NASA AMA: We're a group of NASA Scientists and Engineers analyzing the surface of Mars using the Curiosity Rover, AUA!

NASAMarsSample [1] and r/Science AMAs[1]

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Abstract

Tomorrow marks 5 years since the Curiosity rover's dramatic landing on the red planet! The rover's Sample Analysis at Mars (SAM) instrument suite onboard Curiosity is the most complicated instrument NASA has ever sent to another planet. SAM is designed to measure the composition of the atmosphere and solid samples inside Gale Crater on Mars, and help scientists assess the habitability (could a certain place support life?) of environments recorded in in rocks in Gale Crater. The SAM team has made many amazing discoveries, including finding evidence of a habitable environment – a place that life (think tiny microorganisms, not dinosaurs) could have survived if it had been in that spot on Mars, millions of years ago. SAM also detected the first organics (building blocks of life) on Mars, known to have originated on this planet. We're a group of scientists and engineers from the SAM team, ready to answer your questions about Mars and SAM. We'll be online from 1:00 to 2:00 pm EST and we will sign our answers. Ask us anything! Paul Mahaffy, SAM Principle Investigator, Director of Solar System Exploration Division, NASA Goddard Space Flight Center Charles Malespin, SAM Deputy Principle Investigator, NASA Goddard Space Flight Center Jen Stern, Planetary Scientist, NASA Goddard Space Flight Center James Lewis, Postdoctoral Fellow, NASA Goddard Space Flight Center Brad Sutter, Planetary Scientist, NASA Johnson Space Flight Center Greg Flesch, Instrument Engineer, NASA Jet Propulsion Laboratory Peter Martin, PhD student, CalTech/NASA Jet Propulsion Laboratory Doug Archer, Planetary Scientist/NASA Johnson Space Center We have now been on Mars for 5 years - WOW. The first year after landing we actually played the Happy Birthday song using our SSIT (solid sample inlet tube). You may find this link interesting https://www.youtube.com/watch?v=uxVVgBAosqg EDIT It has been great answering your questions, we are signing off now!

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NASAMARSSAMPLE R/SCIENCE

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We're a group of scientists and engineers from the SAM team, ready to answer your questions about Mars and SAM. We'll be online from 1:00 to 2:00 pm EST and we will sign our answers. Ask us anything!
Paul Mahaffy, SAM Principle Investigator, Director of Solar System Exploration Division, NASA Goddard Space Flight Center
Charles Malespin, SAM Deputy Principle Investigator, NASA Goddard Space Flight Center
Jen Stern, Planetary Scientist, NASA Goddard Space Flight Center
James Lewis, Postdoctoral Fellow, NASA Goddard Space Flight Center
Brad Sutter, Planetary Scientist, NASA Johnson Space Flight Center
Greg Flesch, Instrument Engineer, NASA Jet Propulsion Laboratory
Peter Martin, PhD student, CalTech/NASA Jet Propulsion Laboratory
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WRITE A REVIEW

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Thanks for all the great images you have shown us over the years! What have you seen that really defies any reasonable explanation? Is there anything that you have seen which has really 'stumped' the team?

chernchern

Great question. One really interesting observation is that while we measure a low background of methane in the atmosphere we see these mixing ratios occasional spike to levels that are much higher than the background levels. The methane then drops which is really surprising since photochemical modeling suggests that methane should last in the atmosphere for hundreds of years before it breaks down. Methane is really interesting because in the Earth's atmosphere most of it is produced by life. But methane can also be produced by water/rock interactions. So where does the methane come from and why does it suddenly appear and disappear? We are working on theories to explain this. PaulM

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What's the most exciting thing you've found on Mars that doesn't make normal people go "Wow!" but makes you scientists and engineers go "Holy crap!"

icylurk

We can use SAM to measure the age of the rocks in Gale usingpotassium-argon dating. Back near the beginning of the mission, we measured an age of 4.21 billion years on a sample called Cumberland. Finding a rock that old was exciting, but also kind of expected, since the overall history of Mars is that the planet slowed to a stop geologically around 3 billion years ago. But then, later in the mission, we measured a sample called Mojave 2… The age we got for the minerals that form from interaction with water was as young as 2 billion years! Most people probably wouldn't be shocked by a result like that, but for scientists who are used to thinking Mars only being active before 3 billion years ago this is a big deal!

-Peter M.

My daughter is very interested in space, and particularly loves the Mars rovers. What would you recommend to study, based on the future direction of NASA, for someone that wanted to contribute to NASA? Any particular fields of study?

(Sorry if this is obvious- I come from a non-science background myself)

Anonymoose741258

I'll chime in - NASA does more than science - for sure I strongly believe everyone should have a strong math and science background. But there are other ways to work at NASA. We need artists and communicators to help us convey our work to the public. We need doctors to study the effects of space on the body. So many ways to contribute! I myself have a BA and PhD in geology, but didn't study space science until after grad school. Before, I studied chemical cycles on Earth. - Jen S

My daughter is very interested in space, and particularly loves the Mars rovers. What would you recommend to study, based on the future direction of NASA, for someone that wanted to contribute to NASA? Any particular fields of study?

