THE DISTANT PAST
Susanne Kriemann

No sun was lighted up, the world to view;
No moon did yet her blunted horns renew:
Nor yet was Earth suspended in the sky,
Nor pois'd, did on her own foundations lye:
Nor seas about the shores their arms had thrown;
But earth, and air, and water, were in one.
Thus air was void of light, and earth unstable,
And water's dark abyss unnavigable.
No certain form on any was imprest;
All were confus'd, and each disturb'd the rest.
For hot and cold were in one body fixt;
And soft with hard, and light with heavy mixt.
But God, or Nature, while they thus contend,
To these intestine discords put an end:
Then earth from air, and seas from earth were driv'n,
And grosser air sunk from aetherial Heav'n.
Thus disembroil'd, they take their proper place;
The next of kin, contiguously embrace;
And foes are sunder'd, by a larger space.
The force of fire ascended first on high,
And took its dwelling in the vaulted sky:
Then air succeeds, in lightness next to fire;
Whose atoms from unactive earth retire.
Earth sinks beneath, and draws a num'rous throng
Of pondrous, thick, unwieldy seeds along.
About her coasts, unruly waters roar;
And rising, on a ridge, insult the shore.
And as five zones th' aetherial regions bind,
Five, correspondent, are to Earth assign'd:
The sun with rays, directly darting down,

Fires all beneath, and fries the middle zone:
The two beneath the distant poles, complain
Of endless winter, and perpetual rain.
Betwixt th' extreams, two happier climates hold
The temper that partakes of hot, and cold.
The fields of liquid air, inclosing all,
Surround the compass of this earthly ball:
The lighter parts lye next the fires above;
The grosser near the watry surface move:
Thick clouds are spread, and storms engender there,
And thunder's voice, which wretched mortals fear,
And winds that on their wings cold winter bear.
Nor were those blustring brethren left at large,
On seas, and shores, their fury to discharge:
Bound as they are, and circumscrib'd in place,
They rend the world, resistless, where they pass;
And mighty marks of mischief leave behind.

– Ovid, Metamorphoses, Book 1

We sat in the central hall, under the painted cupola of the Museum for Natural History in Vienna, eating lunch. We were brought together by the same subject matter: he had devoted a part of his scientific career to the study of its epiphenomena; I was concerned with testing the effect of its rays, in the darkness of this museum's cellar, on photosensitive material. We discussed its applications, its hosts and its properties; invisible, odorless, untraceable in the air: radiation. The name echoed in the halls of the museum, just one of many natural history museums to host collections of radiating minerals.

Thinking two billion and five hundred thousand years. Eating. Radiation is eating through its metal and concrete coffers. Man-made radioactivity must be contained, yet because it is so volatile, man-made shells fail

to do so. 400,000 m3 and 7,300 tons susceptible to erosion compete with 740,000 m3 of infinite timeline. These numbers evoke Chernobyl's sarcophagus. A humongous, haunting hall – will I ever see it with my own eyes?

Radioactivity reveals the age of objects, in museums and in laboratories, helping to show the history of the world, both human and natural. It mimics light, imprinting itself on photosensitive material, stealthily creeping into visibility. In mineral form, radioactivity can be picked up and handled, but if done so inappropriately, mutation and fatal changes in the body (human, animal, vegetative) occur (the mushroom I ate, perhaps): picturing pale grass blue Fukushima butterflies.

Uranium is black and shiny. Incrusted in torbernite, granite, sandstone. It is found in all rocks. Uranium, thorium, and potassium have their central role with other naturally occurring radioactive elements in the movement of the earth's plates. The heat produced during the radioactive decay yields convection in the earth's mantle causing the plates to move. In the distant past. Transforming and mutilating the body, radioactivity is a master of DNA. The master appears, inconspicuously at first, as an irregularity. Death wears a mask that is a million years old and will last another million years. This distant past encrusts itself upon the body: taking it back in time, deforming its structure, disabling and sometimes obliterating it. These minerals should have rested in their aluminum shells, their lead housing and their crystal cabins, preserved in the time when earth was untouched by the human hand.

