Sung Soo (Anthony) Cho
Dr. Stephen Mackwell
Pluto Ice Formations
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DISTINCT FEATURES ON PLUTO'S TOMBAUGH REGIO

Sung Soo (Anthony) Cho, Dr. Stephen Mackwell

Clear Lake High School, Lunar and Planetary Institute

ABSTRACT

Pluto's distinct ice features in the Tombaugh Regio are derived from the chemical and physical properties of its composition as well as the thermal variations that are a result of its orbital mechanics, position on the planet, and atmospheric composition. The observations and assertions made are based on the graphical models and data collected by NASA's New Horizon Mission.

I. INTRODUCTION

A dwarf planet discovered by Claude Tombaugh in 1930, Pluto shows great variability in topography and unique characteristics not seen from the eight inner planets. Pluto was explored by NASA's New Horizon Mission in 2015. Pluto is the last body in the solar system to be explored with robotic applications. Pluto has a highly elliptical orbit that can bring it within the orbit of Neptune. Pluto has five moons, the largest of which is Charon. Pluto is tidally locked with Charon, the largest moon in the solar system relative to its diameter and orbiting planet. Also interesting to note is the fact that Pluto is 70% of Earth's moon, but only 17% of its shape relative to diameter. The atmosphere of Pluto is considerably extended due to its own weak gravitational forces.

II. PROPERTIES OF COMPOSITION

Variability within and on the borders of the Tombaugh Regio are a result of the variability in the physical and chemical properties of the various ices. Nitrogen has a much lower melting point than any of the other ices in the region meaning that it will be the first to sublimate. Nitrogen as an ice also exhibits viscous movements similar to glacial movements on Earth. The temperature fluctuations and natural gravitational movements of nitrogen have invariably led to highlighted features. One such highlighted feature is the Ice Mountains that line the borders of the Tombaugh Regio. These Ice Mountains are water ices, which compose approximately a third of Pluto, that have pushed through the soft and viscous layers of nitrogen ice throughout the process of sublimation. Also notable are the topographical features in the icy plains that

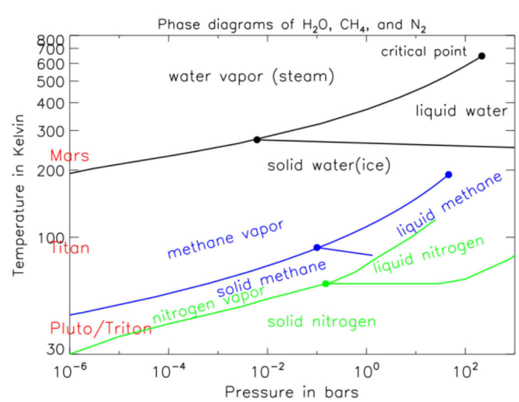

Figure 1: Phase Diagrams for Tombaugh Regio and Sputnik Planum

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show the icy flow of nitrogen ice similar to patterns seen on Earth from glaciers moving along ravines.

Partly due to Nitrogen's susceptibly to sublimation, the atmosphere of Pluto is primarily composed of nitrogen gas and the Tombaugh Regio as a result is primarily composed of nitrogen ices. The atmosphere of Pluto also has smaller components of carbon monoxide and methane. These gases stay in lower altitude. These compounds are also found in the ices of the Tombaugh Regio in greater spread than one would expect from the low atmospheric percentages. This can be explained by sublimation winds and pressure gradients that spread these components which have less total mass than the nitrogen ice.

III. THERMAL VARIATIONS

The Tombaugh Regio shows smooth plains of ice composed of nitrogen, methane, and carbon monoxide. Flat regions indicate young topography as it shows that the topography has not existed long enough to be significantly impacted by external forces such as asteroids or meteorites. The ice here is also noticeably thick based on the fact that the plains show few signs of the ravines typical to shallow ice formations.

There are two primary causes of the location of the ice plains in this region. First, the Tombaugh Regio is located on the farthest side from Charon. Charon is Pluto's largest moon and one that Pluto is tidally locked with. This leads to the assertion of higher gravitational forces in the Tombaugh Regio as there is greater mass of attraction from both Pluto and Charon as we understand from the equation Fg=[G(m1 x m2)]/r^2. Higher gravitational forces mean larger particulates, such as ice, would precipitate largely in this region. In addition, the tidal locking means that the Tombaugh Regio will never be fully impacted by the reflection of photons from Charon meaning that this region is on average colder than the other side of Pluto. The region being colder also means that there will be attraction of humidity and thus higher rates of condensation. The Sputnik Planum, as well as the general area of the Tombaugh Regio, can thus be concluded to be the coldest region of Pluto.

Pluto's highly elliptical orbit also indicates that at the perihelion, Pluto will have far warmer temperatures due to its close proximity to the sun. As Pluto has relatively recently come out of its perihelion we can expect that the ice region of Pluto is actually considerably thinner and smaller in radius than is typical due to sublimation. We can see evidence of this in the surrounding craters that hold small ice reservoirs from retreating masses of ice.

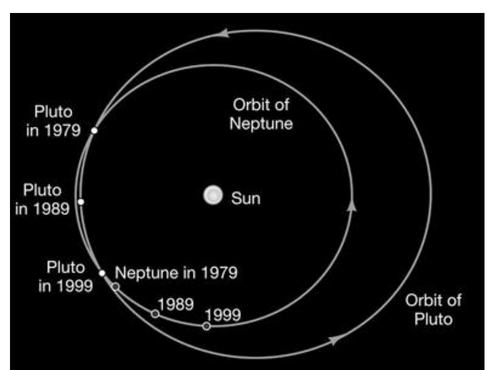

Figure 2: Orbital path of Pluto from an overhead perspective (Clark, 1)

Carbon monoxide and methane gases allow photons to pass but also reflect photons back to the surface, invariably increasing temperatures. The Greenhouse Effect and atmosphere loss is efficiently countered by the presence of hydrogen cyanide in the atmosphere which reduces escape rates of Pluto's atmosphere by releasing heat, effectively cooling the atmosphere. Thus, the thermal variability by atmospheric composition is reduced but still has an effect on sublimation as slight changes in temperature with such low pressures result in large changes in vaporization.

Thermal variations are also present within the surface of Pluto. Convergence of convection currents can lead to the creation of formations that look similar to lava flow. In addition, due to impurities in the surface composition of the ices on the Tombaugh Regio, the possibility of eutectics arises, effectively leading to more phase changes sensitive to temperature fluctuations caused by variation in depth.

Due to the nature of Pluto as a celestial body with extremely low temperatures, there are physics of even water ice that we have not seen before on such a large scale. All theories on the effects of thermal variation must take into account that there may be several unforeseen variables.

IV. CONCLUSION

Initial graphical analysis and knowledge on Pluto's composition in conjunction with calculations from orbital mechanics, triangulation, and occultation can lead to the hypothesis of causes of the distinctive features of Pluto's Tombaugh Regio: Pluto's distinct ice features in the Tombaugh Regio are derived from the chemical and physical properties of its composition as well as the thermal variations that are a result of its orbital mechanics, position on the planet, and atmospheric composition.

It is important to note that there is much more data that has still not been recovered from the New Horizons Mission that may reveal the existence of several other unaccounted variables. The assumptions made in this research are made with understanding of existing data and understanding of the physics of Pluto. Furthermore, these assumptions do not necessarily pertain to formations and topography outside of the Tombaugh Regio.

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