RADON UPDATE

by Larry D. Fellows
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Radon gas has been recognized as a geologic hazard to people in homes and other buildings only since the early to mid-1980's. Radon gas, which is a decay product of uranium and is itself radioactive, seeps into homes from underlying soil and rock. It is hazardous in high concentrations because it is inhaled and causes increased radiation exposure to human lung tissue. A recent survey of radon levels in homes in southwestern Tucson, in an area known to contain elevated uranium concentrations, revealed in a few homes radon concentrations above the maximum acceptable level recommended by the U.S. Environmental Protection Agency (EPA). The EPA has set 4 picocuries per liter (pCi/l) as the level above which radon-reduction measures are recommended.

A radon concentration of 2,700 pCi/l was measured in a home in eastern Pennsylvania in December 1984. Before then, radon was not known to accumulate to such high levels within homes built on uraniumrich rock and soil. Because of this startling discovery, other areas in the country where uraniumrich rocks were known to be present became suspect. Before December 1984 uranium-related environmental health concerns had been limited primarily to natural radioactivity (gamma radiation) levels.

In October 1986 the Arizona Geological Survey (AGS), which is the Geological Survey Branch of the Arizona Bureau of Geology and Mineral Technology, initiated activities to help assess the potential for radon in Arizona homes. Dr. Jon Spencer wrote an article on radon and related geologic aspects, which was published in the Winter 1986 issue of *Fieldnotes* (Spencer, 1986). Many articles had already been printed in newspapers and magazines, including some published in Phoenix and Tucson. Spencer's article was mailed in early January 1987 to more than 4,000 subscribers, including most of the television and radio stations in Arizona. Only two or three questions were generated by his article during January and February.

In November 1986 staff of the AGS and the Arizona Radiation Regulatory Agency (ARRA) discussed the location of areas in Arizona within which rocks are known to have elevated uranium content, and, therefore, might have greater potential for indoor radon. The AGS compiled a preliminary map of the State (Spencer and Shenk, 1986) for the ARRA to use in determining where to place charcoal canisters to measure radon levels. The AGS also prepared an estimate of the cost to conduct a gamma-radiation survey of populated areas where uraniumrich rocks are known to be present at the surface. The ARRA, in turn, estimated costs for canisters, laboratory services, and other items required to complete a statewide survey. These figures were incorporated into House Bill 2288, which was sponsored by Senator Greg Lunn and Representative Chris Herstam, introduced in January 1987, and passed by the House Health Committee in February.

A summary article on radon appeared in the *Tucson Citizen* on March 19. Within a few days a reporter from the *Arizona Daily Star* came to our office for information, presumably as a follow-up of the March 19th article. All the information in our files about the uranium-bearing rocks in southwestern Tucson was made available to him. The most detailed map (Grimm, 1978) showed a football-shaped area of "lake-bed limestone," bisected by Cardinal Avenue, approximately 1,500 feet south of Valencia Road. The mapped limestone area is about 875 feet wide and 1,800 feet long (Figure 1a). The *Arizona Daily Star* article, entitled "Cancer-causing radon gas may be threat on southwest side," was published on March 29. It included a map that designated a "potential radon hazard" in the area bounded by south Mission Road, west Valencia Road, south Sorrel Lane, and west Los Reales Road (Figure 1b). Local television stations followed up on the newspaper story. The following week the AGS received hundreds of telephone calls from concerned residents. At that time radon gas had never been measured in any homes in southwest Tucson.

Immediate response was necessary. Dr. Pat Nolan, Director of the Pima County Health Department, and I met on March 31 to discuss procedures for assessing whether an indoor-radon problem existed. We agreed that the AGS would first define the areal extent of the uranium-bearing limestone and then determine the natural radioactivity levels. This information would be provided to Dr. Nolan, who would use it to determine in which homes to place charcoal canisters.

