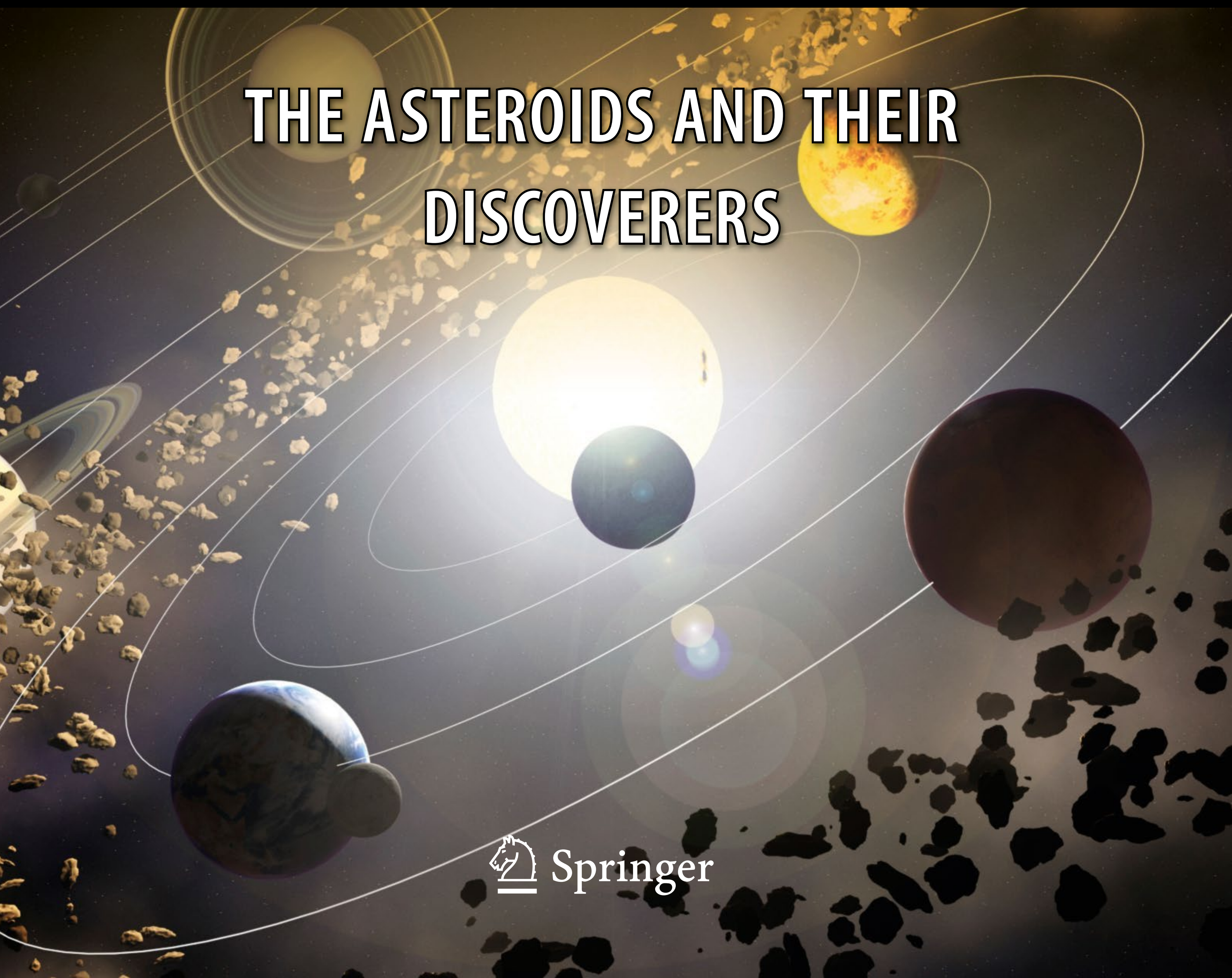
PAUL MURDIN

Rock Legends

THE ASTEROIDS AND THEIR DISCOVERERS



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Chapter 1

My Asteroid, My Book

Fig. 1.1 Chelyabinsk bolide. The trail of smoky dust left by the Chelyabinsk bolide as it passed over the city and exploded (Illustration by Nikita Plekhanov. Used with permission)

ARRESTED DEVELOPMENT OR CHIP OFF THE OLD BLOCK?

