Nuclear & Radioactive Roots of just about Everything

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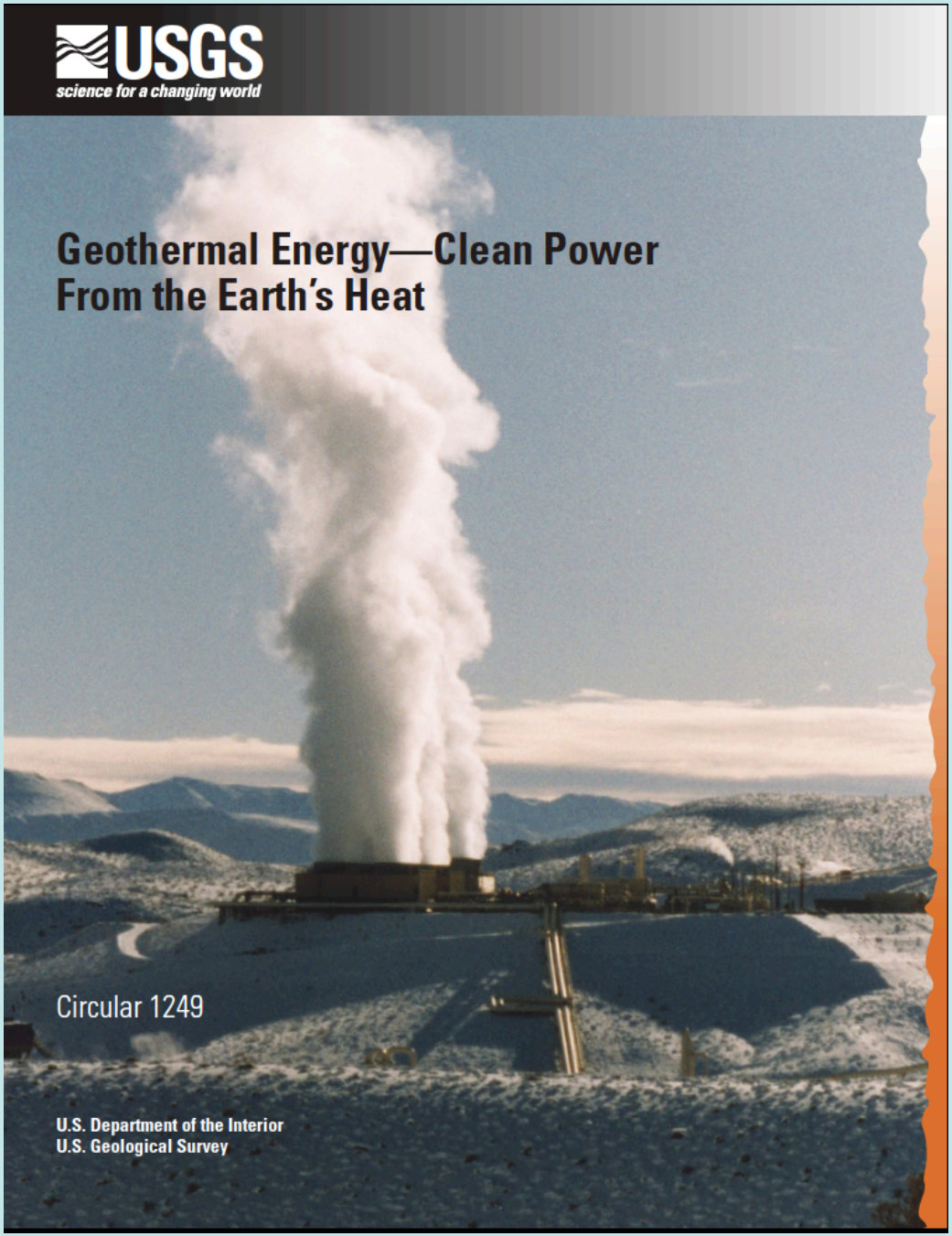


The Earth is a bountiful source of thermal energy, continuously producing heat at depth, primarily by the decay of naturally occurring radioactive isotopes—principally of uranium, thorium, and potassium—that occur in small amounts in all rocks.

83% of present surface heat flow is due to radioactive decay of U, Th, and K

http://www.und.edu/org/ihfc/Gosnold_AAPG07.ppt#316,18,Global Heat Flow

Geothermal energy is the ethical energy source for the future

http://www.heatflow.und.edu/Gosnold2Geothermal.ppt#263,1,Geothermal Energy is the Ethical Energy Source for the Future

http://renewnd.areavoices.com/2009/02/01/prof-will-gosnold-research-on-enhanced-geothermal-is-world-class/

