SCIENCE CASE

Mars landing[1]

Team members

Writer: _____

Equipment manager: _____

Reader: _____

Spokesperson: _____

Computer technician: _____

Context

Today, Mars is a cold, dry planet, but in the past Mars was covered in rivers, lakes and perhaps even an ocean. For this reason, scientists wonder whether life could have once existed on Mars.

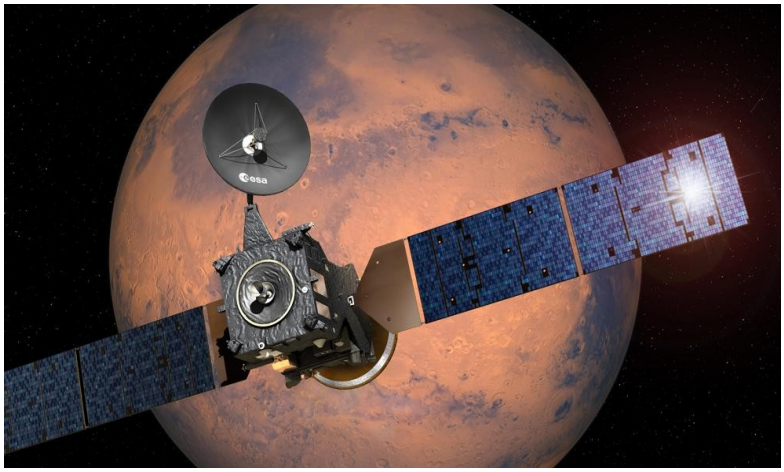


Figure 1: Artist impression of Mars and the ESA spacecraft, ExoMars (Credits: ESA/AP)

[1] *Diseñado por Planeta Ciencias, en colaboración con el equipo de CESAR.*

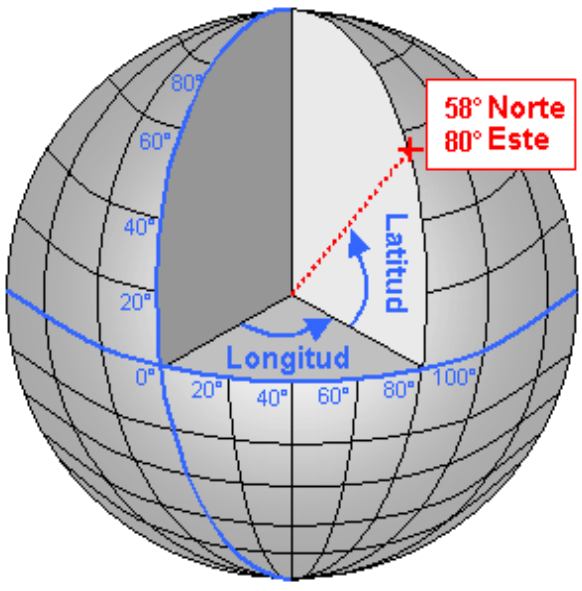
This is one of the main motivations to send more missions to the Red Planet. For example, ESA's Mars Rover 2020 mission will dig 2 metres into the surface of Mars, and look for signatures of past life. Before the rover gets there, however, it needs to make the long journey to Mars and touch down safely on its surface. Each mission to Mars takes many years of work and preparation, as it is very difficult to land a spacecraft on Mars.

One of the key elements for the success of such a mission is choosing the **ideal spot for landing on Mars.** With your support we will find out about it in this activity.

Before starting we are going to refresh the concepts of **latitude and longitude,** what we use to locate ourselves on the surface of a planet (i.e, the Earth).

- The **latitude** measures the vertical position. It is the angle between the equator line and the spot we are in. In the Northern hemisphere, the angle is between 0 and 90º, whereas in the Southern hemisphere, the angle is between 0 and -90º (southern values are written as negative values).
- The **longitude** measures the horizontal position. It is the angle between any given circumference that goes through the poles and the spot we are in (on Earth, that circumference is the **Greenwich meridian**). That angle is between 0 and 360º.

The latitude and the longitude are measured in degrees (º), minutes (') and seconds (").



Fuente:http://tarifamates.blogspot.com.es/2013/11/latitud-y-longitud-coordenadas.html

We are about starting a mission to land on Mars with a rover. For this challenge we will work in teams, each one with a goal. All of you are going to execute the first task, getting familiar with the analysis software tool (Google Earth/Mars) which will be later used for each of the three research missions.

Get familiar with the Google Earth/Mars software (for all the teams)

Access to the Google Earth software installed in the computers at the lab. First the Earth and later Mars. Make use the different functionalities to analyse the different set of images (coloured). Look for some famous regions on Mars (i.e: Valles Marineris, Eos Chasma, Aeolis Mons, Olympus mount).

