<u>SUPER MOON 2012 SHEDS LIGHT ON RADON GAS MIGRATION</u>

A Case Study of Environmental Influences On A Residential Radon Test

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Abstract

This is a case study of environmental influences on a 96 hour residential radon test near Kansas City, Missouri. The test period (May 14-18, 2012) was during dry mild weather, lacking typical spring time atmospheric turbulence. The media coverage of the "Super Moon" which occurred earlier in May prompted comparison of environmental influences. This case involves one dwelling, typical of many mid-American single family homes. The absence of major weather turbulence during the test period provided a good opportunity to compare temperature, barometric pressure, and wind. To evaluate the influence of the moon, 97 radon measurements were plotted with the Galveston Bay tide chart, which falls on the same longitude, about 600 miles south of the test site. The plotted data shows significant synchronicity between radon readings and tidal fluctuations. The timing of the tides closely matched the timing and magnitude of changing radon levels.

Study Summary

A building study in the Central Plains of the United States demonstrates what others have found to be a strong relationship between environmental radon gas fluctuations and the moon. Time plots of a Kansas City area radon test, superimposed with Galveston tide charts from a web based fishing site show a noticeable parallel. Mild weather and temperatures during May provided a good opportunity to evaluate radon levels with minimal interference from atmospheric turbulence. Fluctuating radon levels over a 96 hour sampling period, closely matched fluctuating tide changes. Though the tide chart was for a point about 600 miles south of the test location, the high and low radon readings closely matched the timing of the high and low tides, and proportionally matched the magnitude of the tide changes.

This radon test site was in a walk-out basement, about 950 feet above sea level, on a 10-acre tract of land described by the county soil survey as silt loam.

Background

Radon is the heaviest of the naturally occurring gases found on earth. It is a colorless, odorless, radioactive decay product of uranium. Medical research has identified radon as the second leading cause of lung cancer.[1] Real estate transactions occasionally include radon testing at the buyer's request, during the property inspection period. For Missouri and Kansas, the standard test period is four days, or 96 hours. Current EPA guidelines recommend radon mitigation if standardized tests show levels at or above 4 pCi/L.[2]

The subject of this study is a 96 hour residential radon test in Clay County, Missouri beginning on May 14, 2012 and completing on May 18, 2012. This test period was during dry, mild weather conditions, with no rain or extreme weather changes. Weather information was provided by the Weather Underground website, www.wunderground.com, (see Figure 1.)

Publicity of the May 2012 "Super Moon" encouraged consideration of lunar position in the analysis. This was done by superimposing the radon time plot onto a tide chart for Galveston Texas, near the same longitude of the rural Missouri test site. Tide information was provided by the website www.gofishingforum.com (see Figure 2.)

The test site was a single family brick and wood framed ranch style residence (about 2000 SF) built on a lot of about 10 acres surrounded by undeveloped land. The ranch style dwelling had a partially finished basement of about 1000 SF in size. The house was occupied by senior adults with no children during the test week. The owners indicated negligible ventilation changes, and no entry into the test area. The motion sensor on the test instrument flagged one motion event at the beginning of the test period.

The test instrument used was a Sun Nuclear Model 1028 Continuous Radon Monitor, placed in the center of the finished basement area, on a table about 36 inches above the floor.

