Fe-Si system: a potential major component of the Earth's core

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We investigate the phase diagram of the Fe-Si system, the solubility limits of Si into hcp Fe, and the effect of Si on the thermal and electrical conductivities of iron. For this we perform first-principles calculations based on the density-functional theory and the density-functional perturbation theory.

First we build a series of hcp supercells; we replace some of the Fe atoms with Si in various amounts and configurations. In this way we mimic the dissolution of silicon into hcp and take into account a realistic solid solution. Silicon slightly increases the specific volume of iron, but the differences levels out at high pressures. We show that the density and seismic profiles of the core can be easily matched by Fe-Si alloys with small amounts of Si. Further phonon analysis suggests that stoichiometric Fe_3Si is dynamically unstable at high pressure. This results in decomposition into Si-bearing hcp Fe and Fe-bearing B2 FeSi. Then we follow the evolution of the Fe-FeSi immiscibility gap as a function of pressure.

Finally we compute the electrical and thermal conductivities of Si-bearing hcp iron at inner core conditions. We obtain that a relatively small amount of Si decreases the conductivity of iron, but then this quickly reaches saturation.

Based on these considerations we conclude that Si can be a major light element of the Earth's core.

Mantle-derived fluids in Central Mediterranean: Geochemical and geophysical constrains on sources of fluids and migration

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The geodynamics of the central Mediterranean is characterized by the interaction between the European plate and the African's. In this setting Sicily is a sector of the Appenine-Maghrebide accretionary prism, which is located between two areas affected by extensional tectonics (Sicily Channel to the south and the Thyrrenian back arc basin to the north).

Significant mantle-derived helium ($0.4<R/Ra<2.8$; $R={}^3He/{}^4He$ in the sample, Ra in atmosphere) is found in the CH_4 and N_2-CO_2 rich fluids released in central western Sicily, a region without evidence of recent magmatism. CH_4-dominated gases are released from mud volcanoes localized in an area of both low heat flow and seismicity. On the contrary CO_2 is mainly associated to the thermal groundwater circulating mainly in Mesozoic limestone over an area characterized by high seismicity and heat flow anomaly. Total carbon dissolved in thermal water is a mixture of mantle-derived and crustal inorganic CO_2, while CH_4-dominated fluids show a mixing between a ^3He rich and CH_4-poor term and a CH_4-rich and ^3He-poor one typical of crustal reservoir of gases. The computed mantle derived He, much higher than stable continental areas, indicates that the transfer of fluids is controlled by tectonic mechanism through the crust. Finally, recent geophysical investigations discovered the occurrence of active lithospheric faults that could control the transfer of mantle derived fluids from the sources to the crust and throughout this towards the surface.

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