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Subsidence and landslide processes in the Wieliczka area (Poland): insights from PSI and ground data integration

J. Wasowski (1), C. Lamanna (1), M. Graniczny (2), Z. Kowalski (2), M. Czarnogorska (2), A. Wojcik (3), F. Bovenga (4), A. Refice (4), D. Conte (5), and R. Nutricato (5)

(1) Bari, CNR-IRPI, Bari, Italy (j.wasowski@ba.irpi.cnr.it, +39 080 5929 610), (2) Polish Geological Institute, Warsaw, Poland, (3) Polish Geological Institute, Cracow, Poland, (4) CNR ISSIA, Bari, Italy, (5) Dipartimento Interateneo di Fisica, Politecnico di Bari, Italy

This work builds upon the earlier Persistent Scatterers SAR Interferometry (PSI) study of the Wieliczka area [1], focused on the detection of long-term subsidence caused by the activity of the ancient Wieliczka Salt Mine (Unesco Heritage Site, Poland). The SPINUA processing of several tens of ERS images covering the period 1992-2000 has led to the identification of over 3000 radar targets (density about 100 PS/km2) and shown that the subsiding zone (movements up to 24 mm/yr) corresponds well to the subsurface extent of the salt deposit and mine works. The Wieliczka area is characterized by a range of ground instability phenomena (subsidence, landslides, slope creep), as well as variable geological, geomorphological and land cover conditions, and hence offers an excellent opportunity to test the practical applicability of multi-temporal differential interferometry techniques. Here we extend the study to the peri-urban and rural areas surrounding the town of Wieliczka and explore the utility of C-band PSI to investigate landslides and related ground instability phenomena. Furthermore, we provide a more in depth interpretation of the satellite-borne observations by supplementing the PSI data with in situ information, including also the data from a local geodetic network consisting of over 1000 benchmarks. It is shown that i) the PSI-detected ground displacements agree very well with the levelling results and provide useful complementary data (increased density of measurements); ii) a very small percentage (below 3%) of PS falls within the landslide limits (in relation to the low degree of urbanization of failure-prone slopes and presence of vegetation) and relatively little information can be obtained on slope movements.
Furthermore, there is a concentration of large, pre-existing landslides that originate on the north-facing slopes of the Carpathian overthrust front and descend towards a few km long subsidence bowl in the central-western part of Wieliczka. The toes of some landslides include several slowly moving PS (within 1 cm/yr), but since they also overlap the southern part of the subsidence bowl, no straightforward interpretation of the causative processes and relative hazard assessment are possible without high precision data on the horizontal component of motion. It should be useful to fulfill this additional data requirement (e.g. by installing a local GPS network), because the affected area includes buildings and roads that have already suffered damage in the past. Regardless of the exact cause(s) of the observed PS displacements, the case of concentrated large slides suggests that the changes in the Wieliczka morphology, linked to the subsidence induced by centuries of mining (lowering of slope base and hence steepening), have been responsible for the long-lived landsliding on slopes facing the mine area.

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References
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