CALIBRATION EXPERIMENTS OF NEUTRON SOURCE IDENTIFICATION AND DETECTION IN SOIL

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A method of detection of neutron source in soil

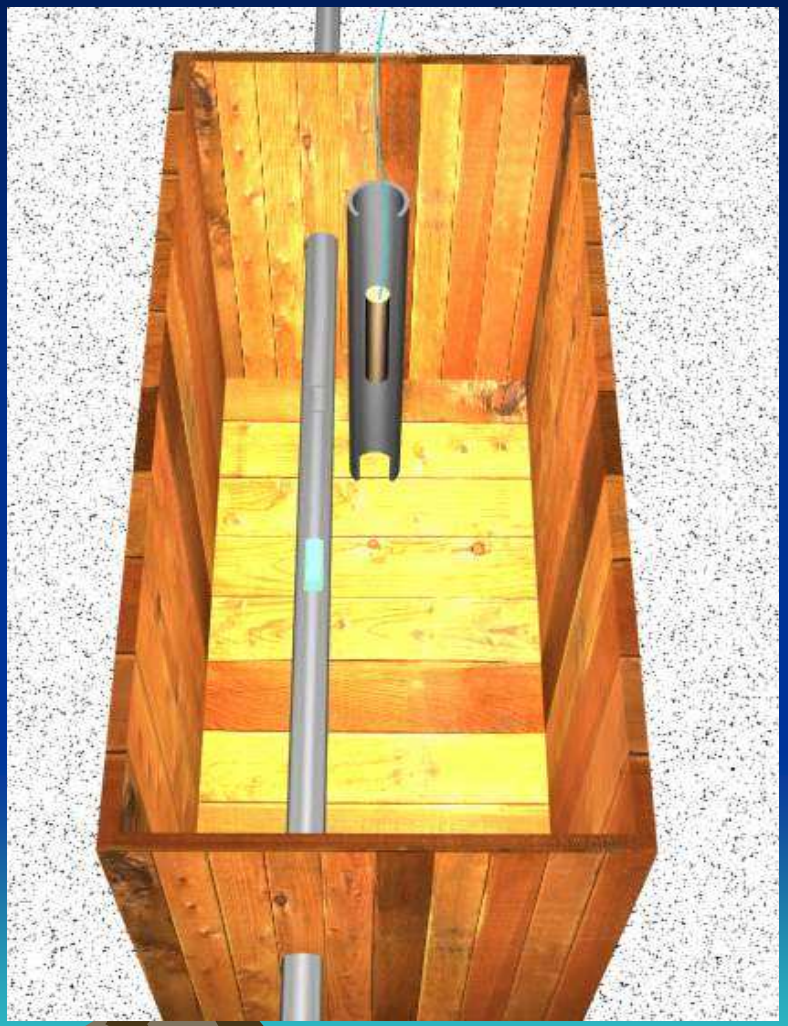
- A method of detection of neutron source in soil is proposed and proved in the present work by means of registration of neutrons in wells drilled close to laying of the source, a fundamental efficiency of method is shown and preliminary calculation estimates are carried out.

Main goals of experiment

- Method of neutron source in soil detection sensitivity measurement.
- Minimal source activity and maximal range at which the source can be surely detected estimation.
- Obtaining of experimental results to verify calculational methods.
- Investigation of influence of water contents, presence of heterogeneous bodies and neutron source spectrum on sensitivity of method.

Experimental conditions

- The experiment was carried out in vitro at the specially designed borehole mock-up.
- Measuring container is filled with sand. Appearance of empty container with installed pipe – borehole mock-up and a device for moving of a neutron source is given at Fig.1.



Experimental conditions

- Borehole mock-up is a pipe of aluminum with outer diameter of 95mm and wall thickness of 7.5mm is installed vertically at full height of container. SNM-18 neutron detector is located inside borehole mock-up.

Fig.2. Borehole mock-up.

Experimental conditions

- Sand was used as a soil. Its chemical composition was explored and all of its components with content no less than 1% were identified. Attention was paid to neutron absorbing materials, mainly boron and rare-earth elements.

- Three series of measurements with various contents of water in sand were carried out: 0.3 mass percents (further as “dry” sand), 3.8 mass percents (further as “moist” sand), 8.1 mass percents (further as “wet” sand).

Experimental conditions

- Stone and water- and air-filled cavities were used as heterogeneities.
- Stone chemical composition and water contents analysis was carried out.

Fig.3. Stone photo.
Next to stone a matchbox is located.