John Welty, a geologist on our staff, reviewed existing literature, went to the field to examine the limestone, and prepared a map showing its area of outcrop. In response to the March 29th newspaper article, Dudley Emer, an independent consultant, called to volunteer his services and equipment to help measure the natural radioactivity levels associated with the limestone. On April 3 Dr. Nolan issued a news release that identified the area of concern and described plans to measure gamma radiation there. On April 6 Emer and Jon Shenk, a graduate research assistant on our staff, began measuring the gamma-radiation levels. Results of their findings were presented to Dr. Nolan and outlined in a news release issued on April 9. The news release included a map that showed the area within which measured radioactivity is two or more times the level of background radioactivity (Figure 1c). On the basis of this information, the Pima County Health Department, with the approval of the Pima County Board of Supervisors, decided to purchase charcoal canisters and place them in every home within the two-times-background boundary. A public meeting was held on April 14 at the Miller Elementary School in that vicinity to explain the origin, occurrence, and health effects of radon, the geologic setting of the site, and plans to measure radon within area homes. Questions were also answered. Canisters were placed in 37 homes the following week.

Radon levels determined from analysis of the charcoal canisters were made available on May 1 at a press conference. The maximum levels detected were 37.3 and 42.9 pCi/l from one home; canisters from two homes recorded 10 to 20 pCi/l; 17 samples were in the 4 to 10 range; and 19 indicated less than 4 pCi/l. On the basis of these results, Dr. Nolan decided to place canisters in 17 adjacent homes to define more fully the extent of elevated radon levels in the area. Two additional homes tested at 4 pCi/l. Results of radon testing were generally consistent with predictions based on gamma-radiation measurements; high radon levels were largely confined to areas with high gamma radiation (Spencer and others, 1987).

One question asked several times by concerned residents was, "Why didn't we know about this before?" As the second paragraph of this article states, until the early 1980's, radon was not known to accumulate to hazardous levels within homes built on uraniumrich rock and soil. Many radon measurements made between 1980 and 1985 provided sufficient data to indicate that hazardous radon levels could be present in many U.S. homes, especially in areas where higher than normal uranium concentrations are present in underlying soil and rock. In the mid-1980's, State and Federal agencies began to respond to this new knowledge with radon surveying programs, especially in States such as Pennsylvania, where radon had been found at very high concentrations.

Geologists and environmental health scientists in Pennsylvania and other States have subsequently learned much about the occurrence of indoor radon. Thousands of charcoal canisters have been placed throughout Pennsylvania. Radon concentrations greater than 100 pCi/l have been measured in many homes. The area of primary concern in Pennsylvania is known as the Reading Prong, which covers about 300 square miles, includes an estimated 22,000 homes, and extends into New Jersey and New York. The State of Pennsylvania has spent about $5 million on radon programs and added 21 full-time employees to implement them.

Elevated radon levels have also been measured in other States, including Alabama, California, Colorado, Connecticut, Florida, Illinois, Kentucky, Maine, Maryland, Montana, New Hampshire, New Jersey, Ohio, and Wyoming. The EPA is currently funding statewide radon surveys in 10 States. Congressional hearings have been held this year to assess the problem and make plans to address it.

Limestone in the Cardinal Avenue area of southwestern Tucson, originally described by Brown (1939), was the target of five uranium claims, referred to as the Dutchess claims, which were filed in 1955 during the uranium "boom." Uranium was never mined from this area because

