noteworthy since the depth of water in the flume was 1.5 to 4 times the largest pipe diameter studied and the dune wavelength was 1.23 to 2.4 m, or from 9 to 17 times longer than the maximum wavelength observed in the present study. These limited data indicate that sand waves in closed pipes, open flumes, rivers, and channels are closely related phenomena and hence any theories must account for the data from all these systems.

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Radioactive Particle in Sediment from the Columbia River

Abstract. *A "hot particle" containing only fission product radioactivity is comprised of a number of characteristics that make the particle unusual and its origin uncertain.*

A single particle with fission product radioactivity in the millimicrocurie range has been isolated from sediments in the Columbia River. High activity, large size, and apparent lack of fractionation make it quite unlike other reported individual fallout particles (*1*). The particle was isolated from sediments taken 23 July 1963, near Blalock, Oregon, about 210 km down river from the nuclear reactors at Hanford, Washington.

Surface sediments were collected from beneath about 2 m of fast-flowing water. The samples were then air-dried and passed through a 200-mesh screen. Seven 5-g portions of sediment (particle size less than 74 μ in diameter) were counted in the well of a 5- by 5-inch NaI(Tl) crystal. The signal from the detector was resolved with a 256-channel pulse-height analyzer.

Unusually high activity was noted in one of the samples (No. 5, Table 1). The single particle was isolated by repeated divisions of the highly active portion. Fission product radioactivity of the particle was equivalent to that found in about 200 g of average sediment from the same location.

When examined under a microscope, the particle, 11 by 25 μ in size, appeared colorless and isotropic except for several small, poorly defined anisotropic inclusions. One large inclusion was brown. The particle itself was highly angular and had at least three cleavage planes. Adams *et al.* (*2*) describe similar particles and inclusions associated with surface shots at the Nevada test site.

Neutron-induced radioactivity in sediments results from activation of trace elements in river water that is used to cool nuclear reactors at Hanford. However, very few fission products arise from this source (*3*). Neutron-induced radionuclides appear to be more evenly distributed throughout sediments than fission products. Scandium-46, for example, showed only small variations between portions of the same sample (Table 1). This would seem to indicate that fission products are associated with relatively fewer sediment particles than are neutron-induced isotopes.

The gamma spectrum of sample No. 5 (Fig. 1*A*) contains peaks due to neutron-induced radionuclides such as zinc-65, cobalt-60 and scandium-46. When the particle was isolated from the sediment and recounted, its spectrum (Fig. 1*B*) showed peaks only for the fission products zirconium-95–niobium-95, ruthenium-103, and cerium-141-144. The slight increase in fission product activity after separation is due to changes in geometry and self-absorption (*4*). Equations of Rock *et al.* (*5*), for changes with time in the apparent half-life of the Zr^{95}-Nb^{95}, were used to set early April 1963 as the approximate date for the formation of the particle. No Russian tests were reported from December 1962 to June 1963. However, underground tests were conducted at the Nevada site during this period (*6*). A test was reportedly conducted in the Sahara Desert by the French government on 18 March (*7*).

Table 1. Fission product activity and neutron-induced activity in 5-g samples of Columbia River sediment.

Sample No.	Fission product Zr^{95}-Nb^{95} (pc/g)	Neutron-induced Sc^{46} (pc/g)
1	33	44
2	22	40
3	82	40
4	11	34
5	760	34
6	22	47
7	14	38
Mean ± S.D.	31 ± 24*	40 ± 4.5

* No. 5 is not included.

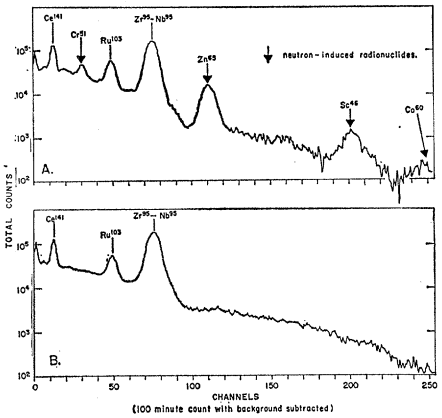

Fig. 1. *A*, Spectrum of 5-g sediment sample. Peaks indicated for scandium-46 and cobalt-60 are "sum peaks." *B*, Spectrum of "hot" particle after isolation (one channel equals 10 kev).

