SPECIAL ISSUE

PLANCK!

I'm going to be a little scientist!

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PLANCK! SPECIAL ISSUE
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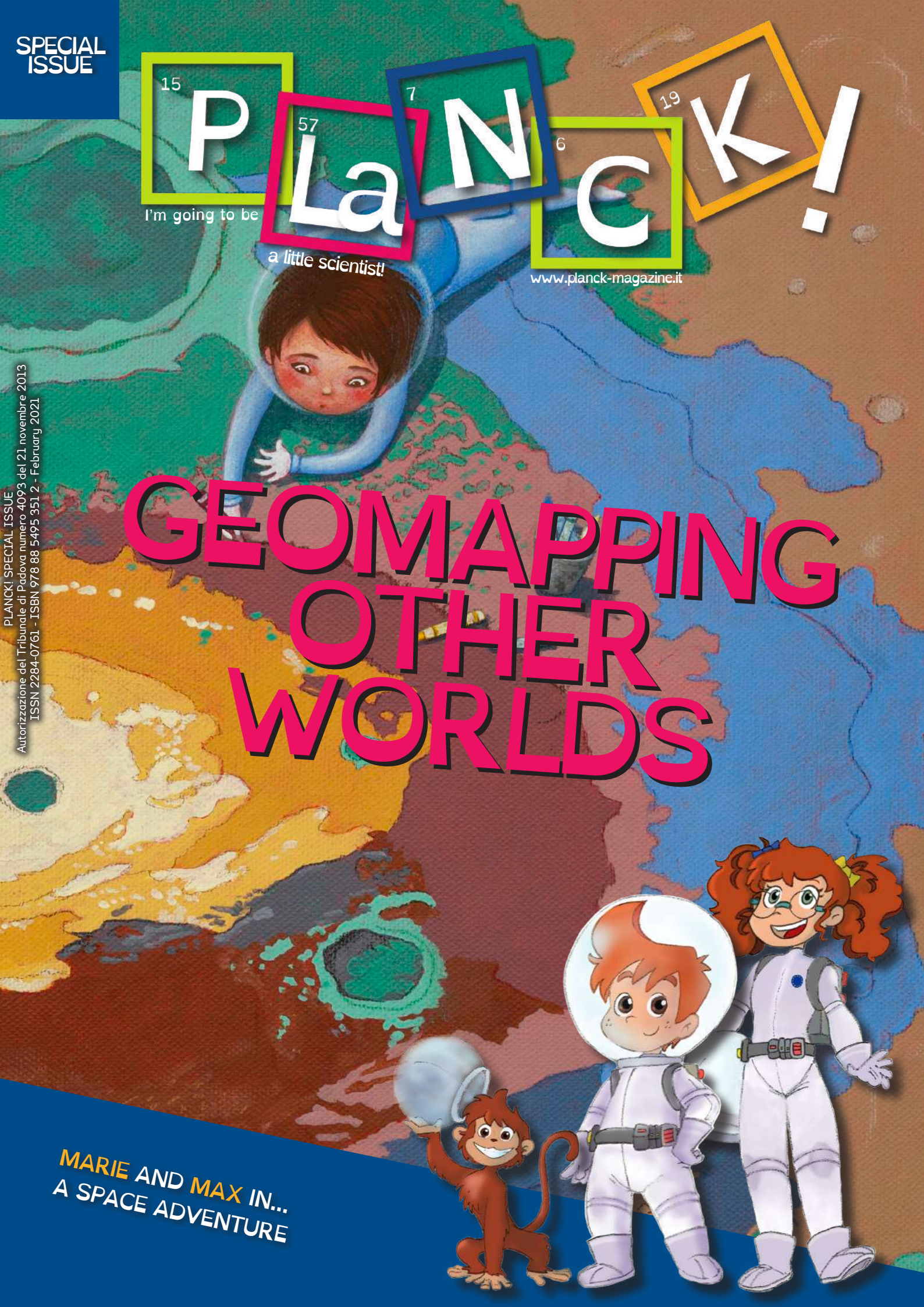
GEOMAPPING OTHER WORLDS



MARIE AND MAX IN...
A SPACE ADVENTURE

Let's begin the geological mapping experience!

To all of you who, like me, have a real intimate passion for planets and geology, I must announce: we are lucky! We are extremely lucky! We are living in a golden age for planetary exploration. We have something like 12 missions active on Mars, soon the first woman will imprint her footprints on the lunar soil, we are planning settlements on the Moon, we have already accompanied a comet along its journey around the sun and landed on its nucleus; we are exploring several asteroids and many other small bodies will be visited in the future; we have imaged the entire surface of Mercury and in a few years we will visit again this small planet close to the Sun; we have studied the dense atmosphere of Venus; we will deeply explore the icy moons of Jupiter; we have visited Titan, Pluton, Enceladus, and many other objects in the outer Solar System. But planetary exploration cannot be limited to the collection of breath-taking images, because it is aimed at the scientific understanding of these planetary objects and, in the case of the Moon and Mars, even at the evaluation of their resources. This can be achieved only if adequately supported by maps.

Since the work "Geographike hyphegesis" by Ptolemaeus (150 AD), where territories were correctly projected on a papyrus, geographic and topographic maps were used as the best representation of known worlds. But geographic and topographic maps do not contain any specific information on the composition of the surface material like geological maps, the first one being the important map of England and Wales produced by William Smith in 1815.

Geological maps are planar representations of a territory that show the composition and the ages of rocks and deposits on its surface, and from which we can know the geological evolution and the related subsurface structure and lithology. These maps are essential for science investigation, evaluation of resources, and exploitation, hazard and risk assessment, land use and infrastructure planning, and also environment safeguard. Any country without a geological mapping program is a nation unaware of its own territory. In other words: a lost land.

The same applies to planetary surfaces: any planetary mission which does not include the production of geological maps is a mission whose aims are at serious risk. In planetary exploration programs, geological maps are crucial for science investigation, safe landing and rovering, exploration of local resources, astronauts' safety, planning of stable settlements, and identification of sites of astrobiological interest.

To be prepared for the exponential increase of planetary missions in the years to come, we need to start producing geological maps all over the world, especially because at the moment the United State Geological Survey is the only institute that can produce such maps regularly. For this reason, the European project PLANMAP, involving many research institutes and universities in Europe, has the objective of producing innovative geological maps to support future missions to Mercury, the Moon and Mars.

Geological maps are colorful maps where each color and symbol, like a music sheet, has its meaning and timing and, like a symphony, only all the elements together are able to reveal a story. In this case, the story is the evolving geological history of exotic regions of remote worlds. Let's begin together our first geological mapping experience!

Matteo Massironi

Matteo Massironi is a professor of the Department of Geosciences at the University of Padova, where he teaches Geological mapping, Satellite Remote Sensing and Planetary geology. He got his degree in Geology in 1994 from University of Padova and gained his PhD in "Space Science and Technology" in 1998, working on Satellite Remote-Sensing applications for geological mapping. He has been involved in several cartographic and field survey projects in the Italian Alps, North Africa and South America, and he was a team member of several ESA missions (Bepi-Colombo mission to Mercury; CaSSIS-ExoMars; Rosetta mission to the 67P/Churyumov-Gerasimenko comet and JUICE mission to Jovian satellites). Since 2016 he has been the scientific coordinator and prime instructor of the ESA PANGAEA course, which aims at training ESA astronauts in planetary and field geology. His research interests include planetary surface geology, alpine tectonics, geological mapping and geo-modeling. He was awarded the "Giuseppe and Paolo Gatto" award of the Accademia Nazionale dei Lincei for his post-doctoral studies on the Italian Alps and in 2017 the International Astronomical Union named the Asteroid 11440 "Massironi" in recognition of his research on small bodies. He is the coordinator of PLANMAP project.

PLaNCK! is a bilingual scientific magazine for children edited by Accatagliato, an organization aimed at communicating science to the public that was involved in the dissemination activities of the PLANMAP project.
This is a special issue aimed at communicating the scientific contents and results of the PLANetary MAPping (PLANMAP) European project to children.

PLANMAP
Geologic Mapping of our Solar System

PLaNCK!

Accatagliato

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the grant agreement No 776276.

In this issue

Rocks can talk

Rocks can talk. Did you know? Rocks can talk and they tell stories. Or better, they tell "the" story: the history of our Earth, how it was born, how it has changed, and who inhabited it. Rocks are witnesses to everything that happened on Earth and they can help us predict what will happen. They tell us if once the rushing water of a river flowed on them or the wind touched them lightly; if their tough surface was once fertile land, or if it was covered with meters and meters of snow and ice. They can even tell us what living beings used to walk on them, and some rocks have preserved those living beings till today, turning them into fossils. But there is something more: there are "special" rocks on other planets that can tell us interesting stories about the other planets!
In short, the rocks have a lot to tell... if we can listen to them!
Enjoy your reading!

Andrea Frison

PLaNCK!

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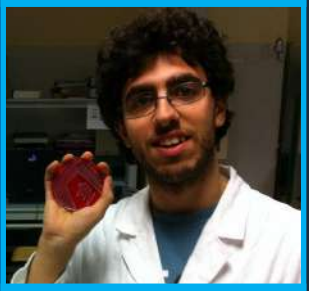
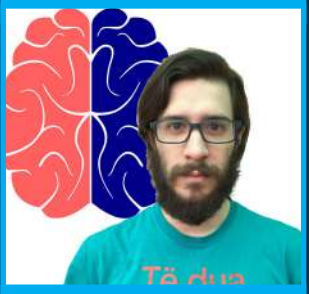
He works as a private consultant. He has a PhD in Materials Science and Engineering and he's an expert in optical devices.



MARCO MAGGIONI
Biotechnologist, science teacher, and science communicator.



FRANCESCO ZANI
Gratuated in neuroscience and very passionate about games and design.

