AL-FARABI KAZAKH NATIONAL UNIVERSITY

DEPARTMENT OF MECHANICS AND MATHEMATICS

DEPARTMENT OF MECHANICS

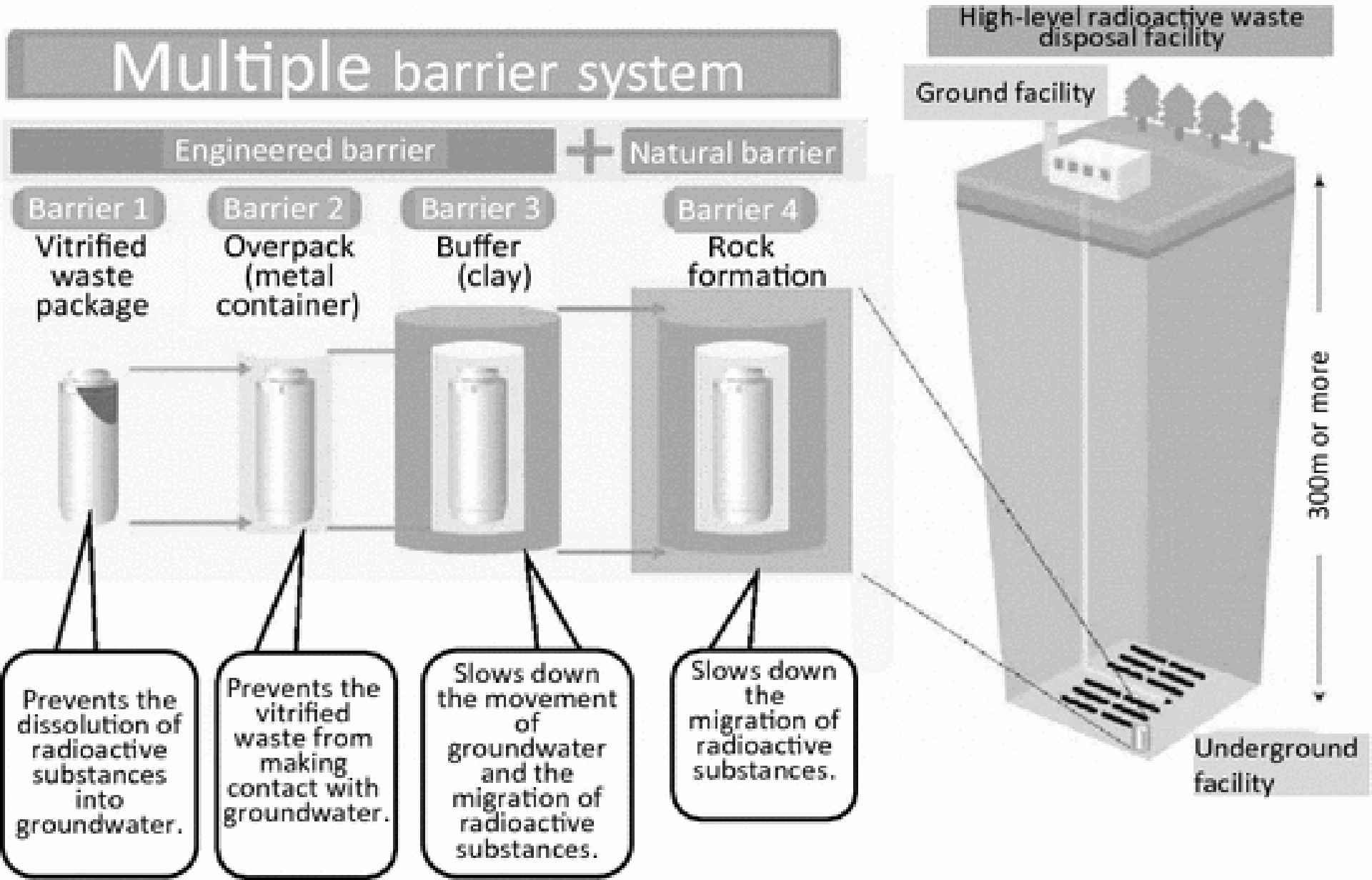
# Study of migration of radioactive elements in clay layers during the burial of radioactive waste

Prepared by Zhumanova M.I.

