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Slope instabilities of the Larzac Plateau: the Pégairolles-de-l'Escalette rotational landslide

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Introduction

The Larzac carbonate plateau extending from Millau (Aveyron) to Lodève (Hérault) is submitted to several slope instabilities, from rock toppling to large rotational landslides (see Figure 1). Our study focusses on the deep-seated landslide located on the right bank of the Lergue river, close to Pégairolles-de-l'Escalette village and the A75 highway (Fig. 2). Its activity, with a low slip rate of 3 mm/year, has been characterized through in situ (borehole) geophysical monitoring (Denchick et al., 2019). In order to find the failure scenario accounting for the current activity of the sliding mechanism, 2D modeling based on data field such Rock Mass Rating evaluation (RMR), UCS (Uniaxial Compressive Strength) measurements was performed.

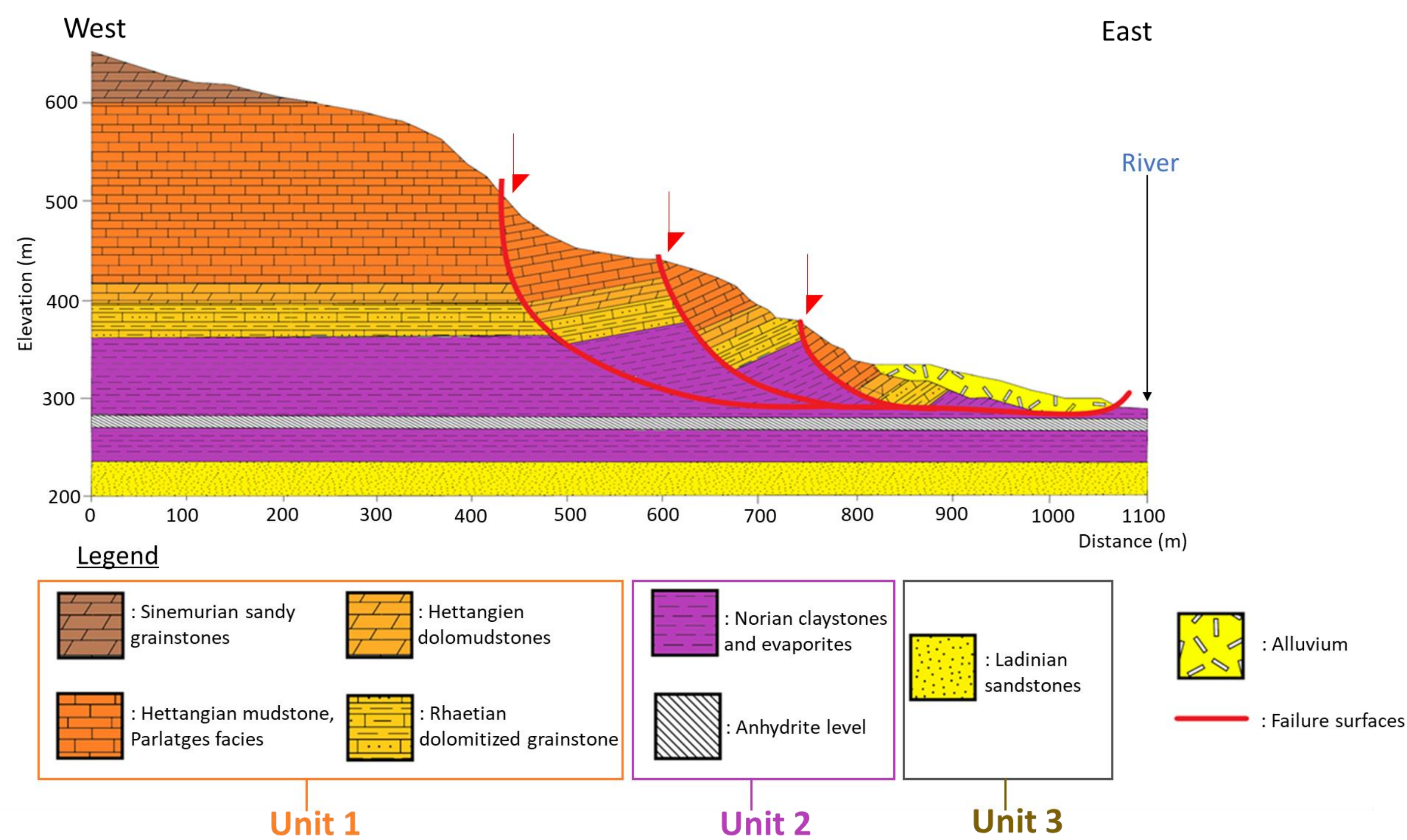


Figure 2: Geological cross-section of the Pégairolles-de-l'Escalette landslide. This geological model has been simplified for the numerical simulations into three geotechnical units (Unit 1: Late Triassic sandstones and Jurassic Carbonates, Unit 2: Triassic clays and Unit 3: Triassic sandstones). Location of the deep-seated failure surfaces are given after Denchick et al. (2019).

2. Effect of joints on mechanical parameters

Measurements of fractures at different places on the plateau (see Figure 3) show two main directions related to tectonic events, globally:

- N-S, related to the Pyrenean orogeny
- E-W, related to the Liassic extension.

Despite the fractures may span around these two main directions, our measurements show that the fracture distribution does not depend on the location, the lithologies and the *in situ* versus slided nature of the rock mass. Rock Mass Rating (Bieniawski, 1993) and UCS measurements was applied to 6 localities and used to estimate different mechanical parameters (Hoek and Brown, 1990) of the faulted rock mass for the different geological units (field parameters). Comparison of the obtained values and those derived from laboratory experiments allowed to quantify the scale factor for the Young modulus, cohesive strength and friction angle (Fig. 4).

