woman Meteorite” is on display. Both are dedicated to the preservation and promotion of the scientific, historical and cultural heritage of the Mojave Desert.


[3] Another California Meteorite — where the finder will not disclose its find location! How many other undisclosed meteorites are there?

External links:

NevadaGram #207 – Squaw Tom, The Picon Drinker and the Guy from Tahoe.

“Fate and circumstance have decreed that this month’s NevadaGram will feature Squaw Tom Sanders at the top of the page. This is one of the stories that won him the Nevada Press Association’s First Place award for Writing by a Rural Correspondent in the Gold Hill NEWS in 1975. Truth be told, he didn’t write his stories at all; he told them, spoke them into a cassette tape recorder and one of us at the paper wold transcribe them. His stories about Native American life in Nevada of the 1920s – 1970s are unique, and
this is one of my favorites, a short police procedural, with a wry twist at the end: “ALBERT HICKS, Indian Police” .... “


“When Tom Sanders ran away from home at 13, he was taken in by an Indian couple and for most of the rest of his life he lived among the Indian people of Nevada.

This is one of the recordings Tom made for The Gold Hill NEWS. He would sometimes stop by with a handful of new stories on cassettes, other times he would take a chair out behind World Headquarters and tell a story into the recorder.

Ideally you are seated in a comfortable chair with a refreshment at hand, mind prepared to cast the modern moment aside and drift through time into a different world as you punch the Play button and in deadpan fashion Tom tells the racy tale he called “Under the Trampoline”...”

My previous Bob’s Findings can be found *HERE*

If you have any information as to whatever happened to this 5-ton “pseudometeorite”, then please contact this author at: bolidechaser at yahoo-dot-com
NWA 487 L/LL3.4 was distributed by Marvin and Kitty Killgore. They called it The Coffee Piece for its brown tint. I bought this thin section from them at the May 2003 Costa Mesa show.

Even though an unequilibrated Type 3.4, it is apparent from its texture that its material has been recycled. Complex and compound chondrules, relict grains and aqueous alteration signal that this material has made the rounds. After accretion, at least part of the parent body was deformed resulting in the strong alignment of the rock's components.

Sample is about 16mm by 23mm.
Strongly aligned matrix and elongated chondrules. Field of view is about 12mm tall.
Field of view is about 6mm tall.
Large chondrule thickly encased in opaque fine grained matrix. Plane polarized light.
Chondrule fragment thickly encased in opaque fine grained matrix. Plane polarized light.
Compound chondrule.
Compound chondrule.

Orange relict grain at center.
Dark blue relict grain at center.
At center is a cratered radial pyroxene chondrule with edges white from aqueous alteration of the feldspathic glass between pyroxene laths.
Norm’s Tektite Teasers: Cosmic Glass Tektite Patties
By Norm Lehrman (www.TektiteSource.com)

In previous columns, we have been working through a review of the classic tektite morphologies. If the perfect minimalist tektite collection was limited to just three variations, I would choose a dumbbell, a teardrop, and a patty. In this edition, patties take the stage.

Patties are a proxy for a range of shapes that began life as oscillating spheroids of molten glass entrained in a fireball of billowing plasma. In the case of the c. 780,000 year Australasian tektite event, a majority of the primary spheroids near the apparent impact zone were secondarily distorted by atmospheric friction as they fell. They flattened into forms resembling hamburger patties. These range in size from poker chips to half-kilo monsters. The one pictured is 442 gms, but I have seen photos of one larger used as the socket for a door-post!

For many years I supposed that the flattening deformation of patties was the result of impact on the surface of the ground while the glass was yet in a plastic state. I am now quite sure I was wrong.

I wish I knew how many tektites we have examined over the years, but it is well over a million pieces, and not a single one shows clear evidence of having draped over or welded onto anything on the ground beneath it. The evidence is that most, if not all, of the pieces that fell to the ground in what appears to be the proximal region assumed their final form in flight and were quite thoroughly solidified before impact.

