Assessing fault capability and developing paleoseismic constraints for PSHA in regions with low strain rates: a case study from the Krško Basin, Slovenia

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The Krško Basin in southeastern Slovenia is being investigated as a potential site for a new nuclear power plant. The basin lies within a complex structural zone between three tectonic domains, all of which have unique structural styles that are present within a 25 km radius of the proposed site. The basin is in a region of moderate seismicity; however, the rates of tectonic deformation and seismic sources remain poorly constrained. Locally, the basin is structurally defined by a post-Miocene syncline in response to regional stresses from general N-S convergence of the Adriatic Microplate and the European Plate. This has led to reverse and strike-slip faulting (i.e. transpressional tectonics) and several of these faults exist within five km of the proposed site.

There are several notable mapped structures in the local area (i.e. within 10 km) that may have had activity in the past 500,000 years (i.e. capable faults). Some of these have been recognized in geophysical data and others have been verified by field mapping. Two major obstacles have precluded accurate assessment of their deformation rates: sparse chronometric data, and the lack of outcrop or near-surface evidence of deformed, Pliocene-Quaternary sediments. The major deterrent to reliable geochronologic data has been the inappropriate selection of dating methods used to date Quaternary sediments. The majority of the geochronology methods that have been used near Krško have inherent limitations on their age capacity, which has led to erroneously young age interpretation for stratigraphic units. We are overcoming this issue by applying multiple dating methods that cover broader time frames, and by dating previously dated stratigraphic units to determine the cause for the erroneously young ages on some units. This approach is allowing us to reduce the uncertainty in the age constraints for faulting in the region.

The lack of outcrops exposing evidence of tectonic deformation in Quaternary sediments poses a significant challenge to establishing fault constraints. Fortunately the client has flown LiDAR data for the primary areas of investigation at extremely high quality, and Slovenia recently released a complete national LiDAR dataset with 1 m cell spacing. These data have revealed an absence of geomorphic evidence for fault movements, but given the relatively high erosion rates in the region, direct observations of surface expressions of faulting may be masked. To address this, we have applied specific methods in tectonic geomorphology that target the components of the landscape that archive long-term tectonic deformation. We are also applying a multi-method approach in geophysics to youngest deformed sediments in high resolution.

We present early-phase results of the geochronology, tectonic geomorphic analyses, and geophysics from the region. The approach may serve as a model for some U.S. nuclear facilities where low tectonic deformation rates pose challenges to assessing seismic hazards.