Temecula Valley Astronomer

The monthly newsletter of the Temecula Valley Astronomers Aug 2017

Events:

General Meeting : Monday, Aug 7, 2017 at the Temecula Library, Room B, 30600 Pauba Rd, at 7 pm.
What's Up by Skip Southwick.
Topic: "Eclipse Extravaganza"

For the latest on Star Parties, check the web page.

Solar Eclipse Shoes in the Classroom

NASA APOD 8 March 2016 Image Credit & Copyright: Astronomie-AG, Progymnasium Rosenfeld, Till Credner, AlltheSky.com

WHAT'S INSIDE THIS MONTH:

Send newsletter submissions to Mark DiVecchio <markd@silogic.com> by the 20th of the month for the next month's issue.

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General information:
Subscription to the TVA is included in the annual $25 membership (regular members) donation ($9 student; $35 family).

President: Mark Baker 951-691-0101 <shknbk13@hotmail.com>
Vice President: Skip Southwick <skipsouthwick@yahoo.com>
Past President: John Garrett <garrjohn@gmail.com>
Treasurer: Curtis Croulet <calypte@verizon.net>
Secretary: Deborah Cheong <geedeb@gmail.com>
Club Librarian: Bob Leffler <bobjleffler@msn.com>
Facebook: Tim Deardorff <tim-deardorff@yahoo.com>
Star Party Coordinator and Outreach: Deborah Cheong <geedeb@gmail.com>

Address renewals or other correspondence to:
Temecula Valley Astronomers
PO Box 1292
Murrieta, CA 92564

Member's Mailing List: tvastronomers@googlegroups.com
Website: http://www.temeculavalleyastronomers.com/

Cosmic Comments – Aug/2017
by President Mark Baker

Following is an excerpt of my 2016 rant…

> "July 20th of 1969…do you remember where you were and what you were doing??
>
> This is a date indelibly etched in my memory…following a summer league basketball game, I was invited to the home of a longtime friend that was nearby. Skip, his Father, and I sat up through the wee hours of the next morning watching the first Moon landing. I can still "feel" the excitement that this singular event imposed on my psyche…after I got home, I then stayed up to watch, first Neil Armstrong, and then Buzz Aldrin, take those small steps that were supposed to become a giant leap. All this time later and I, for one, am still awaiting that Leap…
>
> However, this date was when I decided on what course to pursue educationally, and that alone was a great thing for me. I just knew I would soon have the opportunity to be considered for a seat on an upcoming mission, either back to the Moon, or maybe even Mars or elsewhere. It is what jump started my technical interest in things Astronomical and you all know how that has worked out…so far!!!
>
> The bottom line is that we of the TVA are all drawn to the skies and celestial stuff for different reasons, maybe, and with varied intensities, but we provide a good in our community that transcends who we are and why we do Astronomy… I'm proud to be associated with such a wonderful organization that sacrifices so much to get our children neighbors, and friends to just look up. Thanks for all you do…"

I still "feel" the excitement, and my work this year with both NASA JPL as a Solar System Ambassador, as well as being accepted into the ranks as a Docent at CalTech Palomar Observatory, have done everything to elevate those feelings. I know, at this point, that I won't get to make THAT Leap, but I sure as heck intend to push somebody else to do it…Jump will you, just Jump!!!

And my pride in my association with you all of TVA grows with time as well, so once again, Thanks for all you do…!!!

Clear, Dark Skies my Friends…

Looking Up – Aug 2017
by Curtis Croulet

Full Moon is August 7 at 11:11 PM PDT; **Last Quarter Moon** is August 14 at 6:15 PM PDT;

New Moon is August 21 at 11:30 AM PDT; **First Quarter Moon** is August 29 at 1:13 AM PDT.

Mercury is low in the western sky as August begins. It'll probably be difficult to see then. It'll be impossible after the first week.

Venus is in the pre-dawn sky. It dims from mag -4.0 to -3.9.

Mars is too close to the Sun for observation.

Jupiter is in the western evening sky, well past the meridian at sunset. It sets as early 9:10 PM by July's end.