Research 1: **From the spacecraft point of view**, identify a safe landing region on Mars. Explain the reasoning behind your choices.

Identify an ideal landing region on Mars (in terms of latitude, longitude and elevation) for having a safe landing from the spacecraft point of view. Take into account the region where the planet spins faster, the amount of atmosphere crossed is thicker, ..

Research 2: **From the rover point of view**, identify a safe landing region on Mars. Explain the reasoning behind your choices.

Identify an ideal landing region (in terms of latitude, longitude and elevation) taking into account the Mars orography and the terrain properties where the rover needs to drive on.

Research 3: **From a scientific point of view**, identify an interesting landing region on Mars. Explain the reasoning behind your choices.

From a scientific point of view, an interesting landing site could be where water could have existed in liquid format. Looking back into the Mars history, there are some epochs where this conditions could have occurred. Let's search for regions tracking those periods by looking for craters and water remnants on the Mars surface.

Conclusions (an ambasador per team)

Identify an optimum landing site on Mars by putting in common previous research findings

Resources (for teachers)

Google Earth Pro: https://www.google.com/earth/

CESAR Booklet: ***The solar system***
http://cesar.esa.int/index.php?Section=Booklets

Mars Exploration (ESA):
http://exploration.esa.int/mars/
http://exploration.esa.int/mars/44997-the-red-planet/
http://exploration.esa.int/mars/43608-life-on-mars/
http://exploration.esa.int/mars/53845-landing-site/
http://exploration.esa.int/mars/58307-the-hazards-of-landing-on-mars/

Mars geological maps: https://pubs.usgs.gov/sim/3292/
ESA Educacion: http://www.esa.int/Education

CESAR project: http://www.cesar.esa.int
ESA Kids: http://www.esa.int/esaKIDSes

Planetary Latitude and Longitude:
http://tarifamates.blogspot.com.es/2013/11/latitud-y-longitud-coordenadas.html

MISSION DEVELOPMENT

Getting familiar with the Google Earth/Mars software

Material

- Computer or touch screen
- Software ***Google Earth*** installed

Let's get familiar with *Google Earth software*, in particular for Mars:

- Open the Google Earth program.
- At the top of the screen, you should see the symbol of a planet with a ring around it; use this to select which planet you want to look at.

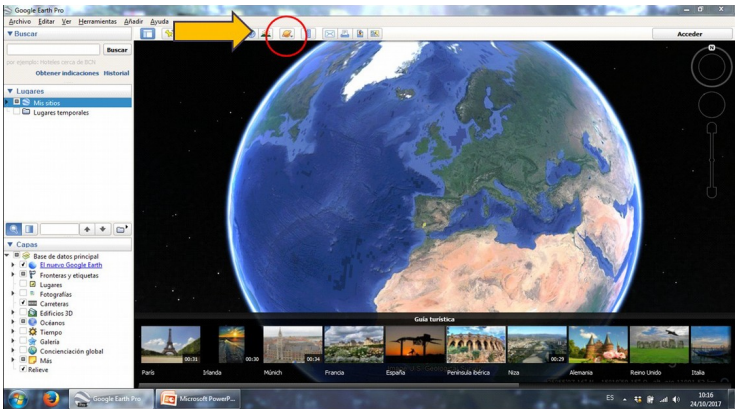


Figure 2: Google Earth software showing the Earth (Credits: Google Earth)

You can also use the hand symbol to rotate the globe in google Maps, so that all areas of Mars can be easily seen and compared, and you can switch between different layers to show you visible imagery, colourised terrain etc as indicated by the arrow below.
(see example in Figura 3)

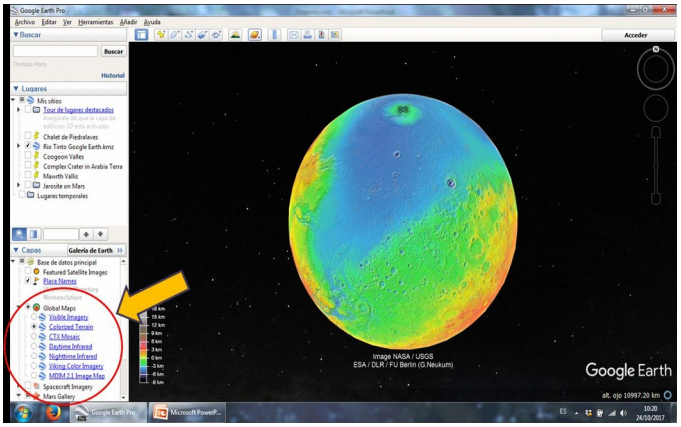


Figure 3: Mars regions seen with different colors depending on the type (Credits: Google Earth)

Search in Google Mars regions that you may consider interesting (for example, you may have heard about them). Some examples are: *Valles Marineris, Eos Chasma, Aeolis Mons*

Research 1 :From a spacecraft point of view where will you land on Mars?

