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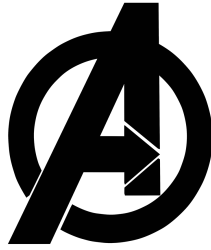
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ATTN: Agents in training
RE: EXOPLANET

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Form a team of scientists to investigate the provided data on the exoplanet. You are to analyze the atmosphere of the planet, the core of the planet, and the planetary system that it resides in. We need to know if this planet can harbor life. Once you have completed your mission, you are to present your findings to your teacher, who is an undercover Agent of Avengers with level 5 classified clearance. Your teacher will then relay the information directly to Avengers. Good luck. The world is depending on you.

CONFIDENTIAL

**SPECTRAL ANALYSIS OF STAR
AND EXOPLANET ATMOSPHERE****MISSION OVERVIEW_**

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MISSION BRIEF_

Light can tell us a great deal about the composition of even distant stars and planets. This is because elements and molecules absorb very specific frequencies of light. Use the data tables and spectrographs provided to fill out the report and enter your results into the Avengers database. This is a level 3 classified mission. Good luck.

EARTH SCIENCE

SPECTRAL ANALYSIS OF STAR
AND EXOPLANET ATMOSPHERE

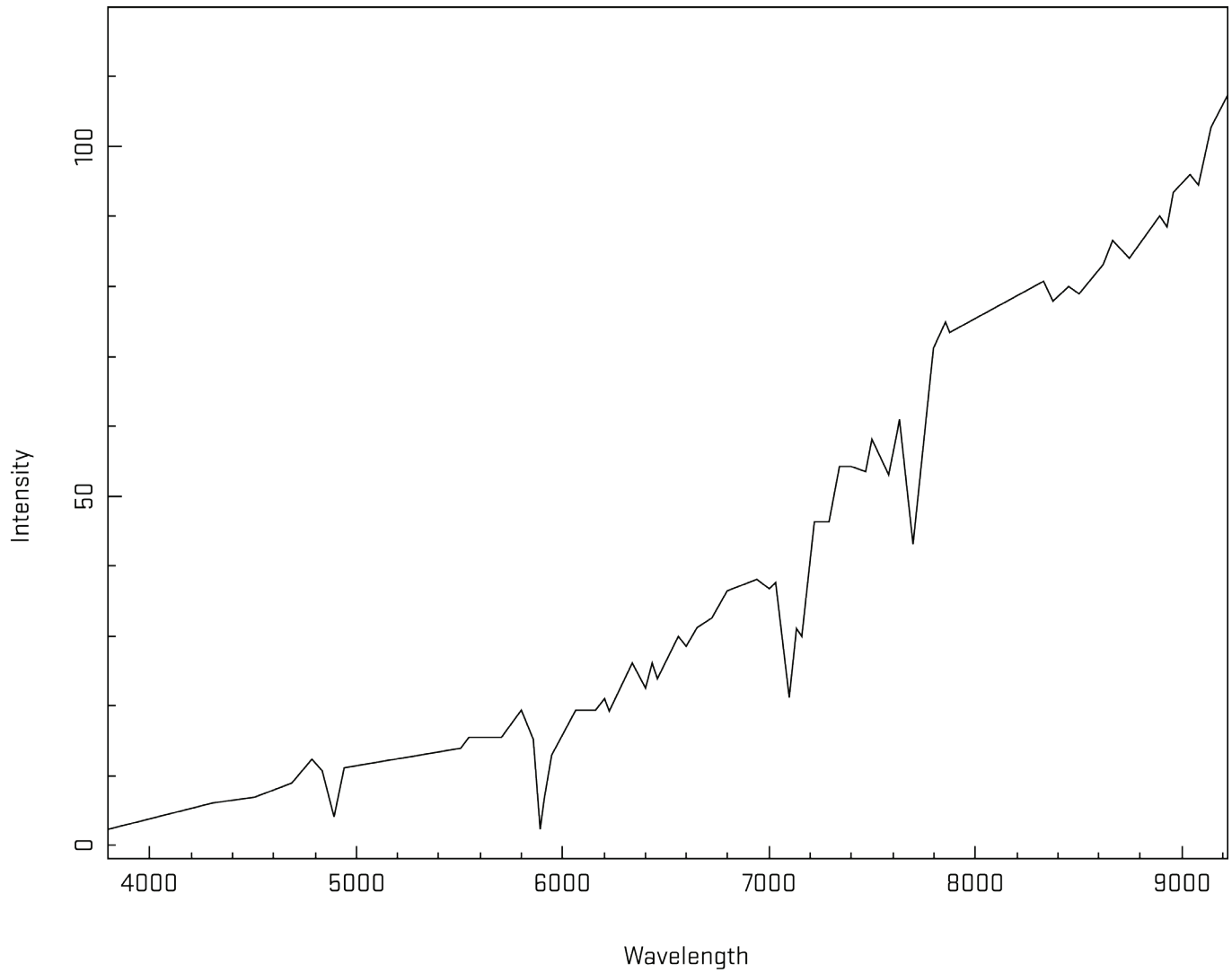
Table of Star Classifications

CLASSIFICATION	TEMPERATURE	MAX WAVELENGTH	COLOR	SPECTRAL LINES
O0	40,000k	72.5 nm	Blue	Ionized Helium
B0	20,000k	145 nm	Light Blue	Helium, some hydrogen
A0	10,000k	290 nm	White	Strong hydrogen, some ionized calcium
F0	7,500k	387 nm	Yellow-White	Hydrogen, calcium, iron
G0	5,500k	527 nm	Yellow	Many metals, especially calcium
K0	4,000k	725 nm	Orange	Many metals, sodium
M0	3,000k	966 nm	Red	Very strong sodium, strong titanium oxide

