



# Terrain Categories in RAMMS::Rockfall

*Representing ground interaction and energy dissipation in rockfall simulations*

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# Why Terrain Matters in Rockfall Modelling



## Ground Interaction/Scarring:

- Rockfall impacts are strongly influenced by terrain properties
- Energy dissipation occurs mainly through **ground deformation and drag forces**
- Terrain properties determine **scar depth, drag forces and rebound behaviour**

$\Omega$   $v$  **Free Fall**

These processes control the transition between **bouncing, rolling and stopping**.

**Rolling**

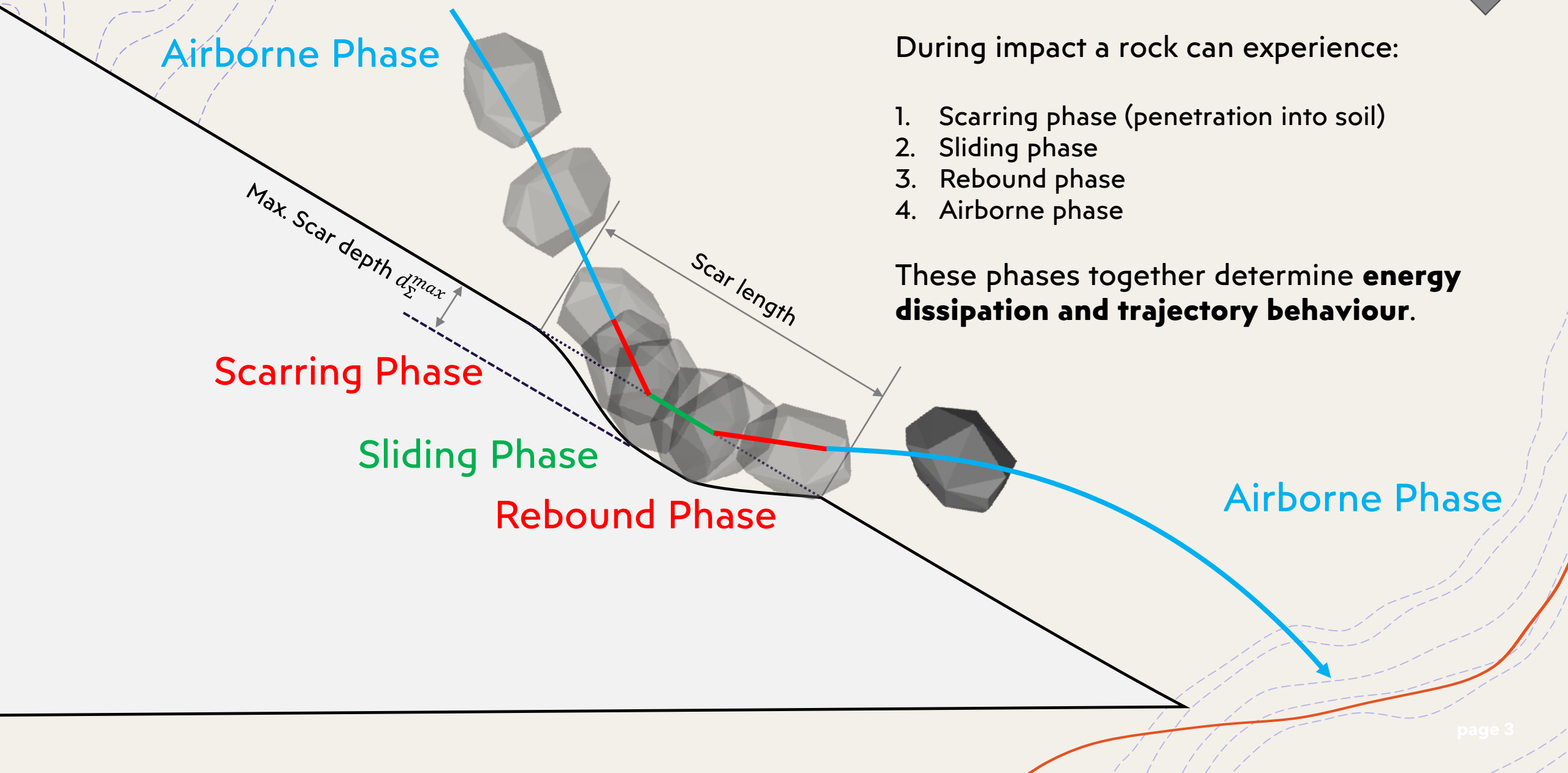
**Bouncing**

Jump height

## Ground interaction includes

- penetration (scarring)
- frictional sliding
- viscous drag

# Ground Interaction Model with Scarring



During impact a rock can experience:

