ASTROEDU

Peer-reviewed Astronomy Education Activities

Children's Planetary Maps: Titan

Learn about the only other known body in the Solar System with Seas and Lakes

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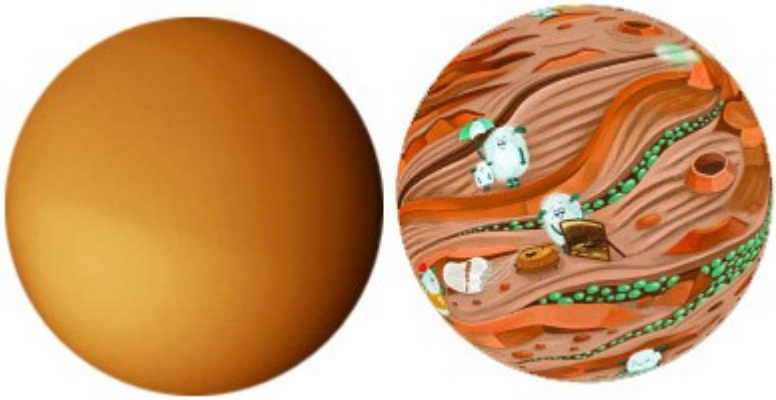


AGE

6 - 12

LEVEL

Primary, Middle School

TIME

2h

GROUP

Group

SUPERVISED

No

COST PER STUDENT

Low Cost

LOCATION

Small Indoor Setting (e.g. classroom)

CORE SKILLS

Asking questions, Developing and using models, Planning and carrying out investigations, Analysing and interpreting data, Constructing explanations, Engaging in argument from evidence, Communicating information

TYPE(S) OF LEARNING ACTIVITY

Structured-inquiry learning

KEYWORDS

Planetary science, Planetary cartography, Spatial thinking, Astrobiology, Titan

SUMMARY

GOALS

- Obtain a general view of a Titan as a world with geography.
- Learn about reading map legends and symbols, and cartographic projections.
- Learn about surface landforms.
- Associate surface activities with surface environments.
- Create coherent stories using visual cues displayed on the map.
- Be able to evaluate the possibility of life existing on an extra-terrestrial body.

LEARNING OBJECTIVES

- Students will be able to name landform types exits on planetary bodies and compare them to landforms on earth.
- Students will be able to explain which landforms are climate-independent (endogenic – volcanism, tectonics, or cosmogenic - impacts) and which are climate-driven (rivers and oceans only exist where atmosphere is present, temperature is 0-100 C).
- Students will be able to describe the difference between surface features and their cartographic representation, and draw/create a symbol using a spacecraft image of a landform.
- Students will be able to name a reason for importance of space exploration.

EVALUATION

Fill out the Worksheet
Sample questions for evaluation:
- Identify and describe a surface landform / landscape types on the map using the legend, using a vocabulary of place names, and cardinal directions.
- Identify common and rare surface features.
- Identify which landforms were produced by cosmogenic processes (by impacts from space - meteorites, radiation)
- Identify which landforms were produced by endogenic processes (by lava or earthquakes - volcanism, tectonics)
- Identify which landforms were produced by exogenic processes (by wind or water: aeolian, fluvial, marine, weathering)
- Compare orbital and physical parameters of the earth and the planetary body using the "control panel" symbols on the map and draw conclusions.
- Determine a place where you would land on that body.
- Determine if the creatures shown on the map are real, or not, and explain why do you think it so.
- Explain why animals, plants or fungi can't exist in that environment (or why they can), based on the values shown on the map control panel.
- Identify what kind of spacesuit/protection an astronaut would need on a discovery mission on the surface, using the information on the control panel.

MATERIALS

Map of Titan, either printed in large format or projected if a computer projector is available.

Printed Handouts

Printed Worksheets

BACKGROUND INFORMATION

What is this activity about? *Astrogeology*. It is about the *geography / geology of planets*, and about how to read and make maps (cartographic representation). At elementary school level, the concept of "geography" (that can be a part of the more general "Science" curriculum) covers basic concepts of several fields in Earth and Atmospheric Sciences, for example geology, geomorphology, cartography, meteorology and climatology. We follow this concept.