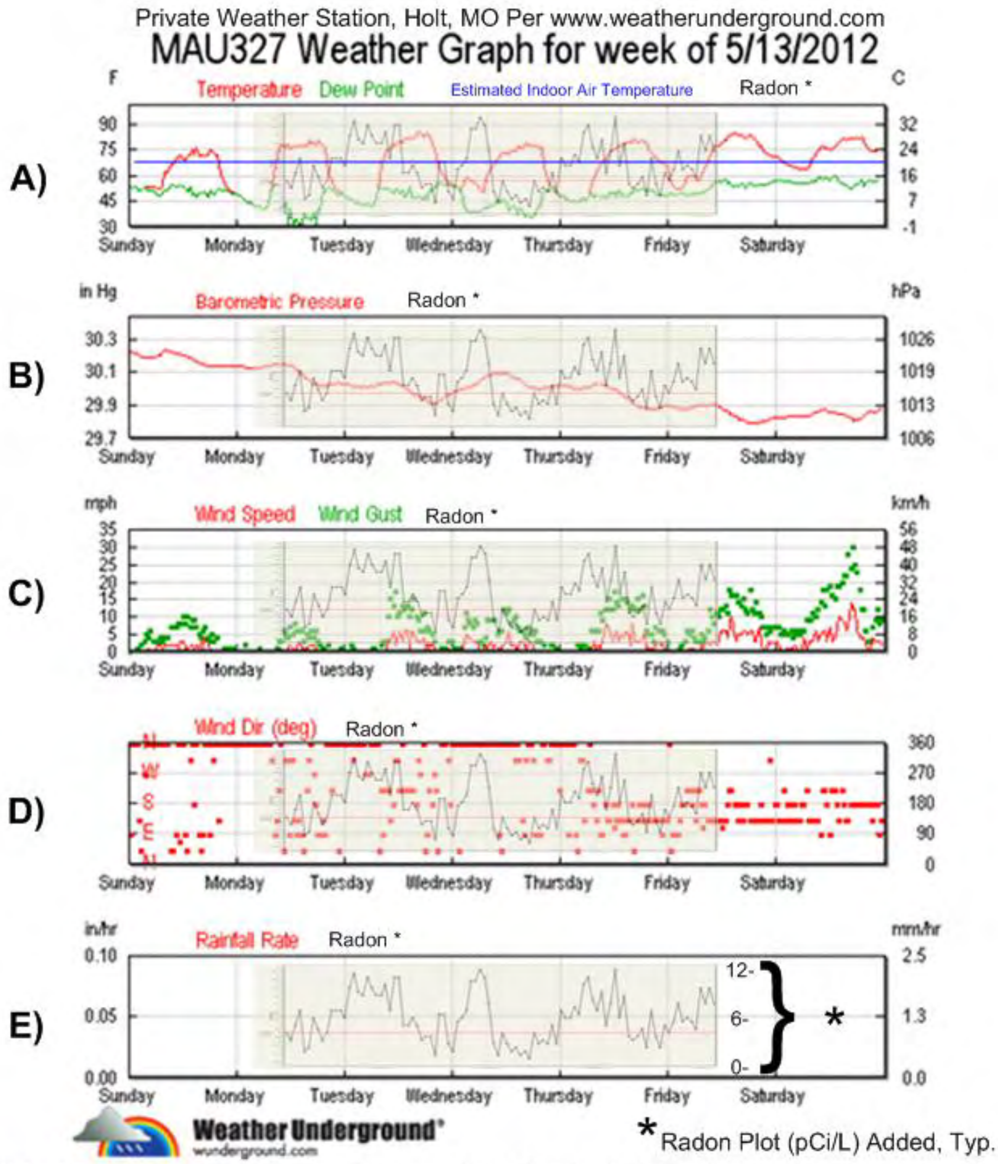
The recorded plot generated by the instrument was downloaded to a computer and copied to a Visio drawing with the weather and tide information.
See Figure (1). This figure superimposes the radon sampling plot over each of the five weather parameters reported by Weather Underground Private Station MAU327 (about 5 miles NNW of the test site) for the week of 5/13/2012. (See www.wunderground.com)

Temperature Effects

Figure (1A) shows an outdoor sinusoidal temperature plot. As temperature rises in the building attic, one would expect air to be drawn in through cracks around and under the house. The air conditioned indoor temperature was estimated to be constant. The dwelling isa well built brick and wood frame home with tight windows and doors, so outdoor temperature may have a smaller impact on this structure. Figure (1A) implies that radon levels are rising and falling independent of the outdoor temperature changes.

Barometric Pressure Effects

Figure (1B) shows the general trend of barometric pressure during the test period is decreasing with slight undulations. Though second order pressure fluctuations may have influence on the changing radon levels, this plot shows major changes in opposition to the expected barometric effects, such as a major rise in radon levels early Wednesday, at the same time barometric pressure is rising.



Weather data provided by Weather Underground. See www.wunderground.com for web site information. Weather Underground is not responsible for the accuracy, or interpretation of the data used in this document, and assumes no liability for the opinions expressed by this writer.

SUN NUCLEAR UNIT-OVERALL AVERAGE: 5.8 pCi/L

DATE	DRAWN BY	DESCRIPTION	PROJECT NO:
6/1/12	M.H. WHITEHEAD, PE FILENAME 5609-WUNDERDATA.VSD	FIGURE 1: RADON DATA WEATHER COMPOSITE	#5609--CLAY COUNTY HOLT, MO 64048

Wind Speed Effects

Figure (1C) shows average wind speed and gust velocity. The tight windows and doors may have minimized the influence of wind effects during this test, and the low wind speed helped reduce air exchanges from wind. Some radon fluctuations may be influenced by wind gusts. Overall, the radon levels appear independent of the moderate winds during this test period.