Excavated, used, and made essential to our current lifestyle instead, it becomes the story of the earth's superhero turned villain. Distance bisects fear. Our separation from the sun is vital, yet we depend on it. Radioactivity is in the air, for you and me. Chernobyl, Harrisburg, Sellafield, Hiroshima. Chernobyl, Harrisburg, Sellafield, Fukushima. As the human eye witnesses one unsettling event after another as singular occurrences on a line that only moves forward, radiation stretches over thousands of years, yet never loses its destructive power and in its full, gigantic uncontrollability exists on a plane that touches past, present and future simultaneously. Though more and more radioactive resources may be exploited for our use, their chemical echoes will most likely outlive humanity. Chain reaction and mutation. Chernobyl, Ostrovets, Chernobyl, Ostrovets.

Today, even with all the information available about the dangers of radiation, economic desperation compels people to find work in radioactive mines. And voracity compels people to find ever more illuminated cityscapes. Belarus builds its first nuclear power plant. Long after Curie (her corpse is still radiating), what it means to be poisoned by gamma rays has been well documented; body parts acquiring a post-mortem luminescence, or a hand blacker than burnt wood in sunlight. Ray. Radium girls, who were assured of the safety of the radioactive paint they used to apply to the faces of watches, so that time might become visible, even in the darkest of places. They worked with death unknowingly, licking their paintbrushes for that precision point. They were deformed or destroyed in the name of visibility. I feel they work away in a dawn that precedes not a morning, but the end of sleep – the dream of permanent illumination –, the half-life of labour conjoined with the half-life of uranium. Their, others’ and our mutations foreground the virtual nature of radiation. Grace Fryer, Edna Hussman, Katherine Schaub, Quinta McDonald, Albina Larice. Aleksandr Fyodorovich Akimov, Alexei Ananenko, Anatoly Ivanovich Baranov, Boris Baranov, Valeri Bezpalov.

They worked with death knowingly, saving many.
And so many more, inhaling, from a distant present,
704,000,000 years.

Thinking 2 x 1012 and 500,000 (Uraninite)

FB: In the area around Oklo in the West African state of Gabon,[1] there is a natural uraninite deposit that today has been almost fully exploited by French corporations, both above and below ground. At the beginning of the 1970s a French physicist discovered an “isotopic anomaly”[2] there, unexplainable at the time, in a uranium compound obtained from the uranium ore mined from what was determined to be a naturally occurring reactor in Oklo. Theoretical deliberations and further investigations eventually lead to the discovery that around two billion years ago, in the area surrounding what today is Oklo, a large amount of uranium was enriched, forming several natural nuclear reactors.[3] It is estimated that these natural nuclear reactors (allowing for periods of dormancy) were active for over a period of 500,000 years. One can imagine the enormous interest the “Oklo Phenomenon” garnered from the scientific community[4] and that many research groups surveyed these natural reactors intensively. These are known as fossil nuclear reactors that work on the basis of the fission of uranium atoms.[5]

Handling 1.85 × 1011 Bq, or 5 Ci (Uranium)

FB: The following incident was used in a radiation safety training-course that I took over thirty years ago, so my memory of it is a little sparse. It happened in a North African country (Libya or Algeria)[6] where a steel plant owned by a French corporation was operated. There, the welding seams of various supporting elements (steel beams, pipes, etc.) were inspected for cracks or weak points that may have been caused by "fluoroscopy," meaning the radioactive rays shine through the encasing. This kind of fluoroscopy occurs from a radiation source used in the plant that emits gamma rays (even more intense than x-rays).

The source of the radiation itself is an artificially produced material that is so intensely radioactive that a person must not come into contact with it without appropriate protection from gamma radiation. Due to sloppy handling, the radiation source, which resembles a sort of silver pen, was lost during transport, either to or from the construction site. At some point, a local man came across it – it looked to him like an "interesting metal pen" – and put it in his pocket, taking it home and placing it on his night table. In a little while, the man came down with radiation toxicity. The reason for his illness was eventually discovered, but by then the man was beyond help. He eventually died an agonizing death. His body parts (specifically his upper thigh) were exposed to an amount of radiation immeasurably higher than the established lethal dose, a fact that no doubt made him an object of scientific interest during his stay at the hospital... Unfortunately I can't tell you any further particulars about the incident. However, there are several other well-documented cases of this kind. There are several reliable reports about similar incidents from the IAEA, such as one from Iran – that thankfully did not come to the same lethal end – and another quite instructive example from Thailand. Here we are faced with another example of the damage radioactive material can do when it is mishandled.[7] The parts were sold to a junk dealer as scrap metal. During further handling of the scrap metal, ten people were contaminated with radiation and, out of those people, three were dead within two months after

being contaminated. In the IAEA report there are several photos of the radiation damage suffered by all the persons concerned. Of course this report contains many technical details, but the circumstances of the accident are well illustrated and generally understandable.