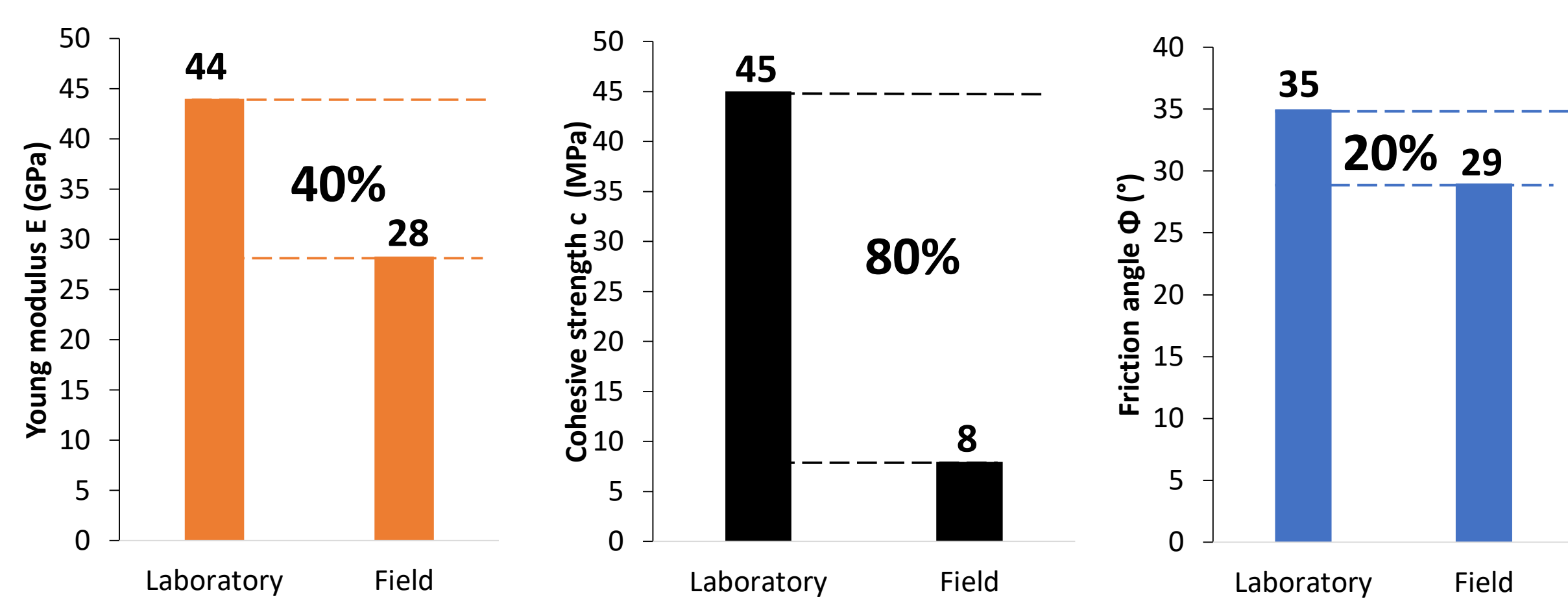


Figure 4: Mechanical parameters of carbonates rock samples (laboratory tests) and of the faulted rock unit 1 (based on field measurements). The three graphs show the Young modulus, cohesion strength and friction angle. The difference between laboratory and field estimation is indicated in percentage.

3. Modeling

On the basis of the geotechnical model established from the slide geometry and obtained "field" rock parameters (see above), different rupture scenarios were simulated using the strength reduction analysis of OPTUMG2 solver:

- Scenario 1: Lithological assemblages and behaviour model (Fig. 5A)
- Scenario 2: Different piezometric level (Fig. 5B)
- Scenario 3: Mix behaviour model and joints (Fig. 5C)
- Scenario 4: Mixt behaviour model and mechanical weakness level (Fig. 5C)
- Scenario 5: Mixt behaviour model with mechanical weakness level and joints (Fig. 5C)

All models shown a tend of decreasing of factor of safety when multilayer, piezometry and mechanical weakness level are considered. However factor of safety stay above a critical limit. Sliding conditions suggested in two models are taken with caution considering the error bars.

Figure 5: Numerical modeling of different rupture scenarios of the Pégairolles-de-l'Escalette landslide. A: Modelised units and calculated rupture surface for control model, color's scale is for strain deviator and mesh indicate the failure surface obtained. B: Scenario 1 considering different geological models and failure criteria. C: Scenario 2 considering different piezometric levels. D: Scenario 3 (with joints cutting Unit 1), scenario 4 (with a weak layer in Unit 2), and scenario 5 (with joints and weak layer).

Conclusion

These numerical simulations demonstrate the importance of considering several predisposing factors (joints, mechanical weakness level, lithologies) and triggering factors (water, gravity). Mechanical parameters obtained with field estimations are empirical so they need to be compare with laboratory tests. This work open the way to a new consideration of implemented mechanical parameters and tend to define another method than only a parametrical.

