DESIRED

Tracing differentiation processes through siderophile elements, from meteorites to giant ore deposits

DURATION	BUDGET
15/12/2019 - 15/03/2024	**643 755 €**

PROJECT DESCRIPTION

The primary aim of the DESIRED project is to **trace the source and study the distribution of (partially) siderophile elements** (including gold [Au] and the platinum group elements [PGE: [Os, Ir, Ru, Rh, Pt, Pd], and rhenium [Re]) **in terrestrial rocks and meteorites** to **better constrain planetary differentiation processes and the formation of (giant) ore deposits**. Because siderophile elements are typically depleted in the crust and mantle by several orders of magnitude relative to their solar abundances, they are also known as precious metals. Mineable deposits of these metals usually result from the erosion of (ultra)mafic rocks that may sample distinct mantle domains.

Particular sets of elements with distinct affinities for metal have been shown highly useful to decipher **the isotopic nature of the Earth's accreting material through time**. Of special interest is the late veneer, a late addition of meteoritic material after core-mantle differentiation. By constraining the relative contribution of the late veneer to specific mantle domains, sampled by Archean magmatic rocks with distinct ages and siderophile element concentrations, **pre-late veneer meteoritic contributions to the Earth** can be traced and identified. The latter are crucial to **refine the building blocks of the Earth**, **unify opposing observations for different isotopic proxies** (volatile-rich versus dry contributions), and **improve our understanding of the unique characteristics of our planet, including the presence of water and other volatiles, a magnetic field, plate tectonics, and life**. By studying a unique combination of siderophile element abundances (Cr, Co, Ni, Mo, PGE, W, Re, Au) and isotope ratios (Cr, Ni, Mo, Ru, Os, W), the DESIRED project can be summarized as follows:

Objective 1: First, this project aims to determine **the origin of the world-class precious metal deposits (PGE and Au) in the Kaapvaal Craton (South Africa) and the transfer of these elements from magmatic reservoirs to the crust** by studying a selection of mafic magmatic rocks (and related shales) with ages spanning from ~3.5 to ~2 Ga. The Kaapvaal Craton is unique among Archaean cratons worldwide because of its exceptional endowment in many metallic mineral resources. Despite their enormous economic significance, no unifying genetic model has been established that can explain the vast geochemical anomalies in the Kaapvaal Craton. This first objective targets to test **the isotopic nature of these deposits and determine whether they display consistent late veneer or pre-late veneer isotopic signatures**, possibly relating to **geochemically anomalous mantle domains**. Such domains could reflect **remnants of incomplete core-mantle differentiation in the early days of the planet** or **the late addition of undifferentiated extraterrestrial material**.

Objective 2: To discriminate pre-late veneer isotopic patterns from late veneer signals, a set of meteorites needs to be studied to determine what specific information is carried by the applied isotopic proxies. Based on the absolute concentrations of the selected elements in these meteorites, their isotopic ranges, and up- to-date partition coefficients at high pressure and temperature, **contributions of particular meteorite types to the Earth during the early and late stages of accretion can be discriminated**. While several elements indicate that a large fraction of this material was isotopically most similar to enstatite meteorites, recent work has recorded signatures that only overlap with CI-type carbonaceous chondrites for the late accretion after core formation. These interpretations imply that **the late veneer may have originated from the outer Solar System** and was of lower mass than previously estimated. To successfully complete this objective, particular focus will be put on both enstatite meteorites (enstatite chondrites and aubrites) and carbonaceous chondrites and achondrites.

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Objective 3: To study the ancient extraterrestrial flux to the Earth, some of the isotopic proxies developed for *objectives 1 and 2* will also be applied to study **Belgian Phanerozoic limestone deposits that exhibit Cr- enrichments and thus the possible accumulation of extraterrestrial matter, for example as cosmic dust**. This objective of the DESIRED project allows assessing whether isotopic signatures linked to meteorite bombardments are preserved over time and can thus help to better understand the signature preserved in the geological record.

Objective 4: The DESIRED project finally aims to **expand and improve the efficient curation of all Antarctic meteorites at the Royal Belgian institute for Natural Sciences** (RBINS). Thanks to the two meteorite recovery missions planned within the framework of this project (2021-2022 and 2022-2023), the size of the Antarctic RBINS meteorite collection (>1200 specimens to date) is expected to increase substantially, ensuring sufficiently large meteorite masses needed to apply the high-precision isotopic methods required for *objective 2*.

By integrating these four objectives, our consortium aims **to better constrain the natural processes leading to siderophile element enrichment and link mantle heterogeneity to early differentiation processes or late accretion**. The DESIRED project builds on both newly acquired and established analytical expertise shared between the partner institutions. The measured isotope ratios, determined at the Laboratoire G-time of the ULB, will be coupled to the study of the PGE, Au, and Re concentrations, measured both *in situ* and on bulk samples by the VUB partner, to provide appropriate tools to answer all scientific questions outlined above. At the same time, the mineralogical analyzes and metallogenic interpretation of the obtained data will be overseen by the RBINS. The DESIRED project will **thus strongly reinforce the synergy currently existing between three Brussels partner institutions** (VUB, ULB and RBINS) and help the early career collaborator from South Africa to establish an international scientific network.

CONTACT INFORMATION

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