The ejection site of Black Beauty revealed by 90 million impact craters.

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Introduction: The geological record of the formation and differentiation of our planet has been destroyed by its subsequent evolution, but extremely rare clues may be obtained from other terrestrial planets. Mars provides a unique and accessible example of an early evolutionary path corresponding to that, inaccessible, of our own world. We can investigate it with spacecraft, and samples are available for in-depth analysis on Earth in the form of martian meteorites. So far, the only available martian samples that appear to have recorded the early conditions and the evolution of the planet until the present time are Northwest Africa (NWA) 7034 and its paired stones, nicknamed "Black Beauty".

This regolith breccia has been ejected a few million years ago by the formation of a large impact crater, and contains the oldest martian igneous material ever dated: ~4.5 Ga old [1-4]. However, its source and geological context have so far remained unknown. and with it, a region where the earliest geological records of the planet [1-4] are exposed on the surface. Knowing this source region would provide insights into early Mars geological history and crustal extraction [1-4]. This source region may therefore become a high-priority target for detailed orbital analyses and in-situ exploration [5].

Constraints on the meteorite launch site: Following a hypervelocity impact, ejecta materials moving faster than the escape velocity (5 km/s) may get through the martian atmosphere and continue their course into interplanetary space to become martian meteorites [6]. Slower debris fall back on the surface in a radial pattern or ray around the primary crater, forming secondary craters. The presence of 100 meter-size secondaries attests to the freshness of their associated primary craters [7]. Using the size and spatial distribution of more than 90 million impact craters >50 m (both primaries and secondaries) detected using a Crater Detection Algorithm (CDA) [7-8] on the whole surface of Mars from the global Context Camera (CTX) mosaic [9], a previous work [7] identified ray systems of secondary craters <150 m associated with 19 large primary craters, potential source of the ejection of martian meteorites.

Here we compare the abundance of K and Th [10-11] as well as the magnetic field intensity and the magnetization of the surface of Mars derived from orbital measurements [12] at the immediate vicinity of each crater candidate with those of the breccia. We also compare the geological context of each of the crater candidates with the chronology and the lithology of the meteorite [e.g. 1-3, 13-14].

The ejection site for Black Beauty: Among the 19 crater candidates investigated, we found that only one match with the characteristics of the meteorite: a 10 km crater located in the north-east of the Terra Cimeria – Sirenum (TCTS) region, between Hesperia Planum and the Tharsis bulge. Our work suggests that clasts contained in the regolith breccia are representative of the TCTS province, making this region a relic of the early crustal processes on Mars [e.g. 15], and thus, a region of high interest for future missions.

Details on the identification of the crater source of this unique meteorite, as well a its geological context and broader implications for early crustal processes on Mars will be presented at the conference.

References: [1] Udry, A. et al. (2020) *Journal of Geophysical Research: Planets,* 125, e2020JE006523. [2] Bouvier, L. C. et al. (2018), *Nature* 558, 586–589. [3] Goodwin, A. et al. (2022) *Astrobiology*, ahead of print. [4] Costa, M. M. et al. (2020), *Proceedings of the National Academy of Sciences* 117, 30973-30979. [5] Rapin, W. et al. (2021) *Bulletin of the AAS*, 53(4). [6] Artemieva, N. & Ivanov, B. (2004), *Icarus* 171, 84-101. [7] Lagain, A. et al. (2021), *Nature Communications* 12, 6352. [8] Benedix, G. K. et al. (2020) *Earth and Space Sciences*, 7, e2019EA001005. [9] Dickson, J. L. et al. (2018) *49th Lunar and Planetary Science Conference*, Abstract #2480. [10] Boynton, W. V. et al. (2009), *Journal of Geophysical Research* 112, 12-99. [11] Taylor, G. J. et al. (2007) *Journal of Geophysical Research* 112, 03–10. 27. [12] Langlais, B., et al. (2019), *Journal of Geophysical Research: Planets* 124, 1542-1569. [13] Humayun, M. et al. (2013), *Nature* 503, 513-516. [14] McCubbin, F. M. et al. (2016), *Journal of Geophysical Research: Planets* 121, 2120-2149. [15] Bouley, S. et al. (2020), *Nature Geoscience* 13, 105-109.