Planetary Volcanism

Reference:
Encyclopedia of Volcanoes: pp. 721-774

General Information

- Volcanism in some form or another has affected the surfaces of all solid planetary bodies in the solar system
- Gravity, magma/lava rheology, and environmental conditions greatly affect eruption styles and the final appearance of any volcanic products

Contrasts

- Volcanism on the terrestrial planets
  - Dominated by basaltic effusive volcanism
- Volcanism in the outer solar system
  - Dominated by some weird stuff
  - Water, brines, methane, and ammonia

Volcanism on the Moon

- The surface is very old
- Few explosive eruptions
  - “Orange” and “green” glass beads
  - Dark halo craters
  - Dark mantling deposits
  - CO most likely volatile

Lunar Lavas

- Lunar mare
- Basaltic
- Primitive, hot & runny
- Thin, long flows
<table>
<thead>
<tr>
<th>Sinuous Rilles</th>
<th>Mercury</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Thermal erosion? Schroter’s Rille</td>
<td>• Relatively huge core</td>
</tr>
<tr>
<td></td>
<td>– Resulting from early enormous impact</td>
</tr>
<tr>
<td></td>
<td>• Mariner 10 imaged only ~1/3 of Mercury's surface</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Surface Features</th>
<th>Venus</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Intercrater plains</td>
<td>• Earth's &quot;twin&quot; in terms of size, mass, density...</td>
</tr>
<tr>
<td>• Smooth plains</td>
<td>• Early Earth and early Venus similar?</td>
</tr>
<tr>
<td>– Both intercrater and smooth plains are probably volcanic</td>
<td></td>
</tr>
<tr>
<td>• Both most likely &gt;3.8 by (billion year) old</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Current Conditions on Venus</th>
<th>Venusian Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Surface temperature ~450°C</td>
<td>• No terrestrial-style plate tectonics</td>
</tr>
<tr>
<td>• Pressure ~90 bars (~1500m depth below sea level on earth)</td>
<td>• Current surface as young as 0.5-0.3 by</td>
</tr>
<tr>
<td>• Thick CO₂ atmosphere with some sulfuric acid clouds</td>
<td>• Formed by lithospheric overturn?</td>
</tr>
<tr>
<td></td>
<td>• All sorts of funky volcanic forms</td>
</tr>
</tbody>
</table>
Domes Near Alpha Regio

- ~25 km wide
- ~750 m high
- Small central pit
- Variety of crack patterns
- Obvious overlapping

Domes on Eistla Regio

- ~65 km wide
- ~1 km high
- Tops flat or bowl-shaped
- Small central pit

Ushas Mons

- > 500 mk wide
- 2 km high
- Bright rough lavas
- Smooth summit
- N-S faults

Sapas Mons

- 120 km wide
- 1.5 km high
- Many narrow lavas
- Darker lavas older

Lava Types

- Landers suggest primarily basalt
- Possibly some trachytes
- Maybe some rhyolites

“Ticks”

- 66 km wide
- Broad and flat
- Short radial ridges
- “Head” has collapse pits
Other Lava Compositions

- Komatiites
- Carbonatites
- Sulfur lavas?

Mars

- No terrestrial-style plate tectonics now
- Spreading center in ancient past?

Crustal Dichotomy

- Smooth, young northern hemisphere
  - Primarily basaltic (TES data)
- Cratered ancient southern hemisphere
  - Primarily andesitic (TES data)

Wide Range of Volcanic Landforms

- Tharsis and Elysium landforms suggest primarily basaltic lavas
- Possibly some andesites?
- Maybe some komatiites?
- Patera
- Scoria Cones

Tharsis Montes

Chain ~ 1500 km long
25-27 km high
May have formed over a shifting hotspot

Olympus Mons
Olympus Mons
Caldera

Tyrrhena Patera

~300 km wide
2 km high
Central caldera
Ring fractures
Broad radial furrows

Scoria Cones

Scoria Cones

Io

Only other volcanically active planet in the solar system (besides Earth)
Tidal heating. Over 300 volcanoes identified

Io Composition

- Lavas primarily silicates
  - Probably basalts
- \( \text{SO}_2 \) is probably primary volatile
- \( \text{SO}_2 \) “snow” common

High Temperature Consequences

- Very high temp lavas may indicate komatiitic compositions
- Hot spots migrate over time (comparison of Voyager and Galileo data)
<table>
<thead>
<tr>
<th>Europa (and Others?)</th>
<th>Triton</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Cryovolcanism</td>
<td>• Solid nitrogen and methane surface (probably some water ice too)</td>
</tr>
<tr>
<td>• Quite young (but how young?)</td>
<td>• Seasonal geysers of liquid methane and nitrogen due to solar heating</td>
</tr>
<tr>
<td>• Water ice &quot;crust&quot; with liquid water &quot;mantle&quot;</td>
<td>• 8-year cyclicity tied to the seasons</td>
</tr>
<tr>
<td>• What are the mechanisms of water/ice eruptions? What are the volatiles involved?</td>
<td></td>
</tr>
</tbody>
</table>