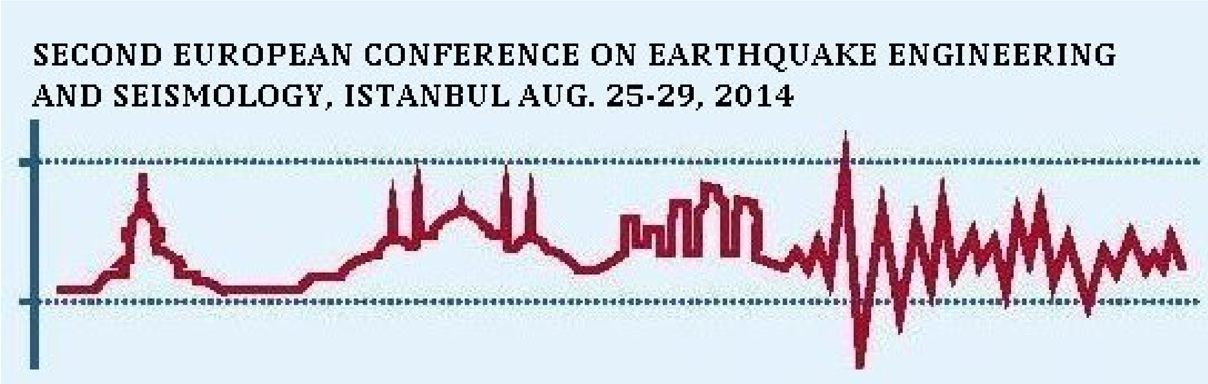

MECHANISM OF MICROEARTHQUAKES WITHIN THE CIGAR LAKE MINE, CANADA

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The moment tensor (MT) used today as a universal tool for descriptions of the mechanism, captures general balanced dipole sources. However, in the case of small-scale earthquakes, the moment tensor need not always be reliably determined. In an effort to fit the data, there may be notable non-shear components caused by the low quality of input data. Implementation of a constrained model of the mechanism, described by less parameters than the traditional MT, can reduce the error in the retrieved source model. In addition, constraining the source model to directly determine a simpler one is convenient for describing the physical phenomena expected for a particular focus. An opening of new fractures can be described, to a first approximation, by a tensile crack, optionally combined with a shear slip. The reverse motion describes a closing of a vacancy. This model alternative to MT is called a shear-tensile crack (STC) source model. The combination is practical, and can be used to both identify events that reflect purely mode-I (tensile/implosion) failure and to determine the dilation angle of the fracture undergoing shear. Its application is useful in situations where there is a physical reason to expect volume changes in the foci of seismogenic events, which is the case of most processes taking place in induced seismicity. Due to the process implying the load which resulted in the fracturing we expect that the mechanisms of these events contain a non-DC component. In the oil and gas industry, hydrofracturing of the treatment wells initiates tensile fracturing of the rockmass by injecting a high-pressure fluid, which opens tensile cracks important for enhancement of the permeability of the reservoir. A similar effect is desirable in exploitation of geothermal reservoirs. In contrast, the induced seismicity in mines is expected to be related to the occurrence of implosive phenomena caused by collapsing of void spaces like stopes, corridors, and other cavities. The Cigar Lake Mine is rather atypical; due to the technology applied underground we expect just tensile fracturing.

The Cigar Lake mine is the second largest high grade uranium deposit in the world: it is located in northern Saskatchewan, Canada. A microseismic monitoring system was installed as a tool to locate potential ground movements during or after the mine dewatering process. The microseismic monitoring system initially included six monitoring boreholes. Each site is equipped with four three-component geophones stationed between 275 – 575 meters in depth. The seventh borehole is configured with eight geophones: four near surface string and the other four in a lower positioned string (see Figure 1). The approximate surveillance coverage of the microseismic monitoring system spans a 600 square meter area in map view and is situated around the vicinity of the mine infrastructure. The particular reason for the study of the mechanisms of microearthquakes at Cigar Lake is the relationship of these events to the specific technological operation performed in the mine. In order to reduce water inflow during extraction, a portion of the deposit was frozen. Due to the tensional loading imposed by the expanding ice, tensional fracturing can be expected. We studied five events from the mine using the two different source models, namely MT and STC. All of the events display large non-DC components and we focused on studying their reliability with the aim to assess their correspondence to the tensile fracturing of the rock-mass.

