TERRESTRIAL CRATERS AS ANALOGS FOR DEGRADED CRATERS ON TITAN. T. Duncan[1], C. Neish[1], J. Hedgepeth[2]. [1]Dept. of Earth Sciences, University of Western Ontario, 1151 Richmond Street, London, ON, N6A 3K7. [2]School of Earth and Planetary Sciences, Curtin University, Kent Street, Bentley WA 6102, Australia.

Introduction: Titan and Earth share several commonalities. They are the only known planetary bodies in our Solar System to currently have flowing liquids on their surface [1]. Stream channels are observed near impact craters on both worlds, such as Selk and Sinlap craters in Titan's dune fields [2][3]. The Dragonfly mission aims to use existing stream channels to sample the subsurface material within Selk crater [4]. Research on stream formation near Selk crater would therefore prove beneficial to the Dragonfly mission, as it will be landing there in the mid-2030s.

However, the formation of these stream channels is not well understood. Previous studies note that within Titan's dune field, there are dendritic and rectangular stream patterns [5]. Rectangular stream patterns are associated with faulting while dendritic refers to streams that cut through uniformly resistant rock with little to no regional slope [6]. Stream morphologies such as these near Titan's impact craters may suggest that the target lithology or regional faulting patterns are influencing stream formation in these regions. We wish to study the formation of these drainage networks and their patterns around Titan's craters, to determine what role the presence of faults and different geologic units have in their formation. To do this, we studied the relationship between fault lines and differing rock types around Earth's craters as an analog to Titan.

Methods: For this study, we use the terrestrial craters Haughton, Siljan, and Popigai. All three craters are moderately eroded and complex, making them ideal analogs for Sinlap and Selk craters on Titan. We highlight these terrestrial craters' stream channels and faulting networks using two different mapping techniques to quantify the percentage of overlap between the faults and streams.

The first method uses publicly available shapefiles of faults and streams that were mapped at a 1:100,000 scale (**Fig. 1**). The second method also uses publicly available stream shapefiles through DIVA-GIS, but at a 1: 1,000,000 scale. It is important to note that for the second method, geological maps from previously published work are used as a guide to map the faults for both Siljan and Popigai at a 1:1,00,000 scale [7][8]. Haughton is exclusively mapped using the first method while Siljan and Popigai are mapped using the second method. This is due to a lack of high resolution faulting data in the regions where Siljan and Popigai are located. We also conduct an analysis of the correlation between target material and stream channel location for all three terrestrial craters. The area for each crater's basin was calculated using the polygon feature in ArcGIS. Calculations of the stream density within the crater's basin and crater rim are then done using the equation below:

$$\text{Drainage Density } (m^{-1}) = \frac{\text{Total length of channel (m)}}{\text{Basin Area } (m^2)}$$

To determine the stream morphologies within the crater basin and the crater rim, we use similar techniques from previous studies [4][5][9] to classify the junction angles of streams (rectangular: 80°-100°; dendritic: 40°-85°). This information, combined with an evaluation of the local geology, allows us to learn how stream channels form around craters.

Finally, mapping of stream channels near Titan's craters, Selk and Sinlap, is done using Cassini's Visible and Infrared Mapping Spectrometer (VIMS), highlighting the visible stream channels near the craters (**Fig. 2**).

Results and Discussion: Mapping of the terrestrial craters' streams and faults allows for a percentage of overlap to be calculated for each crater. Streams less than 100 m distance from fault lines are considered to "overlap" the fault. At the Haughton impact, there is an overlap of roughly 62% between streams and faults (**Fig. 1**). The intersection of streams and faults for both Popigai and Siljan craters are negligibly small (<2%), although when mapping streams at a higher resolution, Popigai has a percentage of 27%. The low percentage of overlap for Siljan and Popigai is likely due to overprinting from glacial erosion and regional slope influencing streams to trend towards lower elevations respectively. For all three craters, the highest concentration of intersect is around the crater rim.

Analysis of the target lithology shows that the composition for all three crater's rims are carbonates (limestone, dolomite, and other carbonate sediments). The impact basin, however, differs. Haughton and Popigai's basin is composed of impact melt breccia, while Siljan's is comprised of Precambrian basement rock (primarily metasiltones and metasandstones).

