First Training Course: *THM behaviour of clays in deep excavation with application to underground radioactive waste disposal*

TiMODAZ

Numerical modeling exercise

Simulation with LAGAMINE of a simple THM coupled case. Scoping calculations

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Scoping calculation

➢ **Host argillaceous formations**

  ➢ **Plastic clay**

  ➢ **Indurated clay 1**

  ➢ **Indurated clay 2**

➢ **Different drainage conditions and liner**

  ➢ **Drained / Undrained / Seepage conditions**

  ➢ **Liner / No liner**

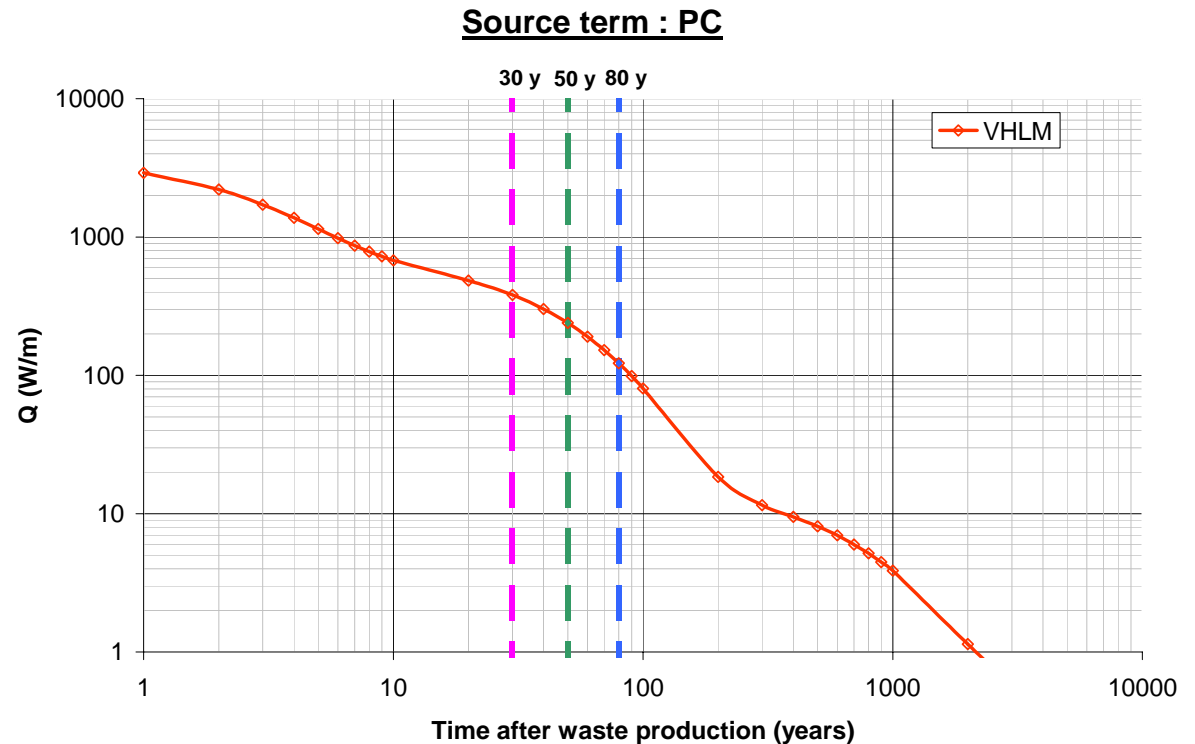 ➢ **Type of waste (VHLW, MOX, Spend fuel, …)**

