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Not My Fault: Radiation and you

Lori Dengler and Don Garlick/For the Times-Standard

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It's time to try something new. Over the years I have received many interesting comments and questions on what I write in this column. After my series on the PG&E nuclear power plant and concerns about radioactive waste, my colleague Don Garlick thought I should take on the bigger issue of uranium enrichment. I've stuck my neck out a few times and ventured into areas that I have no great expertise in, but Don's request was definitely outside of my lane. I responded, "Don that's a great idea. Why don't you write something?"

Anyone who has ever met Don Garlick or taken a class from him knows what an extraordinary individual he is. Don was the mineralogist and Geology Department Chair at Humboldt when I first arrived and is perhaps the most original thinker I have ever met. I first met him in 1977 when I was being considered for a temporary teaching position. I was more than a little nervous when I first walked into his office.

We exchanged a few pleasantries and he asked me how my thesis was coming. I was working on fracturing produced by underground nuclear explosions and had done a number of laboratory experiments on how rocks fail. Then he pulled out a piece of paper and a pencil and proceeded to sketch the principal stress directions and a failure curve in a way that I had never considered before. The questions he asked were far more astute than anyone had posed on my PhD orals committee. I guess I muddled through ok as that was the beginning of a 37-year stint at Humboldt.

After Don retired from teaching in 1998, he never walked away from thinking about geologic problems. He was a regular at department colloquiums and when Don's hand went up to ask a question, you knew it would be a good one. For a number of years, he wrote "Garlick's Notebook", a weekly column in the North Coast Journal that tackled topics from bedrock to banana slugs. He broached the subject of nuclear fission in a 2010 Notebook article (https://www.northcoastjournal.com/humboldt/nuclear-matters/Content?oid=2130999). I am so happy I corralled him again into walking us through this complex issue. Don writes:

"We are all involved with radiation, some bad, some good. Lori Dengler has already dealt with the problem of radioactive waste from our decommissioned PG&E reactor. The 1986 explosion of the Chernobyl reactor in Ukraine caused thousands of thyroid cancers, mostly in children, because their thyroid glands absorbed radioactive Iodine. Yet, the same isotope of iodine is administered to patients suffering from over-active thyroids.

The issues are nuclear weapons, nuclear power, and beneficial nuclear medicine. With the recent addition of North Korea, there are now nine countries that possess very destructive nuclear weapons. Furthermore, such fission devices can be used to detonate extremely destructive hydrogen-fusion weapons. The largest one ever tested was "Tsar Bomba" in 1961 by the Soviet Union with a yield equivalent to 55 megatons of TNT (Hiroshima's bomb was equivalent to 15 kilotons of TNT).

Uranium occurs naturally as 2 isotopes, U238 (99.3%) and U235 (0.7%). When hit with a neutron, U235 fissions into 2 radioactive nuclei plus 2 or 3 neutrons that can continue a chain reaction. Controlling chain reactions is a topic that has filled libraries. Power reactors require U235 to be enriched to 3.6% while weapons require enrichment to about 90%. During WWII the U.S. separated uranium isotopes by fluorination into UF6 gas, then diffusing the gas through membranes.

The modern method in the world today is to pass UF6 gas through high-speed centrifuges which also separate molecules having slightly different masses. The world is currently concerned that Iran is using centrifuges to highly enrich the fissionable isotope. Hiroshima was destroyed by 2 subcritical masses of U235 that were shot together within a gun to achieve criticality. Plutonium, produced in Uranium reactors is also fissionable. A sphere of Pu239 was compressed by TNT to destroy Nagasaki. NASA controversially uses the heat from Pu decay to power distant spacecraft.

It is possible for fusion to occur naturally. When a shipment of uranium arrived from Gabon slightly depleted in U235, we realized that nature had sustained a nuclear chain reaction 2 billion years ago (https://blogs.scientificamerican.com/guest-blog/natures-nuclear-reactors-the-2-billion-year-old-natural-fission-reactors-in-gabon-western-africa/). Scientists have found evidence of at least 17 sites in equatorial Africa produced

spontaneous nuclear reactions, some of which may have continued for over a million years. Just like commercial nuclear reactors today, the Gabon sites produced radioactive waste. That waste appears to have been safely contained for two billion years, suggesting that when the conditions are right, long-term geologic storage of nuclear waste is feasible.

The uses of nuclear gamma rays and non-nuclear X-Rays in medicine, for diagnoses and treatments of cancers, are ubiquitous. Technetium, a synthetic isotope (Mo100 + proton = Tc99 + 2n) with a 6-hour half-life, emits long range gamma rays. It accounts for some 30 million tests per year. The Tc99 and other gamma-emitting nuclei can be chemically treated to find various cancers. Gamma rays are then detected externally by photographing sodium iodide scintillation plates. Some heart stress tests use injections of Tc99 that can reveal blood flow in heart muscles.

X-Rays are produced by accelerating electrons and slamming them into the orbital electrons of metal targets such as copper. My prostate cancer was cured by a narrow beam of X-Rays, aimed from different angles to avoid killing surrounding tissue. Cyclotron-accelerated protons (the nuclei of hydrogen atoms) are increasingly used to treat cancers. Fast protons can penetrate many cm of tissue and have the advantage of depositing most of their ionizing energy near the ends of their trajectories.

As with many scientific discoveries, there are potential harms and potential benefits. May they be used wisely.

I Thank Lori Dengler for inviting me to write this guest column. G. Don Garlick”

Lori Dengler is an emeritus professor of geology at Cal Poly Humboldt (formerly Humboldt State University), an expert in tsunami and earthquake hazards. The opinions expressed are hers and not the Times-Standard’s. All Not My Fault columns are archived online at https://kamome.humboldt.edu/resources and may be reused for educational purposes. Leave a message at (707) 826-6019 or email rctwg@humboldt.edu for questions and comments about this column, or to request a free copy of the North Coast preparedness magazine “Living on Shaky Ground.”