Comparative Silicate Magmatism of Asteroids and Terrestrial Planets

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Silicate magmatism was or is common on the terrestrial planets, our Moon, Jupiter's moon Io, and several asteroids. We have samples from the Moon, Earth, Mars, and several asteroids; these magmatic rocks are probes of the nature of the interior of the planetary bodies. What I've done here is compile chemical analyses of:

CI chondrites – undifferentiated meteorites that are thought To be building blocks of the terrestrial planets

Pyrolite – a compositional model for the Earth's mantle

Mid Ocean Ridge Basalt – the approximately uniform lava erupted from ocean ridges around the world

Lunar volcanic glass – relatively primitive Lunar mare basalt

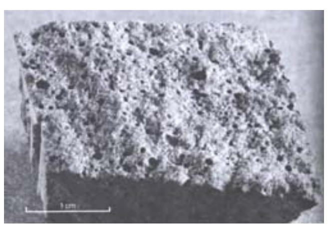
Shergotty, a basaltic meteorite from Mars

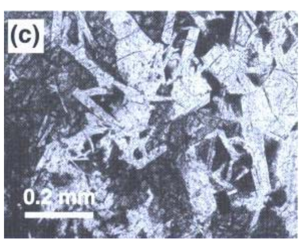
Average Gusev Crater soil

Adirondack, a Martian surface rock, "as is" and abraded

Sioux City, a basaltic meteorite (eucrite) thought to be from The Asteroid Vesta

Acapulco, a partially melted, primitive meteorite from an unknown source





Basaltic meteorite Ibitara (left – note vesicular texture) and thin section of basaltic clast from eucrite Pasamonte (right – note ophitic texture common in terrestrial basalts). Left image taken by F. Wlotzka and P. Deibele in Wasson (1985); right image from Hutchinson (2004)

Planetary Basalt Compositions

Sample	CI	Earth Mantle	MORB	Lunar glass	Mars basalt	Gusev soil	Gusev rock	Gusev rock-abr	Eucrite	Acapul
FeO	33.69	8.08	10.45	22.17	18.67	16.47	17.67	18.19	18.41	32.84
SiO_2	32.18	45.57	50.77	39.34	49.44	47.74	46.51	45.88	49.23	34.78
MgO	22.30	38.50	7.62	14.68	14.14	9.69	10.46	12.03	6.88	22.91
S	5.08	0.03	0.08	0.07	0.13	2.43	1.41	0.46	0.07	1.22
Al_2O_3	2.30	3.33	15.38	6.20	6.79	10.42	11.27	11.02	13.11	2.09
CaO	1.78	3.13	11.36	7.52	7.30	6.36	7.35	7.50	10.41	1.46
Ni	1.55	0.16	0.02	0.01	0.01	0.05	0.01	0.02	0.00	2.04
Na_2O	0.92	0.40	2.69	0.41	1.24	3.44	2.74	2.73	0.41	0.77
total	99.80	99.21	98.37	90.39	97.72	96.61	97.42	97.82	98.52	98.10

The idea is that students can manipulate and plot these data to learn about similarities and differences about the mantles and melting processes on the planets. For example, the low Ni (a siderophile or Fe-loving element) content of many of these basalts show that the Earth, Moon (by proxy), Mars and Vesta formed cores whereas the parent body for Acapulco did not. I'm reasonably confident (although at this writing on Wed PM I haven't had the time to do the calculation) that a mass balance equation can be used to exploit the distinct FeO contents of Martian and terrestrial basalts to show that the Earth must have a much larger core than Mars.

The high SO_3 content of the Martian soils and surface rocks compared to the Marian meteorite can be used to alert students to the evidence for evaporite deposition on the Martian surface.

The analyses have been culled from .the literature (see handout) and made comparable by making all Fe as FeO, and all oxidized S as S. Oxides are normalized to 100% although if you add up the columns above the totals will be less than 100% because some oxides (e.g., TiO_2) are not listed. Oxides are listed in order of abundance in chondrites (and plotted in that manner) to make comparison to chondrites easier. Of course one could normalize to chondrites but I did the simplest thing first

Images to the right: Oxide abundances from Table plotted in order of abundance in chondrites. Note strong depletion in Ni for MORB, Martian rocks and soils, and eucrite indicating core formation on parent bodies; note higher S contents in Martian surface rocks compared to Martian basaltic meteorite supporting evaporitic sulfate deposition in the Martian surface.