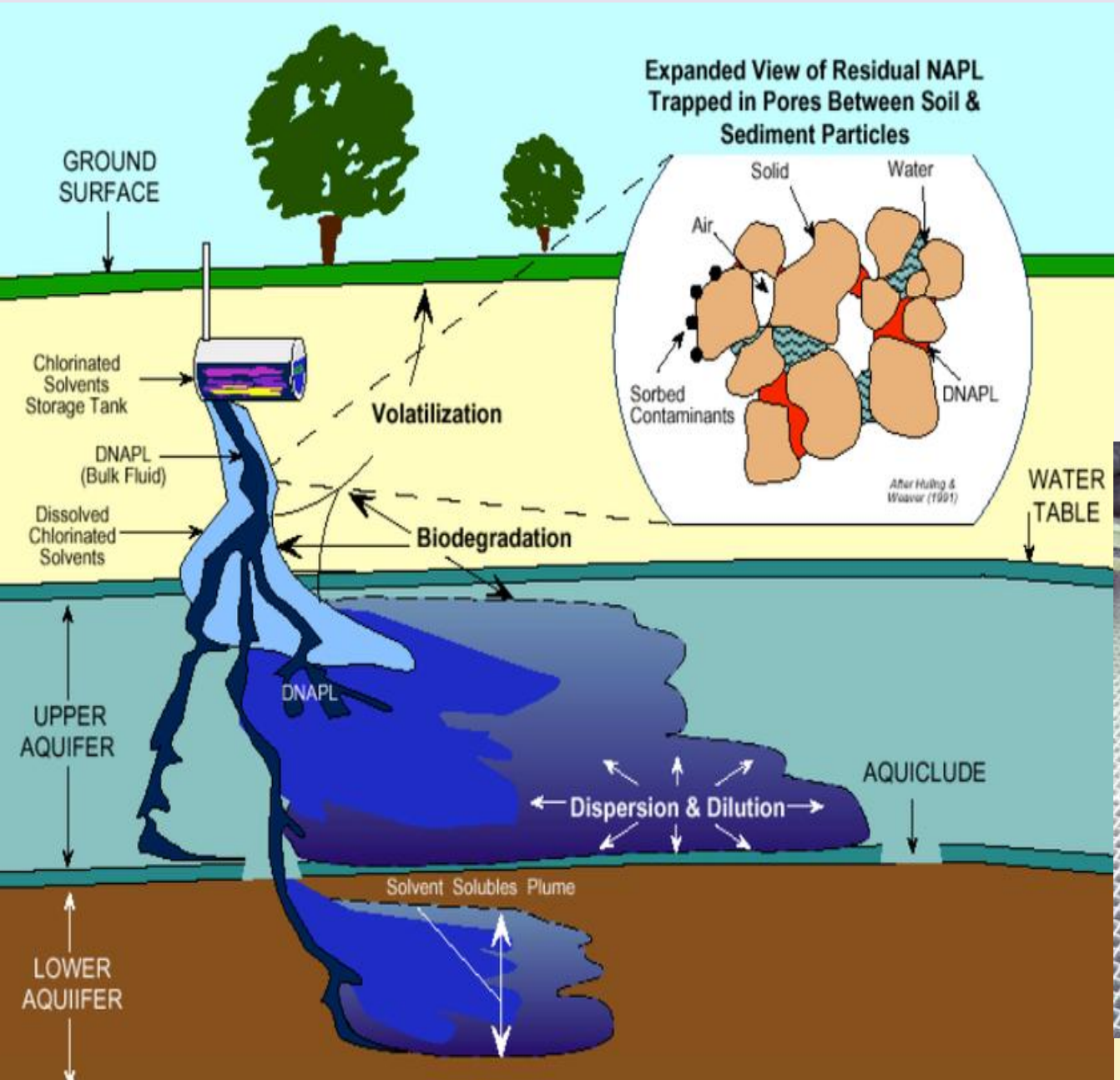
Scientific adviser Tungatarova M.S.

