Preface

The monitoring of induced seismicity: observations, models and interpretations

Human technological activity can alter the natural environment in many ways. These alterations provoke various, often unwanted responses. The phenomenon of triggered and induced seismicity is one example of such unwanted by-products. It can result from stress or pore pressure changes, from a volume change, from loading or unloading in the rockmass or from combinations of such causes. Therefore, induced earthquakes usually accompany mineral exploitation, hydrocarbon production, reservoir impoundment, geothermal energy production and many other technological processes that perturb the boundary conditions in the affected rockmass. In general these events give rise to a smaller energy release than that associated to natural earthquakes, yet they can be dangerous, often damaging and occasionally devastating. The M6.3 earthquake that occurred in Koyna region in India on December 10, 1967 with more than 200 casualties opens a list of seismic events, all connected with artificial water reservoirs, whose magnitude exceeded 6.0. A mining-induced tremor beneath the town of Polkowice in Legnica-Glogow Copper District in Poland on February 20, 2002 caused panic and considerable damage in multistory buildings. Rockbursts in hard rock and coal mines persist, threatening significantly the continuity of production and underground staff safety.

The problem of induced seismicity is intrinsically interdisciplinary, because it comprises a combination of human action on rocks with the rock response. Hence to study the phenomenon one must master seismology and have a thorough knowledge of the particular technological processes that lead to the induced seismic activity. Since these processes can be quite different the community studying induced seismicity is quite diversified. Therefore, permanent communication and information exchange between groups working with earthquakes caused by human activity in different areas of technology is a matter of primary importance. The present Special Issue intends to respond to such needs.

This Special Issue arises from presentations provided in the Special Session “Monitoring of Induced Seismicity: Observations, Models and Interpretations” of the 33rd General Assembly of the International Association of Seismology and Physics of the Earth’s Interior (IASPEI) held in Santiago de Chile during October 2–8, 2005.

The issue starts with a set of seven papers related to mining-induced seismic phenomena. Due to the complexity of mining environment, where local geology variations are intermixed with an often complicated geometry of mining openings, the mining-induced seismicity appears to be also complex in many aspects. This complexity is a common leitmotif of the first four papers. Sileny and Milev show examples of mechanisms of seismic events from a gold mine in South Africa not having pure double-couple (DC) mechanisms. Non-DC components are in good agreement with the geometry of the underground mining and geology structures. In order to enhance event location Lesniak and Pszczola propose a new combination of the two well-known location procedures: P-arrivals and P-wave directions. Their fast algorithm is suitable for flat sensor arrays and for the considerable heterogeneity of mining rock mass, and is used for both hypocenter determination as well as nonlinear error estimation. Lasocki and Orlecka-Sikora provide statistical evidence that the source-size distribution of mining seismic events could be essentially different from the Gutenberg–Richter law and might have a multi-componental structure. They also apply in practice the nonparametric kernel estimators, which are accurate regardless of the complexity of the actual event size distribution. In the next paper Orlecka-Sikora also discusses the nonparametric approach to estimate the event size distribution and related hazard parameters. Her paper provides a resampling-based algorithm for determining the uncertainty of the nonparametric estimates of source-size probabilistic functions. The next two papers deal with the premonitory recognition of fracturing process changes that may lead to a high-energy event occurrence close to a mining stope: a vital topic for mining practice. Orzepowski and Butra use borehole deformation measurements to monitor unwanted changes of the stress field. This is the same goal of the Cianciara and Cianciara paper, which however attempts to monitor stress field changes by studying the attenuation of microseismic signals. The mining seismicity set of papers is completed by that of Holub and Petros, who provide an analysis of strong damaging events (i.e. rockbursts) from Ostrava-Karvina Coal Basin in the Czech Republic.

The last three papers of this special issue consider induced seismic phenomena of non-mining origin. Vavrycuk et al. show that source mechanism complexity is not exclusively restricted to mining seismology. Mechanisms of selected events recorded during the 2000 injection experiment at the KTB deep borehole in Germany turn out to have a similar percentage of DC and

non-DC components. The authors relate the non-DC components to the presence of anisotropy in the focal area. Chadha et al. study water-level fluctuations in observation wells distributed around the Koyna-Warna region. The water level in wells seems to respond to both local and teleseismic earthquakes. The last paper of the volume by Ferreira et al. presents a case study and a preliminary analysis of reservoir-induced seismicity from Brazil.

Discussing triggered and induced seismicity topics at IASPEI and IASPEI Commission meetings has continued since the Chile conference. The "Seismic Hazard and Risk due to Induced Seismicity" session was convened by Steve Oates and Torild van Eck during the First European Conference on Earthquake Engineering and Seismology, a common undertaking of the IASPEI European Seismological Commission and the European Association of Earthquake Engineering, which took place in Geneva (Switzerland), September 3–8, 2006. The next event devoted to these problems was the workshop "Induced Seismicity", organized by IASPEI during the XXIV General Assembly of the International Union of Geophysics and Geodesy (IUGG) in Perugia (Italy), July 2–13, 2007. All participant of this workshop expressed their interest in setting up a platform for integrating the efforts of all groups working on different aspects of induced seismicity. As a consequence the Working Group on Triggered and Induced Seismicity (TAIS) was formed within the Commission on Seismological Observation and Interpretation (CoSOI) of IASPEI. TAIS plans to summon a common session together with the Moment Tensor Working Group of ESC during the next ESC conference in 2008 in Greece, and a session during the next IASPEI assembly in 2009, which will take place in Cape Town in South Africa, the country where mining-induced seismicity problems are of paramount importance.

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