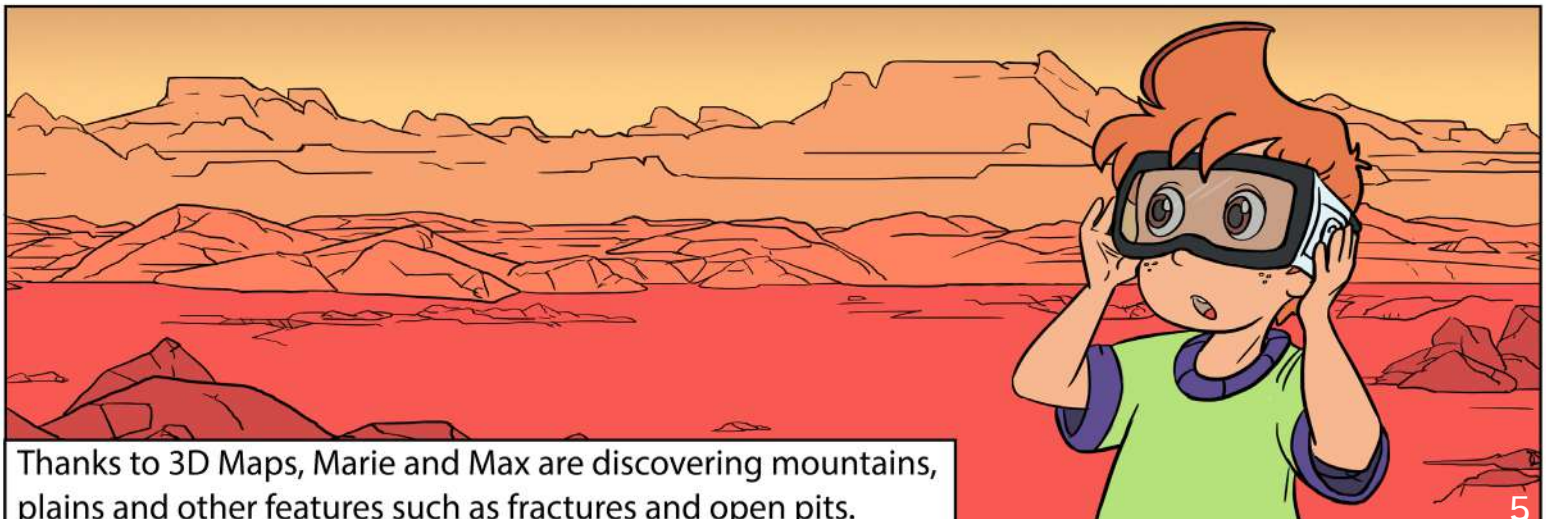
Do you want to contact us? Are you curious about science? Do you want to send us some pictures of your scientific experiments at home or at school?
Write an e-mail to
redazione@planck-magazine.it
We will be very happy to answer you and to have you as a new friend!

Marie & Max in...

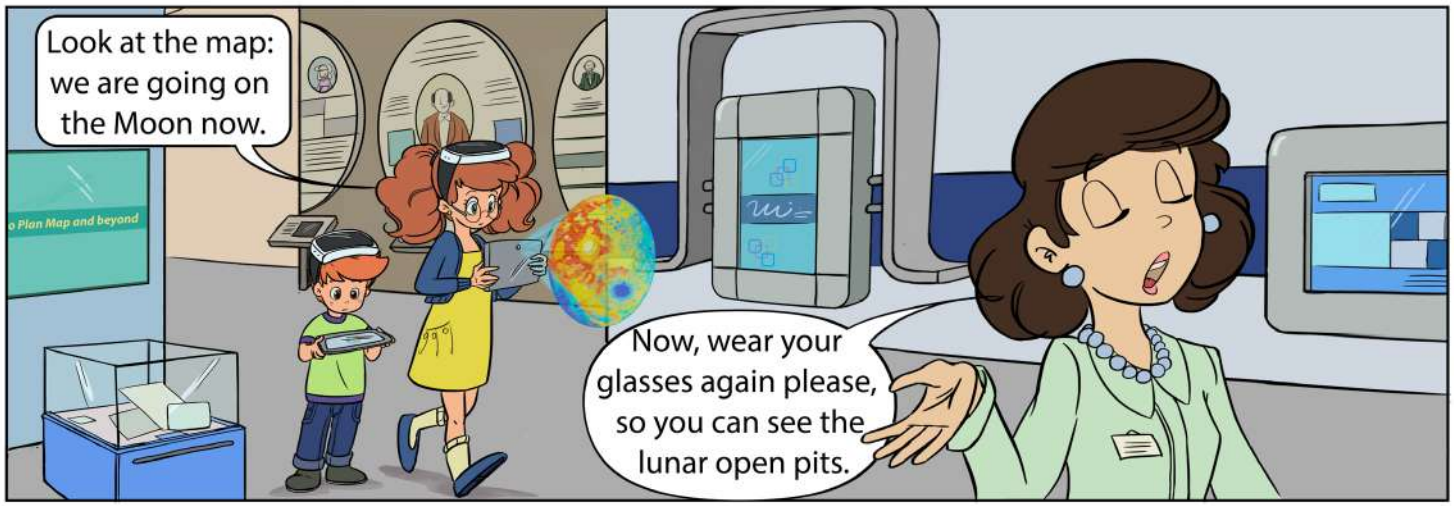
A space adventure

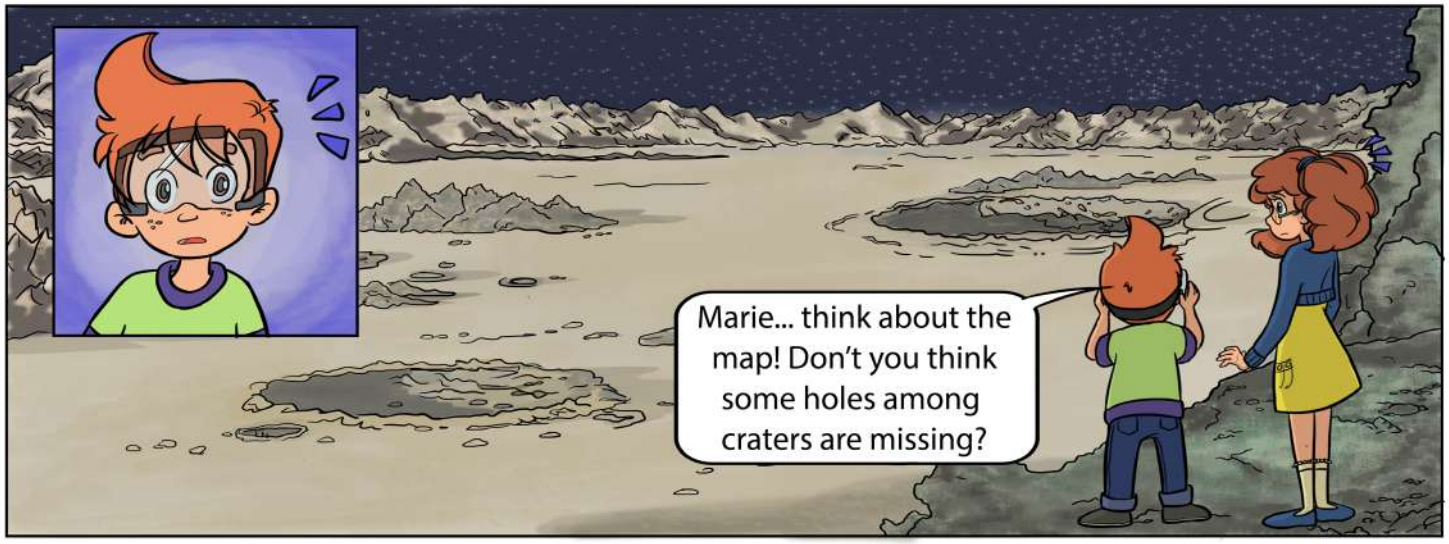
2021, PlanMap Museum: Marie and Max are having a space journey with Virtual Reality glasses and Augmented Reality.