Orbiting somewhere in the space between the planets Mars and Jupiter there is a big rock on which there is the name of this writer, Paul Murdin, (128562) Murdin.[1] The rock is called "(128562) Murdin." It is the 128,562nd asteroid in the census of confirmed asteroids. (An asteroid's number in the list is placed in parentheses before its name.) It was discovered on August 10, 2004, by the Lowell Observatory Near-Earth Object Search (LONEOS) at the Anderson Mesa Station in Arizona. When it was discovered and its orbit was first determined, it was given an earlier, provisional catalog number: 2004 PM90. The designation has my initials in it, which is why this particular asteroid was chosen for me. An asteroid was seen near the expected places in the orbit of 2008 PM90 during the next season for being able to view it, so it was safe to assume that it was my asteroid seen again. In fact, my asteroid has been seen and measured over 100 times since discovery. This means that its orbit is well determined. Because its orbit is well known, my asteroid can be tracked indefinitely by any astronomers who become interested in it. They will not be able with an Earth-based telescope to see its surface—it will be just a point of light like most other asteroids—so it will be impossible to recognize its features. But because it is in the right place at the right time, it can be recognized indefinitely into the future. Thus, it has become recognized as a permanent entry on our census of the Solar System. That is how it has been given its accepted status and not only re-numbered but also named as asteroid (128562) Murdin.

The Jet Propulsion Laboratory in Pasadena, California, keeps a Small-Body Database that lists and shows the orbits of minor planets and comets, and other data. You can visit the database at http://ssd.jpl.nasa.gov/sbdb.cgi. The International Astronomical Union sponsors the Minor Planet Center in Cambridge, Massachusetts, with pages of data on minor planets at http://www.minorplanetcenter.org/iau/mpc.html.

Asteroids are minor planets. Within our Solar System there are eight planets recognized as such by astronomers, namely Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune, all of them large, solid and gaseous bodies orbiting the Sun. There are also innumerable, considerably smaller, solid, icy bodies orbiting the Sun; these include asteroids, which are icy rocks, and comets, which are dirty lumps of ice. The modern, technical name for all these objects is "small Solar System bodies." The early, still common and more elegant, but now informal, name for them is "minor planet," which I often use in this book.

Some minor planets jaywalk across the orderly, almost circular flow of the normal traffic of planets in the Solar System. Accidents happen, and sometimes a planet and a minor planet collide. The collision could be a small bump or a devastating crash.

[1] Where possible, the number and name of any asteroid that is named after a person will follow that person's name. See the JPL Small Body Database, referred to above, for further biographical details about the person, such as dates of birth and death.

P. Murdin, *Rock Legends*, Springer Praxis Books, DOI 10.1007/978-3-319-31836-3_1

The smallest collisions between minor planets and Earth are called "meteors." If a very small minor planet (less than pea-sized) collides with Earth, it burns up in the atmosphere, causing a streak of light. Its dust drifts unidentifiably to the ground, adding a hidden cosmic zest to the carrots that grow in the garden. At the present time about 40,000 m. tons of meteorite dust fall on Earth each year, but of course it is spread thinly and hard to identify on the ground. High-flying aircraft, exposing sticky material to the air like flypaper, can catch meteor dust. A lot of it is ground up bits of asteroids; some of it is dirt loosened from the ice of comets when they melted.

If a larger asteroid (pea- to pebble-sized) collides with Earth, it will make a very bright meteor (a "fireball"). A boulder-sized asteroid (called a "bolide") may break up as it traverses the atmosphere and fracture into many pieces that run parallel as they streak through the sky.

The most dramatic bolide of recent times was the meteor that entered the atmosphere at a shallow angle over Alaska, streaked across the sky in a 30 s journey, and disintegrated over the city of Chelyabinsk near the Ural Mountains in central Russia on February 14, 2013. It was recorded by many Russians who had video cameras mounted on their cars (as a measure to record road incidents). Leaving a white trail in the sky (Fig. 1.1), the Chelyabinsk bolide seemed as bright as the Sun as it exploded at an altitude of about 35 km (20 miles). It carried an explosive power equivalent to ten times the atomic bombs of the Second World War. The boom of the explosion broke windows in numerous buildings and knocked people over; flying glass and other debris injured about 900 people. The asteroid that became the meteor was probably about 17 m (55 ft) in size with a mass of 10,000 m. tons. The event was of a size that occurs once per century on average. There was no warning of this event, because the asteroid was too small to be detectable at a distance large enough to be able to see it coming before it arrived.