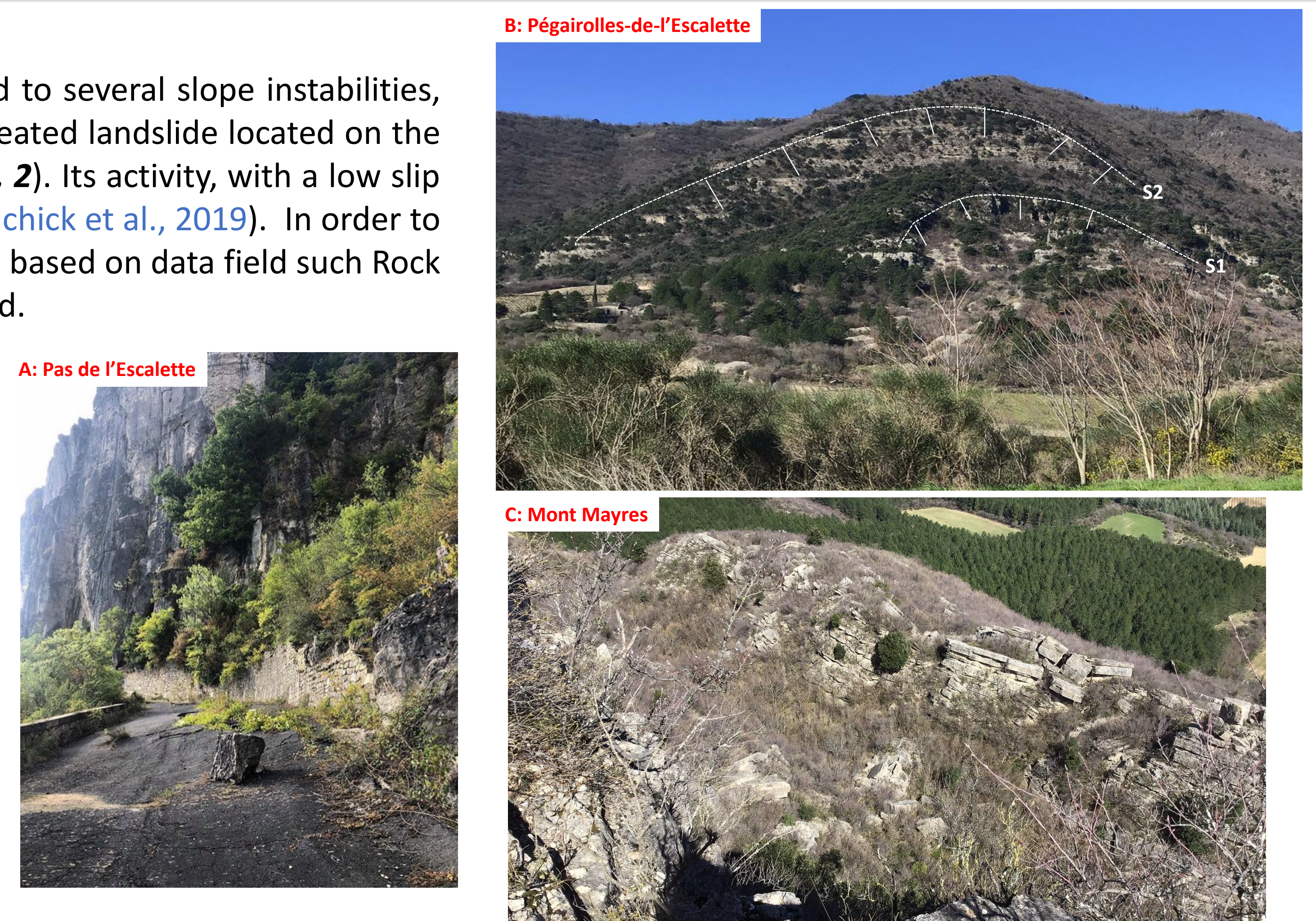


Figure 1: Illustrations of different landslides or rocks toppling at different locations. A: Pas de l'Escalette, B: Pégairolles-de-l'Escalette, C: Mont Mayres

1. Geological model

The geologic model of the landslide is given in figure 2. The rotational slide involves sedimentary rocks from Ladinian (Triassic) sandstones to Sinemurian (Jurassic) carbonates and includes several slides surfaces. The presence of similar landslides in the area (Fig. 1), suggest a common (causal) factor such as heavy rain events common in this area. This geological model will be the base of the modeling experiments.