They can visit Moon, Mars and Mercury

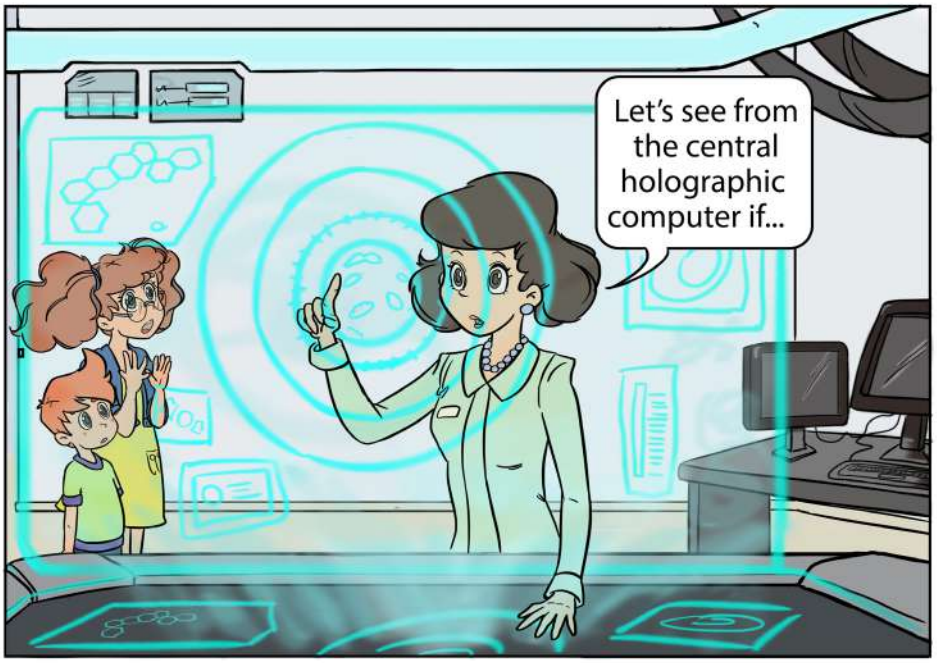


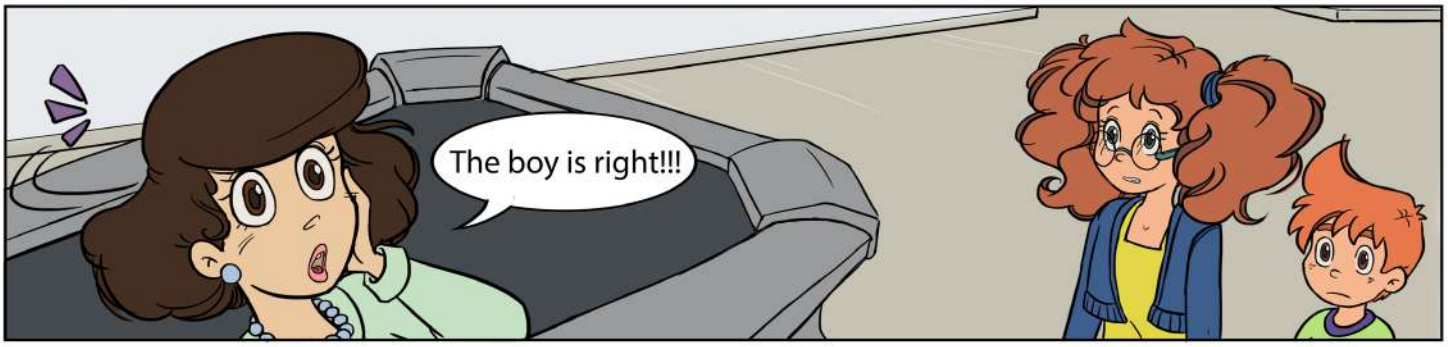
Thanks to 3D Maps, Marie and Max are discovering mountains, plains and other features such as fractures and open pits.

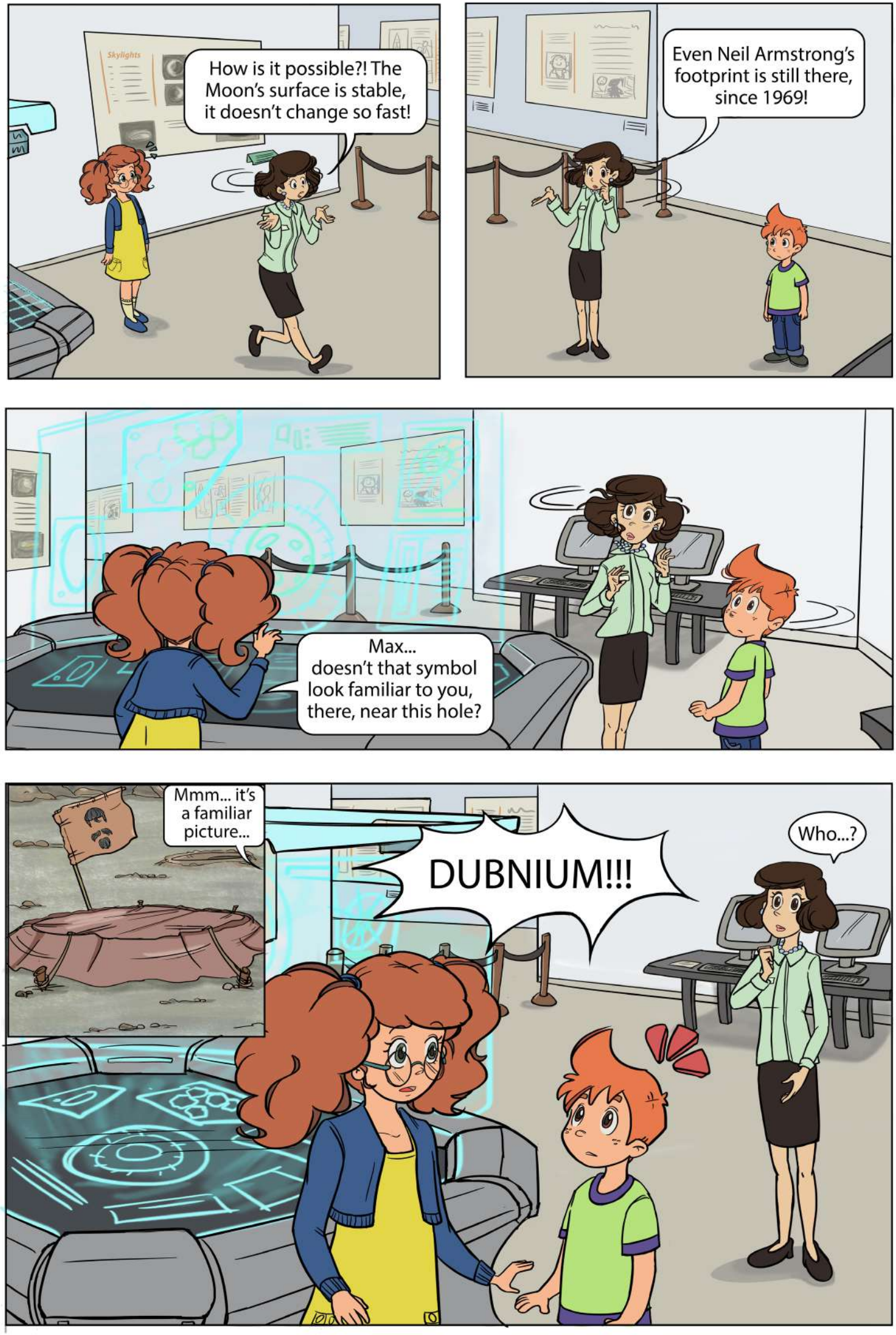

Look at the map: we are going on the Moon now.
Plan Map and beyond
Now, wear your glasses again please, so you can see the lunar open pits.

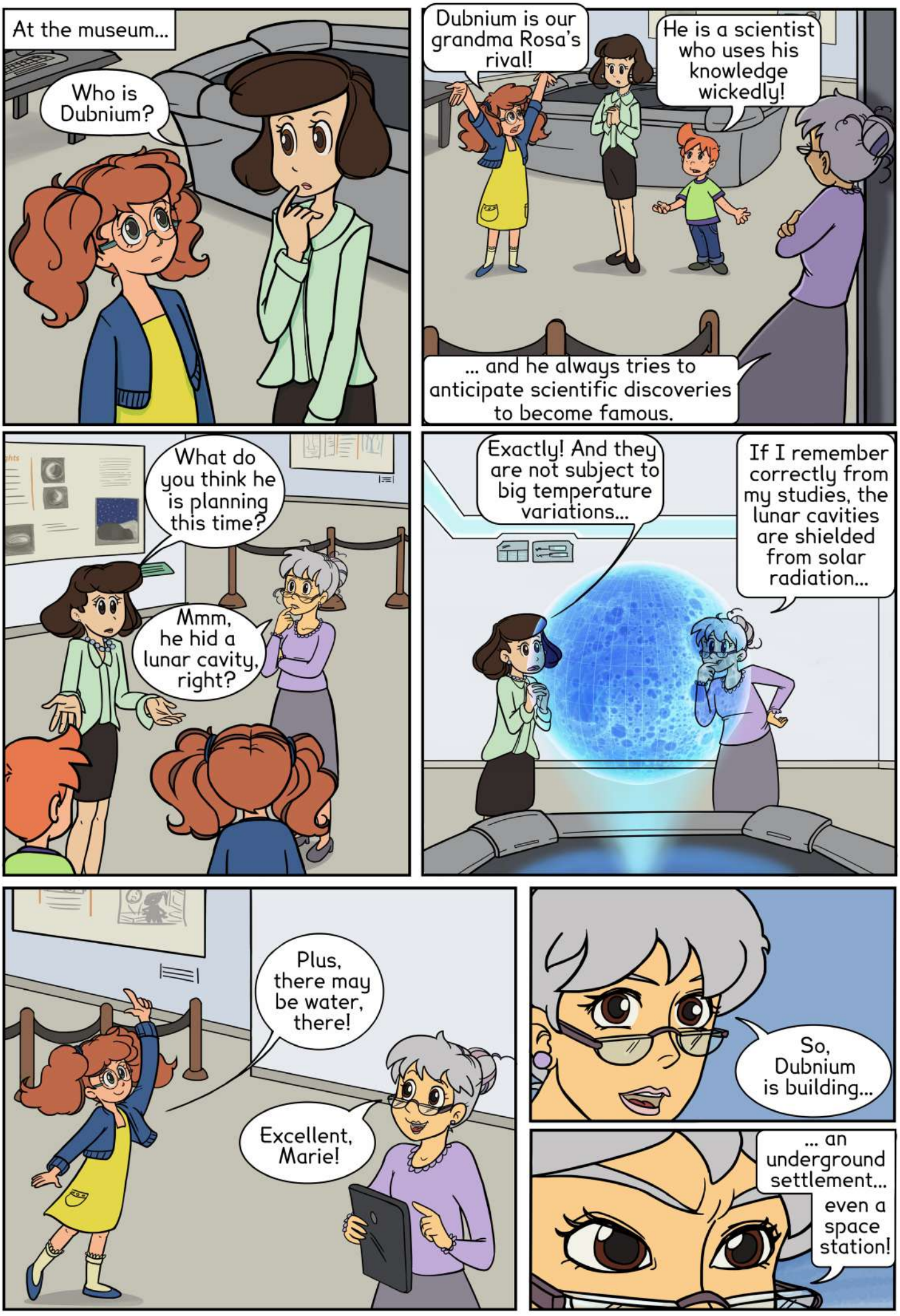

Marie... think about the map! Don't you think some holes among craters are missing?