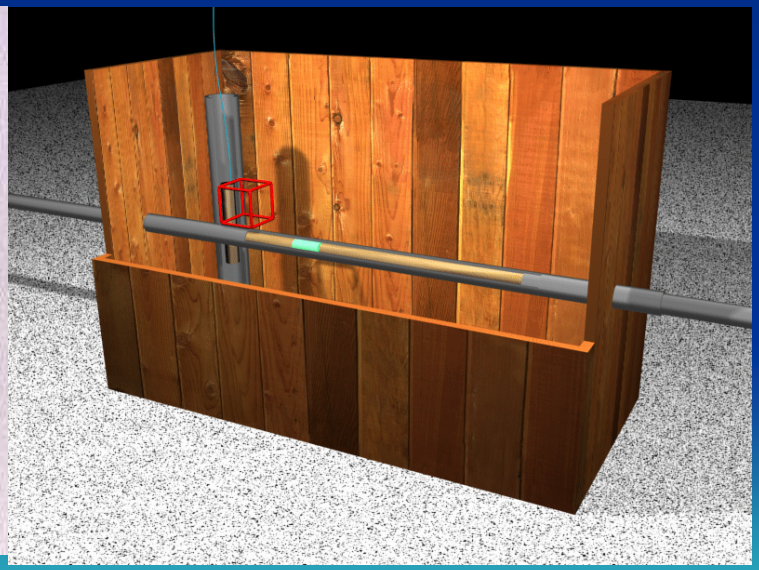


Fig.4. Heterogeneities location in the experimental container.

Calculations results

- Obtained experimental results were verified by means of MCNP calculating program (developed by LANL). MCNP code allows to create three-dimensional models of objects and to calculate tasks of neutron transport by means of Monte-Carlo method.

- While modeling the experiment, calculational configuration was set maximally close to real. A wooden box was located on a concrete floor. The box was filled with sand with various humidity. Borehole pipe with a neutron detector mock-up was located vertically on a longitudinal axis of the box. In a central plane of the box a channel for moving neutron source was set.

Calculations results

- Fig.4,5 show comparative results of experiments and calculations for various humidity of sand, filling the box.

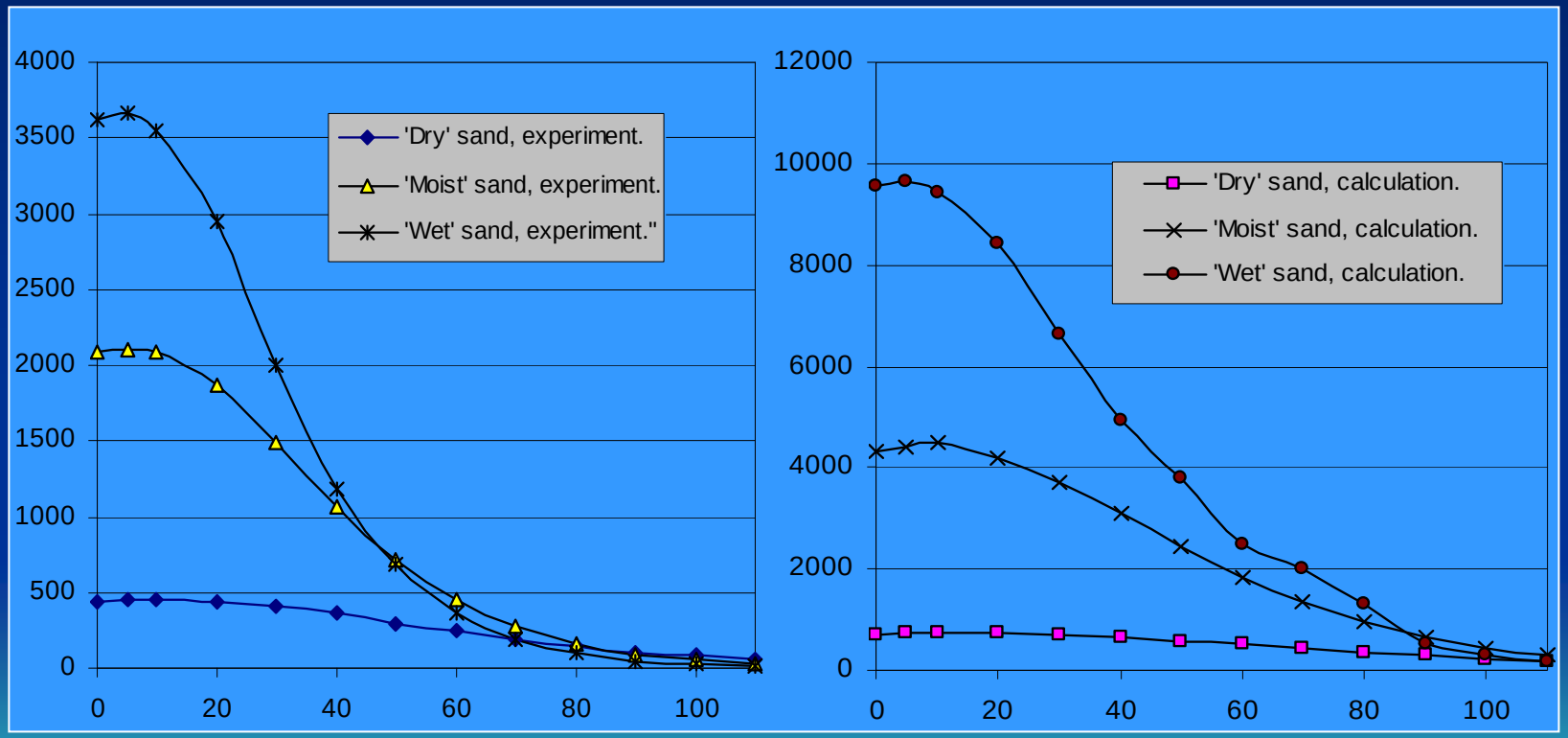


Fig.4,5. Experimental and calculational soil humidity detector counts dependencies. Plutonium-Berillium neutron source. Horizontal: source-detector range; vertical: detector counts at 100 sec.