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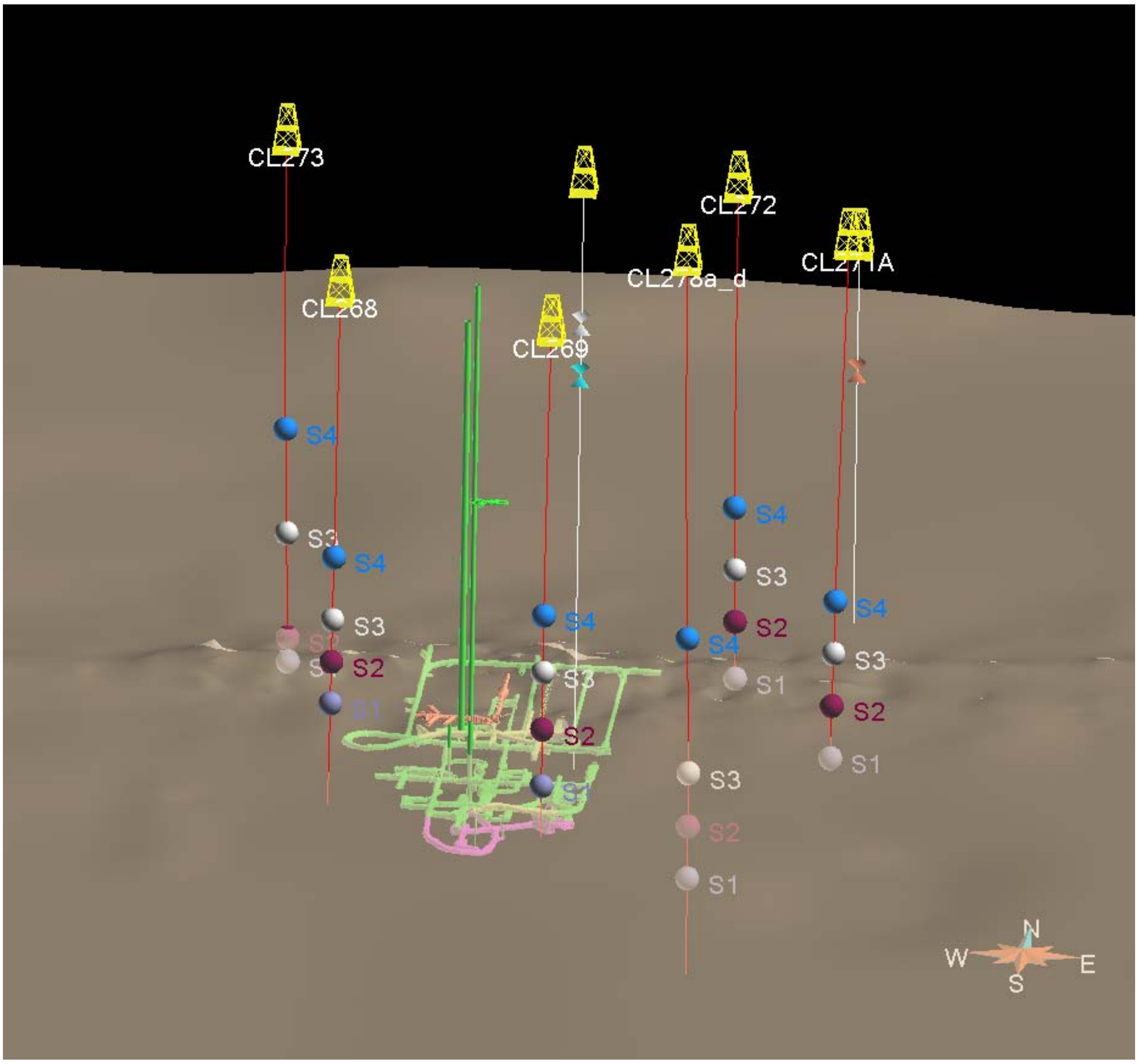

Figure 1: Schematic figure of the monitoring system.