A GLOBALLY DISTRIBUTED COMPRESSIONAL RIDGE SYSTEM ON MARS?
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Recently, it has been suggested that a globally distributed ridge system is evidence of global compression resulting from planetary cooling over a large portion of the geologic history [1, 2]. The concept of a globally distributed compressional ridge system involving many units with widely different ages, is in contrast to a number of studies that show that the vast majority of the wrinkle ridges, landforms generally attributed to folding and/or thrust faulting, occur in ridged plains material that are dated Middle Noachian (Nplr) and Early Hesperian (Hr)[3, 4, 5]. Of the two, the Hr units are by far the most extensive. Many landforms, however, mapped or described as wrinkle ridges occur in other units [3, 4, 5, 6], including Noachian cratered uplands units. Features mapped as wrinkle ridges occurring in units other than ridged plains were examined using the morphologic criteria introduced in [7]. With very few exceptions, these landforms did not have the morphologic elements characteristic of wrinkle ridges. They fall into two general categories, simple ridges and scarps.

Simple ridges are generally linear to sinuous, narrow topographically positive features that lack the characteristic morphology of wrinkle ridges. Simple ridges may have a variety of origins, however, many appear to be either erosional or depositional in nature. Examples of simple ridges that are the result of erosion are found on Hellas Planitia (figure 1A). The plains material appears to have been deeply dissected forming ridges and valleys oriented toward the center of Hellas. In the south polar region, the Dorsa Argentea is comprised of a number of very narrow, highly sinuous simple ridges (figure 1B). These features, and others like them in the Argyre region and elsewhere, are possibly either inverted stream topography, spits or bars, exhumed igneous or clastic dikes or glacial eskers [see 8]. Exceptions to simple ridges that are not either erosional, depositional or volcanic in origin are found in the Noachian cratered uplands adjacent to units of ridged plains material, are larger than wrinkle ridges (1 - 3 km in height), but are much less abundant [9]. They are interpreted to be compressional tectonic features because they deform crater floors and are generally similar to terrestrial thrust fault scarps [9, 10].

Scarps are generally one-sided, often lobate and segmented features. Many of these scarps are morphologically similar to highland scarps observed on the Moon and Mercury that are interpreted to be the results of reverse or thrust faulting [11, 12, 13]. A relatively large concentration of scarps occur in the Noachian cratered uplands of Terra Cimmeria, north of Hesperia Planum (Figure 2A). The scarps of this region as well as others that occur in the cratered uplands are thought to be Noachian in age [4]. However, this is difficult to determine with confidence because there are no clear superposition relationships and many of the scarps can be traced through crater floors.

The results of this study indicate that there is no strong evidence for a globally distributed system of compressional tectonic features on Mars, consisting of either wrinkle ridges, scarps or simple ridges with a compressional origin, that deform materials that range widely in age. The only evidence of significant compression during the Noachian is found in the ridged plains unit mapped as Nplr. Based on several lines of evidence, Frey et al. [14] suggest that the Nplr resurfacing event was contemporaneous with the Early Hesperian ridged plains (Hr) event. Even if Nplr is Noachian in age, compressional deformation on Mars clearly peaked during the Early Hesperian. If Nplr is Early Hesperian in age, then there is no evidence of globally significant compressional deformation outside the Early Hesperian. The scarps and simple ridges of compressional origin that occur in the upland material, assuming they are Noachian in age, do not constitute a significant globally distributed system of compressional features. This suggests that if global contraction due to rapid cooling was a component of the compressional stresses that formed the wrinkle ridges, that it was the most significant during the Early Hesperian. The Early Hesperian pulse of global volcanism likely resulted in a phase of rapid cooling and global contraction that contributed to the deformation of the ridged plains material.
COMPRESSIONAL RIDGE SYSTEM: Watters, T.R.


Figure 1. Examples of simple ridges that have been mapped as wrinkle ridges. (A) Simple ridges formed by erosion on Hellas Planitia and (B) ridges of Dorsa Argentea.

Figure 2. (A) Example of a simple ridge located in Memnonia. (B) Upland scarps of Terra Cimmeria. These features are probably the results of compressional deformation.