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Spatial patterns, causal factors and initiation mechanisms of sinkholes above underground limestone quarries: a case-study in South Limburg (Belgium)

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This study uses historical records for the compilation of a database of sinkholes resulting from collapses of abandoned shallow underground limestone quarries in two villages in Belgian South Limburg. During the last 350 years the formation of such sinkholes caused at least 38 casualties, but more often it caused a change in topography and damage to public and private property. The main objective was to better understand the spatial distribution and temporal patterns of quarry collapse-related sinkholes in the study area. Apart from sinkhole locations and ages, the compiled database provides information on the dimensions of the area affected, the damage caused and the causal factors. For the latter a classification system is presented.

173 sinkholes were reported since 1665, but most (i.e. 80%) reported sinkholes postdate 1965. Sinkhole dimensions provided information on the type of collapse. Seven large sinkholes, displacing a total soil volume of 480,000 m^3, resulted from large-scale roof breakdown after pillar failure. The other smaller sinkholes were the result of throughflow of the overburden into galleries after local roof collapse or suffosion of a solution pipe. In total, these small sinkholes displaced 12,300 m^3 of soil. At present almost all known large quarries in the study area have been affected by sinkholes. These features are caused by natural and anthropogenic factors, and generally occur during spring in zones with thin roofs or where pillars are affected by pillar robbing, on

locations above quarries with inappropriate sewerage systems, and during years with high moisture contents in the overburden, being periods with either high groundwater recharge or above average precipitation. With increasing time since quarry abandonment, quarries are more susceptible to pillar creep and bending of the roof. Hence, if no appropriate mitigation measures are taken to reduce roof collapse or pillar failure, the number of sinkholes is expected to increase.