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Nevada Test Site Fallout Atom Ratios: $^{240}Pu/^{239}Pu$ and $^{241}Pu/^{239}Pu$

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NEVADA TEST SITE FALLOUT ATOM RATIOS:

$^{240}Pu/^{239}Pu$ and $^{241}Pu/^{239}Pu$

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The exposure of the population in Utah to external gamma radiation from the fallout from nuclear weapons tests carried out between 1951 and 1958 at the Nevada Test Site (NTS) has been reconstructed from recent measurements of ^{137}Cs and plutonium in soil.[1] The fraction of ^{137}Cs in the fallout from NTS events was calculated from the total plutonium and the $^{240}Pu/^{239}Pu$ ratios measured in the soil, using the values of 0.180 ± 0.006 and 0.032 ± 0.003 for that ratio in global fallout and NTS fallout, respectively. The total population exposure from NTS events was then calculated on the basis of exposure rates resulting from short-lived radionuclides associated with the ^{137}Cs at the time of deposition.[2]

While the $^{240}Pu/^{239}Pu$ ratio is constant in global fallout, this ratio varies greatly in the fallout from individual events. While the composition of fallout on Utah from NTS events is rather uniform, the Off-Site Radiation Exposure Review Project is currently reconstructing radiation exposures for locations close to NTS where the fallout may be predominantly from one event. Therefore, the authors compiled the pertinent ratios in order to provide information concerning the exposure resulting from any individual event.

The plutonium ratios measured at 30 days postshot, shown in Table 1, were compiled from unpublished values in the archives of the Nuclear Chemistry Division of LLNL and INC-11 of LANL. These ratios are pertinent to fallout data. Dates for each event were taken from a publication by the Nevada Operations Office of the Department of Energy.[3]

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TABLE 1. Some NTS Fallout Plutonium Atom Ratios
30 Days Postshot

Event	Date	Ratio $\frac{^{240}Pu}{^{239}Pu}$	Ratio $\frac{^{241}Pu}{^{239}Pu}$
OPERATION RANGER			
Able	1/27/51	4.2×10^{-4}	-
Baker	1/28/51	0.0267	6.2×10^{-4}
Easy	2/1/51	0.0179	3.8×10^{-4}
Baker-2	2/2/51	0.0256	5.0×10^{-4}
Fox	2/6/51	0.0261	5.4×10^{-4}
OPERATION BUSTER-JANGLE			
Baker	10/28/51	0.0326	0.0011
Charlie	10/30/51	0.0283	0.0010
Dog	11/1/51	0.0282	0.0010
Easy	11/5/51	0.0355	0.0011
Sugar	11/19/51	0.0010	-
Uncle	11/29/51	9.7×10^{-4}	-
OPERATION TUMBLER-SNAPPER			
Able	4/1/52	6.9×10^{-4}	-
Baker	4/15/52	7.2×10^{-4}	-
Charlie	4/22/52	0.0506	0.0028
Dog	5/1/52	0.0346	0.0012
Easy	5/7/52	0.0236	5.4×10^{-4}
Fox	5/25/52	0.0236	5.9×10^{-4}
George	6/1/52	0.0257	0.0015
How	6/5/52	0.0271	5.0×10^{-4}
OPERATION UPSHOT-KNOTHOLE			
Annie	3/17/53	0.0246	0.0010
Nancy	3/24/53	0.0283	0.0012
Ruth	3/31/53	1.5×10^{-4}	-
Dixie	4/6/53	0.0217	5.5×10^{-4}
Ray	4/11/53	1.8×10^{-4}	-
Badger	4/18/53	0.0342	0.0011
Simon	4/25/53	0.0267	6.2×10^{-4}
Encore	5/8/53	0.0517	0.0028
Harry	5/19/53	0.0375	0.0018
Grable	5/25/53	9.7×10^{-4}	-
Climax	6/4/53	0.0342	9.0×10^{-4}
OPERATION TEAPOT			
Wasp	2/18/55	0.0533	0.0036
Moth	2/22/55	0.0778	0.0065
Tesla	3/1/55	0.0189	3.1×10^{-4}
Turk	3/7/55	0.0326	8.0×10^{-4}
Hornet	3/12/55	0.0577	0.0036
Bee	3/22/55	0.0853	0.0071
Ess	3/23/55	-	-
Apple I	3/29/55	0.0245	5.5×10^{-4}
Wasp Prime	3/29/55	0.0522	0.0034
HA	4/6/55	0.0510	0.0033
Post	4/9/55	0.0194	5.0×10^{-4}
Met	4/15/55	0.0068	1.4×10^{-4}
Apple II	5/5/55	0.0313	8.0×10^{-4}
Zucchini	5/15/55	0.0319	8.1×10^{-4}
OPERATION PLUMBOB			
Boltzmann	5/28/57	0.0787	0.0060
Franklin	6/2/57	2.1×10^{-4}	-
Wilson	6/18/57	0.0818	0.0065
Priscilla	6/24/57	0.0108	-
Hood	7/5/57	0.0673	-
Diablo	7/15/57	0.0624	-
John	7/19/57	0.0591	0.0048
Kepler	7/24/57	0.0722	0.0054
Owens	7/25/57	0.0702	0.0047
Pascal A	7/26/57	0.0761	-
Stokes	8/7/57	0.0074	-
Shasta	8/18/57	0.0571	-
Doppler	8/23/57	0.0700	0.0046
Franklin Prime	8/30/57	0.0029	-
Smoky	8/31/57	0.0058	-
Galileo	9/2/57	0.0753	0.0060
Wheeler	9/6/57	0.0376	-
Coulomb B	9/6/57	-	-
Laplace	9/8/57	2.4×10^{-4}	-
Fizeau	9/14/57	0.0630	0.0040
Newton	9/16/57	0.0716	0.0058
Whitney	9/23/57	0.0734	-
Charleston	9/28/57	0.0735	-
Morgan	10/7/57	0.0773	0.0063
Coulomb C	12/9/57	-	-

