

**Prof Ray Cartwright**, former member of  
NRPB radon group and AGIR

DNE LLC meeting 1980s

“There is absolutely no point  
in looking at artificial sources  
until we have sorted out the  
natural sources because  
they account for 90+% of the  
alpha activity.”

# U238 decay series (a)

nuclide	1/2 life	nf	air	atoms	lung alpha	
			conc	per	activity Bq	
			Bq/m3	litre	ns	s
U238	4E9 yrs	P	E-6	ca.1E8	0.01.	??
Th234	24 days	P	equilib		equilib	
Pa234	1 min	P	equilib		equilib	
U234	2E5 yrs	P	equilib		equilib	
Th230	8E4 yrs	P	equilib		equilib	
Ra226	1600 yrs	P	equilib		equilib	
Rn222	4 days	A	20	10000	ca.0.1	
Po218	3 min	A		ca.3	total of about 10	total of about 10
Pb214	27 min	A	10...20	ca.25		
Bi214	20 min	A		ca.20		
Po214	E-4 secs	A		<1		
Pb210	22 yrs	A/P	ca.1E-3	100	0.02-0.1	0.2-0.4
Bi210	5 days	A/P				
Po210	140days	A/P	ca.2E-4	0.2	ca. 0.1	ca. 0.4
Pb206	stable					
Pu239	2.4E5 yrs	P	<ca.E-6		0.01	??

nf natural form .....type of source that occurs in our environment without human intervention (includes trichomes)  
 unf unnatural form..... type of source that **only** occurs in our environment with human intervention  
 P particulate.....many unstable atoms in a single source  
 A atomic .....no more than one unstable atom in a single source  
 F.....equilibrium factor between radon and its short lived daughters (=actual pae/equilib pae)  
 s/ns.....smoker/non smoker  
 E3/E-2 etc.....10x10x10/0.1x0.1x0.1  
 Radon decay products attach to condensation nuclei. There are typically 1E7-E8 cn per litre i\_e ca.1dp atom/E7cn@20 Bq/m3

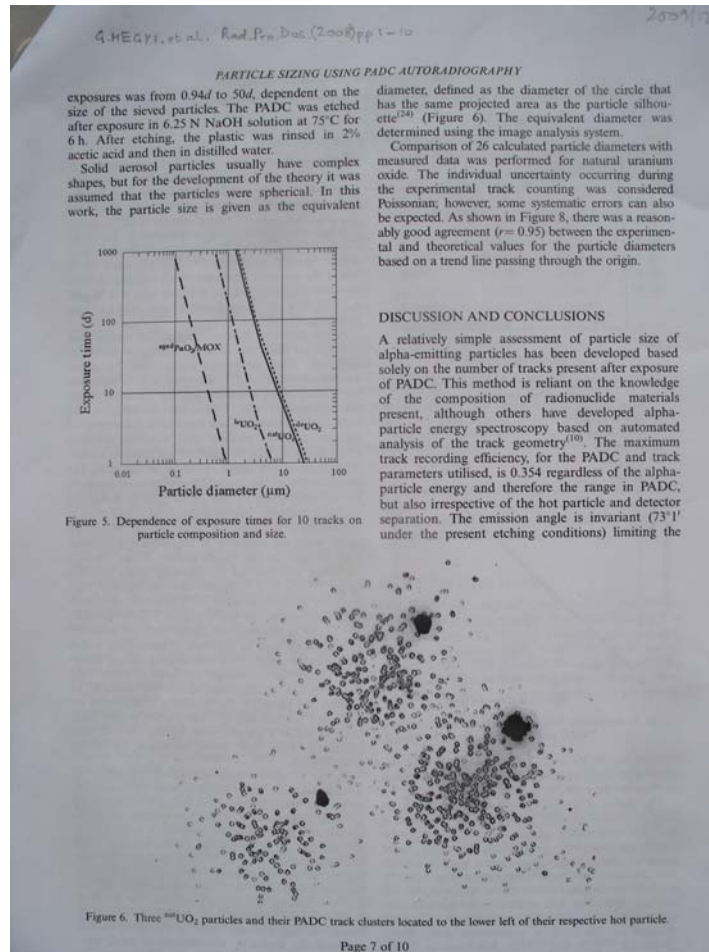
# U238 decay series (b)

