Complex calc-alkaline volcanism recorded in Mesoarchaean supracrustal belts in SW Greenland

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Abstract

In this geochemical study we investigate the petrogenesis of three Mesoarchaean co-magmatic supracrustal belts (Ravns Storø, Bjørnesund and Perserajoorsuaq) situated in southern West Greenland. They comprise mainly amphibolites with a tholeiitic basaltic composition and leucoamphibolites with a calc-alkaline andesitic composition. Both lithological units are cut by aplite sheets of tonalite-trondhjemite-granodiorite (TTG) composition with U-Pb zircon ages of c. 2900 Ma. Lu-Hf and Sm-Nd isochrons based on whole rock samples yield ages of 2990 ±41 Ma and 3020 ±78 Ma, respectively. Leucoamphibolites from the three supracrustal belts show apparent chemical mixing trends between tholeiitic amphibolites and TTG gneisses end-members. By assimilation-fractional-crystallisation (AFC) modelling we can show that one group of leucoamphibolites can be explained by contamination of the parental melts by a TTG-like end-member and another group of high P_2O_5, La and Nb leucoamphibolites can be explained by contamination involving a hypothetical low-silica adakite (slab-melt) end-member. However, the leucoamphibolites are juvenile with $\varepsilon Nd_{(2970Ma)}$ from +2.1 to +3.5 and $\varepsilon Hf_{(2970Ma)}$ of +3.5 to +4.3. Thus, the mafic source of the felsic contaminant melts must have been derived from a depleted mantle source more or less at the same time (<60 Ma) as the volcanism took place. Contamination by older continental crust is not a viable explaining of the data.

Accordingly, our preferred interpretation of the geochemical and isotopic data is that the protoliths of the supracrustal rocks formed in an island arc setting, where early tholeiitic volcanism gave way to calc-alkaline volcanism in a maturing island arc. The apparent AFC trends are best explained by in-situ partial melting of basaltic arc crust to form juvenile TTG- and adakite-melts that mixed with mafic magmas or contaminated their mantle source to produce the calc-alkaline leucoamphibolite protolith. This model has important implications for the general interpretation of other Archaean supracrustal belts, because AFC and chemical mixing trends towards a TTG-like end-member are not uniquely diagnostic of crustal contamination, but may rather reflect processes operating at source levels in volcanic arcs such as melting-assimilation-storage-homogenisation (MASH) or slab-melt metasomatism of their mantle source. This study strongly argues for the operation of uniformitarian subduction zone processes as far back as at least 3000 Ma.

Understanding the formation and properties of Titan's aerosols with the PAMPRE laboratory experiment

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In order to support the treatment and interpretation of data collected by the Cassini and Huygens instrumentation, our team developped in 2004 a laboratory experiment based on a radio-frequency reactive plasma to produce analogues of Titan's aerosols (or "tholins"). This experiment, named PAMPRE, enables to produce tholins under variable controlled conditions compatible with the present and past Titan's upper atmosphere ones. The originality of PAMPRE, compared with other experimental set-ups used to porduce tholins, comes from its capability to generate and maintain the tholins inside the plasma without any wall effects. This specificity thus allows to study the tholins production and growth directly in situ by using the appropriate analytical diagnostics.

The studies we do with PAMPRE can be shared in four distinct actions:

1. Study the physical and chemical properties of tholins. This part is originally the most important one since it is partly dedicated to produce reference data which can be compared with observational data. We also study the influence of the production conditions on the tholins properties to better understand the context in which Titan's aerosols can be produced.
2. Characterize the plasma chemistry in order to constrain the chemical pathways leading to the production of solid organic particles directly from the gaseous phase. This part is obviously correlated to the chemistry that occurs in Titan's atmosphere to generate the aerosols.
3. Characterize the physicla properties of the plasma. This original task is very important to understand the influence the context in which the tholins are produced in the experimental set-up. This makes easier the transposal of our results obtain in laboratory to the Titan's atmosphere.
4. More recently we started the study of the evolution in time of Titan's tholins we produce in the context of Titan's geological times.

The goal of this paper is to present an overview of results obtained in the different branches of study of Titan's tholins with the PAMPRE experiment, with an emphasize on the most recent ones.