1. Scarring phase (penetration into soil)
2. Sliding phase
3. Rebound phase
4. Airborne phase

These phases together determine **energy dissipation and trajectory behaviour.**

# Ground Interaction Model with Scarring



Coulomb friction coefficients for maximal soil density are set by RAMMS and are always the same

$$\mu_P(S_P) = \mu_P^{min} + \frac{2}{\pi} \cdot (\mu_P^{max} - \mu_P^{min}) \cdot \arctan(\kappa \cdot S_P)$$

Different types of soil are modelled by changing the scarring behaviour ( $M_E$  and  $C_d$ ) and not the frictional behaviour on the rebound plane

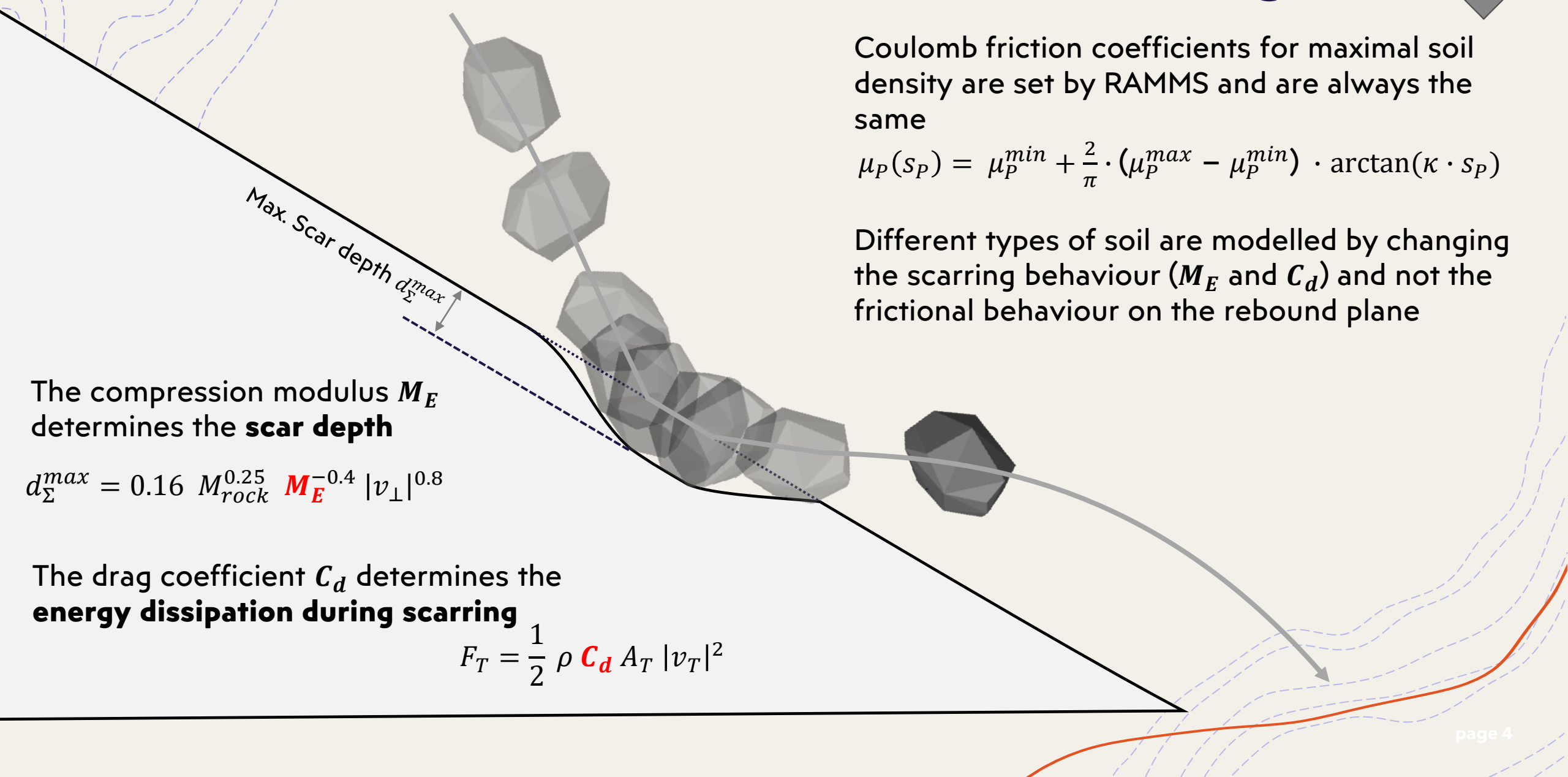
The compression modulus  $M_E$  determines the **scar depth**