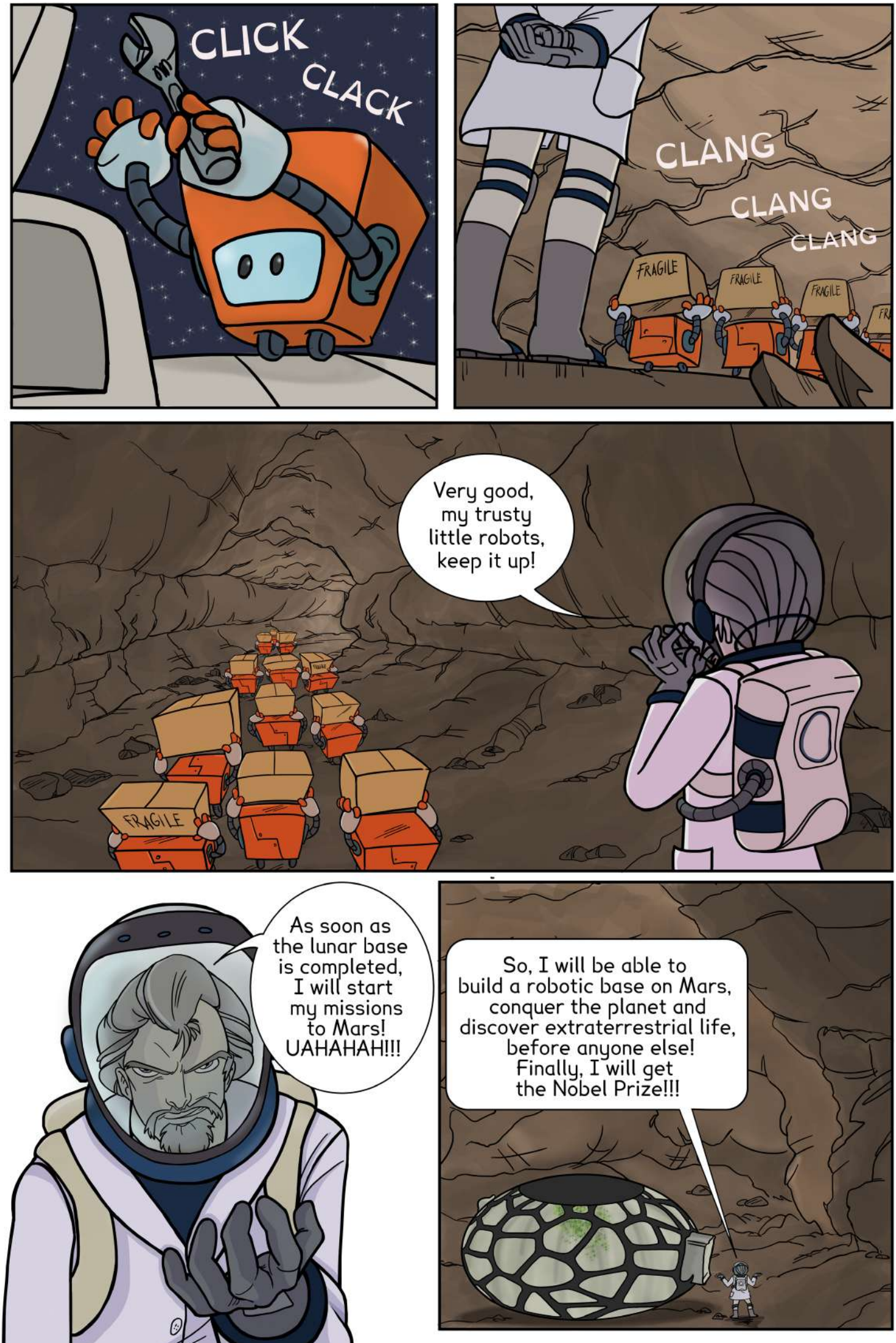

What did you say, boy?
It seems to me that some lunar cavities are missing...

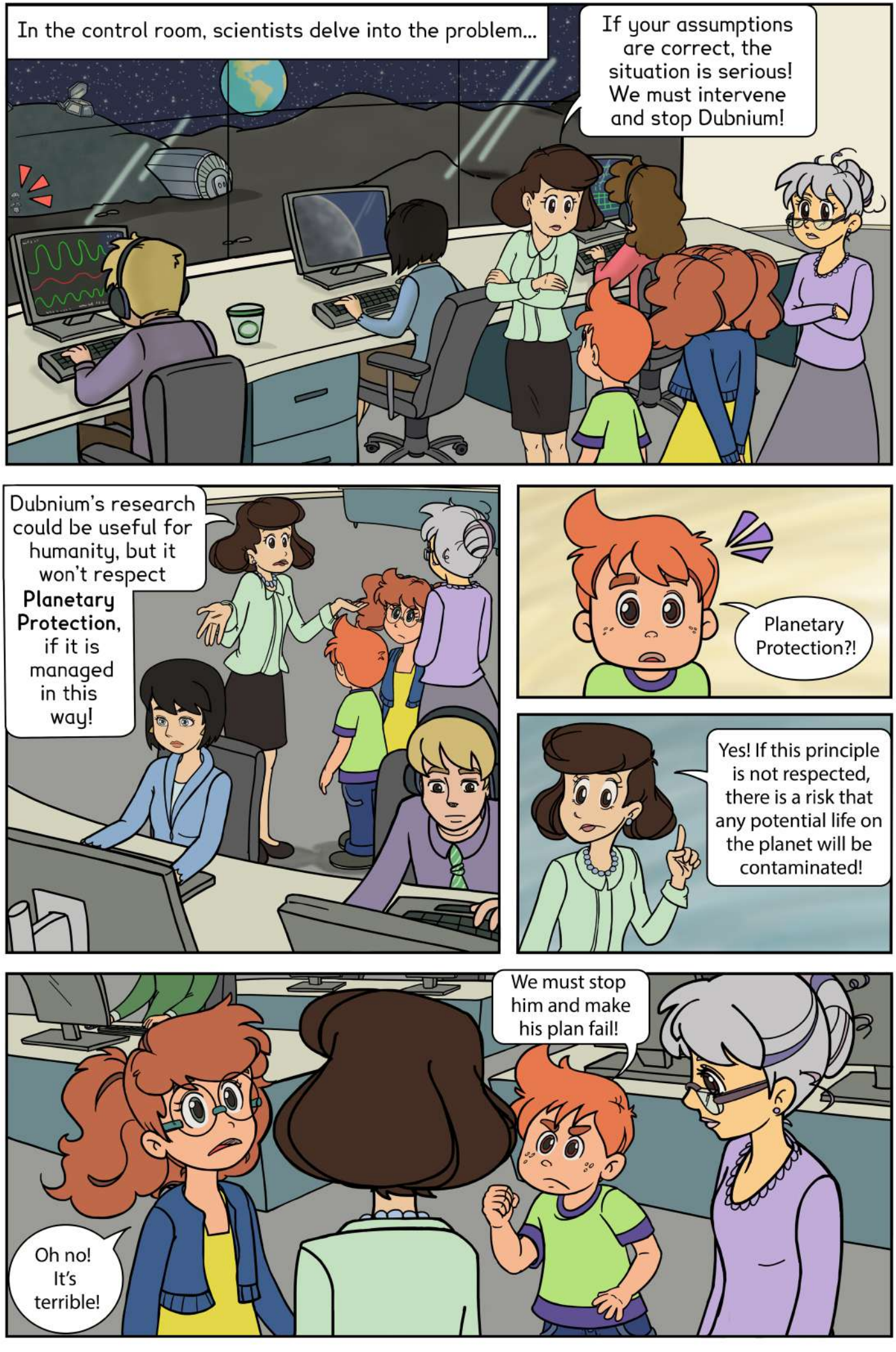

Let's see from the central holographic computer if...

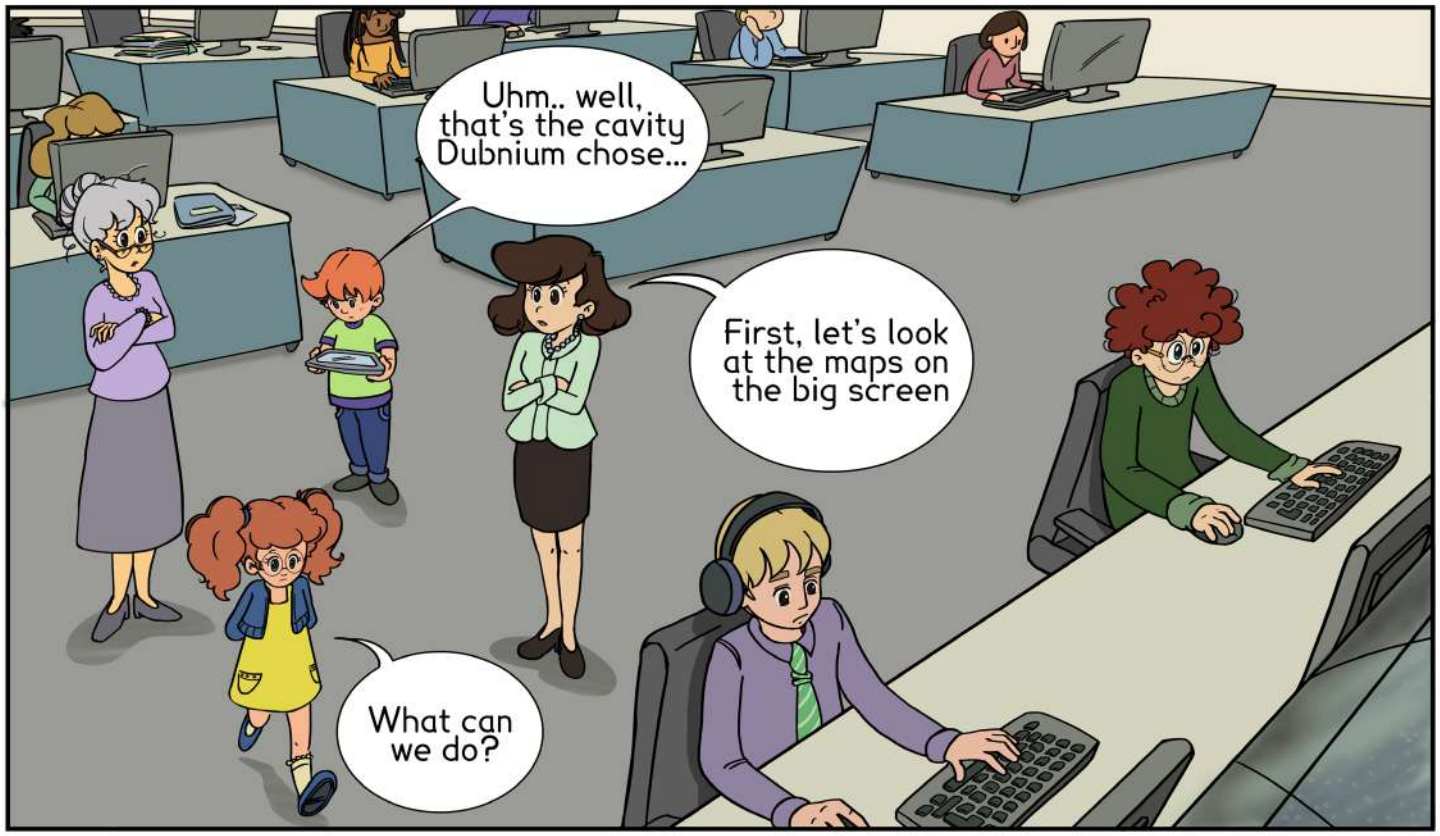

The boy is right!!!


