

TABLE OF CONTENTS

PREFACE	5
1. CONTEXT, INTRODUCTION, AND OBJECTIVES OF THE GUIDELINES	9
1.1. Induced seismicity in post-mining coal areas	9
1.2. PostMinQuake project.....	10
1.3. Objectives of the guidelines	11
1.4. Structure and use of the guideline.....	12
1.5. Intended audience of the guidelines.....	14
2. CHARACTERIZATION OF POST-MINING HAZARDS	15
3. METHODOLOGY OF GEOLOGY AND MINING DATA COLLECTION	17
3.1. Geological data.....	17
3.1.1. Geological conditions.....	17
3.1.2. Surface conditions	18
3.1.3. Rock mass properties	19
3.1.4. Hydrogeological conditions	21
3.1.5. Water level management during mines flooding and water pumping	22
3.2. Mining data.....	22
3.2.1. Mining history and mining conditions	22
3.2.2. Mining methods	23
3.2.3. Mining panels and mining thickness.....	23
3.2.4. Seismic monitoring network data and monitoring protocol during and after closing of mining operations.	24
3.3. Database structure	25
4. HYDRO-MECHANICAL MODELLING AS A TOOL FOR SEISMICITY PREDICTION IN FLOODED COAL MINES.....	26
4.1. Hydro-mechanical simulations.....	27
4.1.1. Methodology	27
4.1.2. Modelling method	28
4.1.3. Data	29
4.1.4. Practical application	31
4.2. Recommendations	35

5. SEISMIC HAZARD CONTROL AND PREDICTION OF SURFACE ADVERSE EFFECTS	36
5.1. Seismic hazard monitoring and control	38
5.2. Ground motion prediction equation (GMPE).....	40
5.3. Shake-Maps	41
5.4. Seismic scenario	43
5.5. Seismic hazard assessment using the Mining and Post-Mining Seismic Instrumental Intensity Scale (MSIIS-22)	44
5.6. Empirical dynamic resistance criterion for buildings per the MSIIS -22 scale.....	48
5.7. Recommendations and conclusions.....	50
6. DAMAGE ASSESSMENT OF POST-MINING EARTHQUAKES ON BUILDINGS AND INFRASTRUCTURE	52
6.1. Application of seismic fragility models	53
6.2. A macroseismic scale adapted to mining and post-mining earthquakes	55
6.3. Application to damage scenarios.....	55
6.4. Recommendations and conclusions.....	58
7. MONITORING STRATEGIES FOR SAFETY USE OF POST-MINING TERRAINS .	59
7.1. Temporary near-surface geophysical surveys	60
7.2. Continuous and periodic monitoring of gravity	62
7.3. Seismic monitoring and seismological techniques.....	66
7.4. Monitoring of surface deformations.....	70
7.4.1. General principles of implementing satellite GNSS measurements	72
7.4.1.1. Methodology for GNSS monitoring in seismically active post-mining areas	75
7.4.1.2. Practical application	77
7.4.2. Interferometric SAR Technique.....	80
7.4.2.1. InSAR monitoring of post-mining areas	83
7.4.2.2. InSAR practices for post-mining applications	84
7.5. Monitoring of water in soils and rock mass	86
7.6. Best practices for post-mining monitoring.....	89
8. GUIDELINE TO DESIGN AND MANAGE AN EARLY WARNING SYSTEM FOR POST-MINING SEISMIC RISK.....	95
8.1. Design of post-mining early warning system applied to ground movement.....	95
8.1.1. Physical parameters to monitor.....	96
8.1.2. Technical requirements	96
8.1.3. Seismic data processing	97
8.1.4. Alarm criteria and monitoring procedure.....	98
8.2. Data governance	100
8.3. Recommendation and conclusions	101
9. CONCLUSIONS AND GENERAL RECOMMENDATIONS	103
REFERENCES	107