This specimen is particularly instructive. This is a fragment of the upper surface of an extremely splatted disk, mostly less than one cm thick. The ornamentation includes distentional concentric rows of thin brittle-skin icebergs in a frozen sea of younger glass which is, in turn, shattered by starburst skin splits from impacts internal to the mushroom cloud. I can imagine no way that such a thin plate would have an adequate heat budget for these features to be related to earth-impact (with retained internal plasticity). It is more likely that the brittle fragmentation breaks happened on impact.
The biggest tektite patties on earth are mostly from Guangdong Province, China. I should say were from that area, as there are few being found anymore. The days of container-loads of tektites from China and Thailand are long over.

The selection of mostly over 200 gram world-class pieces in this image represents our crème de la crème after 20 years of highly selective acquisitions. The big one below the pencil, our pride and joy, is the 442 gm piece shown in the opening photograph.

The majority of tektite patties are near-circular in outline, giving evidence to their spheroidal primary form. However, do bear in mind that these are end-point examples. Less symmetrical blobs of glass wobbled into every intermediate form of biscuit and bar shape.

Most patties are concavo-convex in profile, but concavo-concavo forms occur, suggesting modification by Frisbee-like spinning. There are specimens that thinned and ballooned in the center like parachutes capturing the wind. We have one that looks like it popped in this fashion.

Oddly though, this story is mostly about Indochinites in a very restrictive sense. The monster patties were from China. Smaller examples are abundant in Vietnam, Thailand, Laos, and adjacent regions. The Rizalites of the Philippines are characteristically ovoid-profiled biscuit shapes. The primary forms of the Australites were mostly spheroidal. Some moldavites formed patties, but most other tektites were dominantly spheroidal. Most big patties, and all the monsters, are from Guangdong, China.

One of our personal favorite patties was collected by Harvey Nininger in 1958 in Dalat, Viet Nam. Nininger is something of an unsung hero to all of us who know of him. His words:

“Apply your mind to at least one problem which has never been solved, which in general is considered impossible of solution, but which, being solved, would help humanity. Do with your life something that has never been done, but which you feel needs doing.”

Harvey, you inspired more than you could ever know! Thank you.
The interiors of the terrestrial planets still remain a realm of absolute mystery. The internal compositions and thermodynamics of the terrestrial planets are keys to ultimately understand how they initially formed and evolved in differing planetary systems and can put important constraints on their geological diversity in the entire Universe.

Today, in the modern era, we have the possibility to use numerical modelling to study and infer some information about planetary interiors, since we have no real way to directly access these extreme places. However, numerical modelling alone can be affected by large errors involving underestimation or overestimation of certain parameters. Thus, in order to reduce these errors another method accompanying the numerical modelling is needed: the chemical analysis of pristine planetary samples.

In my PhD research at the University of Glasgow my goal was to put new constraints on the formation and evolution of the interior of Mars. I used the only available samples from Mars that we have on Earth – these are martian meteorites, volcanic rocks erupted on Mars and with precious information about the martian interior. In a few words, when a large asteroid impact on the martian surface lots of material from the Red Planet is ejected into space. This material orbits the Sun for millions of years. Eventually, one day they reach the Earth’s gravitational field and fall on the ground, where they can be found and collected. The hot and cold deserts (for example, the Sahara or Antarctica) are the best places to find meteorites, due to their aridity and absence of significant geological activity (Figure 1). This is a fantastic way of obtaining samples of Mars for free. On the other hand, these samples are immediately affected by terrestrial contamination and alteration once they fall on the ground. In this sense, when chemical analyses are conducted one need to have this in mind and to try to discriminate whether terrestrial alteration is present in the chemical data.

