fusa was not visibly effected by conditions in either treatment. Overgrowth by *Z. parishi* continued in the treatment without UV and smothered the *C. diffusa* within 2 months. *Callyspongia diffusa* in the treatment with UV remained healthy.

Photosynthetic reef organisms require light and cannot avoid the associated harmful UV. Corals and other marine photosynthetic plant-animal associations can produce pigments that selectively absorb, reflect, or harmlessly fluoresce UV radiation (*9*). The ability of these animals to shield their contained algae from UV could be important in the success of symbioses on shallow reefs. Certain species of benthic algae are known to contain UV-absorbing substances (*10*), but the overall impact of UV on reef productivity and calcification is unknown.

The dramatic effects observed in this preliminary investigation demonstrate that UV can be an important physical factor on coral reefs. Ultraviolet radiation levels covary with other depth-related environmental parameters. Consequently, effects of UV appear to have been confused with effects of water motion, sedimentation, abrasion, desiccation at low tide, algal competition, predation, or other factors.

Experiments analogous to those discussed in this report have been carried out with very similar results. When rubble is overturned on reef shallows the cryptofauna is quickly destroyed (*4*). This was believed to result solely from predation and sedimentation. Sponges grow more rapidly in situ when shielded by transparent acrylic plastic, but again the effect was attributed to reduced sedimentation rather than reduced UV dosage (*11*). Hawaii (21°N) is near the extreme northern latitudinal limit of reef development. The effects noted in these experiments probably are much more severe on reefs closer to the equator where incident UV is greater. Intensity of UV diminishes with increasing depth, but subtle UV effects can be expected in the deeper portions of the photic zone. Thus UV is a niche dimension that must be carefully evaluated in future research.

PAUL L. JOKIEL
Hawaii Institute of Marine Biology,
Post Office Box 1346,
Kaneohe, Hawaii 96744

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Fallout Plutonium in an Alkaline, Saline Lake

Abstract. *Plutonium isotopes, derived from global fallout following atmospheric testing of nuclear weapons, have been measured in the water and sediments of a natural alkaline, saline lake. The activities of fallout plutonium in the water column are about two orders of magnitude greater than in most freshwater lakes, where these nuclides are found predominantly in the sediments.*

Measurements of radionuclides can provide valuable information about many types of chemical, biological, and physical processes in aqueous systems. Such information is useful in helping us to understand the behavior of unperturbed natural waters and in predicting the fate of materials which may reach ground and surface waters as a result of man's activities. Plutonium is relatively reactive in natural waters, and in most lakes, rivers, estuaries, and coastal ocean waters fallout plutonium is found predominantly in association with particles. The most frequently observed value of the apparent distribution coefficient, K_d (*1*), for fallout plutonium in lakes, rivers, estuaries, and coastal waters is ~ 10^5 (*2*), and in a water body such as Lake Michigan about 97 percent of the total activity is found in the sediments.

We have analyzed samples of water and sediment from Mono Lake, a natural closed-basin (*3*) alkaline, saline lake in California, for fallout plutonium isotopes. The concentrations in the water column are about two orders of magnitude greater than usually observed for surface waters and the K_d between sediments and water is ~ 10^3, about two orders of magnitude lower than generally found for surface waters. Our original purpose in measuring the present distribution of fallout plutonium in Mono Lake was to explore the possibility that CO_3^{2-} complexing could be an important factor governing the amount of plutonium in the aqueous phase of natural water systems, as appears to be the case for uranium (*4*). The evidence reported here tends to support such a hypothesis but is not sufficient to prove the importance of CO_3^{2-} complexing of plutonium. Other factors such as the oxidation state of plutonium (*5*) are probably also quite important in controlling the effective solubility of plutonium in natural waters. Laboratory experiments carried out with sediments from a pond contaminated with wastes from the Rocky Flats Plant in Colorado indicate increased mobility of plutonium at high *p*H, but the solution properties regulating the release were not established (*6*). On the basis of our data for Mono Lake and data from other studies, some of which are referred to above, it seems reasonable to suggest that plutonium can be substantially more mobile in natural waters than was generally accepted only a few years ago. This finding has important implications for management policies related to plutonium in surface waters and in the evaluation of alternatives for radionuclide waste isolation (*7*). There is a clear need to improve the general understanding of the factors that control the mobility of plutonium and other radionuclides in natural water systems.

