The Natural Nuclear Reactor of Gabon Africa and how it may have Initiated its Sustained Reaction

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Abstract

This paper will examine natural nuclear reactions by looking at the natural nuclear reactor in Gabon, Africa and speculate on what may have caused the reaction to initiate.

I will address in detail the natural nuclear reactor deriving information from multiple sources to establish how the reactor functioned and sustained operations and create a foundation to support my concept of how the reactor initiated the fusion process.

I will:

- Address the natural nuclear reactor deriving information from both independent studies and governmental research.
- Discuss how 16 reactor zones worked for more than 150 million years on a 30 minutes on and 2 hours and 30 minutes off cooling cycle while using the ground waters to moderate the reactions and how the reactor ultimately shut down operations 1.8 billion years ago
- Speculate briefly on how the reaction initiated relying on maps of tectonic plates through geologic time and overlaying known recoverable uranium deposits on geologic maps to understand where the uranium was.

I will conclude that nuclear energy is safe and that radioactive waste is a natural occurring event and can be contained by geology.

The Discovery of the Natural Nuclear Reactor.

France is a country that embraces nuclear power providing more than 75% of its electricity needs by operating 59 nuclear power plants. Given this, France conducts exploratory mining and uranium mining in many places around the world [8].

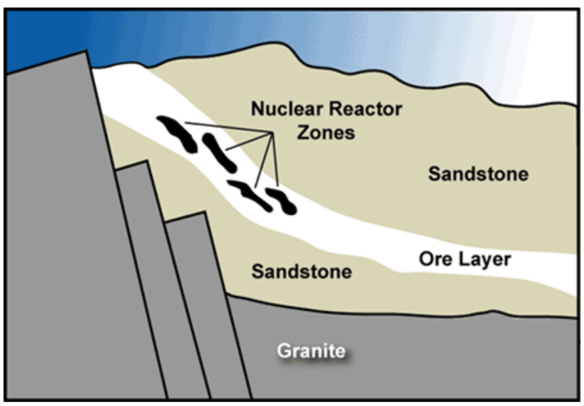
The country of France was mining in Gabon Africa for uranium when they discovered that something was incorrect in the ratio of elements. In nature there are several types of uranium but there are two predominate isotopes. These uranium isotopes are ^{235}U and ^{238}U and as they are radioactive elements they are subject to decay. This decay however occurs at different rates because the uranium is of different isotopes but they still maintain the same ratios wherein ^{238}U comprises about 99.3% of all uranium in an ore deposit and ^{235}U constitutes the other .7% in any given ore deposit. As these ratios were not found in the ore recovered from Gabon in was ultimately found that the ^{235}U species had already been depleted [18].

Scientists from around the world argued against this concept and insisted that the uranium had been displaced but that nature could not have depleted the ^{235}U as too many intricacies were involved in conducting a nuclear reaction. It was demonstrated that the level of ^{235}U found in Gabon could only be found after depletion in a nuclear reactor and there was no proof offered to support the displaced ^{235}U concept. With no other plausible explanation, the topic of how a natural reaction occurred was pursued [18].

The Operation of the Nuclear Reactor

Operating a conventional nuclear reactor is difficult as it requires a specific cooling rate and the fuel must be introduced at a specific speed to ensure there is neither an explosion nor a burnout. How nature depleted the uranium became the topic of discussion.

We can se in the basic profile depiction of the Gabon area, from the U.S. Department of Energy, that the uranium ore deposits are located in a sandstone bed. This sandstone was inundated with water which served to cool the reaction, facilitating a 150,000 year long nuclear reaction, finally ended 1.8 billion years ago.



U.S. Department of Energy (image 1), [18], [19].

As mentioned earlier, ^{235}U typically consist of about 0.7% of the uranium content. These two species have different half-lives, thus decaying at slightly different rates. Calculating the half-lives of ^{235}U and ^{238}U back 1.8 BYA, there would have been three percent more ^{235}U than present and that may have been enough to facilitate a natural reaction. This will be a topic of discussion further-on.

