after doing everyone this is our briefing to help us answer the question what do we know about Mars and here to help answer that question is Michael Meyer the lead scientist for the Mars exploration program Bethany Elmen scientists from the Jet Propulsion Laboratory assistant professor at the California Institute of Technology and John Grotzinger the project scientists from Mars laboratory at the California Institute of Technology and we'll begin first with Michael Meyer Michael thank you George
for millennia humans have been wondering

about the red planet and studying it and

it's only recently that we've actually

be able to go there and look in 1976 we

sent two missions there the Viking

missions both were orbiter and Lander

and we set them to the Red Planet if I

can have the first slide please

so Viking landed and this is from Viking

and shows a cold barren dry

apparently dead planet and as you might

imagine the enthusiasm for Mars

exploration and kind of took a plummet

but interestingly enough during the same
period of time we found in the subsurface ocean life in scalding hot hydrothermal vents and that started a whole line of study looking at life in extreme environments and through that study we came to learn that life is capable of adapting to all sorts of environments where it seemed like the only real necessary ingredient would be liquid water this was encouraging to the broad scientific community and understanding that there may be more places where life is possible than we originally thought
so we began the error a modern era of

Mars exploration so in nineteen two
decades later in 1996 we sent the Mars
Global Surveyor could I show the next slide and what this slide shows is the missions that we've had to Mars since Mars Global Surveyor and with that we've had orbiters and Landers and with each successive mission we've been all to increase the spectral and spatial resolution of art look at the Red Planet and we learned so much more we've learned that Mars is a dynamic planet we've learned that it has a history where it was warm and wet at the
same time that life started here on earth and we know that it's gone through a massive transition from that more benign planet of early on to what it is today and so we're actually here to give you a rundown on some of the things that we've learned in the last 10-15 years about the red planet that encouraged us to think that Mars is worth exploring for many different reasons including the potential of having been habitable at least in its past.

George thank you Michael and now to Bethany Elmen the scientists from the
Jet Propulsion Laboratory and assistant professor from the California Institute of Technology Bethany so so I have the privilege of talking to you about some of the discoveries from this flotilla of missions that we've sent to Mars over the past decade and if we can start with the first graphic I mean I'm gonna begin the story with what we know about Mars as it today so these are these are the top highlights of what we know about Mars Mars today and so Mars today on this graphic is is what you see in the top
left of this picture Mars like Earth is tilted on its axis and as it's spinning like a top so as Mars has seasons you can see the two polar ice caps at the north and south of Mars but Mars unlike Earth is not stable around around it spinning axis so what happens is that Mars is axis tilts okay and what we found through a combination of modeling and observations of the surface is that this results in in ice ages on modern-day Mars you can see that when Mars is tilted more extremely than it is today
ice builds up around the equator when

Mars sort of straightens out along its axis the poles grow in size so the this changing distribution of ice is one of the emerging stories that's come out of come out of the work of the recent decades and if we go to the next slide we see evidence of this the high-rise camera on the Mars Reconnaissance Orbiter it's able to examine the surface at very high resolution what we found is that that impact craters that impact into the mid latitudes of Mars have excavated ice from beneath the surface and that's what
you see in this image here ice

associated with these small craters now

this ice isn't isn't stable at the

surface it's a relict of these of these

paths tilts and changes in Mars as

obliquity and so if we look back at this

on the order of a few weeks in a few

months at the same spot the ice is gone

but it but it's a hint at past climate

change if we head to the next graphic

the other hint of this changing dynamic

modern Mars is is in this recent

discovery where you can see from right

to left these dark streaks emanating
from the walls of a crater these streaks were recently in a recent paper by Alfred McEwen at all the best hypothesis we have to explain those streaks is that they're formed by short-term discharge of briny waters when when modern-day Mars heats up during the summer for a brief period in time is ephemeral quick period of time we may in fact have salty waters on Mars so if we go to the next graphic I've talked to you about modern Mars the story of ice very very very short term rare water but if we look at ancient
Mars this is a topographic map where red is high elevations blue is low.

