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Moving Earth and Rock with a Nuclear Device

Abstract. A test in Nevada increases confidence that nuclear explosions can be used for large excavation projects.

Of all the potential peaceful applications of nuclear detonations perhaps the most obvious, certainly the best understood, and probably the most practical for realization in the near future is excavation. The test program for nuclear weapons has produced several craters, and well over 100 have been made with chemical high explosives in the Plowshare program. The data from both kinds of explosions have provided valuable new information concerning the feasibility and safety of nuclear earth-moving projects. Indications are that the use of nuclear explosives will bring substantial savings in cost and time on large-scale excavation projects. The experiments have been conducted for the most part in tuff, a cemented volcanic ash, and alluvium, an unconsolidated valley-fill material.

Detonations in other rock types remain to be investigated. The effects of arranging charges in a row and other variations have been studied with chemical high explosives, which have relatively low yield. The extension of these techniques into the range of yields obtainable with nuclear devices is desirable.

A test program has been planned to acquire the techniques necessary to make nuclear excavation a reality. The first of the projected series of cratering experiments designed to develop these techniques was Project Sedan (*1*), which was conducted at the Atomic Energy Commission's Nevada test site. The experiment involved detonation of a device of about 100 kilotons' yield, buried at a depth of 635 feet in alluvium. This depth is greater than optimum depth if crater dimensions are proportional to the 0.3 power of the yield, as has been observed with devices of kiloton yield. By this scaling relation, it was predicted that Sedan would produce a crater about 1400 feet in diameter and 300 feet deep. But some theoretical considerations indicated that this scaling relation might not be applicable to devices of hundreds of kilotons' yield, and that the dimensions for these higher yields might be proportional to the 0.25 power of the yield. In this case, it was predicted that the crater would be about 1200 feet in diameter and 170 feet deep. With either law, it was predicted that less radioactivity would be released than the equivalent of 2 kilotons of fission.

Among other technical programs were measurement of air blast and seismic effects both on- and off-site. Photography from five camera stations was planned to determine surface motion and cloud dimensions.

Trays and collectors were positioned throughout the planned fallout sector, and bioenvironmental plots were laid out to study radiation effects caused by the explosion. Radioactive pellets were placed in holes near the shot point to study particle trajectories. Tarpaulins, trays, and measuring rods were distributed to measure and document the distribution of the throwout and dust.

A 100-kiloton thermonuclear device in which less than 30 percent of the energy released came from fission was used for the test. It was placed in a cased hole 36 inches in diameter and backfilled with dry sand. Measures were taken to reduce the radioactivity induced by the neutrons. Preliminary calculations indicate that the yield was probably within about 10 percent of the expected value.

Sedan was detonated at 10 A.M. Pacific Daylight time on 6 July 1962. A roughly hemispherical dome of earth 600 to 800 feet in diameter rose to a height of 290 feet in 3 seconds, when venting of burning gases resulted in a secondary explosion and flash. As this tremendous volume of earth fell back to the ground a base surge was formed that expanded radially to a distance of approximately 2.5 miles. The main cloud then rose to a height of 12,000 feet above the desert floor, where it was topped by inversion conditions.

The crater formed has a maximum apparent depth of about 320 feet and an average apparent diameter of about 1200 feet. The height of the crater lip ranges from about 20 to 100 feet. By comparison with pre-shot predictions (depth of 170 to 300 feet and diameter of 1200 to 1400 feet) it appears that in the 100-kiloton yield range the crater diameter scaling may approach the 0.25 power of the yield and the depth scales as the 0.3 power.

The dust cloud was carried downwind at a mean speed of about 19 knots from 185 degrees (slightly west of south). The heavier fallout was confined to within approximately 2 miles upwind and crosswind and 4 miles downwind of ground zero. The intensity of radioactivity deposited downwind was moderate considering the large amount of dust carried by the cloud. The radiation level on the crater lip 4 weeks after the detonation was less than 1 r/hr. The maximum total dose received by any person off the Nevada test site was 275 mr, which is well below the 500 mr/yr guide recommended by the Federal Radiation Council for peacetime uses of nuclear energy.

Analysis of data from the Atomic Energy Commission's off-site monitoring program (operated by the U.S. Public Health Service) and from the environmental monitoring network of the Public Health Service indicates that only a small part of the iodine-131 measured recently in milk produced in Utah is attributable to Sedan. Officials believe that Sedan is responsible for the initial increase measured on 13 July in the Salt Lake City area but attribute subsequent higher levels to two other nuclear weapon tests held at the Nevada test site—one at a shallow depth on 11 July and the other a few feet above ground on 14 July.

Ground shock intensities were much less than expected from previous experience in tuff and alluvium. Accelerations of only 0.1 grav were recorded at a distance of approximately 1.5 miles from ground zero. Air blast stations in the caustic range (80 to 150 miles) recorded peak pressures up to 0.83 mb at China Lake, Calif., some 137 miles southwest of ground zero.