# A second shipment of low enriched uranium was delivered to our country

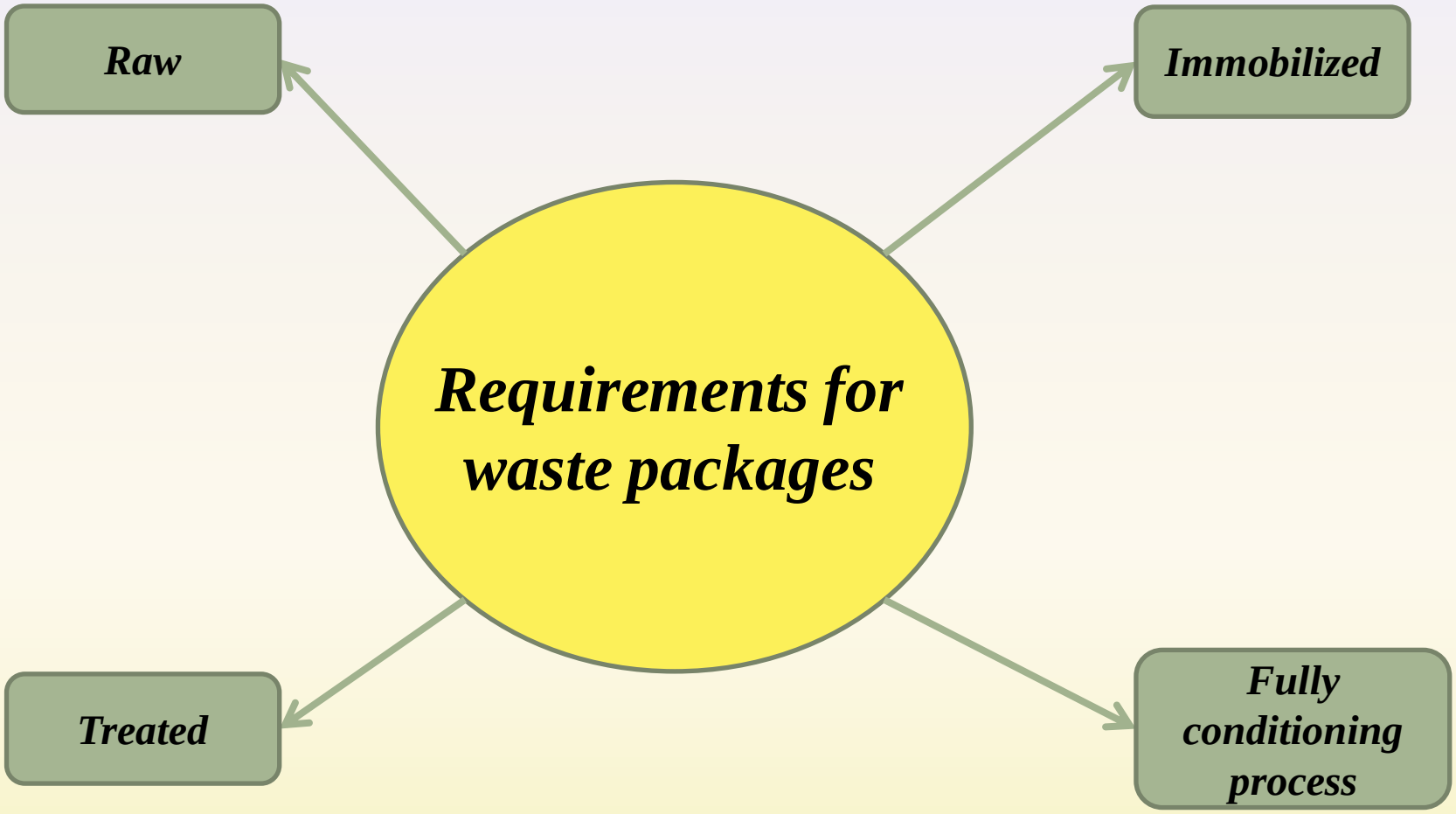

# Near zone


Multiple barrier system
Engineered barrier
Natural barrier
Barrier 1
Vitrified waste package
Barrier 2
Overpack (metal container)
Barrier 3
Buffer (clay)
Barrier 4
Rock formation
Prevents the dissolution of radioactive substances into groundwater.
Prevents the vitrified waste from making contact with groundwater.
Slows down the movement of groundwater and the migration of radioactive substances.
Slows down the migration of radioactive substances.
High-level radioactive waste disposal facility
Ground facility
300m or more
Underground facility

# CORROSION OF PACKAGES WITH RADIOACTIVE WASTE




Radioactive waste may exist in several forms when it passes through the treatment and conditioning processes



