MAR 18 1986

R-2811

MEMORANDUM FOR: Leon L. Beratan, Chief
Earth Sciences Branch, DRPES, RES

THRU: Andrew J. Murphy, Leader
Seismology Section
Earth Sciences Branch, DRPES, RES

FROM: Richard B. McMullen, Geologist
Seismology Section
Earth Sciences Branch, DRPES, RES

SUBJECT: JANUARY 31, 1986 NORTHEASTERN OHIO EARTHQUAKE

Enclosed are summaries of two meetings regarding the January 31, 1986 earthquake of northeastern Ohio. The first summarizes a meeting with the USGS during which the possibility that the earthquake and its aftershocks could have been induced by nearby waste injection wells was discussed. The second meeting was among NRC and its consultants concerning the possible effects of the seismicity on the earthquake design bases of the Perry Nuclear Power Plant.

Richard B. McMullen, Geologist
Seismology Section
Earth Sciences Branch, DRPES, RES

Enclosures:
2, as stated.

Distribution/R-2811:

Circ/Chron	RMinogue	EConti	JPhillips
DCS/PDR	DRoss	LBeratan	IAlterman
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RBM		
ESB:RES:pf	ESB:RES	ESB:RES
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THE POSSIBILITY OF WASTE DISPOSAL WELL INJECTION BEING THE CAUSE OF THE JANUARY 31, 1986, NORTHEASTERN OHIO EARTHQUAKE AND AFTERSHOCKS

A meeting was held in Silver Spring, Md. on 12 February, 1985, among representatives of the USGS, NRC-NMSS, NRR and RES. The purpose of the meeting was to examine information presented by the USGS regarding two chemical waste disposal wells in NE Ohio and their possible relationship to the seismicity that began on 31 January with a magnitude 4.9 earthquake.

The main shock epicenter is near Hambden, Ohio, about 18 to 20 km from the Perry Nuclear Power Plant. The two disposal wells are about 5 km south of the Perry NPP and 15 km north of the January 31 epicenter.

The wells are operated by the Calhio Company and are used for the disposal of agricultural fungicide wastes. They are about 6100 feet deep, extending 10 to 14 feet into Precambrian crystalline basement rock. The wells consist of an inner injection pipe that extends into basement, and an outer casing that extends through a shale stratum about 500 feet from the well bottom. From the bottom of the casing the inner pipe is perforated and allows the fluids to pass into the surrounding rocks. These rocks consist, from basement up, of sandstones of the Mt. Simon Formation, dolomites and sandstones of the Rome Formation, and limestones of the Maynardville Formation.

Well Number 1 was established in 1971, and since that time nearly 300 million gallons of waste have been injected. Wastes are injected at head pressures of 14,000 to 16,000 psi. When not pumping, head pressures are maintained at about 1000 psi to prevent backflow through the pipe. Maximum injection occurs in the spring and minimum injection occurs during the winter. The annulus pressure (space between pipe and casing) has remained at about 1000 psi since 1971, but in 1984 it temporarily rose to 2000 psi. The annulus pressure at the well head should be 0, and the pressure may indicate that there is leakage either through the seal packer at the bottom of the casing or through the casing from an artesian aquifer.

A total of about 41 million gallons of waste has been injected through Well 2, which is similar in design to Well 1.

Preliminary calculations and comparisons with known cases of well induced seismicity (Rangely and Denver, Colo.) indicate that the relatively high pressures and volumes involved in the pumping could effect the area of the earthquake hypocenter. Arguing against this possibility is the occurrence of similar earthquakes, such as the 1943 magnitude 4.5 event, in the vicinity prior to construction of the wells, and the observation that previous well induced seismicity has occurred much closer to the injection wells.

The meeting participants examined representative well strip chart records from Well 1 taken during the time span just before the earthquake. The record showed that the annulus pressure rose about 50 psi several hours before the earthquake. One half hour before the earthquake the pressure in the injection pipe dropped and the annulus pressure rose sharply (ramped). The earthquake occurred and the pump was turned off. The annulus pressure dropped when the pumping stopped, but did not return to the pressure level recorded prior to the earthquake. The Environmental Protection Agency of Ohio then called the USGS to inquire about the possibility of damage to the wells from the earthquake.

R. Wesson, USGS, presented calculations developed during the analysis of the Rocky Mountain Arsenal and Rangely, Colorado well injection induced seismicity. Assuming that conditions along the causative fault were near failure, and taking into account the orientations and magnitudes of the regional stresses, the calculations showed that the pressures resulting from pumping in to the wells could have caused displacement on suitably oriented strike-slip and normal faults. If the source mechanism is determined to be a thrust fault, the well is not likely to have been the cause.