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Anonymoose741258

Good question. NASA needs a whole range of engineers and scientists to accomplish the mission of space exploration. So a technical background in math or physics or chemistry or science is great. For planetary studies of the surface of Mars a geology background would be excellent. You could take a look at the background of our team members found on our web site https://ssed.gsfc.nasa.gov/sam/ PaulM

My daughter is very interested in space, and particularly loves the Mars rovers. What would you recommend to study, based on the future direction of NASA, for someone that wanted to contribute to NASA? Any particular fields of study?

(Sorry if this is obvious- I come from a non-science background myself)

Anonymoose741258

If you're a US citizen at college or high school NASA has some greatinternships.

If you're from outside the US like me I would strongly recommend doing an undergraduate degree in a STEM field and then looking for graduate opportunities with researchers directly involved in NASA missions or those who do research applicable to current or upcoming missions. James L

The work all of you are doing is incredible! During the journey towards your current scientific accomplishments, there were obviously numerous seemingly impossible problems. What is one of the most creative, ingenious and inventive solutions to one of these problems?

Montemurro

On the spacecraft end the challenge of EDL (entry, descent, and landing) through the thin atmosphere of Mars was solved by the very creative "SkyCrane" approach where in the last stages of descent the rover with its wheels extended was tethered down to the surface. This was amazing and successful. In the instrument end for SAM there were many challenges. How to heat samples to more than 900 C with just a few 10's of watts. Our lead flight software engineer developed a high level scripting language that lets us rapidly adapt to discoveries and control the many valves, heaters, and the parameters of the 3 instruments in SAM. Just to be sure this will work properly on Mars we test this experiment sequence out using an instrument in a Mars environmental chamber here at Goddard Space Flight Center in Greenbelt. PaulM

If you decided the order for places to send rovers (submersibles too) next in our Solar System what would the top 5 places be?

TheOneAndOnlyKirke

In my personal opinion as a planetary scientist, Mars is definitely at the top, and we know nothing about what's under the surface! Europa is also at the top due to its liquid ocean, although it lies underneath many km of ice - a submersible would be awesome to send here. Enceladus is in the top 3 for me also, because hydrogen has recently been detected in the plume, suggesting that hydrothermal activity might be present. Titan is also awesome due to its liquid methane lakes and we need to know more, would like to send submersibles! Finally, we know very little about our other neighbor, Venus, so we're developing materials that can withstand the pressures and temperatures so our landers don't get crushed or melted on the surface! -Jen Stern

How is the rover holding up on the Martian surface? I've seen a few pictures recently showing the wheels starting to deteriorate. What is the designed lifetime of the rover?

shiruken

It is remarkable that we have been on Mars for 5 years now and the rover and its instruments are in mostly good health. We have a few puncture holes in the wheels but we should be good to go for many kilometers. With SAM our pumps are still spinning at 100,000 RPM and our instruments are in good health. We have plenty of helium left for our GCMS experiments. See https://ssed.gsfc.nasa.gov/sam/ for an overview of our SAM instrument. PaulM

Hi there!

I do archaeology in Canada and I've long been interested in soils research. How are you defining

stratigraphy? Or is that not important to your research? Most of the soils you're hoping to find are going to be alluvial, but if I understand correctly the vast majority of soils are aeolian. How are you detecting the presence of alluvial soils? Pure chemistry or are there other techniques?

If you are using a purely chemical method, what are the markers of water that you are looking for? How does the lack of a strong atmosphere affect your research? Solar radiation is going to affect a lot of the surface so how deep are your probes going? Most of what I've seen on the gosh-wow sites online don't go into much detail. Are there papers you can guide me towards?

Are there clay deposits on Mars, or is that one of the materials you are hoping to find?

I have many many more questions. I've been interested in your research partially because I think some of those techniques could possibly be used in archaeology back on our home planet for looking for markers of human occupation of sites where the visible evidence has been erased by time, water and all the other (intensely annoying) factors, and partially because I think your research is amazing. Robots on Mars! I mean, come on, how cool is that?

I remain slightly jealous but eager to hear your responses, and hope you forgive the wildly general nature of my post.

Thanks, and keep on with the amazing research!

jqpublick

Hi, Yes, most of the loose unconsolidated material on the surface is eolian in nature. However, the possibility exists that some materials may have had fluvial/alluvial origin but after deposition get blown around. The smaller the grain the easier it is to blow around.

We detect the water directly with the Sample Analysis Mars instrument that possesses a mass spectrometer that can detect the water that is evolved as the sample is heated to 870C. Some water is adsorbed and some water occurs in minerals that decompose at characteristic temperatures.

The lower pressure of the martian atmosphere does not affect how we do our work as SAM is designed to work under the conditions.

We can only drill down to 6cm. And yes this can be factor as to how organic-C can be preserved. We think the proximity to the surface of our samples is probably why we are having difficulty in detecting complex organic molecules.

Go to Google Scholar and do literature searches for what you are interested in. Another place to get started in determining who is doing what in Mars research is to look at the latest abstracts from the Lunar Planetary Science conference.
Brad S.

Thanks for coming!

I'm curious--how do you test equipment to find out if it will be durable under mars atmospheric conditions? Do you have a special test environment?

asbruckman

Mars is a very harsh environment, which requires us to rigorously test any instruments or electronics we send there. For SAM and Curiosity, we build special environmental chambers here on Earth which replicate the thermal and atmospheric conditions on Mars as best we can. SAM was put in the Mars chamber here at Goddard, and tested for many months to ensure it operates safely.

