3-D rockfall simulation model using terrestrial LiDAR in the active Pajacuaran Fault, Mexico

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Introduction

The town of Pajacuaran, located northwest of the state of Michoacan, experienced an intense rockfall event at the beginning of November 2013 due to an exceptional rainy season. The high precipitation regime, the local seismic activity and the rugged topography, as well as the lack of a proper urban development plan, are only some of the factors that contribute to the rockfall hazard in this area. The purpose of this investigation is to evaluate the potential rockfall threat throughout a portion of the active Pajacuaran Fault.

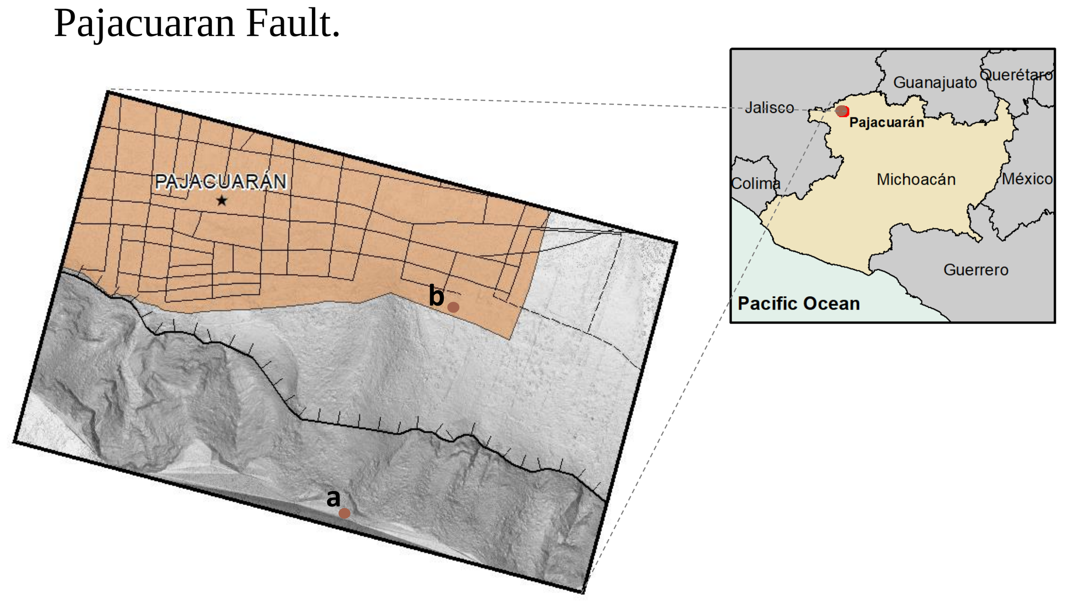

Fig. 1: Location of the study site, a) release and b) deposit points of rockfall event.

Fig. 2: Geological fault scarp, arrow indicates release zone of rockfall event.

Fieldwork

Phase 1: Preparation

Review records on historical events [1]

Map –
- Release zone (very steep)
- Transit zone (steep-moderate)
- Deposit zone (gentle-flat)

Prepare model input data

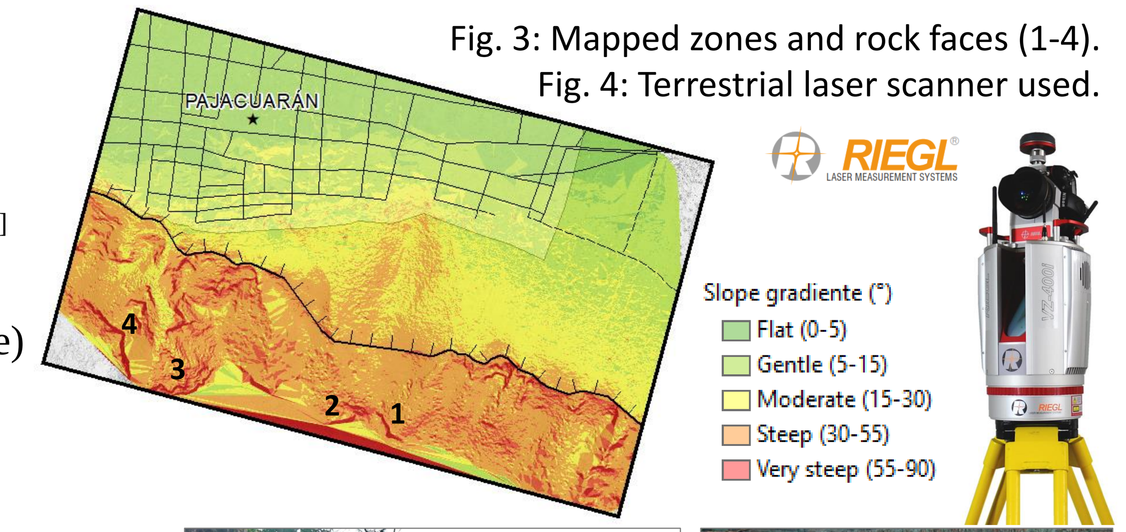

Fig. 3: Mapped zones and rock faces (1-4).
Fig. 4: Terrestrial laser scanner used.

Phase 2: Release scenario definition

Define release location, size and shape of blocks

Fig. 5: Rock face at release zone and block diameter > 2 m at deposit zone (from left to right).

Rockyfor3D

Phase 3: Rockfall simulation

Iteratively repeat simulations on *Rockyfor3D* [2]

Fig. 6: 1-meter resolution DEM of a portion of the Pajacuaran Fault, vertical offset of > 500 m.