Radiation-driven Ecosystems

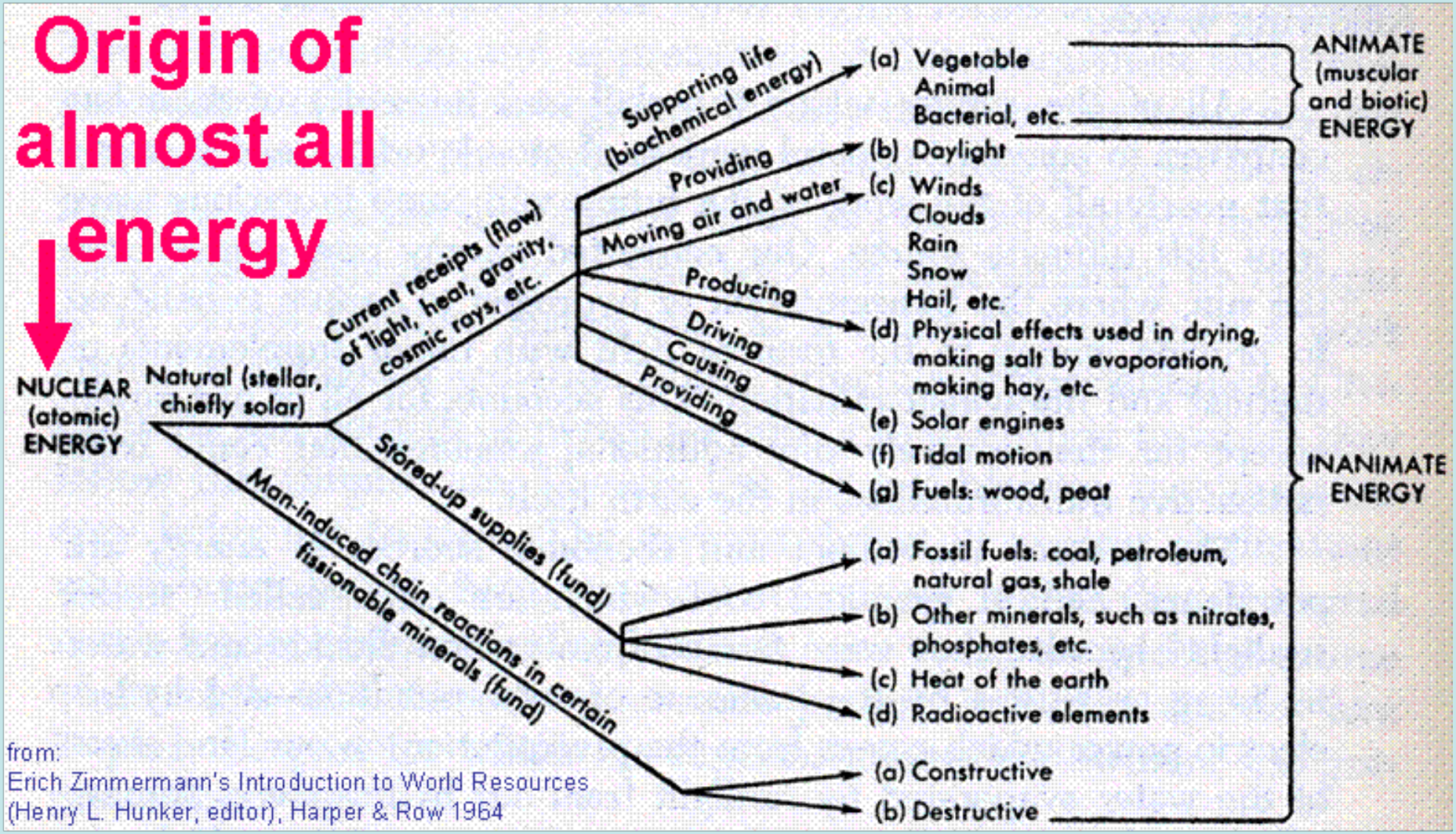
Fusion is the process that takes place in stars like our Sun. Whenever we feel the warmth of the Sun and see by its light, we are observing the products of fusion. We know that all life on Earth exists because the light generated by the Sun produces food and warms our planet. Therefore, we can say that **fusion is the basis for our life**

http://www.lbl.gov/abc/Basic.html

…virtually all of the energy we use originates in the power of the atom. Nuclear reactions energize stars, including our Sun. The energy we capture for use on Earth comes largely from the Sun or from nuclear forces local to our own planet.

http://needtoknow.nas.edu/energy/energy-sources/the-sun.php

Origin of almost all energy



from:
Erich Zimmermann's Introduction to World Resources
(Henry L. Hunker, editor), Harper & Row 1964

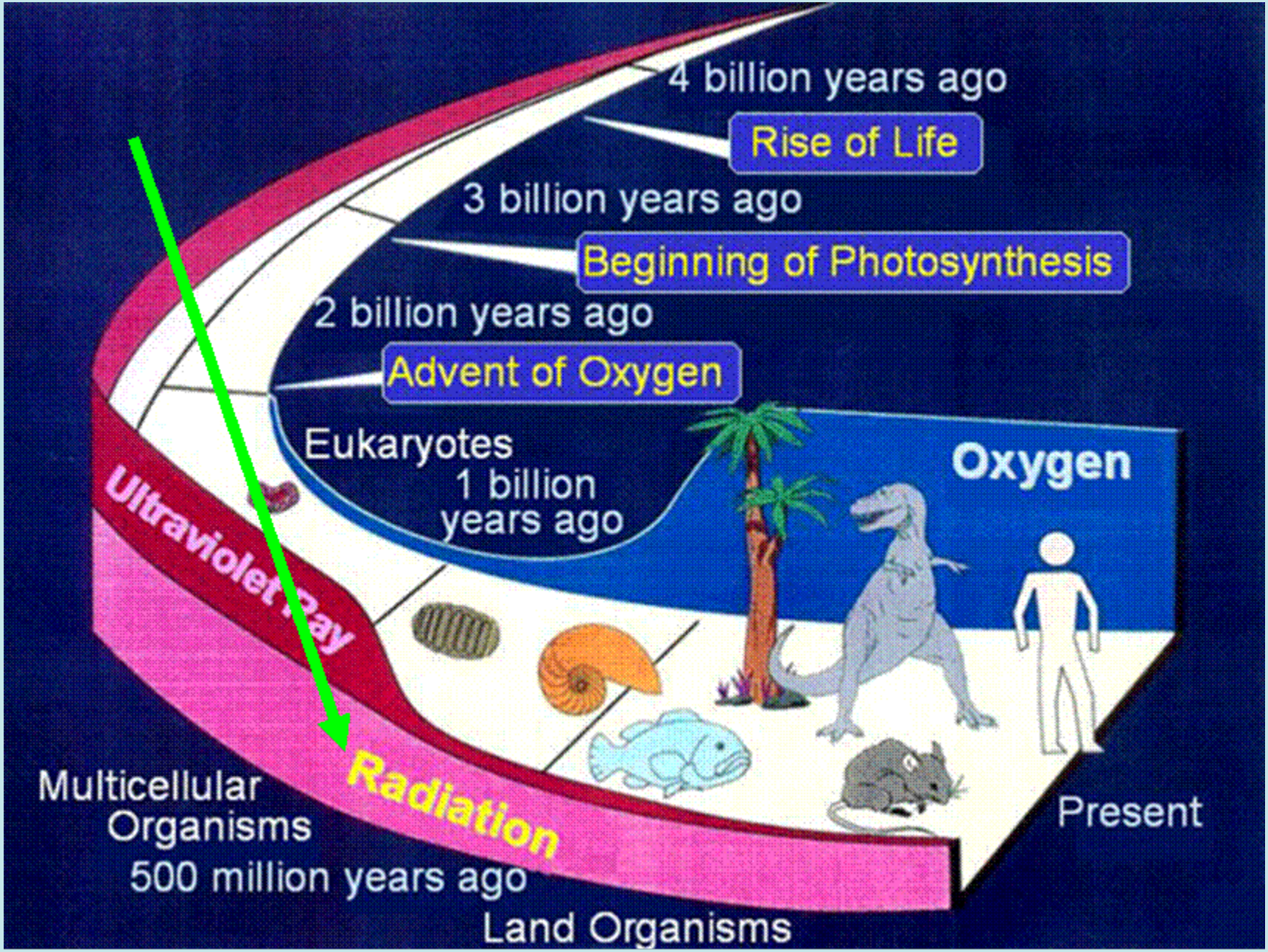
While generations of students and scientists have learned about radioactive decay and the half-lives of various radioactive elements and isotopes, virtually **no one has turned the telescope around** and discussed or documented the reverse view: The same number of half-life years taken back into the past produces a double-life, a doubling of radioactivity for these elements, and an incremental terrestrial background level many times higher than today's levels.

