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Historic and prehistoric landslides and rock falls in the Bolonia Bay region/SW Spain

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The identification and evaluation of triggering mechanism and dating of landslides is an essential prerequisite for hazard and risk evaluation with regard to natural disasters. This is even more important as the results from landslide investigations are relevant not only for landslide hazard identification but also for earthquake risk evaluation and paleoseismicity. For example the new Environment Intensity Scale - ESI 2007 initiated by the INQUA also uses secondary effects like landslides and rock falls to rate earthquake intensities (Guerrieri & Vittori, 2007). The Bolonia Bay in the province of Cádiz/Spain provides an excellent research area to investigate landslides and rock falls triggered by gravitational/hydrological forces and earthquakes. Vertices from prehistoric and historic settlements like the ruins from the Roman city of Baelo Claudia are located in the bay. Traces from at least two major earthquake events were identified and dated (Silva et al., 2005). The bay is flanked by three small mountain ridges build of flysch sandstones; San Bartolome, Sierra de la Plata and La Laja. Below the steep rock faces, traces of rock fall events of all sizes and ages can be observed. At the slopes below steep walls, single blocks with the size of up to 600 m3 and events with runout distances of up to 1 km can be observed showing the character of rock avalanches. Some large flat laying landslides can be identified at the slopes below the La Laja ridge, described by Silva et al. (2005 and 2006). The ruins of Baelo Claudia also show impacts from shallow-seated landslides. Dating of both, mass movements and

earthquake damages, is in progress. The geodynamic and geological setting yields the potential for earthquake triggering as well as for gravitational/hydrological triggers, so the correct classification and dating of the events is important for a qualified hazard analysis. Extensive field mapping was conducted to map the runout distances and sizes of single rock fall events. Ground Penetration Radar (GPR) was applied at the slopes below the mountain ridges in order to identify hidden rock fall events and to determine the thickness of the debris cover at the foot of the rock walls. GPR profiles were also taken at several locations to determine the dimensions of potential landslide bodies and to map soil thickness. The data show that the claystones are normally not deeply weathered and the normal thickness of the clay rich soil is not more than 0.5 m. The observed translational slides are normally thin and show quite long runout distances compared to the slope angle. To clarify the triggering mechanisms, geotechnical back analysis will follow in the future. The potential of rock falls to identify the trigger mechanism and to date the events is regarded as suitable, while intensive fracturing in the rock wall and weathering are the main triggering factors at least for smaller rock falls, seismic shaking seams to provide the triggering forces for large events. Especially the long runout distances for even very large blocks support this idea. Also, large rock blocks at the foot of San Bartolome mountain range with orientated, post-rock fall carved tombs of visigothic times show post-deposition rotation. Phenomena like this are often linked to earthquakes, especially as no indication for ground failure or landsliding in the underlying very thin soil can be observed. Rock fall simulations will be used to model the causative processes: earthquake or gravitational driven.

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