Table 1. Fallout plutonium activity in Mono Lake water. All activities reported are for whole water samples. The activities of ^{239,240}Pu published for Lake Michigan (~0.5 pCi/m^3), Lake Ontario (~0.3 pCi/m^3), Hudson River estuary (~0.3 pCi/m^3), and New York Bight (~0.7 pCi/m^3) are much lower (*2*).

Volume (liters)	^{239,240}Pu (pCi/m^3)	^{238}Pu (pCi/m^3)
80	19.5 ± 0.7	0.9 ± 0.1
80	19.0 ± 0.7	0.7 ± 0.1
160	19.1 ± 0.8	0.8 ± 0.1
240	22.9 ± 1.6	1.3 ± 0.3
240*	≥ (16.4 ± 0.8)	≥ (0.5 ± 0.9)
240*	≥ (11.1 ± 0.7)	≥ (0.5 ± 0.1)

*Data reported represent minimum values only for these samples.

Mono Lake is located in a closed structural depression at the base of the

Table 2. Radionuclide activities in Mono Lake sediments; N.D., not detected.

Depth interval (cm)	Dry weight* (g)	^{239,240}Pu (pCi/kg)	^{238}Pu (pCi/kg)	^{137}Cs (pCi/kg)	^{210}Pb (pCi/g)	Excess† (pCi/g)	^{40}K (pCi/g)
0 to 1	6.4	12.9 ± 1.0	1.4 ± 0.3	132 ± 50	2.0 ± 0.2	1.2 ± 0.2	15.5 ± 1.3
1 to 2	9.0	18.8 ± 1.2	1.6 ± 0.3	275 ± 40	1.8 ± 0.2	1.0 ± 0.2	14.0 ± 1.1
2 to 3	6.7	20.6 ± 1.8	N.D.	260 ± 50	2.1 ± 0.2	1.3 ± 0.3	17.7 ± 1.1
3 to 4	7.1	N.D.	N.D.	16 ± 40	1.4 ± 0.1	0.6 ± 0.2	12.6 ± 1.0
4 to 5	6.5	N.D.	N.D.	60 ± 40	1.1 ± 0.1	0.3 ± 0.2	12.8 ± 1.1
6 to 7					0.8 ± 0.1	0.0 ± 0.2	

*The core diameter was 5 cm (~ 20 cm^3 per centimeter of depth). †Excess indicates ^{210}Pb in addition to that in equilibrium with ^{226}Ra in the sediments.

Sierra Nevada escarpment in eastern California. The lake and its associated sediments overlie a thick sequence of low-density volcanic debris that fills the basin to a depth of ~ 1000 m. Mono Lake is the remnant of a much larger pluvial lake (*8*) and is fed by streams (*9*) draining plutonic and metamorphic terrain in the Sierra Nevada to the west as well as by numerous springs including thermal springs. The lake water is quite saline, having a total concentration of dissolved ions about twice that of seawater. Unlike the ocean and many other saline lakes, the dominant anions balancing the cations in solution are CO_3^{2-} and HCO_3^- rather than Cl^-. The total $[CO_3^{2-}]$ in Mono Lake (~ 0.3 *M*) is about three orders of magnitude greater than in seawater. The $[OH^-]$ in Mono Lake (~ $10^{-4}M$) is about two orders of magnitude greater than that of seawater (~ $10^{-6}M$). The chemical evolution of saline, high alkalinity lakes, of which Mono Lake is reasonably typical, has been studied by a number of investigators (*10*), but the critical processes which govern the development of carbonate lakes still remain somewhat obscure. In general, however, the major source of dissolved ions is believed to be normal weathering products of silicate rocks, which become highly concentrated by evaporation.

Fallout radionuclides derived from the atmospheric testing of nuclear weapons have been distributed over the entire surface of the earth, including the oceans and the soils and surface waters of the continents. The time history and geographical distribution of delivery in precipitation of the long-lived fission products ^{90}Sr (half-life ~ 29 years) and ^{137}Cs (half-life ~ 30 years) are well documented (*11*). The information base for fallout plutonium is considerably less extensive, but the general features of the deposition pattern are certainly well known by analogy with the record for the fission products (*12*). Most of the fallout plutonium reached the earth's surface during the period 1962 through 1965, in the years immediately following the largest atmospheric tests of the United States and the U.S.S.R. prior to the adoption of an atmospheric test ban treaty in 1962.