Skylights
How is it possible?! The Moon's surface is stable, it doesn't change so fast!
Even Neil Armstrong's footprint is still there, since 1969!
Max... doesn't that symbol look familiar to you, there, near this hole?
Mmm... it's a familiar picture...
DUBNIUM!!!
Who...?

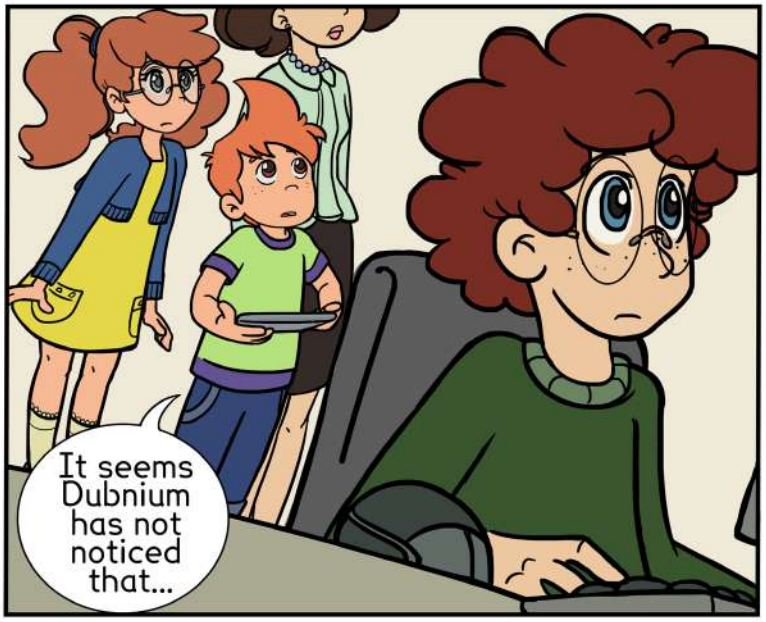

At the museum...
Who is Dubnium?
Dubnium is our grandma Rosa's rival!
He is a scientist who uses his knowledge wickedly!
... and he always tries to anticipate scientific discoveries to become famous.
What do you think he is planning this time?
Mmm, he hid a lunar cavity, right?
Exactly! And they are not subject to big temperature variations...
If I remember correctly from my studies, the lunar cavities are shielded from solar radiation...
Plus, there may be water, there!
Excellent, Marie!
So, Dubnium is building...
... an underground settlement...
even a space station!

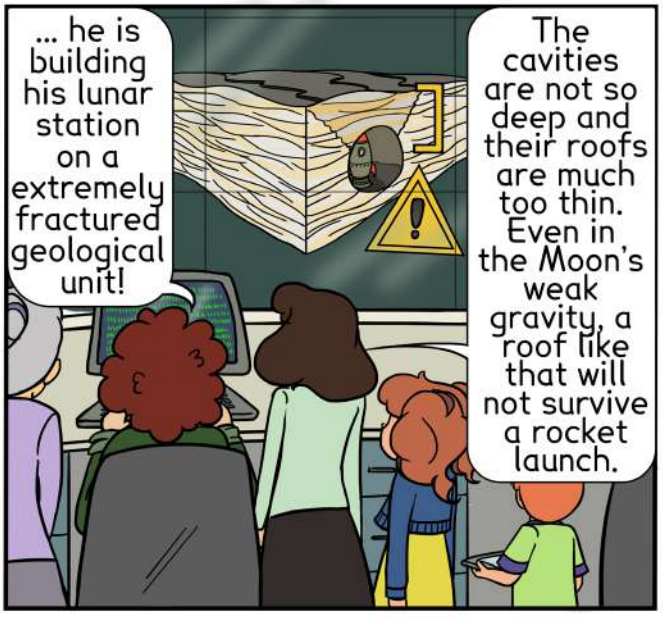

CLICK
CLACK
CLANG
CLANG
CLANG
FRAGILE
FRAGILE
FRAGILE
Very good, my trusty little robots, keep it up!
FRAGILE
As soon as the lunar base is completed, I will start my missions to Mars! UAHAHAH!!!
So, I will be able to build a robotic base on Mars, conquer the planet and discover extraterrestrial life, before anyone else! Finally, I will get the Nobel Prize!!!

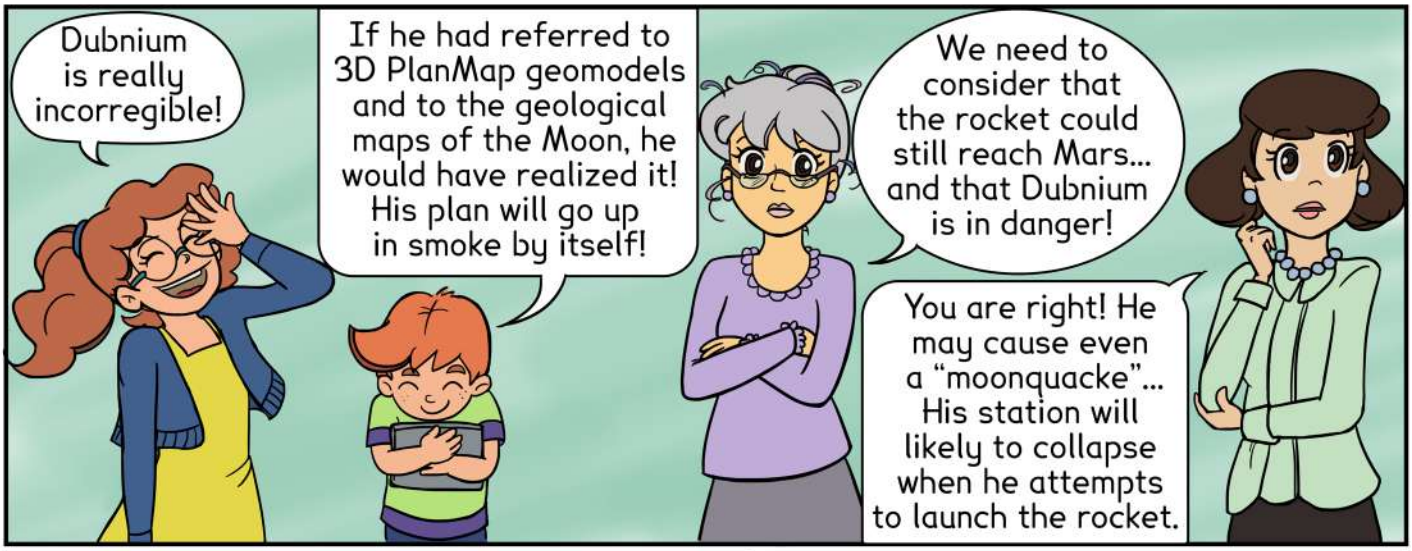

In the control room, scientists delve into the problem...
If your assumptions are correct, the situation is serious! We must intervene and stop Dubnium!
Dubnium's research could be useful for humanity, but it won't respect **Planetary Protection**, if it is managed in this way!
Planetary Protection?!
Yes! If this principle is not respected, there is a risk that any potential life on the planet will be contaminated!
We must stop him and make his plan fail!
Oh no! It's terrible!


Uhm.. well, that's the cavity Dubnium chose...
First, let's look at the maps on the big screen
What can we do?

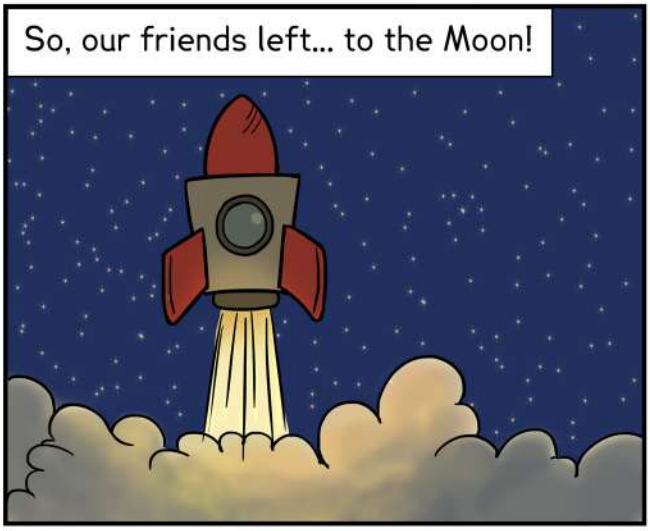

Steve, can you open the lunar maps on your computer, please?
Of course!