Comparing the drainage densities for both the crater basin and crater rim, there is a higher density of streams within the basin for both Haughton and Popigai, while Siljan's higher density is surrounding the crater rim. The majority of the streams circumventing the crater rim at Haughton show rectangular stream patterns, indicating stream patterns controlled by local faulting. The morphology of the streams for the other craters range from dendritic, parallel, and trellis. Parallel patterns are associated with moderate to steep regional slope while trellis refers to dipping or folded rock with contrasting resistance to erosion [5].

Stream channels present in the VIMS imaging of Selk and Sinlap show only the main stream networks but do not have a high enough resolution to show external links. Therefore, we cannot confidently characterize the stream morphologies there.

Conclusions: We seek to understand the formation of streams channels around Titan's craters in advance of the Dragonfly missions. The investigation of terrestrial analogs may clarify how streams form around impact craters in general.

Stream morphologies for terrestrial craters Haughton, Siljan, and Popigai show a range of patterns. Haughton's streams are strongly controlled by faulting while Siljan and Popigai's are controlled by regional slope and rocks with inconsistent strengths to erosion. Both Haughton and Popigai have a higher density of streams within the more friable impact melt while Siljan has a higher density around the crater rim. In this case, the crater rim is composed of softer material compared to the crystalline basin.

With the current imaging of Titan's surface we cannot confidently define the stream morphologies around Selk and Sinlap. The Dragonfly mission will produce higher resolution images of the moon's surface. These in turn, will allow for a more precise comparison to Earth's streams and an understanding of their formation mechanism.

References: [1] Black, A. B. et al. (2017) *Science,* 356(6339), 727-731. [2] Soderblom, J. et al. (2010) *Icarus,* 208(2), 905-912. [3] Neish, C. et al. (2015) *Geophys. Res. Lett.,* 42(10), 3746-3754. [4] Neish, C. et al. (2018) *Astrobiology,* 18(5), 571-585. [5] Burr, D. et al. (2013) *Icarus, 226,* 742–759. [6] Howard, A. D. (1967) *AAPG Bull., 51,* 2246-2259. [7] Sivalneva, O. et al. (2021) *Geosci. J.,* 11(7), 281. [8] Masaitis, V. L. et al. (2019) *Aus. J. Earth Sci.,* 66(1), 81-94. [9] Ichoku, C. and Chorowicz, J. (1994) *Water Resour. Res., 30(2),* 161–174.

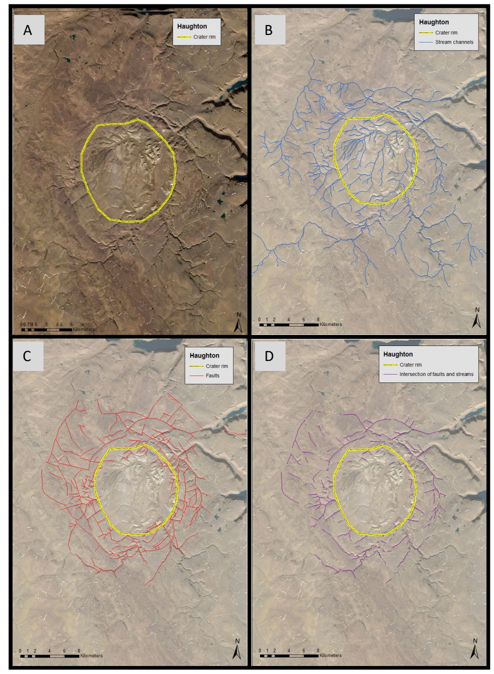

Fig. 1 The Haughton impact structure located in the Canadian Arctic, situated on Devon Island. All mapping is done at a 1:100,000 scale. (**A**) Highlights crater rim; (**B**) Stream channels; (**C**) Faulting networks; and (**D**) Intersection between the streams and faults.

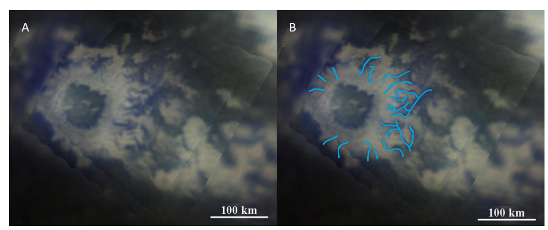

Fig. 2 Modified Cassini VIMS image of Selk crater from [2]. (**A)** Selk crater and (**B**) Stream channels around Selk crater highlighted in blue.