The Rise of the Raj
and
the Fall of Shergotty

Painting by Dorothy Norton
The farmer who witnessed the fall of Shergotty prays over the impact hole.
"Shergotty" is written in Sanskrit around the Hindu god of the sky, Varuna.

"I at first doubted whether it was a true aerolite or not, in consequence of the colour being different from the one that fell in the Furreedpore District in 1850... but I find from Mr. Peppe, the Sub-Deputy Opium Agent, that there can be no doubt of its being a true aerolite, as he has seen two that fell in the District..."

This account is found in a deposition submitted in late 1865 by W.C. Costley, Deputy Magistrate of Shergotty, India to his supervisor A. Hope, Magistrate of Behar.

Had Mr. Peppe not been in the neighborhood that day to oversee the opium crop, perhaps W.C. might have tossed the "wrong-colored" rock into the River Ganges.

The deposition was accompanied by an aerolite, and both were presented to the *Asiatic Society of Bengal* by S.C. Bailey, Officiating Secretary to the Government of Bengal, during their meeting of December, 1865. He also gave them communication No. 829, "with enclosures from the Commissioner of Patna, containing some particulars connected to the fall of the stone...".

The nearby city of Patna was the British government's opium processing center for product bound for China.

Bailey was fulfilling a government edict hoping, "... your Society will be good enough to cause all the particulars of interest connected to this Aerolite to be communicated to the authorities of the British Museum."

That was code for "send the rock to Story-Maskelyne, Keeper of the Minerals".

Theater from the Sky

The farmer's field where Shergotty landed was just a gritty corner of a grand stage stretching from somewhere on Mars to London, Calcutta and Shanghai. The actors you will meet in this performance filled roles both memorable and execrable.

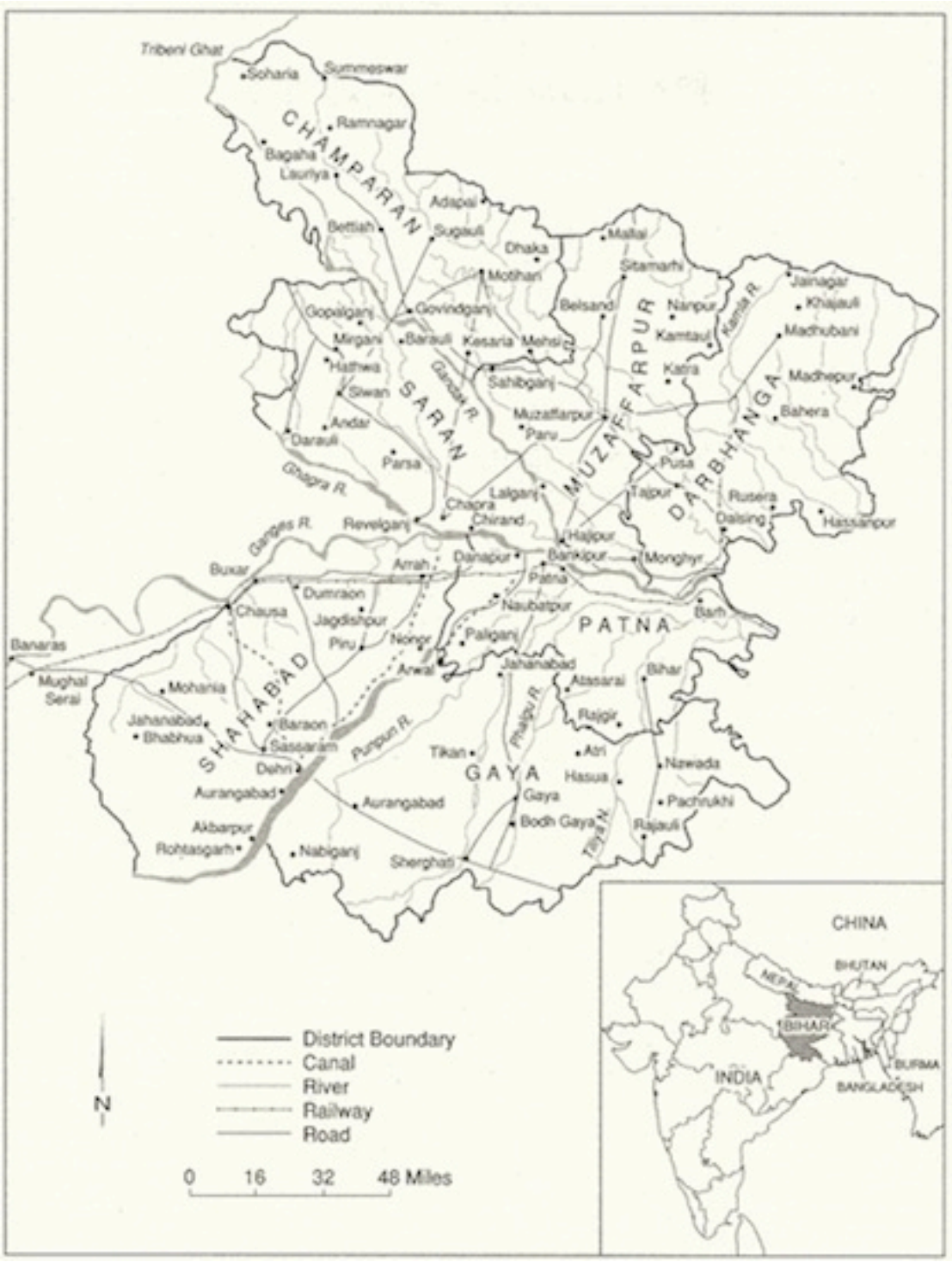
Before the lights dim, let's open the playbill and review the literature regarding the fall of Shergotty.

The *Calcutta Gazette* was quoted in the August, 1866 *Report of the 36th Meeting of the British Assoc. for the Advancement of Science*, "A stone fell from the heavens accompanied by a very loud report, and buried itself in the earth knee-deep. At that time, the sky was cloudy and the air calm, no rain. The stone has been forwarded by the government to the Asiatic Society of Bengal."

The Costley deposition and aerolite are mentioned in *The New Englander*, *New Haven and Yale Review* vol XXVII, P. 134, 1868.

Referenced in "*The Academy and Literature*" vol.2, p 540, 1871, an analysis by Dr. F. Crook in 1868 purported to be of Shergotty is discovered to be of a specimen from another fall.

On February 22, 1872, Von G. Tschermak submitted the first analysis of the achondrite writing of its recovery, “There is no information on the accompanying circumstances.”



Shergotty is found to the south in this map of Bihar, India

Most recently, Charles Meyer's (NASA) *Mars Meteorite Compenium* relates, “The Shergotty achondrite fell on August 25, 1865 at 9:00 a.m. near a town called Shergahti in

Bihar State, India after detonations were heard (Graham *et al.* 1985). Duke (1968) refers to several stones with fusion crusts, but this has not been confirmed.*"*

The Costley deposition best describes the circumstances of the fall of Shergotty. This document has been forgotten, archived in the British Library. It was retrieved by a librarian in Edinburgh for which we can be forever grateful.

Now**,** *almost 147 years after the fact***,** you will read *the first complete description of the fall of Shergotty*, the namesake of the largest class of meteorites from Mars- shergottites.

Shergotty Meteorite on display in Vienna

But before we discover how Shergotty was saved from the meteor-wrong pile by a government employed drug dealer, it's imperative to understand the political and cultural environment of the era surrounding this event and examine the key role India's first scientific associations played in revolutionizing historic attitudes.

Shergotty as written in Sanskrit. Drawing by Dorothy Norton

The Asiatic Society of Bengal Births a National Collection of Meteorites

Sir William Jones (1746 – 1794) founded the *Asiatick Society* in Calcutta on January 15, 1784, advising thirty European invitees, "The bounds of investigations will be the geographical limits of Asia, and within these limits its inquiries will be extended to whatever is performed by man or produced by nature."

What evolved into *The Asiatic Society of Bengal* became instrumental in collecting and studying meteorites. First, those from India, then others acquired in exchange from around the world, breaking an intensely competitive duopoly formed by the British and Vienna museums. Shergotty became one of the first Indian meteorites not to be wholly and dutifully transported by the British bureaucrats governing India to the Natural History Museum in London.

For fans of trivia, besides the Shergotty meteorite fragments and the report of its fall, other gifts to the Society during that fateful December meeting in 1865 included:

• a "brass image of the Dhurm Rajah of Bhotan", a populist leader worshiped by the *Bhooteas* (Bhutanese). The statue was "preserved from destruction" when the British captured a fort on the frontier of India.

• twelve copies of "a brief analytical review of the Administration of Lord Mornington, afterwards Lord Wellsley."

• and lastly, "from Babu Rajendra Mullick, a dead Gayal."

A gayal was an oxen never put to work, treated well, then slaughtered and eaten.

Society founder Jones was not born into wealth even though his father was the mathematician who devised the symbol for *pi*. William graduated from Oxford and became a recognized "Orientalist", writing history books and articles about past Asian societies. Preceding the American Revolution, Jones journeyed to Paris and met with

Benjamin Franklin, but was unable to negotiate a work-around to the Colony's' demands. Assigned to Calcutta, he sat as a judge and was knighted for his service.

After Jones' death, the Asiatic Society opened India's first public library in 1808 and the country's first public museum in 1814. In 1829 the Society integrated, opening its membership to Indians.

Libraries amass books and papers. Museums amass collections of objects. The pursuit of these needs resulted in the end of England's colonial practice of harvesting every object of historic or scientific value from the sub-continent for its own institutions.