The amounts of fallout radioactivity derived from weapons testing present in soils and surface waters are comparable to natural radioisotope activities and thus usually require fairly elaborate sample collection and analytical techniques to detect. We used procedures similar to those employed aboard oceanographic vessels (*13*) to extract radionuclides from samples of Mono Lake water. Large volumes (80 to 240 liters) of unfiltered water were pumped into shallow settling tanks and acidified to ~ *p*H 3. Considerable quantities of acid (~ 14 liters of concentrated HCl for a sample volume of 240 liters) were required to overcome the carbonate buffering capacity of the lake water. A solution of $FeCl_3$ and a yield tracer for plutonium extraction (^{242}Pu) were added and allowed to equilibrate with the sample for several hours with frequent stirring to facilitate mixing and degassing of the copious quantitites of CO_2 released upon acidification. Then NH_4OH was added to increase the *p*H to ~ 8, and the flocculated precipitate of $Fe(OH)_3$ that resulted was allowed to settle after stirring. The precipitate, which effectively removes plutonium and a number of other reactive elements from solution, was then returned to the laboratory (*14*). The activities of the plutonium isotopes were measured by alpha spectrometry, after electroplated sources had been prepared by chemical purification procedures similar to those used in a number of laboratories where environmental plutonium measurements are made (*15*). The activities of fallout plutonium in water samples that we collected in May 1978 are reported in Table 1.

The activity of ~ 20 pCi per 1000 liters of ^{239,240}Pu in Mono Lake water (*16*) is about two orders of magnitude greater than the activities we have measured in the Hudson River, Hudson River estuary, and coastal seawaters, and which have been reported for other surface waters (*2*). The activities of ^{239,240}Pu that we measured (~ 20 pCi/kg) in one core of Mono Lake sediments (Table 2) are similar to those reported for the fine-particle sediments of other lakes, rivers, estuaries, and coastal waters (*2, 17*).

A first-order estimate of the total quantity of fallout plutonium in Mono Lake water and sediments can be made and compared with the amount which would be expected from regional fallout delivery patterns. If we use an estimated volume of the lake water of ~ 3 km^3 and a concentration of ^{239,240}Pu of 20 pCi/m^3, the water column contains ~ 60 mCi of these nuclides. If the data in Table 2 for one core are considered representative for the entire lake, then the sediments contain on the order of 30 mCi of ^{239,240}Pu (*18*). The total quantity of ^{239,240}Pu in the water and sediments indicated by these calculations is compatible with a first-order estimate of the amount that would be expected from fallout (80 to 100 mCi) (*19*). The data available for Mono Lake indicate that more than half of the fallout plutonium delivered to the lake surface by precipitation, primarily during the early to middle 1960's, is now found in the water column.

H. J. SIMPSON
R. M. TRIER
C. R. OLSEN
Lamont-Doherty Geological Observatory and Department of Geological Sciences, Columbia University, Palisades, New York 10964
D. E. HAMMOND, A. EGE
L. MILLER
Department of Geological Sciences, University of Southern California, Los Angeles 90007
J. M. MELACK
Department of Biological Sciences, University of California, Santa Barbara 93106

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14. The dispersed Fe(OH)$_3$ precipitate was concentrated by successive decantation of the clear supernatant from a series of containers of decreasing size (400, 80, 20 liters) until a final volume of ~ 2 liters was achieved to allow convenient transportation.
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18. We obtained this esimate by using a concentration of ^{239,240}Pu in Mono Lake sediments of ~ 17 pCi/kg (dry weight), a sediment particle density of 0.4 g/cm^3, a depth of measurable plutonium of 3 cm, and a total lake sediment area of 160 km^2.
19. Fallout delivery of ^{239,240}Pu at Mono Lake can be roughly estimated from the rate of fallout for a station from a similar latitude (New York), multiplied by the ratio of the mean annual precipitation at Mono Lake to that of the reference station, multiplied by the total surface area of Mono Lake during the peak fallout years:

$$1.8 \text{ mCi/km}^2 \times \frac{25 \text{ cm}}{100 \text{ cm}} \times 200 \text{ km}^2 = 90 \text{ mCi}$$

Integrated fallout of ^{239,240}Pu to 1978 at New York, N.Y., has been estimated to be 1.8 mCi/km^2 (H.L. Volchok, personal communication), based on a production ratio of ^{239,240}Pu to ^{90}Sr of 0.017 from weapons testing [J. H. Harley, in *Proceedings of the Environmental Plutonium Symposium* (Publication LA-4756, Los Alamos National Laboratory, Los Alamos, N.M., 1971), pp. 13-19] and the history of ^{90}Sr deposition in New York.

