HETEROGENEITIES WITHIN THE NOACHIAN CRUST REVEALED IN THE TERRA CIMMERIA-SIRENUM REGION. V. Malarewicz[a,b], S. Bouley[a,c], D. Baratoux[d,e], B. Langlais[f], O. Beyssac[b], B. Zanda[b], [a] GEOPS, CNRS, Univ. Paris Saclay, France, [b] IMPMC-Sorbonne Univ., MNHN, UMR CNRS 7590, France (virgile.malarewicz@universite-paris-saclay.fr), [c] IMCCE-Observatoire de Paris, UMR CNRS 8028, France, [d] Géosciences Envir. Toulouse, UMR CNRS 5563, IRD & Univ. de Toulouse, France, [e] UFR Sciences de la Terre et des Ressources Minières, Univ. Félix Houphouët-Boigny, Abidjan, Côte d'Ivoire, [f] Laboratoire de Planétologie et Géosciences, CNRS UMR 6112, Nantes Univ., Univ. Angers, France.

Introduction: *In-situ* observations of possible remnants of continental crust by MSL Curiosity [1] and the recent finding of differentiated crustal clasts in the NWA7533 Martian meteorite [2] raised new questions on the mechanisms involved in crustal growth during the early periods of Mars. The reconstruction of the ancient crustal thickness of Mars, before the formation of some of its major features (Noachian to Hesperian impact basins and the magmato-tectonic complex of Tharsis) revealed the existence of a crustal block which used to be thicker than the rest of the southern Noachian highlands [3]. Located in the region of Terra Cimmeria and Terra Sirenum, it is also characterized by regional enrichment in potassium/thorium [4] and exhibits the strongest crustal magnetic fields of the Martian surface [5]. Furthermore, former paleolakes have been documented in the region [6,7], possibly hosting hydrothermal activities [8]. Here, we analyze the morphological and geophysical features of this region with the goal to decipher its formation and evolution during the Noachian era. We build a new geological map of the region highlighting the finding of previously undocumented heterogeneities which reveal a rich and complex geological history. Based on these results, we develop models that could account for the evolution of the topography and crustal thickness of the region, as well as for the magnetic remanent signature on the surface.

The geological mapping of the region: Terra Cimmeria-Sirenum was previously described as an assemblage of early to late-Noachian highlands with other terrains from the Hesperian-Noachian transition [9], distributed in 6 different units. Here we distinguish, describ and map 12 different types of terrain within the region. Our mapping effort is based on morphological analysis, and crater counting using the most recent CTX and HiRise imagery, together with Themis imagery and MOLA elevation data.

The map (Fig. 1) highlights the predominance of basins, defined as enclosed topographical low points, in the central part of the region, and bordered by Noachian highlands on the southern and eastern border of the region. Most of the basins are filled with Hesperian-Noachian transition "smooth" terrains, interpreted to be basaltic lava flows or, alternatively, lacustrine deposits. They are usually separated from each other by ridges composed of Noachian terrains. An east-west geomorphological gradient is reported. Indeed, western basins in Terra Cimmeria are narrow and small, while the central basins are usually larger, and more elongated. The easternmost basins, comprising the well-known Eridania paleolake, have a round shape and are densely packed, with usually triple point junction between them. Basins are much more scattered at the southern and eastern limit of the map in Terra Sirenum. The same occur with inter-basins ridges, wider in the west than in the east. The distribution of valley networks also varies along the same direction, from frequent in Terra Cimmeria, to scarce in Terra Sirenum.

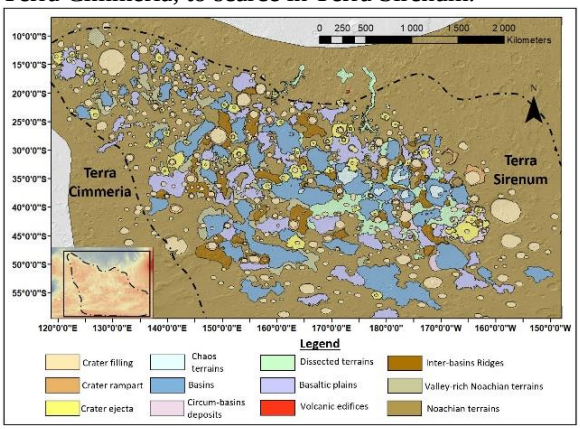

Fig. 1. Geological map of the Terra Cimmeria-Sirenum region, the outer limit of the area being highlighted by a doted-line

Regional-scale heterogeneities: In the present topography, the Noachian highlands (east and west) exhibit similar elevations (2000-3000 m), whereas the central region where the majority of on the basins are located is less elevated (500-1000 m). But in contrast, the ancient topography, inferred from the removal of impact basins, the Tharsis complex and associated lithospheric flexure, reveals an elevation gradient from west to east [10]. In this configuration, a part of Terra Sirenum is clearly higher (3000-4000 m), while Terra Cimmeria and the central part of the region appear to share a lower but homogenous elevation (1000-2000 m). Thus, the most elevated part of Terra Sirenum corresponds to a basin-deprived area, while basins are scattered in the lower and much more teopographically

homogenous area. Furthermore, this trend seems to parallel the distribution of valley networks, denser in the ancient "lowlands" and rarer in the ancient "highlands". It thus appears that the distribution of geomorphological features across the region is much more consistent when compared with a pre-Tharsis topography.