By the time of the fall of Shergotty in 1865, the Society was India's most influential scientific organization, their publications in demand by scholars in Europe. Besides those who sought to belong to this group, the Asiatic Society increased its prestige by offering honorary memberships to influential persons in Europe. Some members of note included:

1. Major H.H Godwin-Austin, famed for performing a difficult topographical survey of India, he had the world's second highest mountain (now called K-2) named after him;

2. W.J.Herschel, the son of the astronomer, who realized fingerprints could be used for identification;

3. Allan Hume, the 'father of Indian ornithology' was the founder of the Indian National Congress, the country's powerful political party;

4. Isaac Newton;

5. Charles Darwin;

6. H.R.H. the Duke of Edinburgh.

Meteorite Legends of the Sub-Continent

Meteorites have long influenced Indian culture.

One story tells of two merchants who offer Buddha food and request a souvenir to commemorate the occasion. He gives them a hair and pieces of his nail clippings. Buddha tells them that should a stone fall from the sky, they should erect a pagoda on the site and worship the hair and nails as if they were Buddha himself.

In 1867, a meteorite fall of many stones near a small town in India causes the local people to suspect they are objects of vengeance from an offended God. They gather the fragments, pound them into dust, and throw the pieces into the wind.

Concurrent with the fall of Shergotty is a report of “meteor stones which fell in this Talook” near Bangalor on September 21, 1865. After describing the angle of incline, the witness Mahamed Ali investigates whether the stones were put there by villagers

maliciously attempting to alarm their neighbors. Because no similar colored stones are nearby, he is convinced that they are meteorites.

Kenda, another eyewitness, is picking grass only 200 meters from where one of the stones fell. He had heard the "report of a cannon fired three times" before watching something fall from the sky. He was "extremely terrified, his eyes were closed up from the rush of the smoky dust which rose directly after the fall of the stone, he did not go close to it, because he thought that some calamity had descended from the heavens." Kenda eventually took yet another eyewitness to the spot were they found something black, half of which was buried in the sandy soil of the field.

"They touched it with a stick. When they found it was safe enough, he took it out of the hole with his hands and brought it to the village."

It was turned over to the authorities. That meteorite is Maddur L5, two specimens with a combined weight of about two kilograms remain extant.

We also have an account by Bakerooddin Shaikh of the fall of Gopalpur, a stone donated to the Asiatic Society earlier in 1865.

"I had been to the field to fetch home my cattle. All of a sudden a hissing noise... the sound was like that made by the flight of a buzzard. I saw something dark falling on the earth... we picked up the stone, it had buried itself seventeen or eighteen *ungoolies* (15") deep under the ground. The stone was not visible from above the hole. I could feel it with a stick. When we picked it up it was warm, not very hot. I picked it up after it had been in the hole for about one *dundo*, or the time occupied by walking eleven *russees* (400m) for a *khunta*, which had to be brought from a neighboring house before we could dig it up."

An additional account of the event by Alif Shaikh ascribes mythology to this H6 specimen of 1.6 kilograms. "Bakher kept it in a new earthen pot as something extraordinary. We did not make *poojah* (an offering) to it, we knew not what it was, but as Hindus have several idols, we thought it must be one of them."

Introducing Adversaries
Thomas Oldham and Nevil Story-Maskelyne

By the 1800's, England, under the auspices of the East India Company, treated India as private property, managing its resources and establishing and controlling its civil service with a spirit of benign condescension. The sun would never set on an independent India. This style of organization extended to the scientific community, their various disciplines headed by British nationals.

But with the advent of the Asiatic Society, then of the Geological Survey of India (GSI), a change came about. The British colonists heading these organizations realized that they were qualified researchers capable of studying the material at hand. With the opening of

India's first museum in Calcutta, it was felt that items collected in India should remain in India. This included meteorites.

India was considered an unequaled venue to observe falls. Clear skies and a dense population allowed for multiple observations of a single event. As soon as a meteorite fell, researchers, government officials, even the police were sent to retrieve specimens. All haste was made to collect pieces before the indigenous population had a chance to worship or destroy the meteorite. Witnesses were interrogated as if the strewn field were a crime scene, leaving behind observations both accurate and dubious but an excellent historic record of the times.

These depositions, often coerced under threat, led to recovery of specimens that would otherwise have been lost. Government officials, both British subjects and their Indian counterparts, were strongly encouraged to collect fallen meteorites and take depositions.

The first Indian meteorite to enjoy this complete cycle of observation, deposition and recovery was Akbarpur H4, with 1.8 kg recovered in 1838.

The person most instrumental in acquiring, studying and curating India's meteorites was Irish geologist Thomas Oldham. Beginning in 1851, Oldham elevated the Geological Survey of India from a collection of papers filling a shoebox to a world-class organization. His countryman Joseph Portlock once said, “I have found him possessed of the highest intelligence and the most unbounded zeal.”

Thomas Oldham
(1816–1878)

Both the GSI and the Asiatic Society worked to earn a reputation for professionalism and built important connections with researchers and museums throughout Europe and America, much to the chagrin of the British, who believed they owned a monopoly on the study and ownership of all important Indian natural history objects.

Oldham successfully cultivated a relationship with meteoriticist William Haidinger of the Imperial Geological Institute of Vienna, even hiring Austrian geologists to work for the GSI. But no mention of meteorites appeared in the GSI literature until 1865 and all Indian meteorites not yet forwarded to England remained with the Asiatic Society. Oldham was focused on the regions' coal reserves and fossils.

While the right to maintain a collection of meteorites in a proposed national museum in Calcutta was a concept gaining popularity, a larger movement was afoot. Many levels of Indian society were growing weary of British dominance.

The first instance of Indian independence was manifest in 1857 when a series of unrelated religious and duty issues sparked spontaneous mutinies within the mixed ranks of the military. For a brief time, small areas within India returned to autonomous rule.

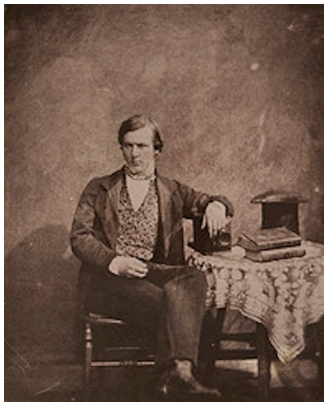
And with these successes, landowners, discouraged by limited social and business opportunities while suffering from outrageously high taxes - 60% to 90% of the “gross produce of the soil”- were encouraged to take up arms.

During a disorganized rebellion, atrocities were committed by both sides. When British troops regained control they sought vengeance. Indian captives were tied to the front of cannons and the fuses were lit. Such stories of unspeakable retribution were received back in Britain as justified revenge.

The East India Company was dissolved in favor of the powerful British Raj (*reign* in Hindi), and Queen Victoria ruled the land. She wrote of her “feelings of horror and regret as the result of this civil war” and felt that by India becoming part of the Empire, this “should breathe feelings of generosity, benevolence and religious tolerance”.

While the British blamed Muslims for instigating these rebellions, they blamed themselves for trying to institutionalize economic schemes that destroyed the fabric of Indian culture. They now installed policies inclusive of India's former political hierarchy while simultaneously opening universities and educating an Indian elite less influenced by the past.

But coincident with Victoria offering opportunity and equality to her Imperial subjects, Nevil Story- Maskelyne was being appointed Keeper of the Minerals for the British Museum. Someone forgot to copy him on her message.



Keeper of the Minerals, Nevil Story-Maskelyne

Story-Maskelyne's efforts to grow the National Museums' meteorite collection to be the world's largest were uncompromising. Proclaiming that he and his staff could best study and curate meteorites, his papers reflect an attitude akin to divine authority. He would claim for Britain everything that fell out of the Bengal sky, “Meteorites have no nationality.”

He and Thomas Oldham were soon to become well acquainted.

The Meteorite Wars Begin - Colonial Calcutta v Imperialist London

In his seminal paper, “Science and politics of colonial collecting: the case of Indian Meteorites 1856-70”, Savithri Preetha Nair writes, “Story-Maskelyne employed a multi-pronged effort to acquire Indian meteorite specimens in the early 1860s by using science as an alibi to perpetuate an unequal exchange economy. To enhance its national collection of meteorites, the British Museum, represented by Story-Maskelyne, influenced the Government of India to control the activity of meteorite collecting through coercive and legislative means. Collectors, magistrates, police inspectors and medical officers were all enrolled in this extensive collecting network.”

The British Museum Trustees urged the Asiatic Society “to cooperate in improving the National collection... which is only one or two points inferior to that in the Imperial Collection (Vienna)”, and was told to give up its duplicate meteorites, limiting the Society's ability to trade these for others. For best effect, meteorites would be skillfully sliced in London, not hammered apart in Calcutta.

Acting quickly after his appointment, Story-Maskelyne was able to convince England's Secretary of State for Foreign Affairs to direct the government of India *to turn over all meteorites and depositions* to the British Museum. Parnallee LL3.6 and Dharamsala LL6 were the first meteorites to arrive in London under this decree.

After slicing, the Natural History Museum retained twenty-eight pounds of Dharamsala.

One pound was returned to the Indian Museum.

The Bustee Aubrite (courtesy of USNM)

Story-Maskelyne's exchanges were unashamedly one-sided. He received three pounds of the Bustee aubrite and twenty-four pounds of Yatoor H5 from the Asiatic Society while returning to the Society mere ounces of both.

Yatoor H5 (courtesy of Peter Marmet)

In 1861 and 1862, the Asiatic Society responded to relentless requests from Story-Maskelyne and sent off eight more meteorites. The British Museum would cut them after preparing casts, and specimens and casts would be distributed to Calcutta and Vienna. Again, the returned “gifts” were modest.