Gerald L. Looney (2003) Radiation hormesis and the radiological imperative
(http://www.sepp.org/Archive/NewSEPP/Hormesis-Looney.htm)

Decrease in the activity of the earth's crust due do the decay of long-lived radioactive isotopes

Million years ago	Relative decrease in radioactivity			
	U-238	**U-235**	**Th-232**	**K-40**
5000	2.14	128	1.29	14.3
2000	1.35	7.05	1.08	2.82
present	~1	~1	~1	~1

Simplified from L.A. Pertsov, The Natural Radioactivity of the Biosphere,
Israel Program for Scientific Translations, Jerusalem, 1967

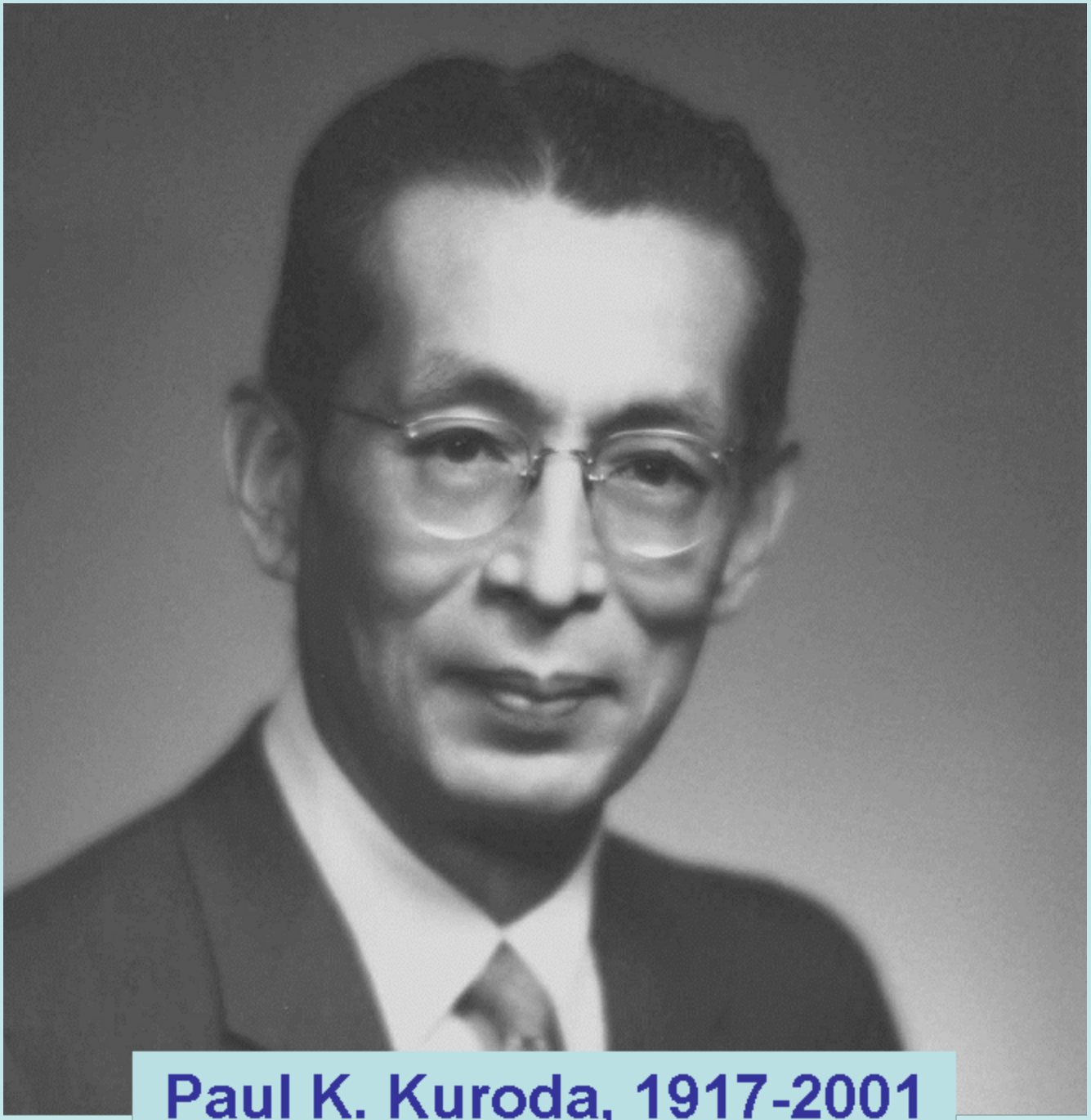


T.D. LUCKEY, 1982

Radiation and Life

- Life evolved in a radiation field ("vitamin-R") that was much more intense than today:
  - Higher Concentration of Radioactive Elements
  - Natural Reactors
- Natural background radiation levels on Earth vary by at least two orders of magnitude.

after S. M. J. Mortazavi, 2006, at:
http://www.ecolo.org/documents/documents_in_english/ramsarMORTAZAVI-HLR-06.ppt



Paul K. Kuroda, 1917-2001

Paul Kazuo Kuroda
1917-2001

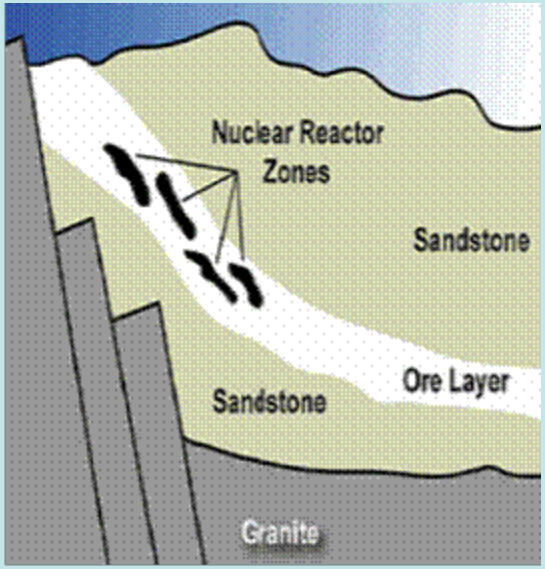
- Was inspired by Francis W. Aston lecture on mass spectra and isotopes 1936 and Niels Bohr's lectures at Tokyo University 1937
- Emigrated from Japan 1949; became US citizen 1955
- Taught chemistry, U. of AR 1952-1987
- Published theory of Pre-Fermi natural reactor in *Journal of Chemical Physics*, v. 25. p. 781 (1956) (Oklo discovery 1972)

"99 out of 100 graduate students are neither smart enough nor truly motivated to become good scientists. I clearly belonged to that group."