Table of Wavelength Absorption for Elements and Molecules

SPECTRAL LINES	WAVELENGTH (ANGSTROMS)
Hydrogen	6563
Ionized Calcium	3970, 3930, 8490, 8540, 8660
Nitrogen (N2O)	7900
Oxygen (O2)	7500
Argon	4800, 5145
Sodium	5890
Helium	4200
Titanium Oxide	Many lines. Most notably 4900, 7100, 7700
Carbon Dioxide	4300, 14000
H2O (water)	6300
Methane	3300, 7700

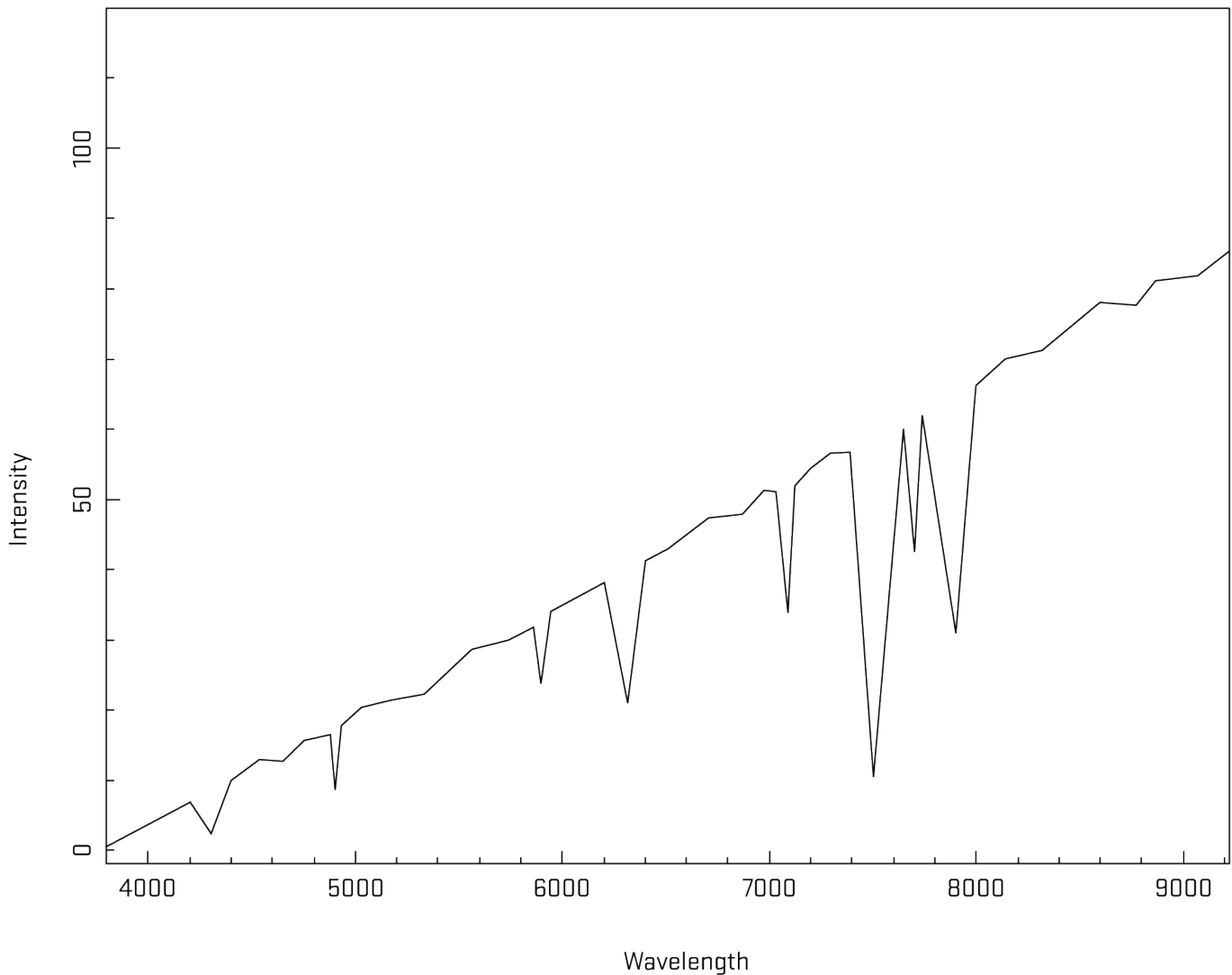
[SPECTROGRAPH OF STAR]



As photons from the star center pass through the outer layers of the star, some of the light is absorbed. By looking at the wavelength of those absorptions, we can identify the elements present in the star and thus, the star type.