Research 1:

- Computer or touch screen
- Software ***Google Earth*** installed

Activity 1: Compare Mars and Earth. ¿What do you know about both planets?

Example: There is no liquid water on Mars but on Earth

At this moment there is no liquid water on Mars but ice.
The low atmospheric pressure and temperatures of the planet make the water sublimate. The Martian past can be observed, the climate conditions created the conditions to have a huge amount of water on the planet surface.

Activity 2. Latitude and Elevation

[USE A GLOBE TO ILLUSTRATE THE LATITUDE AND LONGITUDE CONCEPTS]

Think about a spot on the surface of a planet as it rotates. As the planet turns around, this spot effectively travels in a circle. The circle made by a spot at the equator will be bigger than the circle made by a spot closer to the poles.

Given this, where do you think a planet rotates the fastest: at the equator or at the poles?

The planet rotates fastest at the equator, because the circumference of the circle it has to move in is larger.

Look at ESA's spaceport using Google Earth. Why do you think the spaceport is located here, and not closer to the poles?

The spaceport is located here and not closer to the poles because the Earth is turning faster nearer the equator than the poles. This added velocity helps a spacecraft get up to speed when they are trying to escape the gravitational pull of the EarthTierra.

Switch the Google Earth to Google Mars. From no won we will refer to it as **Google Mars.**

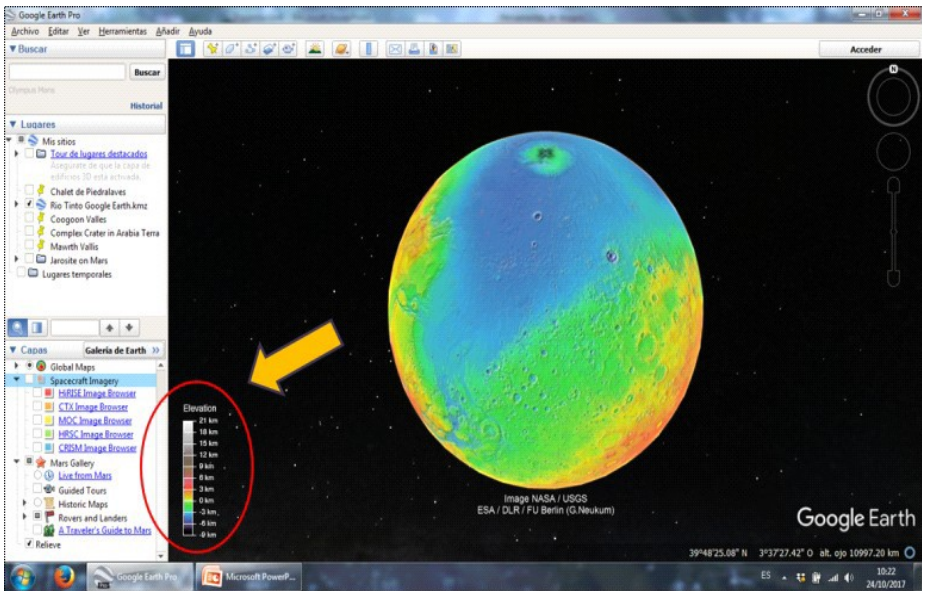
Think of a spacecraft going to land on Mars that is travelling at high speed from Earth.

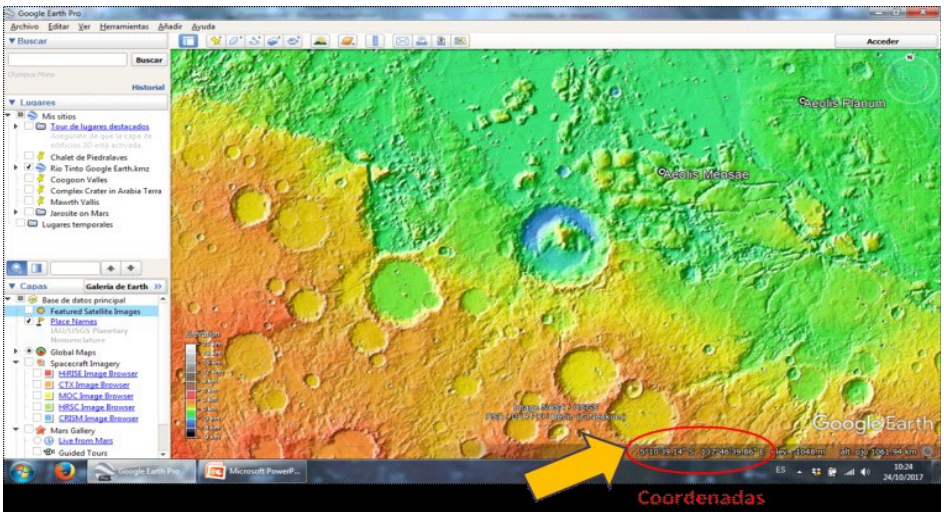
Where on the planet do you think the spacecraft has to slow down less in order to match the speed of the rotating planet- closer to the equator or to the poles? Why?