What is this activity NOT about? This activity is not a planetary science image interpretation practice. This is also not an introduction to the structure of the Solar System or Astronomy. Astronomy is a completely different discipline from planetary science. The subject of Planetology is planetary bodies, and an important part of it is called *astrogeology*, which studies the surface geology of planets and moons. This activity is an astrogeologic and planetary cartographic activity. Astronomy is about for example stars, galaxies, and the celestial motions of planets.

Cartographic problems: The maps show the bodies in Lambert Projection (two separate hemispheric views. This requires additional explanation from the teacher on how two "sides" of a sphere is projected into two circular views which is not therefore not the view of two different bodies).

Astrobiology: About "alien" creatures: On the map, every geologic feature shown is real and placed at their true position, however the living creatures are completely fictional which also requires the teacher's explanation so that the students will not think that people or "aliens" live on planets and moons. It should be clarified that no life or sign of past life has ever been identified on any planet or moon other than on Earth. This might be a good opportunity to talk about the billions of exoplanets that exist in the universe that, unlike most extra-terrestrial Solar System planets and moons, include millions of planets and moons where conditions are much more favourable for life than extra-terrestrial worlds within our Solar System. An exciting new part of planetary science is exoplanetology, which deals with planets outside our Solar System. Many of those exoplanets and exomoons are completely different from those in our Solar System.
The very basis of space missions is to search for life. On Mars, scientists are looking for places where life could have developed in the past or may have survived in geologic refuges (caves, in the subsurface, within rocks, water-containing layers etc.). This is why NASA was looking for signs of water. Now that water (ice) containing sites and geologic units have been identified, they are searching for signs of past or present life. Europa may have a subsurface ocean that is exposed to space in new fractures. Scientist today are looking for life forms that are based on the same materials as terrestrial life, i.e. carbon-based life that relies on water, so they are looking for places where water can exist in liquid form. Other forms of life may exist, however as we do not know about them or how to identify them, the main focus is searching for identifiable carbon-based life.

About space programs: In addition to search for life, or bodies and regions that are habitable for terrestrial-like life, space programs are also motivated by the competition between countries. Space exploration also helps understand the geological processes on our planet and Earth's past and future. For example, the intense greenhouse effect on Venus can help predict similar processes in Earth's future or impact craters show how the Earth looked like 4 billion years ago. One of the most unexpected results of the Apollo program that sent humans on to the Moon was the so-called "overview effect": this was the first – and so far, last – time when human eyes saw our planet as a fragile "blue marble" against the black space that changed our perception of our world and our place in the universe.

About space research: Individual scientists can do research on a single landform for years, trying to explain how and when it formed. Others map specific regions in detail and classify the features seen on the maps. After a scientist publishes the results of the research, it becomes a little brick in the large building of planetary science and other scientists can use these results to improve their surface evolution models or can use these results in their own research.
Most of the content shown on these maps were obtained in the last decades, in some cases, only in recent years. The formation of some landforms is still not fully understood.

General descriptions of parameters that could be discussed when characterizing the chosen planet or moon.

Body type: Planet or moon. Planets orbit the Sun, moons orbit a planet. One side of a moon generally always faces its planet (tidally locked).
Body composition: Rocky bodies are made of silicate rocks (example Earth). Icy bodies are made of a rock and H2O ice mixture but their surfaces are usually mostly ice (example: Europa). On these worlds mountains and plains are made of rock-hard ice. Icy bodies occur only in the colder Outer Solar System.
Atmosphere: Atmospheres only occur if the gravity (and size) of the body is sufficient to hold gas molecules. It is easier to hold a gas molecule if it is colder.
Liquid: Liquids may be water in the inner Solar System or methane-ethane-nitrogen in the Outer Solar System. Liquids only occur where there is an atmosphere that produces air pressure. If air pressure is too low, liquid molecules

