U-Pb geochronology of the Southern Scandinavian Caledonides: The Mesoproterozoic Espedalen anorthosite-gabbro-norite massif and associated rocks

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Exactly 100 years ago V.M. Goldschmidt completed his PhD thesis on contact metamorphism in the Oslo Graben, and shifted attention to the Caledonian mountains and their problems concerning tectonics, metamorphism and magmatism. Based on these studies, in 1916 he provided a detailed description of the two main plutonic suites that occur in the nappes, the anorthosite-charnockite series and the contrasting opdalite-trondhjemite series. He outlined the main features of the rocks and discussed many of the fundamental question concerning these suites, their relationships, ages, origin and processes controlling their formation. Interestingly, and in spite of the enormous progress in many fields, many of the problems discussed in his paper remain relevant and unsolved today, a century later. In our present study we deal with an anorthosite massif and associated rocks in the eastern-most part of the Jotunheimen mountains investigated by Goldschmidt. One basic question concerns the relationship between these rocks and the major other anorthositic domains in the Jotunheimen and Bergen regions, and the relationships between the various members of the suite including the out of order sequence of crystallization of anorthosite and other mafic to intermediate rocks. Zircon found in coarse grained noritic anorthosite in Espedalen indicates an age of about 1520 Ma, similar to, or slightly younger than those for tonalite and granite in the supposed metamorphous sub-volcanic complex at the interface with tectonically underlying psammitic rocks. Zircons from a lamprophyre dyke yields an age of 1514 Ma. The U-Pb data also record partial disturbances during the Sveconorwegian orogeny, a feature typical of most rocks of the Jotun Nappe Complex. The age of 1520 Ma for the Espedalen massif shows that this intrusion is clearly distinct from the Sveconorwegian anorthosite (ca. 965 - 970 Ma) in the Jotun and Lindås nappes. The 1500 Ma event correlates instead with the very intense activity that build much of the south-Norwegian crust, thus supporting a provenance of the nappe from southern Baltica.

Nuclear imaging of ^{99m}Tc transport and immobilisation through porous media

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^{99}Tc is a β-emitting radioactive fission product of ^{235}U, formed in nuclear reactors. Its long half life ($2.1x10^5$ years) and high environmental mobility in oxic conditions as the pertechnetate anion ($Tc(VII)O_4$) presents a major challenge to nuclear waste disposal strategies.

We demonstrate non-invasive quantitative imaging of the transport of ^{99m}Tc, a γ-emitting metastable isomer of ^{99}Tc commonly used in medical imaging. Transport of this radionuclide was measured during co-advection through quartz sand and various cementitious materials commonly used in nuclear waste strategies, including crushed ordinary portland cement (OPC), OPC combined with blast furnace slag (BFS) or pulversised fly ash (PFA), and Nirex Reference Vault Backfill material. Pulse-input experiments of approximately 25MBq ^{99m}Tc were conducted under saturated conditions and at a constant flow of 0.33ml/min. Dynamic gamma imaging was conducted every 30s for 2 hours.

Relative changes in mass distribution of ^{99m}Tc over time were quantified by spatial moments analysis of the resulting plume. ^{99m}Tc advected through quartz sand and crushed OPC demonstrated typical conservative behaviour, while transport through BFS- and PFA-containing cements produced a significant reduction in colloid centre of mass transport velocity over time. We propose that this is likely due to reduction of ^{99m}Tc by active reducing agents such as Fe and S in the cementitious material. Concurrent batch experiments using ^{99}Tc demonstrated the relatively irreversible sorption of Tc to these materials.

Gamma camera imaging has proven an effective tool for helping to understand the factors which control the migration of radionuclides for surface, near-surface and deep geological disposal of nuclear waste.