EPSC Abstracts
Vol. 11, EPSC2017-711-1, 2017
European Planetary Science Congress 2017

Transpressional tectonics on Uruk Sulcus, Ganymede

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Abstract

Ganymede shows an icy crust strongly shaped by past and possibly still active tectonics. Kilometric morphotectonic features, grooves and furrows, develop within the light terrain and the dark terrain, respectively. Open debate exist on the geodynamic processes responsible for these features. In this contribution we explore the tectonic setting of the light terrain region of Uruk Sulcus. We classify three groove systems and one furrow system within the sulcus using methodologies of structural geology. An automatic lineament domain analysis was progressed and results were compared with the recognized groove/furrow systems giving insight on the stress field in the study area. Obtained results concern the relative deformation intensity and the rheology within the crust of the studied region. We found that Uruk Sulcus is a corridor characterized by a dextral transpression, approximately N-S oriented, that in turn is responsible for localized transtension among crustal blocks within the shear zone. Being the target area of the radar sounder RIME (Radar for Icy Moon Exploration) for ESA's upcoming JUICE (JUpiter ICy moon Explorer) mission, the present work aims also to contribute to the scientific preparation of this mission.

1. Introduction

The icy surface of Ganymede is globally divided into two terrains, the light terrain and the dark terrain [1], deformed by diffused secondary features including craters and linear structures. The latter correspond to kilometric subparallel, linear and subcircular ridge and trough systems [2] , [3] and are considered evidence of tectonic activity deforming the crust. Furrows are the main tectonic features occurring within the dark terrains, and the light terrains are intensely etched by grooves. Authors [3] proposed extensional tectonic models to explain groove formation. On the other hand, evidence of compression has not been yet recognized, leaving open the research to clarify the tectonic balancing on Ganymede surface. The investigation on the surface deformation is still open and aid to understand the internal processes of this satellite.

2. Methodology and data analysis

2.1 Groove/furrow system detection

Specific processing of Voyager and Galileo images allowed the preparation of a high-resolution mosaic (with maximum resolution up to 50 m/pixel) of the anti-jovian area framing the Uruk Sulcus (Fig. 1). Groove and furrow of Uruk Sulcus region were carefully identified, for a total of 795 elements.

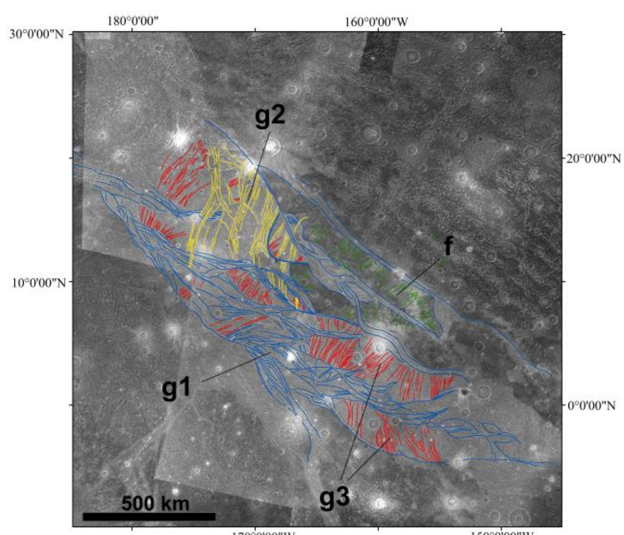


Figure 1: Groove and furrow systems recognized within Uruk Sulcus.

These structures were grouped into systems based on their features together with their spatial and crosscutting relationships and were quantitatively characterized by morphology, sinuosity, location, azimuth, and length. For each system, azimuthal analysis of multiple and single elements by frequency and cumulative length was performed. The azimuthal analysis was performed by a polymodal procedure best fit with a family of Gaussian curves that show the independent azimuthal groups within each system with their statistical parameters [4], [5]. We measured, for each group, the mode/sd ratio that represents the sharpness of the corresponding population. The texture of the spatial distribution of the systems was represented by the ratio L/S where L is the structure length and S is its distance with the closest structure belonging to the same group [6]. These analyses allowed to recognize 3 main groove systems, namely g1, g2, g3, together with a furrow system (f) (Fig. 1).

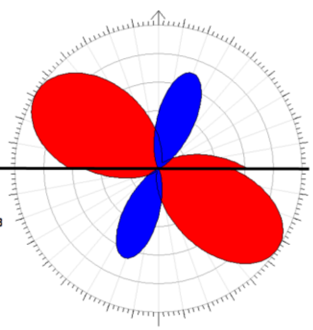
2.2 Lineament domains detection

Automatic lineament detection was performed to understand the kinematic/dynamic setting of Uruk Sulcus. Lineaments derive either from the geodynamic stresses, the dynamic lineaments, or from movements within shear zones, the kinematic lineaments, as along strike-slip regional faults [7]. Results show the presence of a kinematic related NW-SE lineament domain and a sharp NNE-SSW lineament domain resulting from a surface stress field with maximum horizontal stress (Sh-max) parallel to it (Fig. 2).

AZIMUTH BY FREQUENCY

Total Data: 2501 max: 68 min: 2 mean: -42.005 sd: 4.3
RMS = 2.12022756522239

GAUSSIAN PARAMETERS					
#	%	Nor. H.	Max H.	Azimuth	sd
1	100.00	100.00	45.02	-57.59°	27.57°
2	57.14	70.47	31.73	19.71°	14.96°



AZIMUTH BY CUM LENGTH

Total Data: 124934.4 max: 3703.16 min: 97.58 mean: -42.8
RMS = 129.062046600899

GAUSSIAN PARAMETERS					
#	%	Nor. H.	Max H.	Azimuth	sd
1	100.00	100.00	2478.3	-56.22°	24.41°
2	59.54	66.39	1645.4	21.10°	15.02°

Figure 2: Lineament azimuthal analysis showing two lineament domains.

3. Discussion and conclusions

The comparison of the groove/furrow systems with the lineament domain analysis allows to propose a tectonic model for the investigated area. Uruk Sulcus represents a right-lateral strike-slip corridor with evidence of transpression (up to 70% of compression) responsible for the development of the stress-parallel NNE-SSW lineament domain. The NW-SE g1 groove system relates to the shear along the corridor. The NNE-SSW g2 groove system represents the antithetic structures given by the shear. The NE-SW g3 groove system relates to the internal stress conditions induced by the shear.

Acknowledgements

This research is part of a PhD project and is funded by Roma Tre University and its GeoQuTe Lab.

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