

Experimental and numerical investigations of the formation of felsic asteroidal crust

T. USUI^{1*}, J.H. JONES¹ AND H. SENSU²

¹KR, NASA/JSC, Houston, TX 77058, USA

(*correspondence: tomohiro.usui@nasa.gov)

²PERC, Chiba Institute of Technology, Chiba, Japan

Achondrites exhibit a diverse set of petrographical and geochemical features that individually reflect distinct environments during differentiation processes on their parent asteroids. Our study reports on experimental and numerical investigations that constrain the formation of felsic asteroidal crust recorded in paired achondrites GRA 06128 and GRA 06129 (GRAs).

GRAs are characterized by high abundances of sodic plagioclase, resulting in alkali-rich, felsic, whole-rock compositions. Geochemical studies suggest that the GRAs originate from a partial melt from a volatile-rich asteroid that did not segregate metallic core. We performed partial melting experiments on a synthetic, alkali-bearing, H-chondrite composition under a wide range of fO_2 conditions (IW-1 to IW+2). The experiments suggest that fO_2 conditions significantly influence the compositions of partial melts. Partial melts at IW-1 are distinctly enriched in SiO_2 (up to 70 wt%) and depleted in FeO contents relative to those of >IW melts (~39-47 wt% SiO_2). The silica-enriched, reduced (IW-1) melts are characterized by high alkali contents, resulting in silica-oversaturated compositions. In contrast, the silica-depleted, oxidized (>IW) melts, which are also enriched in alkali contents, have distinctly silica-undersaturated compositions. These experimental results suggest that alkali-rich, felsic, asteroidal crusts as represented by GRAs should originate from a low-degree ($F = <15\%$, $T = <1050\text{ °C}$), relatively reduced (~IW-1) partial melt from a parent body having near-chondritic compositions.

We also performed numerical simulations for the thermal evolution of a GRAs parent body by assuming ^{26}Al and ^{60}Fe with the CAI canonical values as dominant heat sources. The numerical investigations suggest that a GRAs parent body should have accreted 0.7-1.2 Myr after CAI and reached a size of 18-50 km in radius in order to satisfy both chronological and experimental constraints of GRAs. This implies that a planetesimal that possesses a felsic crust produced by low-degree partial melting would have intermediate characteristics regarding the size and/or timing of accretion between chondrite and highly differentiated achondrite parent bodies.

Thermodynamic consequences of the injection of CO_2 - H_2S gas mixtures in sulfur-rich hydrocarbon reservoirs

RAKHIM UTEYEV¹, LAURENT RICHARD^{2*},
AURÉLIEN RANDI¹ AND JACQUES PIRONON¹

¹Nancy-Université, G2R, 54506 Vandoeuvre-lès-Nancy cedex, France (rakhim.uteyev@g2r.uhp-nancy.fr, aurelien.randi@g2r.uhp-nancy.fr, jacques.pironon@g2r.uhp-nancy.fr)

²Amphos21, Passeig. de García i Fària 49-51, 08019 Barcelona, Spain

(*correspondence: laurent.richard@amphos21.com)

Many petroleum basins around the world, among which the recently discovered giant oil and gas fields of the Northern Caspian Sea, are characterized by very high H_2S contents. In order to overcome the tremendous environmental challenge associated with the exploitation of these petroleum and natural gas reserves, the capture on the platforms and reinjection inside the reservoirs of CO_2 - H_2S gas mixtures has been proposed. If these gas mixtures are out of chemical equilibrium with the water-rock-gas-hydrocarbon systems at depth, predicting the occurrence of such reactions as the formation and destruction of organic sulfur compounds, or the precipitation of elemental sulfur in the reservoirs is of major importance for the oil industry.

Activity diagrams and temperature – $\log f_{H_2S(r)}$ diagrams have been constructed to determine the relative stabilities of H_2S , hydrocarbons, organic sulfur compounds, and elemental sulfur at temperatures and pressures typical of petroleum reservoirs. The diagrams suggest that thiacycloalkanes and thiophenes may react with H_2S to produce hydrocarbons and elemental sulfur, while benzo- and dibenzothiophenes should not react with H_2S due to their higher stability.

Experiments have been conducted at 150°C and 500 bar in sealed autoclaves, in which various classes of organic sulfur compounds were reacted with H_2S in the presence of water. In accord with the thermodynamic predictions, thiacycloalkanes and thiophenes reacted with H_2S , while benzo- and dibenzothiophenes did not. Elemental sulfur was formed only in the reactions involving the thiophenes, which we interpret in terms of the potential for reduction (electron transfer) which is higher in the case of the thiophenes. In contrast, no hydrocarbons were detected at the end of the experiments. Dithiacycloalkanes were produced instead. Group additivity estimates of the thermodynamic properties of dithiacycloalkanes suggest that these compounds may be stable under the conditions of the experiments.