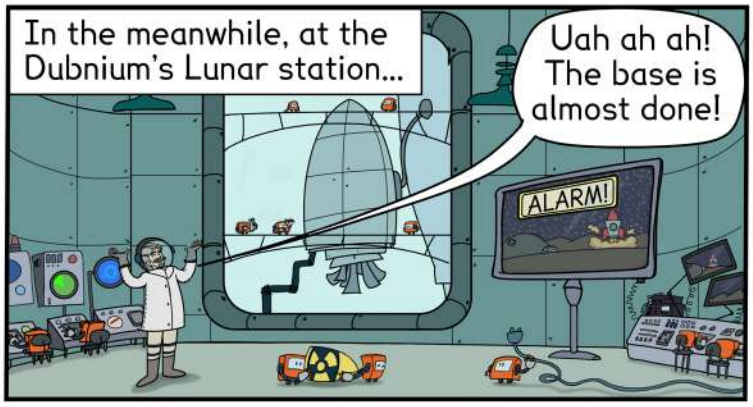

It seems Dubnium has not noticed that...


... he is building his lunar station on a extremely fractured geological unit!
The cavities are not so deep and their roofs are much too thin. Even in the Moon's weak gravity, a roof like that will not survive a rocket launch.

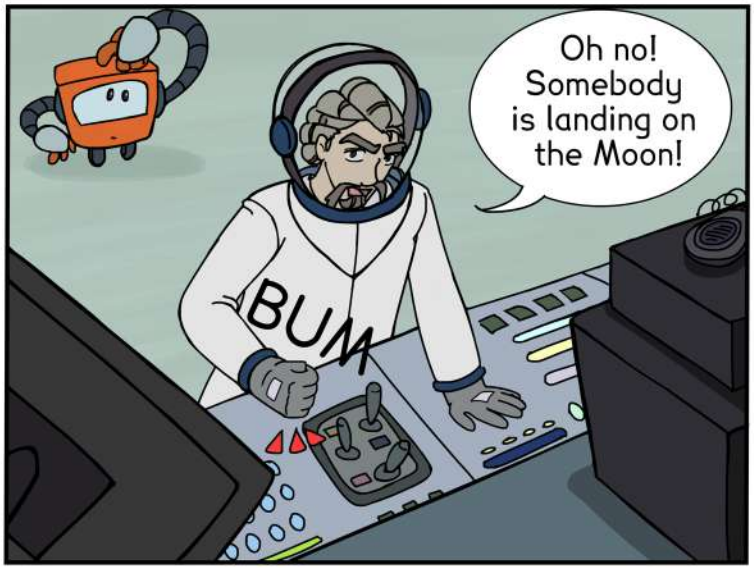

Dubnium is really incorregible!
If he had referred to 3D PlanMap geomodels and to the geological maps of the Moon, he would have realized it! His plan will go up in smoke by itself!
We need to consider that the rocket could still reach Mars... and that Dubnium is in danger!
You are right! He may cause even a "moonquacke"... His station will likely to collapse when he attempts to launch the rocket.

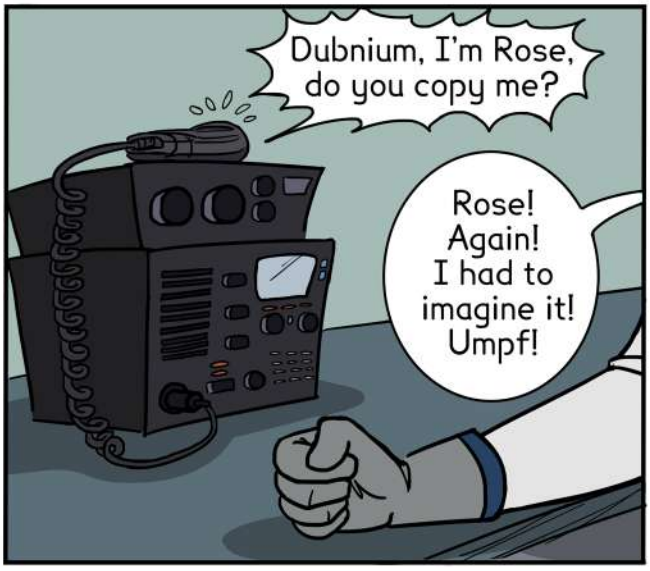

Let's get ready! We will stop him!

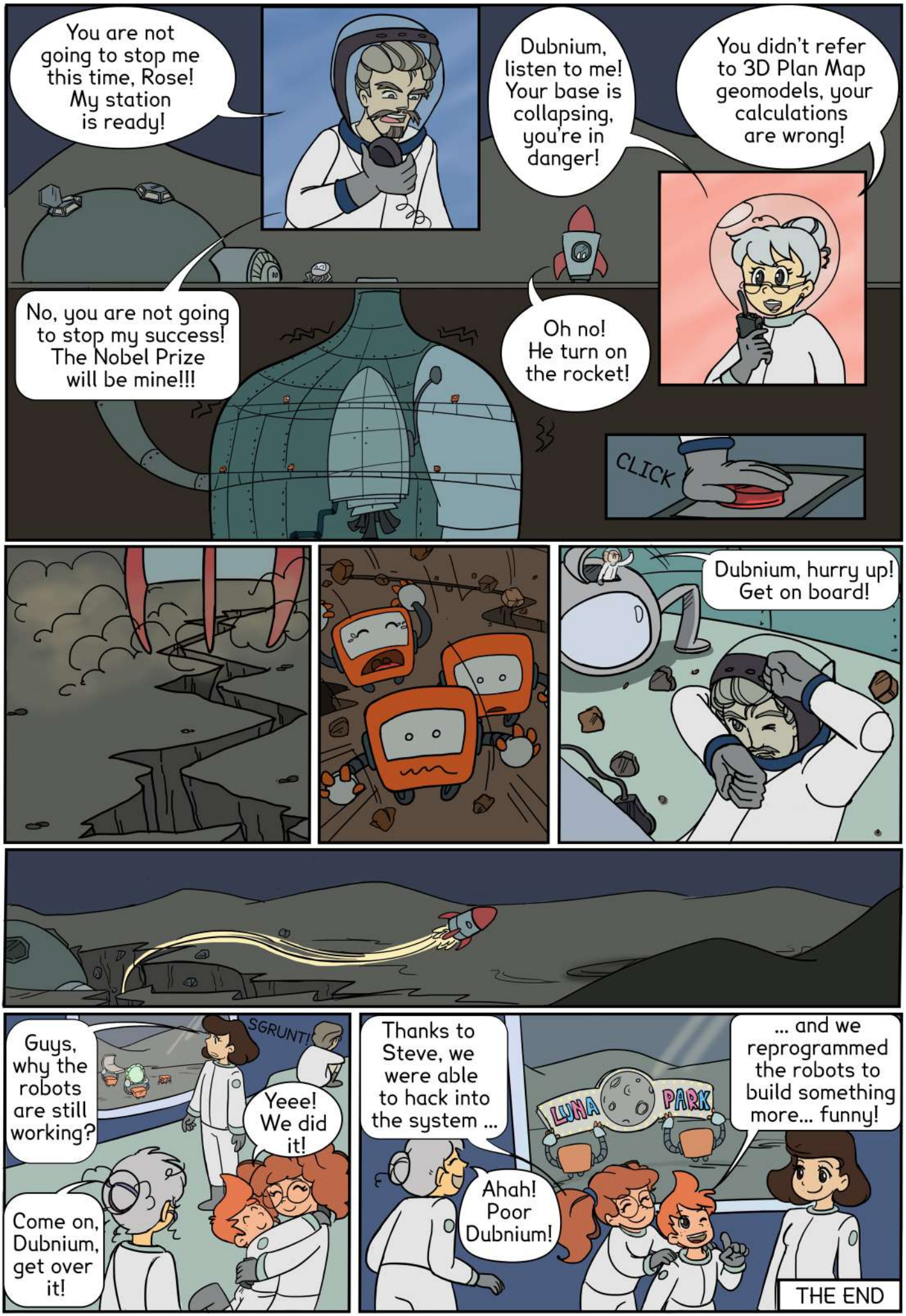

So, our friends left... to the Moon!


In the meanwhile, at the Dubnium's Lunar station...
Uah ah ah! The base is almost done!
ALARM!


BIP! BIP!
Uh?! What is happening?


Oh no! Somebody is landing on the Moon!
BUM


Dubnium, I'm Rose, do you copy me?
Rose! Again! I had to imagine it! Umpf!


You are not going to stop me this time, Rose! My station is ready!
Dubnium, listen to me! Your base is collapsing, you're in danger!
You didn't refer to 3D Plan Map geomodels, your calculations are wrong!
No, you are not going to stop my success! The Nobel Prize will be mine!!!
Oh no! He turn on the rocket!
CLICK
Dubnium, hurry up! Get on board!
Guys, why the robots are still working?
SGRUNT!
Yeee! We did it!
Come on, Dubnium, get over it!
Thanks to Steve, we were able to hack into the system ...
Ahah! Poor Dubnium!
LUNA PARK
... and we reprogrammed the robots to build something more... funny!
THE END

DISCOVER PLANMAP: A MULTIPLANETARY PROJECT

by ***Barbara De Toffoli*** (geologist and researcher at the German Aerospace Center - DLR) *and* ***Sarah Libanore*** (editorial board)

Name: PLANMAP
Start: 2018
End: 2021
Countries: Italy, Germany, France, United Kingdom
Scientist: geologists, astronomers, physicists, engineers
Main goal: providing innovative geological maps of different planets for space exploration

When we talk about space exploration, we often think about astronauts floating in space or stepping on new planets. However, this is only the end of the story: before getting there, hundreds of scientists work to make the mission safe. There are many ways to do so; one is to discover as much as we can about the planets.

The objective of the PLANMAP project is to do exactly this! PLANMAP scientists look at the surface of the Moon, Mars and Mercury and do a lot of different analyses. This is not easy and requires the collaboration of many experts, each one giving a precious contribution to the common goal. Not only different scientific fields are involved, but also different institutions in different countries. Working together is the first step to succeed in such a big and difficult project.

WHY DO WE STUDY THE MOON, MARS AND MERCURY?