Inhaling 7.6 Days (Radon)

FB: In a forest located northwest of Vienna the subsoil is comprised of rocks (gneiss, granite, etc.) that, due to their natural radioactivity, cause a much higher "natural ambient radiation" than in other areas (similar circumstances also apply to comparable areas in Germany: The Bavarian Forest, the Fichtel Mountains, the Ore Mountains). The particular consequence of such places is the presence of the noble gas radon.[9] Radon emerges as a natural by-product of uranium decay. In some stones in this area, like granite, for instance, there is a significantly higher proportion of uranium (and other elements) than in others – limestone, for example. Radon is a heavy gas that collects near ground level (low-lying spaces). Radon itself is radioactive and decays in other radioactive elements. In this way, a locally high concentration of radon can be produced, one that is dangerous for humans. If radon gas is breathed in, the products of radioactive decay can inflict radiation damage on the lungs and, in the worst cases, cause lung cancer.[10]

In principle we do not differentiate between artificial and natural radioactivity – in the sense that a naturally grown diamond and a diamond grown in a lab do not differ from each other, because they exhibit the same physical-chemical characteristics. The difference comes first in how they are used.[11]

Today, it is impossible to imagine medicine a nd science without the application of "radioactivity." Its uses range

I type 'Uraninite' in my search engine and images appear, many. I choose the one that draws my attention, as it visualizes the enclosure of the mineral in another stone. I take a picture of the stone, of the file, of the light, of my computer. On my other screen (the one of my camera), a moiré effect appears, each time differently while image and camera do not move. The screens are parallel and sit there to depict, in the same way, an ungraspable transformation: rendering, enclosing, scaling, 4 times 1/60 seconds, the file to the file to the file to the file.

from the medical (cancer treatment) to determining the age of stones (answers to the questions: how old is the earth? How did our solar system form? etc.), the absolute age determination in archaeology right up to everyday uses, for example, in smoke alarm systems in buildings and so on.

On that point, I must explain that the majority of the rocks that I handle do not emit any dangerous radioactivity. It might be interesting to mention here the fact that we (with meteorites in any case) deliberately make non-radioactive rock samples radioactive by artificial means in order to determine their chemical makeup. To that effect, the samples are irradiated with neutrons in a nuclear reactor and made radioactive. The radioactive emissions from the thus treated samples are then measured accordingly in order to accurately discern the concentration of elements that are present in the samples in very small amounts.[12]

A million years from now, will naming radioactivity still be appropriate? Someone, "human" by our standards or not, might read and pronounce this phenomenon in a different way. Reading radioactivity, reading 1,000,000, I imagine mirroring the past into the future. The thin line between the one and the other distant time is now. A volume smaller than a day. Thinking about nuclear waste fills this day with one million years into the future. Imagining the earth's plates moving, this time witnessed by my children's children's children's children, displaces my position and thoughts on this subject today. I am turning off the coffee machine. I am switching off the light. I am taking off my shoes and walk out of the cellar on this bright winter's day.

1 Uranium from Oklo is, in contrast to naturally occurring uranium, composed of less Uranium-235.

2 0.7171%. At the moment of fission (2 billion years ago) the percentage was at about 3%.

Fission-products still immobilized in the core: lanthanum, cerium, praseodymium, neodymium, europium, samarium, gadolinium, yttrium, zirconium, ruthenium, rhodium, palladium, niobium, silver, molybdenum, iodine, krypton, xenon. See "The 'Oklo Reactor': A Nuclear Detective Story," *Re-actions* 9 (Sept. 1993): n.p., <http://www.ans.org/pi/np/oklo/docs/reactions.pdf>, accessed December 12, 2014.

