Geological Investigation for the Braidwood Reactor θ_{13} Experiment

The geology underlying the proposed location of the Braidwood Experiment has been well studied and documented in preparation for the building of the nuclear power station. More than 80 investigative bore holes, to depths greater that 100 feet, were drilled prior to the plant construction. Based on this data, and a general understanding of the geology of Northeastern Illinois, the Braidwood site was identified as a strong candidate to host a neutrino experiment requiring earth shielding of more that 300 meter water equivalent (mwe).

The experimental plan calls for two sets of detectors (near detector for flux measurement and far detectors to search for oscillations) to be located under 500 to 600 feet of rock somewhere within the geological stratigraphic groups known as Galena and Platteville. The Galena and Platteville groups are made up of layers of limestone and dolomitic limestone which are notable for their favorable mechanical/structural properties and for their low radioactivity. While these general properties were promising, direct knowledge of rock properties at the depth of the experimental halls was lacking. In addition there was no good information on the site hydrology (water table level and likely water inflow rates at depth). Of the 80 plus original bore holes only eight reached down to the top of the Galena/Platteville. The deepest of these holes only went down to 345 feet. So in the fall of 2004 the Collaboration, in coordination with the Exelon Corporation, commissioned a new geological study which was completed in January of 2005.

The new study was involved drilling two bore holes, one at each site. The bore holes were located along the centerline of the proposed shaft locations (see Figure 1). Each bore hole was drilled to a depth of over 625 feet. At 647 feet the far bore hole reached the top of the sandstone layer below the Platteville and thus established the practical depth limit for the site. The soil and rock core from both holes was retrieved, logged by geologists and stored for later use. The subsurface exploration program included the following:

- Air monitoring for methane and other gases during drilling;
- Geophysics testing for the length of each hole using acoustic televiewer, natural gamma, spontaneous potential, and electrical resistivity methods;
- Water pressure testing in rock in 40 foot intervals at each hole;
- Field testing, description and classification of rock core samples;
- Geotechnical laboratory testing of soil samples including grain size analysis, hydrometers and Atterberg limits; and
- Geotechnical laboratory testing of rock core samples including rock density, unconfined compression strength tests, Brazilian tensile strength tests, slake durability and swell potential.

The collected data and analysis were compiled into a Geotechnical Data Report (GDR). The bore holes were drilled by Raimonde Drilling Corporation; the core logging, pressure

Figure 1: Arial photograph of the Braidwood Nuclear Power Station showing the locations of the near and far investigative bore holes. The bore holes were located at the proposed shaft sites.

testing and lab work was done by GZA GeoEnvironmental, Inc; the borehole geophysics was done by the Illinois Geological Survey; and the GDR was prepared by GZA.

The results of the bore hole study confirmed the expectations that, from a geological perspective, the Braidwood site is an excellent location to mount this experiment. As a result of this study we now understand that

- A detector hall depth of 600 feet is readily constructible;
- The earth shielding at 600 feet will be between 460 and 470 mwe;
- The radioactivity at 600 feet is low, as expected for limestone;
- The structural integrity of the rock for excavation purposes at and around 600 feet is good to excellent; and
- There are no surprises or showstoppers with the site hydrology.

The data obtained in this study will be an important input to the engineering and design of the underground facility. The existence of rock core and bore hole data along the line of the shafts will reduced the uncertainty associated with the excavation and construction and will allow for a relatively low contingency, on the shaft construction of about 25%.