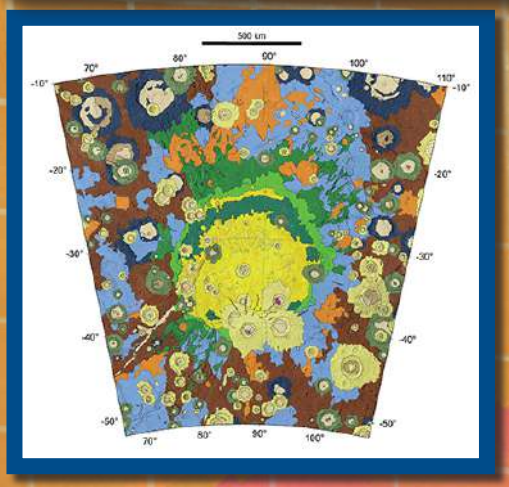
- They have rocky surfaces, so we can compare them to Earth and study their evolution using techniques similar to the ones used on our planet.
- They have thin or no atmosphere at all. Thick atmospheres make it very hard or impossible to take pictures of the surface of the planet from its orbit, like in the case of Venus.
- Space agencies are working to bring humans on the Moon and Mars in the next decades. These planetary bodies are very close to Earth, so we already had the opportunity to do many space missions to study them and collect new information. But to make the astronauts' trip safe we need to study these planets in great detail!

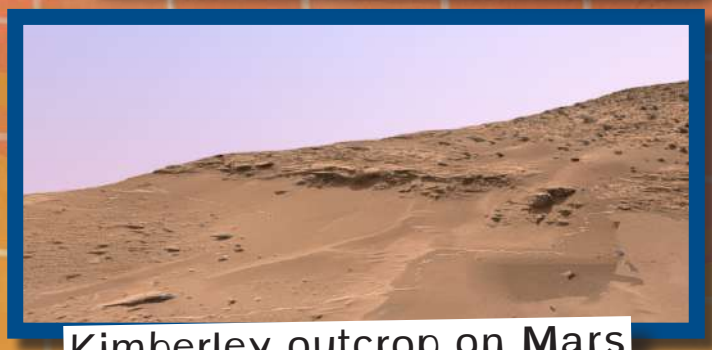
The Moon is not a planet: it's the natural satellite of the Earth

What are the main products of PLANMAP?

GEOLOGICAL MAPS: using different colors and symbols, they collect and visualize all the information about the planet surface to discover what happened in the past.
See pages 22 and 23 to learn more!

3D GEOMODELS: combining different pictures, scientists can recreate the 3D shape of the alien rocks to study their evolution. Learn more by reading pages 16 and 17!





Kimberley outcrop on Mars

Thanks to the PLANMAP project, a lot of European scientists worked together to explore our neighbouring planets. They obtained very useful information to deepen our knowledge of space and expand our horizons for the explorers of today and tomorrow.

IN THE BACKGROUND: Image by Jacopo Schiavo realized for the dissemination of PLANMAP project (for more information see page 18).

3D AND VIRTUAL REALITY

A way to discover out of this world geology

by ***Gwénaël Caravaca*** (planetary geologist and researcher at the Laboratoire de Planétologie et Géodynamique - CNRS, Université de Nantes, Université d'Angers)

Studying the geology of other planets is difficult, mainly because we cannot go there! So, how can we observe the rocks there? That is where 3D and virtual reality come into action.

It is very important to look at rocks and "*outcrops*" in 3D. Here on Earth it is easy: we take a hammer, a magnifying glass, and then we go outside. But for the Moon, Mars and beyond, we have hundreds of thousands of kilometers to travel… Not easy at all!

So, we send robotic explorers, for example Curiosity and Perseverance on Mars. These robots take many pictures so we can see the rocks and their details. The pictures are really a lot: Curiosity took nearly one million in eight years!
These photos are great, but we can do better: we can use the images to recreate the true 3D shape of the rocks! To do so, we overlap many different pictures of the same rock: this technique is called "photogrammetry". In this way, it is also possible to understand the true shape of the cliffs and canyons that are on Mars.

3D images can teach us many things about the story of these geologic formations: for example, it is possible to understand in which places water flowed. Moreover, using 3D images we can virtually tour around the rocks and the outcrops to see their shape from any point of view, just as we do on Earth.

The illustration shows how measurements are done using virtual reality (© CNRS-LPG-VR2Planets)

IN THE BACKGROUND: The illustration shows how virtual reality behave (© CNRS-LPG)

But we can do even more and, like with videogames, we can use Virtual Reality. This is a powerful technique: wearing a headset, it "transports" you wherever you want, to explore any planet without being there.

When we wear the headset, we are transported exactly where Curiosity was on Mars, and we can even move between places in an instant. We can explore the outcrops, just like on the field on Earth, without months of travel! It is very important for us to explore Mars in this way because when we have the rocks in front of us we can see the details better. In virtual reality you can see the true size of the rocks: many scientists who try the virtual reality for the first time say «Whoa, I thought it was bigger!».

It is a wonderful experience to "walk" on Mars or the Moon this way and it allows us to better understand these other worlds… by staying grounded on Earth (for now!).

The image shows what you see when you wear the headset (© CNRS-LPG)

Outcrop of volcanic rock in Germany

An "outcrop" is a place where the rocks are accessible and we can study them.

If you want to know more, you can visit
PLANMAP Sketchfab account: https://sketchfab.com/planmap.eu
LPG Sketchfab account: https://sketchfab.com/LPG-3D

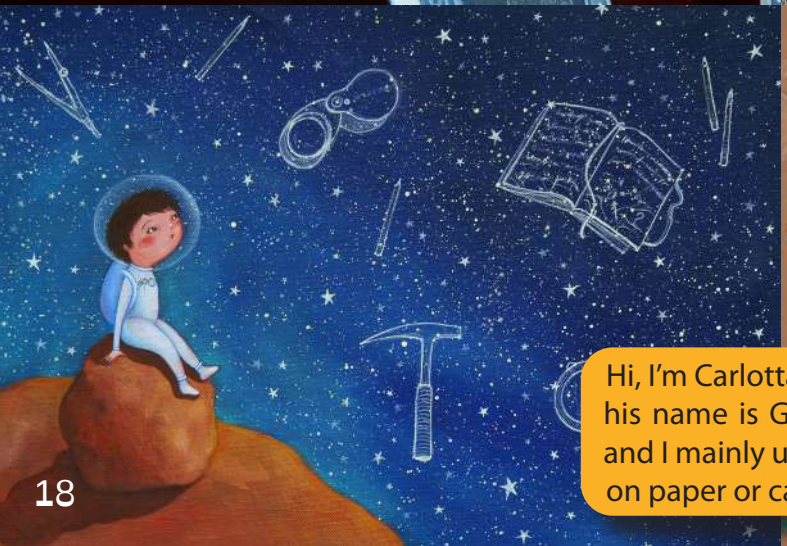
COMICS AND ILLUSTRATIONS DESCRIBE THE RESEARCH

A special dissemination of scientific research!

PLANMAP is a research project that has achieved many important results and it is very important that the results of the research projects and also everything that is done during that research is also told to those who do not work in science. For this reason researchers are always looking for a way to tell what they do to the public. This activity of telling what is done in research has a specific name: it is called "dissemination". And the dissemination of PLANMAP was… special! In fact, the PLANMAP research project was told to the public in three different ways!

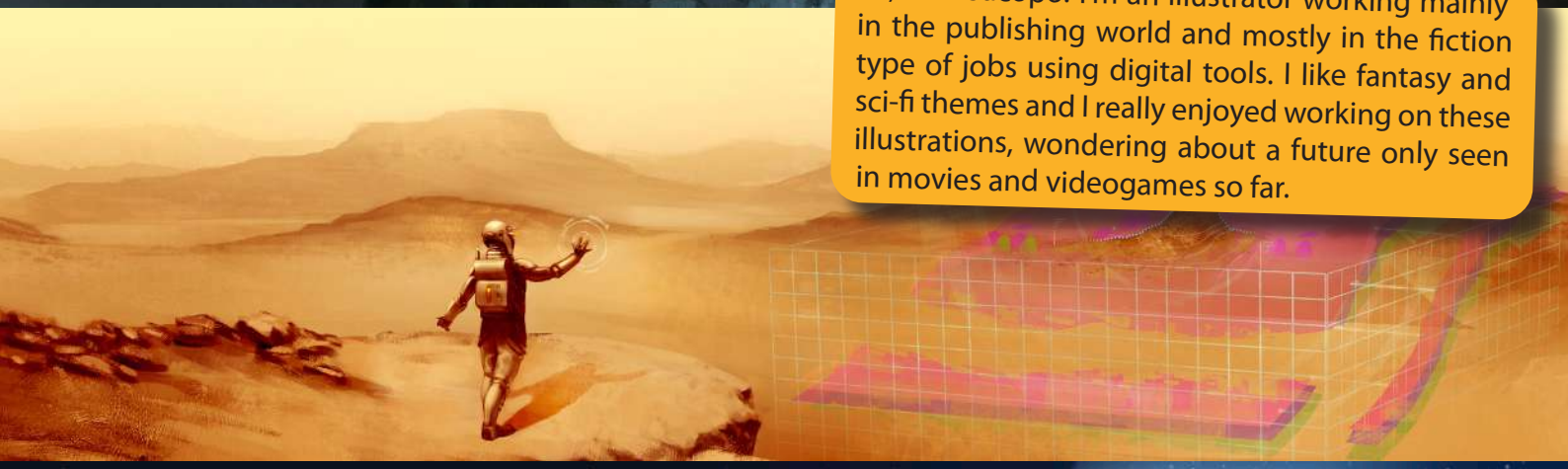
1) With a special comic adventure of Marie and Max by Bianca Maria Scotton
2) With illustrations for kids by Carlotta Montagna
3) With illustrations for boys, girls and adults in general by Jacopo Schiavo

You can read the comic strip on page 5, while you can see illustrations by Carlotta and Jacopo in these two pages.