Another well-recorded bolide of recent times was the Peekskill bolide, which flew eastwards across Kentucky, North Carolina, Maryland and New Jersey at 8 o'clock in the evening on October 9, 1992. It was witnessed by many Americans, some of them watching football games with video cameras in their hands, and at least 16 video records are known. The ill-fated space shuttle *Columbia* took on the appearance of a bolide when it disintegrated on re-entry in 2003.

Some pieces of a bolide may fall to the ground. What might then be found is typically a stony or metallic lump of rock called a "meteorite." Pieces of the Russian bolide were collected from the ice-covered ground and from a lake at the end of the trajectory of the largest piece, which had a mass of 654 kg (1442 lb). The Peekskill bolide ended up as a 12.4-kg (27-lb) meteorite that plunged through the trunk of a red Malibu coupe car, one of the few cars whose value has been increased by dented bodywork.

Between 18,000 and 84,000 meteorites bigger than 10 g (one third of an ounce) fall on to the surface of Earth each year. Most sink to the bottom of the ocean, hide in vegetation or become mixed into the litter of rocks on the ground and are never found. Meteorites are very easy to spot when they land on an ice-field. That is why most of the meteorites that have been collected have been picked up in Antarctica. The largest known intact meteorite was found, buried, by a farmer ploughing his land on the Hoba West farm in Namibia. The Hoba meteorite is shaped like a flat slab, $3\times3\times1$ m in size ($9\times9\times3$ ft), and its mass is more than 60 m. tons. It fell perhaps 80,000 years ago. It still lies where it fell, exposed in a crater. The crater is however not a meteor crater, excavated by the fall. It is an amphitheater that has been dug around the meteorite, the better to display it to tourists and school parties.

If an even larger minor planet collides with Earth, one larger than say 50–100 m (150–300 ft) in diameter or more, it will puncture a fiery hole right through the atmosphere and, if it impacts on the ground, it will do so with such force that it makes a crater. There are a few hundred meteor craters on Earth; it is hard to be precise about the number because the weather and other erosion processes work over geological time to make craters hard to recognize. The Barringer meteor crater near Flagstaff in Arizona is 1.2 km (4000 ft) in diameter and was the result of a recent strike, only about 50,000 years ago, of an asteroid of that size. The plain around the crater is littered with fragments of the asteroid that made it; many fragments have been collected, and there are fewer now than there used to be.

If the minor planet is smaller (10–100 m in size, 30–300 ft), or made of rather weakly bound rock (perhaps bits of solid rock, frozen together with a lot of ice), it might disintegrate in the atmosphere, but in doing so it might cause an airburst with enough power to cause local damage. A minor planet (or comet) about 30–40 m (100 ft) in diameter created an airburst over the Tunguska River in Siberia in 1908 that stripped the branches off all the trees below, and toppled many, for a radius of 4 km (3 miles). The toppled trees are still visible today. The Tunguska bolide caused damage in the forest out to a distance of more than 30 km (20 miles), fully evident when the first scientific investigation of the impact was made in 1927 by the Russian mineralogist and meteoriticist Leonid Kulik, (2794) Kulik.

An asteroid of about the same size as the Tunguska minor planet passed close to Earth on February 14, 2013, coincidentally on the same day as the Chelyabinsk bolide fell to Earth. 2012 DA14 had been discovered almost exactly a year earlier from an observatory in Granada, Spain, and, traveling northwards, passed 27,700 km (17,200 miles) above the surface of Earth near Indonesia, the closest recorded approach for an object so big. Its trajectory took it inside the orbits of the geostationary artificial communications and meteorological satellites that provide continuous coverage over regions of Earth. Had it impacted Earth over an inhabited area, it would almost undoubtedly have caused casualties.

If an asteroid is very large, kilometers or miles in size, say, the crater that it would make on collision with Earth would be of considerable size; impact craters made on Earth by minor planets this size range up to 300 km (200 miles) in diameter, including the famous Chicxulub Crater in Yucatán, Mexico. This crater, the third largest meteor crater known on Earth, is 170 km (110 miles) or more in diameter and was created by an asteroid 10 km (6 miles) in diameter. The impact energy of such an asteroid would be equivalent to the simultaneous explosion of many, many times the world's entire nuclear arsenal. An impact like this could destroy an entire region, including the living things in it. Its effects would include vast clouds of dust that would spread over the world, causing serious climate change. This could result in the mass extinction of whole species. This happened when the Chicxulub asteroid struck 64 million years ago and helped make the dinosaurs extinct. If the asteroid plunged into the ocean, it would create a tsunami that would destroy the coastline of the surrounding continents.

