Chapter 4: Basic Tasks in Seismic Monitoring

Modern sensors, such as those deployed at the recently refurbished Yellowknife Seismic Array in Canada's Northwest Territories, are extremely sophisticated and sensitive. They are able to accurately reconstruct the continuous, three-dimensional ground motions at the recording site resulting from the arrival of seismic waves from a distant source of tremor. However, the waves, which are already weakened during their long passage, are not recorded without some undesirable companions: locally and regionally generated background noise due to atmospheric perturbations, ocean waves, vehicular traffic, construction and mining activities, and other man-made or natural causes. The relative ratio between the signal strength and that of this ambient noise is called the signal-to-noise ratio. Noise reduction can be achieved by prudent site selection for the monitoring sensors; special design of the seismic array configuration; and, in some places, by installing the sensors in deep bore holes well below the surface of the Earth. A small seismic signal from a distant, low yield underground nuclear explosion may be clearly recognized and analyzed if the recording site noise level is sufficiently low.

Shown in Figure 5a is the cruciform-configured Yellowknife Seismic Array (YKA) — a modernized listening post with an enviable recording history spanning nearly three decades. Because it is within 10,000 km of most of the present underground nuclear test sites in the world, the YKA is strategically located (Figure 5b). The dots in Figure 5a are short-period stations unless otherwise specified; BB and HF are acronyms for the broadband and high frequency stations, respectively. The broadband sensors are exquisite instruments requiring a strictly regulated temperature and pressure environment. To achieve the desired recording environment, the vaults housing these instruments are located in horizontal tunnels dug 10 m into a granite cliff and insulated by two protective doors.

Seismic monitoring consists of four basic tasks: a) event detection; b) epicentral location; c) seismic source identification; and d) yield estimation, in the case of an explosion.

Event Detection

When monitoring seismic activities, the first step is detection — the process of confirming that a seismic event (whether it be an earthquake, nuclear explosion, chemical explosion, volcanic eruption, etc.) has taken place. Detection capability is affected by such factors as the type of seismic stations deployed, the spatial distribution and coverage density of the station network, the ambient background noise, and the tectonic environment in which the network is located.