-Charles M

Why have we not sent any rovers over nearer to the ice at the North Pole, wouldn't this be the place we would want to look for microbial life, or have we done this already? Ps I think you guys are awesome

boskoliscious

We have! The Phoenix lander mission landed in 2008 to study water near the pole. Here is the wiki to give you more info! https://en.wikipedia.org/wiki/Phoenix_(spacecraft)

https://www.nasa.gov/mission_pages/phoenix/news/phx20100524.html

And from Doug A - I worked on the Phoenix mission and the jury is still out about whether or not the ice is a good place to look for life. And it really comes down to if life has existed recently on Mars. The polar ice is, at most, a hundred million years old or so. So if life hasn't existed in that time frame, it's not a great place to look. If life has existed more recently, then yes, the ice could be a good place to look.

Charles M and Doug A

Awesome AMA. What Martian facts are you most fascinated by, even after five years of hard work ?

averhaegen

It is amazing that we can understand what happened billions of years ago on Mars - for example that we are in an ancient lakebed or that big parts of the atmosphere have been lost over time by looking at the record locked into rocks and into the isotopes (heavy and light version of atoms such as C, N, H, S, and O) of molecules that we measure. PaulM

The viking lander had one positive test result in the initial search for life on mars. What is your take on the result and do you think it is still possible it was a real result? Levine stands by the positive result to this day.

Shnugglez

Without re-doing the experiment, we can never completely rule out biology. However, many of the reactions observed can also be explained by what we've discovered about the oxidizing nature of martian soil. Mars soil contains perchlorate and other oxidants that react with heat and/or UV to cause organic degradation. It is highly likely that the result of adding nutrient broth added to the reactive martian soil caused reaction of the labeled carbon in this broth with oxygen in oxidants, causing the positive test result. - Jen S

Hi, thanks for joining us! I heard from some other Mars mission people that they've spent a lot of time living sol by sol. Have you been doing that/are you still doing that? How difficult has it been to adjust to such a schedule?

themeaningofhaste

Only for the first 90 days of the mission did the mission scientists and engineers live on Mars time. This was difficult to some degree as the martian day length is approximately 40 minutes longer than the Earth day. So your day keeps getting shifted to stay in sync with Mars. Brad S

How much longer will the Rover mission last and what is the next big Mars mission?

finicius

We hope that Curiosity will be running happily for a good few years yet. It's 5-6 years until the radioisotope thermoelectric generator will have less power to charge the rover and we are being very careful about wheel wear. There are a bunch of really exciting missions planned for the near-future. In 2018 there will be InSight and in 2020 NASA will be sending a rover with a very similar design to Curiosity (but different scientific instrumentation) - NASA 2020. Also in 2020 ESA and Roscosmos will be sending the ExoMars rover! James L

I recently graduate with a Biology degree, and am extremely interested in Astrobiology. I am taking a gap year right now, while applying to medical school and wanted to do something that would allow me to spend that year exploring/ contributing to the Astrobiolgoy field. I have strong intentions to pursue a career at NASA following medical school. Any recommendations on how to go about this/ resources I can check that would helpful?

I've found Astrobiology research labs, but their positions are very limited and exclusive to post doctoral student.

whydee99

This looks like a group at NASA Johnson where you could contribute expertise after you have finished your medical degree: https://www.nasa.gov/hrp -Jen S

I could have sworn that at some point in the hype leading up to the landing, that someone mentioned getting video footage from Mars. Was I dreaming? Is there any and if not, is it possible?

liarandathief

There is! We have a camera on the belly of the rover called MARDI, and it recorded the decent of Curiosity during the '7 minutes of terror'. https://www.youtube.com/watch?v=RyBffhiOuVU

We also use cameras on the mast to monitor for dust devils on the surface and have made a few short movies you can find online.

-Charles M

At the current rate of mapping and exploration, how long will it be until we have a relatively accurate topographical map of the entire surface of Mars?

foxsable

We actually already have an awesome global topographic map of Mars, the Mars Global Surveyor orbiting mission had an instrument called the Mars Orbiter Laser Altimeter that produced this map. The map shows the dichotomy between smooth northern lowlands and ancient cratered highlands to the south. You can also see giant volcanoes and the huge canyon system Valles Marineris - James L

Spirit and Opportunity were just so cool (nerd alert: I named my 2 tool chests in my garage after them).

Then Curiosity came along and upped the game. That landing procedure was epic. Will you talk about a few major lessons learned from the Spirit and Opportunity missions and the impact that it had on Curiosity's mission, focusing of course on the analysis aspects of the missions. Thanks for doing this!

0100101001001011

We agree! Spirit and Opportunity have had a huge impact on Curiosity. First, the way we do operations with Curiosity was defined for Spirit and Opportunity, so the entire structure of how we do things on Mars comes from those rovers (with some Pathfinder heritage as well). Science-wise, Spirit and Opportunity helped confirm from the ground that Mars is a very diverse planet with a wide range of environments, geologic processes, and chemistries. We saw a hydrothermal environment with Spirit and long-lasting aqueous activity resulting in many sedimentary layers with Opportunity. These results influenced landing site selection for Curiosity where we ultimately decided to explore a mountain composed of sedimentary material spanning a time in Mars that included a shift from a warmer and wetter climate to a colder and dryer climate. The lessons we have learned from Spirit and Opportunity directly contributed to that decision and how we think about Mars in general. -Doug A