Saturn is in good observing position much of the night. It seems like just yesterday we greeted it at opposition (actually, it was June 14). By August the ringed planet is already near the meridian at sunset. By month's end, it sets shortly after midnight.

Uranus rises in late evening. It's in Pisces.

Neptune rises in late evening (but not as late as Uranus). It rises at about 9:30 PM as August begins. It's in Aquarius. While preparing this, I was interested to note that Neptune is almost exactly two hours ahead of Uranus.

Pluto is in northeastern Sagittarius. You need a big scope and a dark sky. The July 2017 issue of *Sky & Telescope* has a detailed finder chart for the dwarf planet on pp.48-49.

The most important meteor shower of August is the **Perseids**, which peak this year during mid-day August 12. The nights of August 11-12 and 12-13 should be about equally good to view the shower close to its peak. The bad news is that the Moon rises just as viewing gets good. It will be a bright, waning gibbous during prime meteor viewing hours between 2 AM and the beginning of dawn twilight. Under good conditions, you will probably see a Perseid meteor every minute or two, with occasional outbursts of two or three in quick succession. There may be pauses of several minutes. The radiant is in the area of the Double Cluster, but you may see the meteors in almost any part of the sky. Because my sky is darkest toward the southeast, that tends to be the direction I face when watching Perseids.

Lesser meteor showers visible in August include the **Southern Delta Aquariids**, which peak on July 30 but continue until about August 23; the **Orionids**, which begin August 25 but don't peak until October 22; the **Kappa Cygnids**, which run from August 6 to August 31, peaking on August 17; and the **Aurigids**, which run from August 29 through September 4, peaking on September 1.

Let's look up.

One astronomical event this month eclipses all others (pardon the pun): the total solar eclipse on Monday, August 21. The path of the eclipse across the U.S. begins at the Pacific coast of Oregon and ends at the Atlantic coast of South Carolina.

I suspect that most of you reading this will view the eclipse from somewhere in southern California. You will see a partial eclipse, that is, only part of the Sun will be covered. Maximum coverage (about 70%) in southern California will occur around 10:21 AM PDT. While a partial eclipse can be very interesting, it is orders of magnitude less spectacular than a total solar eclipse. It's kindergarten scribbles compared to Rembrandt. It's Tiny Tim compared to Bach.

I probably shouldn't need to explain this to an astronomy club, but you'll get questions from your friends and neighbors. Under no circumstances should you attempt to directly view the partially-eclipsed Sun with your eyes or through a telescope or through ordinary binoculars. The only safe optical devices are glasses equipped with special solar film or telescopes equipped with dedicated solar filters. Lunt Solar sells "solar binoculars" that are safe. The smaller ones are only $30. OPT has them.

If you have a solar telescope filter, it should be the type that goes over the aperture of the telescope. The screw-in eyepiece filters supplied with cheap telescopes are not safe. The filter may crack under the heat of the focused Sun's light, and your eye will be instantly exposed to the full brilliance of the Sun. Forget "welder's glasses." Forget old black-and-white negatives.

The best way to view a partial solar eclipse is by projecting the image of the Sun through binoculars or a telescope onto a white surface. A tree will create hundreds of tiny pinhole apertures that will create images of the crescent Sun on the ground and walls. Look around you. You'll probably find tiny images of the Sun somewhere nearby.

For those of you who intend to see the total eclipse, if you haven't already made detailed plans and reservations for a viewing spot and accommodations, you may have a problem. The best weather prospects are in eastern Oregon, southern Idaho, and Wyoming. Hotels and campgrounds along the path of totality are already booked, some at outrageous rates. Major highways and two-lane roads in these areas are expected to be packed. Small towns in sparsely-populated areas will be briefly filled to overflowing. Still, if you haven't seen a total solar eclipse, it's probably worth risking the crowds and expense to experience the event of a lifetime. Linda and I have already reserved a viewing spot in southeastern Idaho.

Of our two major astronomy magazines, the best issue covering the upcoming eclipse is *Astronomy*'s August 2017 issue. August 2017 *Sky & Telescope* is also worth having, but *Astronomy* is better.

