Venus Surface Geochemistry-Landers

Sapas Mons (NASA/JPL)
Venus lander probes and their landing sites

Source: NASA/JPL/Massachusetts Institute of Technology
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## Lander Summary

<table>
<thead>
<tr>
<th>Lander</th>
<th>Data</th>
<th>Result</th>
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<tbody>
<tr>
<td>Venera 8</td>
<td>K-U-Th</td>
<td>High K, Th, U</td>
</tr>
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<td>Venera 9</td>
<td>K-U-Th</td>
<td>Low K, U, high Th</td>
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<td>Major element comp.</td>
<td>Alkali basalt</td>
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Tholeiitic basalt- relatively high Si; ocean island
Alkali basalt- high K and Na; ocean island and continental
Outline

Volcanic Plains and Rises
- U-Th-K
- Ca-Al-Ti
- FeO
- Mg/Fe
- FeO/MnO

Bonus Geochemistry! Venus’ Highlands
- Highland Plateaus
- Ishtar Terra
- Steep-Sided Domes
- Long Channels (Canali)
Color as seen on the surface of Venus

Color with atmospheric effects removed

VENERA 13

Pieters et al., 1983
U-Th-K

Geochemical Processes

- U and Th behave the same in melt (incompatible) and in nebula (refractory)
- High U, Th, K indicative of felsic rock

Implications for Venus

- Th concentrations not homogenous: chemical differentiation
- Possible U and Th fractionation: alteration by fluids?
- High K$_2$O values: extensive crust/mantle differentiation
FeO

Geological Process
• Fe of mantle and mantle-derived basalt comparable (if mantle is peridotitic, like Earth’s)

Implications for Venus
• Venus basalts comparable to primitive Earth MORBs (Mid-ocean ridge basalts): comparable mantles

Peridotite (Smithsonian MNH)

Mid-ocean ridge (UMD)
\[ \text{Mg}^* = 100 \times \frac{\text{Mg}}{\text{Mg} + \text{Fe}} \]

Geological Process

- \text{Mg}^* \text{ indicator of degree of basalt’s fractionation}
  - Primitive: \( \approx 68 \)
  - Highly evolved: \( \approx 40 \)

Implications for Venus

- Venus basalts have \( \text{Mg}^* = 73 \): formed from mantle, or Venus’ mantle contains more Mg than Earth’s

Modified from Zhang et al., 2009
FeO/MnO

Geological Process
- Fe/Mn ratio tracer for core formation - behave similarly in condensation, but not core differentiation

Implications for Venus
- Mn value very imprecise, averages about 50: basalts most similar to Hawaiian OIB (Ocean island basalts)

Modified from Zhang et al., 2009
## Geochemistry of Venus’ volcanic plains

- Volcanic plains and rises made of basalt, most similar to Earth’s OIB (uncertainties!)

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Does structure give a clue?

Steep-sided (Pancake) Domes
- Structure suggests lava more viscous than basalts
- Difference in composition or mechanical properties (crystals or bubbles)?

Long Channels (Canali)
- Short channels- similar to those on moon
- Long, wide channels- very low viscosity fluid
- Liquid sulfur, carbonates?

Pancake domes (LPI)
Canali (NASA/JPL)
Venus lander probes and their landing sites
Conclusions

• Venus is morphologically diverse - lowlands, highlands, volcanos...
• Basalts geochemically diverse - depleted/enriched in incompatible elements; magmatic/mantle differentiation
• Silica-rich, widespread terrain would suggest plate tectonics - Ishtar Terra?

Sapas Mons (NASA/JPL)
Future work

• Remote Sensing
• Landers
  – Instrumentation: APXS, CheMin from MER and MSL
  – Where to land? Balloon?
• Sample Return- technically possible