An asteroid orbiting round and round the Sun in space that comes as close to Earth as one third of the distance between Earth and the Sun is called a Near-Earth Asteroid (NEA, or NEO, the O for "Object"). An asteroid that ever comes as close of 5 % of that distance, and is greater than 140 m across (460 ft), is called a Potentially Hazardous Asteroid (PHA). It is pretty certain that if an asteroid of 140 m diameter strikes Earth, it will reach the ground in one piece and make a crater. If an asteroid larger than this impacts Earth, to call it a "hazard" is scientific understatement.

I would not like to have my name on an asteroid that could wipe out the human race, however distant the prospect. Fortunately, I can take unalloyed pleasure in my modest association with my own large rock. It is certain that my asteroid is not a near-Earth asteroid, nor is it a potentially hazardous asteroid (PHA).

I did not discover this asteroid, nor have I ever worked on finding out about it. I am associated with this particular asteroid only because people kindly offered to name an asteroid after me, in recognition of my work in astronomy over the last 50 years, both research and administration; and because astronomers like their colleagues to write books such as this one that reach out and try to help people understand what astronomy is about. The asteroid has my name on it, but, given its orbit, I am not worried that this bullet will ever be fired at me, or those who come after me.

I don't know precisely how large my asteroid is, but it is pretty average. What can be said with some certainty is how bright it is. In the catalogs it says that, placed a standard distance from the Sun, such that it is illuminated in a certain way, and viewed from a standard distance in a certain orientation, it is like a star of magnitude 15.6. Imagine that the asteroid replaces Earth in its orbit and we are viewing the asteroid from the surface of the Sun. It would look like a star of magnitude 15.6. However, this is all a bit misleading. The problem is not only that nobody can stand on the surface of the Sun but also that the asteroid never puts itself in the standard conditions.

My asteroid is always further from the Sun than it is from Earth. In practice it never gets brighter, as seen from Earth, than magnitude 18.3. That is quite faint. I have only seen my asteroid in a picture taken by someone else, but in principle I could see it myself only if I looked through a hefty telescope with a lens or mirror with a diameter more than 40 in. (100 cm, say) (Fig. 1.2).

Asteroids generate no light for themselves; they reflect sunlight. The bigger an asteroid is the more sunlight it reflects and the brighter it appears, so there is a relationship between magnitude and surface area. From this relationship, I can estimate the size of my asteroid, but I need to know how effective it is in reflecting sunlight. If it is covered with white ice and reflects 80 % of the light that falls on it, it is small. If it is black like coal and reflects 4 %, it is larger. My asteroid is a stony composition and reflects quite a large fraction of the sunlight that falls on it, perhaps 20 %. If it were spherical, it would be perhaps 1.8 km (1.1 miles) in diameter.

The area of my asteroid is perhaps 10 sq. km (4 sq. miles), as large as one or two European countries—Gibraltar and Monaco. Few countries and territories (none at all?) are regular shapes. Likewise it is almost certain that my asteroid is not spherical; it is likely to be an irregular, potato-like, rocky shape. And it is more like a mountain than a country—or both, as in a volcanic island, such as Pitcairn Island (area 5 sq. km, 2 sq. miles). I like the thought of these comparisons. In one of my less modest, and completely unjustified, fantasies, I like to put myself on a par with those kings and queens, dukes and duchesses, presidents and explorers who have countries and territories named after them—Victoria, the Falkland Islands, Louisiana, Virginia, Alberta, Bolivia, Rhodesia, Washington, the Cook Islands…