# Waste form, container and waste package

***Waste form***

***Immobilization of waste***

Conversion of waste into a waste form by

- Solidification
- Embedding or Encapsulation

Non-immobilized solid waste

Immobilized waste


***Waste package***

- Waste form
- Containers
- Internal barriers

# Waste form, container and waste package

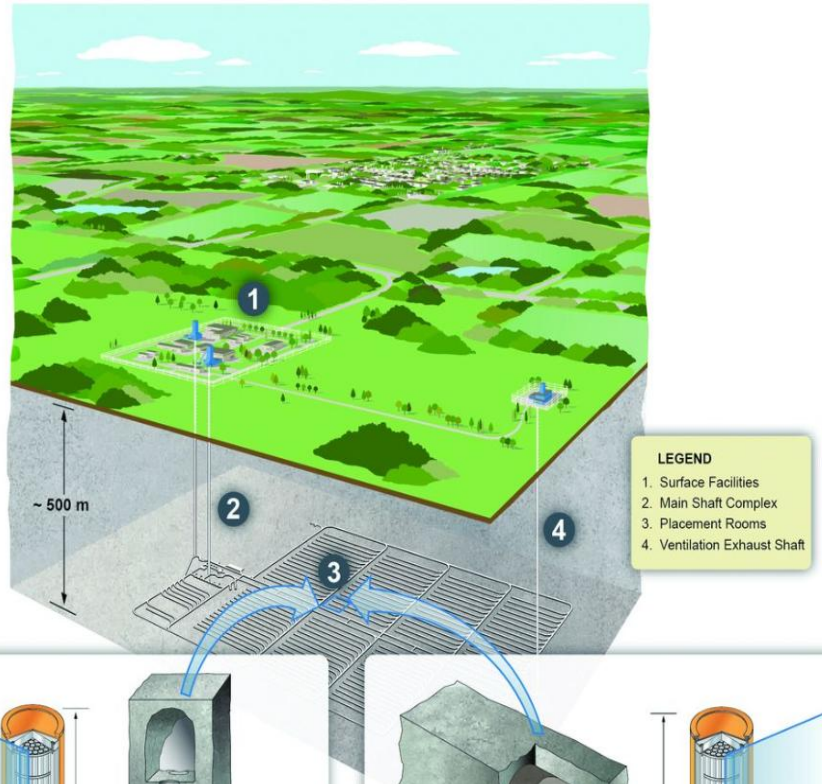
***Container***

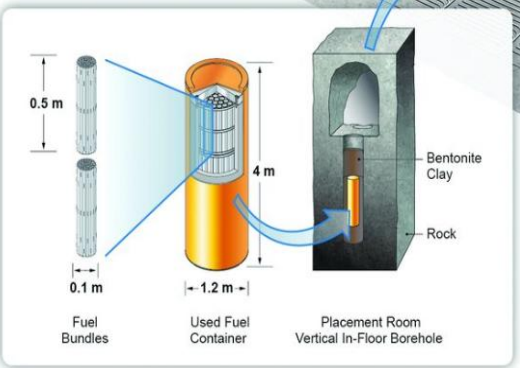
Long lives

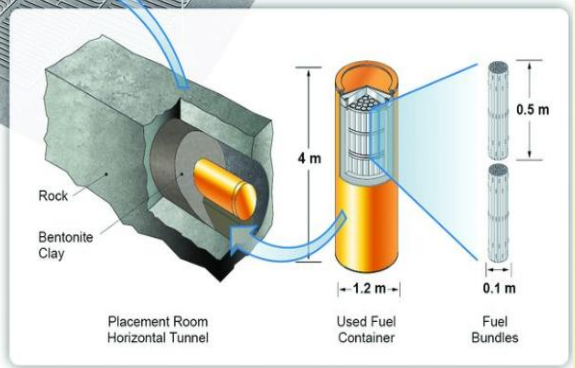