Magnetic characterisation of the region: Surface magnetic anomalies all over the planet are extrapolated to the surface using a model based on MAVEN and MGS orbiter measurements [5]. Results show that volcanic provinces and northern lowlands are almost free of any significant magnetic signature, but the southern hemisphere shows spots of intense magnetic anomalies located on ancient terrains. Specifically, the region of Terra Cimmeria-Sirenum bears the most intense surface anomalies of the planet. At the regional scale, the magnetic anomalies tend to follow a west-east trend. The eastern part, Terra Sirenum, contains more intense anomalies than the Terra Cimmeria. Investigations of the relation between topography and magnetic signal at the surface in the western and eastern part of the region, did not reveal any significant trends or differences. However, using the pre-Tharsis topography, a distinction can be made between the higher terrains associated with intense magnetic anomalies (like Terra Sirenum) and lower terrains which have weaker anomalies (like Terra Cimmeria).

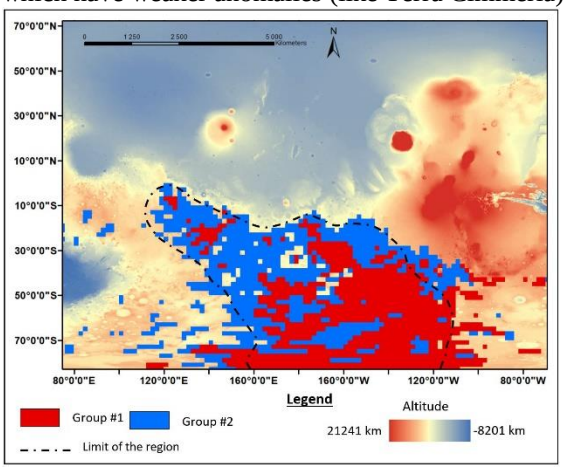

Fig. 2. Localisation of the data from group #1 and #2 compared to the localisation of the region of interest.

To investigate the differences between Terra Cimmeria and Terra Sirenum that are apparent in multiple data set, the ancient crustal thickness model is paired with the correlation between the ancient topographic and magnetic signal variations. This is achieved by working on a global grid with a 2°x2° resolution. Each cell is attributed a value of ancient topography, ancient crustal thickness and surface magnetic signature. It is then possible to spatially identified groups with similar characteristics. Cells with low magnetic signatures (>200 nT) were discarded as they are associated to volcanic and northern terrains. Remaining data were sorted using ancient crustal thickness values. The Terra Cimmeria-Sirenum region typically corresponds to values of crustal thickness between 55 and 47 km. We searched for an ancient crustal thickness value that could distinguish Terra Cimmeria from Terra Sirenum according the previously described morphological and topographical variations. A thickness value limit of 51 km allows us to define two different groups fitting the different description of Terra Cimmeria and Terra Sirenum. The group #1 includes thickness values of 55 to 51 km and mostly corresponds to the Terra Sirenum area with intense magnetic signatures. The group #2 with values of 51 to 47 km includes the basin-rich area of Terra Cimmeria, with smaller pre-Tharsis crustal thickness and lower topography values than Terra Sirenum. The rest of the southern hemisphere composed of a <47km crustal thickness is labelled group #3.

Summary and conclusion: The Terra Cimmeria-Sirenum region is a remnant of an ancient crustal block that reveals a rich geological diversity. Geological mapping revealed the presence of diverse geomorphological features unevenly distributed across the region. These observations appear to be much better correlated with pre-Tharsis crustal thickness and topography. Two entities may also be delimited from the map of magnetic anomalies.

In summary, the eastern part, Terra Sirenum, is predominantly composed of highlands-type terrains, associated with a thick crust (> 51 km), and bears the most intense magnetic anomalies. The western part corresponds to Terra Cimmeria with lower ancient altitudes and crustal thickness, with weaker magnetic anomalies but bearing a wider diversity of morphologies. It can be noted that a recent study located the ejection site of the most magnetic Martian meteorite in the vicinity of Terra Sirenum [11]. Future work should focus on the mechanism responsible for the formation of two distinct regions during the Noachian and pre-Noachian eras.

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