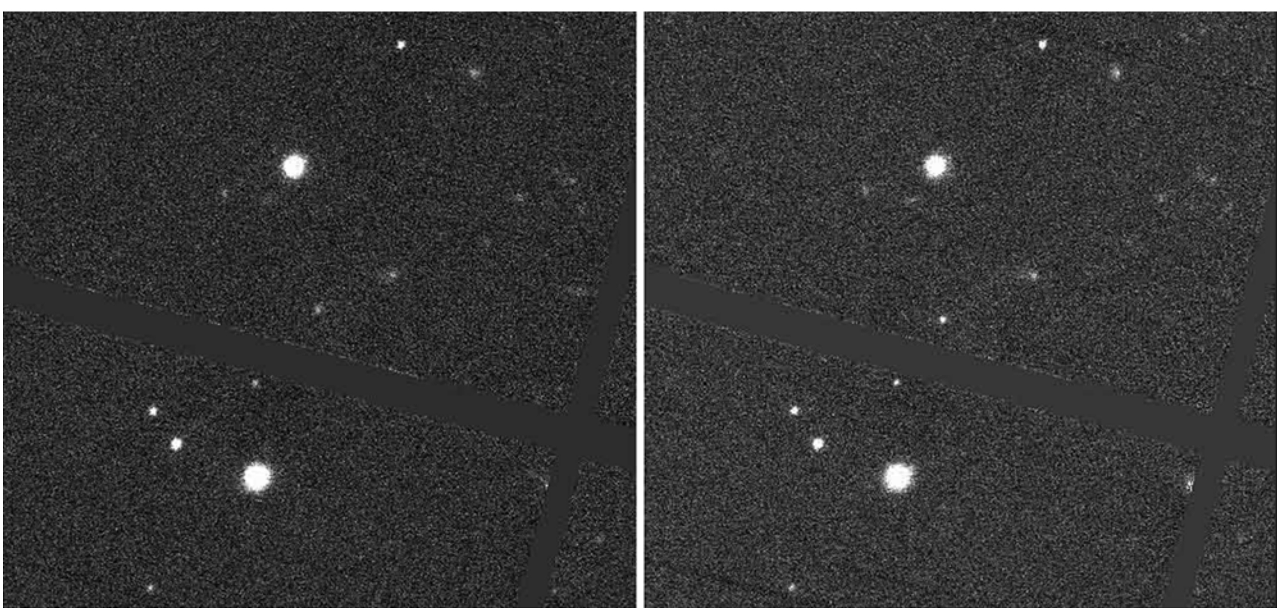

Fig. 1.2 Two views of asteroid (128562) Murdin moving among the stars. The asteroid is the central "star" that has moved a little bit down and to the left in the right-hand shot. Alan Fitzsimmons took these two pictures with the Pan-STARRS telescope on Hawaii. (Picture by courtesy of Alan Fitzsimmons, QUB)

I float off into a reverie, inspired perhaps by stories of living on a tropical desert island. I could settle there, for the peace and quiet. Maybe my asteroid has valuable minerals that I could mine and become rich, just as Ben Gunn dug up wealth from Treasure Island in Robert Louis Stevenson's story. Maybe, if I really controlled my asteroid, I could create a spacecraft docking station and charge the space agencies to moor there. I wouldn't have to live there to do this, but if I did, maybe I could establish an interplanetary service station.

I wake up. Life here on Earth is good and would have to become very bad indeed to make it better to live on a dry, dusty, sterile, airless asteroid, its surface exposed to the glare of the Sun, deadly cosmic rays, and the impact of other asteroids. On my asteroid I would have to be careful not to move too impulsively, in case I leapt off the asteroid by mistake, escaped its weak gravity and went drifting off, untethered, into space. Marooned on a desert island, like Ben Gunn, I would find it difficult to get away. Marooned on my asteroid, I imagine myself escaping too easily!

I come back with a bump from my reverie, returning to Earth and scientific reality.

I do not think that my asteroid is a very scenic place. It is made of a stony rock (silicate minerals, akin to quartz or the material of which a typical sandy beach is made), which reflects sunlight with characteristics that give it a classification of "S-type." S-type asteroids comprise 17 % of the asteroid population in the Main Belt of asteroids between Mars and Jupiter at distances of 1.5 and 5.2 times the distance of Earth from the Sun, so my asteroid is not a rare kind. My asteroid has an average distance from the Sun of 2.77 × the Earth-Sun distance, so if I lived there I would see a smaller, weaker Sun. Its orbit is quite elliptical, and its distance from the Sun changes over the 1689 days of its orbit by ±12 %. I would notice how the Sun gets larger and smaller, and the temperature would be rather seasonal. The average temperature of the surface is –70 °C (–100 °F), with a maximum temperature a balmy minus –20 °C.

Minor planets are a mixed bunch. Some are old bits of material leftover from the formation of the planets. The planets formed from a disc-like nebula of gas and dust that formed around the newly born Sun. The dust in the solar nebula stuck together and built up into bigger and bigger lumps. Jupiter, the giant planet on the outer edge of the Main Belt, grew so large that it had an inhibiting effect on this process. It kept stirring up any material that was close, and stopped the material from gathering into really big lumps. So Jupiter inhibited the formation of a single planet in the Main Belt, but this region is still populated by the small lumps. These asteroids are planets that, like Peter Pan, never grew up. Herded and jostled together in a confined region of space for billions of years some of these asteroids have collided and broken into pieces. These fragments made further small asteroids.