The spacecraft has to slow down less at the equator. This is because the planet is rotating faster here, so the spacecraft has to slow down less to match it.

Actividad 3:

Now switch to the “Colorized Terrain” on the “Global Maps” section and you should see a coloured image of Mars, where the higher areas have orange/brown colours and the lowest areas have bluish colours. Use this to compare the two hemispheres.





What differences do you notice between the two hemispheres of Mars? Which has generally higher ground, and which has lower?

The southern hemisphere has higher ground and is more cratered (and conversely the northern hemisphere has lower ground and is less cratered).

The difference between the two hemispheres that you see is known as Mars “global dichotomy”.

Using Google Mars, identify the coordinates of:

The Highest place on Marte.

Name	Altitude	Coordinates
Olympus Mons	21 000 m	18° 05' 13.53" N 133° 53' 45.31" W

The lowest place on Marte.

Name	Altitude	Coordinates
Hellas Planitia (Peneus Palus)	-7.540m	41° 35' 54.83" S 64° 49' 19.84" E

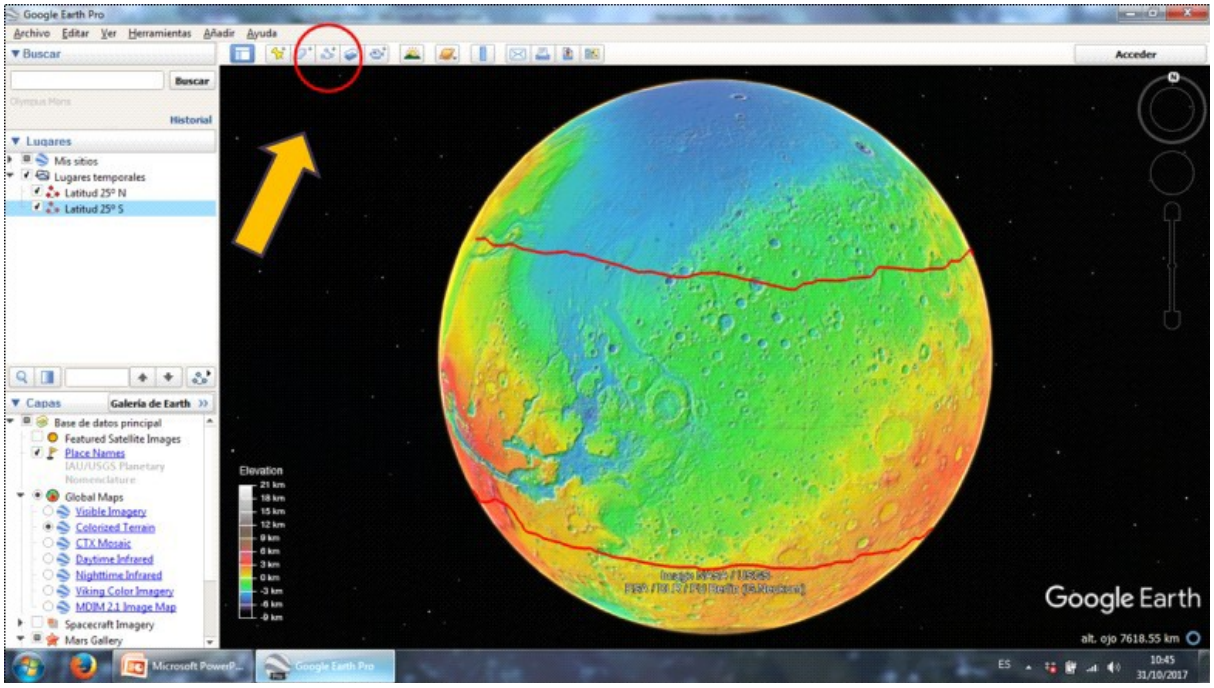
The atmosphere of Mars is very thin. Most landing equipment uses some form of parachute to help slow the spacecraft down. Out of these two places, where do you think the parachute would be most effective??