Clear skies.

Random Thoughts
by Chuck Dyson

Eclipse and Transit Chasers

It is with great excitement and some small trepidation Barb and I prepare to go on our first great solar eclipse chase; however, you should know that this is not our first chase of a solar phenomenon. My first solar expedition consisted of throwing my grab-and-go refractor and my Coronado PST along with two tripods and some potato chips and beer into the car, driving two miles to a friend's house with a big front lawn and watching Mercury glide across the face of the Sun between sips of cold beer and handfuls of potato chips. My second solar experience was more dangerous and daring. I had decided to take the family to Hawaii to watch the transit of Venus.

The dangerous part came when I told my wife how much it cost for me to ship all of my observing gear to Hawaii and the daring part was the belief that I could maintain my sanity for five hours in an airplane that was 100% booked with young families each with two to three screaming children. The smart thing that I did was to join the Maui Astronomy Club and tell them what my observing plans were, to wit, go to Haleakala and observe from the parking lot. An astronomy club member got back to me with some suggestions. First; observing at 10,000 feet for six hours would be like sitting under a UV blowtorch with or without SPF 70 sunscreen protection. Second; setting up my equipment in a parking lot full of tourists would be like taking a plump puppy to a flea farm, it would not end well. Third; the club recommends that I join them at a small park used by locals; I do this and have a great time and get in some great observations, as for my wife and daughters they look once and say "that's nice" and go shopping. My wife and daughters may not have been impressed but I was and because I had prepared, packed, and trekked to an almost foreign land to view the event I felt a great kinship with those who had gone before me to view the transits of Venus.

Just who were these intrepid astronomers and why was it so important to see the transits of Venus? Kepler's third law states that the period of a planet's rotational period squared is equal to its semi-major axis cubed and the semi-major axis the average distance of the planet from the Sun. Edmond Halley realizes that if you can get the parallax of Venus at the transit then one can work out the Earth/Venus distance and from that work out the distances of all of the planets from the Sun and measuring the Earth/Sun distance is proving to be very difficult to do.

Halley also works out that the next Venus transits will be in 1761 and 1769; although Halley will not live to see the transits his work inspires others to view and record the transits. In 1761 France and England are at war (again) but the nations have agreed on safe passage for the scientists, but as we will see not everyone gets the word, The first team to go out in 1761 is the English surveyors Mason and Dixon, yep the same guys that will survey the Mason-Dixon line in the US. They sail on the HMS Seahorse for Sumatra but about one day out of port they encounter the French Frigate le Grand and a sea battle ensues with the Seahorse getting away after dark. The next day sees the Seahorse back in port looking like the HMS Swiss Cheese and 1/3 or more of its crew dead or wounded. Mason and Dixon are in no mood to try

again but they are strong armed into it and the Seahorse is patched up and sails. The team only makes it as far as South Africa but does manage to get some data.

The next 1761 expedition is headed up by Jean-Baptiste Chappe d'Auteroche (Chappe) who takes the overland route to Russia to make his observations. Chappe discovers that Russia in spring is basically just one big mud puddle and 1761 is wetter than usual but Chappe persists and is able to arrive at his destination and set up his observatory. Chappe has only one problem, the extra rain is killing the crops and the local serfs think that the cause of the problem is the foreigners and their equipment. To the serfs the answer is simple, kill the foreigners and destroy the equipment. To prevent the local serfs from implementing their climate changing plan, Chappe hires local Cossacks (Hells Angels on horseback) to form a protective ring around the expedition. Chappe gets his observations and heads back to France.

The third expedition that we will look at is headed up by Guillaume Joseph Hyacinthe Jean-Baptiste Le Gentil de la Galaisière (Le Gentil for short). He sails for an island in the Indian ocean but due to the fluid nature of the war he is shuttled from one port to the other and on the day of the transit is at sea. Le Gentil can see the transit but can gather no useful data. The major problem that all expeditions had was the tendency of Venus to form a teardrop as it approached the edge of the Sun and that made it very difficult to say exactly when first contact was and that made the readings much less precise than hoped for but now that the astronomers were aware of what to expect they hoped to gather much better data in 1769 when there would be the second Venus transit.