S-type asteroids can be either of these two sorts. Perhaps my asteroid is a small planet with arrested development. Or maybe it is a descendant of such a planet, a chip off the old block.

If asteroids are scraps and broken bits, why do astronomers think they are important enough to study? They were not always well-regarded. Astronomers once regarded them as the "vermin of the skies." But astronomers have completely changed their attitudes. Asteroids are now thought of as key to the early history of the Solar System. But how do you read history from rubble?

If there are no reliable documents, as is the case for much of the distant past, historians turn to archaeology. What, for example, was the history of the Trojans? We can read Homer's *Iliad* about the siege of the city of Troy, but the *Iliad* is a heroic poem, not a factual account to be relied on. For the history, we'd do better to read the account by Heinrich Schliemann, a wealthy German businessman and archaeologist, about his excavations of the city.

The excavation site was almost ideal: orderly, undisturbed and layered. The palace and the religious precincts of the city sat at the summit of a hill, and the sprawl of commercial and residential buildings below show the political hierarchy of the site, from the governors to the governed. Walls and gates delineate zones of the city inhabited by the social and occupational classes of the civilization that built the city—villas, commercial premises and tenements. The walls of the royal precincts were used by later peasants to make farm buildings offsite, but the foundation stones are still there, showing in map form how the civil buildings were laid out and how government functioned. The more recent buildings are layered over the earliest simple houses and encampments that show the development of the city over time.

Rubbish heaps are the opposite of orderly, but they, too, were rewarding places in Troy for the archaeologists to investigate and reveal the way of life of the Trojans. They contained abandoned building material, shards of pottery, bones and other food waste, broken household items, keys no longer needed, worn clothing, irreparable shoes and a few lost items of jewelry and coins. Some discarded items had been brought from distant regions and showed how the people of Troy interacted (by trade) with other peoples across the eastern Mediterranean.

The rubbish heaps contained everyday material that was simultaneously archaeological treasure. They revealed the history of the city and the way of life of its people, even if the evidence was all mixed up.

So, likewise, some astronomers study the major planets of the Solar System to see what they might reveal about its origins and history. The eight major planets—Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune—are the orderly and massive governing features of the Solar System. They delineate its architecture, its functioning under the rule of gravity.

However, an increasing number of astronomers study the majority of the bodies of the Solar System, the minor planets. The major planets herd them together so that they congregate in permitted zones. There are other zones into which minor planets venture only seldom and briefly.

The minor planets constitute both the governed masses of the Solar System and the discarded items from its construction and use. The minor planets are small planets, comets, asteroids and meteoroids. They are planets that never grew up, solid icy fragments. They are broken rocks from the insides of planets that collided and split up. They are rocky bits of planets that separated because they were made to spin too fast. Among them are occasional transitional items, rare, revealing objects that show features that link one kind of item with another. In one case, the minor planet Sedna might be a planet that has strayed into our Solar System from another planetary system far away. These are the astronomical treasures in the zones where the minor planets have collected.

Just as archaeologists can attempt to find out about the history of a civilization by studying its rubbish, so astronomers can attempt to find out about the history of the planets by studying the small bits of left-over building material and broken bits that have accumulated in three zones of the Solar System: the Main Belt of asteroids (between Mars and Jupiter), the Kuiper Belt of trans-Neptunian objects (TNOs) (beyond Neptune) and the Oort Cloud of comets (on the periphery of the Solar System). These are the rubbish pits of the Solar System, their contents taken there and abandoned, after planet-building or world-shattering events that took place early in the history of our planetary system.

This view of the importance of the minor planets has emerged in the past few decades, and has altered the trajectories of spacecraft. NASA's policy for space missions to the outer planets is that, even if the primary target of the mission is a major planet such as Jupiter, the mission planners must consider whether the spacecraft will fly by minor planets on the way. If it is feasible and does not jeopardize the mission, they will divert the spacecraft to study them.

Astronomers and space mission designers think that asteroids are important. So does the Swedish Royal Academy. In 2012, it awarded the Kavli Prize for Astrophysics to the three pioneer discoverers of minor planets that orbit in the regions beyond Neptune, in the Kuiper Belt, Dave Jewitt, Jane Luu and Mike Brown. The Kavli Prize is the astrophysics equivalent of the Nobel Prize for Physics.