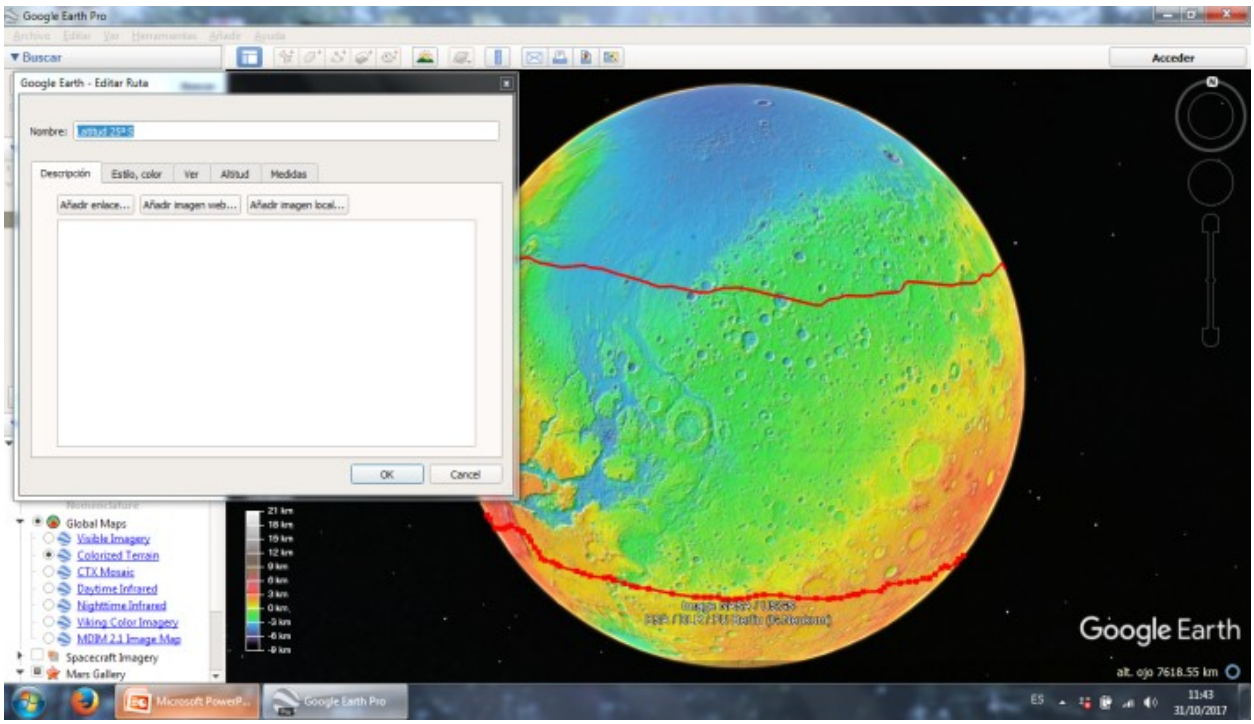
In Hellas Planititas, because it is lower in altitude. This means the spacecraft travels through more atmosphere to reach the surface, and therefore there is more atmosphere hitting the parachute to help slow the spacecraft down.

Bearing in mind your results from Activity 2 and Activity 3 and also the general shape of the surface, is it safer to land on the Northern or the Southern part of the planet? Why?

Determine on the Martian map a latitudinal band which is the safest area to land in. To draw this on Google Mars:

- Go to the option ‘adding a route’ (as shown below).


Google Earth Pro
Archivo Editar Ver Herramientas Añadir Ayuda
Buscar
Acceder
Lugares
Mis sitios
Lugares temporales
Latitud 25° N
Latitud 25° S
Capas
Galería de Earth
Base de datos principal
Featured Satellite Images
Place Names
Global Maps
Visible Imagery
Colorized Terrain
CTX Mosaic
Daytime Infrared
Nighttime Infrared
Viking Color Imagery
MDIM 2.1 Image Map
Spacecraft Imagery
Mars Gallery
Elevation
Google Earth
alt. ojo 7618.55 km


Google Earth Pro
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Descripción
Estilo, color
Ver
Altitud
Medidas
Añadir enlace...
Añadir imagen web...
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Global Maps
Visible Imagery
Colorized Terrain
CTX Mosaic
Daytime Infrared
Nighttime Infrared
Viking Color Imagery
MDIM 2.1 Image Map
Spacecraft Imagery
Mars Gallery
Google Earth
alt. ojo 7618.55 km

Research 2: From a *rover* point of view, where will you land on Mars?

Material

- Computer or touch screen
- Software ***Google Earth*** installed

Now that we have decided which latitudinal bands are the safest to land in, we need to look for a more specific area to safely land the spacecraft.