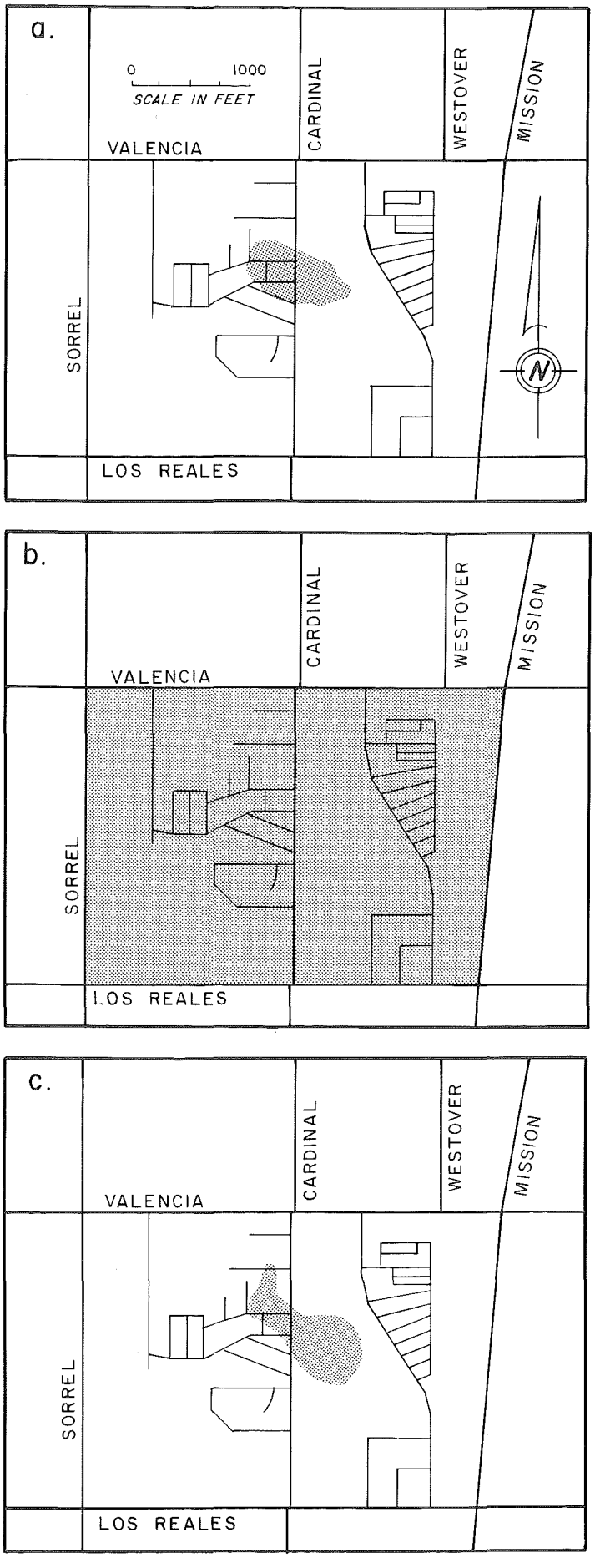

Figure 1 (left). *(a, top) Map showing location of limestone in southwestern Tucson that has small quantities of uranium-bearing minerals. Modified from Grimm (1978, p. 43). (b, middle) Map prepared by* Arizona Daily Star *and included in March 29th issue (p. 1-A) that shows "potential radon hazard" area in southwestern Tucson. (c, bottom) Preliminary map prepared by Dudley Emer, West Tech Geophysics, and Jonathan D. Shenk, Arizona Geological Survey, showing area with two times background radiation due to uranium mineralization. Modified from an AGS news release issued on April 9.*

uranium concentrations were too low. In February 1976 John Vuich, a geologist with the Arizona Bureau of Mines, the former name of the Arizona Bureau of Geology and Mineral Technology, informed the Arizona Atomic Energy Commission (AAEC), now known as the ARRA, about the elevated radioactivity levels associated with the limestone. Two staff persons from the AAEC visited the site and conducted a gamma-radiation survey of the Chastain housing-development property near Valencia Road and Cardinal Avenue, using equipment on loan from the EPA (Figure 2). Radon detection and measurement were not the objectives of this survey. The investigators determined that the background radiation was 12.5 microroentgens per hour on Cardinal Avenue and that the maximum reading on the Chastain property was 25.5 microroentgens per hour (AAEC, 1976). The latter figure was calculated to a yearly total of 0.22380 roentgens per year. Because the AAEC permissible yearly total was 0.5 roentgens per year, no remedial action was recommended by them.