So, the primary scientific motivation for investigating the minor planets is to find out what they are and how they reveal the processes of the early history of the Solar System. By contrast, astronomers of earlier generations were interested in the orbits of minor planets as an exercise in mathematics. The mathematics is formidable. A century ago, it was a very complex calculation to predict the future orbits of asteroids. It was so notoriously difficult that in 1914-15, the author Arthur Conan Doyle used it as a marker for the intellectual prowess of Professor James Moriarty, the master criminal and arch-enemy of the private detective, Sherlock Holmes. As well as being "the greatest schemer of all time, the organizer of every deviltry, the controlling brain of the underworld," Moriarty is also described as the "celebrated author of *The Dynamics of an Asteroid*, a book which ascends to such rarefied heights of pure mathematics that it is said that there was no man in the scientific press capable of criticizing it."

The original mathematical problem was complicated but limited. Astronomers wanted simply to be able to follow an asteroid over a working lifetime, or perhaps into the next century. This limited problem has now been solved to almost arbitrary accuracy through the power of modern computers and mathematical techniques. But astronomers widened their ambition and tried to track the orbits of asteroids into the indefinite future or back to the almost unimaginable past. The idea here was to find out from where asteroids originated and to see to where they will evolve, to write the early history of the Solar System, and show how it will develop. Astronomers came up against new difficulties in the mathematics, known by the name of "chaos." These difficulties are not just technical, they are fundamental, and no amount of extra knowledge will enable mathematicians to circumvent them. They have to learn to deal with the fundamental limitations that chaos imposes.

Chaos is the same property of mathematical systems that makes it difficult to predict the weather more than a short time in advance. Chaos in celestial calculations arises from the shifting backdrop of intermittent interactions between the major and minor planets, and the phenomenon of chaos was first recognized here. The minor planets form a laboratory for the study of chaos in the Solar System.

I'm interested in astronomy, but I am also interested in astronomers. Asteroids were first discovered in the early years of the nineteenth century. The astronomers who worked to find them did so against the backdrop of political and social turmoil. The French Revolution of the last decade of the eighteenth century had destabilized Europe, and was followed by two decades of war and continuing political strife across the entire continent, when the nations so furiously raged together. While soldiers died in battle and seamen drowned, while families starved, while kings and queens were deposed and executed or, the luckier ones, reinstated, while constitutions were torn up and re-written, while royal courts were being torn down and parliaments erected, astronomers looked outwards to the stars. They communicated and collaborated across frontiers, sometimes mocked in cartoons for having their gaze on irrelevant details up in the heavens while being indifferent to great human events around them. The same remains true today, though in less stressful times. Astronomers stand shoulder to shoulder looking up to the stars, while political leaders stand eyeball to eyeball, staring each other down.

Asteroids bring astronomers together in a widely drawn community. Professional astronomers travel to telescopes, perhaps between continents. There they meet their colleagues. Although each astronomer is focused on the work that he or she is there to carry out, they are, for the duration of their stay on the mountain, a member of a community, almost like a monastery, united by unusual working hours and common mealtimes. It is inevitable that the astronomers talk and create relationships. Amateur astronomers support themselves on a more modest scale of equipment and travel, but just as strongly in their social interactions, within societies, internet groups and working teams. The observation of minor planets is within the scale of effort that amateur astronomers can bring to bear, with plenty of modest telescopes, cameras, computer systems and software available at affordable prices and capable of measuring the positions of many minor planets or their brightness.

In the early nineteenth century, most asteroids were discovered by eye, by non-professional astronomers. In recent decades, well-financed, professionally staffed, computer-assisted searches with quite large telescopes have produced by far the majority of asteroid discoveries, although asteroid discoveries are still made by amateurs, especially those who have upped their game from stargazing to systematic searches. So the swing of the pendulum for amateur astronomers, too, has been away from finding asteroids towards studying the asteroids themselves. There are huge numbers of minor planets to observe, and some amateurs happen upon a significant one and make a notable advance.

In one example, in 2008 the British amateur astronomer Richard Miles used the Faulkes Telescope South at Siding Spring Observatory, Australia, set up for the benefit of school students and amateurs, to discover that asteroid 2008 HJ rotates every 42 s, the fastest known rotation period for an asteroid. Asteroid 2008 HJ was discovered on April 25 but predicted to be visible for only a few days as it approached near to Earth, coming within 2.8 lunar-distances. On April 29 at its closest approach, it was moving so fast (45 km/s relative to Earth), that Miles had to reposition the telescope to continually keep it in view. Miles made very short exposures—less than one minute long. The telescope accurately tracked the stars so their images were circular but, even with exposures a few seconds long, the images of the asteroid were trailed by the asteroid's motion. Miles immediately noticed that there was a change in brightness along the trail, caused by the oblong-shaped asteroid turning, repeatedly presenting its wide and narrow sides in succession towards Earth and reflecting more or less sunlight (Fig. 1.3). A period search confirmed it to be a superfast rotator, having a rotation period of just 42.67 (±0.04) s, making it the shortest known rotation period of any natural object in our Solar System. The position and brightness of asteroids evolve in time, so an amateur astronomer can adopt a minor planet for study, follow it, elucidate its properties and make it his or hers.