Even the recent advent of not-so-rare-after-all NWA meteorites being traded by dealers for European museums' prestigious, historic specimens pales besides Story-Maskelyne's ultimate coup

An eager, new British governor of Madras would send the entire mass of Parnallee to London in return for a cast.

When Story-Maskelyne heard this news he was ecstatic. To seal the deal, he threw in “two or three good specimens of duplicate meteorites both of iron and of stone”. The museum in Madras was left with a fragment of Parnallee weighing about three ounces while Story-Maskelyne had acquired the main mass of 130 pounds.

His research on acquired material was not without results, and his other achievements were notable. He developed the reflective light microscope and opened the science to the study of opaque minerals. This directly helped him discover the mineral enstatite in Yatoor H5. Then in 1862 he named a new mineral in the Bustee aubrite 'oldhamite', his intent in honoring 'competitor' Thomas Oldham unknown. But Story-Maskelyne also seemed focused on accumulating as much material as possible, and tripled the meteorites in the national collection.

Now he grew discontent even with the depositions taken from eyewitnesses. When four separate named meteorites were later found to fit perfectly together, he demanded a review of the fall ten years after the fact. George Osbourne, a government official in India, blamed the shoddy reporting on shifting assignments for those in charge, worsened by the rebellion of 1857-1858. Another official blamed errors in the depositions on the “apathy of Natives and their natural carelessness in noting such events”.

In 1863, Story-Maskelyne transmitted revised instructions to the responsible agencies in India, a precise methodology for preparing depositions and collecting *aerolites*, all for the benefit of the National Museum in London.

The friction between Oldham and Story-Maskelyne ignited in 1865. Oldham, using his influence as head of the Geological Survey of India, convinced the Indian government to purchase a collection of 223 meteorites from a mineral dealer in England. Upon receipt, India's meteorites rivaled the collections of Vienna and London as defined by the number of specimens.

Following a proposal by the Asiatic Society, the *Indian Museum* opened in Calcutta in 1866. The substantial Society holdings in materials biological and mineralogical had found a home and were merged with the GSI mineral and meteorite collections. Shergotty was among the objects transferred to the new site.

Oldham grew bolder. He rewrote the protocols for preparing depositions and collecting *aerolites* authored by Story-Maskelyne. Oldham requested that new falls be brought to Calcutta “for distribution” to other institutions.

In 1867 Oldham toured European institutions on a fact-finding mission, realizing that his compatriots doing research in India were as qualified as their European peers.

When Oldham returned home, he and the trustees of the India museum turned the table on Story-Maskelyne *making a gift* of four meteorite fragments, including Shergotty, to the British.

Story-Maskelyne did not hesitate to publicly rebuke Oldham. In a letter, he made it clear that in the future, Oldham would not be 'selecting' anything. There would be no more 'gifts', all meteorites would be sent to London where researchers' abilities surpassed those stationed in Calcutta. Properly cut specimens might be returned as presents to India.

And exhibiting pettiness, he explained that the collection the GSI purchased from the English mineral dealer was unimportant since it only consisted of small examples.

Documents reveal that Story-Maskelyne had negotiated to acquire some specimens of that collection and was outbid at the last moment when Oldham's group purchased it all.

The nefarious superintendent of the British Museum (National History) Richard Owen approved of these demands, calling it “a great moment in the elucidation of one of the most interesting and obscure problems of Meteorology and Mineralogy’. Owen is best remembered for denouncing the theories of Charles Darwin.

The Asiatic Society didn't feel Story-Maskelyne's remarks worthy of comment and ignored them except to suggest that “good science could come from small specimens”.

Their reply maintained that were India to hand over all its meteorites to the British, there would be no incentive for anyone to collect them. The India Museum's trustees sought “a

museum worthy of the Capital of India and a center from which a knowledge of the natural sciences, and interest in their pursuit, may radiate throughout the land".

In the concluding acts of "*The Rise of the Raj and the Fall of Shergotty*" you will become a tourist in 19th century Shergotty, Bihar and visit the meteorites' strewn field where the identity of the man who witnessed the fall will be revealed.

Von G.Tschermak's discovery of a new mineral and the more recent discovery of seifertite in the meteorite will be discussed.

We will detour to Mars at Rover site Meridiani Planum to meet Shergotty's cousin, Bounce.

The final curtain will fall after an agent of the British opium trade saves Shergotty, adding this tale to the ranks of meteorites' greatest legends.

Opium Poppy drawing by Dorothy Norton

Conclusion

“Look! Brahmins and Chumars, bankers and tinkers, barbers and bunnias, pilgrims and potters – all the world going and coming. The Grand Trunk Road is a wonderful spectacle. It runs straight, bearing without crowding India's traffic for fifteen hundred miles – such a river of life as nowhere else exists in the world.”

So proclaimed Rudyard Kipling of India's main commercial byway.

The Grand Trunk connects Kabul to Calcutta and bisects Shergotty, Behar, where on August 25, 1865 a meteorite from Mars would fall, burying itself beneath the ancient Bengal soil.

Before continuing this drama authored by a Red Planet rock, let's review what transpired in the First Act.

We learned from the *Proceedings of the Asiatic Society of Bengal for December, 1865* that after being recovered, the presumed *aerolites* passed into the possession of the Deputy Magistrate of Shergotty, W.C. Costley. Not sure about the stones, he showed them to a local opium agent familiar with past subcontinent falls. Mr. Peppe correctly identified them as meteoritic. Accompanied by Costley's report, which named the finder, they found their way to S.C. Bayley, the Secretary of Bengal.

A chain of possession was established by British bureaucrats. Cecil Beadon, the Lieutenant-Governor of Bengal instructed Bayley to relinquish the specimens and Costley report to the Asiatic Society. Thomas Oldham, their President, should forward everything to the British Museum (Natural History) in London. *Keeper of the Minerals,* Nevil Story-Maskelyne, would classify and add the meteorite to the national collection, and perhaps return a small sample to India.

I'll cut to the chase.

In 1865 one person watched as Shergotty penetrated a Bengali hillside. He recovered specimens. But his name had been consigned to oblivion, his story lost.

Likely the last link to this witness are the minutes from a December, 1865 meeting of the Asiatic Society of Bengal recently discovered in the archives of the University of Edinburgh, Scotland.

Here and now his voice will be heard, his account of the fall re-told for the first time in 147 years.

The lights are dimming and the curtain is rising. Please take your seat, strap in tight, and prepare to tour colonial India and meet the players, dabble in a little science, before diverting momentarily to Mars.

Then we'll return back to Bengal to witness the fall of Shergotty.

A slice of Shergotty from the collection of Rob Elliot

Two Rivers, a Lion and a Road

Sher Shah Suri (1472-1545), a Pashtun noble who rose to become ruler of the Delhi Sultanate was said to hunt lions near two rivers in the Gaya district of Behar. That place became known as ***Sher*** (lion) ***ghati*** (pier or platform).

Sherghati, Sherghatti, Shergati, Sherghauti, Shergotty... Hindi, Bengali, English... the spelling has changed over the years.

A Temple in Sasaram

Shah Suri funded a tree-lined road across the Plain of the Ganges to connect the capital city of Agra with his home town of Sasaram.

Caravansarai (inns) were built along the route which was extended to connect Peshawar, then Kabul, with Calcutta. This became, and still is, India's most important commercial highway, the Grand Trunk Road, and it ran through Shergotty.

The town is bounded by the parallel rivers Mor and Sor. For millennium, rice, wheat, pulses (peas and lentils), ground nuts, cotton, indigo, tobacco and sugar cane were cultivated on the low surrounding hills. A road ran north twenty miles to Gaya, then on to Patna, a trading hub on the Ganges River with access to the world.

Gaya was a sacred site. Entrepreneurs in Shergotty would offer to guide the visiting faithful the final few miles. Beggars lined the route creating a gauntlet, reminding pilgrims that “the path to Heaven lies through the gateway of charity.”

This confluence of produce, rivers, roads and religion made Shergotty a marketing center.

The regions' original settlers, aboriginal people collectively called *Adivasi,* had historically been allowed autonomy and cultivated the land as a joint patrimony.

But as the power of the British colonialists grew, their territory was divided among non-local landlords. The Adivasi had to borrow to purchase seed and fertilizer and endured high interest rates and taxation. Their poverty became so profound they couldn't afford their only luxury, salt.

Dried and collected from Bengal sea brine ponds, salt was taxed 7.5% by the Raj.

The Adivasi vented their frustration by burning down the houses of the landlords as part of the Indian Rebellion of 1857-58. Amar Singh was their leader and his followers cut off communications and trade in the districts surrounding Shergotty.

W.C. Costley was then the Deputy Magistrate of nearby Sasaram. Costley and his force were being constantly harassed by belligerent villagers while on patrol, so the Commissioner of Patna requested that “European troops now passing along the Trunk Road, this body of 400 or 500 be collected to make a demonstration against Amar Singh so as to drive him into the hills....the police have no power in that quarter whatsoever.”

That same 18 August, 1857 memorandum from Commissioner Samuells to General Sir James Outram revealed the true motive for this essential show of force.

“The second of these objects, pacification of the Arrah District, is of very great importance. On the speedy attainment of this object the opium crop in that district depends, which is worth to the Government not less than half a million Sterling.”

Opium?

The memorandum is specific on where the crop is most threatened.

“Gaya, it is obvious, is in a dangerous position, if the rebel troops from Ramshur should move upon it, the small party there being quite inadequate for its protection... it is not at all improbable that they may avail themselves of the Trunk Road as far as they can...it would seem the safety of Gaya and Shergotty would be, in great measure, secured by a small force from Saseram.”