Short lives

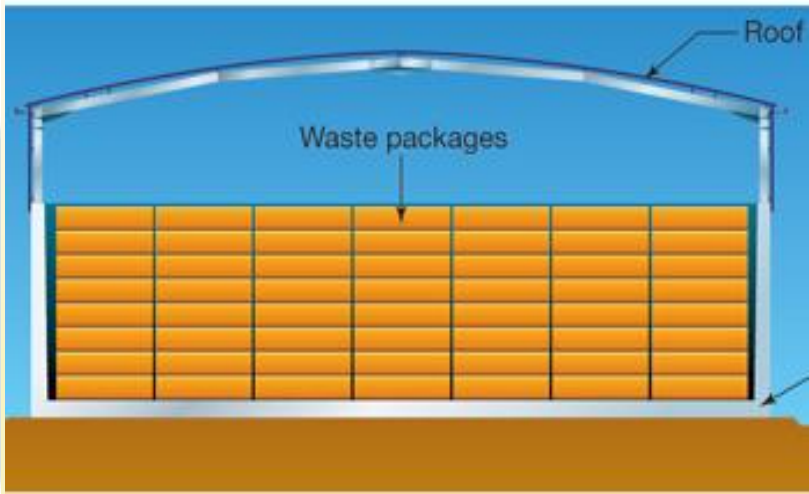
HLW

LLW

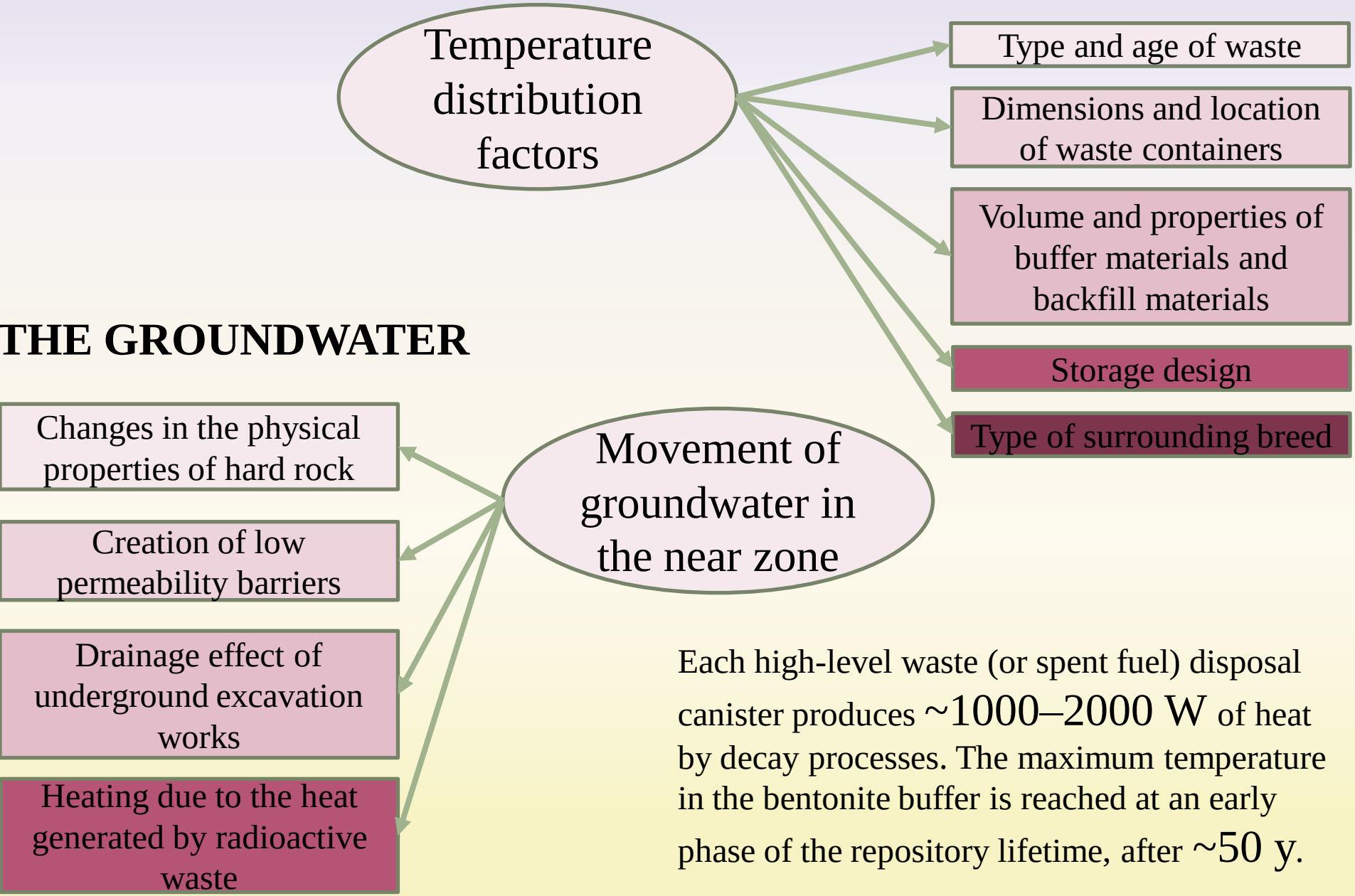


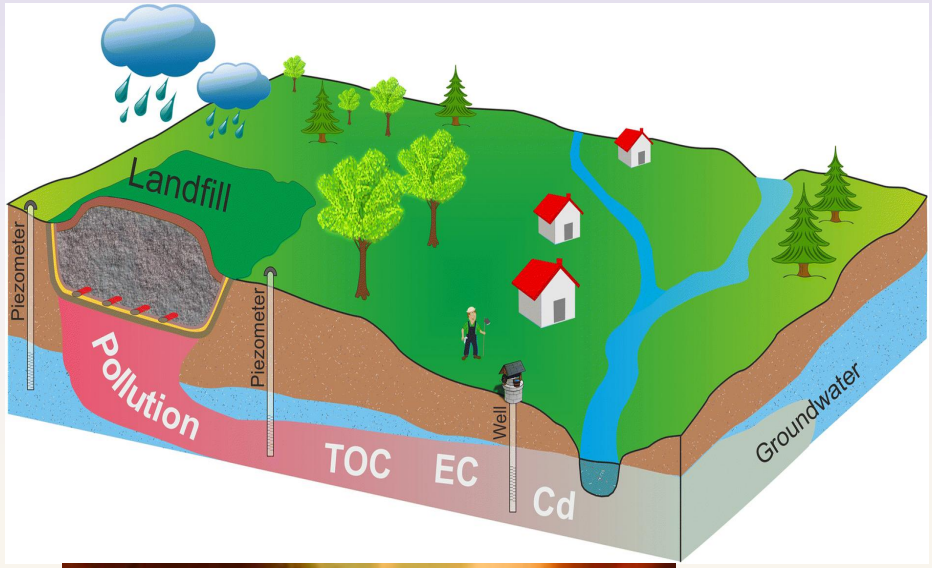



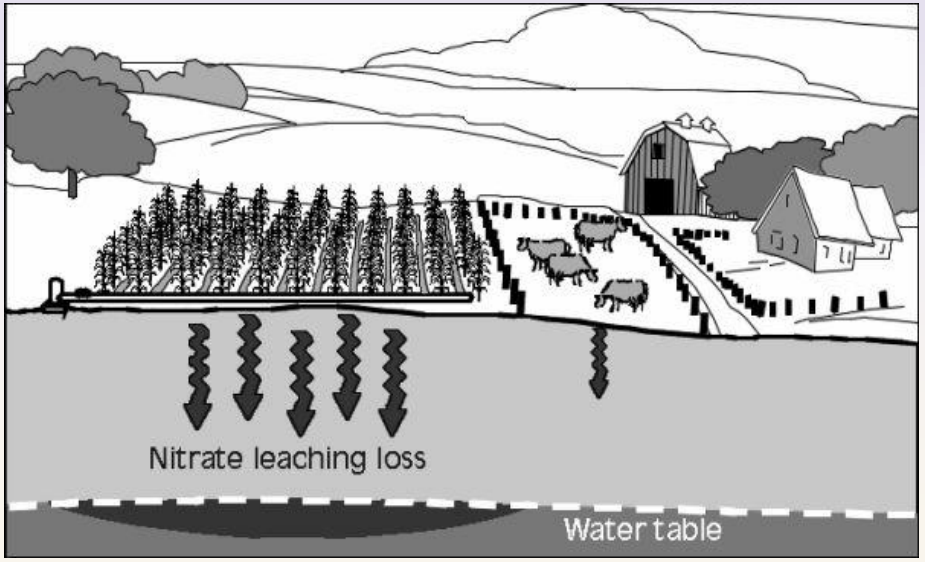
# THERMAL EFFECTS

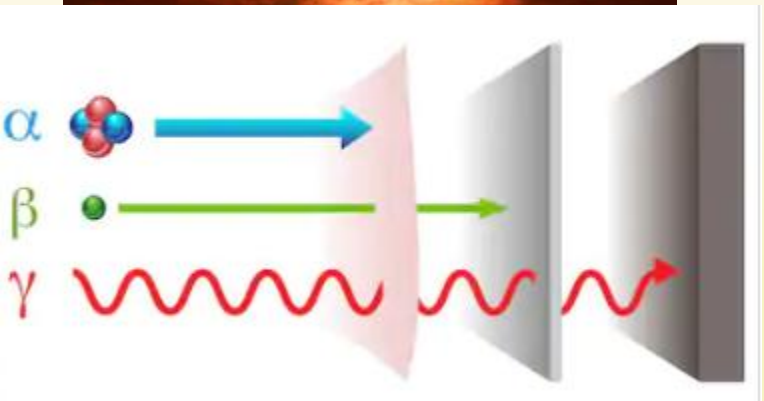



Each high-level waste (or spent fuel) disposal canister produces ~1000–2000 W of heat by decay processes. The maximum temperature in the bentonite buffer is reached at an early phase of the repository lifetime, after ~50 y.