Nigeria
CAMEROON
Gulf of
Guinea
EQUITORIAL
GUINEA
LIBREVILLE
Gabon
CONGO
Lambaréné
Oklo
ATLANTIC
OCEAN
ANGOLA

Oklo Nuclear Geysers (16 individual reactors)

- Operated 1.8 billion years ago,
  - for >150 000 years,
  - in 30-min pulses with 2.5 hr dormant periods,
  - consuming >5t U.
- **Prove nuclear fission is natural.**
- **Suggest other natural reactors waiting to be found.**



Natural Uranium in Groundwater

- Can vary considerably from place to place depending on local mineralization, hydrology and geochemistry
- Although typically a few micrograms / liter (a few pCi / liter), U has been measured in public drinking water sources 10 -100 + greater than this
- No permanent health effects have been observed in populations drinking water for generations with these high natural levels

Sources:(1) *Assessing Potential Risks from Exposure to Natural Uranium in Well Water. Hakonson-Hayes A.C, P.R.* Fresqueza,, F.W. Whicker, Journal of Environmental Radioactivity, 59 (2002)
(2) *Public Health Goal for Uranium in Drinking Water.* Office of Environmental Health Hazard Assessment California Environmental Protection Agency, 1997 (3) U.S. Dept. of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry. *Toxicological Profile for Uranium. 1999.*

SENES Consultants

SHB, Inc.

http://www.nma.org/pdf/urw/brown.pdf

"Normal" or average v. highest known natural background radiation on Earth

"normal"	Ramsar
Radium in groundwater (Bq/l)	
<10	~500
Radium in soil, rock, food (Bq/g)	
<0.5	~350
Radon inside homes (Bq/l)	
<0.5	>4
Population dose (mSv/yr)	
2-3	20-250

"no consistent detrimental effect has been detected so far"

http://www.ecolo.org/documents/documents_in_english/RamsarHLNRAPaper.doc

Source:
The Very High Background Radiation Areas of Ramsar, Iran: Geology, Radiobiology, and Policy
Andrew Karam, Ph.D., CHP
University of Rochester
Presented to NO CHPS, Radiation Safety Without Borders
November 12, 2002

Background Radiation and EPA and NRC Regulations

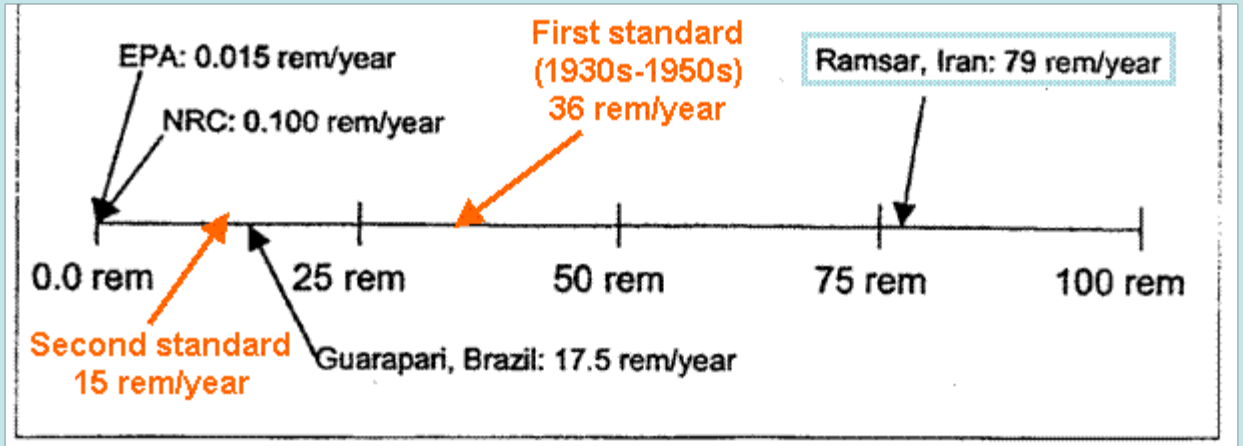


Fig. 2. Scale comparing EPA and NRC regulatory limits to natural background radiation environments (100 rem = 1 sievert; 100 rad = 1 gray)