Does this suggest that insuring the 'safety' of Shergotty was less about protecting its populace from pillaging and all about guarding its opium crop from rebels?

And is this why Mr. Peppe, a British opium agent, was conveniently present eight years later to identify the Shergotty meteorite when Costley could not?

In “The Naval Brigades in the Indian Mutiny, 1857-58”, William Bevill Rowbotham remembers, “One company at a time reached Shergotty, where our company parted with the brigade and proceeded across the country 20 miles to Gaya, the principle town in the opium district of Behar.”

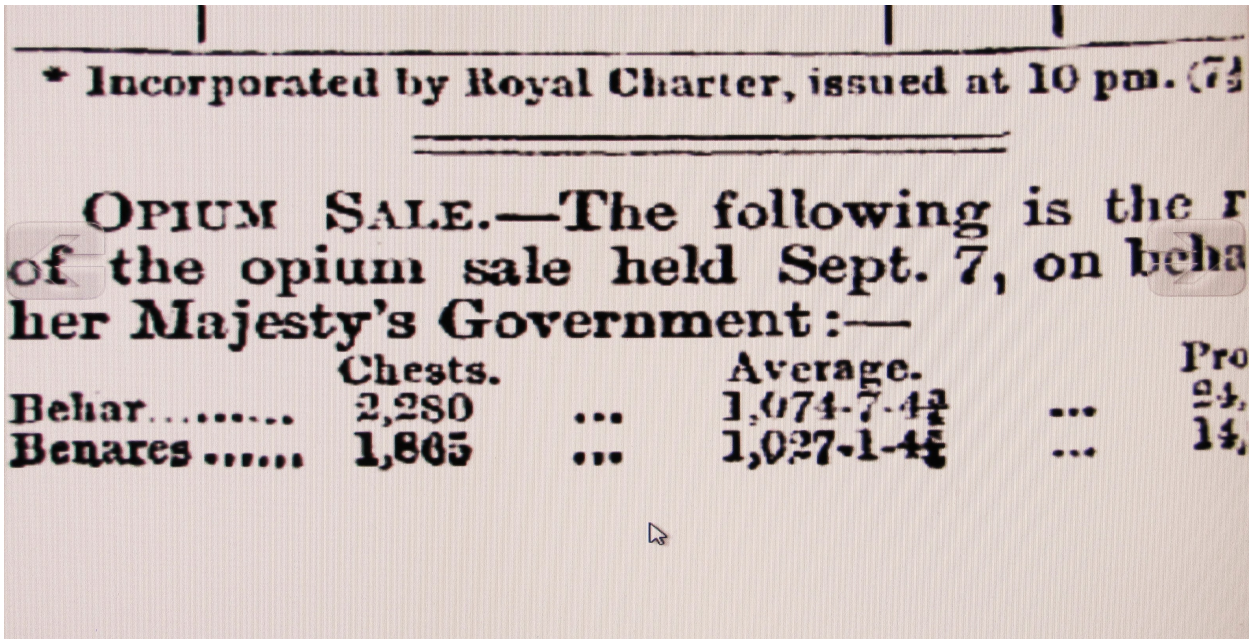
A passage from “The Peasants Armed: The Indian Revolt of 1857” best describes this deployment, “British military formations moved along with the sureness of destroyers passing over a dark and turbulent ocean.”

Once Raj reinforcements arrived, Shergotty's poppy plants were safe from seizure.

Absent the British opium trade, Mars' NWA's would be *zagami-ites*

Europeans coveted Chinese silk, tea and pottery. For these commodities Middle Kingdom merchants accepted payment in silver. English precious metal reserves were being depleted.

Warren Hastings, the first Governor-General of British India had an idea. He offered opium in trade.



* Incorporated by Royal Charter, issued at 10 pm.

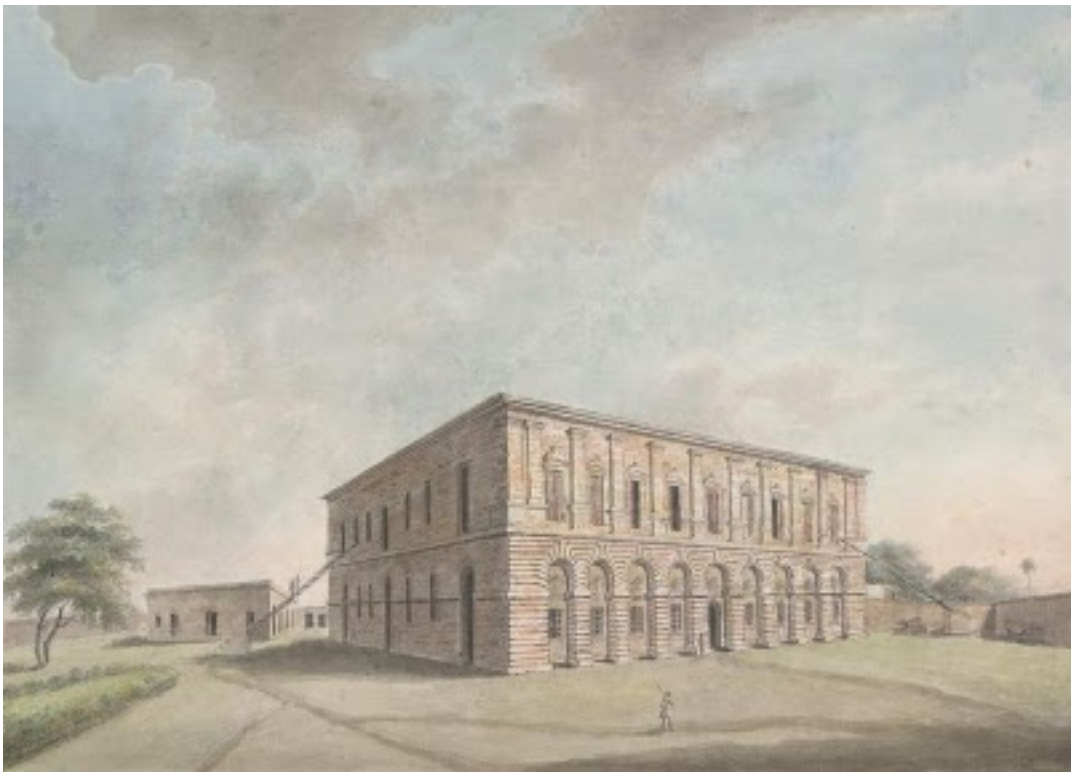
OPIUM SALE.—The following is the r
of the opium sale held Sept. 7, on beha
her Majesty's Government:—

	Chests.		Average.		Pro
Behar.....	2,280	...	1,074-7-4	...	24,
Benares	1,865	...	1,027-1-4	...	14,

A government announcement placed in Allen's Indian Mail during the 1850's

Opium became the engine that enriched English merchants but derailed the Indian economy.

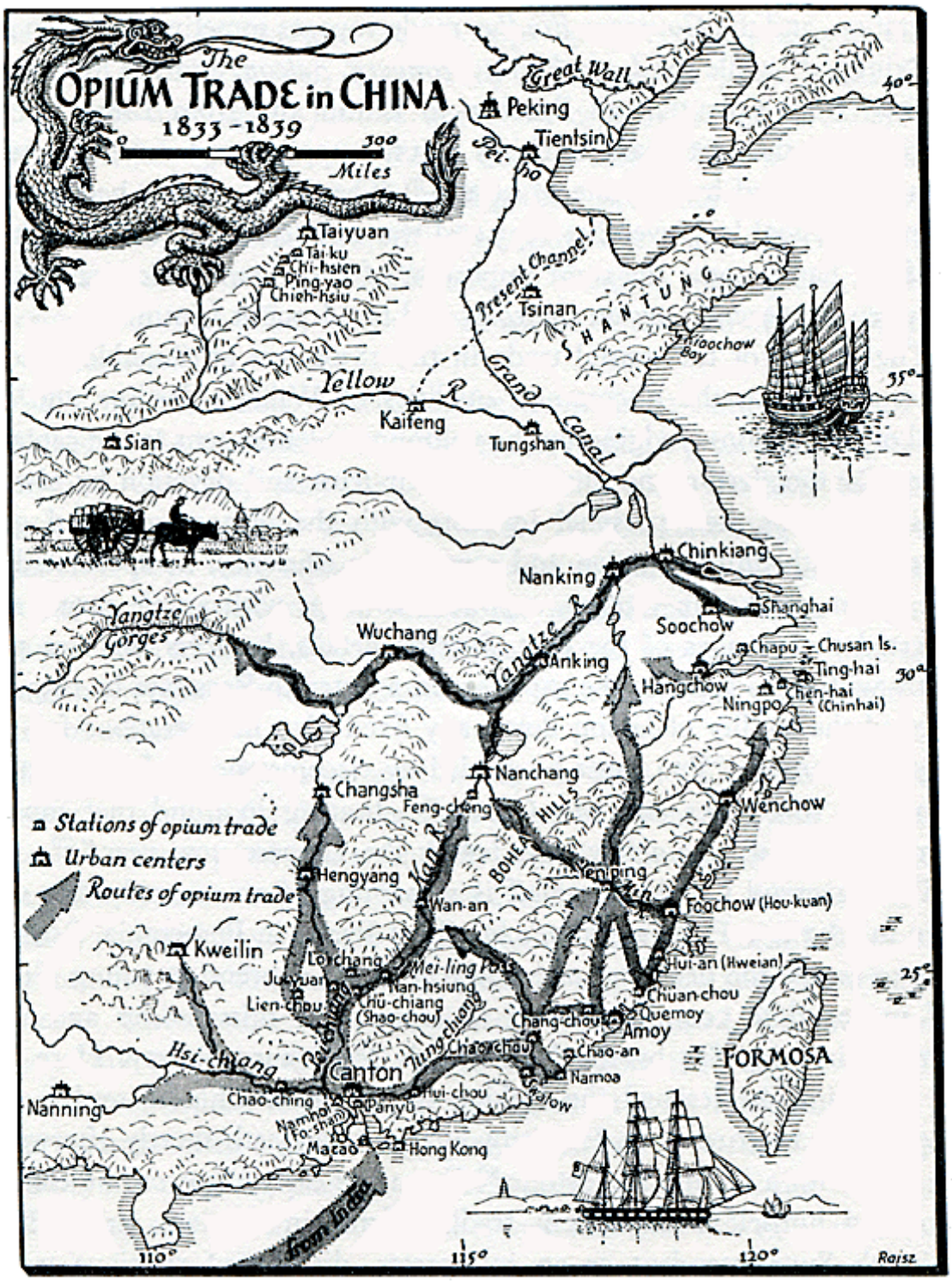
Chinese Emperors demanded an end to this immoral exchange and destroyed thousands of chests of opium.