nuclide	1/2 life	nf	air	atoms	lung alpha		pot.alphas/day		quotes	photos	refs/notes
			conc	per	activity Bq	respirable P	nf	unf			
			Bq/m3	litre	ns	s	nf	unf			
U238	4E9 yrs	P	E-6	ca.1E8	0.01.	??	<2	leU>100		Hegy 2008	D(1)H,I(15) K(12)
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Rn222	4 days	A	20	10000	ca.0.1		n/a		Morken D		E(15),J(8)
Po218	3 min	A		ca.3	total of about 10	total of about 10	n/a	0..>1000		Chamie,	
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Pu239	2.4E5 yrs	P	<ca.E-6		0.01	??		0..>1000			D(4)F(7,2) Rn'sG6 uncle!
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# Questions

- (1) What causes this unnatural irradiation?
- $^{235}\text{U}$ ,
- $^{238}\text{U}$ ,
- Daughter aggregates,
- Fallout, accidents,  $^{210}\text{Po}$
- (2) What are its consequences?

# uranium particles



# U238 decay series (b)

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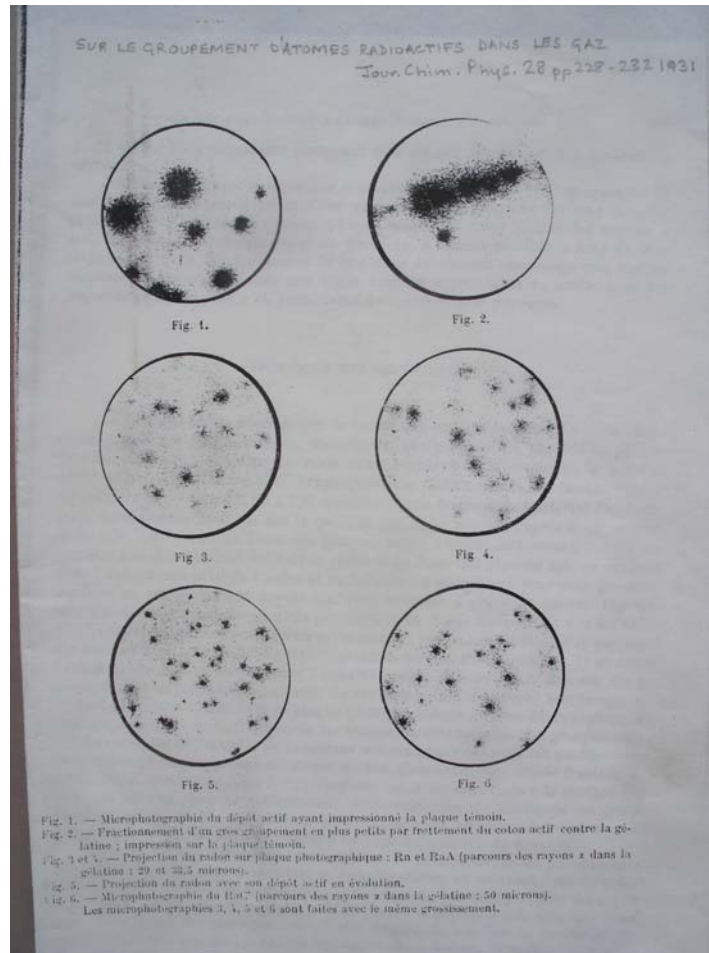
# radium

- **Kodak Phys Rev 76 no3 1949**
- “Preceding the time of appearance of the above-mentioned contaminants and during the war, a great deal of the cardboard in this country became contaminated with radioactive materials as a result of the paper salvage program. Paper and cardboard salvaged from war plants where radium dials were prepared became mixed with paper stocks and as a result, specks of radioactive material could be found sporadically distributed in almost any sort of packaging paper.”

