Dense Array Seismic Study of a Legacy Underground Nuclear Test at the Nevada National Security Site

Evans Onyango, Lindsay Worthington, Robert E Abbott.

Abstract

Underground nuclear explosions form vertical rubble-filled chambers known as chimneys. Compared to explosions that cause surface disruptions, nuclear explosions with little or no surface manifestation are significantly harder to study intact. Understanding the subsurface structure of partially collapsed explosions has significant national security implications as well as benefits to the mining and construction industry. Here, we use a dense 3D seismic array and active sources to study the chimney structure associated with the 1964 HADDOCK test. The 1964 HADDOCK test was a < 20 kt nuclear explosion detonated underground at ~364 m and failed to crater the ground above the site. Our seismic data was acquired in 2017 as part of the FREY experiment run by Sandia National Laboratories and coordinated by the Desert Research Institute and Mission Support and Test Services, LLC. The team acquired 6 km of 2-D and 3-D seismic reflection data, recording over 270 survey shots (Figure 1. b) from the Seismic Hammer™ (a 13,000 kg Accelerated Weight Drop) and 65 survey shots from a smaller accelerated weight-drop. The survey geometry included two 2 km-long orthogonal lines, each with 401 receivers at 5 m spacing between receivers (Figure 1. a) dense grid of fourteen 140 m-long lines with an inline and crossline spacing of 10 m also recorded seismic profiles at the intersection of the two long lines. The instruments were cable-less 3C 2 Hz nodes deployed for 1 month. We will use the data to create high-resolution seismic reflection images that will better constrain the chimney height, chimney radius, and possibly the length and radius of fractures. Successful imaging of the HADDOCK underground chimney using active source reflection seismology techniques will elucidate underground structures caused by nuclear explosions by providing a detailed 2-D and 3-D seismic image and velocity structure. In addition, techniques employed here could potentially be used to image geological features such as magma chambers and hydrocarbon reservoirs. As such, the results have the potential to contribute to academic research, national security and have economic applications. Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

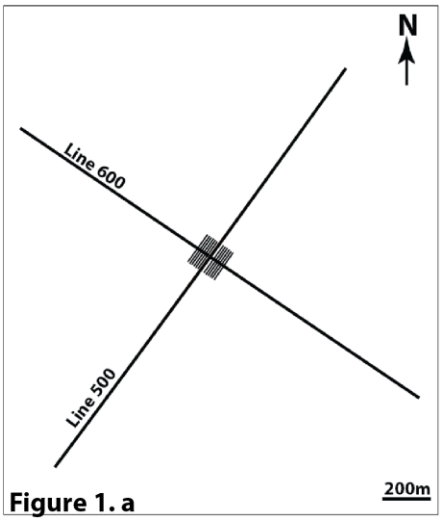

Figure 1. a: Receiver lines for the Haddock survey.

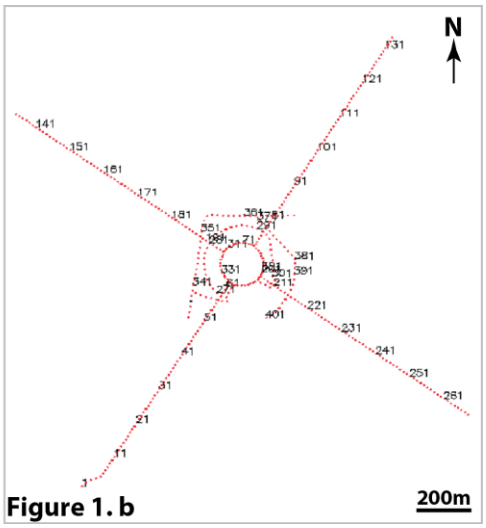

Figure 1. b: Shot lines for the Haddock survey.