NOTE: A dip in intensity indicates absorption of that wavelength.

[ATMOSPHERE SPECTROGRAPH OF EXOPLANET]



As the light from the solar system's star passes through the exoplanet's atmosphere, more of it is absorbed. This creates a new absorption spectrum which helps us identify the elements and molecules present in that atmosphere. We are assuming that the aliens' lungs are similar to our own, and therefore are looking for a planet with an atmosphere similar to our own.

NOTE: A dip in intensity indicates absorption of that wavelength.



Avengers Report:

Re: Spectral Analysis of Star and Exoplanet Atmosphere

Star Analysis:

(Reference spectrograph of star.)

1. What is the approximate peak continuum wavelength (max wavelength) of the star?
2. Where are the absorption lines, and which elements do they correspond to?
3. What type of star is it? What is its approximate temperature?
4. Based on your classification of the star, will a habitable planet in the alien planetary system need to be closer or farther away than a planet in our solar system?

Atmospheric Analysis of Exoplanet:

(Reference spectrograph of atmosphere.)

1. Based on the spectrograph and wavelength markers for certain elements/molecules what elements are present in the atmosphere?
2. What molecules are present in the atmosphere that are similar to our own?
3. Are there absorption lines in the spectrograph that you suspect are not from elements or molecules in the atmosphere?
4. Write a brief assessment of whether or not the alien atmosphere could support humanoid life. In your analysis include any unknowns that would require further research.

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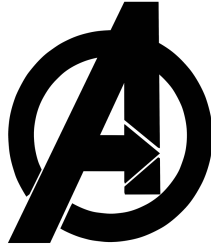
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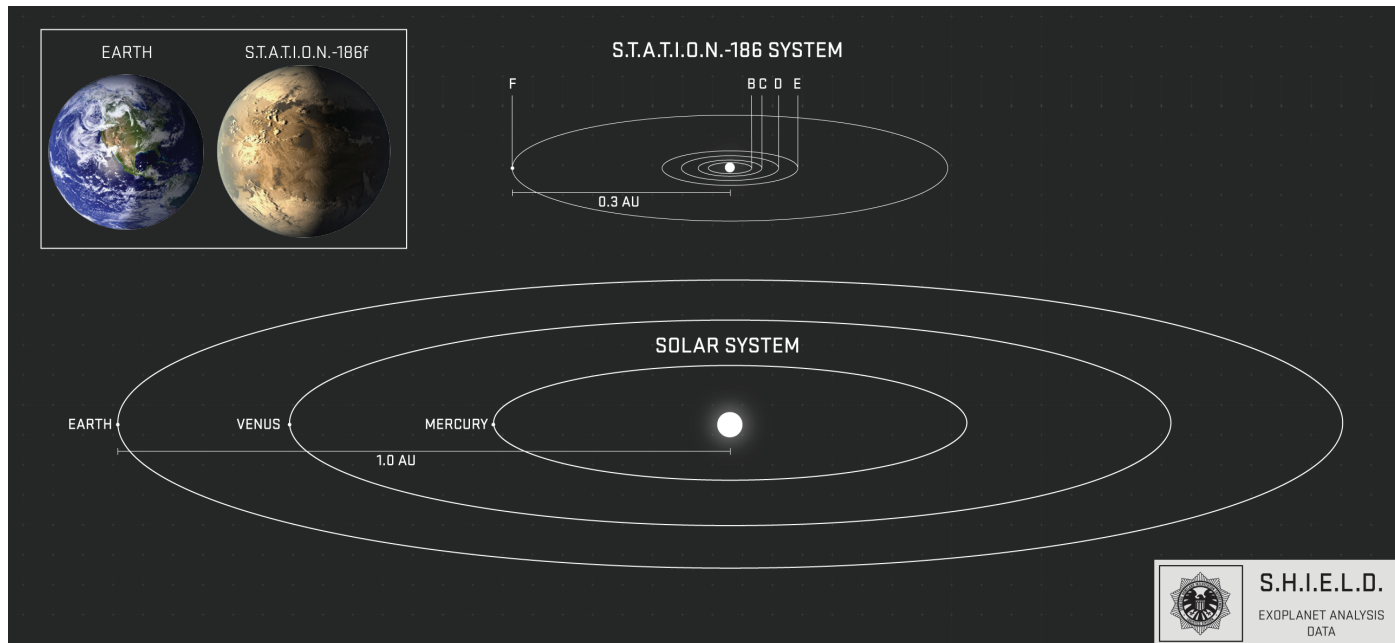
MISSION OVERVIEW_

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MISSION BRIEF_

Potential Agents, we have located a planetary solar system for you to analyze. The structure of the solar system is an integral part for determining if the planets in it are habitable or not. The solar system's star, S.T.A.T.I.O.N.-186, is orbited by a few planets, but of special interest is planet S.T.A.T.I.O.N.-186f. You are to analyze the provided data scans, and use your knowledge of our own solar system to classify this planet. The size of the star, the orbit of the planets, as well as the distance the planets are to the star will play a key role in your analysis. We need to know if it is in the "habitable zone" around its star and may harbor life. This is a level 3 classified mission. Good luck.