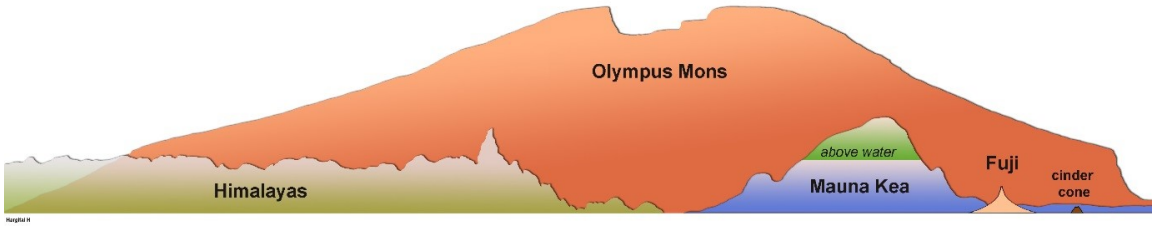
evaporate/sublimate. If temperature is too low, liquids freeze. If temperature is too high, liquids evaporate. Water may exist underground.
Weather: Diurnal temperature range (changes in temperature due to day and night) and forms of precipitation.
Endogenic features: Features produced by forces in the interior of the planet. **Volcanism** requires molten interior. Heat is provided from planetary formation (impact / accretion heat) or the irreversible decay of radioactive elements. Small bodies cool quicker than large bodies, so volcanism is found only on larger planets. An exception is if the interior is continuously heated. This happens inside moons on elliptic orbits where tidal forces produce interior heat (e.g. Io). **Tectonic** features are caused by stresses in the brittle crust. Tectonic forces produce fractures during earthquakes. This requires movements within the planet, also driven by internal heat. Volcanoes grow upward by adding more lava but may collapse and produce crater-like caldera.
Exogenic features: Features produced by processes on the surface or atmosphere. Includes aeolian (wind), fluvial (river), lacustrine (lake), oceanic features and their deposits.
Cosmogenic features: Features produced by impacting bodies (smaller craters and larger impact basins). Younger craters have radial rays (produced by ejected materials)
Common features: The most common features are craters. Most craters were formed soon after the Solar System formed and still had many small bodies in space. Craters are rare on surfaces that have been resurfaced recently, because resurfacing removes or buries craters. Resurfacing processes include volcanic plains, fluvial erosion and sedimentation, and subduction by plate tectonics.
Rare/Special Features: Features not found in many other places, they may be caused by very specific atmospheric/climate conditions or a remnant of an unusual event in the bodies past.
Life limiting parameter: Life should be able to grow and reproduce. Life may be limited by below freezing or above boiling temperatures, lack of atmosphere, lack of water or lack of magnetosphere (magnetospheres protect bodies from dangerous radiation in solar winds).
Nomenclature (Naming): Placenames can be proposed by the scientists who study a region or feature and it is approved by the working group of the International Astronomical Union's specialized to planetary placenames. Each feature type and each body has a particular theme (for example, gods of fire for Io) and the generic terms (like Mountain) are in Latin language to ensure language-neutrality. This also follows the geographic traditions of the 1600s when the first maps of the Moons were created in Europe with Latin names.
Age: Age of the surface. Many craters on the surface indicates an old surface age (4 billion years old), fewer craters indicates a younger surface age (0-3 billion years old). In the early solar system (c. 4 billion years ago) there were many small objects that could impact on the bodies causing craters. Later on, there were far fewer objects as they had impacted onto the planets or been moved away by their gravitational fields.

Shapes of geologic features:
Circular: usually an impact crater, occasionally a volcanic caldera
Linear (straight): negative elevation = tectonic fracture, positive elevation = dune, ridge or mountain
Sinuous: river or lava channel
Lobate: water rich impact crater, ejecta (debris thrown out by an impact or volcano), glacier, landslide
Radial: impact crater ray
Concentric: impact crater ring

Earth for comparison:
(MAP: use http://countrymovers.elte.hu/countrymovers.html for Earth map or Google map).