If the spacecraft crashed upon landing, the mission would be a failure. It is therefore very important to find a site that is less likely to damage the spacecraft upon landing.

Activity 1: What surface features on Mars might be best to avoid landing on?

High mountains; very cratered areas; areas with lots boulders; dunes (as the spacecraft might sink too far into the sand and/ the wind could cover it in dust); slopes of a high inclination.

Activity 2: Within your chosen latitude band,

- mark with green circles the safest places you found to land,
- mark in red circles the ones you think you should avoid.

Why did you choose those?

There is a strong recommendation to avoid areas with many hills, sharp terrain and/or slopes with a large inclination. It is therefore recommended to choose flat and smooth areas.

Activity 3: Do you think that any of these could be a good choice? Explore them and provide an explanation.

Valles Marineris

Eos Chasma

Aeolis Mons

Research 3: From a scientific point of view, where will you land on Mars?

When selecting a region to land it is important to identify a scientifically interest area. For this we need to get informed about the geological properties of the terrain.

The geological history of Mars can be divided into the Noachian, Hesperian and Amazonian. These geological eras are distinguished by specific climate conditions, which leave their mark on the surface to the present day.

- During the **Noachian,** which is the most ancient period of Mars from approximately 4.1 to 3.7 billion years ago, the planet was warmer and wetter than it is now. Vast amounts of liquid water ran across the surface, carving out huge channels, and there was a magnetic field that protected the surface from solar wind.
- The **Hesperian** period, which ranged from roughly 3.7 to 3.0 billion years ago, was characterised by widespread volcanism and huge flooding. During this time, huge lava plains were deposited, and liquid water became less widespread and more acidic where it existed.
- During the **Amazonian**, which spans from 3.0 billion years ago to today, the magnetic field disappeared. This allowed the solar wind to divide water in the atmosphere into its constituent molecules, hydrogen and oxygen. The Martian atmosphere could not retain the hydrogen and the hydrogen was dragged off by the solar wind into space. On the other hand, the oxygen oxidized (rusted) the planet: the reddish colour of Mars is due to the iron oxide that results from this.

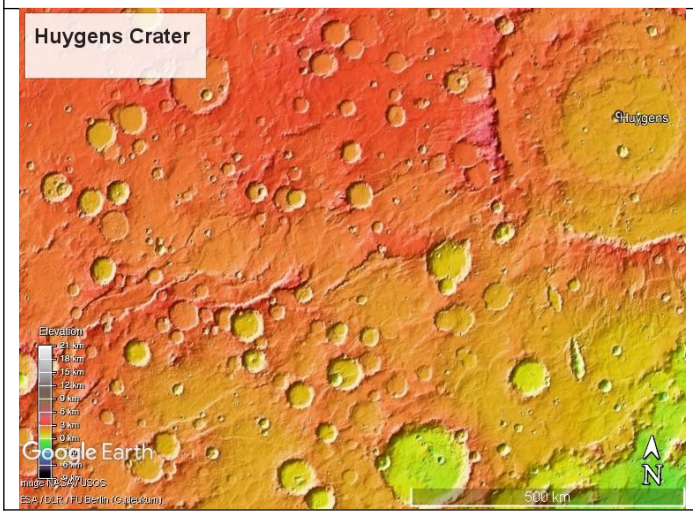
Activity 1: Which period/s do you think had the highest probability of having life on Mars: the Noachian, Hesperian or Amazonian? Why?