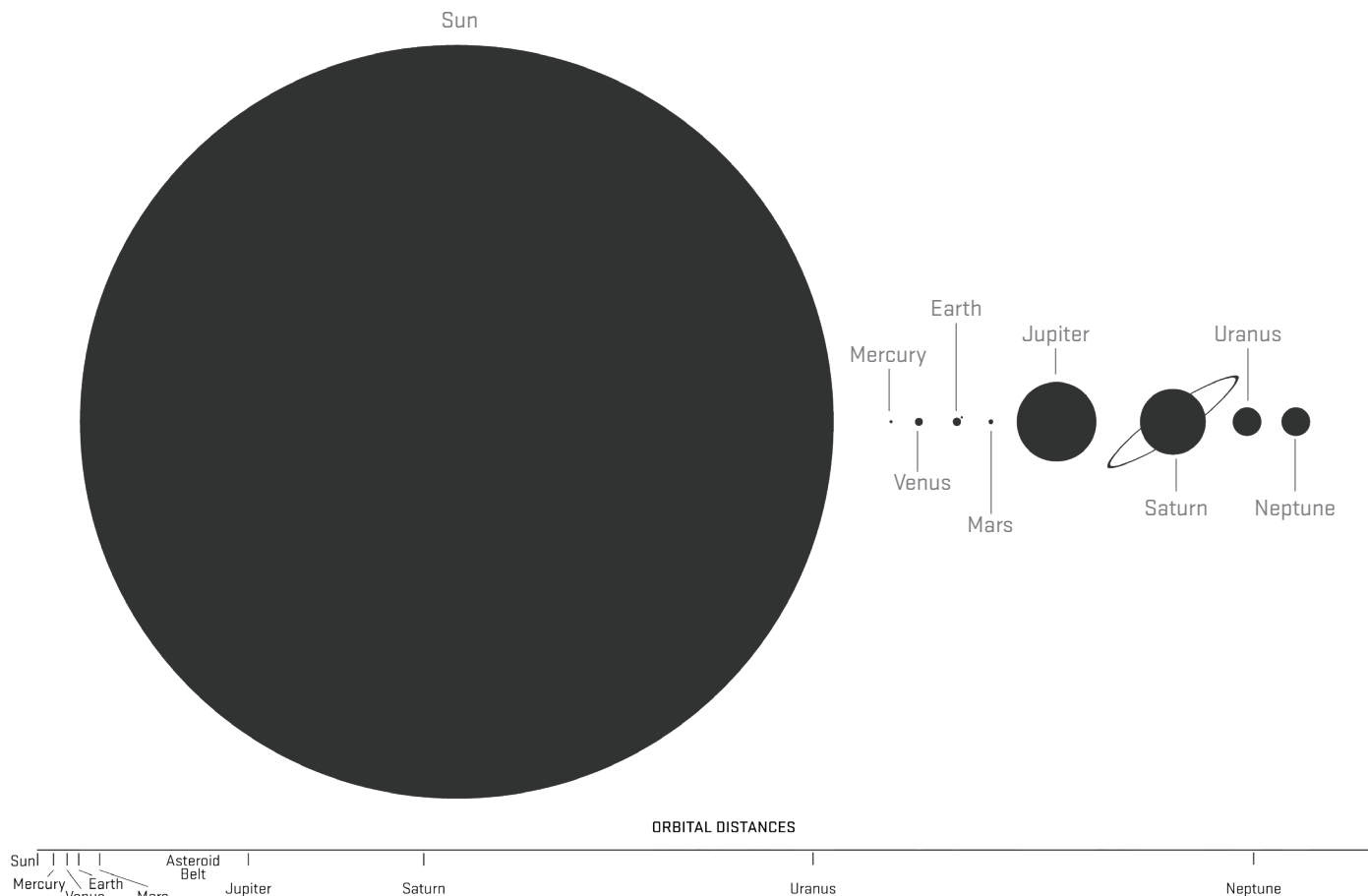
[SYSTEM COMPARISON]

**S.T.A.T.I.O.N. - 186f Analysis**

- **Parent Star:** S.T.A.T.I.O.N.-186, (Red Dwarf, 0.47 solar masses)
- **Distance from Parent Star:** 0.3 AU
- **Primary Composition of Surface:**
 - Granite
 - Silicate
 - Carbon
- **Orbital Period:** (P) 130 Earth days
- **Mass:** (m) 1.17 Earth mass
- **Radius:** (r) 1.11 Earth radius
- **Galaxy:** Resides in Milky Way galaxy, 500 light years from Earth

PLANETARY SYSTEM ANALYSIS

[OUR SOLAR SYSTEM]

**Sun**

- ▶ Star Type: Yellow Star, Type G
- ▶ ~4.5 billion years old
- ▶ Has approximately 5 billion years left in its life until it will become a red giant, expel its outer layers, and become a white dwarf.
- ▶ Second generation star. The previous star before our own sun went through a massive Super Nova at the end of its life, and sprinkled heavier elements into our now solar system. These would eventually become the building blocks for everything we see today.