Hi, I'm Carlotta and this is my geologist astronaut, his name is Geolino. I love traditional illustration and I mainly use acrylic, tempera and pencil colors on paper or canvas.

Hi, I am Jacopo! I'm an illustrator working mainly in the publishing world and mostly in the fiction type of jobs using digital tools. I like fantasy and sci-fi themes and I really enjoyed working on these illustrations, wondering about a future only seen in movies and videogames so far.



INTERVIEW to Gloria Tognon

By ***Martina Tardivo***
(editorial board)

"BEHIND THE SCENES" OF A SCIENTIFIC PROJECT

PLANMAP involves different fields of science and many countries, so working in this project is an incredible experience! We talked about it with Gloria Tognon, a geologist with a special passion for the Moon. She is currently finishing her PhD in Space sciences, technologies and measurements at the Center of Studies and Activities for Space "G. Colombo" in Padua. During her PhD she joined the PLANMAP project working on the production of geological maps, in particular for the Moon and Mercury.

Gloria, PLANMAP is a project characterized by the collaboration between different European institutions and research profiles. What did it mean for you?

For me it meant becoming part of an incredible team and knowing a lot of special people: I shared experiences and ideas with other PhD students and I became a colleague of planetary geologists that wrote articles that I studied during university. Each person contributes to the project by sharing his/her point of view and by approaching problems in different ways, based on their experience, and that is why we are a great team.

Gloria Tognon

What can you tell us about the cooperation between geologists and astronomers?

The interaction between scientists of different fields is at the basis of every great project. Astronomers and geologists, in particular, find common ground in the planetary sciences.
The combined experiences and efforts of astronomers and geologists allow us to reach bigger objectives than the ones we reach separately.

What happens "behind the scenes" of a project like PLANMAP?

The backstage work is really varied, but always focused on sharing and collaborating. For example, each month we organize an online meeting to discuss our results and plan the next steps. Another important aspect is to spread our knowledge and discoveries, a process called "dissemination". Each one of us is an active member of the scientific community and we always participate in scientific congresses on planetary sciences. Each institution is also involved in the organization of events for the general public and young people. In particular, in Padua we participate in the European Researchers' Night, where we introduce planetary geology to everyone and we show what we do in the PLANMAP project.

What is the most beautiful thing that you will remember about PLANMAP?

My best experience during the project was the Geology and Planetary Mapping Winter School organized by PLANMAP (February 2021): I had the opportunity to be an instructor during the Moon mapping practical activity. For me it was a fantastic experience and a pleasure to share my knowledge with students interested in learning the art of geologic mapping.

IN THE BACKGROUND: Image by Carlotta Montagna realized for the dissemination of PLANMPAP project (for more information see page 18).

SAILING THE SOLAR SYSTEM... WITH GEOLOGICAL MAPS!

by **Jack Wright**
(researcher at The Open University, UK)

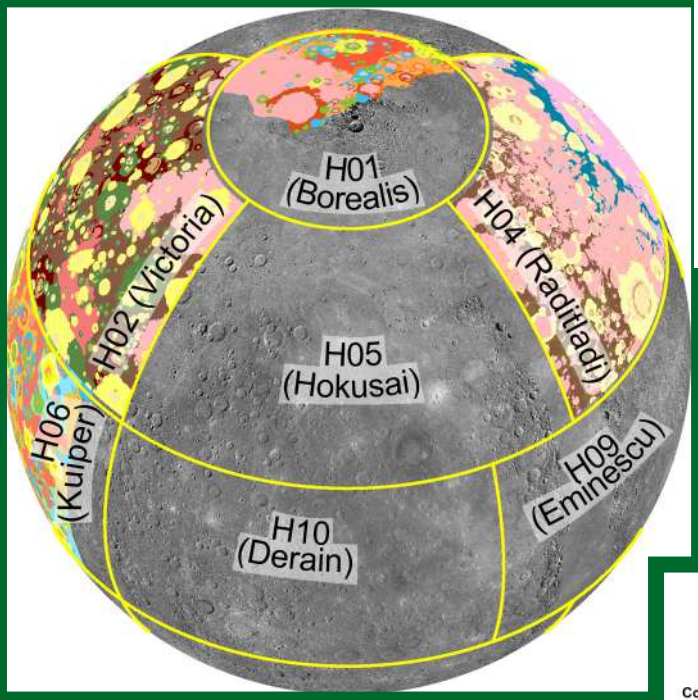
Imagine you are an explorer and that you have landed on an undiscovered continent. What is the first thing you do? Look for water? Look for food? Find a place to take shelter? What happens if you walk away from your ship and get lost?
When explorers travelled to distant parts of the Earth long ago, the most important tool they had was a map! Yes, "just" a map! With a map, they marked the locations of water, food, shelter, and their ship, so that they could later sail home to tell everybody about the new land.
Now we are living in the "space age", and there are a lot of planets waiting to be explored, which means... there are a lot of maps waiting to be made!

WHAT IS A PLANETARY GEOLOGICAL MAP?

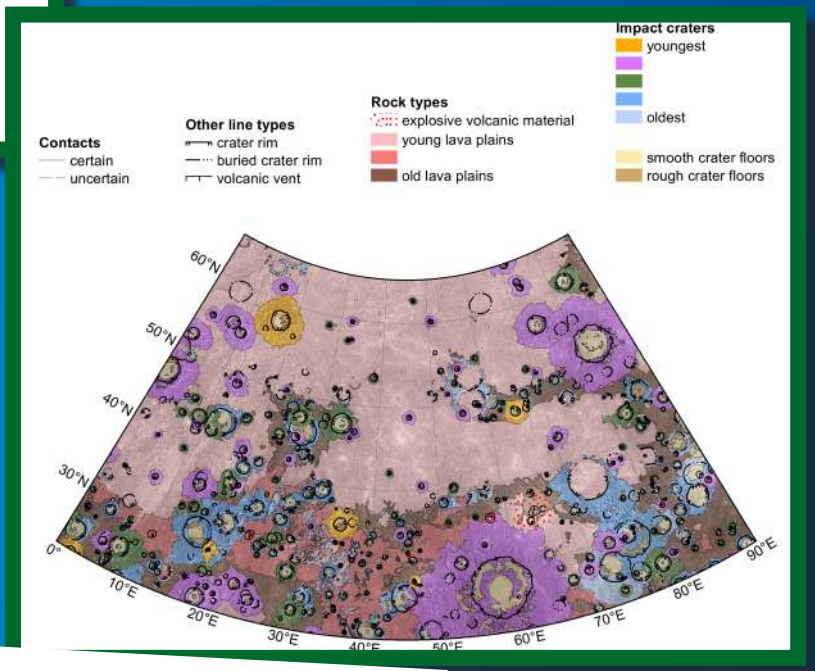
Geological maps show rock types. They are useful for finding valuable minerals (like gold!), understanding environmental hazards (like landslides), and for scientific investigations (like understanding how often a volcano erupted). Planetary geological maps are important for understanding how planets formed and changed over the history of our Solar System. For example, if we look at the planet Mercury, we find gigantic lava plains and colossal impact craters to put in its geological map! Don't worry explorers, Mercury's surface reveals a long history of volcanic eruptions and impacts, but things are much quieter there now.

HOW ARE PLANETARY GEOLOGICAL MAPS MADE?

Mercury has been visited only by robotic spacecrafts that took pictures as they flew over the planet's surface. Geologists mapping Mercury are like the crew of a ship sketching a new continent from what they can see through a telescope. They can map a large area, but they will need to wait until the ship lands (a rocket ship, in Mercury's case) to be able to add small details, like where the gold is! Geologists load spacecraft images into computer software that allows them to draw lines on the images marking the boundaries between different rock types, called "contacts", and other geological characteristics, like impact craters and faults. Lines are given symbols and the rock types are given colours to make the map. These planetary geological maps are useful for deciding where a future mission can land!



Mercury's geological maps. The Hokusai area is missing! PLANMAP scientist Jack Wright made this missing map and others are working on the remaining areas.



New geological map of a part of Mercury. Eventually, the whole planet will be mapped so that scientists can understand where to find each rock type on Mercury. For example, the light pink colour represents smooth lava plains, which are similar in volume to the eruptions on Earth 65 million years ago when the dinosaurs went extinct! This whole area is about the same size as the European Union!

Credits: H02 (Victoria) map: credits to Valentina Galluzzi (Galluzzi, V., Guzzetta, L., Ferranti, L., Di Achille, G., Rothery, D. A., & Palumbo, P. (2016). *Geology of the Victoria quadrangle (H02), Mercury*. Journal of Maps, 12(sup1), 227-238.). **H04 (Raditladi):** credits to Paolo Mancinelli (Mancinelli, P., Minelli, F., Pauselli, C., & Federico, C. (2016). *Geology of the Raditladi quadrangle, Mercury (H04)*. Journal of Maps, 12(sup1), 190-202.). **H06 (Kuiper):** credits to De Hon, R. A., Scott, D. H., & Underwood Jr, J. R. (1981). *Geologic map of the Kuiper (H-6) quadrangle of Mercury*. United States Geological Survey, Geologic Investigations Series, Map I-1233. **H01 (Borealis) map:** credits to Grolier, M. J., & Boyce, J. M. (1984). *Geologic map of the Borealis region (H-1) of Mercury*. USGS Misc. Investig. Ser. Map I–1660.

This is a special issue aimed at communicating the scientific contents and results of the PLANetary MAPping (PLANMAP) European project to children.
The project coordinator is professor Matteo Massironi (Department of Geosciences, University of Padova).
Deputy Principal Investigator: Angelo Pio Rossi, Jacobs University (Bremen).

PLaNCK! is a bilingual scientific magazine for children edited by Accatagliato, an organization aimed at communicating science to the public that was involved in the dissemination activities of the PLANMAP project.

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www.planmap.eu
www.planck-magazine.it
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PLANMAP
Geologic Mapping of our Solar System

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