In 1768 Captain Cook with an astronomer named Charles Greene on board sets sail for Tahiti and only eleven months later arrives at his destination (the reader will note that is ever so slightly longer than my trying flight of five hours to Hawaii). At Tahiti, Captain Cook's troubles began, first the native women are willing to trade sex for iron nails as the Tahitian society was still Neolithic at this time and sailors being sailors the Endeavor was soon in danger of falling apart and Cook put a firm end to this practice. The second problem that Cook faced was the theft of his observing instruments, the Tahitians seemed to feel that if you couldn't get iron, go for the brass. To stop this, Cook built a stockade around the instruments and had them guarded twenty-four hours a day. In the end Cook and Greene were able to get good observations and were successful in their mission. After the transit Captain Cook did not sail for England but had been ordered to survey several islands and he did so. Unfortunately during the survey period of the voyage, Mr. Green became sick and died, the first casualty of the 1769 expeditions. In the end, Captain Cook returned to England with very good data.

Our intrepid Monsieur Chappe decides to have another go at getting transit data and heads for the Baja California peninsula as part of a twenty-eight man expedition. After a lot of sailing and some hiking the expedition arrives at the desired location for the transit measurements and the team sets up and gets great data now all the team needs to do is establish their longitude through lunar measurements. Unfortunately during the time needed to make the lunar measurements a plague brakes out in the area and locals and expedition members start dropping like flies, Chappe himself is quite ill when he makes his last measurements and after turning the expedition log book over to a member who was not sick Chappe dies. When the

expedition log book is finally presented to the French Academy of Science, the person presenting it is the only survivor of the expedition; twenty-seven of the original twenty-eight members have perished.

Remember our unfortunate Le Gentil does he go home after being frustrated in his attempt to record the transit in 1761? No, he does not; he decides to stay in the area for the next eight years in order to be assured of getting measurements of the 1769 transit. When the big day arrives our Le Gentil is set up, ready to go, and has clear skies. Unfortunately just before the transit starts the clouds come in and stay until after the transit is over; for the second time Le Gentil gets no data. Le Gentil allows himself two months of severe depression and then decides to get on with life and heads for home, the trip home as you would expect with his luck is beset with raging storms, wrecked ships, and disease; however, in the fullness of time Le Gentil finally gets on a Spanish ship the makes it to the port of Cadiz in southern Spain. As there is virtually no public transportation Le Gentil walks the 900+ miles to Paris only to find that the French Academy has removed him as a member in his 11½ years of absence (even though he has sent in reports of observations during his stay in the Indian Ocean) and his wife and relatives after having had him declared legally dead have run off and remarried and plundered his estate respectively. Le Gentil is able to go to court and is eventually able to regain his seat in the Academy and retrieve most of his property and possessions back from his relatives and remarries so in the end all is not lost for our poor astronomer.

There is one more astronomer that measures the transit of 1769 that I will talk about that is David Rittenhouse. Mr. Rittenhouse, with the American Philosophical Society, decided to measure the transit at three stations in order to determine the parallax of Venus. To this end Mr. Rittenhouse makes three transit telescopes which are thought to be the first telescopes manufactured in America. The American group makes their measurements but no one wants their data because, well, they are bumpkins from the colonies, but, when the data is finally reviewed in the 1840's it is found to be very good data and this is the start of science in America.

So what did the astronomers accomplish with all of their work and sacrifice? The astronomy community got an Earth/Sun distance that was within 4% of today's accepted value and for the first time an idea of just how big the solar system was. In 1874 and 1882 there were another pair of transits and with better tools astronomers were able to get the Earth/sun distance to within 1% of today's value.

As we are done with transits of Venus until the next century, if you have a burning desire to see one there will be a transit of Mercury in May of 2019 that will be completely visible from the East coast and partially visible from the West Coast. W

With the Great American Eclipse (part II) coming up I had a look at the history of eclipses in the U.S.A. and I was expecting to find a plethora of adventures and stories emanating from the adventures, alas this was not to be. Unlike the transits that can be a hundred years between events there is, on average, a total solar eclipse every eighteen months somewhere on the Earth and there are up to five partial eclipses in a single year. Also one is able to view a transit

event over a wide area but the path of totality in an eclipse is only about 70 miles wide so the astronomer must exactly position himself to see the event not an easy thing to do.