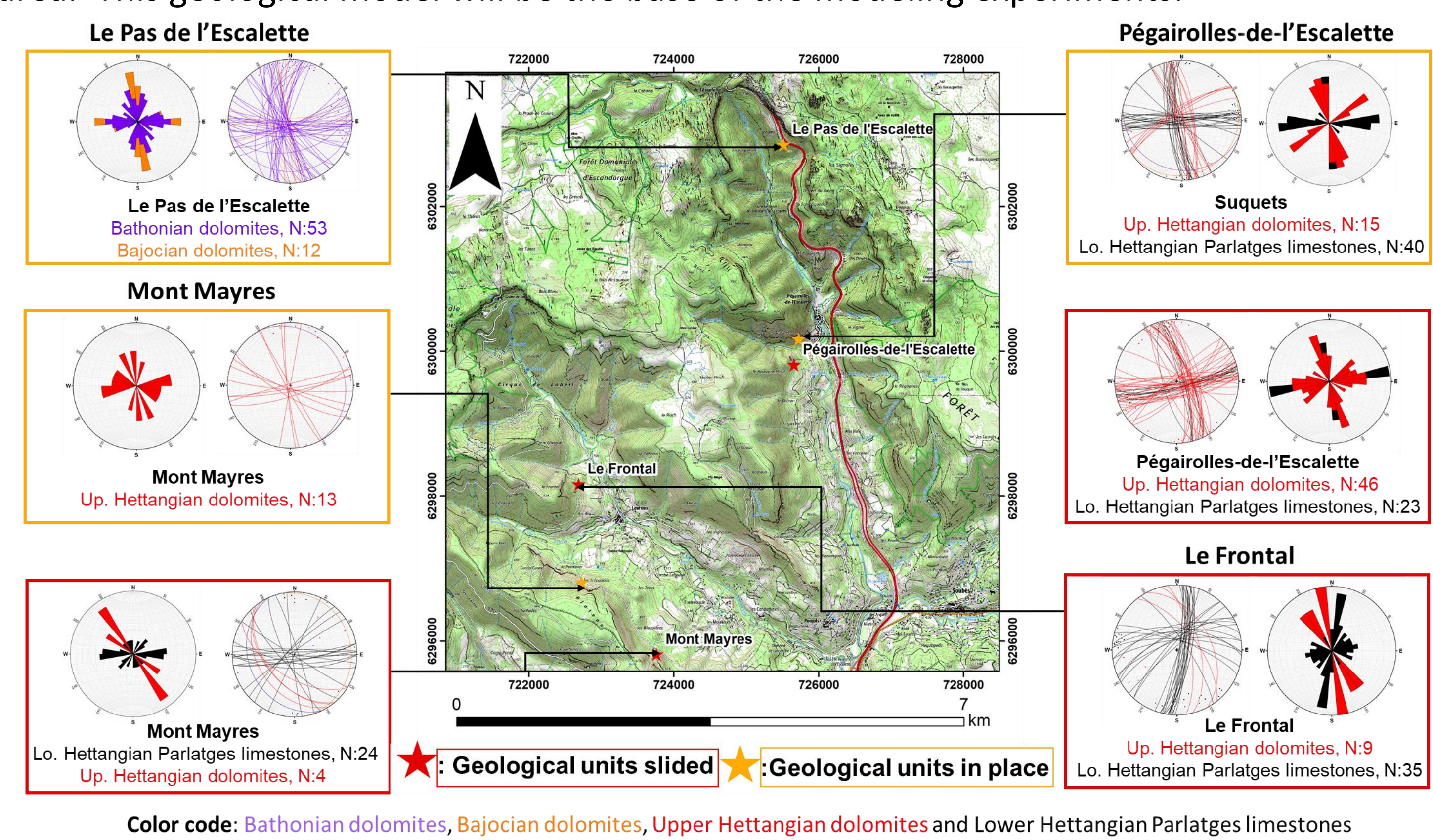


Figure 3: Distribution of fractures in geological units slided or in place rock masses. Colors in the stereographic projections and rose diagrams refer to the rock units. Number of measurements at each location is indicated.

A large difference is observed, this is due to the fact that fractures are taking account in field values. The ability to change a value of property according to the scale named the scale factor is clearly illustrate.

