

**Core Formation on EPB, Moon,  
Mars, Earth & Venus:**

**Rhapsody on a Theme by  
~~Paganini~~ Ringwood**

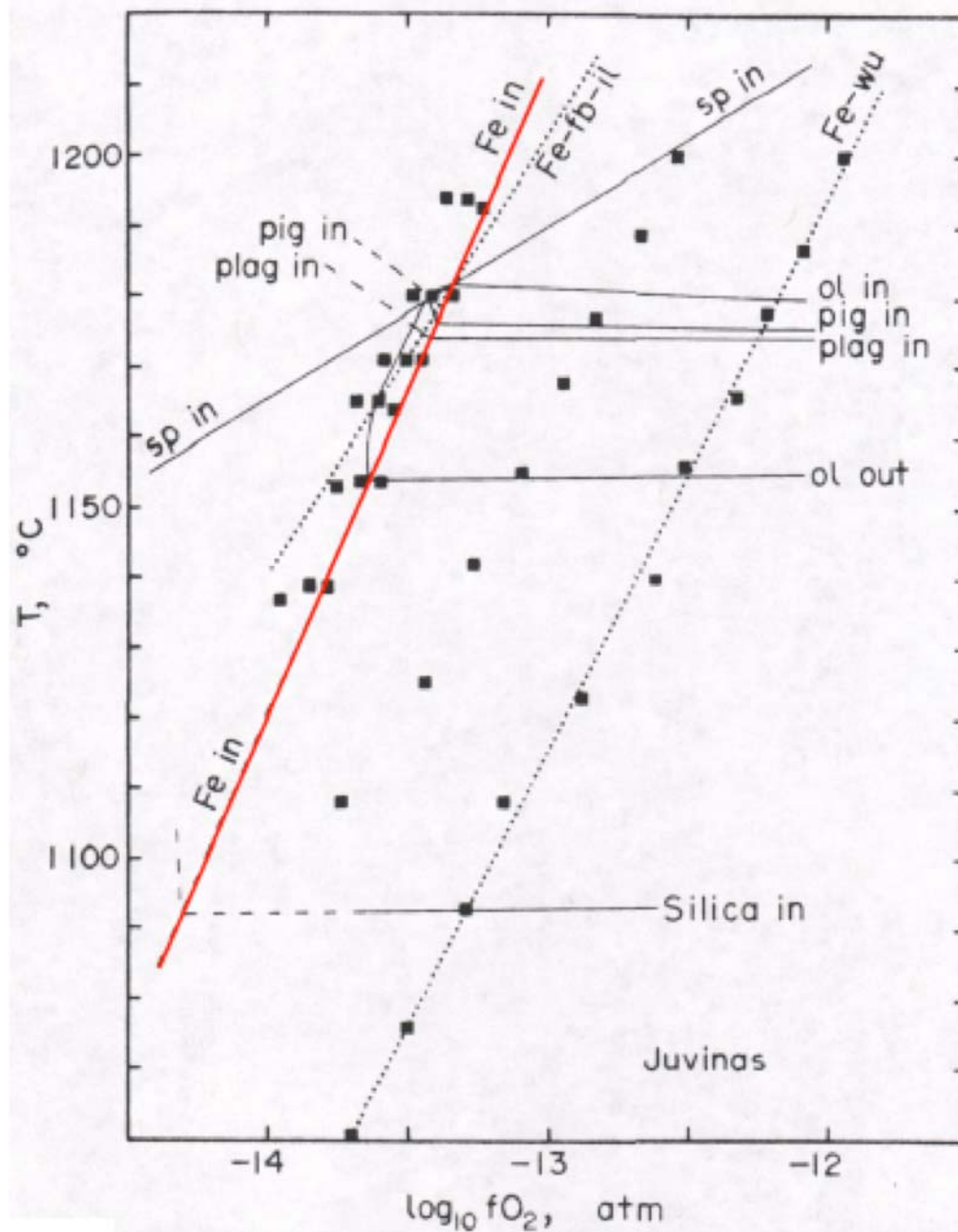
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# What Should the FeO Content of Planetary Basalts Be?