$$d_{\Sigma}^{max} = 0.16 M_{rock}^{0.25} M_E^{-0.4} |v_{\perp}|^{0.8}$$

The drag coefficient  $C_d$  determines the **energy dissipation during scarring**

$$F_T = \frac{1}{2} \rho C_d A_T |v_T|^2$$

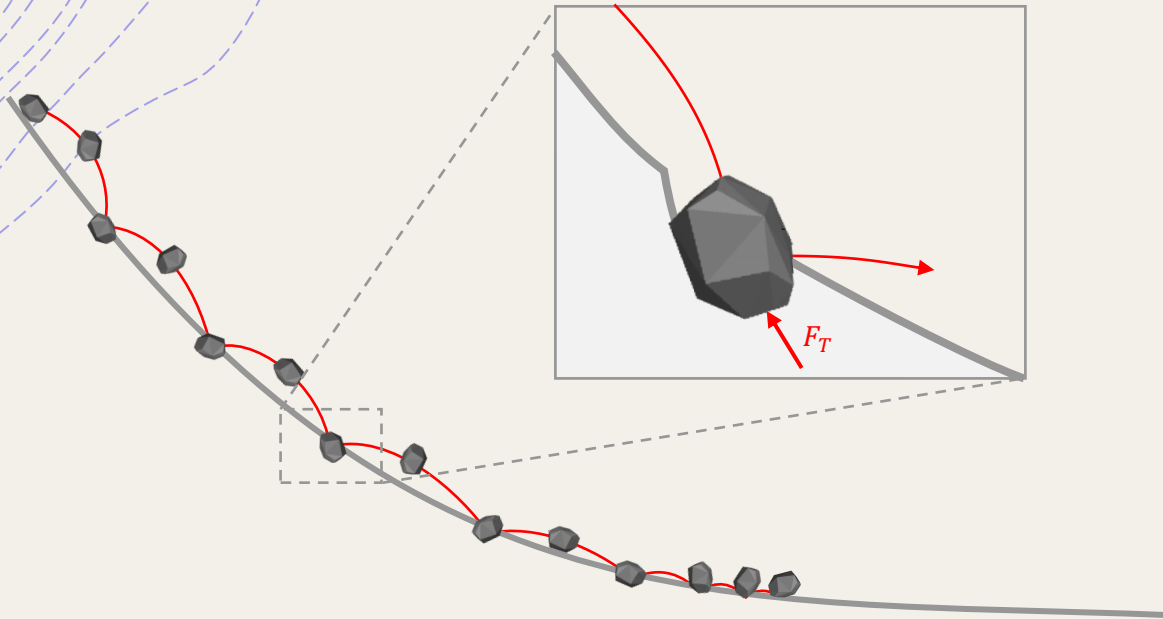
Max. Scar depth  $d_{\Sigma}^{max}$



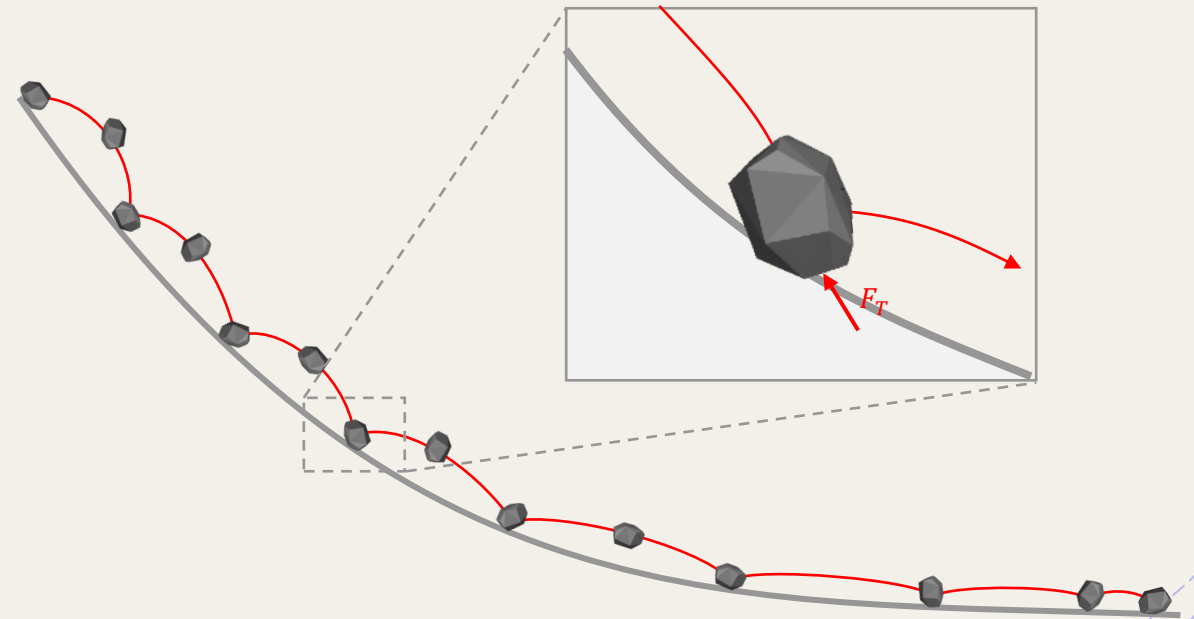
# Soil Parameter: ME



- Changes in **ME** affect the **penetration depth** of the rock.
- The **resistance upon penetration** remains unchanged, but its effect lasts for a **longer/shorter time** → energy dissipation and range of the rocks are affected.