Much more must be learned about the occurrence of radon in homes in Arizona. During the legislative session that ended in May, $58,000 was appropriated to the ARRA for fiscal year 1987-88 to survey areas with elevated radioactivity levels and to purchase canisters for homes within those and other areas. The AGS will receive $8,000 to conduct a reconnaissance analysis of natural radioactivity levels in several areas known to have uraniumrich rocks exposed at the surface. This investigation is planned for completion during late August and September, after the monsoon season has ended (rainwater interferes with radiation measurements). The results of the survey will assist the ARRA in placing charcoal canisters.

Those who would like more information about radon may obtain these free pamphlets from the Environmental Protection Agency (EPA Region 9, 215 Fremont St., San Francisco, CA 94105): (1) A Citizen's Guide to Radon: What It Is and What to Do About It; (2) Radon Reduction Methods: A Homeowner's Guide; and (3) Radon Reduction Techniques

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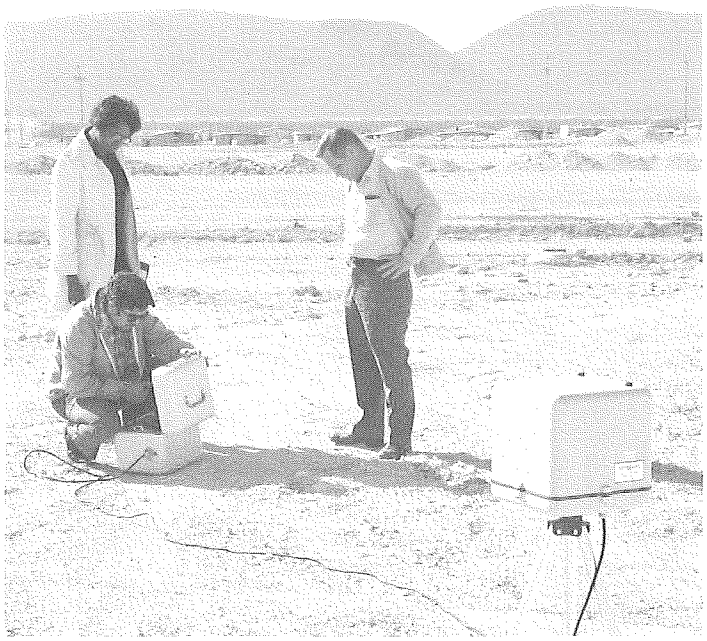

Figure 2 (above). *Gamma radiation being measured by Ralph B. Ochoa (kneeling) and Mattie Coleman (standing, left), both of the Arizona Atomic Energy Commission. Richard T. Moore, Arizona Bureau of Mines (right), observes. Photo taken by John S. Vuich, Arizona Bureau of Mines, February 25, 1976.*

Arizona Geological Survey Established

The Arizona Bureau of Geology and Mineral Technology, a State agency administered by the University of Arizona, is composed of the Geological Survey Branch and the Mineral Technology Branch. The Geological Survey Branch functions as the Arizona Geological Survey.

Senate Bill 1102, which was sponsored by Senator Doug Todd, passed by the 38th Arizona Legislature, and signed by Governor Evan Mecham on April 24, 1987, specifies that the Geological Survey Branch will become the Arizona Geological Survey, an independent State agency located in proximity to the University of Arizona in Tucson. The Arizona Geological Survey will be directed by the State Geologist, who is appointed by the Governor. The Mineral Technology Branch will be transferred to the University of Arizona. SB1102 becomes effective on July 1, 1988.

(continued from page 7)

for Detached Houses: Technical Guidance. The first two pamphlets are also available from ARRA, 4814 S. 40th St., Phoenix, AZ 85040; (602) 255-4845.

References

Arizona Atomic Energy Commission, 1976, A radiation survey of Chastain housing development property near Valencia Road and Cardinal Avenue, Tucson, Arizona, February 25, 1976: summary report, 1 p.

