NOACHIAN TO AMAZONIAN VOLCANIC ACTIVITY IN NE SYRTIS REGION C. Quantin-Nataf[1], G. Dromart[1], L. Mandon [1] . [1]Laboratoire de Géologie de Lyon Terre, Planètes, Environnement (CNRS-ENSLyon-Université lyon1), 2 rue Raphaël Dubois 69622 Villeurbanne Cedex, France(cathy.quantin@univ-lyon1.fr).

Introduction: NE Syrtis has been selected as one of three candidate landing sites for the Mars2020 mission. The Mars2020 rover mission is designed to search for signs of ancient Martian life, assess habitability and geologic context, and cache samples for potential future return to Earth. The sampling of igneous rocks is of first order importance for accomplishing radiometric dating. So, the identification, mapping, and characterization of igneous units in the exploration range of the Mars2020 rover is of importance. If an igneous sample is returned to Earth, any tentative age determination for this sampled unit by crater counting techniques would be important for geologic context, constraining the timing of habitable conditions on Mars, and for potential calibration of the Martian cratering chronology curve as it has been done on the Moon thanks to Apollo Samples [1].

The NE Syrtis region has been well documented [e.g. 2, 3, 4, 5]. The region is composed of a Noachian altered basement overlain by an olivine and carbonate-bearing unit [5]. Overlying these two units is a crater-retaining capping unit [5]. This capping unit has been mapped as the upper part of remnant buttes inside the proposed landing site ellipse for Mars2020 and further southwest inside a topographic depression [5]. Further to the southwest is a distinctive lava flow deposit from Syrtis Major volcano. The volcanic activity of Syrtis Major has been dated to the Hesperian [6].

This study focuses on all capping units of NE Syrtis region with the goal of constraining their age and origin for potential Mars2020 exploration. We mapped the capping units in the NE Syrtis region (landing ellipse and southwest of the landing ellipse) and analyzed their texture and geology to decipher their origin. We also analyzed impact crater statistics to assess crater retention age that allow further discussion of formation age.

Methods: We have gathered thanks to MarsSI facility [7] all High Resolution Imaging Science Experiment (HiRISE) and Context Camera (CTX) images of the area into a Geographic Information System (GIS). Topography has been obtained from Mars Orbiter Laser Altimeter (MOLA) and from High Resolution Stereo Camera (HRSC). For crater statistics analyses, we used the Martian crater frequency distribution as well as the Martian age model from [8].

Results: We have distinguished and mapped 4 distinct capping units within the study area (Figure 1).

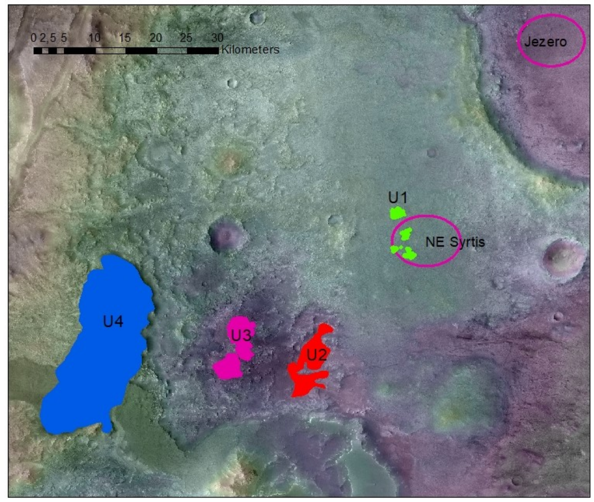

Figure 1: Location and identification of the capping units studied here. Background is CTX image mosaic overlapped by MOLA elevation in transparency (MOLA elevation range: -239 m to -3172 m). Pink ellipses are the landing site ellipses proposed for NE Syrtis and Jezero sites. Unit 1 (U1) to Unit 4 are the capping unit detailed in this study.

Capping unit 1 (U1 in figure1) corresponds to the upper unit of the mesas observed in NE Syrtis landing site ellipse. The patchy area extent of each mesa exposure is limited and varies from 0.05 km^2 to 2.6 km^2. Investigation of the topographic context suggests that the mesas are localized in the local lows. At high resolution, U1 is not layered, but appears to shed abundant meter-scale boulders (figure 2A) as previously observed by [5]. The surface of this unit is impacted suggesting that this unit has been exposed too and retained evidence of meteoritic bombardment. The unit is about 10 meters thick [5].

Capping Unit 2 (U2) and 3 (U3) are both located in a depression southwest to NE Syrtis landing site ellipse (figure 1). This depression is about 500 m in elevation below the landing site ellipse. Also filling the local low of this depression, U2 and U3 are layered (figure 2B). U2 and U3 have similar morphology and texture, bearing abundant meter-scale boulders and retaining impact craters. Capping unit 4 (U4) corresponds to the termination of a well identified lava flow from Syrtis Major volcano. The volcanic products of Syrtis Major have been dated between 3.5 and 3.8 Gy [6]. At high resolution, this unit also produces abundant meter-scale boulders and has been impacted, suggesting an exposure to the impact bombardment.