Elevations we're looking at the Mars globe and I've oriented it so that you can see Mars has these enormous outflow channels and valleys that flow out where water previously flowed out into the northern lowlands that's that blue low depression toward the left-hand side of the screen so liquid water was not short-term in the past we know that it carved had a role in carving out these large channels if we head to the next graphic it also had a
role in depositing sediments within

00:06:33,240 --> 00:06:37,348
craters now this isn't this is a a

00:06:35,699 --> 00:06:38,520
image that's a combination of some of

00:06:37,348 --> 00:06:40,139
the datasets from the Mars

00:06:38,519 --> 00:06:41,879
Reconnaissance Orbiter

00:06:40,139 --> 00:06:44,039
the high-resolution camera the context

00:06:41,879 --> 00:06:46,259
imager and an overlay our our colors

00:06:44,040 --> 00:06:48,780
from the chrism infrared

00:06:46,259 --> 00:06:52,379
spectrometer and these colors along with

00:06:48,779 --> 00:06:54,659
the spectra from pixels in this

00:06:52,379 --> 00:06:57,029
image allow us to get at the composition

00:06:54,660 --> 00:06:59,700
of these sedimentary materials that were

00:06:57,029 --> 00:07:02,399
carried by the water and now the key the

00:06:59,699 --> 00:07:04,649
key color here is the green because the

00:07:02,399 --> 00:07:07,049
green materials have been identified as
clays and carbonates now these are minerals that form in the presence of liquid water in the clays in particular indicate the long-term presence of water interacting with the rocks causing alteration of minerals clay minerals also have water in their structure and if we go to the next graphic we see these clay minerals and and other hydrated minerals so minerals with water in the structure in different geological settings throughout the planet this is just another example that we're able to get at now with this high spatial and
spectral resolution of Mars where we can pick out in the walls of this crater kind of like that the pages in a book two different pages in Mars history where we're early in Mars history we had an alteration that process that formed iron magnesium clays maybe not so much water flushing through possibly in the subsurface but on the top we have this this this unit with a higher degree of leaching forming aluminium cave aluminum clay so two distinct periods in Mars history recorded in these strata if we go to the next I'm just gonna provide
another example because here we go from clay minerals formed from long-term chemical interaction of water with rock and there the green color now the pink color is our sulfate minerals identified through spectroscopy now so this is just a subset a small snapshot from a crater that's over a hundred miles in in diameter and what we see when we look around that crater is this bathtub ring of salts so in this crater it was once filled with water and upon evaporation deposited these sulfates sort of ringing
around afterwards what does this all mean

so if you the next graphic what we think this means is that we can trace a progression in Mars history through both minerals and by careful examination of rock strata and a few key locations across the planet now on the bottom our new okyun Hesperian Amazonian they'll name their names you'll hear over the course of other press briefings which are the traditional divisions in Mars time what we think we see as we move toward from the noachian is this clay
you're aware there was abundant water chemically interacting with rocks we move that and then into a drying period where you get sulfate salts deposited as the water begins to go away at the surface and then you're in cold modern Mars where ice is the story not liquid water so there's this fundamental transition between the noachian and the Amazonian between the area of era of clays to the area of sulfates to the area era of anhydrous minerals where it's that critical period that's spanned
by the sediments at Gale Crater

we want to understand those transitions

so that's why we're headed there thank you very much and our next briefer is

John grotzinger the project scientist for Mars Science Laboratory from the California Institute of Technology John

thanks George so what I'd like to do is take you back again to a few decades ago and if we can have the first graphic one of the reasons one of the motivating reasons for the Viking mission to land and look for evidence of life on the surface of Mars was the discovery of the
the channel network systems that you see here these have been studied for decades now I think it's safe to say that that virtually the vast majority of the science community believes that these channels were cut by flowing water emerging from the surface subsurface may be flowing across the surface but it's these channel systems that originally attracted so much attention for Mars now and the more recent decade there have been some spectacular discoveries that sort of fill out the rest of the story because if you look at these channels
it's natural to ask if if

00:11:07,500 --> 00:11:12,990 was flowing where would it take all the

00:11:10,200 --> 00:11:16,440 materials that were eroded away to to

00:11:12,990 --> 00:11:19,110 create the canyons so if you go to the

00:11:16,440 --> 00:11:21,180 next display item what we see here is a

00:11:19,110 --> 00:11:22,950 Delta called a bruise wall Delta it was

00:11:21,179 --> 00:11:26,429 one of the potential landing sites for

00:11:22,950 --> 00:11:28,590 the mission and and it's at the end of

00:11:26,429 --> 00:11:30,839 one of these channel networks and so we

00:11:28,590 --> 00:11:33,629 see all the material that got eroded by

00:11:30,840 --> 00:11:35,580 water here being deposited in water as a

00:11:33,629 --> 00:11:38,879 delta that almost everybody can

00:11:35,580 --> 00:11:41,129 recognize and and this is really amazing

00:11:38,879 --> 00:11:43,019 because in addition to this there was

00:11:41,129 --> 00:11:45,509 also the discovery of clay minerals here

so we're beginning to see a more balanced picture of Mars one where you have source areas that represent the interaction of water with rock to produce sedimentary materials that contain alteration products like clays and then they get transported down river systems to form things like Delta's that would have accumulated in bodies of standing water and this is very attractive from a habitability point of view and it creates the basis then for Mars Science Laboratory to have had a very exciting landing site selection
process so if we go to the next one now

