GLOBAL PATTERNS OF TECTONISM FROM MOUNTAIN RANGES AND VIRGAE. C. Cook[1], J.W. Barnes[1], J. Radebaugh[2], T. Hurford[3], and S.A. Kattenhorn[4], [1]University of Idaho, Department of Physics (Cook6924@vandals.uidaho.edu), [2] Brigham Young University, Department of Geology, [3]NASA Goddard Space Flight Center, [4]University of Idaho, Department of Geological Sciences.

Introduction:

This research is based on the exploration of tectonic patterns on Titan from a global perspective. Several moons in the outer solar system display suggested patterns of global stress fields driven or modified by global forces which affect patterns of tectonism. Patterns such as these are seen in Europa's tidally induced fracture patterns, Enceladus's tiger stripes, and Ganymede's global expansion induced normal fault bands. Given its proximity to Saturn, as well as its eccentric orbit, tectonic features and global stresses may be present on Titan as well. Titan displays possible tectonic structures, such as mountain chains along its equator [2], as well as the unexplored virgae.

Motivations:

Imaged by Cassini with the RADAR instrument, mountain chains near the equator are observed with predominate east-west orientation [1]. Orientations such as these can be explained by modifications in the global tidal stress field induced by global contractions followed by rotational spin-up. A consequence of global contraction, in general, is a corresponding increase in the moon's rotation rate in order for angular momentum to be conserved. A non-synchronous rotation would eventually be damped by tidal torques; however this process would be slow. In order to maintain its current eccentricity, Titan's tidal dissipation factor, Q, must be high. A high Q would also lead to long timescales for rotational synchronization following a contraction event. Also, due to Titan's eccentric orbit, its current rotation rate may be in an equilibrium between tidal spin-up near periapsis and spin-down near apoapsis. A small restoring torque toward rotational synchronization as a deviation from synchronous rotation decreases as a result of these competing torques. Additional stress from rotational spin-up provides an asymmetry to the stress field. This, combined with an isotropic stress from radial contraction favors the formation of equatorial mountain chains in the east-west direction.

The virgae, which have been imaged by Cassini with both the Visual and Infrared Mapping Spectrometer (VIMS) and Imaging Science Subsystem (ISS) instruments, are located predominately near 30 degrees latitude in either hemisphere. Oriented with a pronounced elongation in the east-west direction, all the imaged virgae display similar characteristics: floors the same color as the surrounding terrain, darkened with an apparent neutral absorber, broken-linear or rounded sharp edges, and connected, angular elements with distinct, linear edges (Firgure 1).

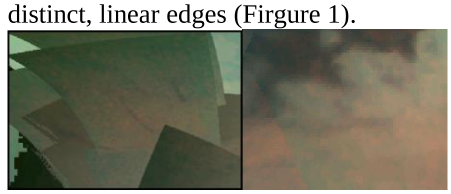

Fig. 1. Examples of virgae on Titan. .(a) Virgae centered at 124^{o}N, 47^{o}E based on a cylindrical map of Titan measuring 180 W to 180 E. (b) Virgae centered at 162^{o}W, 26^{o}S; based on the same cylindrical map of Titan as image (a).

Virgae from the northern latitude passes have also been imaged and are oriented with their long dimensions toward Titan's anti-Saturn point. These northern virgae share the same characteristics as those near 30 degrees latitude. The virgae display a possible tectonic origin as implied by their abrupt, linear edges along with their east-west orientation.

While we interpret the virgae to be of possible tectonic origin, we also consider evolution through flood-outflow deposits and wind-streaks. If they are of tectonic origin, the Virgae could serve as markers to Titan's global stress field. Using them in this way allows for a mapping of global tectonic patterns. These patterns will be tested for consistency against the various sources of global stress. By determining what drives Titan's tectonics globally, we will be able to place Titan into the context of the other outer planet icy satellites.

Global stress may also result from the formation of a high pressure ice layer resulting in contraction and concentration of mass in Titan's interior have consequences for tidal stress on its surface. Formation of a high pressure ice-layer and thickening of Titan's outer ice-shell will reduce the response of Titan to the diurnal tide-raising potential it feels from Saturn. The change in tidal response will produce stress on Titan's surface, affecting the tectonic structures that are seen.

