What are komatiites?

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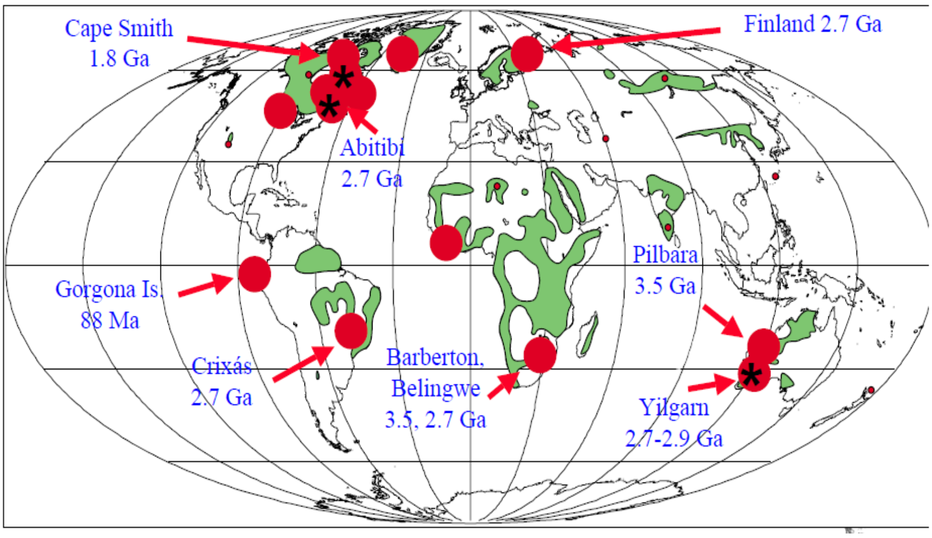
Komatiites are widespread rocks with a spinifex texture (spinifex is a grass, which the texture of komatiites resembles) that occur in ancient shields of 3.7 to 1.8 billion years (Ga) plus an example at Gorgona Island at 88Ma. The type locality is the Komati Formation in the Barberton greenstone belt of South Africa, ultrabasic intrusives and lava flows with up to 25-29% MgO and generally over 18% and an extrusion temperature of 1,600^{o}C. Recent studies reinterpret Barberton komatiites as shallow intrusives derived from hydrous liquids **(**4-6% H_2O**),** with lower liquidus temperatures **(**1370-1400°C**).** The main minerals are olivine (forsterite 90%+, fayalite 10%), pyroxene that is calcic and often chromic (augite), plagioclase feldspar (anorthite 85%, albite 15%), chromite and Fe/Cr mixed oxides. Minor minerals include pargasitic amphibole with >20% MgO, phlogopite mica, baddeleyite, ilmenite and pyrope garnet.

First recognised in the 1960s, they compare with modern basalts, none of which have more than 9%MgO and none have a spinifex texture. They provide an insight into:

- The early volcanic history of the earth;
- The geochemical and thermal structure of the Archaean mantle;
- the formation of Fe, Ni and Cu sulphide ore deposits: and
- the source of diamonds.
- The nature of some extraterrestrial lava flows on the moon and Mars



In the early Hadean, prior to ocean formation, at 4.56-3.80Ga, plate tectonics had not started as everything was molten and anything that solidified sank and converted to eclogite. Oceans formed by 4.40Ga. Evolution of the accreted proto-crust led to the formation of granite and by the late Archaean (about 2.5Ga) plate tectonics started. Banded ironstones were deposited at the end of the Hadean. Komatiites flowed like water, with 10-100 times lower viscosity than picrite magmas. Topographical variations promoted channelization and surface heat loss led to the formation of a crust (density 2.8g/cm^3) with sulphide accumulation (density 4.3-5.1g/cm^3) beneath the flows in depressions. The source of platinum and palladium deposits is ultramafic rocks which have enough sulphur to form a sulphide mineral while the magma is still liquid. This sulphide mineral (usually pentlandite, pyrite, chalcopyrite or pyrrhotite) gains platinum by mixing with the bulk of the magma because platinum is chalcophile and is concentrated in sulphides. Diamonds formed at very high pressure and temperature at 140-190km depth with Carbon-containing minerals providing the carbon source, and the growth occurring over periods from 1 to 3.3 Ga. They were brought to the surface in volcanic eruptions of kimberlites, lamproites and komatiites. The moon went from completely molten to a separate anorthosite crust and olivine/pyroxene at the base, equivalent to the Hadean earth.

All komatiites on earth are metamorphosed to serpentinite. They were deposited in a layered system with from the top of the flow down:

- Olivine, augite, spinel ,glass olivine in a spinifex texture reflecting high heat exchange of about 100^{o}C per hour;
- Picrite, augite, placioclase, olivine, pyroxene with spinifex texture reflectiung heat exchange < or = 10^{o}C per hour;
- Augite, plagioclase, orthopyroxene gabbro reflecting heat exchange of <5^{o}C per hour; and
- Olivine, augite, orthopyroxene basal olivine cumulate in the border zone.

The bulk of the earth is ultrabasic and other rock types developed from this with increasing quartz, decreasing melting temperature and higher viscosity.

The chemistry of komatiites is:

SiO_2	40-45%
Mgo	>18%
K_2o	<0.5%
CaO + Na_2O	<2.0%

Classification is by mineralogy and composition and there is a whole range of types with Al depleted or not and TiO_2 enriched or not, which reflect the effect of partial melting. For example, the Munro-type has Al undepleted with chondritic rare earth elements while the Barberton-type has Al depleted and depleted rare earth elements. Komatiite basalts have 12-18% MgO and high-Mg basalts have 9-12% MgO. They have low Ba, Cs and Rb and are enriched in large ion lithophile elements (K, Rb, Sr, Cs, Ba, (Li, Na, Be, Mg, Pb, Eu^{2+}) with high Ni >400ppm, Cr>800ppm and Co>150ppm.

The initial pulse of komatiite vulcanicity was at 3.3-3.5Ga in the Nondweni, Commondale belts, S. Africa; Belingwe, Zimbabwe; Pilbara, Western Australia, the second pulse at about 2.7Ga at Yilgarn, Western Australia; Belingwe, Zimbabwe; Abitibi, Canada; etc and others at 1.8Ga and 88Ma with cooler, less komatiitic lavas at Cape Smith, Canada; Gorgona Island.. Mg content declines with time. Metamorphism is related to ocean water with conversion to serpentinite and density falling dramatically from 3.3 to 2.7 g/cm^3 with a concurrent volume increase of about 40%. The reaction is exothermic and large amounts of heat energy are produced in the process. The Hadean system was a violent system with C, O, H and S out-gassing, molten silicates and metalsilicate volatile exchange. The formation of konatiites was related to subduction zones and plumes from original peridotite in the Archaean with a bit from eclogite sinks in the Hadean.

Conclusions

Komatiites are excellent indicators of the early composition and development of the mantle. They are primitive lavas, which are important for understanding the evolution of the early earth, other stony planets, the moon and the moons of the outer planets.