we're going to jump up here more

recently within the last seven years the

discoveries by the rover Opportunity in

the Mars Exploration Rover mission and

here we see a number of very important

aspects that that take us into our

understanding of modern Mars one is is

that we see layered rock sedimentary

rock and the sedimentary rock on Mars we

view in an analogous way to sedimentary

rocks on earth which are the principal

repository for all the the records of

life on Earth and while Mars Science
Laboratory is not a life detection mission we are on a mission to investigate the building blocks of life important chemical elements and also potentially look for organic compounds and when you have what a geologist calls a model like this where you can look at the rocks and see that you had ancient sand dunes environments where there was ancient groundwater and then environments where you had ancient streams this gives you a whole diversity of potentially different habitats this is
just one example on Mars you can go back

to the locations that Bethany was talking about very ancient Mars and you see a different type of geological history and a very different type of potentially habitable environments so we're just on the cusp of beginning to come up with a whole range of these possibilities for us to explore into the future okay so in the next one now we take us into as Bethany mentioned there were the three eras where you went from dominantly clays time when weathering alteration and water produced clays to a time when alteration of water
produced a lot of sulfate minerals to a
time when apparently there were not many
hydrated minerals that were formed yet
we still see the accumulation of
sedimentary materials and you might ask
what do you learn about Mars in the
absence of water or in the absence of a
potentially habitable environment for
life if it had evolved on Mars and this
beautiful example of that you see these
very well-organized strata this is like
a heartbeat except this is the heartbeat
of the planets climate cycle so just
like on earth we're very interested in
climate change on Mars we see this very rhythmic alternation of layers that creates a really spectacular record of past climate change on Mars and then that takes us to the era that Bethany talked about first where Mars is dominated more by ice and a very cold climate and atmospheric processes and transport of sediments by wind rather than water so we see we can see in the rock record these these different histories ok so now if we go to the next one what we see here is our destination one what we see here is our destination for Mars Science Laboratory this is Gale
Crater you'll hear a lot about it

tomorrow at the press briefing tomorrow

there is a crater about 150 kilometers

in diameter that's about as big as the

Los Angeles basin surrounded by the

mountains that ringed the Los Angeles

basin and right there in the middle of

it is a mountain about five kilometers

high that's as high as Mount Whitney

which is the tallest mountain and in the

lower 48 states and if you go from the

yellow dot which is in the center of our

landing ellipse we have the ability to

traverse in our mission through the
first few hundred meters of strata that

00:15:44.509 --> 00:15:48.139
you see there and then eventually over

00:15:46.190 --> 00:15:50.300
an extended mission it might be possible

00:15:48.139 --> 00:15:51.620
to go to the top of that Mound but the

00:15:50.299 --> 00:15:54.199
important thing I wanted to say about

00:15:51.620 --> 00:15:55.519
the mound today to sort of walk in some

00:15:54.200 --> 00:15:57.800
of the points that we've been talking

00:15:55.519 --> 00:16:00.409
about at the base of the mound you see

00:15:57.799 --> 00:16:03.259
strata that are composed of clays and

00:16:00.409 --> 00:16:05.329
sulfates as you go farther up the mound

00:16:03.259 --> 00:16:08.179
you see strata that are composed of

00:16:05.330 --> 00:16:11.600
dominantly sulfates and then as you get

00:16:08.179 --> 00:16:14.120
above you know the first 500 meters or

00:16:11.600 --> 00:16:15.920
so you then go into strata that don't

00:16:14.120 --> 00:16:17.990
have hydrated minerals they seem to be
composed of these rhythmites from the drier time of Mars so in one location we can drive the rover through all these successive different environments and sample these various periods in the history of Mars that we've talked about so I'll turn it back to George all right thanks very much we're ready now to take questions so please give your name and affiliation when the microphone comes to you and we'll start right here in the front hi Kent Cramer for Space Flight magazine for Bethany and anyone else who wants to answer please a couple of
questions can you describe the Clay's how widespread they are on Mars or and the sulfates are they very narrow or they're pretty widespread right so so I should say that clays and sulfates are something that that weren't even discovered until until 2004 with the the Mars Express mission from Europe so they'd eluded detection so far and that's because the exposures where we're able to see them are very small and it makes sense if you think about the fact that they're ancient and because they're ancient they're
buried by later materials so it's so

