GLOBAL MAPPING AND MORPHOLOGIC CLASSIFICATION OF TITAN FLUVIAL FEATURES.

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Introduction: High resolution imaging of Titan's surface, using the synthetic aperture radar (SAR) mode of the Cassini Titan Radar Mapper (RADAR) [1] and the Huygens Descent Imager/Spectral Radiometer (DISR) [2], has revealed fluvial features. These features are interpreted as channel or valley networks, likely formed by precipitation and runoff of liquid hydrocarbons or by sapping [2-4].

Analysis of drainage network morphologies on Earth reveals the geologic controls on those networks [5-7]. Drainage analysis is especially useful in areas where topographic data are limited and data resolution is low. The form of drainage networks may be determined by tectonic structures, regional slope, pre-existing topography, and bedrock resistance. Certain network attributes are diagnostic of those geologic controls, such as tributary junction angles, link lengths, and proportion of right angular bends [6]. These attributes can be measured in the field [8], or through analysis of maps and remotely sensed imagery. Specific combinations of attributes result in the basic drainage patterns recognized by [5,7] as: dendritic, parallel, rectangular, trellis, radial, annular, multi-basinal, and contorted.

In this study we apply an algorithm developed for quantitative terrestrial drainage analysis [9] that has been modified for application to Titan [10]. Possible outcomes for networks using the modified algorithm are dendritic, parallel, rectangular, and unclassified, which could indicate secondary geologic controls producing a modified basic drainage pattern [7].

Methods:

Global mapping. Global mapping of fluvial networks on Titan was completed for all SAR swaths through T71 using ArcGIS (Fig. 1). Networks were formed of individual fluvial features, which were mapped using three criteria: distinguishability in tone from surrounding terrain, bright-dark pairing indicative of a depression, and fluviatile morphology [10]. Features meeting two or more criteria are mapped as "known", those meeting one criterion are mapped as "uncertain", and where features are discontinuous, the intervening sections are mapped as "inferred."

Data collection: Data were collected using the appropriate projection for the parameter being measured. These parameters included junction angles of lowest order tributaries visible, lengths of exterior and interior links, orientations of exterior and interior links, and right angular bends. These data were collected in ArcGIS using the Geodesic Tools extension to calculate spheroidal lengths and azimuths from the mapped features.

Results:

Classification: Using these data in the algorithm from [10], we classified 33 networks from a wide range of geographic locations (Table 1). Classifications of networks in areas previously analyzed by [10] were consistent with the exception of one network in the T41 swath. Twenty-two of the 33 networks analyzed were classified as rectangular networks, six networks were classified as dendritic networks, two networks were classified as parallel networks, and three networks did not meet the conditions to be classified as one of the basic drainage patterns (i.e. unclassified). It is important to note that the analyzed networks display a wide range in stream order and drainage basin area.

Latitudinal distribution. The networks classified in this study are distributed across a wide range of latitudes (Fig. 1), and do not show any apparent significant latitudinal preference by network class. Dendritic and rectangular networks are found at all latitudes. In contrast, parallel networks are found only at the northern-most extent of the south polar region.

Rectangular networks constitute 66.6% of the networks analyzes. Their wide-spread occurrence suggests that the geologic controls producing this pattern dominate on Titan and are not regionally constrained. Dendritic networks are the next most common type and consistute 18% of the networks.

Implications:

Drainage patterns are formed by specific geologic controls [5-7]. Dendritic drainage patterns form in horizontally-layered rocks with gentle regional slopes. Parallel patterns indicate steep regional slopes or the presence of parallel, elongate landforms. Rectangular patterns are formed as a result of joints and/or faults directing flow. Rectangular drainage networks indicate the presence of structural or tectonic features at the locations of the networks. Identification of rectangular networks in all areas surveyed may indicate that tectonic activity occurs or has occurred globally. Extensional features, interpreted as fractures, normal faults, graben, or spreading centers, have been identified as the major structural features on many icy satellites [11]. Extension in the outer solar system has been attributed to tidal forces, orbital evolution, and changes in volume due to phase changes. Lateral displacement of features on other icy bodies suggests the occurrence of strike-slip movement [11]. Compressional features have not been widely identified on other icy outer Solar System satellites [11], although mountain chains on Titan may be formed by crustal compression [12].