A "Godown" where the British Raj stored opium prior to sale to the Chinese

Two *Opium Wars* were fought and England twice prevailed. American and French forces aided the British. Chinese rulers grudgingly legalized the drugs' consumption. Hong Kong was surrendered to the Commonwealth as reimbursement for the previously plundered product.

A zone covering 500 square miles in the Ganges River valley was planted to poppies. Patna was the center of collection, refining, storage and transport of product to China.

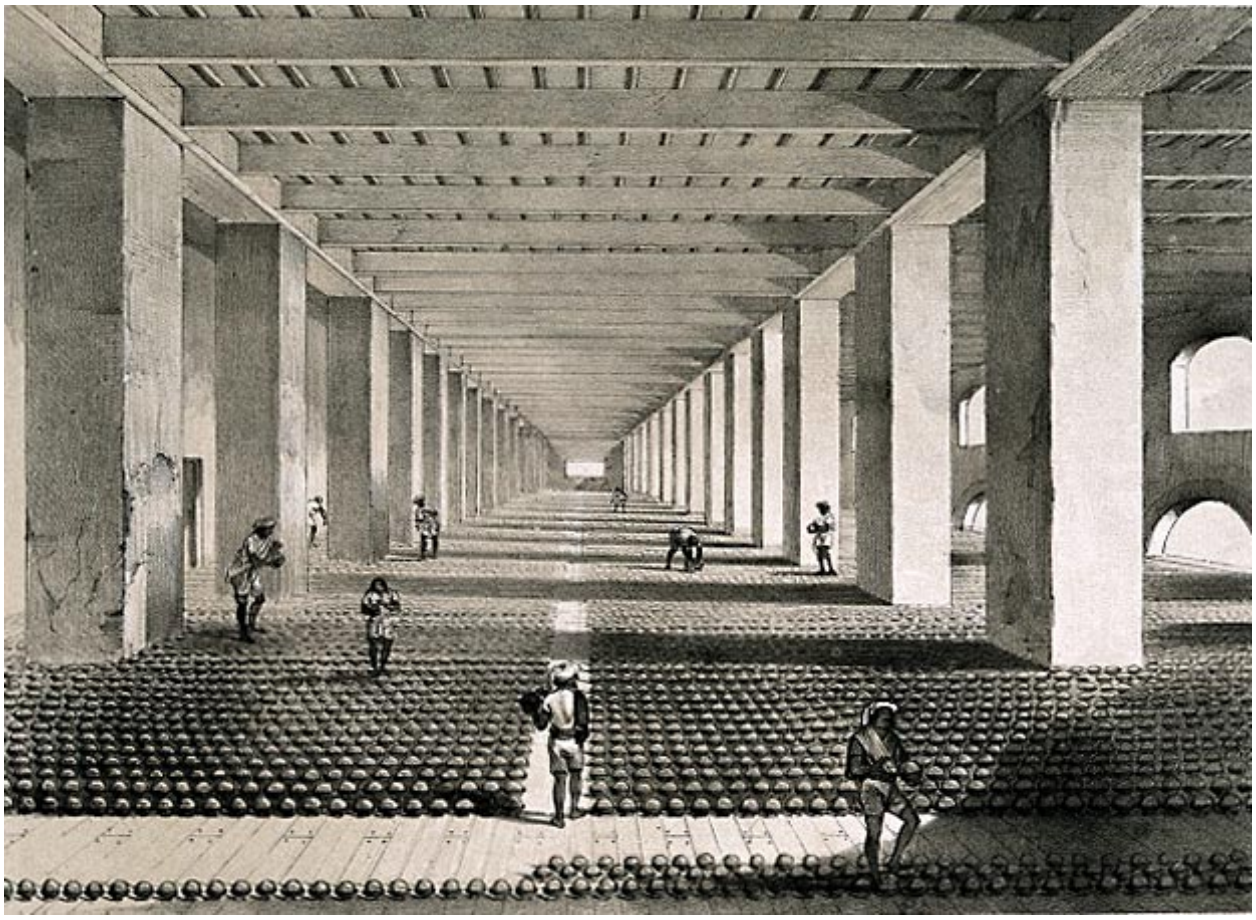


Poppie cultivation was much more profitable for Indian farmers than growing cereals and sugar. They were obligated to sell their crop to the British.

Drying and stacking opium in the Godown

At one point, one million Behar farmers were cultivating poppies on 500,000 prime acres of land. A monoculture was created leaving food crops, even imminently marketable cotton, in short supply.

India suffered periodic mass starvations so that Continental socialites swathed in silk could sip a spot of tea poured into a cup of delicate china.



The world's largest opium refining facility still operates in a red-brick building on 52 acres in Ghazipur, Uttar Pradish, selling pure opium to the world's pharmaceutical companies.

It hasn't change much since 1888, when Rudyard Kipling, reporting for the *Pioneer* newspaper, described the place.

Amitav Ghosh says opium funded the British Raj (Photo courtesy: Wellcome Library)

Kipling himself enjoyed opium for recreation and 'medicinal purposes.'

Export opium is packaged in wooden chests fabricated in Nepal. By tradition, opium is shipped as thirty-one pound balls.

The factory's resident monkeys are not molested as they feed on opium waste, drinking its dregs from the sewage, slumbering where they fall.

“They have become addicted to opium. Most of the time we have to drag them away from this place,” related a worker in a 2008 BBC interview.

Mr. Peppe, the person identifying Shergotty as a meteorite was party to this enterprise, employed as a government opium agent. He would visit growers- now essentially

indentured servants to the Raj - extend credit, supervise planting and inspect the crop, helping to transfer the harvested tar to the 'godown' (refinery/warehouse).

There is but one crop per season. Opium poppies sprout when the monsoon ends.

When Shergotty fell to Earth, it is as likely as not that the meteorite landed in a field being prepped to plant poppies.

A Costley Promotion/ Separating the Links in the Chain of Possession

The nineteenth century periodical *Allen's Indian Mail* gives us access into the life of W.C. Costley, the first British colonialist to handle Shergotty.

He arrived in India with his family on a passenger ship in 1850, assigned to be the “dep. coll. of Chittagong”. His wife and two children departed for London sometime in 1854.

Costley was the Deputy Magistrate in Saseram in 1856, involved in a trial against several 'inhabitants' alleged to have 'plundered' nine rafts of firewood.

Allen's Indian Mail of October 17, 1864 includes this announcement - “By the Lieutenant Governor July 22, No.4, 193 Appointments: The following officers are respectively authorized to perform the duties and exercise the power conferred on district magistrates: … Mr. W.C. Costley, dep. Mag. of Shergotty”.

This may have been a demotion from his post as Deputy Magistrate of Saseram, a more important town and site of the venerated Sher Shah Suri tomb.

Costley took charge of a food relief center in Shergotty, a critical assignment as the rice crop had failed. Only he knows why he didn't distribute the available remaining rice, and as conditions worsened, cholera broke out at the facility.

The next year, a meteorite from Mars found its way into his reluctant hands. According to Costley's report of the fall, he had once seen a meteorite “in the Furreedpore District, which, if I recollect right, was brown in exterior appearance, and the flint or silica, of which iron meteorites are chiefly composed, being distinctly apparent...”

While no iron meteorites fell there, surely we can forgive him for not knowing that a somewhat friable, granular volcanic stone from the fourth planet is akin to the stainless-steel heart of an asteroid.

It appears that Costley relinquished the Shergotty meteorite to his supervisor, the Officiating Secretary to the Government of Bengal, Steuart Colvin Bayley. A graduate of Eton and Haileybury, he arrived at his post in March, 1856.

S.C.Bayley became the Commissioner of Patna, the principle opium processing center, during the Bihar Famine of 1874. As Lieutenant Governor of Bengal, in 1888 he

famously 'rejected the proposal outright' to unite the Orissi territories, leaving them economically disadvantaged.

Medals awarded to S.C. Bayley, Lieutenant Governor of Bengal

In this Mars-struck assemblage of bureaucracy it was then-Lieutenant Governor of Bengal Cecil Beadon who ordered the rocks to London. During his disastrous four year assignment, his attempt to regulate the nascent Assam tea trade caused it to collapse. His misguided diplomacy instigated a war with neighboring Bhutan. Beadon under-estimated the size of the starving masses during the Orissi Famine of 1866 and four to five million people died over two years.