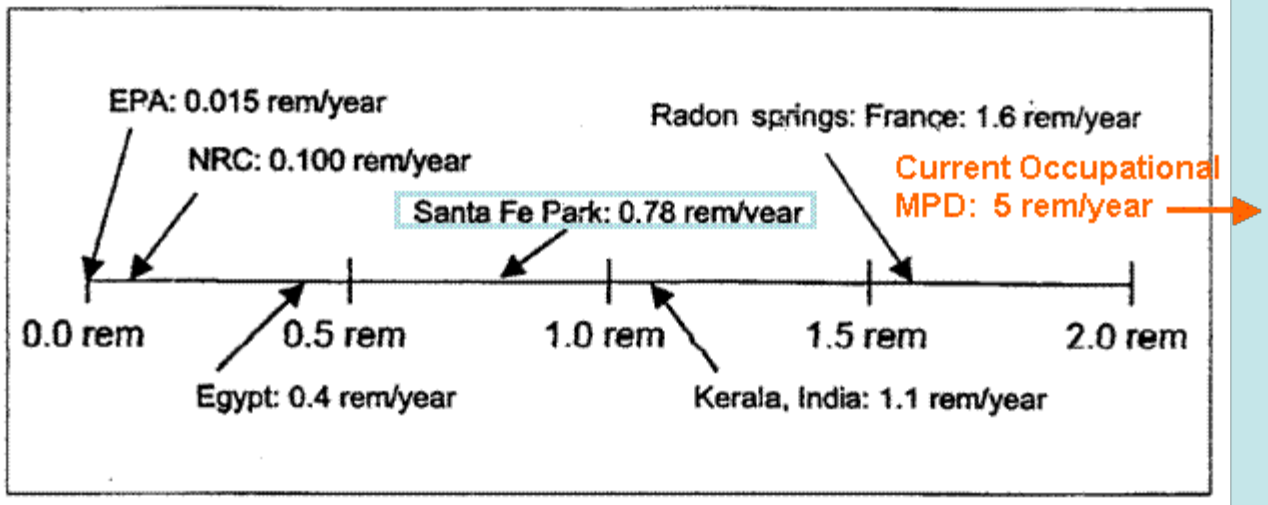
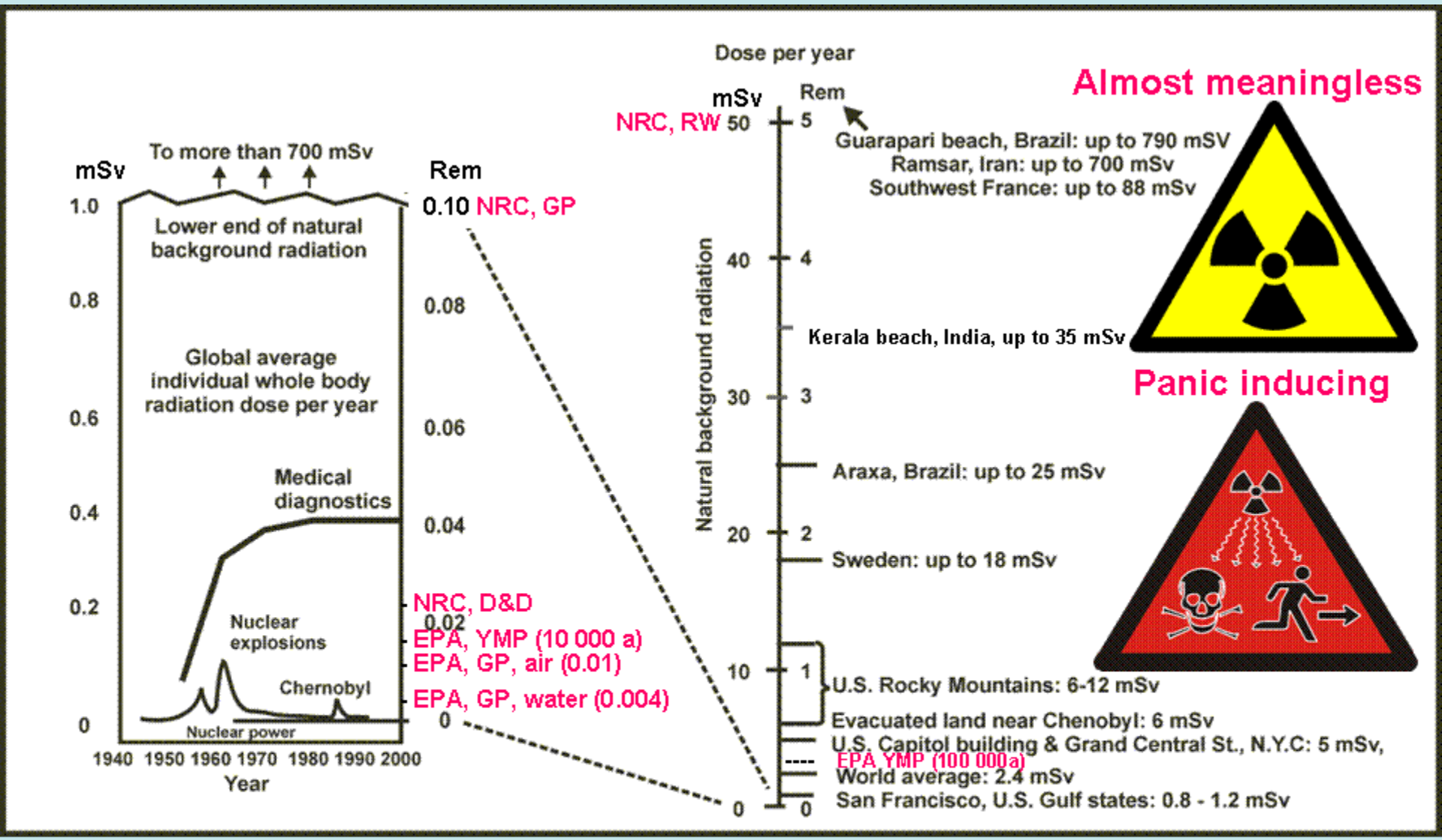


Fig. 3. Expanded scale comparing EPA and NRC regulatory limits to natural background radiation environments (100 rem = 1 sievert; 100 rad = 1 gray)

From Mark M. Hart, "Disabling the terror of radiological dispersal," *Nuclear News* July 2003



Modified from a
Figure prepared by Ted Rockwell from data found in "Radiation Risk and Ethics", Z. Jaworoski, published in Physics Today, American Institute of Physics, September, 1999 and "Ionizing Radiation and Radioactivity in the 20th Century", Z. Jaworoski, presented at the International Conference on Radiation and its Role in Diagnosis and Treatment", Tehran, Iran October, 2000.

http://www.cns-snc.ca/media/uploads/branch_data/branches/Toronto/radiation/natural_and_human_radiation.html
http://hps.org/publicinformation/ate/faqs/regdoselimits.html
http://dspace.mit.edu/bitstream/handle/1721.1/41588/213482682.pdf?sequence=1

Insistence on, and
cadaverous compliance with,
regulations without continuously
questioning and justifying
their factual and rational basis

is the last refuge of
the lazy, incompetent, and
malevolent

General Caution

1. Presentations are open to misinterpretation without (or likely even with) the presenter's interaction with his audience.
2. Data, ideas, and conclusions that are extracted may be in error outside the original context or intent.
3. The presenter or provider of this material is not liable for inappropriate or erroneous use of the material or its consequences.
4. None of the material should be assumed to be be original.

Special Note

Norbert T. Rempe prepared this presentation as a private individual, not for profit. This work was *NOT* sponsored by any private organization or government agency.