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This is a great question, we learn a huge amount from each probe we send to Mars in terms of science and engineering and try to feed that knowledge into future missions. This can be difficult though as it takes many years to develop flight instruments etc. One thing Spirit and Opportunity highlighted is how complex the history of water is on Mars. Mars shows a transition from neutral benign waters early in its history to acidic, sulfur-rich conditions (Spirit and Opportunity visited sediments deposited in this later stage). In Curiosity's study site in Gale Crater sediments in Mount Sharp record this transition and the rover is busy investigating and finding out more! James L

What process was taken to decide on the suite of instruments on SAM? How are these instruments, such as the robotic arm, operated in a precise way all the way from Earth? What was your reaction to the discovery of organic matter 3 years ago and what does it mean for future Mars exploration?

edithkeelermustdye

Great questions ! NASA selects the payload with a competition. So a team I led at Goddard put our best ideas forward to NASA and after a review process we were selected. We included instruments from Goddard, from JPL, and from France that all needed to work together to study both gases from the atmosphere and those released from rocks.

We operate by generating a sequence of commands and test them on Earth using a nearly identical instrument in a Mars environment. After we have reviewed the sequence and the data from the lab we hold a series of reviews and then work with the larger MSL operations team to see where this experiment could fit in our operation for that day or night on Mars. The big sequence that includes both other instrument and rover commands then is checked at JPL and sent to Mars in the morning (Mars time). Curiosity accepts the commands and starts executing them without any input from Earth. When one of the spacecraft orbiting Mars comes over the horizon Curiosity will send as much data as it can up to the orbiter and then this data will be sent to big antenna on Earth. So sometimes it is several days before our data comes down.

Finding organics was great ! If ancient microbial life was present on Mars then this means that we may have some hope of finding molecular biosignatures. But cosmic radiation that blasts through the thin Mars atmosphere can transform these biosignatures so the best bet for finding ancient biosignatures might be to dig deep below the depth (2-3 meters) to where these penetrate.

PaulM

Congratulations on an incredible milestone!

Considering the complexities of operating a device on another planet - and conversely how awesome it must be when things work out - what sort of nail-biting moments you've gone through over the last five years? What were your personal highs?

WhatsMyMageAgain

The 7 minutes of terror were clearly nail-biting but we have had many amazing experiences. Just looking at a new landscape every few days in front of the rover from the great cameras on Curiosity never gets old. Then with SAM our really exciting discoveries have been (1) finding methane in the atmosphere, (2) measuring isotopes in C, O, and N in the atmosphere that are a signature of great atmospheric loss, (3) doing the first ever K/Ar age dating on Mars and releasing 40Ar from 4+ billion year old rock, (4) finding perchlorates in nearly every sample we drilled over the first part of the mission, (5) extracting the D/H and 15N/14N ratios that had been locked into rocks more than 3 billion years ago . . . . and there have been many more. It has really been a tremendous 5 years for learning a lot more about Mars. PaulM

How much control does planetary protection have over where the rover goes and what it does? Are there any big opportunities that have been missed?

shiruken

It is extremely important that we avoid forward contamination of Mars with anything from Earth, particularly life from our own planet. Because of this, generally rovers go to places where there is not any chance of liquid water being present on or under the surface. So yes, there are areas that we cannot go unless the rover undergoes a very high class of sterilization, like the Viking rovers did. Unfortunately, this is very expensive, so this can’t be done for every mission. One area that would be interesting to explore with a very clean rover are the RSLs, areas where hydrated salts leave streaks on the surface of crater slopes that may represent intermittent liquid water. However, any life there would have to adapt to very briny conditions. - Jen S

What would we need in order to sustain human life on Mars once we arrive there?

blackmagevivi9

Being at the Johnson Space Center, which is the center for human spaceflight, this is a question we think about all the time. Astronauts would need oxygen, water, food, protection from radiation, and way home, which are all fairly difficult questions. One of the things we try to do is understand what resources we can use that are already on Mars because the less we have to bring with us, the more likely it is we’ll actually be able to go (less expensive, smaller rocket required, etc). We call using martian resources “In Situ Resource Utilization” or ISRU because we love acronyms :). And this is something that data from SAM is very useful for. When we analyze a sample with SAM, we can tell how much water is in the sample. For example, the Rocknest sample

(https://www.nasa.gov/mission_pages/msl/multimedia/pia16468.html#.WYSsTNMrIn00) contained about 2-3 % water (by weight) that is released by heating to ~500 degrees C. This water can be used to drink, can be split into H2 and O2 to breathe (or for rocket fuel), could be used to water plants, or rehydrate food. So we are investigating the best way to utilize resources like this on Mars to enable long-term human exploration of Mars. -Doug A

Hello, big fan here.

How plausible do you think colonising Mars is in the near future ?

m3tals4ur0n

This is a really interesting topic; NASA is pushing to get people to Mars along with private industry but your question is not just about getting people there but establishing a more permanent presence. If humans are on Mars we would be able to do some amazing science (whilst also needing to be super careful not to contaminate the planet and make it significantly harder to look for evidence for ancient life on Mars). There are some major technical challenges to overcome but I think the lesson from Apollo is maintaining public interest in space exploration is crucial and we'll need that to overcome the challenges of getting to and living on Mars - James L

How long does it take commands to travel to the rover?

ieswideopen

Depending on the orientation of Mars and Earth, it can take anywhere from 4 to 20 minutes one way light time. We are currently coming out of a period called Solar Conjunction where the Sun was between Earth and Mars, so we did not command the rover for about a month. Curiosity got to take a nice Soliday (since a Martian day is called a Sol, we call Martian holidays, Solidays) -Charles M.