Scoping calculation
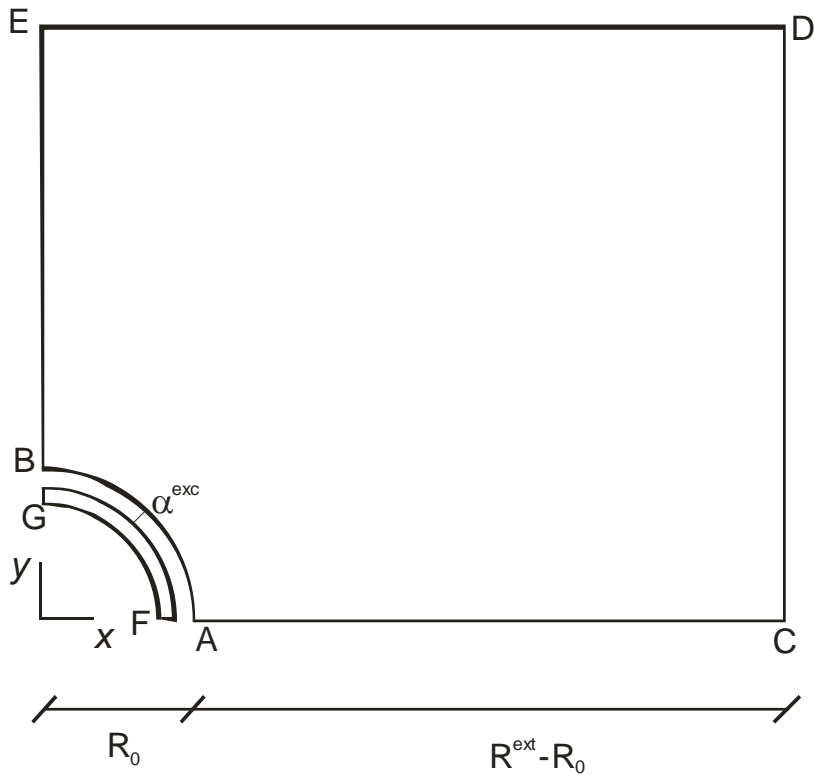
Initial state		PC
Total stresses [MPa]	σ_H	4.05
	σ_v	4.5
Pore pressure [MPa]	P_{w0}	2.25
Effective stresses [MPa]	σ'_H	1.80
	σ'_v	2.25
Temperature [°C]	T_0	16

Scoping calculation

➤ **Modeling phases**

  ➤ **Excavation**

  ➤ **Liner installation**

  ➤ **Heating**

Source term : PC

Exercise definition

- ➢ **Objective**
  - ➢ **Identify the different physical phenomena**
  - ➢ **Identify the relevant coupling effects**
  - ➢ **Sensitivity analysis**
  - ➢ <u>**It is not a course on how to run a FE model !!!**</u>
- ➢ **Exercise definition: 3 parts**
  - ➢ **Thermal problem**
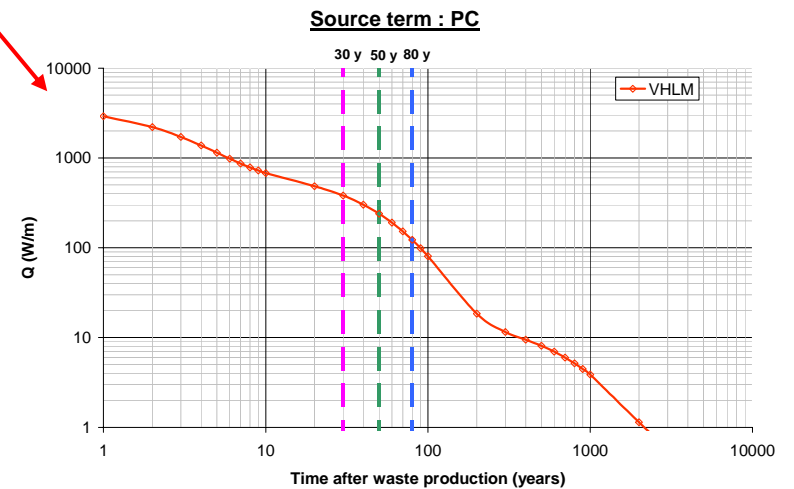 - ➢ **Thermo-hydraulic problem**
  - ➢ **THM problem**

Exercise definition

➢ **Thermal problem**

$$\dot{S}_T + div(\underline{V}_T) - Q_T = 0$$

$$S_T = \rho \, .c.(T - T_0)$$

$$\underline{i}_{cond} = -\Gamma_m.\underline{\nabla}T$$

Source term : PC

30 y 50 y 80 y

VHLM

Q (W/m)

10000

1000

100

10

1

1   10   100   1000   10000

Time after waste production (years)

Exercise definition

> **Thermo-hydraulic problem**

$$\underline{V}_T = \underbrace{-\Gamma_m.\underline{\nabla}T}_{conduction} + \underbrace{(\rho_f.c_{p,f}.\underline{q}_f).(T-T_0)}_{convection}$$

$$\dot{S}_T + div(\underline{V}_T) - Q_T = 0$$

$$\dot{S}_f + div(\underline{V}_f) - Q_f = 0$$

$$S_f = \rho_f.\theta_f = \rho_f.n \qquad \underline{q}_f = -\frac{k_{int}}{\mu_f}.\left[\underline{grad}(p_f) + \rho_f.g.\underline{grad}(y)\right]$$