Brown, W. H., 1939, Tucson Mountains, an Arizona basin-range type: Geological Society of America Bulletin, v. 50, p. 697-760.

Grimm, J. P., 1978, Cenozoic pisolitic limestones of Pima and Cochise Counties, Arizona: Tucson, University of Arizona, M.S. Thesis, 67 p.

Spencer, J. E., 1986, Radon gas; a geologic hazard: Arizona Bureau of Geology and Mineral Technology Fieldnotes, v. 16, no. 4, p. 1-6.

Spencer, J. E., Emer, D. F., and Shenk, J. D., 1987, Geology, radioactivity, and radon at the Cardinal Avenue uranium occurrence, southwestern Tucson: Arizona Bureau of Geology and Mineral Technology Open-File Report 87-3, 16 p.

Spencer, J. E., and Shenk, J. D., 1986, Map showing areas in Arizona with elevated concentrations of uranium: Arizona Bureau of Geology and Mineral Technology Open-File Report 86-11, scale 1:1,000,000.

Fieldnotes

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New Bureau Publications

The following publications may be purchased over the counter or by mail from the Arizona Bureau of Geology and Mineral Technology, 845 N. Park Ave., Tucson, AZ 85719. For price information on these and other Bureau publications, please contact the Bureau offices.

Dickinson, W. R., and Olivares, M. D., 1987, Reconnaissance geologic map of the Mineta Ridge and Banco Ridge area, Pima and Cochise Counties, Arizona: Miscellaneous Map Series MM 87-C, 2 p., scale 1:24,000.

This geologic map of the type area of the Mineta Formation east of Redington Pass was compiled from field reconnaissance by Dickinson and thesis mapping by Olivares, supplemented by previous mapping by earlier workers. The varied internal lithology of the Mineta Formation is depicted in general fashion based on detailed facies analysis by Olivares.

McGarvin, T. G., 1987, Index of published geologic maps of Arizona—1986: Open-File Report 87-1, scale 1:1,000,000.

This index lists 31 references as sources of geologic maps of the State published during 1986. References include publications of the U.S. Geological Survey, Geological Society of America, Arizona Geological Society, Arizona Bureau of Geology and Mineral Technology, and other organizations. The accompanying map identifies the areas within Arizona covered by each reference.

Spencer, J. E., and Reynolds, S. J., 1987, Geologic map of the Swansea—Copper Penny area, central Buckskin Mountains, west-central Arizona: Open-File Report 87-2, scale 1:12,000, with text.

A structurally complex assemblage of Proterozoic through Miocene rocks forms a synformal keel of upper-plate rocks above the Buckskin-Rawhide detachment fault in the central Buckskin Mountains of west-central Arizona. Pre-Tertiary rocks have undergone complex Mesozoic thrust-related deformation and metamorphism. A thick Oligocene(?) to middle Miocene sequence of clastic sedimentary rocks, carbonates, volcanic rocks, and sedimentary breccias is tilted moderately to steeply to the southwest. Cu-Fe mineralization is common along the detachment fault and forms replacement deposits in Paleozoic carbonates at the Swansea mine. This detailed map of approximately 9 square miles is accompanied by descriptions of about 60 map units.

Spencer, J. E., Emer, D. F., and Shenk, J. D., 1987, Geology, radioactivity, and radon at the Cardinal Avenue uranium occurrence, southwestern Tucson: Open-File Report 87-3, 16 p.

Tertiary limestone in an approximately 30-acre area south of the intersection of Valencia Road and Cardinal Avenue in southwest Tucson contains greater-than-average uranium concentrations. A detailed gamma-ray spectrometer survey delineated the extent of the uranium occurrence. Results of the survey are presented in this report, along with a review of the geology of the area and a comparison of background radioactivity to measured indoor-radon levels.

The Bureau of Geology and Mineral Technology is a division of the University of Arizona.

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