What other jobs in NASA have you guys done before your current position, or did you go straight into the work you do now once employed by NASA?

anakikills

I'm from the UK and did my undergraduate (geology) and PhD (organic geochemistry) at Imperial College London. I applied to the NASA Postdoctoral Program and started at NASA Goddard Space Flight Center in June 2016. So far it's been a great experience and if you're at college, interested in NASA's research and planning what to do after a PhD I strongly recommend looking into applying for a NPP - James L

Thank you for doing this AMA!

How much capability does the Rover have to repair itself if something breaks? Is this a feature of space research equipment that has been a focus or improved a lot over time?

neurobeegirl

The answer is not much :)! The one thing that we can actually repair or replace if it breaks is the drill bit. We have a few extra drill bits on the rover so if a drill bit gets stuck or worn down it can be switched out (https://msl-scicorner.jpl.nasa.gov/samplingsystem/). Other than that, when things go wrong, we figure out how to work around the problem. But because we knew that we wouldn't have a lot of repair

capacity, the systems were designed with a lot of redundancy so that if something does go wrong, we hopefully have a backup! -DougA

Hi Guys what you do is awesome! Has anyone recreated martian soil in the lab in terms of chemical compositions (I know there are simulated regolith is out there e.g. JSC-1A), environment in terms of pressures temperatures and tested earth based microorganisms for survival? I'm finishing my microbiology PhD and extremeophiles (environmental colonisation) are something I want to move into, so if you guys have any advice :)

Themightyteadrinker

Yep, we make custom mixes all the time using the mineral composition of the soils and rocks we have measured on Mars with Curiosity. There is no one perfect analog soil, but generally we include things like Ca and Mg perchlorate, sulfates, and iron minerals. We also have Mars chambers where we use vacuum pumps to bring the pressure down to Mars ambient pressure (~10 mBar) and temperatures (-60 C to +20 C). At NASA Goddard we have these chambers and do try to grow microbes under Mars conditions. - Jen S

This mission has been great for informing what we use as martian simulants. We have measured bulk chemistry with APXS, definitive mineralogy using X-ray diffraction with the CheMin instrument, and volatiles from minerals and organics with SAM. So depending on the type of application you're interested in testing, we could produce a number of different simulants. For example, at the Johnson Space Center we have groups interested in the physical properties of the soil and how it might affect space suit materials and seals, how hard the material is for landing, as well as the properties we need to know about from a human health perspective. There is no one simulant that addresses the wide range of materials we've found on Mars, so we make many simulants based on what we've learned from MSL. -Doug A

What happens during the cleaning events??

wittingtonboulevard

Not sure if you mean instrument cleaning events, or dust cleaning events, so I will answer both! If you look at some of the first selfies Curiosity took of herself after we landed, she had a shiny white clean coat of paint. Comparing that to more recent selfies, you can see how much dust we have collected! Dust was a major problem for the prior generations of rovers because they were solar powered, which meant that a layer of dust could cover the solar panel and reduce the amount of sunlight they receive. Curiosity if nuclear powered, so dust cover is not as much of a concern.

As for instrument cleaning events: SAM runs periodic cleanups and blanks to help remove any residual gunk that may have been left over from a prior sample analysis. By heating up the instrument pipes and flushing them with helium, we can pump out any leftover gas to help remove cross contamination. It is impossible to completely clean SAM, so we also run procedural blanks to determine what the instrument 'background' looks like. This background is then taken into account when we analyze a sample, which is how we determine what came from the sample, and what is from SAM. -Charles M

Was the instrumentation entirely custom designed for the rover? Could any of-the-shelf materials be used?

nate

SAM was built using mostly custom designed hardware and electronics. We modified some commercial items to be flight qualified, but since the environment is very harsh, most commercial instruments would not survive under Martian operating conditions. Our lab here at Goddard has been building mass spectrometers for 50 years, which have been sent to many objects in the solar system. - Charles M

I love this research and fully support all of NASA's missions. I can see the big picture but others in our country think space exploration is a waste of money. Can you tell us of any real world advances or uses of the research being done here that have an immediate impact on peoples lives?

Leatherneck55

NASA has a whole office that focuses on technology transfer of space research to health and daily life and discusses these advances in its annual publication "Spinoff" which can be found here: https://spinoff.nasa.gov

Here's one that talks about how autonomous rover technology paved the way for hospital robots: https://spinoff.nasa.gov/Spinoff2012/hm_3.html

-Jen S

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Leatherneck55

This is a good question that deals fundamental research versus applied research. The work we mostly do focuses on understanding fundamental properties of the solar system and in this case, Mars. Will you see a real world advance that will immediately apply directly to you from our exploration of Mars, probably not. However, the fundamental knowledge gained here in time could find use in the future, especially if humans find themselves on Mars. Furthermore technologies developed for these missions could easily find their way back to Earth in the future. Digital photography, for example, we all take for granted these days was developed for satellite and planetary orbiter imaging as it is too costly to return film back to Earth. Brad S.