Power Generation (heat loss) from Earth's Interior

	TW
Total	**31-44**
U+Th	20
K-40	4

(M. Ragheb, Terrestrial Radioactivity and Geothermal Energy, 2011)

Heat is the geological lifeblood of a planet

Rocks and metals, in reality, are truly the lifeblood of the planet Earth.

http://isaacmmcphee.suite101.com/the-production-of-heavy-elements-a48473#ixzz1lr6iMLHj

When we compute the total amount of energy generated by ^{232}Th, ^{238}U, and ^{40}K, we find that the total, global, energy production is 3.8×10^{13} Watts, or 38,000,000,000,000 Watts, or 38 trillion Watts!

http://geophysics.ou.edu/geomechanics/notes/heatflow/global_heat_flow.htm

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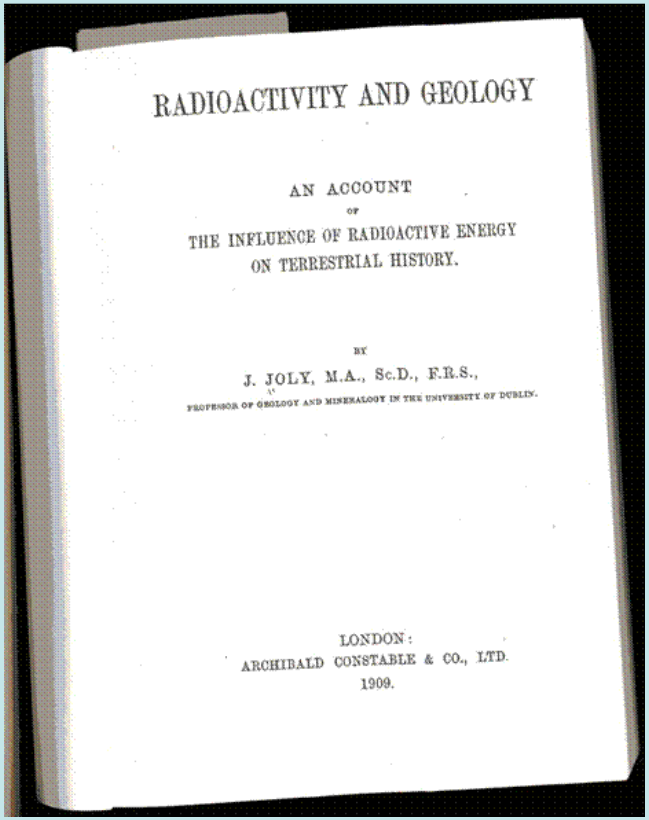
1909 1928 1954 1985

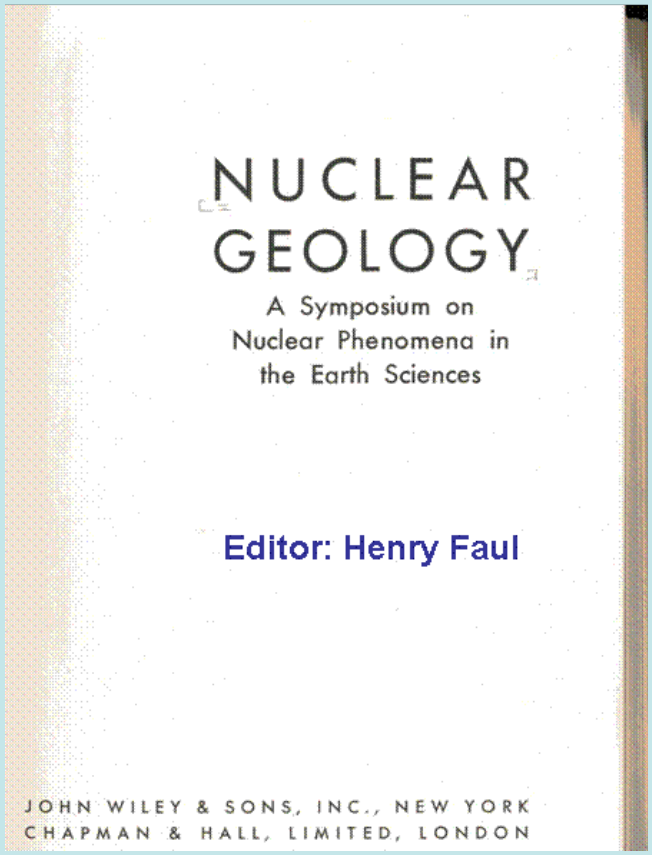


RADIOACTIVITY AND GEOLOGY

AN ACCOUNT
OF
THE INFLUENCE OF RADIOACTIVE ENERGY
ON TERRESTRIAL HISTORY.

BY
J. JOLY, M.A., Sc.D., F.R.S.,
PROFESSOR OF GEOLOGY AND MINERALOGY IN THE UNIVERSITY OF DUBLIN.

LONDON:
ARCHIBALD CONSTABLE & CO., LTD.
1909.

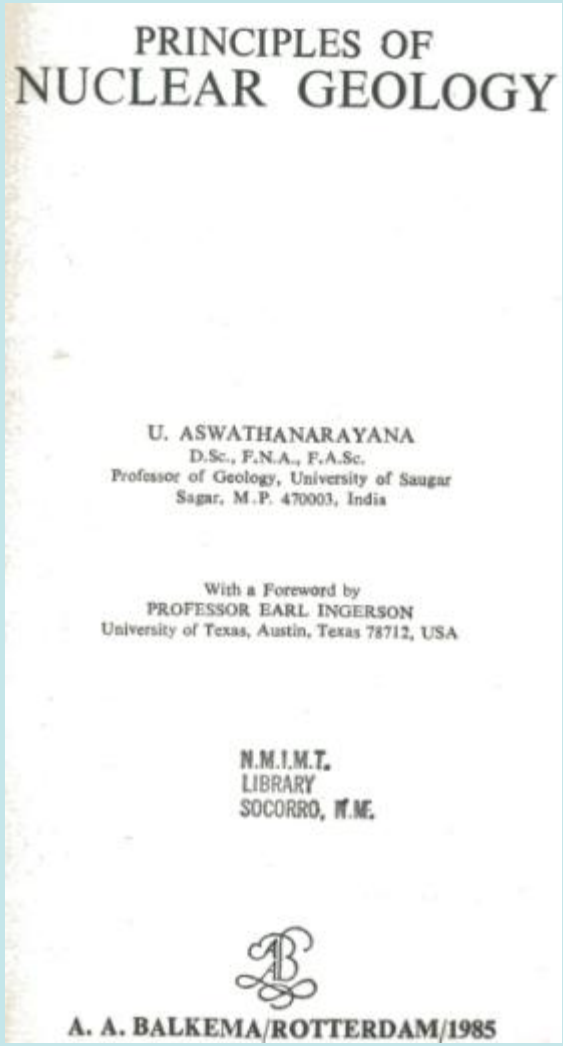


NUCLEAR GEOLOGY

A Symposium on
Nuclear Phenomena in
the Earth Sciences

Editor: Henry Faul

JOHN WILEY & SONS, INC., NEW YORK
CHAPMAN & HALL, LIMITED, LONDON



PRINCIPLES OF
NUCLEAR GEOLOGY

U. ASWATHANARAYANA
D.Sc., F.N.A., F.A.Sc.
Professor of Geology, University of Saugar
Sagar, M.P. 470003, India

With a Foreword by
PROFESSOR EARL INGERSON
University of Texas, Austin, Texas 78712, USA