Wind Direction

Figure (1D) plots the wind direction during the test week. The direction is random, and does not appear to have a strong influence on the radon levels.

Rainfall Effects

Figure (1E) charts the Rainfall Rate and duration. There was no recorded rain during the test week. Extended dry conditions opened visible cracks in the surrounding soil. This significantly increased gas permeability of the soil surface, and likely increased the vertical depth of soil contributing to gas migration.

Local Soil Properties

Site specific soil testing was not performed. The Web Soil Survey was reviewed to consider commentary from county soil survey information. The Web Soil Survey (WSS) identified local soil as Sharpsburg silt loam on the south side of the dwelling (front yard), transitioning to Lagonda silty clay loam on the north side (back yard sloping 5-9% to the north, away from the walk out basement. Lacking site specific analysis, the visible conditions were consistent with the WSS description, so the properties below were assumed to generally describe the shallow surface soil. See Chart (1).

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Physical Properties	%Sand	%Silt	%Clay	Permeability (micro m / sec)	Linear Extensibility (%)
0-17”	2-2-3	50-72-87	18-26-27	4.00-14.00	3.0-5.9
17-55”	1-2-6	40-63-72	27-35-42	0.40-1.40	3.0-5.9
55-60”	2-2-7	40-59-72	25-39-39	0.40-1.40	6.0-8.9

Chart (1): Sharpsburg silt loam chart table (Map unit symbol 10120) provided by the Web Soil Survey, Physical Soil Properties Report www.websoilsurvey.nrcs.usda.gov

The shrink/swell potential, rated above as Linear Extensibility, does imply that dry conditions could result in significant soil shrinkage, and increased gas permeability.

Assuming the silt loam soil continued with properties similar to the table above, it is likely that gas permeability of the fine grained soil decreased with depth.

Past foundation repairs at this site included the installation of six hydraulically driven micro-piers. These piers were driven to refusal at about 20 feet below the foundation. Each pier is composed of 3 inch diameter hollow steel pipe segments, with nested slip joints every three feet. A potential gas migration pathway is created by this type of repair.

Tidal Effects

The variations in the radon levels closely match variations in the Galveston tide chart. The timing of the high and low tide events closely match the maximum and minimum radon level readings. With weather interference minimized during this test period, the synchronicity of the radon levels and tide levels is highlighted. See Figure (2)