Exercise definition

➢ **THM problem**

$$\dot{S}_T + div(\underline{V}_T) - Q_T = 0$$

$$\dot{S}_f + div(\underline{V}_f) - Q_f = 0$$

$$div(\underline{\underline{\sigma}}) + \rho \underline{g} = 0$$
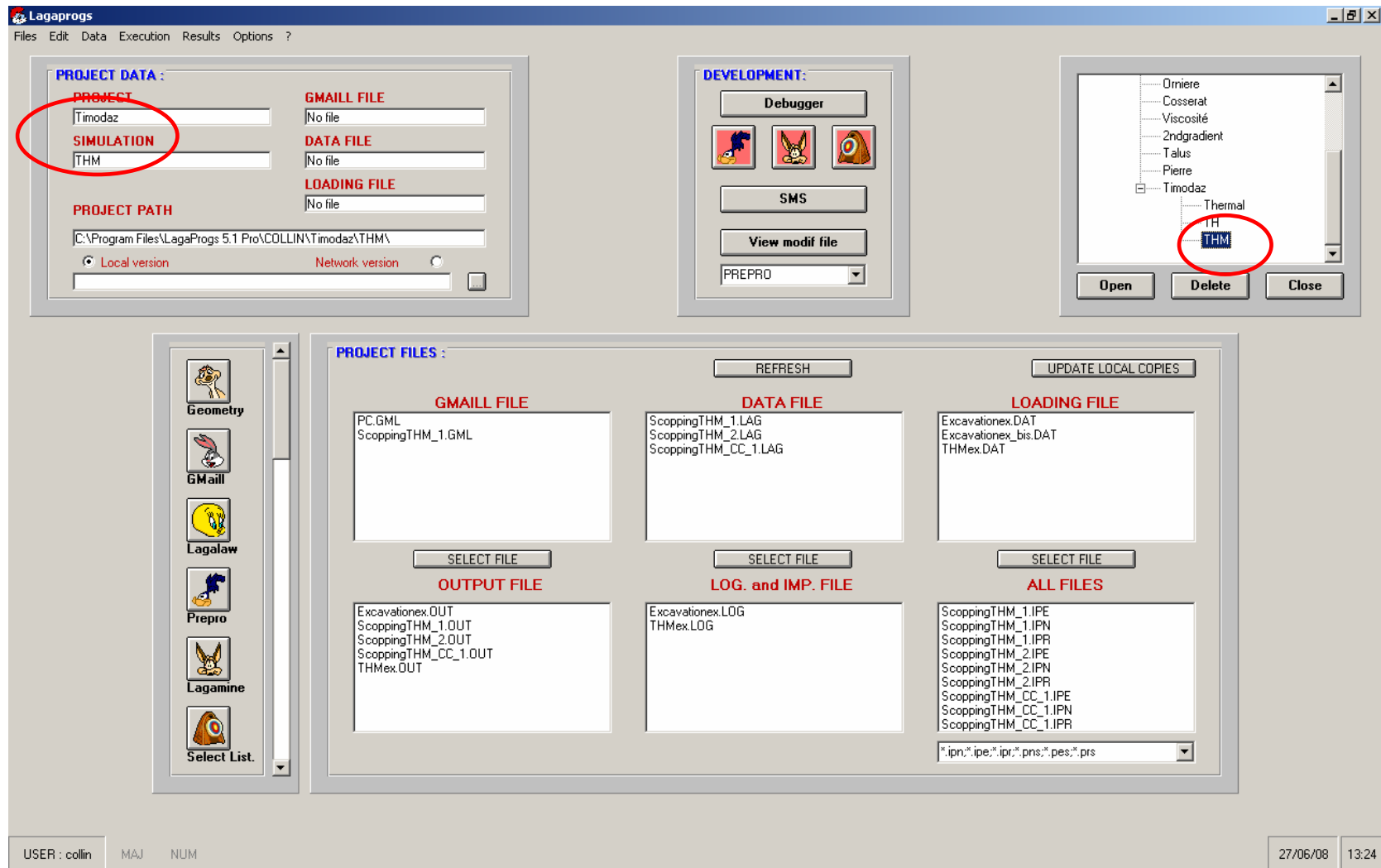
First step in Lagaprogs