$M_E = 2 \text{ MPa}$

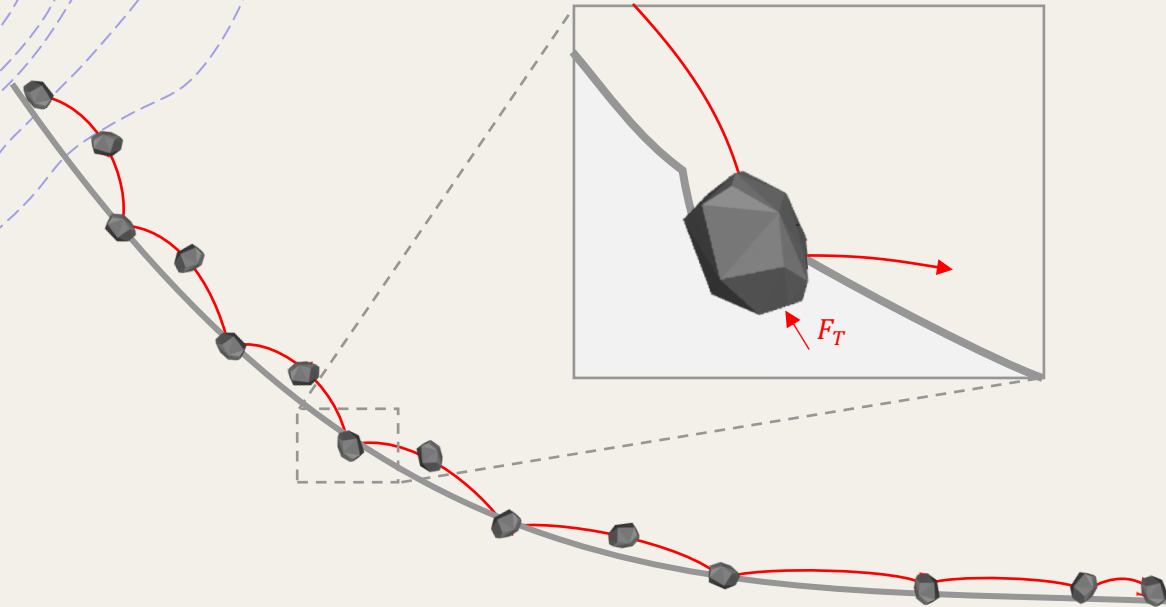


$M_E = 100 \text{ MPa}$

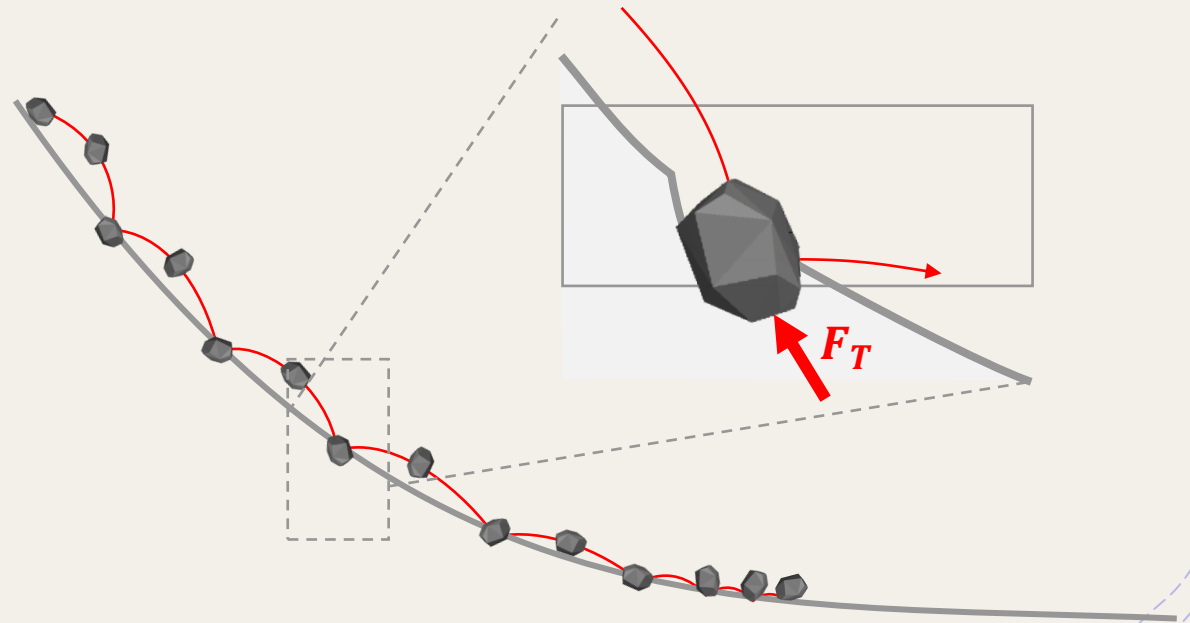
# Soil Parameter: $C_d$



- Changing the  $C_d$  value affects the **resistance during penetration** and therefore also the energy dissipation and range of the rocks.
- The **penetration depth** remains unchanged.



$C_D = 1.0$



$C_D = 2.0$

# Default Soil Parameters



**Surface Soil**

**Subsoil**

**Talus Fine**

**Talus Coarse**

**Talus Blocs**

**Moraine**

**Bedrock**



$M_E = 3 \text{ Mpa}$   
 $C_D = 1.55$

$M_E = 4 \text{ Mpa}$   
 $C_D = 1.8$

$M_E = 7 \text{ Mpa}$   
 $C_D = 2.30$

$M_E = 10 \text{ Mpa}$   
 $C_D = 2.70$

$M_E = 15 \text{ Mpa}$   
 $C_D = 3.50$

$M_E = 20 \text{ Mpa}$   