- No analytical data available.

TABLE 1. Some NTS Fallout Plutonium Atom Ratios (Cont.)

Event	Date	Ratio $\frac{^{240}Pu}{^{239}Pu}$	Ratio $\frac{^{241}Pu}{^{239}Pu}$
OPERATION HARDTACK II			
Otero	9/12/58	0.0521	0.0035
Eddy	9/19/58	0.0503	0.0038
Mora	9/29/58	0.0544	0.0040
Hidalgo	10/5/58	-	-
Quay	10/10/58	0.0541	0.0041
Lea	10/13/58	0.0542	0.0038
Hamilton	10/15/58	0.0537	0.0042
Dona Ana	10/16/58	0.0530	0.0038
Vesta	10/17/58	-	-
Rio Arriba	10/18/58	-	-
Socorro	10/22/58	0.0568	0.0045
Wrangell	10/22/58	0.0513	0.0037
Rushmore	10/22/58	0.0519	-
Catron	10/24/58	0.0487	0.0041
Sanford	10/26/58	-	-
DeBaca	10/26/58	0.0637	0.0049
Chavez	10/27/58	0.0500	0.0037
Humboldt	10/29/58	0.0518	-
Titania	10/30/58	-	-
Santa Fe	10/30/58	0.0538	0.0037

Event	Date	Ratio $\frac{^{240}Pu}{^{239}Pu}$	Ratio $\frac{^{241}Pu}{^{239}Pu}$
OPERATIONS NOUGAT THROUGH BOWLINE			
Danny Boy	7/5/62	0.0682	0.0072
Sedan	7/6/62	0.0625	-
Johnny Boy	7/11/62	4.3×10^{-4}	-
Small Boy	7/14/62	0.0650	0.0056
Little Feller I	7/17/62	0.0660	0.0053
Sulky	12/18/64	-	-
Palanquin	4/14/65	0.0651	0.0061
Cabriolet	1/26/68	0.0628	-
Buggy	3/12/68	0.0649	-
Schooner	12/8/68	0.0656	0.0049

REFERENCES

1. H. L. Beck and P. W. Krey, "Radiation Exposure in Utah from Nevada Nuclear Tests," Science, 220, 18-24 (1983).

2. H. G. Hicks, "Results of Calculations of External Gamma Radiation Exposure Rates from Fallout and the Related Radionuclide Compositions," Lawrence Livermore National Laboratory, Livermore, CA, UCRL-53152 (1981), Pts. 1-8.

   Part 1 - Operation Ranger, 1951
   Part 2 - Operation Buster-Jangle, 1951
   Part 3 - Operation Tumbler-Snapper, 1952
   Part 4 - Operation Upshot-Knothole, 1953
   Part 5 - Operation Teapot, 1955
   Part 6 - Operation Plumbob, 1957
   Part 7 - Operation Hardtack II, 1958
   Part 8 - Operations Nougat through Bowline, 1962-1968

3. "Announced United States Nuclear Tests," July 1945 through December 1982, Nevada Operations Office, Mercury, NV, NVO-209 (Rev. 3).