What is the most rewarding parts of your work

TheWalruz

Most rewarding part of this work has to do with firsts. That is, the first to see images from another plant and trying to determine what processes had operated on the martian surface. Being on the SAM team, it is very exciting to be the first to see the data from our instrument and to be the first to present what we think the data means to the scientific community at conferences and in peer reviewed publications. Brad S.

What is the most rewarding parts of your work

TheWalruz

Being part of an awesome team, and as Brad says, being the first to see or discover something. For

me, communicating the results of our work to interested people is really at the top of the list. -Jen S

Would you still consider the entry onto the planets surface was the way to go for the rover? If you had more money or time, would you chose a different way to bring a rover to the surface?

Salael

If you mean the landing using the sky crane, it was extremely successful. Curiosity is the heaviest thing to ever land on Mars, so the methods used to land previous lighter rovers encasing them in "airbags" and letting them bounce just won't work. The same entry, descent, and landing (EDL) procedure will also be used to land the Mars 2020 rover, with some improvements on targeting the landing site. Mars is super hard to land heavy things on, because the atmosphere is too thin to slow the rover down, but also thick enough to cause heating upon entering the atmosphere. - Jen S

Will the curiosity rover help us find the best place to set up a human habitat on mars? Is a human mission to mars just ridiculous to think about how?

steely-eyedmeky

Curiosity has helped us assess the environment inside Gale Crater on Mars, which does not currently have water or ice. But rover and orbital exploration in general is helping by determine where there might be sub surface ice, shelter from radiation such as lava tubes, etc. There's lots more to learn before we send humans, but its not at all ridiculous to think about human exploration. We need to think about it now, because there's a lot to figure out about how to sustain human life in space in terms of dealing with microgravity and radiation. These things take a toll on the human body, and we can use the International Space Station as a testbed to understand how, say, a year in space can affect the human body. Scott Kelly and his twin, Mark Kelly, were part of an experiment to compare two twins after one spent a year in space on the ISS, and one on Earth - check it out! https://www.space.com/35527-nasa-astronaut-twins-study-early-results.html -Jen S

Mars was totally different thousands of years ago. Is it possible that there was a civilization on mars thousands of years ago?

therealfishbus

Yes, Mars was indeed different BILLIONS of years ago, and we believe there was standing and flowing water, and quite possibly some sort of microbial life. Mars thousands of years ago was pretty much the same as it is today. On our planet, civilization leaves a lot of junk around, which is why archaeologists can find it and even distinguish it from what modern humanity leaves around. Any civilization on Mars would leave evidence behind that would be very hard not to see from all the pictures we've taken on the surface of the planet. Also, life leaves its chemical marks on the atmosphere, which is then recorded in the geological record, and we just don't see evidence of large scale, complex life in the rocks on Mars. -Jen S

Mars was totally different thousands of years ago. Is it possible that there was a civilization on mars thousands of years ago?

therealfishbus

Well, the evidence is that Mars was different billions of years ago, not thousands of years ago... And I

would say that is extremely unlikely.

Funny enough, the person who answered that question from the U.S. representative is my advisor at Caltech, Ken Farley.

-Peter M.

edit: since this has gotten a couple more upvotes, see below for a legitimate answer from Jen

Do current soil conditions on Mars contain the molecules / nutrients necessary to support any type of life, or is there only just trace evidence that life could have possibly once existed on the red planet? Thanks for taking the time to do this AMA!

Sabertooth_Salmon

Do current soil conditions on Mars contain the molecules / nutrients necessary to support any type of life, or is there only just trace evidence that life could have possibly once existed on the red planet? Thanks for taking the time to do this AMA!

From a chemical perspective, yes, we have found multiple soils that contain the chemical ingredients necessary for life, generally accepted as C, H, N, O, P, and S. Some of those, like H, S, and O, are pretty abundant and others, C and N appear to be much less abundant. Otherwise, Mars is currently very cold and dry so even with the chemical compounds necessary for life, the environment isn't very habitable today (not to mention the radiation environment at the martian surface). However, we have a lot of evidence that Gale Crater (where we landed) was the site of a lake ~3.5 billion years ago that could have persisted off and on for hundreds of millions of years. So we have learned with SAM/MSL that Gale Crater was once a habitable environment, but we don't yet know if it actually was inhabited! -Doug A

Can you guys elaborate on what it took to put together the SAM? Apparently it vaporizes matter and analyzes its components, which is awesome. What of interest has it found, what were the challenges in designing it and how does it clean itself?

And thanks for doing this AMA

janmichaelvincents16

SAM was selected in 2005 as part of the payload for Curiosity. It took a team of hundreds of scientists and engineers to build, test, and validated SAM here at Goddard over 5 years. Curiosity originally had a launch date of 2008, which got slipped to 2011, allowing us more time to calibrate and test the flight instrument.

SAM is the most complex instrument NASA has ever sent to another planet. It takes an entire chemistry lab and packs into a box the size of a microwave. We can analyze either solid samples or atmospheric samples with one of our three sub systems. We heat up solid samples to 1000 C, and analyze the gas that evolves as the minerals in the sample break down. There are 54 microvalves, 64 heaters, 2 minaturized turbopumps, 72 sample cups, and many other components that all have to operate autonomously under the harsh Martian conditions for SAM to work! The SAM team has done an amazing job designing such a complicated instrument that is still working after all these years!