# GROUNDWATER LEACHING




*A change in the shape of the waste*

*A change in the composition of any liquid washing the waste*

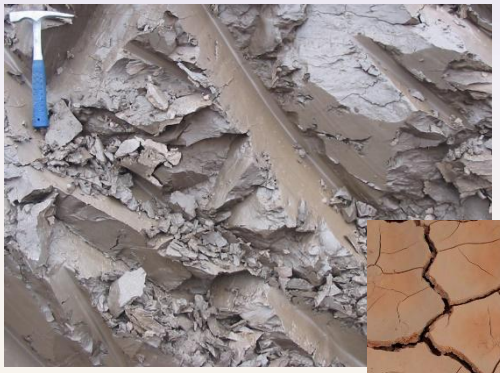
*A change in the surrounding rock*

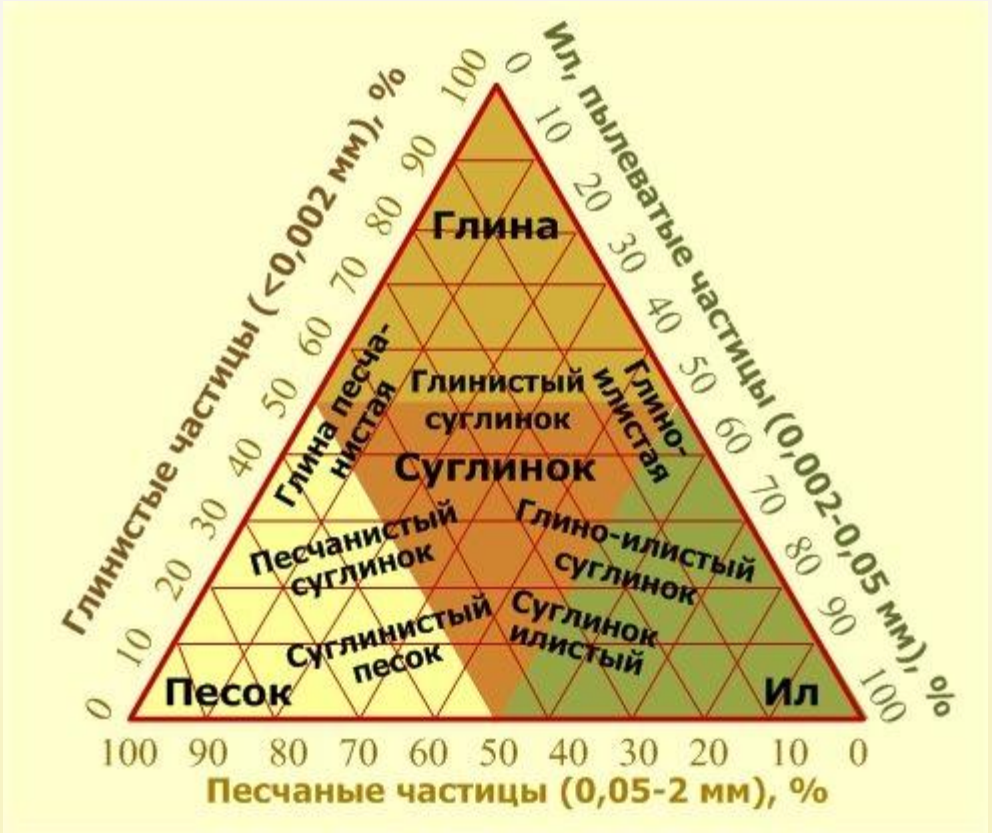
RADIATION EFFECTS

# WATERPROOFING WITH CLAY

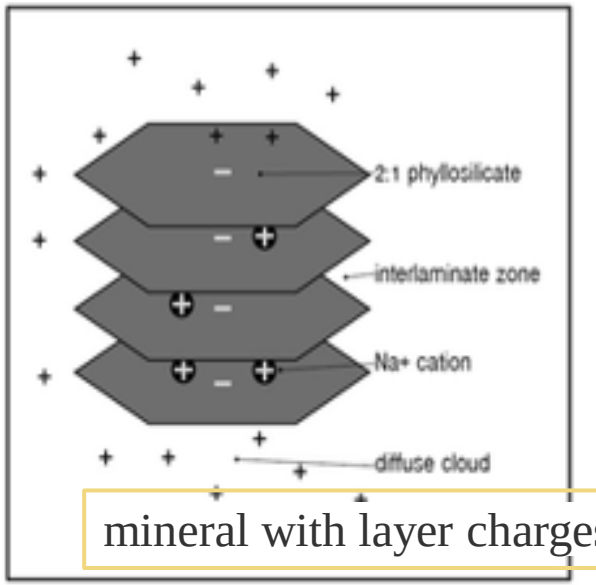
Ability to adsorb

Exchange cations such as sodium or calcium

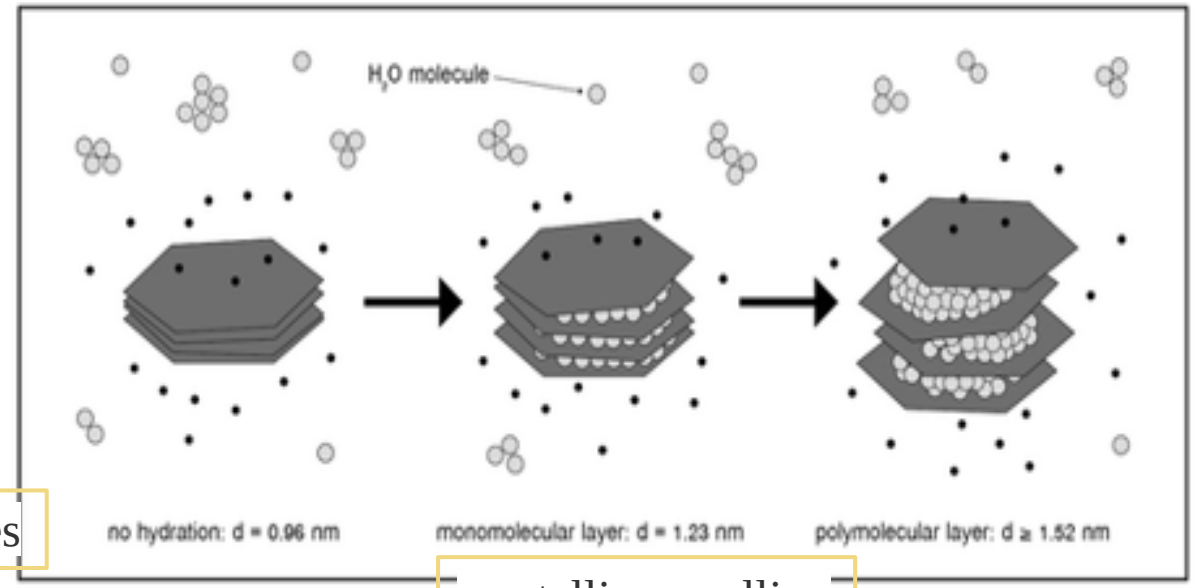




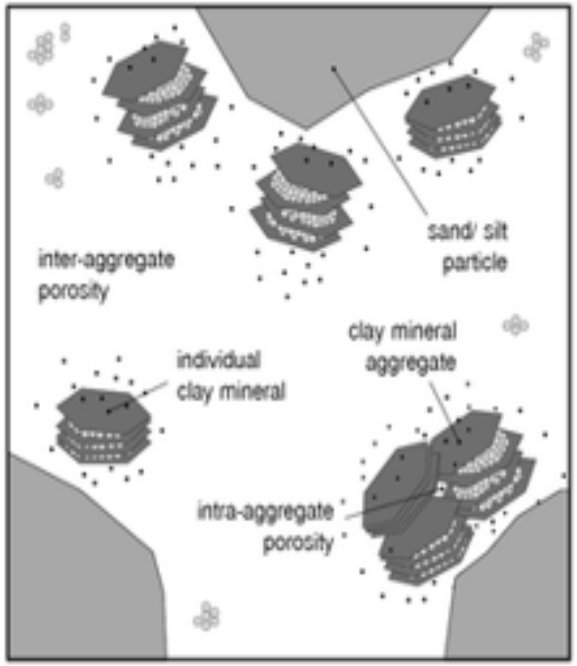
# WATERPROOFING WITH CLAY

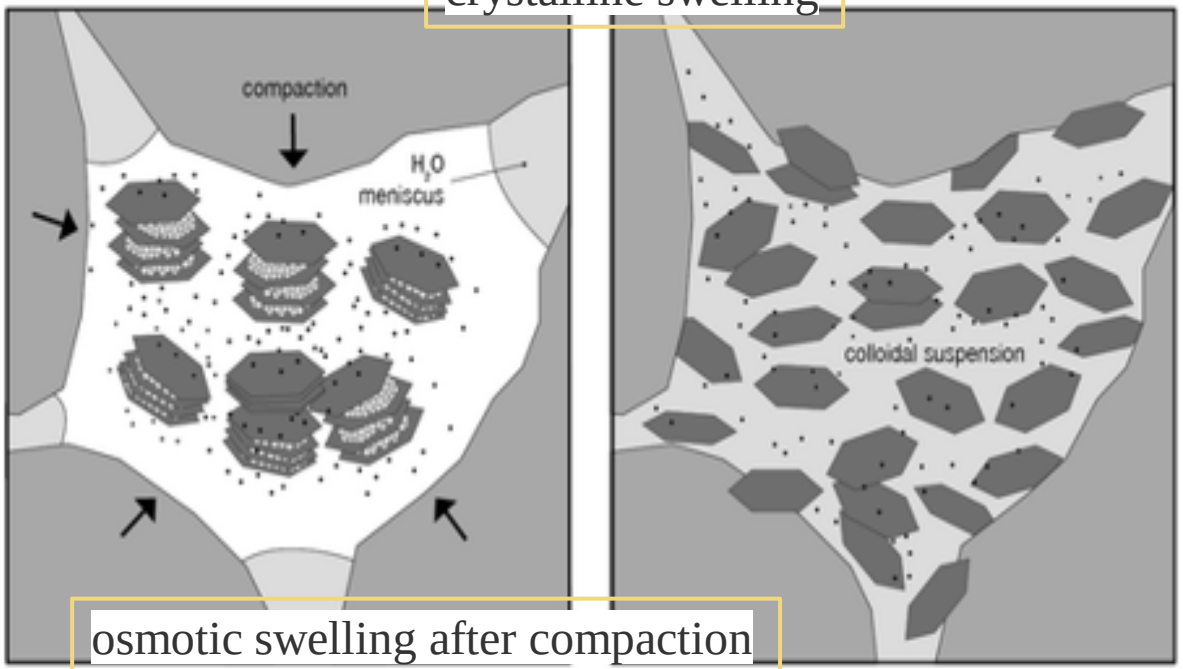



mineral with layer charges




crystalline swelling




osmotic swelling after compaction

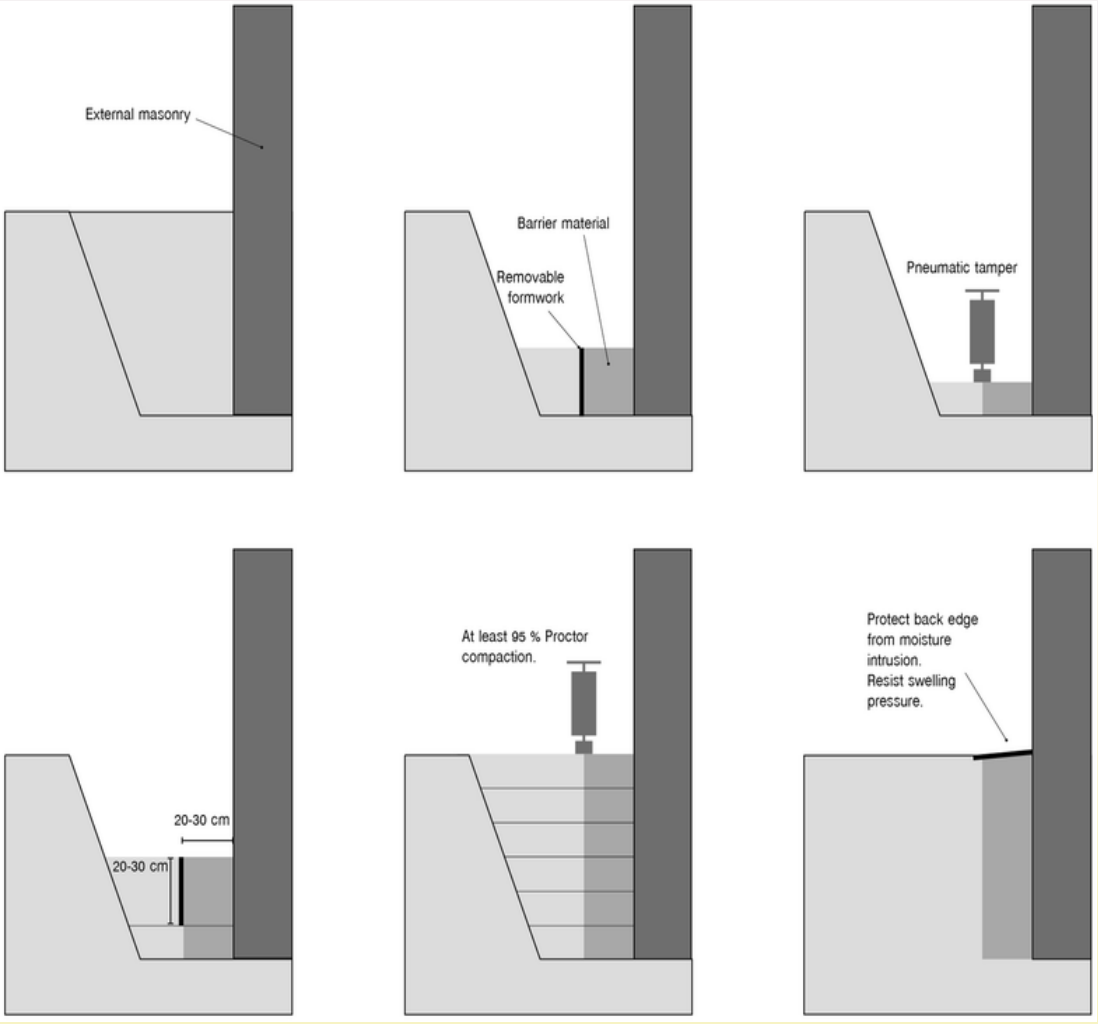
Properties that will contribute towards low hydraulic conductivity when a soil is compacted

