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Polygonal impact craters reveal a global fracture pattern on Mercury

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Mercury's surface displays a rich history in impact cratering and tectonic activity, which both provide insight into the geological evolution of the innermost planet. Global contraction, the volume decrease of the planet associated with a long, sustained period of cooling, and tidal despinning, the slowing of rotation to lock Mercury in its current 3:2 spin-orbit resonance with the sun, are both thought to have played an important role on the observed systematic variations of preferred orientations of thrust fault-related landforms across the planet. While these landforms show preferred north-south orientations in the equatorial and mid-latitudes, they show random or concentric (east-west) orientations at the poles. Other fractures, such as joints, are likely present on Mercury, too, but their expressions are too subtle to be identified unless they are utilized as crater rims during the emplacement of impact craters. Fracture sets that existed in the bedrock prior to impact are widely accepted to produce crater rims showing straight rim segments that overall result in polygonal plan-view shapes of the impact structures, with perhaps the most prominent example Meteor Crater, Arizona. To test if regional fracture sets actually governed the shape of polygonal impact craters on Mercury, we have rigorously mapped all impact craters with diameters between 20 to 400 km. A total of 7,146 impact craters were mapped using Mercury Surface Space ENvironment GEochemistry and Ranging (MESSENGER) global image and topography datasets. After analyzing the shape, lengths, and orientations of 124,671 rim segments, we assessed if these rim segments contain additional information about systematic tectonic patterns. Our results show a strong preferred east-west orientation of straight crater rims at the poles, while in the mid-latitude and equatorial regions, they only have weak north-south or random orientations. That straight crater rims to show preferred east-west orientation at the poles is consistent with observed fault orientations by previous studies. However, we observe a lack of correlation of straight crater rim orientations and mapped faults at the equatorial and mid-latitudinal regions. These results have implications for and will enable further quantitative investigations of the global tectonics and fault reactivation on Mercury.