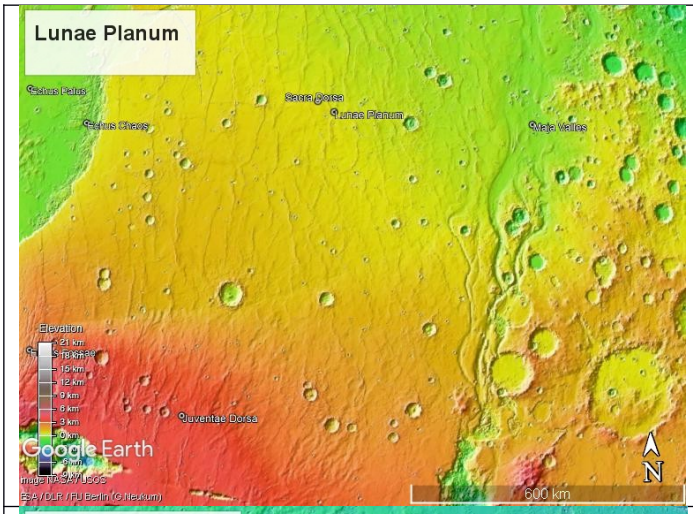
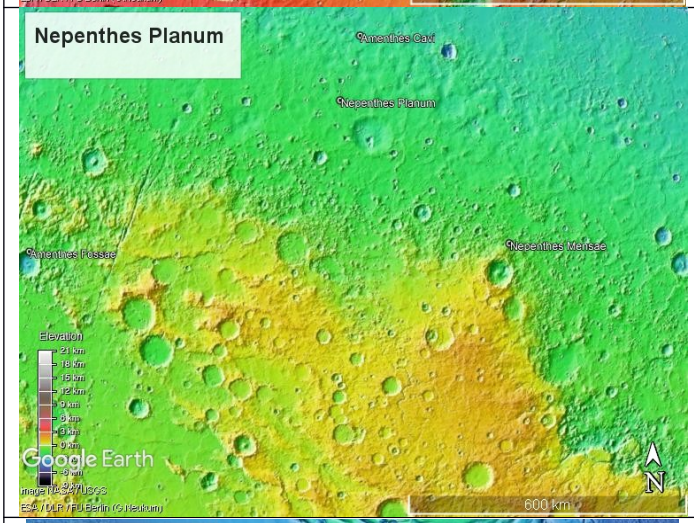
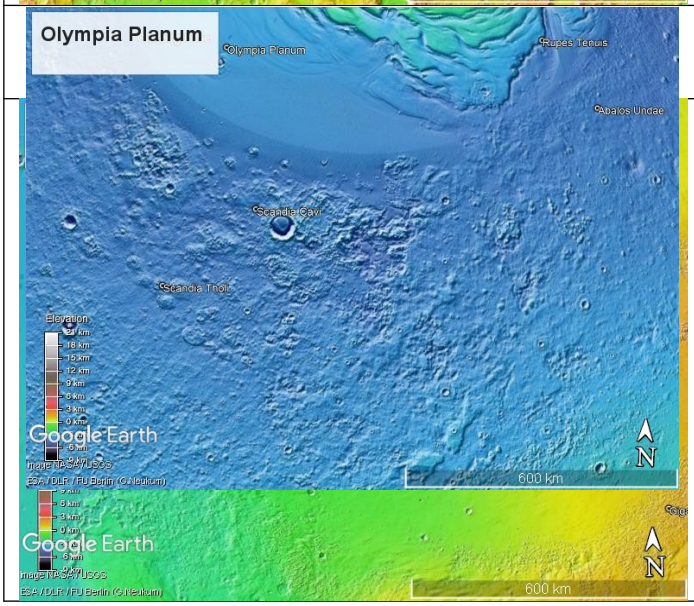
Noachian and Hesperian. There was liquid water (which is important for life) and the planet was protected by a magnetic field, which protects from radiation, but also helped it to maintain an atmosphere.

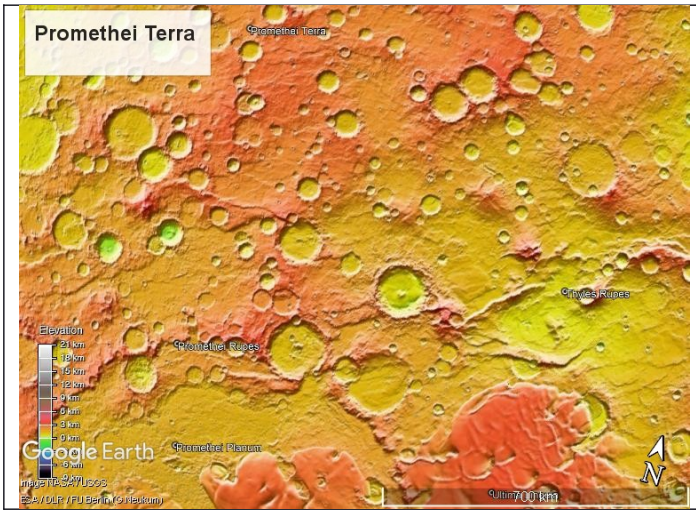
In **planetary geology**, we can know the approximate age of a surface by looking at how many crater impacts it has. An ancient surface has a larger amount of craters, and a larger amount of large craters, as it has been exposed for a longer time, whereas a surface with fewer craters has been resurfaced more recently, and therefore is geologically younger. We are now going to look at different Martian surfaces to try and determine their approximate age.

Activity 2: We are now going to look at different Martian surfaces to try and determine their approximate age.
Remember: the Noachian is the oldest period and there are more craters and those craters are bigger; the Hesperian period is intermediate; the Amazonian period has the youngest surfaces, with smaller craters and there are less of them.

Which geological period do you think these Martian pictures belong to?

