Radioactive Waste Management

Treatment of Colloids in the Safety Case

BELBaR 3rd Annual Workshop
Madrid 5 – 6 March 2015

Lucy Bailey, RWM

Radioactive Waste Management

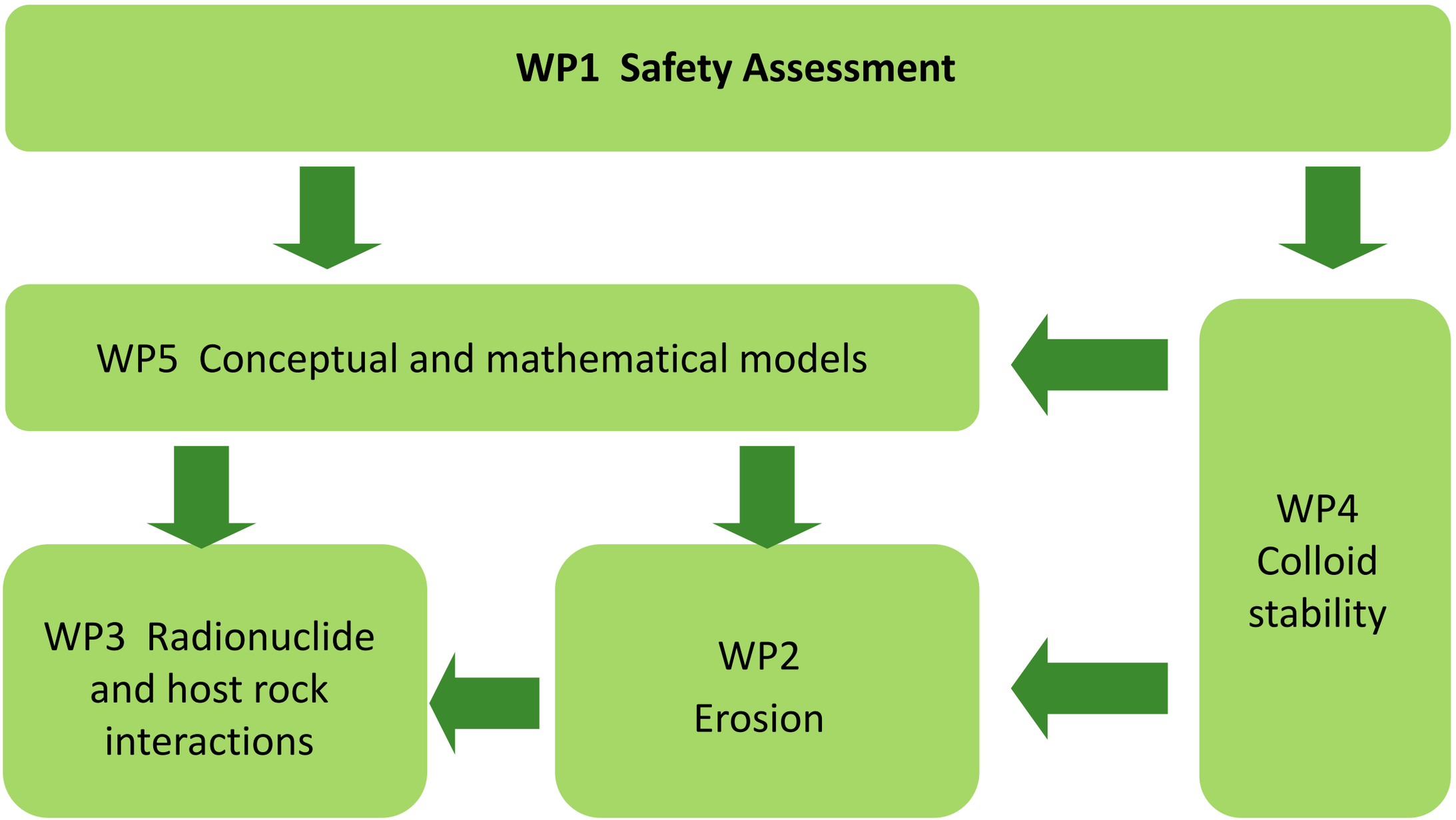
WP 1 Safety Assessment

WP1 objectives:

