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Models for fission products release from spent nuclear fuel and their applicability to the First Nuclides project

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Mr. Christophe Davies (European Commission)	One electronic copy submitted via participant portal	
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The contribution of Amphos 21 during the 2nd reporting period has been focused on updating previous works, specifically:

1) the review of the different models available in the literature to describe FGR and couple with IRF data
2) the development of the saturation model of a pellet immersed in water and the impact that this saturation can have on radionuclide release. Comparison with experimental data.

The presentation of the review within point 1) is presented and reported in the proceedings of the 2nd annual workshop held in Antwerp (Pekala et al., 2013) and will not be repeated here.

The presentation of point 2) is reported in Pekala et al. (2014) and is briefly summarised here, divided into three main parts: first the **Saturation** model is presented, then **Transport** processes are considered, and finally a **Comparison with Experimental Results** is shown. The model was implemented in the finite element code *Comsol Multiphysics* using the Fracture Flow Interface (for flow in the "macro cracks") and the Richards Interface (for flow in the "micro cracks").

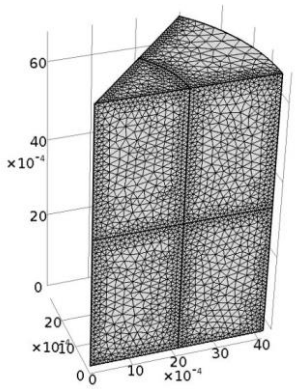
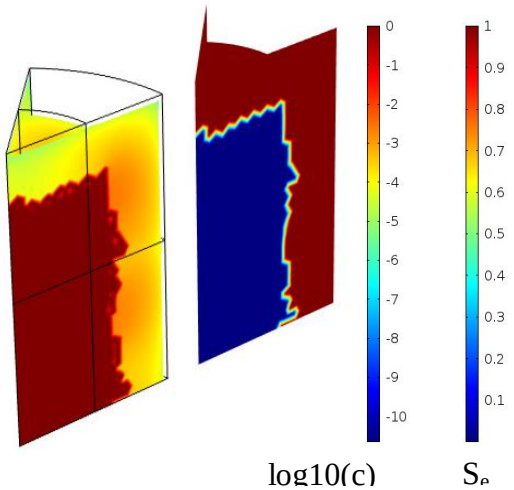


Figure: *The geometry and finite element mesh of the 1/16th fragment of the Reference Pellet for which calculations were performed. Dimensions are in metres.*

The results (not shown) indicate that saturation of the "macro cracks" occurs rapidly, over a period of about 1 day. On the other hand, the saturation of "micro cracks" requires a much longer period of time (over 50 days).

Preliminary 1D calculations of variably-saturated water flow (saturation) and diffusive-advective transport of a tracer from a single crack were performed in order to better understand the relative importance of flow and transport processes for the considered problem. Additional simulations were conducted for the complete interconnected network of "macro cracks".

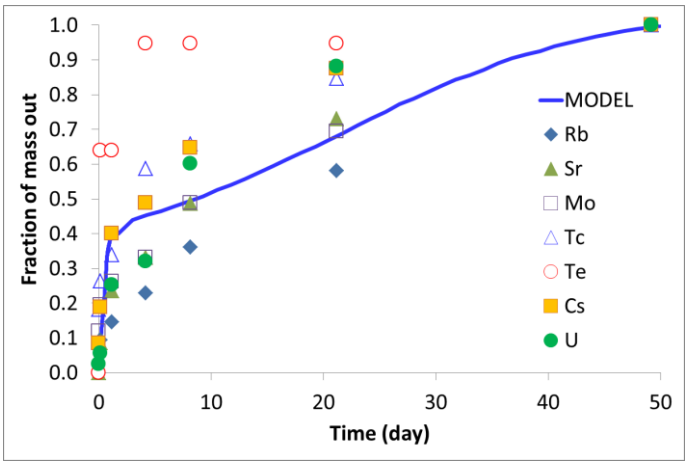
Inspecting the figure on the right, it can be seen that the fronts of water saturation and tracer concentration coincide closely. This is expected for a problem where water saturation constitutes a limiting



Tracer concentration (log10[mol/L] – left) and saturation with water (S_e – right) calculated at time 3 hours in "macro cracks" of the (1/16th)fragment of the pellet.

factor for transport

Comparison of the model with experimental laboratory data (González-Robles, 2011) on radionuclide release from SNF pellet (normalised to unity) and model prediction assuming that 40 % of total tracer mass is initially associated with “macro cracks”.



The work done within this specific activity has permitted the development of new concepts to deal with numerical solution of the pellet saturation. It has been recognised as an important advance, not only for the nuclear waste management industry, but also interesting for other disciplines. A blog entry on the model can be found at:

http://tinyurl.com/nnsrby5

References:

Pekala et al. (2013). Models for fission products from nuclear fuel and their applicability to the FIRST Nuclides project. 2nd Annual Workshop Proceedings, 7th EC FP – FIRST Nuclides, Antwerp, Belgium, 5-7 November 2013.

Pekala et al. (2014). Modelling of spent fuel saturation with water – implications for the instant release fraction (IRF). 3rd Annual Workshop Proceedings, 7th EC FP – FIRST Nuclides, Karlsruhe, Germany, 1-2 September 2014.

Gonzáles-Robles Corrales E. (2011). Study of radionuclide reléase in comercial UO2 spent nuclear fuels. Effect of burn-up and high burn-up structure. Ph. D. Thesis, Universitat Politècnica de Catalunya.