Body type: planet
Body composition: rocky
Atmosphere: just right
Liquid: water

Endogenic features: volcanoes, faults. Plate tectonics is unique to Earth.
Exogenic features: rivers, lakes, dunes, floodplains, deltas, glaciers. Glacial features on Earth are not permanent, most of the time there is no ice cap on Earth.
Cosmogenic features: 100+ impact craters, many buried or eroded due to erosion, or destroyed by plate tectonics (subduction), or impacted into water without permanent crater.
Common features: oceans, mountains, plains, rivers
Rare features: glaciers
Life limiting parameter: where it is too dry (no liquid water - deserts), too cold (no liquid water – Antarctica)
Age: mostly very young, some as old as 1 billion years.



Size comparison of the highest mountains on Earth and Olympus Mons on Mars

FULL ACTIVITY DESCRIPTION

The teacher should have the map of Titan either printed in a size that is still readable and accessible physically for the students, or projected onto a canvas at full resolution.

From this step you can choose one or several of the following subtopics designed to a teacher-instructed structured classroom activity with or without the handouts or you can follow the handout in itself. The instructions for the activities are also shown on the handout.

Read Page 1 of the handout with students, asking them to underline any words they do not understand so you can explain them.

CARTOGRAPHY

Show the map to the class and ask the students why the map representation of the body is circular (e.g., the planet is a spherical body). Now ask why there are two circle (hemisphere)-maps shown on the map. Explain that a sphere is represented by two circular projections, and those are the two sides of the one single sphere. We call one western (left), the other eastern (right) hemisphere.

Activity 1:
- Draw the Equator (a horizontal line in the middle of the two circles),
- Mark the poles (in both hemispheres) and
- Write the name of the body as a map title.

Compare the cartographic representation with real photograph. (SEE HANDOUT FIGURE ONE) Ask about the differences between the two pictures. Cartographic generalization (simplification) has been used and extra emphasis placed on the important but not necessarily visually prominent features. For planets with opaque atmosphere, the surface is not visible on the photo. Map colors may be different from real colors. Which elements are not on the photo that are present on the map? Why are those elements needed? (NOTE: Alien Creatures are NOT REAL).

GEOLOGY

Ask the class what geological information (about the landforms) they can see on the map. Name at least one such feature type (See Activity 2 on the handout for a list of them).

Identify/find endogenic landforms that were produced by magma from below the surface (volcanic landforms: volcanoes, lava flows, tectonic landforms: cracks, fractures).
Identify /find exogenic landforms that were produced by processes that operate on the surface in a planet with atmosphere (wind: dunes, deserts, water: weathering, rivers, oceans, lakes, sediments).
Identify /find cosmogenic landforms that were produced by impact processes (impact craters or impact basins made by asteroids or comets coming from outer space).

Activity 2 - Graphic map. Using the map, draw a generalized (simplified) sketch map, showing the outlines of only the largest and most important features (draw several types of features, e.g., cracks and craters). You can use colors and/or lines. Try to include the following featurs:
- **Exogenic (liquids):**
Groups of Lakes at both poles (Kraken Mare, Ontario Lacus)
Rivers (Fluctus)
- **Aeolian (wind produced)**
Long, subparallel dark dunes at the equator
- **Other**
Xanadu mountainous region

EXPLORATION

Ask students where would they land / build a settlement(s) for more exploration? Which region (or feature) is worth more exploration? Why? What do you want to investigate? What instruments/tools/methods would you use for the investigation? What would you bring with you for this research?

Activity 3 - Your landing site. Where would you land? Which place you find the most exciting for exploration? Find YOUR landing site. Mark it with a symbol. Name your landing site (s). Write down the names next to the symbol.

