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Mining-Induced Tremors Source Modelling Applying InSAR

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Mining exploitation is associated with the occurrence of adverse environmental effects. The most serious of such effects is land subsidence. Although land subsidence can be well predicted and mitigated by several methods, nevertheless, the extraction of mineral deposits is also associated with induced seismicity. The occurrence of seismic events causes ground surface vibrations, land surface displacements and, in many cases, has a negative impact on the safety of surface infrastructure and the inhabitants of endangered areas. Despite this, the issue of induced seismicity is much less recognized and often ignored in the assessment of the negative impacts of mining exploitation.

Induced seismicity is related to stress changes in the reservoir and surrounding rock mass that may be caused by a variety of mechanisms. Consequently, the patterns of induced seismicity vary greatly over time and space for different fields or events within the same field. It is often difficult to determine the correlation between seismicity and mining precisely because of the lack of data detailing the pattern of exploitation at the various wells. As a result, the source mechanism of mining-induced tremor remains a subject of active research.

The research aimed to better identify the phenomenon of induced seismicity caused by mining operations. Research has been conducted in the area of underground copper ore mining in Poland. Firstly, we investigate the pre-and post-seismic land-surface movements following 8 mining-induced Mw 3.6-4.8 earthquakes that occurred between 2016 and 2018. We use Sentinel 1 data to derive these movements 2 weeks before and 4 weeks after the mainshock. The results of these studies show that no substantial pre-seismic surface movements are indicating the possibility of a seismic event occurring. However, the co-seismic deformation fields are quite symmetrical, the maximum land subsidence is almost 10 cm and occurs within a few days after the mainshock. In addition, the time series of post-seismic deformation shows a gradual decay and a good correspondence with the post-shock distribution.

Secondly, we use the Mogi model, assuming the elastic half-space, to invert co-seismic deformation fields and to obtain the source parameters of the mine-induced earthquakes. The spatial distribution of the epicenters indicates a correlation with the fields of mining exploitation. The results also show that the average depth of the hypocenter tremor is approx. 650 m. This corresponds to the depth of the stiff sandstone layers adjacent to the exploration. These layers accumulate the stress of post-exploitation voids. In addition, the modeling results indicate an

approx. the volume of the displaced rock layers of 1.2 x 105 m3. This value shows a high correlation with the volume of post-shock troughs determined based on InSAR data.

The results of this study contribute to research into activities related to mining operations resulting in an induced-earthquake occurrence. This demonstrates InSAR's potential for quasi-constant monitoring of large-scale areas against seismic hazards caused by ongoing mining operations.