The one American eclipse that became a media event was the Great Solar Eclipse (part I). Let me set the stage for this event. The first transcontinental railroad was completed in 1869 so it was possible to get to a solar event not visible from the East coast with relative ease and safety, more or less. In June of 1877 my great-great-great uncle and several of his friends along with their commanding officer a Lt. Col. George Custer rode into the valley of the Little Bighorn and they did not have a good day. In October of 1877 the territory of Colorado became the state of Colorado. The newly minted state of Colorado was looking for ways to attract people and the eclipse of 1878 appeared to be a marketing God-send. The state of Colorado offered to pay the train fares of observing parties and promised every astronomer his own mountain top, carefully forgetting to mention that it could be very hard to get to and off that mountain top. The eclipse became a huge media event and really put Colorado on the map. Almost as an aside, useful observations of the solar corona were made also.

The other solar eclipse that drew worldwide attention was the solar eclipse of May 1919. Arthur Eddington had worked out that the eclipse would occur when the Sun was the Hyades open cluster and this would present an excellent opportunity to test Einstein's theory of relativity; teams went out, measurements were taken, and Einstein becomes the world's first super geek.

To enhance the chances of you having a successful solar eclipse viewing experience I can recommend the following: the web sites Mr. Eclipse and Eclipse Chaser; the August Sky and Telescope magazine (it's full of helpful articles and tips); the Oceanside Photo and Telescope store it is full of viewing aids.

As I have already had several people ask me "at what time of the night will the eclipse occur?" Remember the most important thing, it is a solar eclipse and occurs during the day! Good luck and good viewing.

Cheers
Chuck

Something Wicked This Way Went – Part II
by Clark Williams

We're about to talk about the asteroid that may have killed the dinosaurs. There is still some controversy about whether the asteroid alone did or did not kill off three of every four species existing at the time of impact. Science always has questions and pursues answers. What we do know is that before the Chicxulub crater formed the PK-T boundary didn't exist and after the impact it did. Recent data has added to the knowledge about the extinction level event and as in most cases one event is not the only contributor. In this case the asteroid may have however, been the straw-that broke-the-camel's-back.

Chicxulub:

About 100-million years-ago and approximately 200 million miles from the Asteroid Belt it is theorized that an asteroid traveling at a high velocity in an eccentric orbit, struck and perhaps split another asteroid. One of those splintered pieces was approximately six-miles in diameter (Mt. Everest is only 5.5 miles tall and if you remember the crater that made Tycho on the Moon was estimated at half this size) and made of nickel-iron. Now a six mile in diameter piece of cotton weighs a lot but it is nothing compared to a six mile in diameter rock weighing in at approximately 2-trillion tons.

Since space is so big, things do happen slowly. It took almost 100 million years for the splintered rock to eventually enter the inner solar system and it happened to be captured by the space warp of Earth's mass.

Earth has a few protections in its arsenal and these were more effective in the distant past. The Moon orbited much more closely than today and traveled at a higher orbital speed. So some of the cratering on the moon may be examples of the Moon interceding between an asteroid and Earth. Sixty-five million years ago, as this rock approached Earth, this intercession did not happen.

We need to make at least one assumption here. We need an angle of impact. We will use 30 degrees. This assumption is based on empirical data from the ejecta scattering and is generally accepted.

As the asteroid slipped down the gravity well it picked up speed accelerating from about 9.8 kps (22,000 mph) to 20.1 kps (45,000 mph). The total energy prior to entering the atmosphere was approximately 1.09×10^{24} Joules (2.59×10^{8} megatons of TNT).

Shock wave heating drives the plasma temperature up to 19,426 C (35,000 F) and it hasn't even hit the ground yet.

Now the fun part. What would have happened to us here in San Diego area if we were around during the Chicxulub impact? The crater is located at 21.3999984N—89.5166646W putting us about 3,012.1 km (1,871.7 mi) from ground zero.