Please see the SAM website in the AMA description for more details about how SAM works. -Charles M

What kind of organic molecules have you discovered so far?

liightt

The SAM instrument on Curiosity made the first conclusive detection of organic molecules on the Martian surface! Looking for organics on Mars is really difficult; you have to shrink down laboratory techniques to fit onto a lander or rover and fly them millions of miles through space and survive landing and operating on another planet. Generally we scoop or drill a bit of Mars and then place it in an oven and heat it up and monitor the gases that come off and look for any organic fragments being released. A complication that Mars throws in is that salts called perchlorates are common on the surface (we first discovered this with the Phoenix lander in 2008). When you heat a perchlorate you release oxygen and chlorine that can complicate the signals for organic molecules and make them hard to distinguish from instrument background and contamination. SAM has observed an organic compound called chlorobenzene at high levels that can't be explained purely by contamination, indicating that some of that organic carbon came from the Martian surface! We continue to work hard to find ways of working with the perchlorate issue and looking for minerals hosts that might shelter organic compounds from destruction on the planet's surface and in instrument ovens - James L

What's the most interesting thing you have discovered on Mars so far?

King-Mike

For me, one of the most interesting discoveries was the detection of nitrate. The nitrogen in nitrate had not be detected in the martian surface until the MSL mission. Detecting nitrogen is critical, if life as we know is even possible as nitrogen is required to make DNA, proteins etc. Brad S.

You guys are awesome! How do you deal with BS like Alex Jones claiming that you have a secret child slave colony on Mars? What does this kind of ridiculous claim do to morale?

mousersix

Generally we laugh about it and move on with our work :)! - Doug A

If Curiosity and Opportunity decided to immediately start driving towards each other, about how many years would we have to wait to see their reunion?

osxpert

This is a fun question. Lets do a quick back of the envelope calculation: Opportunity has driven 43.79 km in 4800 sols. That is about 9.1 m / sol if all it did was drive. Curiosity has driven 17 km in 1777 sols. That is 9.5 m/sol. In reality we drive much much slower since we do not drive every sol.

Assuming Curiosity and Opportunity are 2000 km apart, it would take about 105,000 sols, or 157 Mars Years (or 314 years for you Earthlings) for them to meet in the middle. By then, hopefully humans will be on Mars to help push them along…

-Charles M

What are the plans after mount sharp? Good work over the last 5 years, I follow the Rover reports on YouTube.

sportsman5k

Given the immense size of Mt. Sharp (5km high), we will likely never reach the top with MSL. It's possible that at some point we'll reach a point on the mound that we think we've learned the most interesting/important things about it and might turn around and head back down the mountain (or on a different route around the mountain), but it's unlikely we'll ever be done with Mt. Sharp for MSL. -Doug A

Thank you for doing this! I took part in the NCAS program this summer and love the work NASA does! Whether it be on a molecular level or simply a difference in characteristics, is there any difference in the water-ice in areas such as Utopia Planitia compared to the water here on Earth? I heard on a podcast (which one I can't currently remember) that it may be possible for microbes to be living deep in the soil outside the reach of radiation, how deep and likely is this? What causes the reaction between radiation and the soil that kills microbes so quickly? What are the differences in soil composition over the span of the planet's surface? What experiments will be vital for pre-human exploration of Mars on the 2020 rover? I don't expect an answer to all of these, I do appreciate any answer I get. Once again, thank you so much for doing an AMA for the awesome people of r/science! Keep up the incredible work, it is truly inspiring.

edithkeelermustdye

Here an answer to one of the questions: Yes this is possible. We have only scratched the martian surface, which is a very nasty place due to oxidants and galactic cosmic rays (GCRs). But yes, if you go 2-3 meters down, you get beyond the reach of the GCRs. ExoMars, an European Space Agency mission to launch in 2020, will the capability to drill 2 m in depth, and an instrument called MOMA that will look for molecular evidence of life.

Also, in terms of pre-human exploration on 2020, the payload will tell us more about the resources for human exploration, and the MOXIE experiment will perform a demonstration of taking Mars CO2 atmosphere and making O2. For humans, this would have to be scaled up a lot.

-JS

Will Mars2020 rover have a similar instrument cluster, and if so, what improvements are you excited to see the results from?

kgwhipp

The 2020 rover will have a different instrument package than MSL (see https://mars.nasa.gov/mars2020/). One of the goals of the 2020 mission is to "cache" samples that won't be directly analyzed by the rover itself but could be picked up by a subsequent rover and returned to earth. And sample return would be incredibly exciting from a scientific perspective because we could bring to bear all the instruments we have on earth to martian samples and learn a lot about Mars and the potential for past life. - Doug A

Curious, do any of the people that worked on designing/building the Rover ever get to operate it?

jjtitula

Yes, some of the folks who designed and build the Rover are also Rover Planners and help navigate our path through the sand dunes! -Jen S

When testing the SAM on earth before sending it to mars, I guess you tweaked parameters to check if the results were as predicted.

What parameters were the most important to take into account to analyse the results? For example, does gravity on earth prevents its use and good testing compared to the martian environment?

tomahawk077

Good question!

We have an exact replica of SAM here on earth called the SAM testbed. It is housed in a Mars environment chamber here at Goddard which replicates the thermal and atmospheric conditions on Mars as best we can.

The testbed and SAM on Mars run the same experiment scripting language, which allows us to develop new experiments on Earth and extensively test them before use on Mars. Depending on how complicated the experiment is, testing can take weeks to many months before we run it on Mars.