TOPONYMY

Ask students to read one name from the map aloud. Ask what they understand from them, i.e. what the names tell them. The names are in Latin as the planets are not part of any country and Latin is considered a neutral international language. Ask students if they like this "neutral" (Latin) naming or name in English (or your language) would be better. You may explain the meaning of the names on the map. You can find the English equivalents in this site: http://planetarynames.wr.usgs.gov/DescriptorTerms

Activity 4 - Names. After the graphic part is finished, create the nomenclature: write the names of the features you have drawn next to the feature itself. Write three names (you can add more later) onto the map. You can use different colors or letters for each feature type (e.g, capital letters for continents, red color for the lava channel etc. – be consistent).

ASTRONOMY, CLIMATOLOGY, METEOROLOGY

Ask students if there is atmosphere on the planet and why they think this

Find weather data (max/min surface temperature) on the map control board or on the handout. Do not confuse coordinate values (0°, 90° etc.) shown on the map with temperature values shown on the control board.

Ask students if there is liquid water or other liquid material on the planet and how do they know that. Compare local temperature ranges (max-min) with freezing / boiling temperature of water. What is the chance of finding liquid water?

Activity 5 - Weather forecast for "tomorrow", based on the Weather information in the handout. Choose at least three places, and show weather data: display the min/max temperature in your unit (C or F) with LARGE numbers. Consider that on towards the poles it is colder. Next to the numbers, show the weather with a graphic symbol you design: clear (sunny), cloudy, rainy, foggy or any interesting, special weather phenomenon you learn from the handout. Find min/max temperature data on the map's control desk and additional information on the handout.

Ask students what protective clothing they would need if they were to explore the surface away from their vehicles, using the values discussed previously. For example, they may need oxygen tanks, a suit that maintains room temperature, pressure etc.

Activity 6 - Design a flag for Titan, and draw it on the map, based on the characteristics of the body (weather, color, geology etc).

Ask students if the creatures, or plants or animals would survive on Titan, using the values given in the control panel (temperature, pressure – use the concept of liquid water = habitability: if liquid water can exits, life may (or may not) exist). Explain that no present life forms or traces of past life have ever been discovered on any other planet or moon in the Solar System or outside it on exoplanets, however, there are millions of planets never explored by us. What kind of creatures could exist there? What protection / skills would they need for survival? What would they look like? (e.g., thick fur, or underground animals etc.). What would they eat? How would they communicate with each other? (For example, without air, no sound exist).

LEGEND

Activity 7 – Draw a legend where YOUR symbols are explained on the map. You may group them by process (e.g., exogenic (atmospheric, aeolian), endogenic (volcanic, tectonic) and impact processes). Write down the title "LEGEND" and explain your symbols and indicate which feature it corresponds to.

Homework: Ask students to compose or draw stories using the map's landscapes as background for the story, and their creatures as the characters of the story. A possible storyline: how the surface became like what it is now? (as told with a story, not scientifically). You can also Illustrate the story.

CURRICULUM

ADDITIONAL INFORMATION

The language of the maps and accompanying texts about various bodies is translated to 11 languages so if a teacher speaks English, he or she can use materials of this activity in the following languages:
Presently the Pluto map is only offered in English.

English https://childrensmaps.wordpress.com/
French, http://cartespourenfants.wordpress.com/
German, http://kartenfuerkinder.wordpress.com/
Hungarian, http://gyerekterkep.wordpress.com/
Italian, http://mappeperbambini.wordpress.com/
Polish, https://mapydladzieci.wordpress.com/
Portuguese, http://mapasparacriancas.wordpress.com/
Romani (Gipsy) http://mapileshavorenge.wordpress.com/
Romanian, http://hartipentrucopii.wordpress.com/
Russian, http://kartydlyadetey.wordpress.com/
Spanish, http://mapasparaninos.wordpress.com/

CONCLUSION

Using planetary maps, students will be able to read cartographic information and compare the environmental conditions of Titan to those Earth. They will understand the conditions needed for life to exist, and be able to explain why it cannot exist on Titan.

ATTACHMENTS

- Worksheet
- Handout
- Map PDF

ALL ATTACHMENTS

All attachments

CITATION

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