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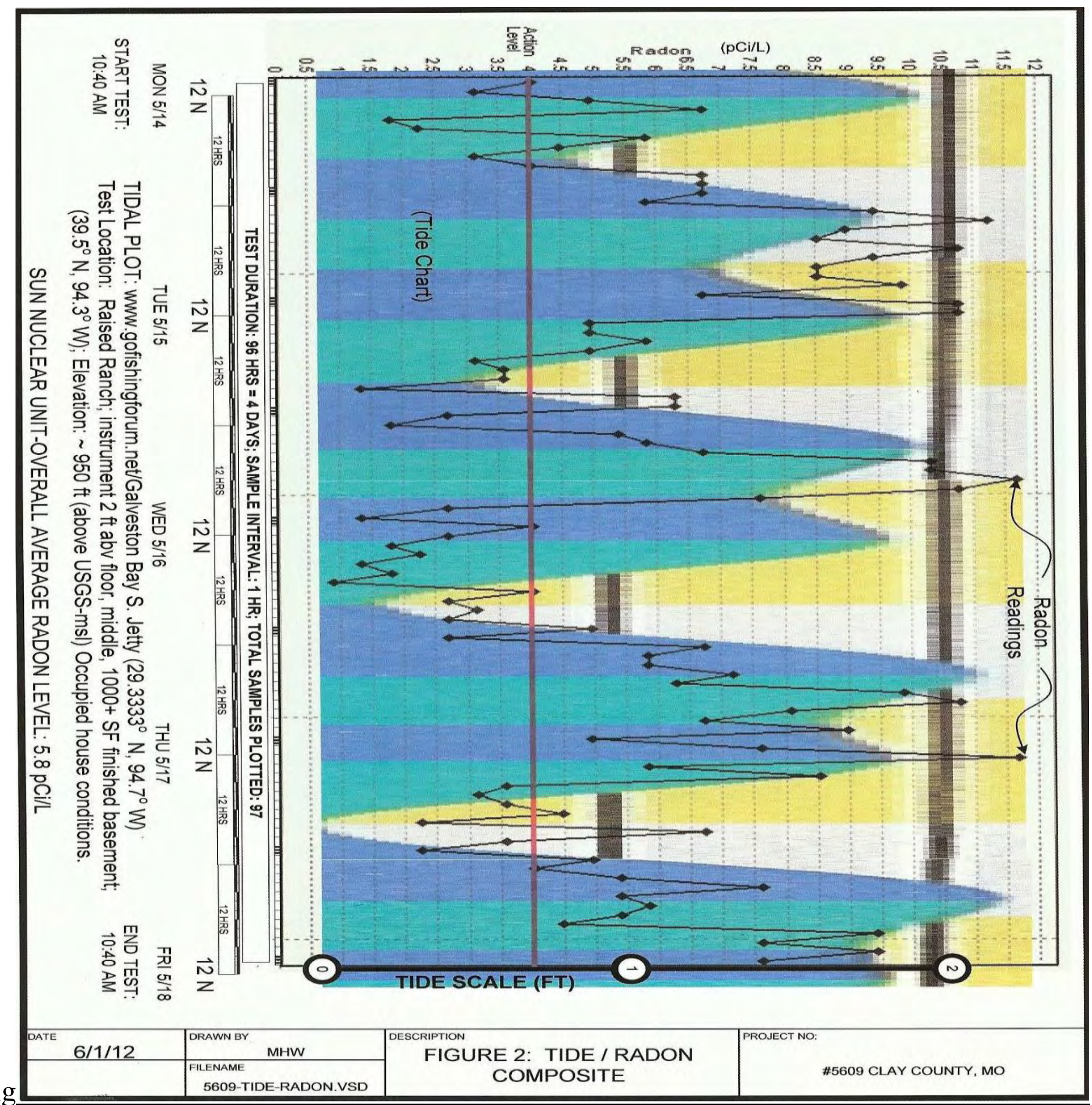

FIGURE 2: TIDE / RADON COMPOSITE

Conclusions

Though the test duration is too brief to be conclusive, the radon level changes show a strong match with the tide chart. Though tidal pumping may have an influence, the instantaneous radon changes indicate the likely source of the gas is very close to the surface. Soil gas migration in the shallow soil would move much easier than through deeper, less permeable material.

It is likely that the gas level fluctuations in this study result from the lunar/solar gravity influence on radon in the permeable shallow soil. It appears that the intermediate low tides between the lunar and solar high tides on Tuesday and Thursday mornings correspond to intermediate radon level changes. Tidal and gravitational radon influence have been documented in a British study (see Crockett, et al. [3]) and an Israeli Study (see Steinitz , et al.[4])

Weather, soil, and construction variables complicate the predictability of radon levels in any given location. A separate Missouri house study by the writer, found ice and snow in February, increased radon levels 400% compared to September readings during mild weather.

The mild weather conditions of this study minimized many of the environmental influences common to residential radon tests. This highlighted radon's sensitivity to gravity. Tide chart analysis is well beyond the scope of residential radon testing efforts. Weather interference, local geology, and site differences can obscure the gravitational fluctuations shown in this brief study. But for the scientist and engineer that seeks to measure and understand the forces at work in this world, it should not be missed, that the same powerful forces that move the tides, move the heaviest naturally occurring gas on this planet.

Notes

[1] American Cancer Society, <http://www.cancer.org/Cancer/LungCancer-Non-SmallCell/DetailedGuide/non-small-cell-lung-cancer-risk-factors>.

[2] Consumer's Guide To Radon Reduction, How to fix your home; EPA 402/K-10/005, September 2010, <www.epa.gov/radon>.

[3] Crockett, R. G. M., G. K. Gillmore, P. S. Phillips, A. R. Denman, and C. J. Groves-Kirkby (2006), Tidal synchronicity of built-environment radon levels in the UK, *Geophys. Res. Lett.*, 33, L05308, doi:10.1029/2005GL024950.

[4] J Environ Radioact. 2011 Aug;102(8):749-65. doi: 10.1016/j.jenvrad.2011.04.002. Epub 2011 May 7. Possible effect of solar tides on radon signals. Steinitz G, Piatibratova O, Kotlarsky P. Source: Geological Survey of Israel, Malkhei Israel, Jerusalem. Steinitz@gsi.gov.il