- Formulate the issues that are important for the long-term safety assessment
- Identify the main uncertainties related to colloids in the safety assessment
- Provide the focus for the research work in BELBaR
- Produce State-of-the-Art Synthesis Report: Colloids and related issues in the long-term safety case

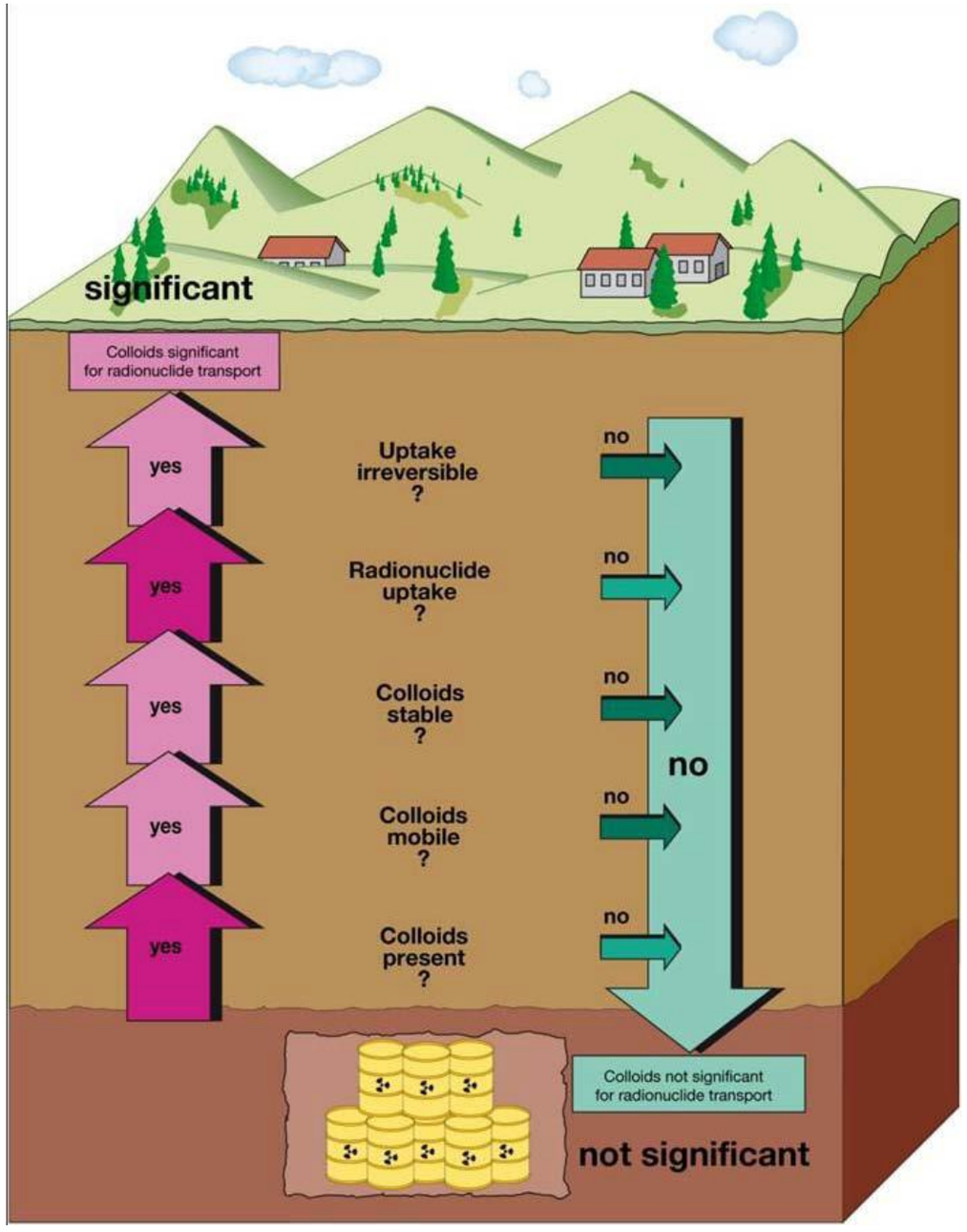
Radioactive Waste Management

BELBaR Project WP Linkages: Information flow at start of project



Radioactive Waste Management

WP1 Initial State-of-the-art report



Radioactive Waste Management

Synthesis of issues: Erosion (WP2)

