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

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NEVADA TEST SITE FALLOUT ATOM RATIOS:

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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 $^{240}\text{Pu}/^{239}\text{Pu}$ 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 $^{240}\text{Pu}/^{239}\text{Pu}$ 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The plutonium ratios measured at 30 days postshot, shown in Table 1, were compiled from unpublished values in the archives of the Nuclear Chemistry Division of LLNL and INC-11 of LANL.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

This work was funded by the Off-Site Radiation Exposure Review Project.

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

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

- No analytical data available.

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

Event	Date	Ratio		Event	Date	Ratio	
		$\frac{240\text{Pu}}{239\text{Pu}}$	$\frac{241\text{Pu}}{239\text{Pu}}$			$\frac{240\text{Pu}}{239\text{Pu}}$	$\frac{241\text{Pu}}{239\text{Pu}}$
OPERATION HARDTACK II				OPERATIONS NOUGAT THROUGH BOWLINE			
Otero	9/12/58	0.0521	0.0035	Danny Boy	7/5/62	0.0682	0.0072
Eddy	9/19/58	0.0503	0.0038	Sedan	7/6/62	0.0625	-
Mora	9/29/58	0.0544	0.0040	Johnny Boy	7/11/62	4.3×10^{-4}	-
Hidalgo	10/5/58	-	-	Small Boy	7/14/62	0.0650	0.0056
Quay	10/10/58	0.0541	0.0041	Little Feller I	7/17/62	0.0660	0.0053
Lea	10/13/58	0.0542	0.0038	Sulky	12/18/64	-	-
Hamilton	10/15/58	0.0537	0.0042	Palanquin	4/14/65	0.0651	0.0061
Dona Ana	10/16/58	0.0530	0.0038	Cabriolet	1/26/68	0.0628	-
Vesta	10/17/58	-	-	Buggy	3/12/68	0.0649	-
Rio Arriba	10/18/58	-	-	Schooner	12/8/68	0.0656	0.0049
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				

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).

TABLE 1. SOME NTS FALLOUT PATTERNS IN ATOM BOMBING