The more in-depth look at the reaction site as addressed by the research paper 'Record of Cycling Operation of the Natural Nuclear Reactor in the Oklo Area in Gabon' details the actions of the reactor site [2] and [18].

During the course of the research it was found that 16 separate reactor zones operated in the Oklo area of Gabon. The remaining amounts of ^{235}U as well as the amounts of ^{239}Pu resultant from fission present in the system indicated that no less than five tons of ^{235}U was consumed releasing about 15 GW of nuclear energy per year. The plutonium's half-life, the half-life of ^{239}Pu is 24,000 years. Given this half-life, an estimate for an effective fission chain could have lasted for about 150,000 years in Gabon. Over the course of 150,000 years the reactor produced an average of 100 kW which is equivalent to the power produced by a nuclear research reactor [2], [18], and [20].

There were several theories for the cooling mechanism that allowed for the self regulation. One possibility presented was the burning of neutron absorbing isotopes, however, proof for the water cooling theory was found in anomalous xenon of alumophosphates which identified a specific cycling process with a time scale. As the reactor temperature increased the "unbound" water was vaporized. At this point the neutron thermalization would reduce and the reaction would shut down. As the waters cooled and condensate reducing the temperature of the reactor, the reaction would reignite [2] and [13].

This was strongly emphasized to me in an email correspondence with the Yucca Mountain Research Team. They also stressed that the ^{239}Pu produced did not move more than 10 feet away from where it was created. That this system was not only self-regulating but also self-contained. This ensured the environment was not inundated with radioactive material which was of special interest to the Yucca Mountain research team [21].

Understanding the cyclic process was the next step in understanding the reactor. It was found that Tellurium was the most retentive fission product in the reactor zones. The measured amounts of fission Te isotopes were exact matches for the theoretical amounts. Subsequently, all of the tellurium β -active precursors were also retained in the reactor material. This led the researchers to assume that ^{129}I had also been retained in the reactor material. Because these materials were retentive they migrated within the system from the uranium oxide to the alumophosphate. After migrating to the alumophosphate they could decay to a xenon. A key to understanding the cyclic process was in determining that the alumophosphate was only retained when the reactor cools between its "operational pulses". The researchers ultimately found that "high concentration of short-lived intermediate fission products in alumophosphate without significant quantities of uranium implies that it precipitated during the operation of the Oklo reactor." The researchers conducted hydrothermal experiments to demonstrate that alumophosphates grow fast at temperatures of $\left(270^{\circ}\, to\, 300^{\circ}\, C\right)$, a rather low temperature. After a fission product is captured by one of these fast growing alumophosphates it remains in place decaying to Zeon. The Zeon can be released if the temperature rises above the blocking temperature of the alumophosphate however the temperatures never got this high during operating pulses of the reactor. In accounting for all of the isotopes and their evolutionary stages, the ^{129}I was not matching the proportions of any of the other elements. The researchers ultimately made an assumption that 37% of the ^{129}I had been lost by the alumophosphate since the reactor shut down. The ^{129}I has a half-life of $16\,X\,10^{6}$ years and is chemically active forming water soluble compounds so it was possible that it was leaked into the aqueous environment. The researcher pursued this line of reasoning and found that there was compelling evidence that the ^{129}I did leak into the aqueous environment. The ratios of the radioactive elements in an unbounded water environment suggest that the reactor functioned in pulses of 30 minutes: converting the water to steam, removing the sustained cooling agent which made the reactor subcritical and the reactor cooled for 2 hours 30 minutes while the water returned to the reaction zone [2].

The Development of Recoverable Uranium

As the source of the Gabon Reactor is a "recoverable source", meaning it can be mined to recover the mineral, I will look specifically at recoverable uranium.

While uranium is found worldwide, recoverable uranium occurs in sandstone formations. The uranium developed in the sandstone – the Earth's mantel has an abundance of uranium as well as other elements. These elements reached the surface of the Earth through volcanism. The uranium was then leached from the volcanic rocks oxidizing the oceans. Sandstone formations serving as aquifers collected and consolidated the uranium as the uranium was precipitated in the sandstone [3] and [12] .