3 Total energy released: 15,000 megawatt-years; Average power output: 100 kilowatts (power for about 1000 light bulbs); Began operating 2 billion years ago, ran for an est. 150,000-500,000 years; Total of uranium reserves: 400,000 tons; Net loss of Uranium-235: 5 tons; Turned on for 30 minutes; turned of for 2.5 hours. See Alex P. Meshik, "The Workings of an Ancient Nuclear Reactor," *Scientific American* (January 26, 2009), n.p., <http://www.scientificamerican.com/article/ancient-nuclear-reactor/>, accessed December 12, 2014; Everlyn Mervine, "Nature's Nuclear Reactors: The 2-Billion-Year-Old Natural Fission Reactors in Gabon, Western Africa," *Scientific American*, blog post (July 13, 2011), < http://blogs.scientificamerican.com/guest-blog/2011/07/13/natures-nuclear-reactors-the-2-billion-year-old-natural-fission-reactors-in-gabon-western-africa/>, accessed December 12, 2014; George A. Cowan, "A Natural Fission Reactor," *Scientific American* 235 (July 1976): 36-47, <http://brendans-island.com/blogsource/20101015ff/a-natural-fission-reactor.pdf>, accessed December 12, 2014.

4 Toxic waste (Xe and Kr-85) was trapped in the chemical compound, aluminophosphate. See "The Natural Nuclear Fission Reactor of Gabon, West Africa," *Today I Found Out* (December 2013), n.p., <http://www.todayifoundout.com/index.php/2013/12/natural-nuclear-fission-reactor-gabon>, accessed December 12, 2014. Thickness of the mineralized layer: 5 to 8 meters. Local tectonic movement served to uplift the sandstone formations bordering on an elongated depression in the sole. A total of 16 reactor zones have been found in the primary location. Another reactor zone was identified about 20 km away.

5 It is estimated that the Gabon reactor had a thermal neutron flux of at least 109 (1,000,000,000) neutrons per cm2/sec and a total fluency of 1021 (1,000,000,000,000,000,000,000) neutrons per cm2. By comparison, the complete fission of one kg of 235 U in a nuclear detonation would release approximately 1026 (100,000,000,000,000,000,000,000,000) neutrons in approximately one microsecond through an area of approximately 200 cm2, giving a neutron flux of about 1030 (1,000,000,000,000,000,000,000,000,000,000) neutrons per cm2/sec.

Current nuclear reactors have neutron fluxes on the order of 1013 to 1014 neutrons per cm2/sec. See Andrew Karam, "The Natural Nuclear Reactor at Oklo: A Comparison with Modern Nuclear Reactors" (2005), 1-9, <http://www.physics.isu.edu/radinf/Files/Okloreactor.pdf>, accessed December 12, 2014.

6 Gilan Radioactive accident: On 24 July 1996 a serious radiological accident occurred at the combined cycle fossil fuel power plant in Gilan, Islamic Republic of Iran, when a worker picked up a Ir-192 industrial radiography source and put it in his chest pocket, where it remained for approximately 1.5 h, resulting in his receiving a high radiation dose.

7 Radiography equipment: The equipment involved in the accident was a Gammamat projector manufactured by Isotopen-Technik Dr. Sauerwein GmbH, Haan, Germany. The radioactive source was an Ir-192 pellet of 2 mm diameter, enclosed in an X540 type stainless steel cylindrical capsule 7.5 mm long and 5.0 mm in diameter. The capsule was attached to a Gammamat link TI series source holder, which was connected to a flexible drive cable. The radiography company assessed the activity of the source to be 185 GBq (1.85 × 10 11 Bq, or 5 Ci) at the time of the accident. Status at the end of the year 2000: K.Z.'s general status was satisfactory 4.5 years after the accident. He had moderate edema and pain in the right elbow, where movement had been limited since early 1997. Severe fibrosis of his left palm (from repeatedly handling the source during the 1.5 h exposure time) appeared unusually late - 4 years after the accident - and has not reacted well to conservative dermatological treatment. See IAEA, *The Radiological Accident in Gilan* (Austria, 2002), <http://www-pub.iaea.org/mtcd/publications/pdf/pub1123_scr.pdf>, accessed December 12, 2014.