with this high spatial resolution we're

able to see them and where do we see

them so clays to the extent that we are

able to figure it out they seem to be

globally widespread but frequently

buried and the way they're exposed often

is in impact craters where again we

punched through the surface and and

these clays are thrown out for us to be

able to see them we also have a few

places

where tectonic activity has exposed a

nice thick stratigraphic section with

59
the clays but they do appear to Clay's

00:17:55,579 --> 00:18:05,389
do appear to be global the sulfates also

00:17:59,359 --> 00:18:07,069
are regionally global if that makes

00:18:05,390 --> 00:18:09,500
sense there are a few regions scattered

00:18:07,069 --> 00:18:13,399
throughout the planet where we see

00:18:09,500 --> 00:18:15,349
sulfates it appears and that some work

00:18:13,400 --> 00:18:17,960
on hydrologic modeling modeling ground

00:18:15,349 --> 00:18:19,669
water flow through Mars and orbital

00:18:17,960 --> 00:18:21,620
detections of sulfates are starting to

00:18:19,670 --> 00:18:23,870
converge or it looks like where we see

00:18:21,619 --> 00:18:25,609
the sulfates are these zones it where

00:18:23,869 --> 00:18:29,349
it's predicted that ground waters would

00:18:25,609 --> 00:18:34,490
be upwelling and reaching the surface

00:18:29,349 --> 00:18:37,009
and for John could you tell me I think

00:18:34,490 --> 00:18:40,430
you said these channels you believe most
are by water formed by water so you say that about Valles Marineris it's mostly water you don't think it's carbon dioxide and also how long is that distance from the yellow dot to the red dot how quickly could you drive the rover right a couple of questions there I think that you know for a long time as long as people have seen the channels there's been a discussion about what the liquid was that it carved them out and and I as I said I think that this is now stabilized on water as being the most likely material and that's been
bolster recently by the discovery of hydrated minerals that do occur as transport weathering products in these in these channels it's it's a it was a prediction of that model it was observed independently and I think it Shores the whole thing up the second question about Valles Marineris Valles Marineris is a different feature it's not produced by erosion it's dominantly produced by tectonic processes that involve big crustal motions that drop blocks down and at the base of Mount Valles
Marineris you do get the successions of

sulfates one of the attractions of Gale

to us is that without being able to fly

into Valles Marineris we capture a lot

of the interest that you would get in

going to Valles Marineris because the

the bottom flares in Gale Crater are

composed dominantly of sulfates and they

sit in a very low topographic

lower than the floor of Valles Marineris

so it's not the same as Valles Marineris

but it's maybe as close as you can get

and then the last question about the

distance you know our landing ellipse is


about 20 kilometers in diameter so we

00:20:15,529 --> 00:20:19,519
would drive outside of the landing

00:20:17,359 --> 00:20:22,159
ellipse on the order of about 12

00:20:19,519 --> 00:20:24,230
kilometers to get to the first

00:20:22,160 --> 00:20:28,220
well-developed sulphate deposits in

00:20:24,230 --> 00:20:34,940
clays we have a question here in the

00:20:28,220 --> 00:20:36,799
back did you have a question Chris

00:20:34,940 --> 00:20:40,670
Hebert United television network

00:20:36,799 --> 00:20:45,470
I was wondering with the the recent

00:20:40,670 --> 00:20:47,600
discovery of shifting the sand dunes are

00:20:45,470 --> 00:20:50,180
you planning on using curiosity if

00:20:47,599 --> 00:20:52,009
there's anything on board that you might

00:20:50,180 --> 00:20:53,870
be able to investigate further with the

00:20:52,009 --> 00:20:59,390
existing equipment that's already built

00:20:53,869 --> 00:21:00,559
into the Rover yeah that would be a good
question to bring up again tomorrow