Issue	Safety case position at start of BELBaR	Outcomes sort for final State-of-art report
Mechanisms of erosion of clay particles from the Bentonite surface	Erosion will cause a loss of bentonite buffer performance under some conditions. This may lead to corrosion failures of the canisters. Corrosion failure leads to the largest impact on risk, a less pessimistic approach may have significant impacts on the calculated risk.	Mechanisms of clay colloid release (WP2 output). Improved quantitative models with new data (WP5 output).
Characteristics of Bentonite clay	Divalent cations have not been studied that systematically. Should the existence and quantitative effect of divalent cations be argued, the importance of this outstanding uncertainty would reduce.	The role of divalent cations (WP2 and WP4). The stability of different bentonites (WP4)

Synthesis of issues: Erosion (WP2)

Issue	Safety case position at start of BELBaR	Outcomes sort for final State-of-art report
Groundwater Chemistry	The key factor for colloid stability is the ionic strength and the content of divalent cations. pH should have an effect, but the pH-range considered in the safety case is rather limited.	The effect of mixed monovalent/divalent systems (WP2, WP4 and WP5)
Clay – Groundwater interactions	Changes in bentonite porewater solute concentrations can be modelled. The related rates assumed to be limited by the availability of different porewater solutes. Mass loss rate assumed to have hydrodynamic contribution. The buffer and the groundwater never reach a true equilibrium.	A validated argumentation for (the conditions for) maximum clay mass loss rate to be used in safety case (cross-WP effort). Summary of how these processes should be integrated in the safety case.

Synthesis of issues: Erosion (WP2)

Issue	Safety case position at start of BELBaR	Outcomes sort for final State-of-art report
Groundwater velocity	Groundwater velocity has been considered as a variable. The loss of bentonite will be affected by the groundwater velocity and it is important to verify this dependence for erosion rates.	Verification of the dependence between the groundwater velocity and the erosion rate.
Clay extrusion paths	Fractures have been assumed to be planar with a constant aperture. Extrusion of clay into a fracture is an integral part of the current model and will have a strong impact on the mass loss. Piping may occur before full saturation of the buffer under certain circumstances.	The effect of fracture geometry on clay mass loss (WP2).

Synthesis of issues: Colloid, RN & host rock interaction (WP3)

Issue	Safety case position at start of BELBaR	Need for additional studies
Colloid mobility controlling processes	Clay colloids have not been considered radionuclide carriers due to the assumed low contribution. Rather than attempting to develop detailed process models for colloid-facilitated transport, potential mitigating processes are ignored so as to place an upper bound on the possible effect.	Validation or invalidation of this assumption (WP3). Is there an upper bound for colloid-mediated transport?
Retention processes	Retardation of colloid transport in the far field, will delay the arrival of radionuclides in the biosphere. The extent of this isn't currently taken into account.	Safety arguments to support retardation mechanisms (WP3).

Synthesis of issues: Colloid, RN & host rock interaction (WP3)

Issue	Safety case position at start of BELBaR	Outcomes sort for final State-of-art report
Radionuclide sorption	To assess the possible role of rapid reversible sorption/desorption onto colloids in facilitating transport, the following assumptions have been adopted: 1. equilibrium sorption of radionuclides onto mobile and immobile colloids, 2. equilibrium sorption of colloids onto fracture surfaces, and 3. colloid-free matrix pore space (conservative assumption, but also realistic for the small pore sizes of granitic rock). Reversible, linear sorption of radionuclides onto colloids has been assumed.	Is the assumption of reversible, linear sorption of radionuclides onto colloids justified? (WP3)