 $C_D = 3.50$

$M_E = 100 \text{ Mpa}$   
 $C_D = 4.00$

**Boulder Field**

**Alpine Spruce/  
Beech Forest**

**Mountain Road**

**Asphalt**

**River/Swamp**

# Field Characteristics of Ground Material



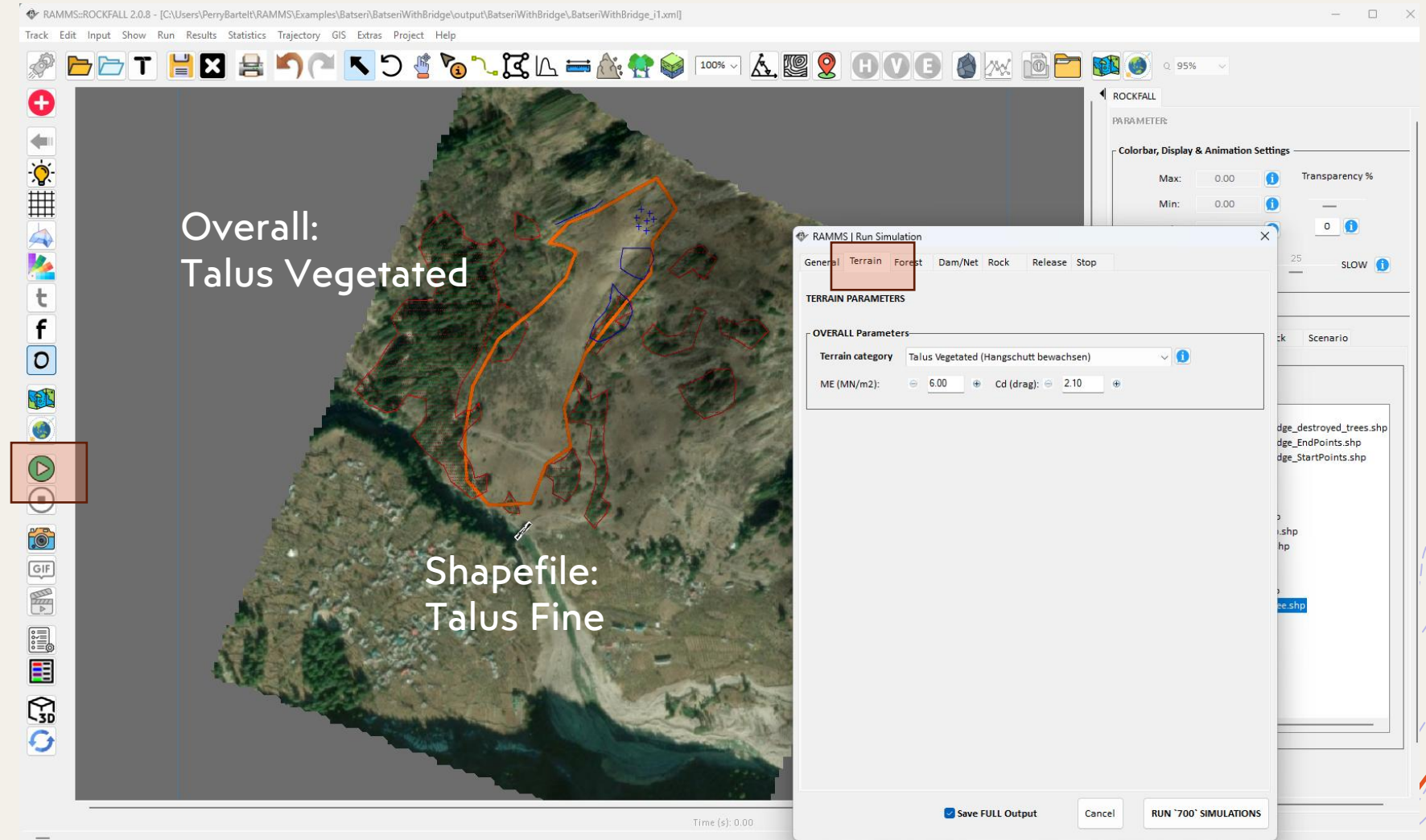
<b>Terrain Type</b>	<b>Field Characteristics</b>
<b>Surface Soil</b>	Deep soil, meadow or grassland, rocks leave clear impact scars
<b>Subsoil</b>	Thin soil layer with debris, shallow scars
<b>Talus Fine</b>	Small loose stones, rocks tend to bounce
<b>Talus Coarse</b>	Mixed rock sizes, frequent bouncing
<b>Talus Blocs / Boulder Field</b>	Large blocks, rocks may get trapped
<b>Bedrock</b>	Hard rock surface, almost no penetration
<b>Forest Soil</b>	Organic soil with roots, moderate energy dissipation