One significant part of my PhD involved the study of the Tissint martian meteorite. This meteorite is a
shergottite, basically with a composition similar to a terrestrial basalt (lava) but richer in iron. In particular, the Tissint meteorite, that fell in the Moroccan Sahara desert on the 18th July 2011, is kind of special because it seems to resemble the chemical composition of the martian mantle. Thus, it was a perfect sample to use for answering my scientific questions. For example, is the interior of Mars still active? Is convective activity still in place in the martian mantle? In fact, when we think about Mars we do not refer to plate tectonics or in general to the same geodynamics that we experience on Earth: this because the martian crust was never characterized by plate tectonics, but is instead characterized by a single plate, a stagnant lid covering the entire planet. In this sense, the internal heat could have been retained for a longer time than on Earth – i.e., despite the planetary size, the heat in Mars could dissipate much more slowly (not efficiently) than on Earth, where plate tectonics provides frequent access from the internal heat to the atmosphere. But if so, why don’t we see volcanic eruptions on Mars today? This is simple to answer. In reality, from orbiter data we can see that Mars has recent volcanic eruptions and lava flows, especially on a flank of the Olympus Mons volcano, with the last one at around 10 millions of years ago. Thus, it seems that the martian interior could be still active, but with the difference that the planet may experience a volcanic eruption once every few millions of years rather than several every day, as on Earth.

With these questions in mind, I analysed the Tissint sample: this lava contains several minerals but mostly olivine, pyroxene, and maskelynite (glass) produced during shock due to the impact (Figure 2). Olivines had all my attention since they are among the first crystals that form in a magma, and so they contain pristine and important information about the martian mantle, that were not “overwritten” by the subsequent crystallization process until the Tissint lava was erupted at around 574 millions of years ago, during the late Amazonian period on Mars. Olivine crystals in Tissint are particularly known for their size: there are both small olivine (around 300 micrometers in size) and mega olivine crystals (even > 2.5 millimeters in size). It was a big surprise for me when I found out that two of these mega olivines represent crystals that were formed in a chemically similar but spatially different magmatic system than the smaller olivine crystals, and that their high content in magnesium and temperature of crystallization are indicative of their formation in the deep part of the magmatic system. Thus, these two mega olivine crystals recorded extremely useful information about the deepest parts of the martian mantle.

![Figure 2](image_url) – One of the thick slices of the Tissint martian meteorite that I studied in my PhD research. A) Backscatter electron image of the sample where two populations of olivines (mega crystals, > 1 mm; and smaller crystals, < 1 mm) are clearly noticeable; B) Mg, Fe, Al, Ca, and Si-X-Ray Elemental Map of the area marked in yellow in (A). OI, olivine; Px, pyroxene.

The first thing I decided to do with these precious mega olivine crystals was to try to acquire hidden information about possible thermodynamics activity in the martian mantle. In order to do this, I used the element phosphorus. Why? Because phosphorus is easily trapped into the olivine crystal structure when the magmatic system experiences a rapid decrease in temperature. For this reason, observing a series of bands (crystal zoning) that are is rich in phosphorus in respect to other areas of the crystal is very useful to know, because it could mean that cycles of convective activity are present in the magmatic system. In fact, during a convective cycle the olivine crystals can be transported from the hotter, lower part of the magma chamber to the colder, upper part of the same. This cycle determines rapid changes in temperature that are recorded by the phosphorus zoning into the olivine crystals, thus confirming the presence of convection in the martian mantle at the time this lava formed.
To further confirm this hypothesis of thermal activity in the martian mantle, I had another idea: using the two mega crystals of olivine as special ‘thermometers’ of the martian interior (Figure 3). Thus, using their chemistry and thermodynamical modelling, I reached the same conclusion from a different point of view. I calculated the temperature of the martian mantle when the Tissint lava formed, i.e. in the middle Amazonian period on Mars, showing that at that time the martian mantle was still geologically active.

![Figure 3 - One of the mega crystals of olivine that I used as a thermometer to measure the temperature of the martian mantle.](image)

These results are of great significance for terrestrial planets thermal evolution, with new constraints on the hypothesis that in a single-plate planet (i.e., without plate tectonics) the internal heat, due to primordial accretion and decay of radioactive elements, can be kept for a longer time than in terrestrial planets characterized by a plate tectonics geology. Now, it is exciting for me to wait for the outcome of the NASA InSight mission, to see if the data about heat flux and interior thermal activity of Mars agree with mine as reported from the geochemistry of this special meteorite.

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Our Meteorite of the Month is kindly provided by Tucson Meteorites who hosts The Meteorite Picture of the Day.

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Once a few decades ago this opening was a framed window in the wall of H. H. Nininger's Home and Museum building. From this window he must have many times pondered the mysteries of Meteor Crater seen in the distance.

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