- Eucrites contain ~18 wt.% FeO
- Experiments of Stolper (1977) constrain the metal-silicate equilibria for one body — the EPB
  - Look for multiple saturation of melt, olivine, pyroxene, metal  $\pm$  alumino-silicate
  - For eucrites this occurs at ~ IW-1
- This is about the  $f_{O_2}$  of an ordinary chondrite



**Stolper, 1977**

# What About the Moon?

- **Mare basalts also contain ~18 wt.% FeO**
- **Experiments of Walker et al. (1977) showed that mare basalts are nearly metal saturated**
  - **Experiments in pure Fe capsules neither gained nor lost FeO**
- **Implies that mare basalts are also formed at ~IW-1**

# What About Mars?

- **Basaltic shergottites also have about ~18 wt.% FeO**
- **Primitive shergottites from the depleted shergottite mantle have  $f_{O_2}$ 's in the vicinity of IW**
- **Because Mars has a core, the inference is that the martian mantle is also at or near IW-1**

# What About the Earth?

- **MORB & Arc magmas typically have ~8-10 wt. % FeO\***
- **OIB have slightly higher FeO contents, ~10-12 wt. %**
- **Fertile mantle xenoliths (spinel lherzolites) typically contain ~8 wt. % FeO**
- **The Earth appears to have lower FeO than the EPB, the Moon, and Mars**

# What about Venus?

- Only analyses of venusian basalts come from the short-lived Venera missions
- Within the uncertainties of the analyses, venusian basalts appear very “Earthlike”
  - ~10 wt.% FeO
- There is an apparent correlation between FeO content and planetary size

# Comparative Planetology of FeO

	<b>Eucrite Juvinas</b>	<b>Mare Basalt 15555</b>	<b>Shergottite Y980459</b>	<b>MORB Average</b>	<b>Venera 13</b>	<b>Venera 14</b>
<b>SiO<sub>2</sub></b>	<b>49.3</b>	<b>44.6</b>	<b>48.7</b>	<b>49.9</b>	<b>45.1</b>	<b>48.7</b>
<b>TiO<sub>2</sub></b>	<b>0.64</b>	<b>2.1</b>	<b>0.54</b>	<b>1.51</b>	<b>1.6</b>	<b>1.25</b>
<b>Al<sub>2</sub>O<sub>3</sub></b>	<b>13.0</b>	<b>8.7</b>	<b>5.3</b>	<b>17.2</b>	<b>15.8</b>	<b>17.9</b>
<b>FeO*</b>	<b>18.8</b>	<b>22.5</b>	<b>17.5</b>	<b>8.7</b>	<b>9.3</b>	<b>8.8</b>
<b>MnO</b>	<b>0.56</b>	<b>0.29</b>	<b>0.52</b>	<b>0.17</b>	<b>0.2</b>	<b>0.16</b>
<b>MgO</b>	<b>7.3</b>	<b>11.4</b>	<b>6.4</b>	<b>7.28</b>	<b>11.4</b>	<b>8.1</b>
<b>CaO</b>	<b>10.4</b>	<b>9.4</b>	<b>19.6</b>	<b>11.9</b>	<b>7.1</b>	<b>10.3</b>
<b>Na<sub>2</sub>O</b>	<b>0.47</b>	<b>0.27</b>	<b>0.48</b>	<b>2.8</b>	<b>—</b>	<b>—</b>
<b>Sum</b>	<b>100.8</b>	<b>99.2</b>	<b>99.0</b>	<b>99.5</b>	<b>90.5</b>	<b>95.2</b>

# Why?

**Larger bodies are more reduced & have intrinsically less FeO?**

- **Wänke heterogeneous accretion model**
- **Why are the Earth and Moon different?**
- **Same oxygen & chromium isotopes but different FeO?**
- **Earth-Moon comparisons suggest that Earth's FeO content is not inherited**

# Why? Con't

## Disproportionation of FeO into Fe & Fe<sub>2</sub>O<sub>3</sub>?

- Frost et al. experiments in perovskite field
  - Have these been reproduced?
- Does not explain high mantle siderophile element abundances
- Can fine-grained metal be separated from silicate matrix?

# Why? Con't

**FeO has entered the cores of Earth & Venus at high (P,T)?**

- Ringwood hypothesis based on almost no data**
- Stolper experiments not yet published?**
- At the time SNC's were not known to be from Mars & the Venera Missions were not yet launched**
- Still has the fewest objections?**

# Implications for the Earth's (and Venus'?) Core

- Need to reduce FeO from  $\sim 25$  wt.% (EPB-like) to 8 wt.% (Earth-like) by removing 17 wt.% FeO to the core
- This means 3.8 wt.% O removed from mantle to the core
- Corresponds to 4.1 wt.% O in core (4.5% if there is no O in the inner core)
- A combination of O and S might explain the density deficit of the outer core ( $\sim 9$ -10 wt.%)

# Summary

- **FeO contents of planetary mantles seem to be dependent on planet size**
- **Need mechanism to accomplish this**
- **FeO into the Earth/Venus cores?  
Negative  $\Delta V$  can cause an unfavorable reaction to occur at high pressure**