TOWARDS A SURFACE AGE MAP OF MARS AT ULTIMATE RESOLUTION, AND THE SEARCH FOR SOURCE CRATERS OF THE MARTIAN METEORITES.

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For planetary geologists who study the solar system, the baseline datasets are images of a surface and a geologic map with included age information. Ages for other worlds are determined by counting the number of craters of a given size over a given area on the surface. More craters equals an older surface. The technique was invented in the early-60s [e.g. 1]. On its own, crater counting provides a relative age, but if we can obtain a radioisotope age from a sample of a cratered surface, that relative age can be calibrated; it becomes an absolute chronometer. This was achieved with the return of Apollo samples. Since then, crater counting has been at the heart of virtually every major advance in planetary science, from deciphering the geological history of the Moon, to the concept of the late heavy bombardment, to the realisation that the icy satellites might have ocean mantles.

Advances in technology have increased spatial resolutions of orbit-derived imagery dramatically (from km/pixel to cm/pixel), allowing craters 10m in diameter to be resolved. However, there has been no change in how that data is processed to derive surface ages. The default method remains manual crater counts; effectively restricting us to craters >1km diameter. There are ~390,000 of these on Mars, which were counted and measured by hand [2]. When we get down to the smaller crater sizes, there are 10s millions of craters; a number that is intractable to count by hand. We have developed an advanced machine learning algorithm to do it automatically. We validated it against [2]. Our algorithm, summarised in [3], automatically counts craters of any size, but is especially helpful for small craters, on any number of high resolution images. Figure 1 illustrates our current capability. We are now applying our algorithm to the highest resolution global imagery dataset of Mars using High Performance Computing resources. It will allow us to develop surface age maps of Mars at ultimate resolution, and importantly, determine ages for all craters large enough to launch meteorites to Earth.

There is a unique repository of martian meteorites on Earth, but we don't know where they come from on Mars. Previous work has produced a number of potential source craters [4-7] for the martian meteorites, however the matches have been tentative or ambiguous. Recent work [8, 9] has focussed on limiting the number of potential source craters based on ages and crater properties. There are currently 8000 craters that could be sources. Using our algorithm will allow examination of all possible source craters of the meteorites to find the best matches.

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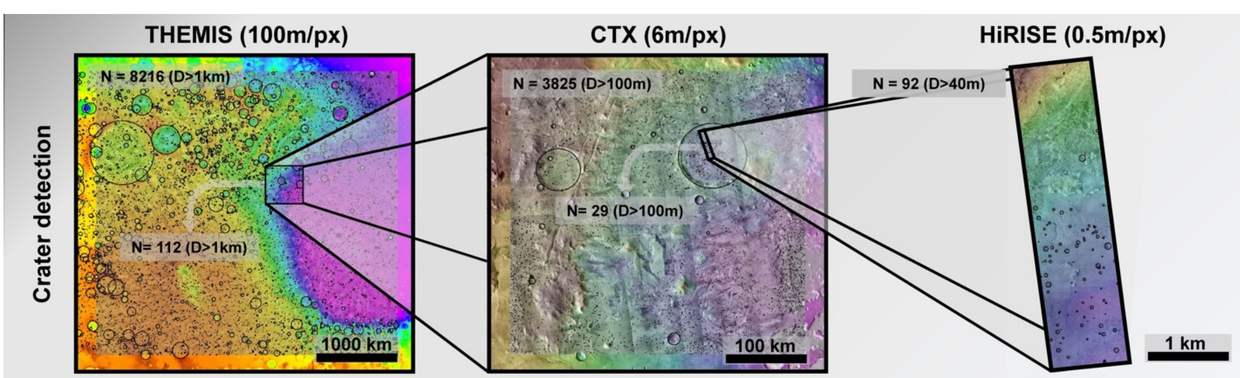

Figure 1. Results of crater counting algorithm for the Syrtis Major region of Mars. (left) at THEMIS Resolution, craters counted = 8216, outline is Jezero Crater region, which contains 112 craters >1km. (center) CTX resolution of outlined area– algorithm counts 3825 craters >100m. (right), highlighted area in CTX (29 craters) image at HiRISE resolution, 92 craters >40m.