Sedimentary rocks did not begin to fully form on the Earth until 2.5 BYA (during the Proterozoic) [4]. For this reason it is not reasonable to believe that the recoverable uranium was emplaced prior to this date.

To back track and see where the recoverable uranium formed and when, we need to look at the present. The majority of the world recoverable uranium is located in the following location in the given percentages where percentage of less than 5% are not mentioned and the percentage of Antarctica is high however not fully known as mining is prohibited there [1], [15].

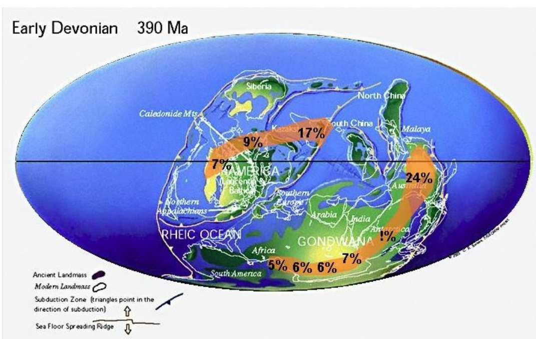
	Tons U	Percentage of World
Australia	1,143,000	24%
Antarctica	!	! %
Kazakhstan	816,000	17%
Canada	444,000	9%

USA	342,000	7%
South Africa	341,000	7%
Namibia	282,000	6%
Brazil	279,000	6%

Percentages of recoverable uranium, Table 1, [14].

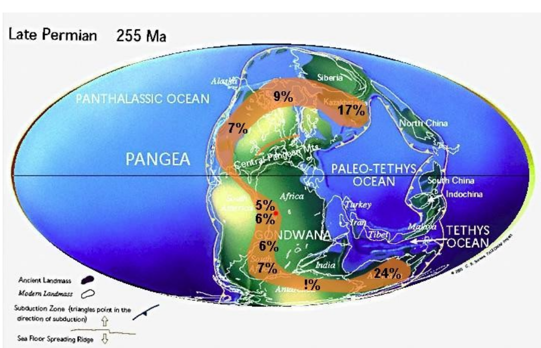
With the amounts of recoverable uranium known today, I superimposed the known locations on geologic maps.

Looking at the Devonian period we see that the necessary landmasses were present to collect the above percentages of uranium with the location indicated by an orange overlay:



Evolution of the Earth Text, Image 2, [5].

By the time of the Permian, all of the land that currently has recoverable uranium was fully exposed as depicted in the below Permian map and once again the recoverable uranium locations are indicated by the orange overlay:



Evolution of the Earth Text Image 3, [5].

The Gabon Reactor Zone is annotated in the above map by the red dot. The reactor began operations about 1.8 BYA [6].

This demonstrates that high amounts of uranium were available throughout the world and it is known that the ratios have been consistent worldwide yet the reaction took place in one place only. This establishes the foundation for a question.

Speculating on why the uranium deposit began a nuclear reaction.

There are numerous documents explaining the geology of the Gabon site, the physics of the reaction, how the reaction was sustained and why it finally quit after 150,000 years of activity, and even documentation how the environment contained the radiation.

The uranium was probably in place for about 500 millions of years based on when sandstone was first available to allow the deposition of uranium to occur. Since all of the components were there, why didn't the reaction happen sooner? If all of the uranium ratios between ^{235}U and ^{238}U are constant today then they must have been constant and emplaced at about the same time in the past; the decay rates would be about the same thus leading us to believe that the uranium contents worldwide would have 3% more ^{235}U than present. If the whole world had 3% more ^{235}U why did the reaction take place only in one location containing only 6% of the recoverable uranium as opposed to some place else such as Australia with 24% of the recoverable uranium? Why did the reaction occur at all? [14], [15].