Rose diagrams constructed from the orientation of rectangular network links appear to show three general trends: NW-SE, NE-SW, and E-W, of which the NW-SE and NE-SW trends are the most prominent (e.g. Fig. 2). This result is consistent with previous work on analysis of structural elements [10,13]. In continued investigations, link orientation in rectangular drainage networks will be analyzed for evidence regarding the prevailing stress field(s). Stress patterns may be used to determine whether structural features result from local effects or from processes affecting the entire body and, if the latter, which processes play a major role in deforming Titan's lithosphere.

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Acknowledgements: We appreciate the assistance of Jeff Jenness with the Geodesic Tools ArcGIS extension, Trent Hare for ArcGIS help and providing the data, Prof. Robert D. Hatcher, Jr. for helpful discussion, and the Cassini Data Analysis Program for partial funding this project.

Tables and Figures:

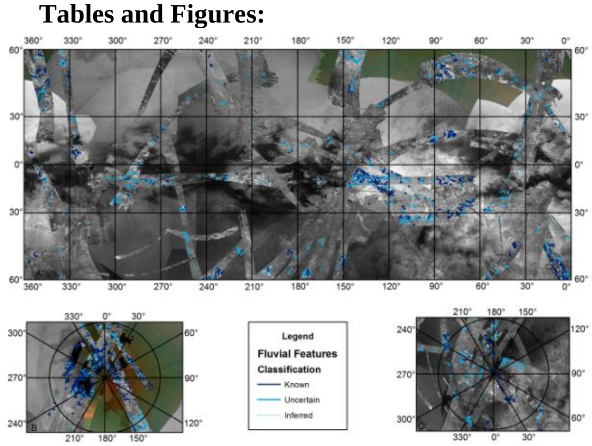

Figure 1. Fluvial features mapped in SAR swaths Ta-T71. Features are mapped according to level of certainty. (a) Fluvial features from 60°N - 60°S. (b) Fluvial features in the north polar region, 60°N - 90°N. (c) Fluvial features in the south polar region, 60°S - 90°S. 10° longitude is equal to 450 km.

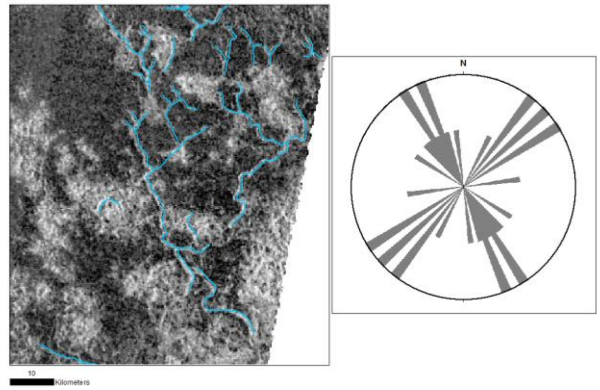

Figure 2. Rectangular drainage networks in the T59 radar swath centered at 150°W, 52°S with rose diagram showing link orientations.

Drainage Pattern	**SAR Swath(s) and approximate centers**	**Total Networks**
Dendritic	T3 (90°W,15°N) T28: (235°W, 75°N), (231°W, 75°N) T59 Db (150°W, 52°S)	6
Parallel	T7: (5°W, 60°S)	2
Rectangular	T7: (8°W, 54°S) T13 A (72°W, 11°S), (135°W, 9°S) T28: (226°W, 75°N), (236°W, 77°N), (242°W, 73°N), (264°W, 75°N) T41 A (74°W,30°S) T43 A (56°W, 4°S) T44: (135°W, 7°S) T59: (150°W, 52°S)	22
Unclassified	T7 B (6°W, 59°S) T28: (235°W, 75°N)	3

Table 1. Results of network analysis for 33 networks organized by drainage pattern.