EXPLORING THE GEOCHEMICAL IMPLICATIONS OF TERRANES DERIVED FROM PRINCIPAL COMPONENTS ANALYSIS. K. R. Stockstill-Cahill$^1$ and P. N. Peplowski$^1$, $^1$Johns Hopkins Applied Physics Laboratory, 11100 Johns Hopkins Road, Laurel, MD 20723; Karen.Stockstill-Cahill@gmail.com.

Introduction: Previous efforts to define geochemical terranes on Mercury [1,2] used limited compositional information and/or defined some terrane boundaries to match geomorphic features, despite a lack of evidence that the two are correlated [2]. To resolve these issues and provide a more robust, analytical definition of terranes that include all available datasets, Peplowski and Stockstill-Cahill [3] utilized a principal components analysis (PCA) of elemental composition (Mg/Si, Al/Si, [1] and K [4]) and neutron (GRS/ACS) [2] maps. These maps provide complete northern hemisphere coverage, but lack coverage in the southern hemisphere; so the PCA maps are also limited to the northern hemisphere (Fig. 1).

Figure 1. An RBG map of the Principle Components derived from PCA of MESSENGER-measured Mercury elemental composition maps (Mg/Si, Al/SI, and K).

Principle component (PC) 1 (green) corresponds with the northern volcanic plains; PC2 (blue) corresponds with Caloris Basin interior plains (but is observed elsewhere for the first time); and PC3 (red) corresponds with the high-Mg region (orange-red is high-Ca, dark red with low-Ca). Scatter plots (e.g., Fig. 2) of the Mercury geochemical data, color-coded by geochemical terranes, were then used to identify the compositional characteristics of the terranes [1].

Figure 2. Scatter plot with data color-coded to geochemical terranes from [1].

Methods: Using the compositional characteristics of the terranes derived by [1], we are evaluating the petrologic history and geochemical implications for the various geochemical terranes. First, we used the methods of [8] to derive oxide abundances from the elemental ratios produced by MESSENGER XRS and GRS. Then a modified CIPW normative analysis [5] was used to derive mineralogy. We used IUGS petrologic classification diagrams [6,7] to classify the rock types. We are also using petrologic modeling to understand Mercury’s mantle evolution.

Results: The PCA/RGB map (Fig. 1) reveals variability in elemental composition. Spatially contiguous regions with distinct elemental properties, or geochemical terranes, are observed. The geochemical terranes inferred from this map largely correspond to previously identified geochemical terranes [2,9] (Table 1), although the map includes new identifications of previous terranes (e.g., “CB/blue” near 330E, 40N) and one new unit – an intermediate, high-K (IHK) of Rustaveli Basin ejecta that appears in orange hues (Fig. 1). Rustaveli is within the northern plains (NP), but is sufficiently large that its ejecta samples below the plains unit, exposing underlying, pre-plains materials. Identification of this new geochemical unit facilitates studies of the pre-plains surface chemistry.

Table 1: Major units identified in Fig. 1

<table>
<thead>
<tr>
<th>PC unit</th>
<th>Color</th>
<th>Terrain</th>
<th>Abbr</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC1-dominated</td>
<td>Green</td>
<td>Low-Mg northern plans</td>
<td>NP-LMg</td>
</tr>
<tr>
<td>PC2-dominated</td>
<td>Blue</td>
<td>Caloris Basin</td>
<td>CB</td>
</tr>
<tr>
<td>High-PC3</td>
<td>Red</td>
<td>High-Mg Terrane; Rachmaninoff</td>
<td>HMG_T; RB</td>
</tr>
<tr>
<td>High-PC3, moderate PC3</td>
<td>Pink</td>
<td>High-Al Terrane</td>
<td>HAIT</td>
</tr>
<tr>
<td>Moderate-PC2, Purple moderate-PC3</td>
<td>Orange</td>
<td>High-Mg northern plains</td>
<td>NP-HMg</td>
</tr>
<tr>
<td>High-PC3, moderate-PC1</td>
<td></td>
<td>Intermediate, high-</td>
<td>IHK</td>
</tr>
<tr>
<td></td>
<td></td>
<td>K Terrane</td>
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The SiO₂ abundances are 51-64%, similar to previous studies [8,10]. When the compositions are plotted on the total alkali silica (TAS) diagram (Fig. 3), they range from basalt to trachyte. The main differences are: 1) the NP-LMg terrain contains more SiO₂ and alkalis, reclassifying it from Trachyandesite of [8] to Trachyte (Fig. 3); and 2) the Rachmaninoff Basin contains more SiO₂ than found by [8]. This difference only reflects differences in how those terranes were defined.
We note that McCoy et al. [10] also defined northern plains as a trachyte. Although the high-Mg nature of Mercury would require classification as komatiites or boninites [6], the units also contain excessive alkalis to be true komatiites or boninites (Fig. 3).

Figure 3. TAS diagram showing the 7 PCA-derived geochemical terranes, including the high-MgO classification (gray fields) of [6]. Symbol colors are tied to the color displayed for that unit on the PCA map.

The derived mineralogy is plotted on IUGS petrologic classification diagrams in Figure 4. In general, the units are rich in plagioclase and pyroxene, with variable amounts of olivine classifying them as (olivine-bearing) gabbronorites (Fig. 3a). The units also vary from orthopyroxene-rich CB to clinopyroxene-rich HMgT (Fig. 3b). In general, increasing clinopyroxene matches well with increasing olivine (Fig. 3a), except for the low-Al Mg northern terrane. This variation results in a range of classifications, including (olivine-bearing) orthopyroxenite, (olivine-bearing) websterite, lherzolite, and wehlrite (Fig. 3b).

When relating the end members that appear in the scatter plot (Fig. 2), we can see that the HMgT (red-orange) end member with the low Al/Si but high Mg/Si is the most primitive composition (Fig. 3) plotting within the basalt field. That composition results in a normative mineralogy that is relatively olivine-rich and completely lacks orthopyroxene (Fig. 4b). In addition, the NP-LMg (green) end member with the low Al/Si and Mg/Si is the most evolved composition, plotting within the trachyte field (Fig. 3). The resulting normative mineralogy contains no olivine, but is a mix of plagioclase and two pyroxenes (Fig. 4). The compositions with relatively high Al appear to be in the intermediate compositions (Fig. 3), plotting as basaltic andesites and andesites, with intermediate amounts of olivine and plagioclase (Fig. 4).

**Conclusions:** Geochemical terranes can be defined solely on geochemical considerations using PCA to identify end member units. Geochemically, these units show a range of compositions, from primitive to evolved with variable abundances of major minerals (plagioclase, olivine, pyroxenes). Compositional information will also be used with petrologic modeling to characterize magma characteristics (solidus temperature, viscosity) where applicable to aid in understanding the petrologic history of Mercury.

**References:**