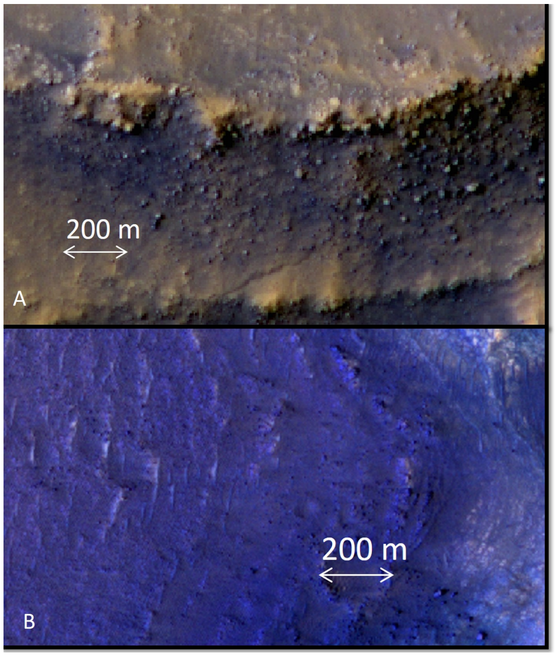

Figure 2 : HiRISE color close-ups of the capping units mapped as U1 in A and U3 in B. U3 is layered while U1 is not.

We performed crater counts on HiRISE and CTX images on the 4 units defined in figure 1 to assess their size distribution of craters smaller than 500 m. To analyze the crater size frequency distribution of U1, we added several areas, ranging from 0.05 km^2 to 2.6 km^2 each, to gather enough sufficient statistics. Craters from 60 m to 500 m follow the saturation curve, suggesting that the surface has been intensely impacted during at least the last 3.8 Gys. However, the limited areal extent of the remnant mesa tops precludes an age assessment. Statistics of craters larger than 500 m would be required to define an age older than 3.8 Gy, but the counted area (< 2.5 km^2) is too small. However, we can conclude that the unit is likely at least 3.8 Gy, and possibly older. The U2 size distribution of craters between 100 and 300 meters follows the isochrons and returns an age of 2 Gy. Capping unit 3, similar in morphology to U2, returns an age of 1.96 Gy with a size distribution of craters from 125 m to 500m that follows the slope of the isochrons. Both counted areas of U2 and U3 are of the order ~10 km^2. The crater size distribution of U4 has two distinct slopes: for craters from 250 to 750 m, the slope is lower than the isochrons suggesting crater obliteration processes, while the slope for craters larger than 750 m follows the isochrons slope and returns an age of 3.55 Gy.

Discussion: Based on the fact that U1, U2 and U3 form capping units, are about 10 meters-thick, fill local topographic lows, and shed meter-scale boulders, we suggest that these units are effusive volcanic units. U4 has previously been interpreted as a volcanic unit [6]. Previous compositional analyses do not rule out this hypothesis, and may suggest that U1, U2 and U3 have a high calcium-rich pyroxene signature in agreement with a mafic igneous composition [5]. Based on their age and similar morphologies, U2 and U3 would belong to the same depositional event. U1 would be the oldest unit, older than 3.8 Gy and would be at least 1.8 Gy older than U2 and U3. These findings suggest that the capping unit within the candidate Mars 2020 landing ellipse is a remnant of Noachian-aged volcanism. U4 would represent Hesperian volcanism with an age of 3.55 Gy. in agreement with the age of Hesperian Syrtis Major volcanism [6]. Lastly, U3 and U4 could be the product of later Amazonian volcanism. This succession of events highlights the age diversity of igneous products present in this region that would be of high priority for sample collection for potential future return to Earth to decipher the Martian global history.

Conclusions: We have shown that several distinct volcanic units of variable age are exposed within NE Syrtis and the candidate Mars 2020 landing site. These units are Noachian, Hesperian and Amazonian in age and represent the rock diversity we may encounter by landing in this region. If samples of these units are returned to Earth, they could be particularly useful for providing absolute age constraints for the Martian geologic timescale.

Acknowledgements: This research received support from CNES and MarsSI facility has been developed thanks to the European Research Council under the European Union's Seventh Framework Program (FP7/2007-2013)/ERC Grant agreement n° 280168.

References: [1] Neukum et al., SSR, (2001). [2] Mustard et al., JGR, 12 (2007). [3] Ehlmann et al., JGR, 114 (2009). [4] Mangold et al., JGR, 112 (2007). [5] Bramble et al., Icarus, 293 (2017). [6] Hiesinger and Head, JGR, 109 (2004). [7] Quantin-Nataf et al., PSS, in press (2017). [8] Hartmann, Icarus, 174 (2005).