OPEN QUESTIONS ON THE GLOBAL CONTRACTION OF MERCURY. Christian Klimczak¹ and Paul K. Byrne², Structural Geology and Geomechanics Group, Department of Geology, University of Georgia, Athens, GA 30602, USA (klimczak@uga.edu), Planetary Research Group, Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University, Raleigh, NC 27612, USA.

Introduction: Mercury’s tectonic history is dominated by global contraction driven by secular planetary cooling, which is expressed on its surface by thousands of thrust fault-related landforms. Although substantial progress has been made on determining the amount, timing, and rate of global contraction [1–3], many unanswered questions remain regarding the temporal aspects of this process, the associated structural styles of faulting, and the interaction of global contraction with other planetary-scale processes.

Timing and rate of global contraction: Given that the planet’s extant magnetic field requires a molten core, and so there remains a flow of heat from the interior to the surface, Mercury must be contracting at present. Geologic observations do not confirm that global contraction-induced large-scale thrust faults are presently active [2], but relatively small, well-preserved thrust fault-related landforms probably formed within the past several hundred million years [4]. As the rate of global contraction has likely substantially decreased over time [2], it remains to be determined if shortening from global contraction at a very slow rate is entirely partitioned into weaker regolith materials, as suggested for the Moon [3], or if strain is also accommodated along larger structures that experience periods on the order of tens to hundreds of millions of years of quiescence.

The timing of the onset of global contraction is not yet well understood, in part because Mercury’s record of tectonic deformation may date to no earlier than the end of the late heavy bombardment (LHB), and because there is an initial phase of global contraction that is not expressed in the geologic record [2]. Additionally, it has yet to be explored how fast Mercury’s early lithosphere cooled relative to the interior. If it initially cooled at a faster rate than the interior, the lithosphere should have undergone extension in a manner similar to thermal contraction of lavas. Such incipient extension has not been substantially investigated for Mercury, however, and any such deformation probably preceded the emplacement of even the oldest surface units now preserved on the planet. Yet the growing body of evidence that Mercury’s early history featured voluminous effusive volcanism is consistent with an early phase of rifting, perhaps contraction-induced, with those rifts facilitating the rapid and widespread eruption of flood basalts onto the surface of the planet [5].

Shortening structures: Our earlier distinction of types of shortening structures with respect to terrain, e.g., “smooth plains structure” [1], was motivated by the observation that such landforms often share morphological characteristics that defy traditional classifications such as “wrinkle ridge” or “lobate scarp”. The broad morphological variety of these structures has not been sufficiently quantified for Mercury. Therefore, there is as yet no robust characterization of key structural information on thrust system architecture at the surface and in the subsurface that would further shed light on the strain rates and diversity of structural styles of thrusting on Mercury, or permit their classification in a consistent structural manner.

Tidal despinning: The influence on global contraction of the slowing of Mercury’s rotation to its present spin–orbit resonance remains to be fully explored. For scenarios under which despinning occurred early in the planet’s history and spanned hundreds of millions of years, or started during or even after the LHB but for a much shorter duration, it is not difficult to imagine it overlapping temporally with global contraction [e.g., 6]. On the other hand, despinning may have been rapid and/or operated only before the LHB. For this process to influence the tectonic pattern Mercury retains today, then, any despinning structures that formed must have been sufficiently deep-seated to survive resurfacing from impact bombardment and effusive volcanism responsible for erasing any of the planet’s surface older than ~4.1 Ga [7]. Determining whether or not the perceived –north–south fabric of Mercury’s shortening structures [1,6] is an artifact of solar illumination is also an important objective, as the answer will either update existing models for the planet’s tectonic and thermal evolution or call for the formulation of new ones.

Influence of other processes: Assessments of areal strain recorded by shortening structures in the intercrater versus smooth plains may indicate whether stresses from vertical loading have contributed to the formation of landforms found in smooth plains [8]. Similarly, the effects of solar tidal stresses, long-wavelength topographic changes, and thermal stresses from Mercury’s spin–orbit resonance on its lithosphere and on its global fault pattern remain largely unexplored.