because we'll have the principal investigator of the camera here

and that's one of his real interests

and so we have the ability to measure the wind speed on curiosity what direction the wind is blowing in and then make measurements of the surface topography of the dunes and see if sand as is being transported we should be able to do that Marsha Associated Press probably for dr. Maier but I'm not sure of the previous Mars missions the several dozen that there have been how
many besides this one have actually looked directly or indirectly at the life issue and what have you learned so far that this will build upon. Well, I actually like to call Curiosity the first astrobiology mission since Viking and basically that's because we're sending a gas chromatograph mass spectrometer which can look at look for organics and characterize them and essentially it's similar much better but similar to the instrument that was sent on Viking here. There are huge advantages that you can
Rove to wherever you think is the best thing to measure. There's been this gaps in essentially in your mind Phoenix had a gas Cremona gas chromatograph mass spec on it that was able could have measured organics if there was you know a sufficient amount but it couldn't move around and is also on the northern Pollard layer terrain so in many ways it's goal was appointed more toward understanding the formation of the layer terrain and what the polar areas are like so curiosity I think is really the first one since
biking to approach the life question now

I should be clear that it doesn't have a life detection instrument on it in the sense that a camera is not a life detection instrument unless something hops in front of it so the capability of the of Sam the sample analysis at Mars which is the gas chromatograph mass spec is that it can look at organics and characterize them and make you more interested in Mars and what what secrets that might hold but unless you're extremely lucky it's not going to tell you whether or not you've found evidence of life ask another question um what is
it about Morris it makes it so treacherous getting there so many missions have failed including one in Earth orbit right now what what what is it about Mars that makes it so tricky so difficult to get to one one one thirty is gremlins the other it's just I'm not sure why we've been that unlucky and it may be that early on in in planetary exploration Mars was a target such that as our space faring agencies we're coming up to speed to how to do planetary missions their first target was Mars so there's a lot of failures
early on and just you know just with how
two rockets work how do you get there
so I think there was a big learning
curve
and now we're just running into Mars is
difficult and so many things have to go
right for a mission to work but we have
a much better track record than we did
in the 70s dan dan billow from w e sh
t v-- on the the time-lapse photo you
had that looked so much like surface
water give me a ballpark estimate if you
can on how long that might persist hours
or days and if you have any idea and
would you discuss a little bit more about but to what extent the planet has kind of a subsurface layer of ice do you think that that's the case so water liquid water is not stable on the on the surface of Mars today so so as for how long it sticks around well it's how long it takes for it to evaporate so we're probably talking on the order of a few minutes but what happens when when that water is at the surface it causes all these noticeable geological changes that we that we can then track but we're talking really short periods of time but
those features form and lengthen over a

00:25:43,730 --> 00:25:47,360
Mars it starts you know kind of in the

00:25:45,619 --> 00:25:50,029
spring goes for the summer and then they

00:25:47,359 --> 00:25:52,119
disappear in the fall and this happened

00:25:50,029 --> 00:25:55,940
on successive seasons

00:25:52,119 --> 00:25:59,509
so although liquid water at the surface

00:25:55,940 --> 00:26:01,789
may be very short time the moisture

00:25:59,509 --> 00:26:06,170
that's causing those features to form

00:26:01,789 --> 00:26:08,450
last over a whole season and at a

00:26:06,170 --> 00:26:10,789
subsurface layer of ice or water what

00:26:08,450 --> 00:26:12,410
are your thoughts on that yeah the

00:26:10,789 --> 00:26:14,750
thought is that it's it's a subsurface

00:26:12,410 --> 00:26:18,410
layer of ice it's probably the most

00:26:14,750 --> 00:26:20,119
likely source for this water and one of

00:26:18,410 --> 00:26:22,279
the things that may be causing it to
melt periodically is the presence of salts which just like you you throw salt on the road in the winter to get the snow to melt in those areas where there's a particularly high concentration of chloride salts you you also those may be the areas were preferentially you get these slope streaks to form over the course of the season and just one more I'm trying to get an idea if you have an idea of what the extent of that might be is there a notion of that water or a little bit or
a lot or what you know well if we're talking ice and we're considering the entire subsurface of Mars there's probably at least a shallow seas worth of water in ice form beneath the surface but when we're talking about how much is available in liquid form it's only these ephemeral short-lived slope streaks that appear to be occurring over the course of the season anyone have any follow-ups all right in that event just a little bit of a programming note we have to Mars briefings tomorrow at one o'clock we'll have briefing on looking
for signs of life in the universe and

then following at two o'clock will be

our Mars Science Laboratory science briefing so if you're joining us for those 1 & 2 p.m. Eastern Time and that

will conclude this briefing thank you

very much for coming