Phase 4: Plausibility check & validation

Model results converge with real events [3,4]

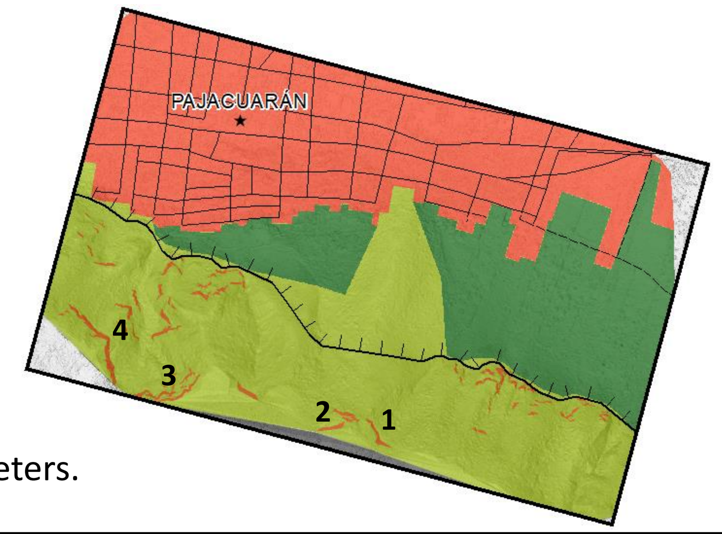

Fig. 7: Input polygon map for *Rockyfor3D* [2] parameters.

Hazard Maps

Phase 5: Fixation of model results

Define valid runout zone

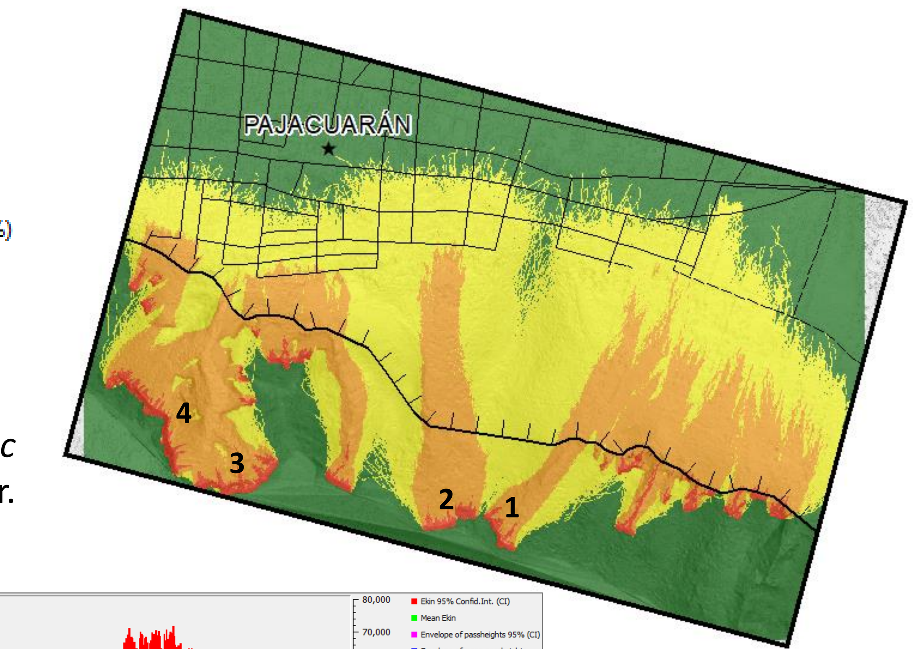

Fig. 8: Hazard zone map from *Reach_probability.asc* output raster.

Phase 6: Transformation into maps

Create spatially distributed datasets

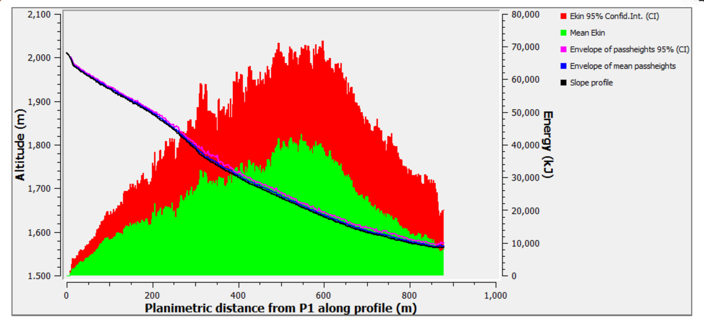

Fig. 9: *Rockyfor3D* simulation results along slope profile.

Conclusions

- The blocks which release from steep rock faces (e.g. rock faces 1-2) achieved the furthest range and reached maximum velocities of up to 70 m/s, whereas blocks from less steep areas came to a stop relatively soon (e.g. below rock face 1).
- The rockfall paths concentrated in channels (e.g. rock faces 3-4), which is also where most of the blocks and the largest volume of material deposited.
- The maximum kinetic energies of over 110,000 kJ were reached where the slope gradient starts to decrease, near the middle of the rockfall trajectories or below steps in the terrain.
- The forest stand did not have much influence in the rockfall runout or in reducing the kinetic energy values, due to its low stem density and diameter distribution.
- These findings can be helpful to authorities in charge of decision making with regards to disaster prevention and mitigation, as well as to aid in the regulation of future expansion in these hazardous settings.

References

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Further Information

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