Earth

- ▶ Planet Type: Terrestrial (rocky)
- ▶ In the habitable zone, 1 AU from the sun. (AU stands for astronomical unit, and it is the distance from the earth to the sun, or 93 million miles).
- ▶ Can support liquid water. If the planet was closer to the sun, it would be too hot for liquid water to exist. If the planet was farther away, it would be too cold for liquid water to exist. This is called the Goldilocks range (the perfect distance from a star for a planet to support liquid water, and life).
- ▶ Has an atmosphere.
- ▶ Has a magnetic field due to a rotating molten iron core at the center of the planet. Because of this, the Earth is protected from the strong solar winds (radiation from the Sun).
- ▶ Can support life.

Venus

- ▶ Planet Type: Terrestrial (rocky)
- ▶ Has no magnetic field
- ▶ 4 billion years ago Venus had water on its surface, however due to a runaway greenhouse effect, all water evaporated.
- ▶ Atmosphere primarily composed of Carbon Dioxide. Because of this, much of the heat from the sun cannot escape through the thick clouds, and is trapped on the planet. The surface temperature of Venus is over 450 degrees Celsius.
- ▶ Cannot support life.

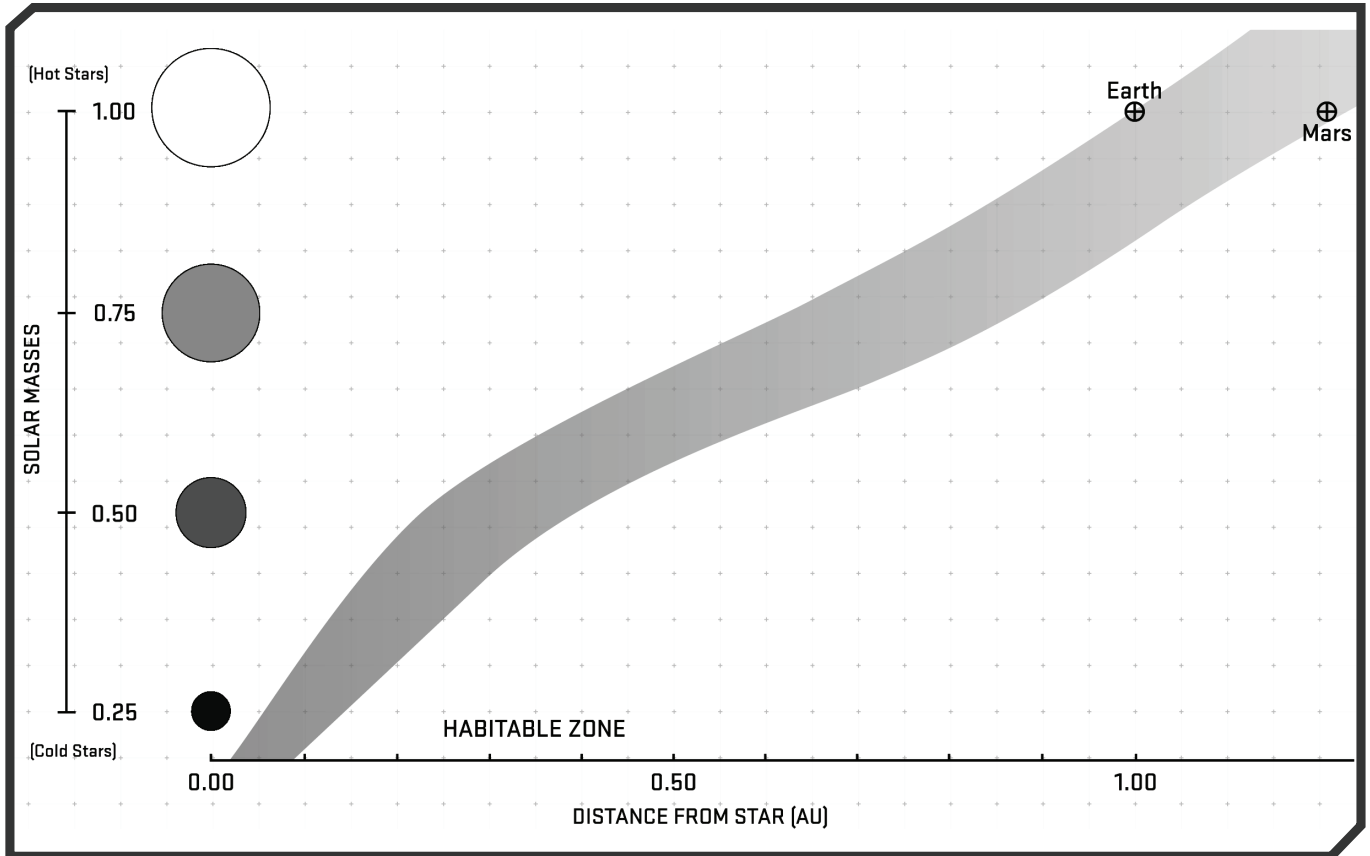
Mars

- ▶ Planet Type: Terrestrial (rocky)
- ▶ The atmosphere of Mars is less than 1% than that of Earth. As a result, it does not protect the planet from the Sun's radiation, nor does it retain any heat on the surface.
- ▶ Solid iron core, not rotating. As a result, there is no strong magnetic field on Mars like there is on Earth. Data from Mars Global Surveyor show that some of the oldest rocks of Mars formed in the presence of a strong magnetic field. Thus, in the distant past, Mars may have had a hotter interior and a molten core.