In order to optimize the science parameters, we run analog samples on the testbed and adjust the experiments to make sure we get the best science possible. The 'most important' parameters depend on what science question you are trying to address with your experiment, we can customize experiments to make specific measurements, eg measure the heavy noble gases like Kr or Xe in the atmosphere.

-Charles M

Is NASA planning to start up plant life on Mars? Maybe with lichens or other ecosystem pioneers?

Mirrorflute88

Not at this time. Such a task would be extremely difficulty given the current Martian conditions. Even if we could, most scientists would prefer to leave Mars as pristine as possible in order to study the surface as it was altered by Martian processes. Brad S.

I read somewhere, maybe incorrectly, that Mars can't actually retain an atmosphere thanks to not having a magnetic field because the core does not spin (any more?). If we were really going to terraform Mars, how feasible is it to jump start the core? Is it too much in the realm of sci fi?

Iforgotmyspacename

Mars has an atmosphere, but the average atmospheric pressure is <1% of Earth's. But that hasn't always been the case. Based on isotopic ratios of certain gases in the atmosphere (and abundant evidence of past liquid water on the surface), we know Mars had to have had a thicker atmosphere in the past. And yes, the lack of a magnetic field contributes to atmospheric loss. At this point, jump starting the core is definitely in the realm of science fiction. However, atmospheric loss is a slow process that happens over millions of years so if you were somehow able to to get more gas into the atmosphere, it would stay there for a long, long time measured on human timescales. -Doug A

With all the data you've gathered now about Mars, where do you think the most interesting part of Mars will be to send more robots?

euxneks

The scientific community is currently debating where to send the next rover, calledMars 2020. We've whittled it down to three sites: Jezero Crater, which is an ancient lake with a delta deposit; North East Syrtis, which is an exposure of ancient subsurface rock alteration; and Colombia Hills, which is where the Spirit rover went, and found interesting hot spring deposits. Since Mars 2020 is going specifically to look for ancient signs of life, these are the places we think were most likely to have life billions of years ago.

-Peter M.

How often are there dust storms in Gale Crater?

CurtisLeow

To my recollection, I don't think we have experienced a traditional dust storm in Gale Crater since landing, and there hasn't been a global dust storm in the past 5 years either. However, that doesn't mean we haven't seen a lot of dust activity. Over the course of a martian year, the amount of dust in the atmosphere varies quite a bit and we have seen that variability. We have also seen dust clouds and a number of dust devils (https://www.jpl.nasa.gov/spaceimages/details.php?id=pia21270) showing that their is quite a bit of dust activity in Gale Crater. -Doug A

Thanks y'all for doing this!

My personal path in life will hopefully lead me through the Air Force Space Command to a civilian space job. So my question is How often do you see a military to civilian transition in the space field?

Also what are y'all LD opinion on the US Space Corps?

Is_Not_Lost

The space community is pretty small and there is a lot of crossover between the different parts of the community. So if you have skills that are useful to NASA (or civilian commercial space companies) I think a transition would be very possible. -Doug A

Hi Paul,

How long 'til we launch an ion trap with the newly developed precursor and neutral loss scanning capabilities?

dalt2424

We'll wish the ExoMars rover the best of success in getting to the surface of Mars after the launch in 2020. Its mission is to drilldeep into the subsurface and search for biosignatures. Its mass spectrometer is an ion trap sourced by both a laser and a gas chromatograph with a team based at Goddard working diligently on the powerful scan modes you mention.

http://exploration.esa.int/mars/45103-rover-instruments/?fbodylongid=2132

Oribitraps should provide yet another capability for in situ planetary exploration with their really high mass resolution capability and these experiments will certainly be implemented in space in good time. Several talented folks are working on these technologies.

In the meantime, our SAM team will continue to focus on the data from Curiosity and hope to repeat this celebration in another 5 years.

PaulM

Please do write some sample commands that you send to it and from what sort of console?

piperror

print “Hello Reddit!”

(but seriously, we use a custom version of BASIC for the scripting language. Our flight software is custom written in C) -Charles M

Thanks a lot for doing this AMA

What advice would you give to young people aspiring to join the aerospace industry?

PhantomSquared

Others have answered this, but I would strongly recommend applying for NASA internships while in high school, college or grad school! I was a NASA intern in grad school and I cant recommend it enough!

-Charles M

Future aerospace engineer here, hoping to join NASA in the near future! Question: If the hydrocarbons on Mars are harnessed, how can they be utilized to help establish civilization on Mars?

carl318

Unfortunately we have only detected very, very , very low concentrations of organics on Mars with the SAM instrument. However, if higher concentrations were found, such organics could possibly be used for support plant growth in enclosed life-support systems for astronaut tended bases.

Hi there! Is there anything like a design review paper or something that follows the design of the rover? It is an incredible feat of engineering and I'd like to learn more about it. Thanks!

ConTron44

About a year after Curiosity landed, we published a book called"Mars Science Laboratory". It's a large-scale overview of the rover's instruments and mission (and you'll find a chapter about SAM in there too!).

-Peter M.

Do you have any in jokes about the Curiosity Rover?

Hasimo74

Yes :) We have a lot of fun during mission ops! - Doug A

You're forced to fight in the arena. You have two choices. Board and sword or dual wield battle axes?

cosmicfarce

Curiosity only has one arm so we're going with the sword - James L