Synthesis of issues: Colloid stability (WP4)

Issue	Safety case position at start of BELBaR	Outcomes sort for final State-of-art report
Colloid stability controlling processes	Stability of compacted bentonite in dilute porewater conditions has been evaluated by laboratory measurements. The controlling process is hydration of exchangable cations limited by the availability of cation free water. Currently the uncertainties in geochemical conditions are greater than in uncertainties in the stability limit. Colloid stability studies have found that model colloids that possess a significant net negative charge at neutral pH, i.e. silica and illite clay, show the greatest stability under neutral pH conditions.	Understanding of the processes controlling colloid stability and their representation in the safety case (WP4).

Synthesis of issues: Colloid stability (WP4)

Issue	Safety case position at start of BELBaR	Outcomes sort from WP
Influence of other factors to colloid stability	Accessory minerals seem to enrich near the bentonite-groundwater interface. Filtration has been discussed as a possible mean to reduce erosion. Colloid size, solution ionic strength and water flow rate are factors which strongly influence colloid migration. Association of inorganic particles with natural organic compounds is an important mechanism for colloid stabilisation. This mechanism could potentially operate to stabilise and enhance colloid populations in the near-field porewater, this remains an area of uncertainty.	Summary of the influences of these factors on colloid stability, to what extent are they significant for the safety case?

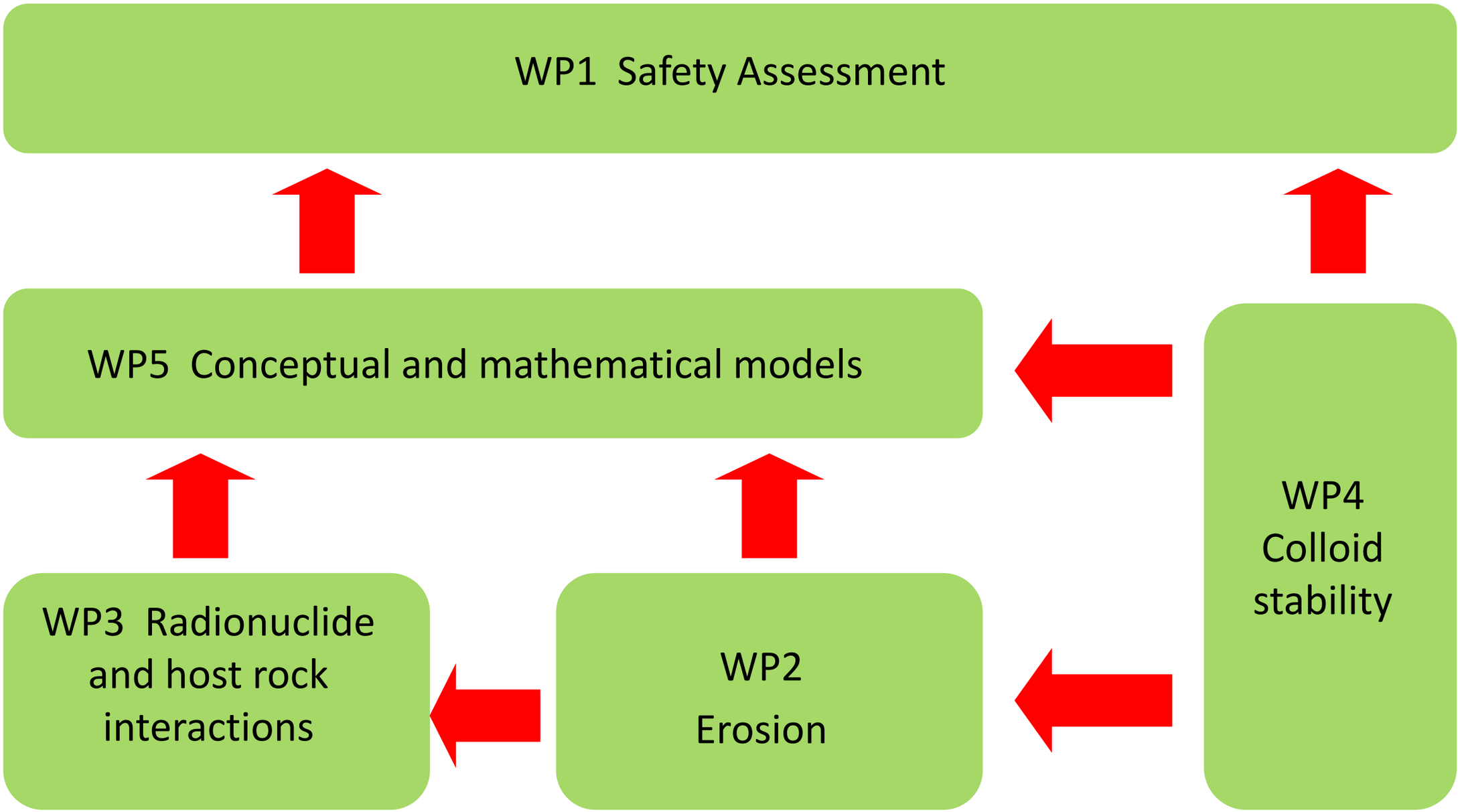
Synthesis of issues: Conceptual and mathematical models (WP5)