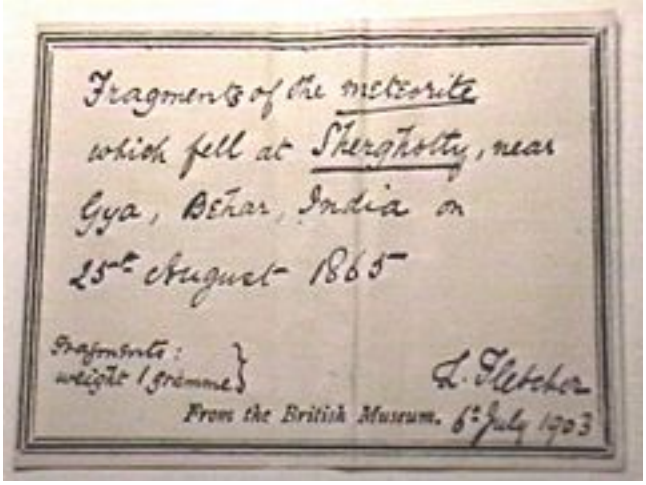
Though Bayley politely relayed Beadon's orders, Thomas Oldham of the Asiatic Society of Bengal did not immediately forward any Shergotty to Nevil Story-Maskelyne in London.

Inside the Rock

British museum documents record that the Trustees of the Indian Museum distributed specimens of Shergotty, Gopalpur H6, Khetri H6, Pulsora H5 and stone meteorite Moteeka Nugla to London during 1867-1870. While London received two Shergotty specimens weighing 62 and 55 grams, there's no indication that Story-Maskelyne even gave them a cursory glance.

The Museum in Vienna received 183 grams in 1867. At a meeting of *His Majesty's Academy of Sciences* on February 22, 1872, G. Tschermak presented the results of his analysis of Shergotty.

He writes of the sample being a single, roundish and angular specimen with fusion crust on three sides. “The crust is pitch-black and glossy, resembling the crusts of Stannern, Juvinas, Jonzac....it is likely that the stone belongs to the group designated as eucrite(s) by G. Rose.”



Shergotty label signed by Keeper of the Minerals Fletcher
(Courtesy Al Lang)

In thin section, Tschermak found five different minerals; an augite-like mineral, a yellow-silicate, magnetite, troilite, and a new mineral - *maskelynite*.

Maskelynite was composed of "colorless, small glassy grains of shell-like cleavage... recognizable only in thin section." He considered it "fused feldspar making up 22.5% of the meteorite."

As a mineral of this composition had never been previously described, "May I take the liberty to propose the designation of 'maskelynite' for this new meteoritic mineral in honor of Mr. N.S. Maskelyne in London who so successfully applied the method of the partial mineralogical and chemical analysis to meteorites and thus opened new territory in the field of meteoritics."

Also found in a few chondrites, maskelynite- shocked plagioclase - has become the signature mineral of meteorites from Mars.

Charles Meyers' *Mars' Meteorite Compendium* also gives Tschermak credit for observing magnetite in Shergotty, stating, "this... indicates a relatively high degree of oxidation at the time of crystallization."

While encouraging the reader to easily track down the geologic history of this meteorite, one other intriguing discovery regards Tschermak's "yellow-silicate".

Workers El Goresy et al. (1996, 1997, 1998) and Sharp et al. (1998) found "silica grains in Shergotty consisting of two phases: (i) a dense amorphous silica glass, and (ii) a post-stishovite polymorph of SiO2."

This polymorph found in Shergotty, Zagami and other shergottites Goresy's group named '*seifertite'*, honoring Friedrich Seifert (founder of the Bayerisches Mineralogical Association) who was a specialist in high pressure geoscience. It is predicted that

seifertite is formed by “shock-induced solid-state transformation of either tridymite or cristobalite (terrestrial volcanic minerals) on Mars.”

The discovery of this mineral opens a discussion about whether seifertite may also exist deep within our own planet.

Hap McSween of the University of Tennessee opined,"it is kind of amazing after more than two decades we are still finding out new things from this one meteorite rock of Shergotty from India."

After Shergotty fell, no more shergottites were recovered until 1962 when Zagami startled a Nigerian farmer calling home his cows.

Since then, assorted shergottites have been found in Antarctica, Africa and the Middle East. Bob Verish's LA001/002 pairing were probably recovered in the Mojave desert of California.

In the 1980's L.E. Nyquist, A.M. Vickery and H.J. Melosh developed models to transfer Mars rocks blasted off the planet's surface into space. Researchers believed they escaped Mars' gravitational field through a physics-constrained doorway, but no one could be 100% sure.

Then one day, Opportunity knocked.

On Mars

Sol 1 for the mission was January 24, 2004.

Secure on the surface after a protective airbag dangerously scrunched a Meridiani Planum rock during the landing, the rover Opportunity phoned home from within a crater called Eagle, hard on the Martian equator, deliciously close to a field of 'blueberries' – hematite inclusions associated with liquid water.

On Sol 67, the spacecraft's Mössbauer spectrometer zapped that small boulder now cleverly named “Bounce”.

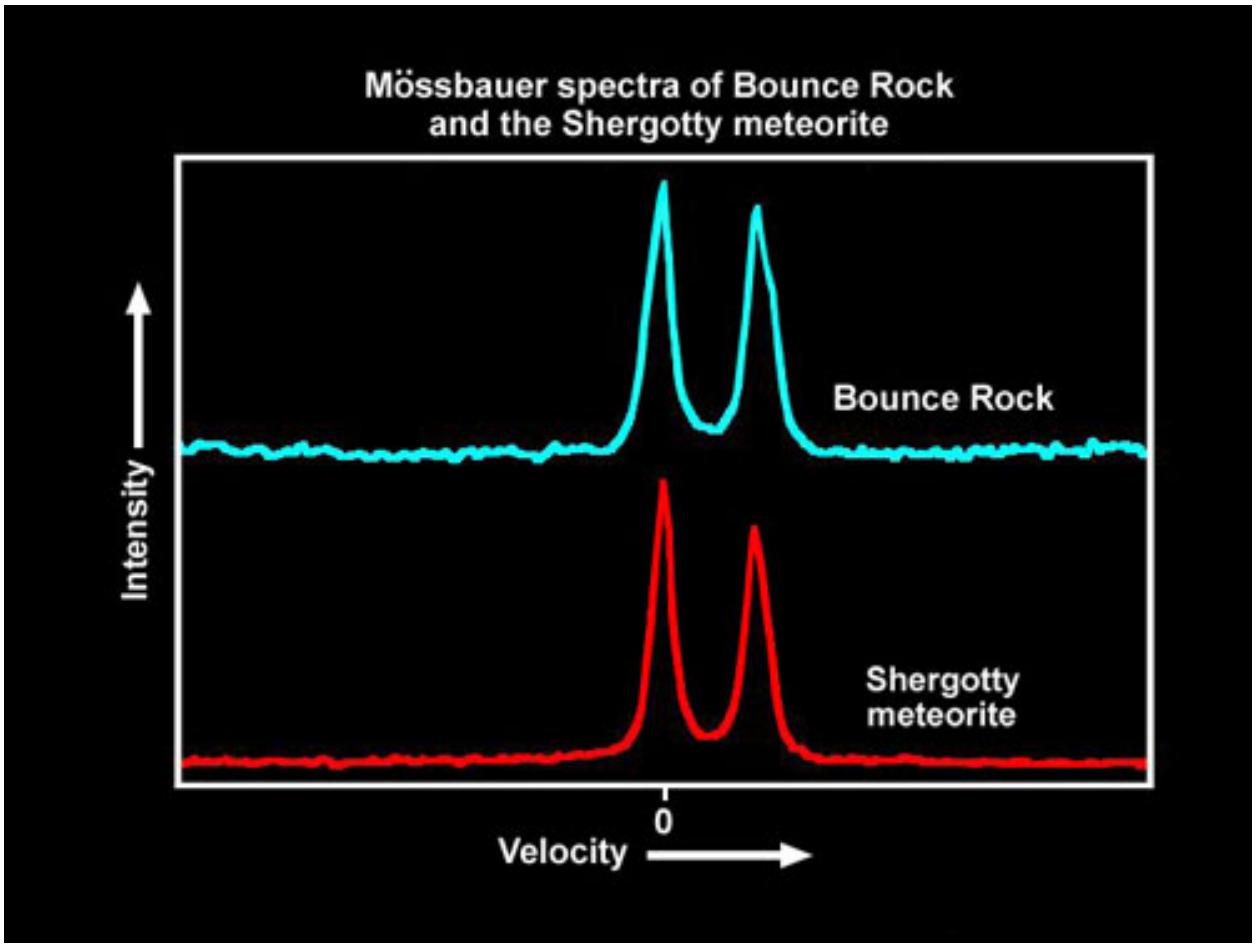
Bounce was targeted for investigation because it didn't belong there, an alien to the soil upon which it rested. NASA researchers believe it traveled about fifty kilometers following a large meteorite impact that created a twenty-five kilometer-wide crater to the southwest.

Courtesy JPL/NASA

The results of the X-Ray were conclusive. Bounce's pyroxene and plagioclase signature lacking olivine closely matched the Shergotty meteorite, but was a twin to Lithology B of Antarctic shergottite EETA 79001.

It was the first time that an orbiter or surface mission had found a rock on Mars matching a Mars' meteorite recovered on Earth.

Elephant Moraine 79001 was the lead actor in the 1983 Bogard and Johnson thriller, “Martian gases in an Antarctic Meteorite?” This meteoritical equivalent of *Genesis* affirmed that certain meteorites originated on Mars.