Calculations results

- Fig.6,7 show comparative results of experiments and calculations for various types of heterogeneities, located between neutron source and detector.

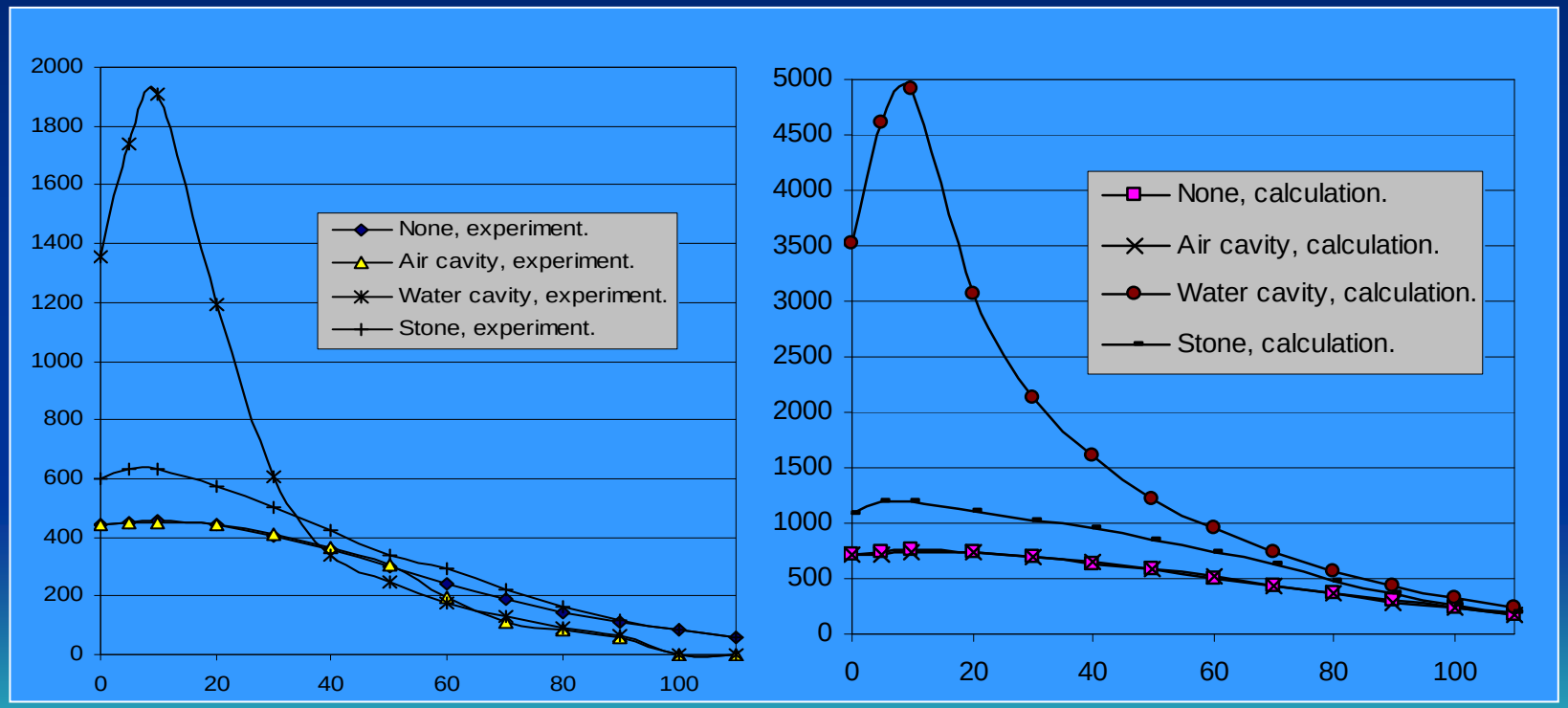


Fig.6,7. Experimental and calculational heterogeneities detector counts dependencies. “Dry” soil. Plutonium-Berillium neutron source. Horizontal: source-detector range; vertical: detector counts at 100 sec.

Conclusion.

- Main objectives of calibration experiment were achieved:
  - Influence of water and heterogeneities in soil on method's sensitivity was explored.
  - Experimental results suitable for calculation methods verifications were obtained
- Experimental data obtained is reliable, contain no inexplicable aperiodicities and at the level of qualitative analysis correspond to a physical meaning.
- Succeeded in creation of calculation model, able to model process of neutron source in soil location at the qualitative level.
- Calculations results correspond to the experimental results, excess of calculation results over the experimental results is explained with peculiarities of experimental parameters registration system.