# Defining Overall Terrain Parameters



## Step 1 – Define the Overall Terrain Category

- Open the **Scenario tab** (green *Run Simulation* button) and select the **Terrain tab**.
- Define the **overall background terrain category** for the entire simulation domain.
- This background terrain is used **everywhere unless overridden by terrain polygons**.



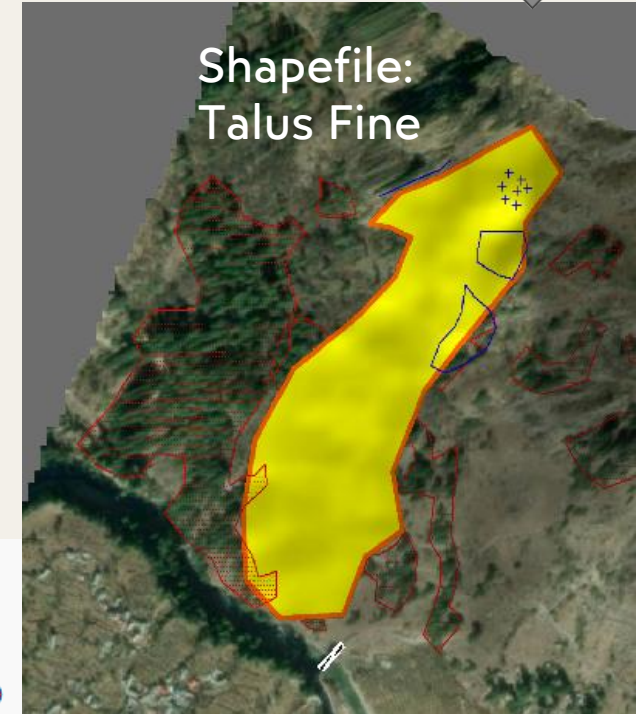
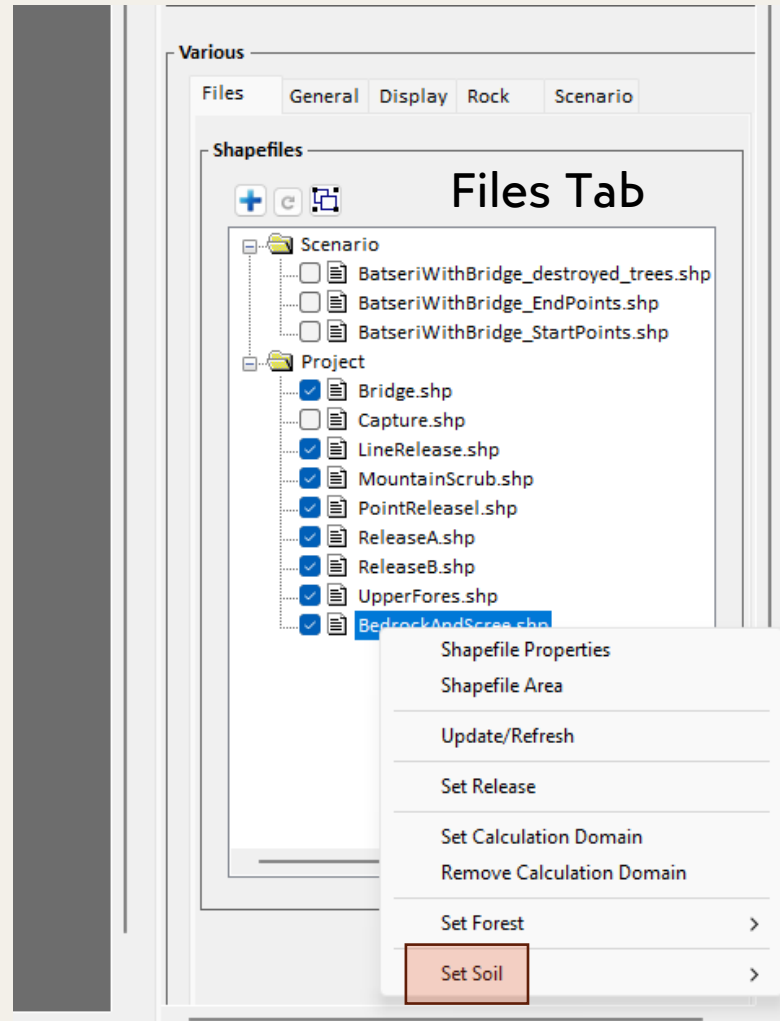