A number of collections were made at four other stations on the river between Hanford and the ocean, but no similar "hot particle" was found. Measurements of fallout radionuclides in marine plankton and of filter samples from Oregon rivers and from rain water have failed to reveal anomalous particles; that is, dividing our samples generally resulted in a corresponding division of radioactivity. For example, Osterberg *et al.* (*8*) report that average activity of Zr^{95}-Nb^{95} in marine organisms (euphausiids) from nine consecutive tows was 13.6 pc/g with a standard deviation of only 1.2 pc/g. This indicates that individual fallout particles generally do not contribute appreciably to the total fallout radioactivity present in the diet of these animals. The small fraction of fallout particles large enough to drop out of suspension in the river and the large fraction of very small "suspendable" particles in the ocean would lead one to expect a more even distribution of fission products in plankton than in sediments. Clearly the "hot particle" was in a class of its own; it contained 7300 pc of Zr^{95}-Nb^{95}, 3600 pc of Ru^{103}, and 1400 pc of Ce^{141} on the date collected.

Origin of the particle is not obvious. Its large size makes it unlikely, but not impossible, that air currents carried it about 800 km from the test site in Nevada [$25\ \mu$ is considered to be the division between local and world-wide fallout (*9*), with most of the latter smaller than $4.5\ \mu$ (*10*)]. It is also unlikely that a particle this large could be carried from the Sahara Desert eastward to the northwestern United States. On the other hand, a particle of this size released into the river at Hanford might be expected to settle out in the quiet waters of Lake Wallula, which lies between Hanford and the collection site.

We conclude that the particle is unusual because of its high radioactivity, large size, and lack of fractionation, and also because its location in the river makes its origin an enigma (*11*).

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Xenon Hexafluoride Complexes

Abstract. *Xenon hexafluoride reacts with* BF_3 *and* AsF_5 *to form 1:1 adducts which are white solids with vapor pressures of less than 1 millimeter at room temperature. The* $XeF_6 \cdot BF_3$ *adduct melts at 90°C to a pale yellow viscous liquid.*

Xenon tetrafluoride reacts with SbF_5 or TaF_5 to form complexes with the composition $XeF_2 \cdot 2SbF_5$ or $XeF_2 \cdot 2TaF_5$ (*1*). However, BF_3 does not appear to form complexes even when heated to 200°C (*1, 2*). Complexes with XeF_6 have not yet been described.

It has now been found that XeF_6 will form 1 : 1 addition compounds with BF_3 and AsF_5.

At room temperature BF_3 and XeF_6 combine to form an adduct of composition $XeF_6 \cdot BF_3$. At room temperature the adduct is a white solid which melts at 90°C to a pale-yellow viscous liquid. Its vapor pressure is less than 1 mm at 20°C. However, it can be sublimed under vacuum (its own vapor pressure) at this temperature. The infrared spectrum of the solid at $-195°C$ is complex, but shows a broad absorption centered at a wave number of about 1025 cm^{-1}, which is characteristic of BF_4^- (*3*). The infrared spectrum of the vapor was obtained in a reflection cell of 60-cm path length (*4*). This shows absorptions characteristic of BF_3 and XeF_6, indicating that the adduct is at least partially dissociated in the vapor phase.

The adduct, $XeF_6 \cdot BF_3$, reacts with NaF at 100°C to form $NaBF_4$ and an ill-defined addition product of XeF_6 and NaF. The XeF_6 can be recovered from this addition product by pumping under vacuum at 100°C (*5*).

Xenon hexafluoride also reacts with AsF_5 at room temperature to form a 1 : 1 addition compound. This is a white solid which cannot be sublimed under vacuum at room temperature. Raman spectra of solid $XeF_6 \cdot BF_3$ and $XeF_6 \cdot AsF_5$ prepared *in situ* in a sapphire cell show scattering peaks at 612 cm^{-1} and 620 cm^{-1}, respectively, which cannot be ascribed to any of the components (*3, 6, 7*). It is interesting that solutions of XeF_6 in anhydrous HF show a scattering peak at 620 cm^{-1} (*8*), and possibly the species in HF may be similar to that in the adducts.

The adducts of XeF_6 compare in chemical reactivity with that of XeF_6 itself (see *9*). They are extremely hygroscopic. Although they can be stored in nickel containers, they appear to react with pyrex. The reactivity of these compounds and their low volatility present formidable obstacles to the determination of their structures.

Peacock (*1*) has suggested that the complex ($XeF_2 \cdot 2SbF_5$) may be covalent, with the possibility of fluorine bridges linking the heavy atoms. The XeF_6 adducts may have similar structures, but ionic complexes of the type $(XeF_5)^+(AsF_6)^-$ cannot be ruled out. The $(AsF_6)^-$ configuration is known to be particularly stable (*7*), while the stability of a possible $(XeF_5)^+$ may be enhanced by the favorable octahedral geometry predicted for one lone and five bonded electron pairs (*10*).

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