- ▶ Cannot support life

Jupiter

- ▶ Planet Type: Gas giant
- ▶ Primarily composed of Hydrogen and Helium
- ▶ Protector of Earth- Jupiter's strong gravitational pull attracts large asteroids and pulls them into the planet. This prevents them from potentially hitting Earth.
- ▶ Cannot support life.

[GOLDILOCKS ZONE]



The Goldilocks Zone (Habitable Zone) is determined by two factors, the size/type of sun the planet is orbiting, and how far away from the star the planet is. If the planet is in this Goldilocks Zone, it can support liquid water, which we believe is required for life to exist.



Avengers Report:
Re: Planetary System Analysis

1. How many planets orbit the star in the system? What type of planet is S.T.A.T.I.O.N. - 186f?
2. Based on the size of the star, how far away (in AU) does the Goldilocks Zone extend?
3. Is S.T.A.T.I.O.N.-186f in the Goldilocks Zone? If so, approximately how far? (use AU as the unit of distance, this is 1 astronomical unit or the distance of the earth to our own sun, 93 million miles).
4. What are the advantages for a planet residing in the Goldilocks Zone?
5. Other than residing in the Goldilocks Zone, in order for this planet to support life, what properties should it have (list at least 3)? Use the data of our own solar system to help.

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AVENGERS STATION

SCIENTIFIC TRAINING AND TACTICAL INTELLIGENCE OPERATIVE NETWORK

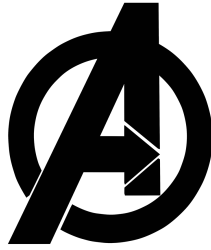
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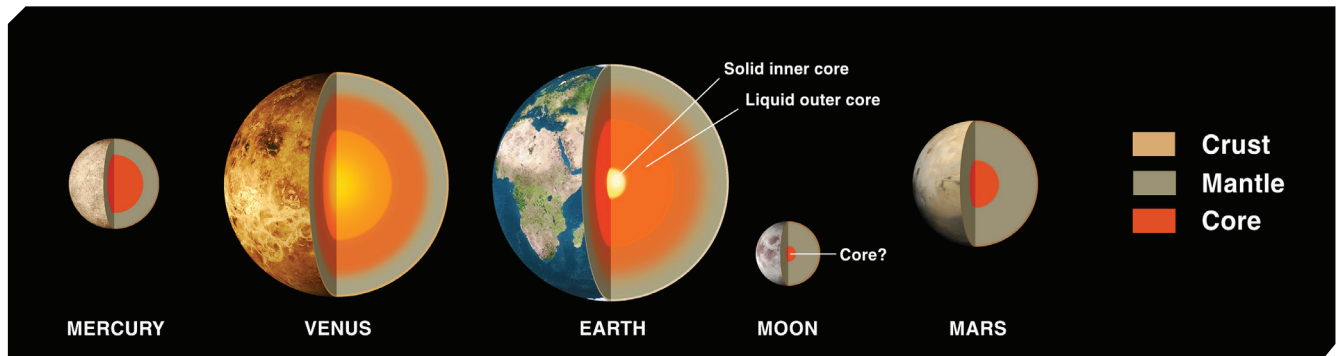
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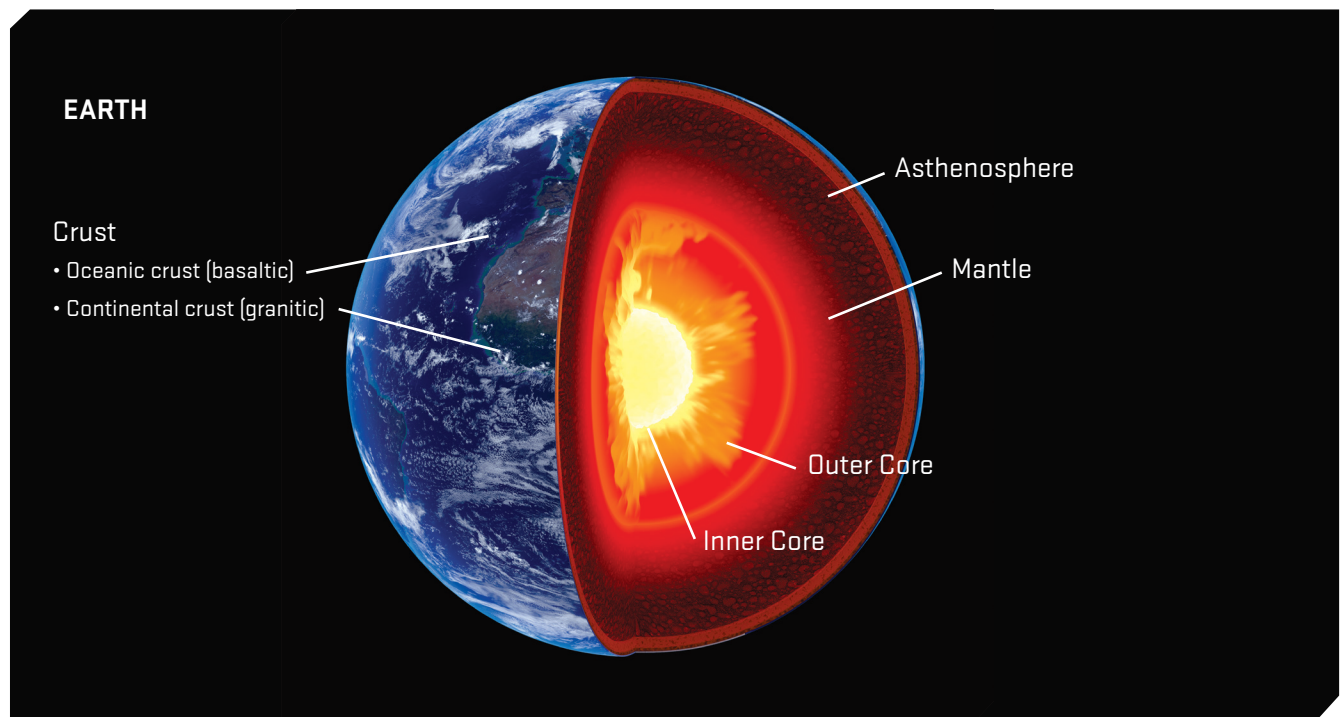
MISSION BRIEF_