The Sedan experiment was highly successful. Its displacement of 7.5 million cubic yards of earth and rock with-

out jeopardy to public health adds significantly to confidence that the use of nuclear explosives in large excavation projects such as the trans-Isthmian sea-level canal is feasible.

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Note

1. The data from these studies are being prepared for publication in technological reports.

3 August 1962

Transfer of the "Sex-Ratio" Factor in Drosophila willistoni by ingestion

Abstract. Thirty-nine females from a normal strain of *Drosophila willistoni* were kept in bottles containing a drop of a supernatant of a macerate of "sex-ratio" females of the same species. Two of these females acquired the "sex-ratio" condition and transmitted it to their progenies.

Some females of several species of *Drosophila* produce unisexual, or almost unisexual, progenies consisting of females and few or no males. This "sex-ratio" (SR) condition, which is dependent on the female and not on the male with which she is mated, has been studied by several workers. Poulson and Sakaguchi (*1*) have shown that in *Drosophila willistoni* this kind of sex ratio is caused by the presence in the bodies of the females of a microorganism which is apparently a species of *Treponema.* The same has been demonstrated in *D. paulistorum* and *D. equinoxialis* by Malogolowkin (*2*). Poulson and Sakaguchi found that the maintenance of the microorganism depends upon the genotype of the host.

Intra- and interspecific transfer of the sex-ratio condition by injection (*3*), and "cure" by temperature treatment of the flies (*4, 5*) were obtained in several species. In order to discover the mechanism by which this character maintains itself in natural populations, Magni (*4*) tried to transfer the factor to normal females of *D. bifasciata* by having different proportions of normal and SR females develop in the same food medium. The results were negative.

Our report describes a new method of transfer of the factor from SR strains of *D. Willistoni* into normal strains of the same species.

One hundred virgin females from a normal strain were kept in ten sterilized bottles (ten females in each bottle) without food for 7 hours. A drop of the supernatant, obtained by L'Héritier's technique (*6*) from a macerate of females of the SR strain was placed in each bottle. Some of the flies immediately approached the drop and fed on it. After 17 more hours, the surviving flies, 54 in number, were crossed in pair-matings, in vials containing banana-agar medium. Thirty-nine of these flies were fertile (pair-matings are not always successful in *D. willistoni*), and 37 gave normal proportions of sexes.

The other two (E18 and E42) acquired the "sex-ratio" condition, which they transmitted to their progenies. The offspring of these two females were counted until the fourth generation. Despite the appearance of females which did not show the "sex-ratio" condition, the "sex-ratio" was maintained in some of the females. The percentage of males produced by the two females, E18 and E42, at different times after the ingestion of the macerate of sex-ratio flies is shown in Table 1.

As a control experiment, the same number of flies were given the supernatant prepared from a macerate of normal females of *D. willistoni.* Among the 100 females used, 49 survived and the 35 fertile matings produced progenies with a normal proportion of both sexes (Table 2).

Table 1. Percentages of males produced by the two females, E18 and E42, at different times after they had ingested the macerate of sex-ratio flies.

Time after ingestion (days)	Flies counted (No.)				Males (%)	
	E18		E42		E18	E42
	F	M	F	M		
1–20	25	14	17	15	35.8	43.7
20–43	40	11	56	34	21.5	37.7
43–53	16				0	

Table 2. Results obtained in F_2, F_3, F_4 of *D. willistoni.*

Control group	Total No. of flies		Females tested (No.)	Unisexual progenies
	F	M		
		Fly E18		
F2	266	91	15	8
F3	291		14	14
F4	249	16	18	14
		Fly E42		
F2	110	53	9	2
F3	69	8	5	4
F4	144	90	13	6

The causative agent of the "sex-ratio" condition in *D. willistoni* can, consequently, be transferred to a normal strain of the same species by allowing flies to ingest the supernatant from a macerate of females from SR strains.

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Direct and Transcallosal Induction of Touch Memories in the Monkey

Abstract. A monkey, after corpus callosum transection, will fail to recall through one hand tactual tasks that he has learned through the other hand. However, if a monkey has already learned a task through one hand, destruction of the corpus callosum does not greatly affect his subsequent recall of that task through the other hand. It is concluded that task learning through one hand develops separate memory trace systems in both hemispheres.

The normally occurring transfer of training between the hands is supported by the corpus callosum in primates (*1*). In the absence of the corpus callosum, tactual experience and tactual learning seem to occur independently through the two hands. In an animal in which the commissure is intact, transfer of training between the hands suggests that memory trace systems may be established in both hemispheres even when there is restriction of tactual learning through one hand. The possibility exists, however, that mnemonic effects may be induced only in the hemisphere related to the "trained" hand and that subsequent performance through the "untrained" hand is sup-