A. A. BALKEMA/ROTTERDAM/1985

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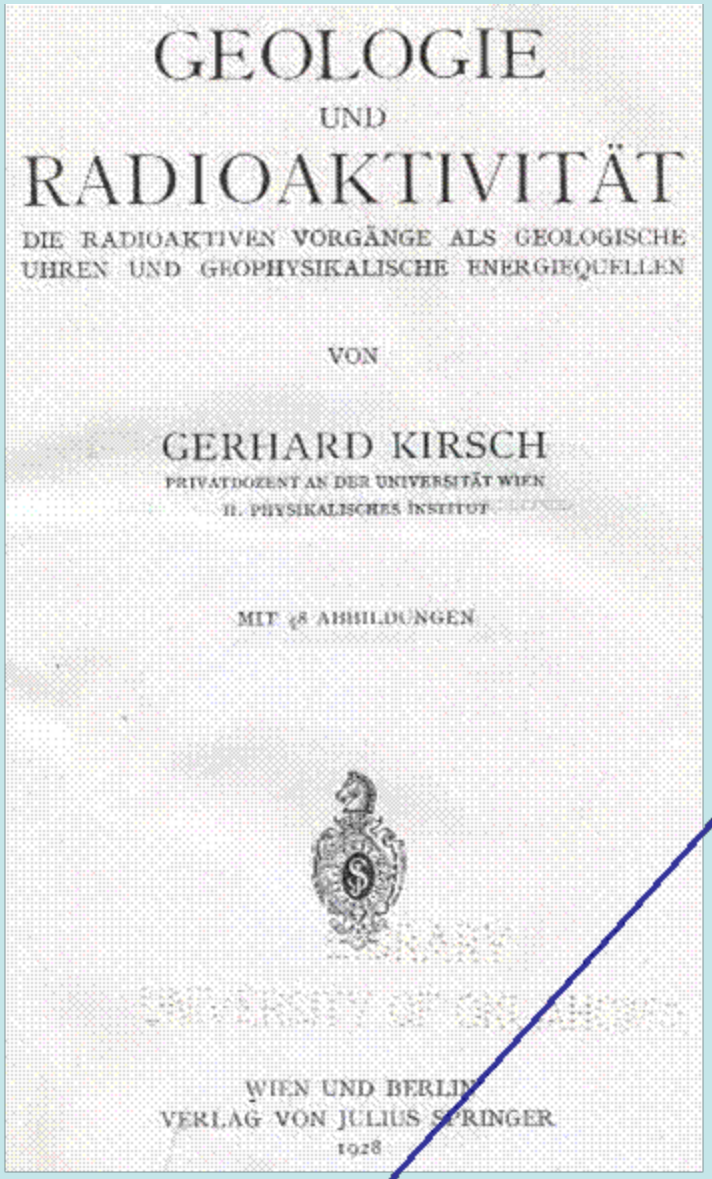
1928



GEOLOGIE
UND
RADIOAKTIVITÄT

DIE RADIOAKTIVEN VORGÄNGE ALS GEOLOGISCHE UHREN UND GEOPHYSIKALISCHE ENERGIEQUELLEN

VON

GERHARD KIRSCH

PRIVATDOZENT AN DER UNIVERSITÄT WIEN
II. PHYSIKALISCHES INSTITUT

MIT 48 ABBILDUNGEN

WIEN UND BERLIN
VERLAG VON JULIUS SPRINGER
1928

"…theories - (that are) the youngest **children of the marriage between geology and radioactivity** …"

from the foreword:

…für die im zweiten Abschnitt dargestellten Theorien ermöglicht werde. Diese letzteren als die jüngsten Kinder aus der Ehe zwischen Geologie und Radioaktivität weisen naturgemäß mehr Hypothetisches auf als die radioaktiven Altersbestimmungsmethoden. Wir haben daher den

Never in Earth history has any part of Earth's surface been void of radioactive isotopes or not exposed to ionizing radiation

Paraphrased from L.A. Pertsov, The natural radioactivity of the biosphere, Israel Program for Scientific Translations, Jerusalem, 1967

Without radioactivity in the Earth, it would have no magnetic field generated by its rotating molten iron and nickel outer core.

It would thus not be protected from the solar winds, like the moon, and our form of life would not exist on its surface.

Geothermal energy: All the benefits of nuclear - but none of the problems

The Guardian, 18 January 2011, guardian.co.uk

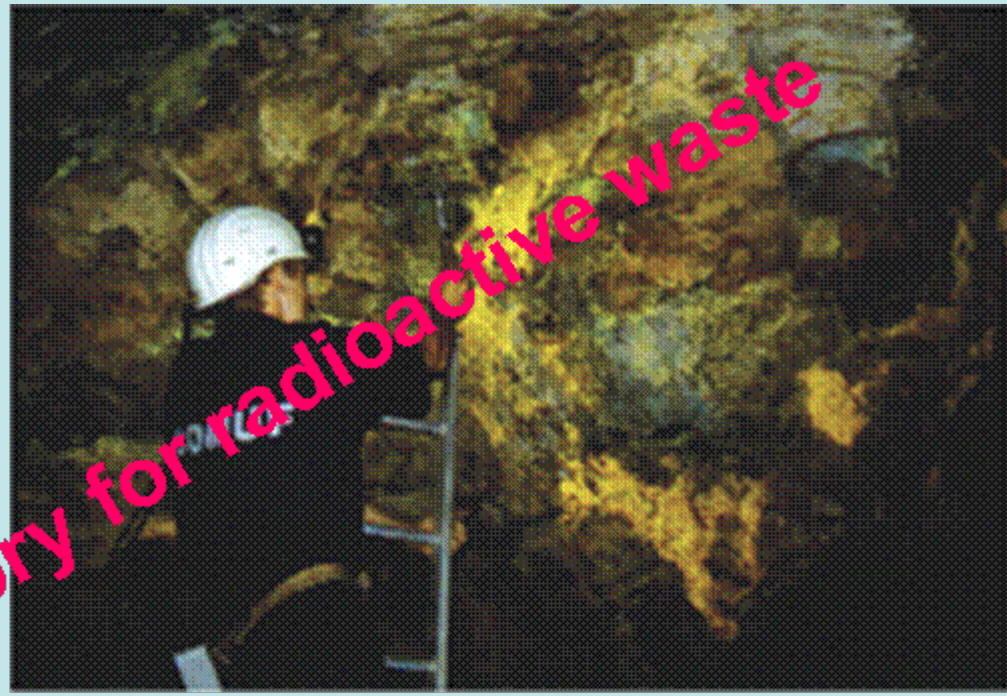
Natural Radioactivity by the Square Mile, 1 Foot Deep