First look at what causes a nuclear reaction to help answer this question. The three main components that produce a nuclear reaction are [16]:

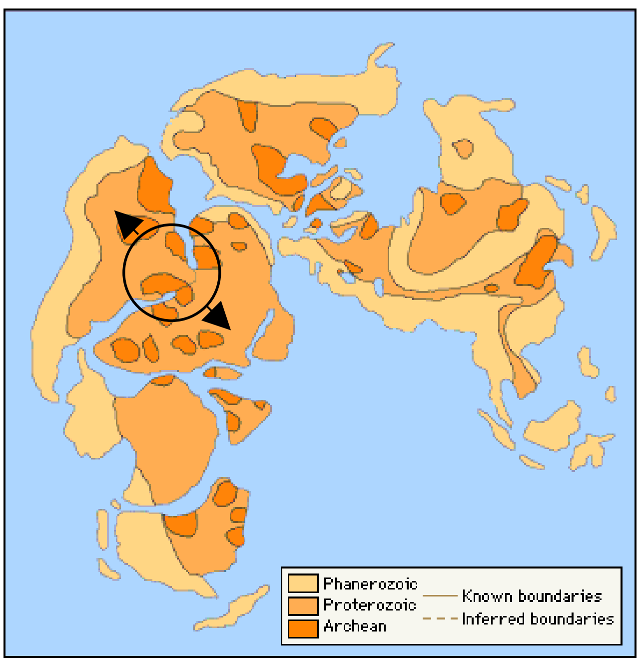
1. Refined fuel or density of fuel
2. Heat

3. A long confinement period

We will ensure that all of the components are available as we address these questions.

In attempting to answer these questions I have poised it is also helpful to look at the conditions when the reaction occurred. At this time when the site initiated a nuclear reaction it was 1.8 BYA, the world was in the Proterozoic. The conditions were:

- Presented below as Image 4, the portion of South America and portion of Africa had developed together during the Archean and began rifting for the first time during the Proterozoic. This rifting action happened again during the Mesozoic but without the same effects [7].



Encyclopedia Britannica, Image 4

- World water levels were low in the pre-Sloss sequences [4].
- A spreading center developed separating the Archean masses and the later Proterozoic masses as depicted by the circle I provided in the center left portion of Image 4 above.

It is my opinion that the reaction initiated for the following reasons:

- A continental rift occurred spreading the two continents apart very near the Gabon reaction site. At the point of the rift the Earth's crust thinner. At this spreading center, the sandstone aquifer in the area was probably drier than normal as the world water levels were in a low pre-Sloss sequence state. These combinations possibly lead to higher temperatures in the area of reaction.
- There was a vertical induced force caused by the rifting, a downward force caused by gravity, and these were combined with the horizontal force induced by the Poisson effect caused by the two aforementioned forces at the uranium site. The Poisson effect was more profound in the sandstone with a Poisson ratio of 0.3 wherein the uranium deposits were far more rigid with a Poisson ratio of 0.23. These amounts are respectably comparable to polystyrene foam and steel. As the sandstone could flex to compensate for the forces being applied, a significantly higher pressure was being applied to the more rigid uranium deposits [9], [11], [17], and [19].
- Heat and pressure may alter the ratio of carbon isotopes [10]. It would stand to reason that similar ratio changes could occur in all native elements. This condition of added heat and pressure may have contributed to an even higher ratio change in uranium isotopes causing a higher then normal ^{235}U percentage as

well as extreme pressure and temperatures.

Reviewing this sequence – These above reasons for the reaction meet the three previously mentioned requirements for a nuclear reaction. I believe that the ^{235}U ratio changed through heat and pressure resultant of the continental rifting; the rifting created enough pressure to initiate a reaction, the rifting allowed ocean waters necessary to cool and sustain the reaction to enter between the continents and subsequently reach the Gabon site to sustain the reaction for 150,000 years until dispersion between the ^{235}U isotopes were so great that the reaction could no longer sustain itself.

Summary

Earth deposited the uranium, refined the ratio to create a natural nuclear reaction, and provided heat and pressures to initiate the reaction as well as a cooling sequence. As this reactor was operating when Stromatolites were creating our atmosphere and used the aquifer coolers in the same lands that eventually served as the evolutionary nursery for many reptiles, mammals and even humans there is no reason to suspect that this uncontained reactor had a derogatory effect on nature. Nuclear reactions are a natural event and the geology of our planet does contain the event and the heavy metals that result from the reaction – our planet possibly even benefits from such events.

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