Favourable grain distribution may result in a densely consolidated matrix

The presence of swelling clays can bind water during hydration.

A certain optimum moisture content will be necessary in order to achieve Proctor compaction (maximum density of consolidated grains)

The proportion of clay to silt and sand should not allow for shrinkage to form cracks in the compacted mass during dehydration



- $\rho_d = \frac{\rho_{Pr}}{(1+\omega_{Pr})*\rho_d}$
- $n = \left(1 - \frac{\rho_d}{\rho_s}\right) * 100\%$
- $S = \frac{\left(\frac{\rho_d}{\rho_w * \omega_{Pr}}\right)}{\left(\frac{n}{100\%}\right)}$
- $\omega_s = \left(\frac{V_d}{m_d} - \frac{1}{\rho_s}\right) * \rho_w$

$\boldsymbol{\rho d}$ is the bulk density,

$\boldsymbol{\rho_{Pr}}$ is the Proctor density,

$\boldsymbol{\rho_s}$ is the measured particle density and

$\boldsymbol{\rho_w}$ is the density of water in g/cm$^3$;

$\boldsymbol{w_{Pr}}$ is the optimum moisture content as a percentage of mass;

$\boldsymbol{n}$ is the total porosity as a percentage of total volume of the consolidated mass,

$\boldsymbol{S}$ is the degree of saturation as a percentage of total porosity.

$\boldsymbol{w_s}$ is the moisture content at shrinkage limit as a percentage of total mass;

$\boldsymbol{V_d}$ the volume of the dried sample in cm$^3$;

$\boldsymbol{m_d}$ the mass of the dried sample in g;

$\boldsymbol{\rho s}$ the particle density of the sample and ρw the density of water in g/cm$^3$

# THANK YOU FOR YOUR ATTENTION