First step in Lagaprogs
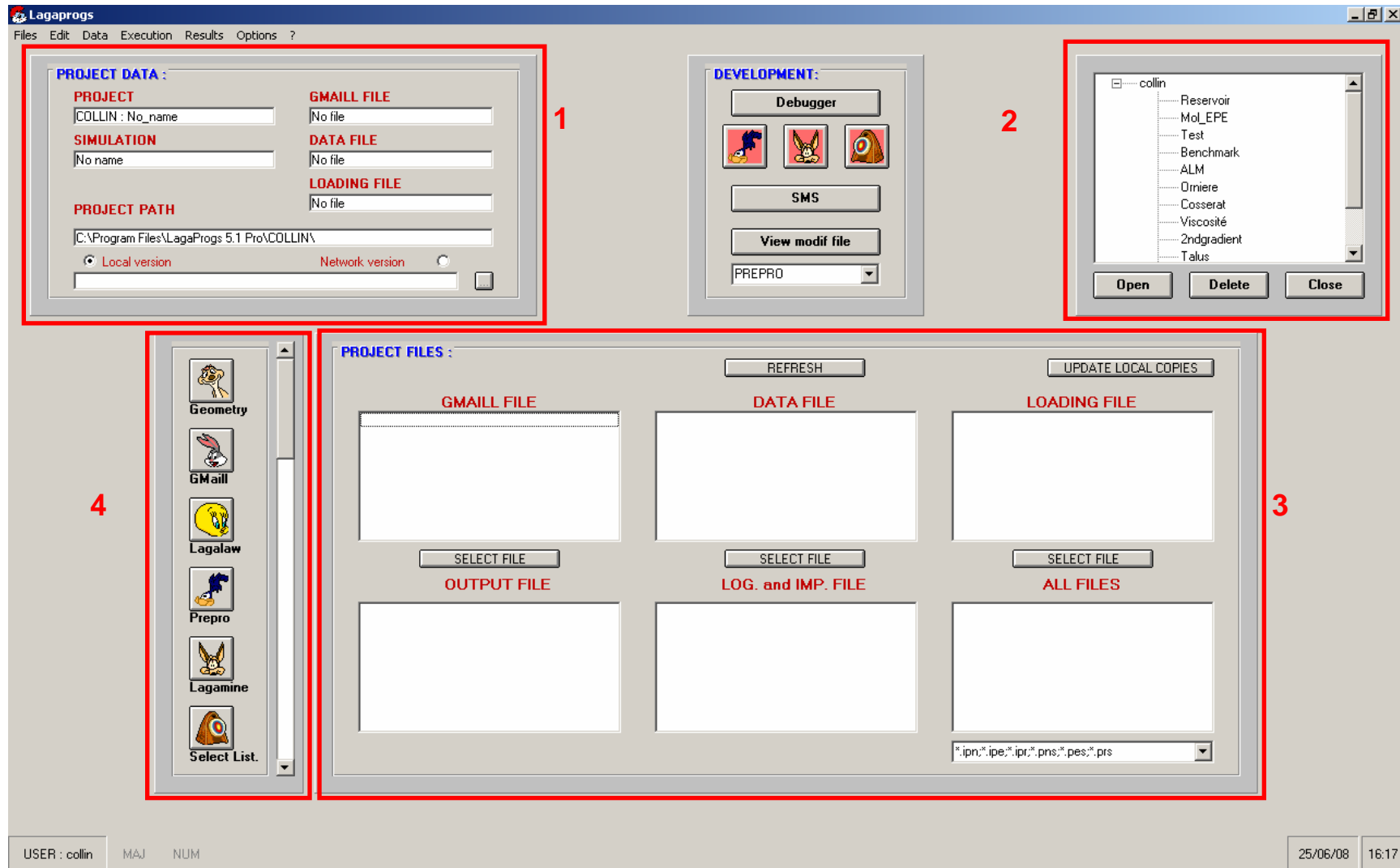
First step in Lagaprogs

Available informations

➢ **Numerical Modeling exercise**

  ➢ **Definition of the problem**

  ➢ **Parameters of the constitutive laws**

  ➢ **Definition of the different simulation cases**

➢ **User manual for Lagaprogs 5.1**

  ➢ **Step by step procedure**

  ➢ **Appendixes: LIC file, IPN/IPE/IPR files**