A planet's core is vital in determining whether or not it is habitable in ways that are observable from space. What elements the planetary core is composed of and evidence that it is currently active will be important to analyze. We've provided information on what we know of planetary cores, images of an aurora occurring on S.T.A.T.I.O.N.-186f, and some eye-opening photos of its surface. If we can discern more about the properties of this potential planet's core, it may lead to a ground-breaking discovery. When you complete your task, input the findings into the Avengers search engine to determine if it is habitable. This is a level 3 classified mission. Good luck.

[PLANETARY AND EARTH LAYERS]



As seen here, most planets have three main layers, including the core, mantle, and the crust.



Here, we see the specific layers of the Earth. It is important to think of the layers as an inside-out system where the inner core has an effect on the outer core and together, they affect the stiffer mantle and so on.

Earth Core Data Analysis:

- Core composition: Primarily Iron (85%), with Nickel (5%), Silicone, Hydrogen, and Carbon.
- Active planetary core causes tectonic activity on the surface

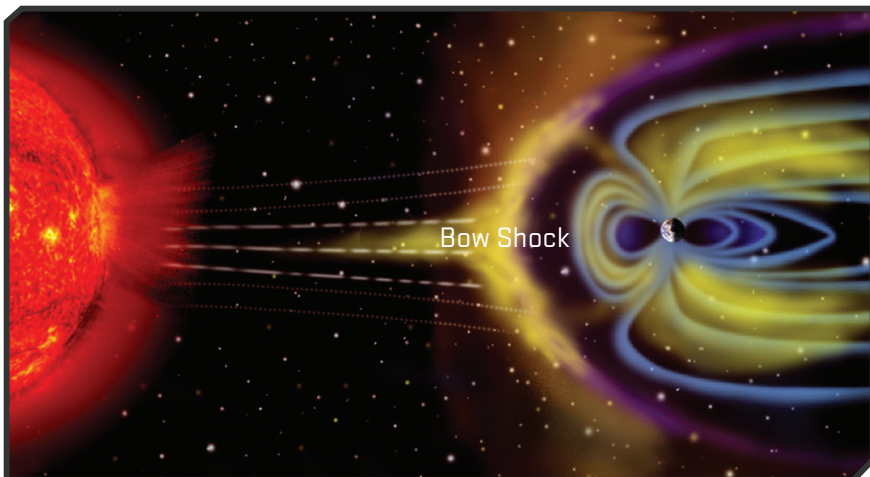
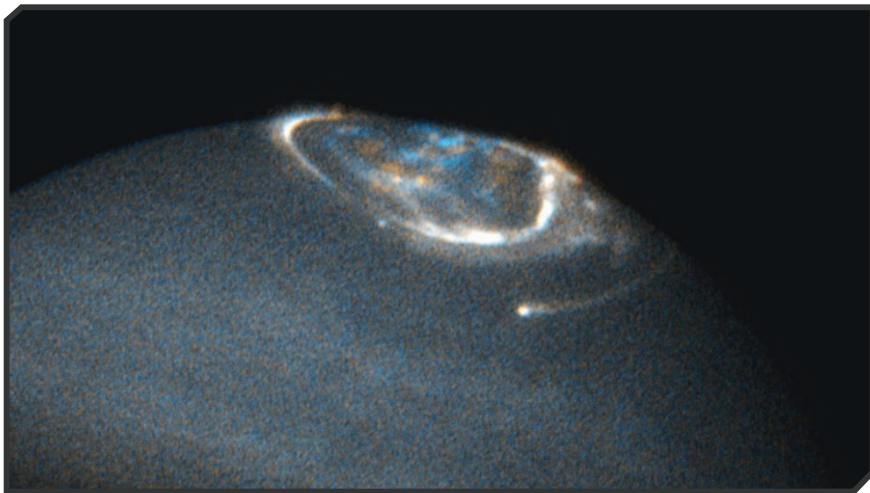
PLANETARY CORE ANALYSIS

