CATENAE: THE GROOVES OF MERCURY. E. R. Fegan1, D. A. Rothery1, S. J. Conway1 and M. Anand1,2,  
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Introduction: Catenae are chains of more-or-less coalesced craters found on the surfaces of various planets and moons in the solar system. On the Martian moon Phobos it has been hypothesised that they are secondary impact chains, the primary craters for which are located on the surface of Mars [1]. On Jovian moons Callisto and Ganymede, comets fragmented by Jupiter's gravitational field are thought to have formed catenae by serial impact [2].

Only three Hermean catenae have been formalised in the USGS planetary nomenclature database. However, catenae are more common on the surface of Mercury than previously identified.

It is possible that these catenae might be chains of secondary impact craters. For example, those that are proximal, straight and radial (or nearly radial) to impact craters are almost certainly chains of secondaries. However, there are others that are apparently unrelated to any potential primary impact feature. Sometimes, Hermean catenae are observed to bend or divert round the edges of older craters (see Fig. 1), which is hard to reconcile with a conventional origin as chains of secondaries. Similar features on the Moon have been suggested to have formed by an internal process such as subsidence of the surface [4] rather than by impact processes.

This work documents the occurrence of catenae across the Hermean surface and investigates whether they have a preferential orientation, or are more common on certain geologic units, as these data may help establish whether they are formed by impact processes.

Method: We conducted a global survey of catenae by visually examining the surface using the MESSENGER (MDIS global mosaic v9) in ArcMap and digitising catenae. Next, we calculated the compass bearing (strike) of each of the catenae to see if there is a global trend in orientation. Finally we examined the geological units in which catenae are most commonly found by calculating the average line density for certain geologic units. The line density of catenae for the

Figure 1: An un-named catena on Mercury, indicated by red arrows. MDIS mosaic, equirectangular projection. A landslide in the crater at the southern end of the catena may have been triggered by its emplacement [3].

Figure 2: Global distribution (red lines) and line density, features/km² (grey-scale shading, light indicates high density with a maximum value of 0.00547) for catenae, shown on a global MDIS mosaic. Blue outline indicate Caloris Plains.
The global survey, which includes 399 identified catenae, and global line density results are shown in Figure 2, and catena density for three geological units is shown in Table 1. Catenae are seen all over the surface, they range from 5-300 km in length and are between 10 and 30 km in width. There are pronounced clusters. Chains formed by the impact of large secondary fragments would be expected to form proximal to a large primary impact crater [6], and should therefore be found in clusters around basins. In some cases this is so, in which case the catena in that cluster are almost certainly all secondary impact chains, but not all.

Globally, the orientations of catenae appear to show a preference for NNE-SSW and NNW-SSE (Fig. 3). If they were all secondary chains, one would expect a random mixture of orientations. The features are large enough that we do not expect lighting bias to be playing a significant role. Perhaps the responsible process might be similar to that suggested for the Jovian satellites [2] – comets or asteroids are fragmented by the Sun and impact upon the surface of Mercury creating crater chains without a primary crater.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Mean line density (per km²)</th>
<th>Areal extent (km²)</th>
<th>Relative age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global</td>
<td>0.000458</td>
<td>7.58 x 10¹</td>
<td></td>
</tr>
<tr>
<td>Smooth plains</td>
<td>0.000065</td>
<td>1.01 x 10¹</td>
<td>Youngest</td>
</tr>
<tr>
<td>Crater materials</td>
<td>0.000173</td>
<td>1.80 x 10¹</td>
<td></td>
</tr>
<tr>
<td>Inter-crater plains</td>
<td>0.000207</td>
<td>1.25 x 10¹</td>
<td>Oldest</td>
</tr>
</tbody>
</table>

Table 1: Mean line density of catenae on selected geological units, and area/relative age of those units.

Catenae are most numerous on the Intercrater Plains (the oldest terrain on the surface [7]) and Crater Materials (a unit consisting of all craters and associated ejecta blankets) units.

This is not simply because these units cover the greatest area (although Crater Material unit is very extensive, see Table 1); the line density of features is higher on these units than on the Smooth plains (see Table 1). It should also be noted that we have found very few catenae on the Caloris plains (see Fig. 2), which might suggest that the responsible process only occurred pre-Calorian.

**Preliminary Conclusions:**

- Catenae are relatively common on Mercury; we identified 399 in our survey.
- Catenae on Mercury are found mainly on older plains and material associated with impacts (ejecta). They are not common on smooth plains, and are very rare on the Caloris Plains. This suggests that the processes forming them were more common pre-Calorian.
- They are not evenly distributed across the surface, which would support their origin as secondary impact chains if these clusters all surrounded impact structures. At this early stage it appears that this is not always the case. Some catenae cannot be easily explained as secondary impact chains.
- Catenae have strongly preferential orientations (approx. N-S). This is not expected if the population is dominated by secondary impact chains.
- Our work so far suggests that the mechanism of formation could be secondary chains, but that other processes (such as the impact of fragmented comets/asteroids, or an internal process which was on surfaces of certain age (possibly pre-Calorian)) could also play a role.