Issue	Safety case position at start of BELBaR	Outcomes sort for final State-of-art report
Current model(s): Erosion of the Bentonite buffer	The factors considered are; 1. groundwater velocity 2. fracture aperture 3. transport resistance of bentonite gel in terms of diffusivity 4. gel cohesivity in terms of viscosity Small-scale tests suggests groundwater ionic strength and the presence of divalent cations are the dominant factors. Pessimistic assumption neglecting safety promoting aspects have been used.	Improved conceptual and mathematical models of the influence of colloids on the erosion of the bentonite buffer (WP5).

Synthesis of issues: Conceptual and mathematical models (WP5)

Issue	Safety case position at start of BELBaR	Outcomes sort for final State-of-art report
Current model(s): Radionuclide transport mediated by Bentonite colloids	Clay colloids have not been considered radionuclide carriers in Posiva's safety case due to the assumed low contribution. SKB incorporated the effective transport parameters using the MARFA code. At the colloid concentrations likely in the far field, a significant increase in risk could arise if a proportion of the radionuclides associated with colloids are irreversibly sorbed. In that case the risk will depend on the mobility and particle lifetimes.	Justification as to whether the assumption of reversible sorption is correct (WP3). If so, the impact of colloid-mediated radionuclide transport will be insignificant. Improved conceptual and mathematical models of colloid-mediated radionuclide transport (WP5).

BELBaR Project WP Linkages: Information flow at end of project



Radioactive Waste Management

WP1 Final State-of-the-Art Report

- Integrate information produced by other WPs, considering implications for current state of the art, i.e. answers to the issues identified on previous slides
- Examine extent to which other WP findings provide satisfactory answers to the needs identified at the project outset
- Define scenarios for colloid issues, discuss uncertainties in these scenarios and identify model and data needs for their treatment
- Updated State-of-Art report to include justified recommendations for improved and updated treatment of colloids and related issues in relation to long-term safety assessments, based on integrated project findings

Radioactive Waste Management

Summary

The key issues to be addressed in the final State-of-the-art report from each WP:

- Bentonite erosion and production of colloids (WP2) – understanding of the main mechanisms of erosion of clay particles from the bentonite surface and quantification of the (maximum) extent of the possible bentonite erosion under different physio-chemical conditions.
- Colloid, radionuclide and host rock interactions (WP3) – the main thing here is to determine the sorption reversibility of radionuclides to the colloids and whether the current assumption of reversible sorption can be justified.
- Clay colloid stability (WP4) – better understanding and representation of the stability and mobility of clay colloids under repository site conditions.
- Improvements to models (WP5) – the target is to obtain improved, validated models of colloid influence on the erosion of the bentonite buffer and colloid-mediated radionuclide transport.

Overall, we are looking to understand where we can justify removing current pessimistic assumptions in the safety case regarding colloid behaviour, to present a more realistic and confident safety case.