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An Interface Phase Transition: Complete to Partial Wetting

Abstract. *When two fluid phases are near a critical point, one of them will be excluded from contact with any third phase that happens to be present by a wetting film of the other critical phase. A simple and quite general strategy that may be used to induce a phase transition from complete wetting of the third phase to incomplete wetting is to add a new component to the fluid phases chosen to drive the two phases away from their critical point. This strategy is illustrated for methanol-cyclohexane mixtures.*

The observation that the contact angle (that is, the dihedral angle subtended by a fluid phase along a line contact with two other phases) may be either zero or nonzero dates back at least to Young (*1*). More recently, Butler found evidence from surface tension measurements for two transitions from nonzero to zero contact angle in the mercury-water-benzene system; however, his contact angle measurements failed to confirm the expected transitions (*2*). In this report we present unambiguous evidence for a phase transition from zero to nonzero contact angle in methanol-cyclohexane-water mixtures. The circumstances under which the contact angle changes from zero to nonzero values supports a group of phenomenological ideas that have been discussed under the title "critical point wetting" (*3*). These ideas relate wetting phenomena to the proximity of critical lines in fluid mixtures; thus they can be used in a wide variety of situations as a guide for locating transitions from zero contact angle (complete wetting) to nonzero contact angle (incomplete wetting). Such a guide will facilitate detailed study of the wetting transition itself and may assist in the control of wetting for technological purposes. We will first briefly review the argument that complete wetting must occur near critical points. This will motivate our measurements on fluid mixtures. Finally, we will comment on some remaining problems.

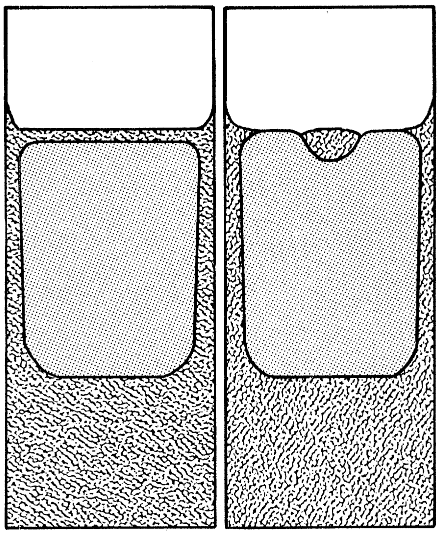

Fig. 1. Sketch of cuvettes containing two liquid phases and vapor. (Left) The lower (CH$_3$OH-rich) phase intrudes between the middle (C$_6$H$_{12}$-rich) phase and the cuvette wall. The lower phase also intrudes between the middle phase and the vapor. (Right) Water has been added to the solution. The lower phase still intrudes between the cuvette wall and the middle phase. The lower phase no longer intrudes between the middle phase and the vapor. Instead, there is a line of three-fluid phase contact near the cuvette wall and a line of three-fluid phase contact surrounding a lenticular drop of the lower phase suspended at the vapor interface.

To argue that complete wetting must occur near critical points we consider two fluid phases, α and β, in equilibrium somewhere near their critical point. The α and β phases may be partially miscible liquids [such as mixtures of methanol (CH$_3$OH) and cyclohexane (C$_6$H$_{12}$)] below a consolute or critical temperature (T_c); alternatively, α may be a liquid and β may be a vapor. In either case, the surface tension between the α and β phases, $\sigma_{\alpha\beta}$, approaches zero at the $\alpha\beta$ critical point as $(T_c - T)^{\mu}$, where μ is known from experiment (*4, 5*) and theory (*6*) to be about 1.3. When a third, noncritical fluid phase, γ, is present (such as a vapor over the liquids), one must consider two additional surface tensions, $\sigma_{\alpha\gamma}$ and $\sigma_{\beta\gamma}$. As the α and β phases approach their critical point, we expect both $\sigma_{\alpha\gamma}$ and $\sigma_{\beta\gamma}$