Example in this project: **Overall terrain = Talus Vegetated**

# Refine Terrain using Shapefiles



## Step 2 – Refine Terrain Using Shapefiles

- Specific terrain regions can be defined using **polygon shapefiles**.
- These shapefiles assign **different terrain categories to smaller areas** within the domain.
- Click on shapefile in the Files Tab and **“Set Soil”**



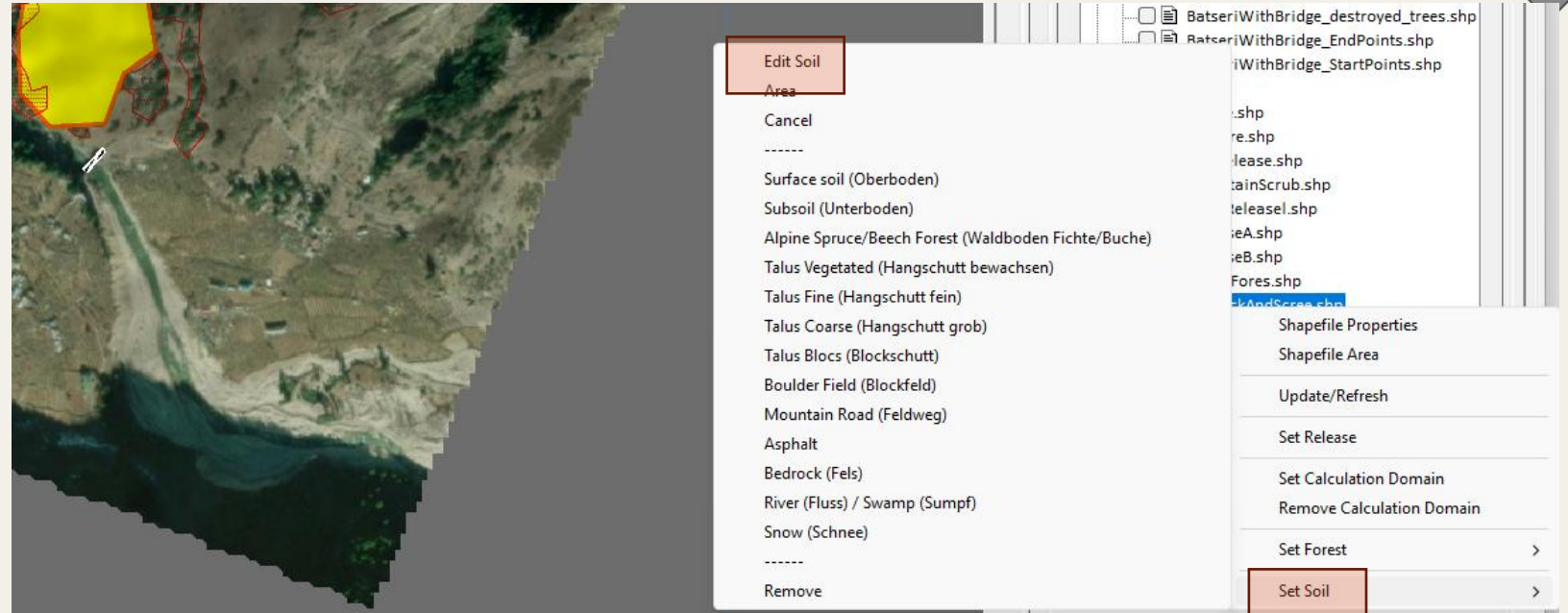
Example: **Talus Fine polygon overriding the background terrain**

