THE GRAVITY POTENTIAL ALONG PALEO-SHORELINES: IMPLICATIONS FOR THE GEOLOGICAL HISTORY OF MARS. C. Sotin¹ and F. Couturier¹, ¹University of Nantes (Faculté des Sciences, 2 rue de la Houssinière, 44322 Nantes, France)

Introduction: The existence of an ocean in the northern hemisphere of Mars is a controversial question that has profound implications for the understanding of the history of water on Mars. Previous studies have suggested the presence of paleoshorelines [1,2]. In this paper, we do not want to discuss the observations that lead authors to propose the shorelines, but we describe the gravity potential along these proposed shorelines. At the time they formed, these shorelines were equipotential lines at the surface of Mars. Present time Earth’s shorelines are defined as the intercept of topography with sea surface which is an equipotential surface. Shorelines are equipotential lines and paleo-shorelines should be paleo-equipotential lines. If the potential of the planet has not changed since shorelines existed, then along a suggested shoreline, gravity potential should be the same. Because Mars does not seem do have undergone major geodynamic changes since the Hesperian period, the gravity potential is supposed to not have varied much.

Potential along the Deuterolinus shoreline: The Deuterolinus shoreline is located in the northern hemisphere. The calculation of the potential is made by using the shape of the planet given by MOLA data (R(λ,φ)) and the potential given by Yuan et al. (2002) up to degree 60 [3], which includes observations made by Viking and Mariner in addition to those of MGS. The result is presented in Figure 1 where the potential is presented versus the longitude of a given point along the Deuterolinus shoreline.

The first observation is that the potential is not constant. It shows variations up to 3000 m²s⁻², which can translate into topography of roughly 1 km. But, one obvious feature of these variations is that they look periodic with a period of 180°. If one removes this long wavelength variation, then the variations are reduced by a factor 6.

Significance of the long wavelength variation: If one keeps only the degree 2 variations of the gravity field, one finds that Mars’ equator is an ellipsoid whose long axis is located at 75°E. This longitude is that where the potential is minimum along the Deuterolinus shoreline. Since the shape of the equator is related to the formation of Tharsis [3], one explanation would be that the shoreline existed before the formation of the Tharsis bulge. It would mean that most of the water would be released in the atmosphere before the formation of Tharsis. Then the water would have disappeared leaving an equipotential surface that is deformed when Tharsis formed. This possibility would be consistent with the idea that Mars experienced two episodes of water content on its surface: a first episode during which water was very abundant and phyllosilicates formed and a second period during which volcanism would have brought in the atmosphere a few amount of water and large amount of acidic species that would allow the formation of sulfates.

Figure 1: potential along the Deuterolinus shoreline.

Figure 2: Depth of the ocean at the time the Deuterolinus shoreline formed…if this shoreline ever existed.
**Depth of the ocean:** Once the value of the equipotential is known, one can calculate the radius of this equipotential and compare with the shape of the planet. The difference between the two surfaces gives the depth of the ocean (Fig. 2). The postdating effect of the Tharsis bulge has been taken into account in order to calculate the surface of the ocean.

The maximum depth is on the order of 1.5 km and the total volume of the ocean is around 11.9 Mkm$^3$. However, these numbers don’t take into account the isostatic rebound that occurred after the water disappeared. The depth of the ocean was equal to the present measured depth time the ratio of the crustal density by the difference between the crustal density and the water density, a value around 1.5 although the crustal density is not well constrained. This correction provides a total volume of about 18 Mkm$^3$.

The total mass of the ocean would have been about $3 \times 10^5$ the mass of Mars. This number can be compared with the mass of water on Earth which is about one order of magnitude larger.

**Discussion and conclusions:** The existence of a paleoshoreline on Mars is still debated. The present study suggests that the Deuterolinus shoreline is close to an equipotential that has been deformed by the formation of Tharsis. It geological studies confirm that the lineaments described by previous authors [1,2] are shorelines, it puts constrains on the relative dating of some of the major events undergone by Mars: (i) outgassing with water precipitation, (ii) disappearance of liquid water from the martian surface (dynamo stopped), (iii) formation of Tharsis and deformation of the planet. It also provides values of the amount of water that came from either outgassing and/or late cometary bombardment: the value is about one order of magnitude smaller than for the Earth. Such a low value has implications for understanding the physical processes that can lead to the formation of an ocean from the outgassing of the interior.