If we could see the fireball in the sky during approach (if we were for instance 800 km [500 mi] from the impact), the plasma glow would be so bright that flash-frames of our shadows would be burned into the ground. The light would be brighter than a million Suns. The air would have been so hot that skin, clothes, trees, grass and hair would burst into flame.

Nearing impact about half the asteroid would be vaporized above the ground and the shock and thermal wave would be devastating to anything that was within line-of-sight of the fire ball.

In San Diego we would be below the horizon and shielded from most of the thermal effects — for now.

Impact!

Impact has an explosive force of 420 zettajoules (4.20×10^{23} joules, over a billion times the energy of the atomic bombings of Hiroshima and Nagasaki). By contrast, the most powerful man-made explosive device ever detonated, the “Tsar Bomba”, had an energy of only 210 petajoules (2.10×10^{17} joules, the yield of 50 megatons of TNT), making the Chicxulub impact roughly 2 million times more powerful, releasing the energy equivalent of 100 petatons of TNT.

Impact fragments are hurled skyward at speeds of 44.7 kps (100,000 mph). 80,000 cubic miles of the earth's crust explodes from the impact. Air temperatures reach 316 C (600 F) 800 km (500 miles) from impact zone. 100 seconds after impact bright streams of rock can be seen in the sky as we look eastward from San Diego.

The Earth is not strongly disturbed by the impact and loses negligible mass. The impact does not make a noticeable change in the tilt of Earth's axis (< 5 hundredths of a degree). Depending on the direction and location of impact, the collision may cause a change in the length of the day of up to 6.12 milliseconds. The impact does not shift the Earth's orbit noticeably.

At impact, boulders the size of buildings were blasted into the air at supersonic speeds; they cannot reach escape velocity though and eventually will come back down.

The blast pulse wave moves outward radially. It travels faster than the speed of sound.

All of this has happened in the first five minutes since impact.

70 billion tons or roughly half the melt remains in the crater, where its average thickness is 1.7 km (1.04 miles). The remaining 70 billion tons of dust and glass from the ejecta cloud fill the upper atmosphere. As these particles re-enter the atmosphere they heat the air below to 8,316 C (15,000 F) and trap the heat so it stays near the surface. The ejecta cloud is traveling at 16,093 kph (10,000 mph).

Piece of Meteorite That Made Chicxulub Crater (Photo: Faith Tucker NASA)

Friction from falling debris and scorching dry air charges the atmosphere with millions of volts seeking a ground. Superheated rocks (heated by impact not air friction) falling back to the ground begin to create a hail of fire that touches off wildfires along with the lightning.

10-minutes after impact:

When the asteroid struck only one-percent of the force traveled into the Earth's crust. This causes major seismic shaking at Richter Scale Magnitude: between 10.2 and 11.0. This is greater than any earthquake in recorded history (see chart below). San Diego residents would not be immune to this shaking. The aftershocks will last for months as the planet rings like a seismic bell.

World's Twelve Largest Earthquakes		
Includes all measured earthquakes since 1900		
Magnitude	Location	Date
9.5	Valdivia,Chile	05/22/1960
9.2	Alaska	03/28/1964
9.1	Off the coast of Northern Sumatra	12/26/2004
9.0	Honshu, Japan	03/11/2011
9.0	Kamchatka	11/04/1952
8.8	Off the coast of Chile	02/27/2010
8.8	Off the coast of Ecuador	01/31/1906
8.7	Rat Islands, Alaska	02/04/1965
8.6	Northern Sumatra	03/28/2005
8.6	Tibet	08/15/1950
8.6	Off the coast of Northern Sumatra	04/11/2012
8.6	Andreanof Islands, Alaska	03/09/1957
Data from the United States Geological Survey		

From a list on USGS site going back to 1600s

The earthquakes will eventually open new faults and fissures. New, as well as existing volcanoes will erupt. Hydrogen Sulfide will be released into the atmosphere. Acid rain begins.

