Permanent Monitoring of Geodynamic Phenomena

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1. Abstract

With the increasing application of subsurface engineering activities, particularly in the energy and construction industry, the impact of induced geodynamic phenomena and seismicity is becoming critical with respect to the stability and viability of surface structures and urban facilities.

Therefore, permanent monitoring to provide detailed risk assessment, optimization and control of such subsurface engineering activities will play an important role in proving future operational viability. This technical monitoring is relevant not only to the engineering operation, but also to potential surface and subsurface impacts affecting the public. It will also affect nearby commercial operations, in turn, with respect to existing and future regulatory permits.

The required Measuring, Monitoring and Controlling capabilities can only be realized with permanent and continuously operating systems. These systems, due to physical and economic constraints, will have to be of passive nature and will operate in the seismo-acoustic and/or electromagnetic domains. Existing solutions are insufficient and incapable of providing for the broad scope of application that is the subject of this – 5DQM - research and development program. We propose to investigate the necessary scientific and theoretical information concerning the geodynamic impacts generated, and to develop and integrate adequate models and technical instrumentation to successfully monitor (geodynamic) phenomena associated with subsurface engineering operations.

We describe a seismo-acoustic permanent monitoring concept – the 5D Quantum Monitor – to continuously detect and analyze geodynamic phenomena in the extended term.

The system is based on a directional planar antenna receiver system operating in the ultra low frequency (ULF) acoustic domain [0,2 ; <30] Hz and providing input to a "Cognitive Data Management System" (CDMS) utilizing a forensic data base (FDB) with artificial intelligence (AI).

The 5DQM system provides forensic probability-based predictive output guidance for controlling the future behavior of a dynamic operating system by modifying specific technical operating parameters.

In the 5DQM Concept:

Measuring   means – acquisition of scalable data
Monitoring   means – continuous recording and analysis of scalable processes
Controlling   means – scalable modification of technical parameters and processes in feedback mode to enhance performance and minimize risk

The main topics under investigation are
   o The impact of induced geodynamic phenomena on the stability and viability of operations, structures and facilities
   o Enhanced Oil Recovery and monitoring of fluid dynamics vs induced seismicity
   o Revitalization of Abandoned O&G fields
   o Unconventional Oil & Gas recovery – Fracture Mapping for Containment Assurance & Performance Enhancement
   o Enhanced Geothermal Systems – optimization of heat exchanger performance
   o Underground storage in natural or artificial formations:
       o Cavern Storage
       o Pore Storage – Carbon Capture & Sequestration (CCS) and Storage in subsurface formations and acquifers.
       o Any kind of fluid and non-fluid waste disposals (including nuclear waste)

The core targets of the investigation are

   o Control of subsurface dynamic operating systems
   o Advanced environmental risk assessment