I cannot improve upon their words.

“Significant abundances of trapped argon, krypton, and xenon have been measured in shock-altered phases of the achondritic meteorite Elephant Moraine 79001 from Antarctica. The relative elemental abundances, the high ratios of argon-40 to argon-36 (equal to or greater than 2000), and the high ratios of xenon-129 to xenon-132 (equal to or greater than 2.0) of the trapped gas more closely resemble Viking data for the Martian atmosphere than data for noble gas components typically found in meteorites. These findings support earlier suggestions, made on the basis of geochemical evidence, that shergottites and related rare meteorites may have originated from the planet Mars.”

In the beginning...

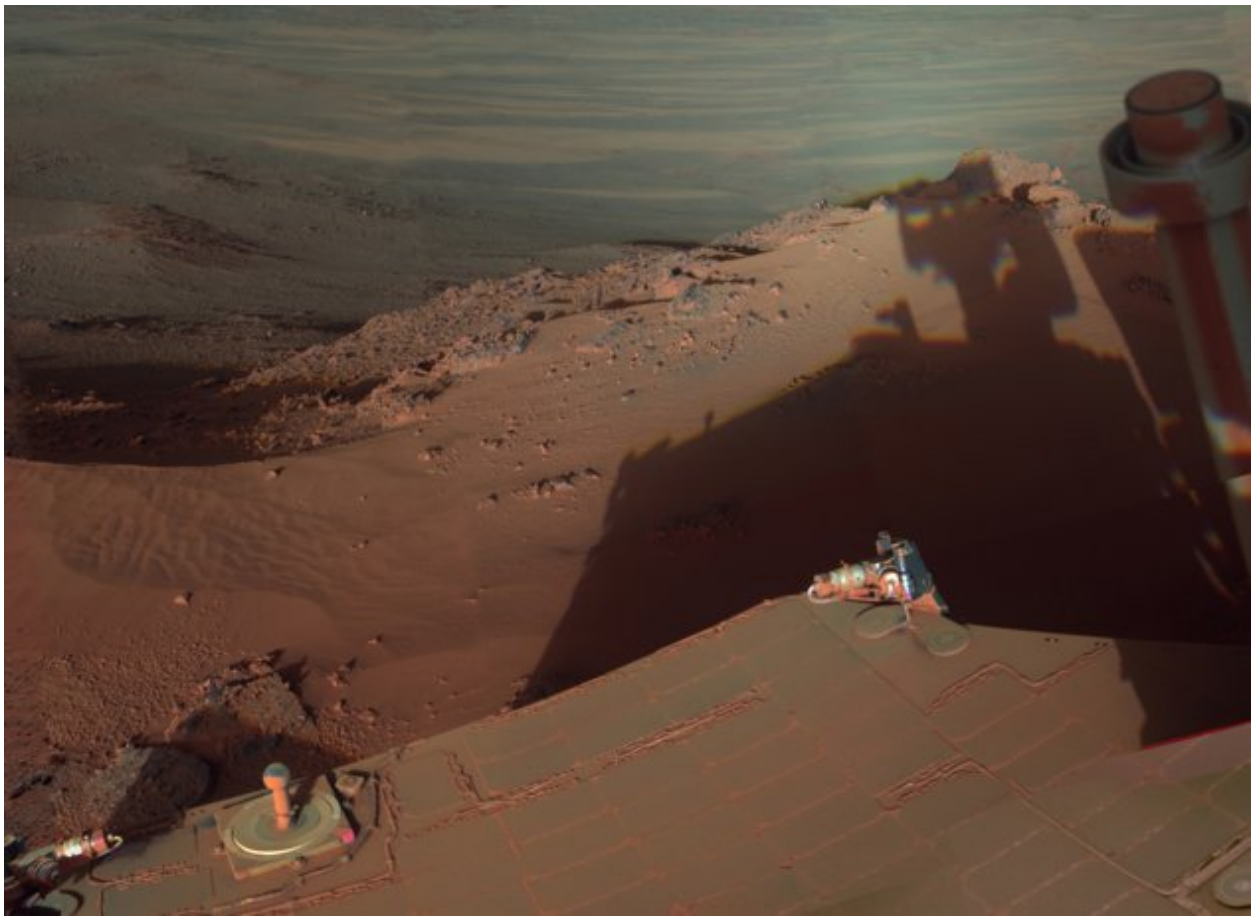
As I write, more than eight years and 34 km after its mission commenced, Opportunity sits tonight on the rim of Endeavor Crater at an outcrop called "Greeley Haven", it's energy-generating solar panels precariously covered in dust.

It's Mössbauer spectrometer runs on cobalt-57 which has a nine-month half-life. Its work identifying minerals normally takes less than an hour, but with its radioactivity depleted, mineral identification now requires a month-long hug.

Upon arrival at Endeavor, Opportunity spotted hydrated calcium sulfate. Steve Squyres of Cornell University proclaimed this "the clearest evidence for liquid water on Mars that we have found in our eight years on the planet."

For now, the rover will sit still on a slippery slope soaking in the sun, the breeze cleaning its panels, passing the time looking for Mars's molten core. But the nights will shorten, the sols will lengthen.

And Opportunity will hit the road again.



The shadow of Opportunity... (courtesy JPL/NASA)

The Fall of Shergotty

During the month of Bhadro in the Bengali calender year 1272, a meteorite from Mars ended its journey to Earth.

The peak of the monsoon in Shergotty, India is hot, cloudy and rainy. On 25 August, 1865 at about 9am, following a 5:27am sunrise likely obscured by clouds, Hanooman Singh witnessed the fall of Shergotty.

Shergotty's Deputy Magistrate W.C. Costley dutifully recorded Singh's story, “... a stone fell from the heavens, accompanied by a very loud report, in some upland appertaining to Mouzah Umjhiawar, burying itself in the earth knee deep, and at that time the sky was cloudy and of a dusky colour, the air calm, and no rain.”

The report to the Asiatic Society of Bengal tells little more of Hanooman Singh, except that he resided in Thannah Nubbeenuggur. Mid-nineteenth century Raj records list a post office there within a reasonable commute to Shergotty.

Bearing the last name of 'Singh', it's likely the witness was a Sikh practicing his religion by leaving his hair long, wearing an iron bracelet, and keeping a sword tucked into a garter strap. He might have worn a turban.

The foundations of Sikh belief are the principles of truth, equality, freedom, justice and Karma.

And a noble bolt of Karma dignifies this fall as sobriquets 'Shergotty' and 'Singh' both have roots deriving from the noun 'lion'.

Although Costley was schooled on Story-Maskelyne memorandums, he failed to obtain answers from the witness to questions regarding “what appearance the aerolite presented, whether it fell obliquely or straight down, and whether the stone was enveloped in fire or not, how soon after the stone was taken out of the earth, and if it were warm or cold..."

There is no information on how Singh extracted the meteorite from the hole or about his reasons for passing it on to the authorities. Being the lone witness, he could have done anything. Or nothing.

Costley continues, “when examined, the stone was found to be broken in two pieces, but it reached me in three pieces, I imagine that the smaller piece must have been chipped off by some accident afterwards. This piece is in the possession of Mr. O'Connor, Assistant Superintendent of Police, who will, no doubt, willingly make it over to you if required.”

Why did Costley give fragment #3 to O'Connor?

Reviewing the Indian Museum holdings, it appears that this piece is lost.

“The latitude and longitude of the spot where the aerolite fell, can, I fancy, be approximately obtained from the knowledge of its position with reference to known localities. But this information, which I do not at present possess, together with the replies to the queries put by me and noted above, will have to be furnished hereafter, as they appear necessary to make the report more ample, and can conveniently form an addendum to it.”

A thorough search of cyberspace's cobwebbed attic does not reveal this addendum.

Next to an asterisk at the bottom of the page in the *Asiatic Proceedings* where Costley's report was noted we learn, “The weight of the two pieces received is 11 lbs. 2 ozs. 368 grs.”

There are 6.48 grams per 100 grains. This will bring the TKW (total known weight) of the fall to 5069.46 grams or 69.46 grams more than the five kilos commonly cited in the literature.

F. Fedden inventoried Indian Museum meteorites in 1880 and 4642 grams of Shergotty remained in the collection. Through gift or exchange, 100.44 gms. (Paris), 117 gms. (London), and 183 gms. (Vienna) were subtracted prior to this weigh-in. Adding these back brings us within a few grams of Costley's original TKW.

The Geological Survey of India (GSI) lists the coordinates of the fall at 24º 33' 00”N, 84º 50' 00” E.

Upon the suggestion of Dr. L.J. Spencer, Keeper of the Minerals of the British Museum, in 1932 C.A. Silberrad, B.A., B.Sc. of the Indian Civil Service (Ret.) reviewed the entire inventory of Indian meteorites “and as far as possible, verified and corrected the recorded places of the fall of all reported Indian meteorites.” He concurs with the GSI locale east of Shergotty and twenty miles SW of Gaya.

At an 800' altitude bird's-eye perspective, *Google Earth* presently shows the area to be a patchwork of small individual farms, the terrain flat to rolling and not indicative of the

“upland” described in Costley's paper. From that height, poppy cultivation can not be confirmed.

The Shergotty story was picked up by the Calcutta Gazette and mentioned again in the 1866 “Report of the 36th Meeting of the British Assoc. for the Advancement of Science”.

An historical note, Roderick Murchison was a permanent trustee of that association. A river and town in Australia bear his name, as does a certain CM2 carbonaceous chondrite that fell in 1969.