Picture	**Martian period**
	Noachian

		Hesperian
		Hesperian
		Amazonian Amazonian

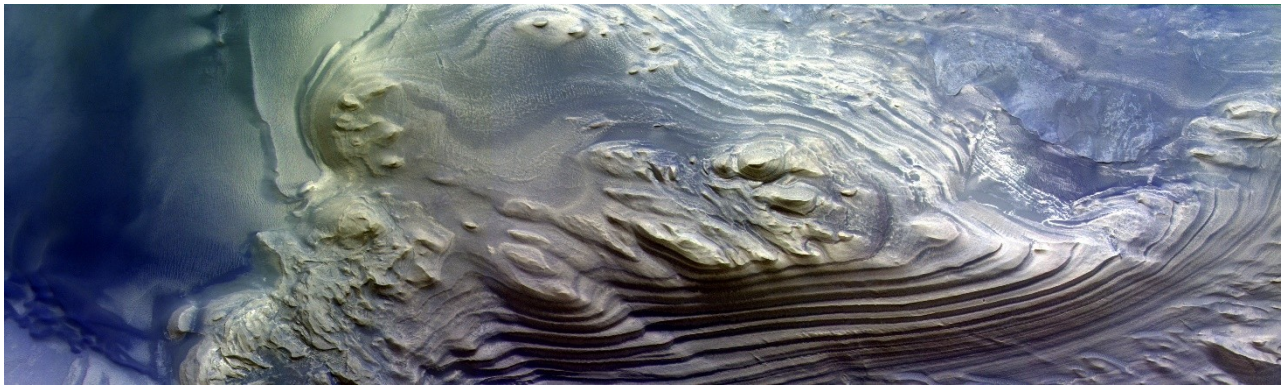
		Noachian

Activity 3: Finally, we need to look for specific features which might be of interest to study when the spacecraft successfully lands on Mars. When scientists look for traces of life, they often look for signs of water.

ILD (*Interior Layered Deposits)* are just one of the many interesting geological formations we know of on Mars that indicate there was water in the past. These deposits, which are in layers or sheets, have been analysed and are known to have hydrated minerals (which means they needed to be in contact with vast amounts of liquid water to be formed).

Since there are many layers, one on top of the other, there is a good chance that **some traces of past life could be preserved in these deposits.**

The image below shows the layered deposits in Juventae Chasma, taken by the CASSIS instrument on board ESA's Trace Gas Orbiter.



Interior Layered Deposits in Juventae Chasma, captured by ESA's Trace Gas Orbiter. The image covers an area 25 x 7 km wide. Copyright: ESA/Roscosmos/CaSSIS, CC BY-SA 3.0 IGO.

Now on Google Mars switch to the "CTX Mosaic" view. This will give you more high resolution pictures of the surface.

- Type "Ganges Mensa" into the search engine on Google Mars
- Zoom out a little to an eye altitude of 80km (shown in the right hand corner as 'eye alt').

Can you see these ILDs?

From this viewpoint students should be able to see many layered deposits. It is a good idea to get them to explore the area for a few minutes.
region.

Is there anywhere safe to put a lander nearby? If not, why do you think landers and rovers have not explored this area before?

Although this area is geologically very interesting, it is difficult to place a lander here as the area has a lot of varied terrain, and the smooth parts of the terrain are mostly sand. This is why a lander or rover has not previously explored the

Conclusions

Taking into account everything you have learnt and discussed today, it's time for you to pick a place to land on Mars!

Finding a balance between every aspect of the mission is going to be difficult. Remember that team work requires you to listen to everybody and to reach an agreement together as to where is the best place to land on Mars.

Team members

Google Mars tecnical expert : _____
Spacecraft safety/security expert: _____
Rover safety/security expert: _____
Astrochemical scientific t: _____
Team leader : _____

Does the landing place fulfil the following conditions? Answer **yes** or **no**:

Correct latitude?	
Suitable terrain?	

Correct period of Mars history?	
Are there traces of past water nearby?	

Record the following information of your chosen landing site here using *Google Mars*:

Name of the area	Latitude	Longitude	Observations

What difficulties have you encountered when looking for a perfect spot for landing, given that the place had to be both safe and scientifically interesting? Did you find it hard to pick a place?

PART 2: Compare the number of craters found in different areas of Mars with those found on the Moon (case 4 of Planeta Ciencias original case)

In the option “Moon maps” you can choose visible images or colored topography (higher places are colored in reddish orange and lower places are bluish), depending which one is more clear to you.

How many craters do you see (aproximately) on the surface of the Moon? And on the surface of the Earth?

Question 3: Have more meteorites fallen on the Moon or on the Earth? Why?

Question 4: Why do you think the surfaces of Earth and Moon are so different?