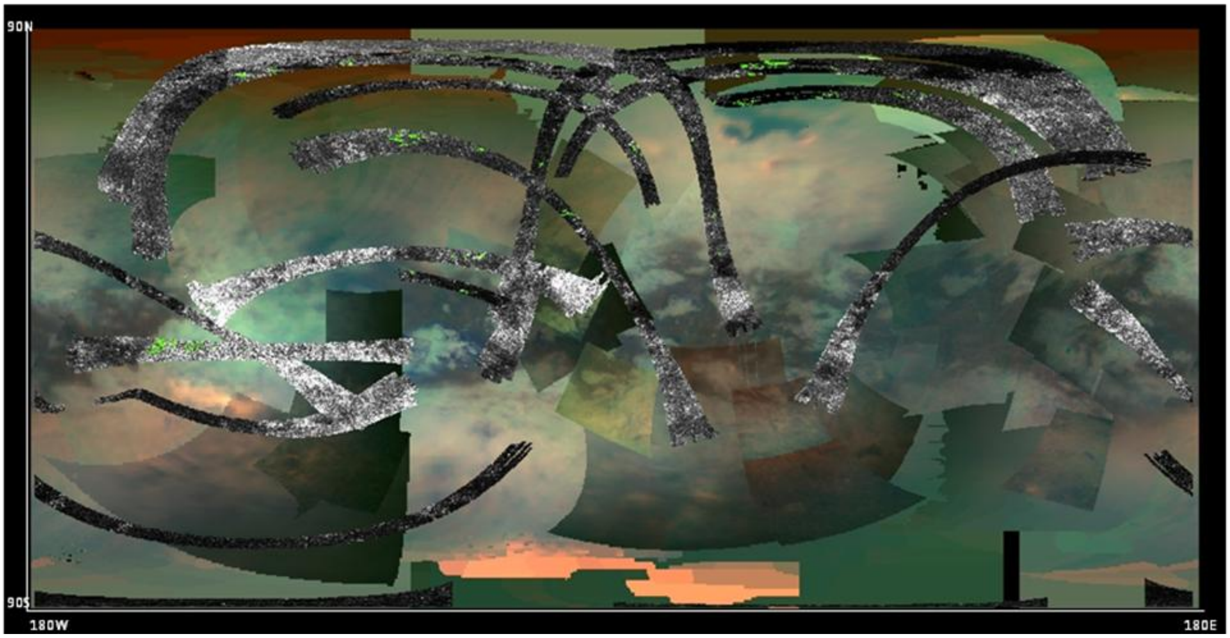

Fig. 2. The map abaove was created in ArcGIS by layering VIMS high resolution images and RADAR swaths. The virgae are mapped using the VIMS high resolution images, while mountain chains are mapped by analyzing the RADAR swaths. This is a map in progress, as not all available RADAR swaths are projected as of this date.

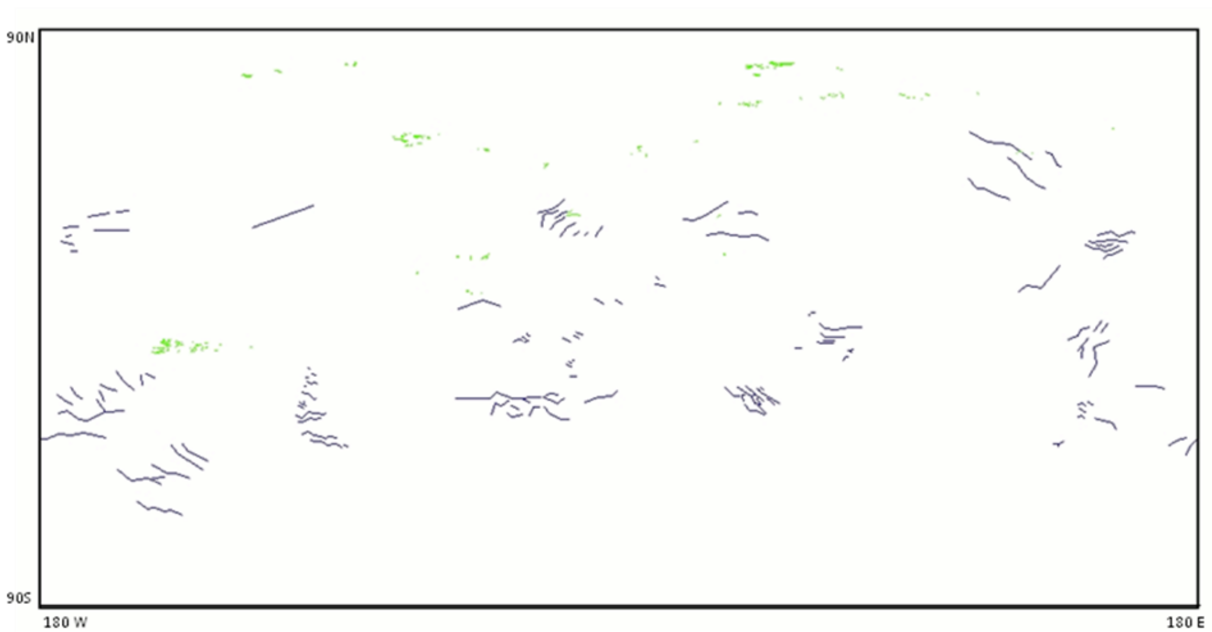

Fig. 3. The images above is a cylindrical mapping of the preliminary results of mapped virgae (blue) and mountain chains (green). Note this images is a work in progress and not all mountain chains have been identified.

By quantifying the magnitude of the diurnal stress produced by the change in tidal response with the stress from rotational spin-up and radial contraction we will be able to see how this source of stress can change the orientation of stresses on Titan's surface. The orientations of mountain chains and virgae formed from the various sources of global stress provide clues to the dominate mechanism driving tectonism on Titan.

References:

[1] Liu et al., Evidence for an Endogenic Origin of Mountains on Titan [Abstract], 43rd Lunar and Planetary Science Conference, March 19-23, 2012, Houston, Tx.

[1] Radebaugh, J., Lorenz, R.D, Kirk, R. L., Lunine, J. I., Stofan, E. R., Lopes, R. M. C., Wall, S. D., & the Cassini Radar Team. (2007) *Icarus, 192,* 77