# Custom Soil Types

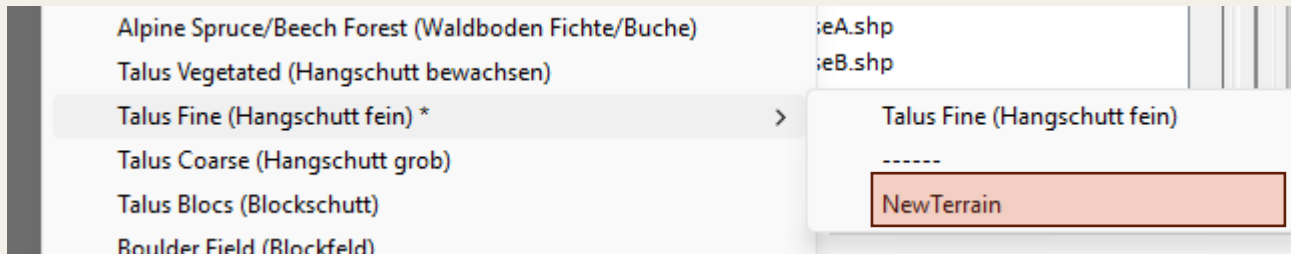


## Creating a Custom Soil Type

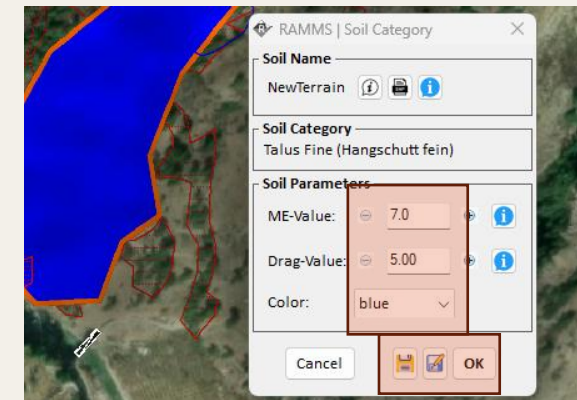
- Select an existing terrain shapefile
- Select “**Set Soil**” followed by “**Edit Soil**”
- Modify **ME (compression modulus)**, **Cd (drag coefficient)** and color
- Click **Save As** to create a new soil type



Select “**Set Soil**” followed by “**Edit Soil**”



New terrain appears under **original terrain category**



Input menu for new terrain type. Must **SAVE**.

# Practical Guide: Calibrating Terrain Parameters



RAMMS provides **experimentally calibrated terrain categories**.

Typical parameter ranges:

Parameter	Typical Range
<b>ME (soil strength)</b>	1 – 200 MPa
<b>Cd (drag coefficient)</b>	1 – 10

## Check plausibility of simulation results

After running simulations, ask:

- Are **scar depths realistic** for this terrain?
- Are **jump heights plausible**?
- Do rocks stop where **real deposits occur**?
- Do trajectories reach areas **without known rockfall activity**?

Problem	Adjustment
Scar depth too large	Increase <b>ME</b>
Runout too short	Reduce <b>Cd</b> or increase <b>ME</b>
Jump heights too small	Increase <b>ME</b> and <b>Cd</b>

**Adjust parameters if necessary.** Calibration should be **iterative**, using observations from the site.

# Summary



## 1. Terrain strongly controls rockfall behaviour

Energy dissipation occurs through soil deformation and drag forces.

## 2. RAMMS represents terrain using two parameters

Compression modulus **ME** and drag coefficient **Cd**.

## 3. Terrain categories are defined using polygon shapefiles

Each polygon represents a specific terrain material.

## 4. Default parameters exist but should be critically evaluated

Terrain parameters can be adjusted or customized based on site conditions.