Saving Shergotty

The actors in this play, until now unperformed gracenotes in the conductor's score, have taken their bows. But the star of the show remains behind the curtain.

He is mentioned but once in W.C. Costley's report on the Shergotty fall. When Costley couldn't tell the rock from a hard place he showed it to another employee of the British Raj.

“... but I find from Mr. Peppe, the Sub-Deputy Opium Agent, that there can be no doubt of its being a true aerolite...”

No doubt at all.

And with that certainty, Mr. Peppe saved Shergotty.

As I worked to bring the people involved with this meteorite back to life, Mr. Peppe stubbornly remained anonymous.

But while reading archived docs about India's nineteenth-century agricultural practices, I found an 1883 reference to a “Mr. T.F. Peppe”, regarding the “cultivation and curing of tobacco in Bengal”.

“The people smoke hookas, and the Behar tobacco is considered very superior to the local narcotic for that purpose.”

The local narcotic was opium. The tar-like substance would hopelessly clog cloth hooka tubes.

A search adding 'T.F.' in front of 'Peppe' uncovered a Raj Renaissance Man... even a mention on Facebook!

But whatever names the 'T' and 'F' abbreviate remains a mystery for another day.

Peppe understood the significance of the area's megalithic sites and communicated their locations to E.T. Dalton in 1873. “There is news that one Mr. T.F. Peppe, a deputy sub agent of the British government, was perhaps the first person to record the finds of megaliths in Sherghatti, Bundu, Tamar, Burunda, and Chokahatu.”

A photo taken by Peppe called “Barabar Hills Cave Entrance – Buddhist Sanctuaries from 3rd century B.C.” is in the British archives, quite an accomplishment for an amateur humping bulky equipment around rural India, pre-Kodak.

Mr. Peppe attempted to start a cottage industry to uplift the indigenous population. An 1887 issue of *Nature* reveals his efforts to collect cocoons of the Tussar worm to cultivate 'wild silk'. “All of the aboriginal tribes of India would be available for this work,” he enthusiastically suggested. Peppe had a head start, having collected cocoons for three years.

Now Mr. Peppe long lies still, his contributions to agriculture and archeology noted in the literature. But his epitaph is incomplete, his legacy worthy of a more appropriate tribute.

I propose that the next important geologic site on Mars bear his name.

After all, he saved Shergotty.

****

In August 2012, Dr. Jeff Grossman of the USGS informed me that the following proposal has been accepted for consideration by the commission reponsible for naming geological features on the Red Planet (the Mars Science Laboratory):

"A nomination to honor the person responsible for identifying Mars meteorite Shergotty and designate a geological feature on Mars to bear the name T.F. Peppe.

Shergotty is the namesake meteorite for the largest (by number and weight) class of martian meteorites, shergottites."

The Rise of the Raj and the Fall of Shergotty – What it Means to Me

The show is over but the band plays on, completing it's encore, hailing the final curtain call for this 'theater from the sky'. I'm out of popcorn, but before I exit, stage left, I'd like to share some thoughts.

Shergotty is a Mars rock instrumental in research so we can begin to understand planetary processes.

It's displayed in museums and awes the public.

We cognoscente treasure its representation in our collections.

This is possible only because of Shergotty's timely identification by a Raj opium trader in 1865.

For me, meteorites are the conveyance that take me places no *Travelocity* bargain ever will. As I ponder the people, places and science involved with these rocks, discovered truths unveil the Universe and conjure magic. I touch infinity.

Over the years I've acquired Shergotty for my collection. I can hold in my hands something from the time of the Raj, know that someone named Hanooman watched it fall and unknowingly dug it out of the exhausted Indian soil for me. Holding it, I inoculate myself with the DNA of W.C. Costley, Tschermak, S.C. Bayley, Thomas Oldham, Nevil Story-Maskelyne … even T.F. Peppe himself.

But this event horizon stretches to Mars. For I also have in my hands a piece of another planet, a place where I shall never go except in my waking dreams. Taken together, this is why I consider the study and collection of meteorites the most pleasurable pastime.

****

Eleven years have passed since an anonymous librarian at the University of Edinburgh, Scotland responded to my message-in-a-bottle, locating and mailing me the Asiatic Society 'Proceedings' from 1865 containing the lost secrets of Shergotty.

Joel Schiff, the former publisher of Meteorite, reviewed these pages for dutifully dotted eyes and correctly crossed tees. He gently constrained my youthful poetic exuberance while utilizing his doctoral-level math skills to keep Shergotty's total known weight, totally correct. Thanks, mate!

I'm prouder than a Babu with a belly full of Vindaloo to again have Dorothy Norton in my kitchen keeping the curry cookin' with spicy illustrations full of local flavor.

References for
“The Rise of the Raj and the Fall of Shergotty”

American Educational Monthly #1 vol. III, January, 1866.

Allen's Indian Mail vol. VIII, Jan-Dec 1850, p.581.

Allen's Indian Mail vol. XII Jan-Dec, 1854 p 67.

Allen's Indian Mail, October 17, 1864.

Bogard D.D.and Johnson P. (1983) 'Martian Gases in an Antarctic Meteorite'. Science 221, pp.651-654.

British Museum (NH) 'An introduction to the study of meteorites: with a list of meteorites represented in the collection' 1894.

Buckland E. 'eBook dictionary of Indian Biography' London, originally published in 1905.

Caillet-Komorowski C.L.V. 'The Meteorite Collection of the Natural History Museum in Paris, France' 2006.

C.A. Silberrad, B.A.,B.Sc. 'List of Indian Meteorites (Communicated by Dr. L.J. Spencer, F.R.S., read November 1, 1932) ' pps. 291, 295.

Catalog of Meteorites (1914) Geological Survey India.

Chaturvedi R. 'Bihar through the ages' 1959.

Clarke F.W. 'Met. Coll. In the US Nat Museum' November 1, 1886.

Das A.C. 'The Indian Ryot' 1881.

Farrington O.C. 'Meteorites, their structure, composition and terrestrial relationships' Field Museum, Chicago 1915.

F.Fedden 'Popular Guide to the Geological Collections in the Indian Museum Calcutta' 1880 p.194.

Ghosh A. 'Opium financed British Rule in India' June 23, 2008 http://news.bbc.co.uk/2/hi/south_asia/7460682.stm

Ghosh A. 'Sea of poppies' Macmillan Picador Press 2008.

Goresy A. Dera P. Sharp T. et.al. 'Seifertite, a dense orthorhombic polymorph of silica from the Martian meteorites Shergotty and Zagami' Eur. J. Mineral 20, #4, 2008 pp. 523-528.

'India – Opium' GlobalSecurity.org

Lyett A. 'Rudyard Kipling' 1999, pp 96-97.

Mars Exploration Rover 'Bounce and Shergotty share common ground'. http://marsrovers.jpl.nasa.gov/gallery/press/opportunity/20040414a.html

McSween H. 'Re-examination of the meteorite rock of Shergotty at Gaya' Times of India, August 5, 2001.

'Megaliths of Jharkhand' http://megalithsofjharkhand.tripod.com/id1.html

Melosh H.J. 'Ejection of rock fragments from planetary bodies' Geology 13, pp.144-148, 1985.

Merrill G. 'Handbook and Descriptive Cat. of the Met. Coll. Of the USNM' Bull. 94, 1916.

Meyer C. 'Mars Meteorite Compendium'- Revision C 'Shergotty' NASA, JSC #27672

Murthy V.N. Srivastava S.N.P. Dube A. 'Indian meteorites' Geol.Surv.India Memoir 99, 172pp. 1968.

Nair S.P. British Soc. 'For the History of Science' 39(1):97-119, March, 2006

Newton H.A. 'The worship of meteorites' Amer. Journal of Sci and Art, 4th series vol. 3. pp.1-14, 1897.

Nyquist L.E. 'Do oblique impacts produce martian meteorites?' J. Geophys. Res. 88 (suppl.) A785-A798, 1983.

'Opium' 1911 Classic Ed. of the Encyclopedia Brittanica, 2011.

'Opium Wars' Wikipedia.org

Peppe T.F. 'Letter' Nature p.256, January 13, 1887.

Prior G.T. 'Catalog of Meteorites' 1923.

'Proceedings of the Asiatic Society of Bengal, for December, 1865' pp. 193-199.

'Report of the 36th Meeting of the British Assoc. for the Advancement of Science, held at Nottingham August, 1866'.

'Reports of Cases Determined in the Court of Nizamut Adawlut for 1857' Calcutta vol. VII, parts 1&2.

Richards J.F. 'Opium and the British Indian Empire: The Royal Commission of 1895' November 15, 2001.

Rowbotham W.B. 'The Naval Brigades in the Indian Mutiny, 1857-58' published 1947.

Samuells 'Memorandum for General Sir James Outram Patna, India, August 18, 1857'.

'Sherghati' Wikipedia.org

'Shergotty (GSI Registration No. : S-179)'.

Stokes E. 'The Peasants Armed: The Indian Revolt of 1857' re-published 1986.

Tewary A. 'Inside the world's largest opium factory' July 21, 2008 http://news.bbc.co.uk/2/hi/south_asia/7509059.stm

The Academy and Literature vol.2, p. 540, 1871.

'The Cultivation and Curing of Tobacco in Bengal, 1874'.

The New Englander/New Haven and Yale Review vol. XXVII p.134, 1868.

Tschermak G. 'The Meteorites from Shergotty and Gopalpur (presented at the meeting of his Majesty's Academy of Sciences 22 February, 1872'.

Vickery A.M. and Melosh H.J. 'The large crater origin for the SNC meteorites' Science 237, 738-743, 1987.