Tectonics on Pluto and Charon: What might we find?

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The majority of Pluto and Charon sized icy bodies that we have visited with spacecraft show evidence of past, or even current, tectonic activity on their surfaces. Ice is generally weaker and squishier (lower tensile strength, lower Young's modulus, lower viscosity) than typical silicate rock at the same homologous temperature, so perhaps it is not surprising that icy bodies are more likely to exhibit evidence of tectonic activity. However, there still needs to be a driving force behind such tectonism. Possibilities include: changes in the rotational and tidal equilibrium figure of the body; diurnal tidal fluctuations; volume change due to freezing of an interior ocean; thermal or compositional overturn within the ice crust; and lateral flow due to variations in ice shell thickness. Much of the tectonic activity we have observed on icy satellites can be traced to stresses induced by tidal interactions with the giant planets around which they orbit. At first glance, Pluto and Charon would seem to be exempt from this general rule as they do not orbit a giant planet, but their close proximity and gravitational influences on each other may actually bring tidal stress back to a central role when considering their tectonics.

Observations of Pluto's tectonics by New Horizons may give us insight into the orbital evolution of the Pluto-Charon binary system (*Collins and Pappalardo,* LPSC 2000; *Collins and Barr*, Fall AGU 2008; *Barr and Collins*, paper in prep.). The initial orbit of Charon is unknown, but the evolution of most possible initial states to the current mutually locked state is dominated by momentum transfer from Pluto's rotation to Charon's orbit. The dominant stress in this case is despinning stress on Pluto, with a smaller amount of stress from tidal recession on Charon. The rate at which the momentum transfer takes place is controlled by the Q of Pluto, which in turn is a function of the effective viscosity and interior structure of Pluto. Since the effective viscosity of Pluto's interior can be influenced by tidal heating during orbital evolution, there is a potential feedback loop in this system that could cause thermal runaways. Modeling by my collaborator Amy Barr (paper in prep.) strongly suggests only two options for self-consistent models of Pluto: (a) undifferentiated, cold, and stiff, with a very long timescale (> Ga) for orbital evolution; or (b) strongly heated during rapid orbital evolution (10s of Ma), with a subsurface ocean. Option (a) does not produce significant despinning stresses, but option (b) may produce hundreds of MPa of despinning stress, enough to form abundant tectonic features. Despinning reduces the oblateness of the spheroid along the polar axis, causing E-W oriented extensional features (e.g. normal faults) near the poles and N-S oriented contractional features (e.g. thrust faults) near the equator, as are found at the opposite end of the solar system on Mercury. Observations of the existence, distribution, and nature of tectonic features on Pluto may thus hold essential clues to the early evolution of the Pluto-Charon system.