Contents

1 Summary **9**

1.1 Activity overview 9

1.2 Significant achievements as concerns short-term warnings, hazard assessments and understanding crustal processes related to earthquakes 10

1.2.1 New methods and algorithms have been developed and are applied - a basis for earthquake warnings 10

1.2.2 New observations and new understanding of earthquake related crustal processes, a basis for long-term as well as real-time interpretations . . 12

1.2.3 Significant warnings and other risk mitigating information during the project period 14

1.2.4 Continuation towards new research projects and enhanced warning service based on the results of the PRENLAB projects 16

1.3 Meetings and workshops 17

2 The role of the responsible institutions **19**

2.1 IMOR.DG: Icelandic Meteorological Office, Department of Geophysics 19

2.2 UUPP.DGEO: Uppsala University, Department of Geophysics 19

2.3 UEDIN.DGG: University of Edinburgh, Department of Geology and Geophysics 20

2.4 GFZ.DR.DBL: Stiftung GeoForschungsZentrum Potsdam - Solid Earth Physics and Disaster Research - Earthquakes and Volcanism 20

2.5 NVI: Nordic Volcanological Institute 21

2.6 CNRS.TT: Centre National de la Recherche Scientifique, Delegation Paris B - Département de Géotectonique 21

2.7 UBLG.DF: University of Bologna, Department of Physics 21

2.8 CNRS.DTP: Centre National de la Recherche Scientifique, UPR 0234 - Dynamique Terrestre et Planétaire 22

3 Summary of scientific achievements by subprojects and tasks **23**

3.1 Subproject 1: Monitoring crustal processes for reducing seismic risk 23

3.1.1 Task 1: Database development and service for other scientists 24

3.1.2 Task 2: Enhancing the basis for alerts, warnings and hazard assessments 29

3.1.3 Task 3: Modelling of near-field ground motions in catastrophic earthquakes in Iceland 30

3.1.4 Task 4: Mobile stations for shear-wave splitting monitoring 31

3.1.5 Task 5: Extending the alert system functions by real-time research . . 33
3.1.6 Task 6: To prepare the SIL system and the alert system for use in other risk areas 37
3.1.7 References 37
3.2 Subproject 2: Applying new methods using microearthquakes for monitoring crustal instability 40
3.2.1 Real-time mass evaluation of relative locations 40
3.2.2 The Spectral Amplitude Grouping method (SAG) for analyzing crustal stress conditions. A potential for intermediate-term warnings 42
3.2.3 Real-time inversion of stress tensor 44
3.2.4 References 44
3.3 Subproject 3: Using shear-wave splitting to monitor stress changes before earthquakes and eruptions 45
3.3.1 Task 1: Continuous monitoring of shear-wave splitting 45
3.3.2 Task 2: Analysis of shear-wave splitting measurements 53
3.3.3 Task 3: Establish shear-wave splitting map of Iceland 54
3.3.4 Task 4: Calibrate techniques and behaviour if and when changes are identified 54
3.3.5 Task 5: Incorporate shear-wave splitting interpretations into routine analysis 55
3.3.6 Meetings and conferences 55
3.3.7 References 55
3.4 Subproject 4: Borehole monitoring of fluid-rock interaction 56
3.4.1 Geophysical logging 56
3.4.2 Task 1: Repeated logging in borehole Nefsholt 58
3.4.3 Tasks 2, 3, and 4: Cross correlation of logs of the same type from different campaigns and earlier loggings; comparison of changes in logs of different type; comparison of changes in logs with changes in seismicity, etc. 63
3.4.4 Acknowledgements 80
3.4.5 References 80
3.5 Subproject 5: Active deformation determined from GPS and SAR 81
3.5.1 Subpart 5A: SAR interferometry study of the South Iceland seismic zone 82
3.5.2 Subpart 5B: GPS measurements of absolute displacements 86
3.5.3 References 90
3.6 Subproject 6: Effects of stress fields and crustal fluids on the development and sealing of seismogenic faults 91
3.6.1 Task 1: Determination of the paleostress fields associated with the test areas from fault-slip data 92
3.6.2 Task 2: Reconstruction of the current stress field associated with the test areas 95
3.6.3 Task 3: Present–day deformation from GPS network and interferograms of ERS-SAR scenes 100

3.6.4 Task 4: Effects of fluid pressure on faulting 103
3.6.5 Task 5: Numerical models on faults and fault populations 106
3.6.6 Task 6: Analyzing the fracture properties of Icelandic rocks in the laboratory 107
3.6.7 Conclusions 112
3.6.8 References 112
3.7 Subproject 7: Theoretical analysis of faulting and earthquake processes 114
3.7.1 Subpart 7A: Ridge-fault interaction in Iceland employing crack models in heterogeneous media 114
3.7.2 Subpart 7B: Modelling of the earthquake related space–time behaviour of the stress field in the fault system of southern Iceland 122
3.7.3 References 143

4 Publications **145**