Past, Present and Future Passive Seismic Tasks for Sustainable Development

Conference Paper · September 2013

DOI: 10.3997/2214-4609.20131639

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Past, Present and Future Passive Seismic Tasks for Sustainable Development

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SUMMARY

Seismic hazard increases every year as economic assimilation of earthquake-prone areas is going on. It is also aggravated by uncontrolled human impact on the Earth's lithospheric shell (extraction of oil and gas, as well as of other mineral resources, construction of large hydro technical structures, burial of industrial waste and so on). Higher seismic risk is also caused by setting up atomic power plants and other ecologically hazardous facilities in earthquake-prone regions, because even insignificant earthquakes and the associated secondary damaging factors (landslides, rock falls, ground breakage and so on) can disrupt their normal operation. The problem of providing seismic safety is thus a complex one, demanding interdepartmental solutions and coordination, the estimation and forecast of, not only direct, but also of consequential loss implementation of a great number of multi-level tasks using passive seismic methods.

Introduction

Seismology is the study of earthquakes, with a focus on the propagation of seismic waves through the Earth's crust, and the movements of tectonic plates. Seismic monitoring allows to better understand the mechanisms in Earth's crust. For example, we can control gas storage, it may be considered as a criteria for governing its performance, leading hydrocarbon reservoirs support and estimate drilling risk. The role of seismic monitoring is important to confirm the stability of the formation, and to prevent in case of a long term rupture process. The problem of earthquake occurrence in platform territories remains still unsolved in many aspects.

Prediction of seismic hazard is particularly important for densely populated southern European Russia. Seismic hazard increases every year as economic assimilation of earthquake-prone areas is going on. It is also aggravated by uncontrolled human impact on the Earth's lithospheric shell (extraction of oil and gas, as well as of other mineral resources, construction of large hydro technical structures, burial of industrial waste and so on). Higher seismic risk is also caused by setting up atomic power plants and other ecologically hazardous facilities in earthquake-prone regions, because even insignificant earthquakes and the associated secondary damaging factors (landslides, rock falls, ground breakage and so on) can disrupt their normal operation. As is known, the first step in decreasing the loss due to earthquakes is seismic zoning of earthquake-prone areas. It is one of the most complicated and very critical problems of modern seismology. Its scientific complexity consists, first of all, in the fact that it belongs to the category of predictions based on incomplete information, meagre and not always successful experience and on methodological approaches that are not precisely enough defined. The problem of providing seismic safety is thus a complex one, demanding interdepartmental solutions and coordination, the estimation and forecast of, not only direct, but also of consequential loss implementation of a great number of multi-level tasks (Ulomov, 2003).

The analysis of the internal micro-seismicity underlines the important link with the exploitation activity. Requirements for environmental screening, to obtain permits for new or modified underground storage operation will become a major key for the sustainable development of underground storage business (Fortier E. et al., 2006). Sustainable development ties together concern for the carrying capacity of natural systems with the social challenges facing humanity [Stivers, 1976]. Sustainability requires that human activity only uses nature's resources at a rate at which they can be replenished naturally. The Government has ratified the Federal Program - "Seismic safety of territory of Russia" (2002- 2010). The purpose of this Program is the maximal increase of seismic safety of the population, reduction of social, economic, ecological risk in seismically dangerous areas of the Russian Federation, decrease of damages from destructive earthquakes by certification, strengthening and reconstruction of existing buildings and constructions, and also preparation of cities and other settlements, transport, power constructions, pipelines for strong earthquakes. The actual frequency of large earthquakes in Northern Eurasia is three and more times higher than previously assumed. The use of straight plots in past years resulted in significant overestimation of the return time of large earthquakes, hence, in underestimation of seismic hazard practically in all the regions of the former USSR (Ulomov, 2003).

The active use of passive seismic techniques is expanding with applications spanning various disciplines. From monitoring fluid sequestration to hydrocarbon exploration, passive seismic is proving to be versatile, cost effective and environmentally friendly, aiding geo-scientists and engineers alike in their daily activities. With easy to find resources behind us and better environmental compliance ahead, the use of passive seismic techniques is only likely to increase. We can impact business objectives and contribute towards subsurface management solutions. We need to identify success cases of passive seismic applications as well as examples where challenges were faced and lessons learned (http://www.ctbto.org/).

Main objectives

The first problem of monitoring of different types of seismic events - geoacoustic precursors of earthquakes, industrial and field explosions, places fragments fall of separating parts of rockets-carriers, etc. is one of the key in the modern ecology of the environment. The peculiarity of this kind of monitoring is that it is mobile seismic groups, which should be based in the proposed area of occurrence of events. One of the most important steps for solving the problems connected with the detection and measurement of parameters of sources of seismic events on the basis of registration of seismic signals with the help of spatially distributed sensors mobile seismic group. The task of determining the geographical coordinates of the source lies in the basis of direction, referred to as the geoacoustic location (Avrorov, 2010).
When solving the problem of geoacoustic location allocate a number of basic steps:

- allocation of seismic and acoustic waves in a noise and measurement of their time of arrival.
- identification (recognition) of the type of the source.
- determination of the parameters of the hearth.
- display of coordinates of the source on a digital map.

The second fundamental research focuses on the main differences between processes leading to earthquakes and the seismic rock mass response to mining. In earthquake seismology the driving forces are fairly constant and relatively slow facilitating the processes of self-organisation. An important agent in the development of spatial and temporal correlations is seismic activity itself. Mining is not a spontaneous process. It induces stresses at a particular place, at a particular time and at a particular rate, which are all highly variable compared to the tectonic regime This process is controlled more by the commodity prices than by the plate tectonics. Consequently, unlike earthquakes, the seismic rock mass response to mining can be controlled to a certain degree (http://www.imseismology.org).