90 minutes after impact:

The air temperature around the globe will top out at about 149 C (300 F) and within another 3 hours it will slowly begin to drop. Not humans, not elephants, not cats and not even rodents can inhale air heated to 149 C (300 F) without damage to their lungs. The lungs of most above ground creatures are seared; osmosis fails and the animals suffocate.

The fires ignited will reach temperatures of 998 C (1,800 F) and begin creating their own micro-weather.

In drier areas, haboobs will sweep the planet. Within three days our blue planet has become a brown pill.

As volcanoes erupt, together with the ejecta cloud, nuclear winter will develop and it will last for about three-years. Most above ground creatures (plant and animal) will be dead including surface plankton. Oxygen levels begin to decline and it gets very cold.

What nature demonstrates with this display is that 40-ton herbivores require more plant intake than a nuclear winter harvest can produce. Smaller animals can and did scrape by and survive.

The real problem is how fast everything happened. Look at the time line and you'll see that enough dirt was flung into the atmosphere by just the asteroid impact to create a nuclear winter for 18-months or more. Add volcanoes, acid rain and global drops in temperature, the oxygen producers are into a real extinction-risk scenario.

Our modern day methodology for coping with disasters is designed to respond to and handle small one-of-a-kind disasters. We count on outside capabilities of supply for replenishment to cope, handle and rebuild the disaster site. The above scenario just does not allow for that. It is too global in effect. Too large in scale. Everyone, everywhere needs assistance and they need it now.

The average interval between impacts of this size over the last 4 billion years has been 3.3 x 10^8 years (330,000,000 years). This means one of these impactors is quite likely in our future.

Next month we'll look at some of the things we can do about falling rocks.

---------- TO BE CONTINUED ----------

Twenty Years Ago on Mars…
by Linda Hermans-Killiam

On July 4, 1997, NASA's Mars Pathfinder landed on the surface of Mars. It landed in an ancient flood plain that is now dry and covered with rocks. Pathfinder's mission was to study the Martian climate, atmosphere and geology. At the same time, the mission was also testing lots of new technologies.

For example, the Pathfinder mission tried a brand-new way of landing on Mars. After speeding into the Martian atmosphere, Pathfinder used a parachute to slow down and drift toward the surface of the Red Planet. Before landing, Pathfinder inflated huge airbags around itself. The spacecraft released its parachute and dropped to the ground, bouncing on its airbags about 15 times. After Pathfinder came to a stop, the airbags deflated.

Before Pathfinder, spacecraft had to use lots of fuel to slow down for a safe landing on another planet. Pathfinder's airbags allowed engineers to use and store less fuel for the landing. This made the mission less expensive. After seeing the successful Pathfinder landing, future missions used this airbag technique, too!

Pathfinder had two parts: a lander that stayed in one place, and a wheeled rover that could move around. The Pathfinder lander had special instruments to study Martian weather. These instruments measured air temperature, pressure and winds. The measurements helped us better understand the climate of Mars.

The lander also had a camera for taking images of the Martian landscape. The lander sent back more than 16,000 pictures of Mars. Its last signal was sent to Earth on Sept. 27, 1997. The Pathfinder lander was renamed the Carl Sagan Memorial Station. Carl Sagan was a well-known astronomer and science educator.

Pathfinder also carried the very first rover to Mars. This remotely-controlled rover was about the size of a microwave oven and was called Sojourner. It was named to honor Sojourner Truth, who fought for African-American and women's rights. Two days after Pathfinder landed, Sojourner rolled onto the surface of Mars. Sojourner gathered data on Martian rocks and soil. The rover also carried cameras. In the three months that Sojourner operated on Mars, the rover took more than 550 photos!

Pathfinder helped us learn how to better design missions to Mars. It gave us valuable new information on the Martian climate and surface. Together, these things helped lay the groundwork for future missions to Mars.

Learn more about the Sojourner rover at the NASA Space Place:
https://spaceplace.nasa.gov/mars-sojourner

Caption: The Mars Pathfinder lander took this photo of its small rover, called Sojourner. Here, Sojourner is investigating a rock on Mars. Image credit: NASA/JPL-Caltech

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