# U238 decay series (b)

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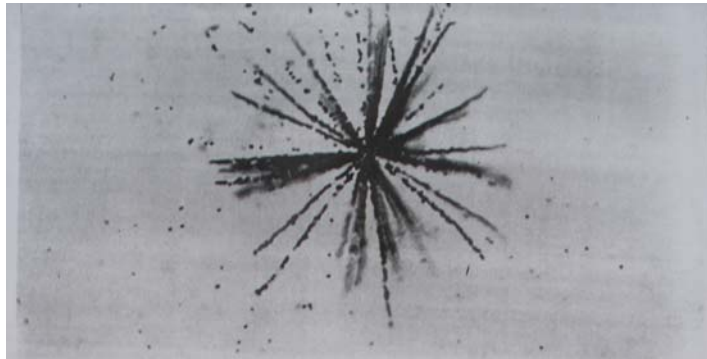
# Daughter aggregates



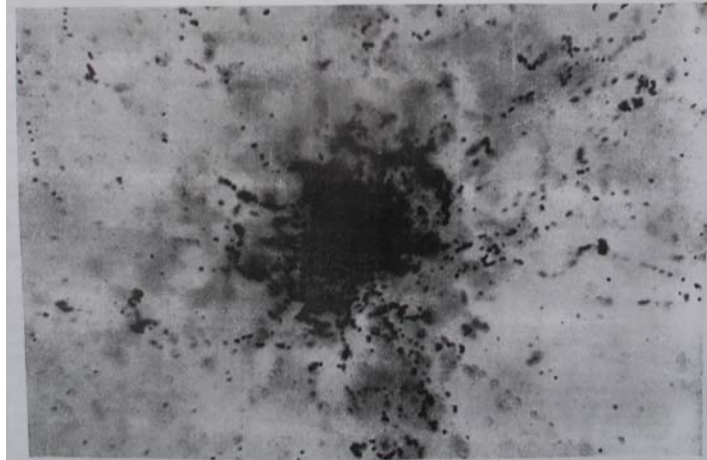
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**Po 210 puzzle (Sci. Am. 1959): “Natural radioactivity in the atmosphere is shown by this nuclear emulsion photograph of tracks enlarged 2000 diameters emitted by a grain of dust. The tracks are produced by alpha particles; their length identifies the dust as polonium a decay product of uranium238.”**



NATURAL RADIOACTIVITY in the atmosphere is shown by this nuclear emulsion photograph of tracks (enlarged 2,000 diameters) emitted by a grain of dust. The tracks are produced by alpha particles; their length identifies the dust as polonium, a decay product of uranium 238. The photographs on this page were made by Herman Yagoda of the Air Force Cambridge Research Center.



MAN-MADE RADIOACTIVITY in the atmosphere produced this second nuclear-emulsion photograph. The irregular traversy surrounding the dust particle is produced by beta particles. The character of these emissions identifies the substance as a fission product formed in a nuclear explosion, but poor definition makes precise identification impossible. The enlargement here is 1,200 diameters.

# Po210 puzzle continued

- Prof D Henshaw (personal crsp) response to my query about Sept1959 Sci. Am. photograph :  
“Certainly Po210 does not exist naturally in cluster form”

# consequences 1

- Cancers but:
- ... The conventional argument is that the more homogeneous the alpha irradiation the greater the cancer risk, because more cells are hit and fewer are killed. Numerous (top down ie fragmentation, or altered specific activity, of particulates) experiments supporting this view have been published: (Fritsch P et al Rad Pro Dos 105/1-4 pp149-152 2003),
- hence the belief that: for a given dose, exposure to radon, since it results in the most homogeneous alpha irradiation possible, must be the most carcinogenic type of alpha exposure. This belief, combined with the **fact** that 90%+ of the alpha irradiation we receive is from natural sources, underlies the prevalent assumption that nearly all radiation induced cancers must be due to natural irradiation....and, I suspect, Prof Cartwright's views, viz: "There is absolutely no point in looking at artificial sources until we have sorted out the natural sources because they account for 90+% of the alpha activity".



# Conclusions

- Equal doses of natural and unnatural irradiation liable to differ in their effects
- Activity a necessary, but not sufficient, parameter for assessing effects
- Need 'bottom up' experiments to test this
- Monitoring should be directed accordingly
- There is every point in looking at the artificial sources before we have sorted out the natural ones!