The third objective of seismic monitoring is to detect and locate underground nuclear explosions (Fig. 1). Nuclear explosion monitoring is as important today as it was at the dawn of the atomic age. Data resulting from seismic monitoring are used to distinguish between an underground nuclear explosion and the numerous natural and man-made seismic events that occur every day, such as earthquakes and mining explosions. Underground nuclear testing began in the 1950's and provoked growing concern. Seismic technology is a very efficient means of detecting a suspected nuclear explosion (http://www.ctbto.org/).

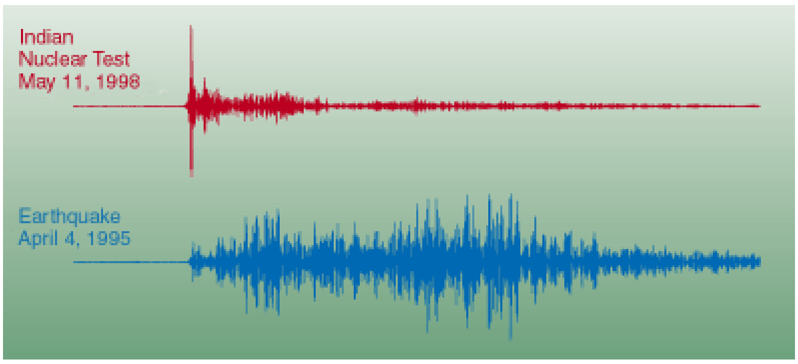

Figure 1 *Seismograms of the Indian nuclear test (top) and a representative nearby (earthquake (bottom) recorded at the seismic at Nilore, Pakistan. These seismic signatures for an explosion and earthquake are typical and clearly distinguish one from the other (https://www.llnl.gov/).*

Examples

There are basically two different types of seismic stations: seismic arrays and three-component stations. An advantage of seismic arrays is a cover area of up to 500 square km. Seismic arrays enhance monitoring capability for several reasons. They improve the signal to noise ratio. This means that it is easier to distinguish the actual signal against the background noise since it is filtered out. In order to eliminate the influence of seismic noise, seismic stations are usually built in remote areas, preferably on the outcrops of geological hard rock and as far away as possible from human activity (http://www.ctbto.org/).

The MIKHNEVO small aperture array (3-C stations) (MHVAR) was installed in the central part of the East European Platform (EEP) in 2004 for seismic passive monitoring. It is useful for identification weak local events at distances of up to 500 km from MHVAR, which is situated in a quiet area which is located about 80 km to the south of Moscow. In 2007, MHVAR independently recorded 623 local events with magnitudes (M_L = 0.79–3.24) which are identified as quarry blasts. Figure 2 shows mine explosion in Novogur'evskyi carrier 03 March 2011 at 11.48 a.m. GMT. The seismic monitoring of the territory of the East European Platform (EEP) is a part of the complex study of dynamics of tectonic processes, manmade influence and geo-ecological effects. It can be used for the purposes of detailed seismic zoning. The main feature of MHVAR is that the constantly operating small aperture array is set up in the region with the presence of sedimentary cover which is 1.5–2 km thick. Nevertheless, insignificant seismic noise in this location has been recorded by MHV and systematic measurements of the short period noise spectra which were carried out during a one-year period at MHVAR also showed a comparatively low noise level. SM3-KV short-period seismometer was used (Sanina et al., 2011).

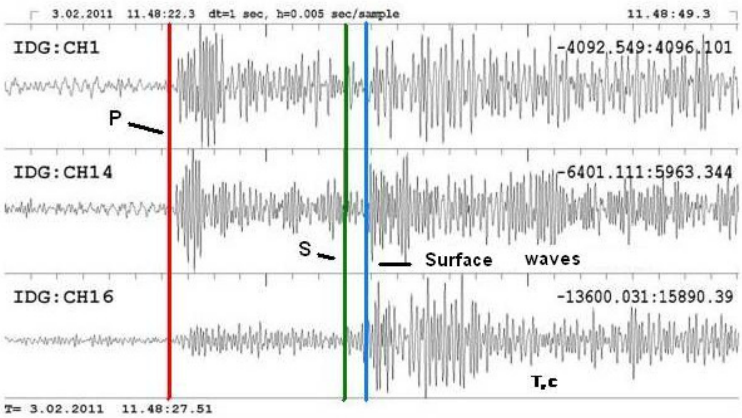

Figure 2 *Mine explosion in Novogur'evskyi carrier 03 March 2011 at 11.48 a.m. GMT.*

Conclusions

Today, we have real-time automated seismic alerts that soon will be transmitted over a global wireless broadband infrastructure. The ways that we control digital data processing have evolved from coding in assembly language, to programming "high-level" languages such as Fortran, to integrating applications with platform independent web technology. Trends in instrumentation are providing us with progressively more and better data, and at lower cost. Mathematics was translated to assembler code in the early days of the computer and through the evolution of the computer the research and business world has seen FORTRAN, BASIC, PASCAL, COBOL, C++ and many other languages, each with their claim as "the" language of the future. Automatic catalog reconciliation is now a reality for scores of formats. Databases are used to integrate and index waveform observations from thousands of stations in many formats into structured collections of uniform data amenable to sophisticated data mining approaches (Anderson et al., 2004).

This great advance allowed several generations of seismologists to write ever more complex programs. This progress can speed up seismic hazard predictions and to make a digital seismic history of the concrete region.

Acknowledgements

I express my thanks to Institute of Geosphere Dynamics for seismic data and my curator Sanina I.A. for problem definition.

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