The USGS suggested the following activities to obtain data needed to resolve the issue of whether or not the wells are involved in the seismicity.

1. Determine accurate location of the mainshock.

2. Locate the aftershocks as precisely as possible and determine the following:

   a. closeness to wells;
   b. whether or not they define a fault; and

   c. if there is evidence for propagation (do aftershocks get farther from the well with time?)

3. Calculate focal mechanisms and determine the orientation of stresses and whether or not a fault plane is defined.

4. Calculate the dimensions of the pressure bulb generated by the well using porosity of the rocks and pressure distribution data, which are all available. Calculate especially the distance the pressure extends from the wells. It should also be determined whether or not the ramping of pressures that occurred just before the earthquake is an anomaly.

5. Determine the state of stress, especially the orientation of the maximum component of regional stress.

6. Identify structure using exploratory methods such as seismic reflection surveying.

The USGS representatives indicated that the work outlined above would require a few person months to complete. They recommended that it be done, and that if the wells are shown to be causing the earthquakes, pumping into them should be stopped. They cautioned, citing the experience of injection well induced seismicity in Denver in the late 1960's, that the largest earthquakes occurred 2 years after the pumps were turned off.

THE JANUARY 31, 1986 NORTHEASTERN OHIO EARTHQUAKE AND ITS EFFECT ON THE PERRY NPP SEISMIC DESIGN BASES

A meeting was held on February 21, 1986, in Bethesda among NRC and several of its seismic design consultants to discuss the impact of the January 31, 1986 northeastern Ohio earthquake on the Perry Nuclear Power Plant.

The earthquake was a magnitude 5.0 located approximately 10 miles south of the Perry Nuclear Power Plant. The earthquake triggered the in-plant monitoring instruments. Some of the recorded ground motions exceeded the OBE and the SSE design spectra at high frequencies (above 15 hertz). The earthquake motion recorded at the reactor building foundation was of short duration (about 1 second) and predominantly high frequencies.

Three subjects that are significant to assessing the potential effects of this event or a future event on the plant seismic design are: (1) geology and seismology of the site and region around the site; (2) the seismic capability of the plant's safety related structures; and (3) the seismic capability of the plant's components and equipment.

Geological and seismological issues include: (1) high frequencies recorded above 15 hertz at the plant; (2) characteristics of the earthquake source structure; (3) the potential for reactivation of the tunnel faults due to the current regional stress regime; and (4) the possibility that the earthquake and its aftershocks may be related to two nearby waste disposal injection wells.

The U.S. Geological Survey has been contracted to determine fault plane solutions and assess the significance of the high frequencies in light of other high frequency recordings in eastern North America, such as those recorded recently at New Brunswick, Canada; Monticello Reservoir, South Carolina; and eastern Arkansas.

Based on analysis of the recent seismicity, the staff's perception of the geology and seismology of the area could change, although there is no evidence that the Perry seismic design bases are inadequate. Because of that change of perception, it is necessary to look again at the tunnel faults which were concluded to be non capable based partly on the state-of-stress in the region as it was perceived at that time.

The USGS will evaluate the data and determine, to the extent possible, whether or not the injection wells had a part in initiating the seismicity.

In addition to the USGS, five RES contractors deployed seismographs in the epicentral area and recorded about ten aftershocks. These data are being analyzed and the results will be a part of the overall analyses.

The second topic, structural responses, is the one that everyone feels most comfortable about because the structures responded dynamically much as predicted from modeling. Generally there was a corroboration between sample modeling and the data. Soil structure interaction did not appear to be a key factor as there was apparently little difference between ground motions in the free field and those entering the structure through the foundation. Several Category 1 structures are founded on soil, but there were no recordings in those areas.

The third subject concerned the behavior of equipment and components in the plant. Sample analyses, based primarily on extrapolation judgements, indicated that those components and equipment analyzed have small sensitivities and large margins. Portions of the response spectra measured from the earthquake exceeded the qualification spectra, but were invariably lower than the test response spectra. The main concern is that it may be necessary to consider a richer high frequency content in the seismic design basis, either from a future event similar in size to the January 31 earthquake, or from a larger event.

Resolution of these issues must await completion of the geological, seismological and ground motion studies by the USGS, the NRC contractors, and the utility's consultants. Completion is estimated to be midsummer.

A safety evaluation report supplement summarizes the current state-of-knowledge and the ACRS meets on March 12 and 13 to discuss the earthquake. Affidavits contain essentially the same information.

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