Thanks to our deep-space satellite, we've been able to photograph images of S.T.A.T.I.O.N.-186f's pole. That swirl of light is what appears to be aurora, also known as the northern/southern lights for the phenomenon that occurs here on Earth. Aurorae also exist on uninhabitable planets such as Jupiter.

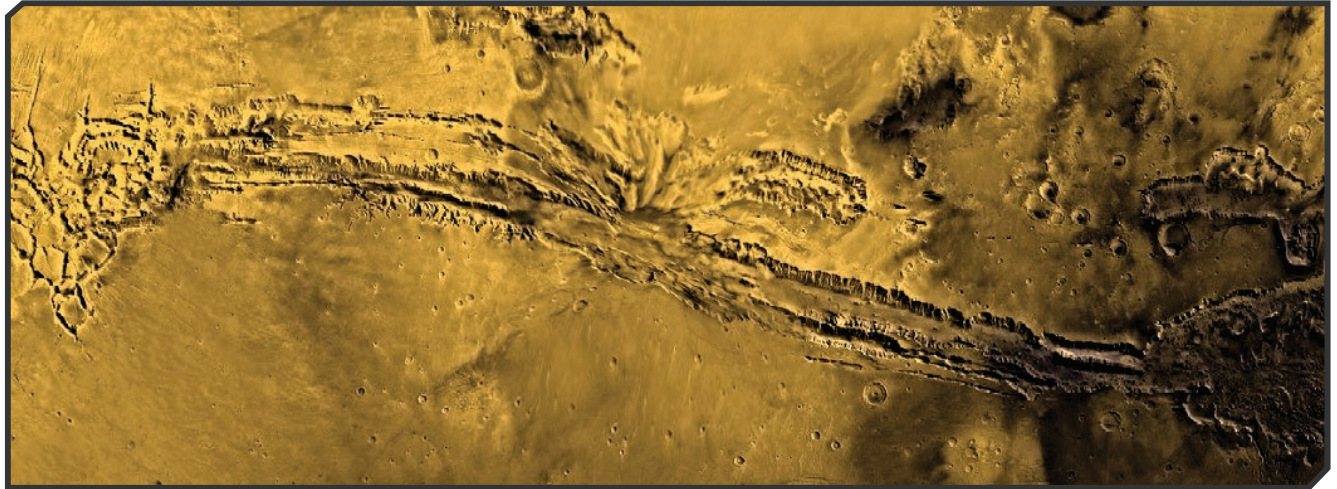
This picture shows what an aurora looks like here on Earth. Other than being extremely beautiful to observe, it tells us a great deal about the planet's core. For example, the Earth's inner core (solid) and outer core (liquid) are composed primarily out of metallic iron and nickel, which generates the Earth's magnetic field. This magnetic field expands to the upper atmosphere and protects us from dangerous accelerated charge particles that emit from the sun called solar winds.

As seen here, because of the Earth's active rotating iron core, the magnetic field generated is much larger than its size. The bow shock is the area where the magnetic field comes in contact with the solar winds, warding off most (but not all) of the dangerously accelerated particles.

[AURORAE AND MAGNETIC FIELDS]



[PRESENCE OF RIFTS AND MOUNTAINS ON PLANETARY SURFACE]



We were able to take a snapshot of S.T.A.T.I.O.N.-186f's surface, revealing interesting patterns on the terrain. The land appears to have diverged (pulled apart), creating a small series of rifts along the surface. There also appear to be small mountain ranges where the land may have converged (come together). Here is the image we captured of the rifts. We have been able to determine that this rift was caused about two years ago.



Here is an image of a rift here on Earth. However, while Earth has many of these rifts and mountains, the planet under investigation has considerably less.



Avengers Report:
Re: Planetary Core Analysis

1. What does the presence of an aurora on S.T.A.T.I.O.N. - 186f tell us about its planetary core?
 - a. What possible group of elements is it composed of (refer to the periodic chart to know what is considered a "category"):
2. What does tectonic activity on S.T.A.T.I.O.N. - 186f tell us about its planetary core?
3. Have your findings made it more or less likely that S.T.A.T.I.O.N.-186f is habitable? Why?