Like professional astronomers, amateurs create social occasions on which to meet, perhaps physically through astronomical societies, or perhaps virtually through internet social media, like Yahoo's Minor Planet Mailing List (MPML). This list boasts nearly 2000 active members, posting typically 100–200 messages per month. Both professional and amateur astronomers focus minor planet observations through the IAU's Minor Planet Center, whose website provides aids to observers (including ways to check whether a minor planet that you think you have discovered has actually been seen before). It encourages people to observe minor planets

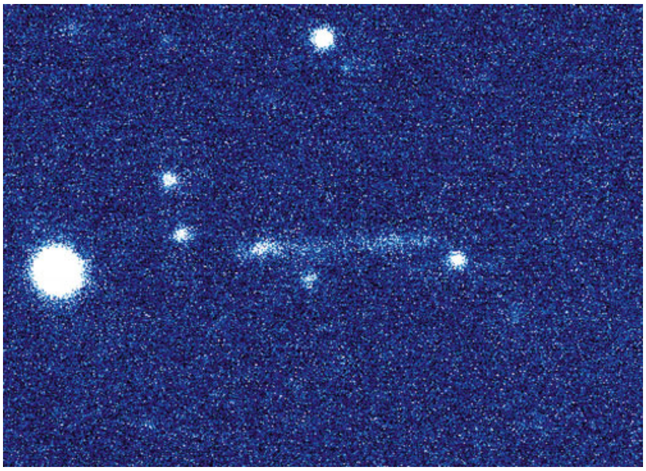

Fig. 1.3 At its closest approach to Earth asteroid 2008 HJ was moving at 1000 mph and made a trail among the stars in this time exposure of about 40 s. In that time it made one revolution and changed in brightness by one cycle of its rotation, reaching maximum brightness near one end (Image by Richard Miles. Used with permission)

whose orbits and positions are especially in need of improvement, vacuums up the observing data and mediates the orderly progression of the science. It lists over 2000 observing sites worldwide that have at one time or another made observations of asteroids, most of them in recent decades.

At the same time that astronomers manifest this selfless behavior in engaging with their science, they engage with each other in a revealingly human way. "Science" is a system of thought that develops under objective and dispassionate rules. "Science" is also a human activity that shows all the features common to emotional and irrational human behavior. In the study of asteroids this shows particularly distinctly in the manner in which astronomers name their discoveries, because the name of an asteroid has no scientific significance whatsoever. A name is a subjective human invention that helps scientists to remember what they are talking about so that they can discuss the science. A numerical designation is more useful as a label for a database or a spreadsheet in a computer file, used to correlate the asteroid's properties. But a name is easier to remember, and usually easy to pronounce.

A name is the product of the imagination and the names of asteroids have taken on an enormous human significance, for the discoverer, for his or her colleagues and for the wider community. So I follow the history of naming asteroids in this book in parallel with the history of their discovery and the scientific significance of the discoveries.

The act of discovery of a planet is in itself regarded as an achievement. We can all admire the single-mindedness and the persistence of astronomers who put themselves in the position to find a planet or a comet, or devote themselves to a long search. In times when planets were big and seldom discovered, the discoveries attracted international fame and national money. Galileo Galilei, William Herschel, Giuseppe Piazzi, Urbain Le Verrier, Clyde Tombaugh—all these astronomers, as I shall tell, came to the attention of kings, dukes and presidents, increased their scientific reputation, and got jobs and increases in salary as a result of their discoveries. Others were overlooked and their careers fizzled out.

Discoveries of planets nowadays attract the attention not only of an astronomer's peers, family and friends, but also, sometimes, the media and the social networks. There are no or few objective rules about the norms of behavior at this time, so there are plenty of opportunities for these scientists to show irrational human behavior, including erudition, wit and humor as well as gender bias, nationalism, self-interest and possessiveness, just like everyone else. "Science" means the activity that scientists carry out as well as what they find. Here, then, are the stories about the asteroid hunters, told alongside the knowledge they have gathered about their prey—stories about both the rocks themselves and the rock legends.