Alpha radiation, which consists of heavy, positively charged particles emitted by atoms of elements such as uranium and radium. Alpha radiation can be stopped completely by a sheet of paper or by the thin surface layer of the epidermis. However, if alpha-emitting materials are inhaled or consumed into the body, they can be exposed directly to internal tissues and consequently may cause biological damage. Beta radiation, that consists of electrons. They are more penetrating than alpha particles and can pass through 1-2 centimeters of water. In general, a sheet of aluminum a few millimeters thick will stop beta radiation. Gamma rays are electromagnetic radiation similar to X-rays, light, and radio waves. Gamma rays, depending on their energy, can pass right through the human body, but can be stopped by thick walls of concrete or lead. Neutrons are uncharged particles and do not produce ionization directly. But, their interaction with the atoms of matter can give rise to alpha, beta, gamma, or X-rays, which then produce ionization. Neutrons are penetrating and can be stopped only by thick masses of concrete, water or paraffin." See IAEA, Factsheets & FAQs, <http://www.iaea.org/Publications/Factsheets/English/radlife.html>, accessed December 12, 2014.

Uranium-234: 0.0054%; half-life: 245,500 years. Uranium-235: 0.7202%, half-life: 704,000,000 years. Uranium-238: 99.2742%; half-life: 4,468,000,000 years. See WebElements, Uranium: Isotope Data, <http://www.webelements.com/uranium/isotopes.html,>, accessed December 12, 2014.

8 Radon has a half-life of 3.8 days and is an odorless, colorless, and tasteless gas; found in soil and rock, seeps into houses where it accumulates. Average radon concentration in living spaces is 50 Bq/m3. See Bundesamt für Strahlenschutz, *Strahlentnehmen* (December 2012),

<http://www.bfs.de/de/bfs/publikationen/broschueren/ionisierende_strahlung/radon/stth_radon.pdf>, accessed December 12, 2014; U.S. Environmental Protection Agency, Decay Chains,

<http://www.epa.gov/radiation/understand/chain.html>, accessed December 12, 2014.

9 The residence time of radon in the human organism is short - it is estimated that about 59% of radon is eliminated within 15-30 minutes. The final decay of radon in the organism to the level not detectable by analytic methods takes place within 2-3 hours. After that time, only the sediment remains in the system; it emits mostly radiation and photons only to a minor extent, during the first 7 hours of residence in the system, resulting in the creation of 210Pb and 210Bi, which becomes a long-term [half-life of 22.3 years] source of weak radiation.

It is important to realize that the renewed interest in radon therapy in recent decades has little relation to the popular fashion in the early part of 20th century, mostly in Europe that attributed a multitude of healing powers to radium. In addition to the use of external sources such as radium-impregnated bed blankets and compresses, Ra intake was practiced as well. Radium was, for example, added to many "health food" items and toothpaste. In many countries in Europe (Germany, Austria, France, Italy, Hungary, Bulgaria, Poland, the Czech Republic and others), South America (Chile, Brazil), and Asia (China, Japan) new centers have been constructed and their operation is frequently harmonized with modern medical approaches to achieve curative effects. Among the traditional spas with high radon concentration, Bad Gastein, Austria is perhaps among the best known.

10 Radiotherapy: Radon has been produced commercially for use in radiation therapy, but for the most part has been replaced by radionuclides made in accelerators and nuclear reactors. Radon has been used in implantable seeds, made of gold or glass, primarily used to treat cancers. The gold seeds were produced by filling a long tube with radon pumped from a radium source, the tube being then divided into short sections by crimping and cutting. The gold layer keeps the radon within, and filters out the alpha and beta radiations, while allowing the gamma rays to escape (which kill the diseased tissue). The activities might range from 0.05 to 5 millicuries per seed (2 to 200 MBq). The gamma rays are produced by radon and the first short-lived elements of its decay chain (Po-218, Pb-214, Bi-214, Po-214). Wikipedia, "Health Effects of Radon," <http://en.wikipedia.org/wiki/Health_effects_of_radon>, accessed December 12, 2014.

11 Excerpts from a conversation with Franz Brandstätter at the Museum of Natural History in Vienna in June 2013. Technical footnotes by Elisabeth Mohr, edited and translated by Kalie Stieda.