Total volume: 7.894 x 10^5 m^3. Activity levels vary greatly depending on soil type, mineral make-up, and density (~1.58 g/cm^3 is the basis of this calculation).

Nuclide	Activity used in calculation	Nuclide mass	Activity found in soil volume
U	0.7 pCi/g (25 Bq/kg)	2,200 kg	0.8 curies (31 GBq)
Th	1.1 pCi/g (40 Bq/kg)	12,000 kg	1.4 curies (52 GBq)
K 40	11 pCi/g (400 Bq/kg)	2000 kg	13 curies (500 GBq)
Ra	1.3 pCi/g (48 Bq/kg)	1.7 g	1.7 curies (63 GBq)
Rn	0.17 pCi/g (10 kBq/m^3) soil	11 µg	0.2 curies (7.4 GBq)
		Total:	>17 curies (>653 GBq)

http://www.physics.isu.edu/radinf/natural.htm


NUCLEAR CHEMISTRY
In the 1950s, Professor Paul Kuroda of the University of Arkansas' Department of Chemistry predicted that self-sustaining nuclear chain reactions could have occurred naturally in earth's geologic history. In 1972, his prediction was confirmed when scientists discovered a natural nuclear reactor in Gabon, Africa. In 1960, he predicted the existence of Plutonium-244 as an element present during the solar system's formation. Confirmation of his theory enabled scientists to more accurately date the sequence of events in the solar system's early history. Kuroda's two papers on these topics were featured in "The 20th Century's 85 Benchmark Papers in Nuclear Chemistry," edited by Nobel laureate Glenn Seaborg.
Arkansas Alumni Association



earliest known repository for radioactive waste

pre-Fermi (*natural*) reactors

Oklo

Gabon

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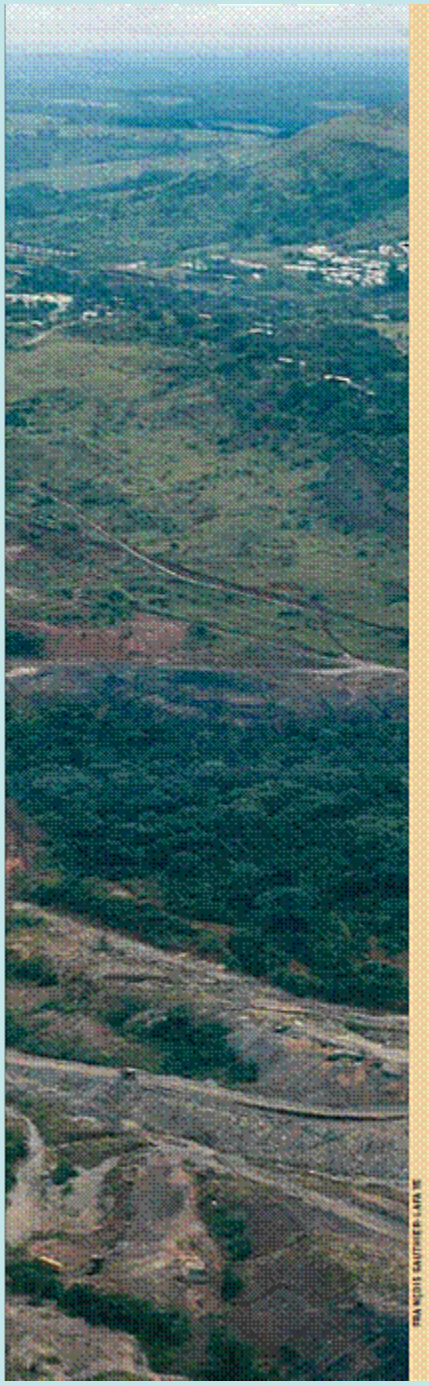
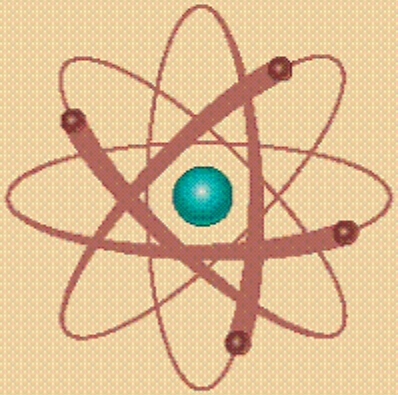
November 2005



THE WORKINGS OF AN

ANCIENT NUCLEAR REACTOR

•BY ALEX P. MESHIK•



Two billion years ago parts of an African uranium deposit spontaneously underwent nuclear fission. The details of this remarkable phenomenon are just now becoming clear

Enrico Fermi

(1901-1954)

Fermi built the first reactor.
Which was an important factor

Running things efficiently,
With atomic energy.

For more information on this physicist, visit: physicscentral.com/coloringbook

URBAN LEGEND

- Oklo is a worst-case analogue:
  - Rocks were jointed and fractured
  - Permeabilities waxed and waned
  - The ore went critical, enduring fission and high temperatures
  - Confinement remained effective without engineered barriers or carefully designed waste forms
  - Fission products were available for migration for billions of years
- Conclusion: geologic repositories did, do, and will confine radionuclides

  (even without human assistance or Yankee ingenuity)

Underground operations at IMC potash mine, Carlsbad

(http://www.laradioactivite.com/en/site/illustration/images/DecayPotassium40_En.htm)

Romantics might like to think of themselves as being composed of stardust.

Cynics might prefer to think of themselves as nuclear waste.

Simon Singh, Big Bang: The Origin of the Universe, p. 389 (Fourth Estate 2004)