ABSTRACT

This report summarizes the results of the radiological surveys and assay of soils and plants collected during the Biological Field Surveys of 1949 and 1950 from the areas contaminated by the Fall-out from the First Atomic Bomb Detonation in New Mexico. The results of these investigations may be summarized as follows:

1. The radiological surveys of the Chupadera Mesa, twenty to thirty-five miles from ground-zero, show the continued presence of measurable amounts of radioactive fission product contamination; relatively small changes in elevation have no detectable effect evident at this late date on distribution of Fall-out and there is little evidence of lateral migration of contaminants during the last two years in the areas surveyed. not moving

2. In the Fenced Area, the area for more than 50 mr./24 hours, gamma radiation has decreased from 1400 feet to approximately 700 feet in diameter in four years.

3. Wind erosion is more effective than water erosion. Some wind-drift material collected adjacent to the Fenced Area assayed as much as 12 dis./sec./gm. of silt and clay. It was demonstrated that vegetation is the most important influence in decreasing the removal of wind-borne material.

4. Water-borne silt deposits within the Crater were always several times less radioactive than the underlying soil or sand.

5. Powdered "Trinitite" is only sparingly soluble in water and dilute alkali solutions and only slightly more soluble in dilute acids.

6. There is some indication from the 1950 data that downward migration of fission product contaminants in the soil is taking place on the Chupadera Mesa. There is as of 1950, an average of approximately one microcurie of fission product activity per square foot one inch deep or 6.0 dis./sec./gm. of soil in Area 21, twenty-eight miles from ground-zero.

going down

7. Preliminary laboratory studies on the clay fraction from Area 21 indicate that Cs^{137} is fixed almost quantitatively while $Sr^{90} + Y^{90}$ are fixed to a much lesser degree.

8. Normal background activity differs between plant species and genera; for a common grass (<u>Bouteloua gracilis</u>) the natural beta-gamma background activity ranges from 0.5 to 0.44 dis./sec./gm. of dried plant material.

9. The ratio of soil to plant beta-gamma radioactivity of residual fission products in Area 21 reveals that in 1949 the activity of a gram of dried plant material was 3.85% of the radioactivity in a gram of soil. In 1950 this value was 5.59%.

10. The uptake of residual beta-gamma radioactivity by Russian thistle (<u>Salsola pestifer</u>) in the Fenced Area has apparently reached an equilibrium based on comparative assays of samples collected in 1948 and 1950.

11. Preliminary greenhouse data presented from research in progress, indicate that the identity and chemical form of the isotopes, differences in soil composition and its chemistry, climatic factors, and inherent differences in plant species are all important factors in determining the behavior of the fission products in the overall biological cycle.

THE 1949 AND 1950 RADIOLOGICAL SOIL SURVEY OF FISSION PRODUCT CONTAMINATION AND SOME SOIL-PLANT INTERRELATIONSHIPS OF AREAS IN NEW MEXICO AFFECTED BY THE FIRST ATOMIC BOMB DETONATION

INTRODUCTION

This report is concerned with additional radiological observations and some consideration of the soil-plant interrelationships due to the residual radioactivity of the Fall-out from the First Atomic Bomb Detonation, July, 1945 in New Mexico. The 1949 and 1950 Biological Surveys were in part concerned with the determination of the fourth and fifth year distribution of remaining fission products in soils and plants and the interrelationships between these two systems with respect to biological cycling.

The several equilibrium or "Threshold" values for fission products and alpha emitters distributed as Fall-out from a detonation in soils, plants or animals have not been established. These values are essential to the establishment of a basis for the evaluation of chronic and acute radiological hazards to man and other biological systems. Annual biological surveys and correlated controlled laboratory research have been designed and are in progress to determine the mechanisms by which the long and medium half-life fission products and the important alpha emitters are absorbed and metabolized by important crops and animals.

In order to further define the residual fission product activity, three areas were selected, Area 21, Ratliff Area, and the Weir Area for the 1949 Survey. These were selected on the basis of the highest beta-gamma activities found during the 1948 Survey. See Detailed Map, Fig. 3, Report UCLA-32[1]. Area 21 and the Weir Area were again selected for the 1950 Soil and Radiological Survey. In selecting these areas, described in detail below, the several objectives were:

1. To determine the relationship between the elevation of the terrain and the radioactivity.
2. To establish additional permanent locations for future soil and biological surveys.
3. To establish a representative area for erosional studies.
4. To recheck previous permanent soil sampling locations.

In each of the annual field surveys conducted so far, soil profile studies have been made in typical locations. These studies have been made each year with the following objectives in mind:

1. The profile soil samples were collected and radiologically assayed for beta-gamma and alpha activity to determine the vertical distribution of radioactivity.
2. To confirm the surface mr./hr. values obtained with the survey instruments.
3. To obtain data on the overall decrease of radioactivity due to the interplay of such factors as erosion, isotopic decay, horizontal and vertical diffusion of the fission products in soil and the effect of temperature and rainfall.

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(1) The 1948 Radiological and Biological Survey of Areas in New Mexico Affected by the First Atomic Bomb Detonation. Report UCLA-32. See map inside back cover. The reader is referred to this report by the authors for data and reference points at which time the Crater Area and the down-wind Fall-out were measured and the reference transect and permanent markers were established.

One phase of the annual field surveys by this group has been the determination of the uptake of residual radioactivity by plants. For this purpose plant specimens have been collected each year from the following areas:

1. The Fenced Area, the area of primary Fall-out.
2. The Chupadera Mesa, the area of secondary Fall-out.
3. Various locations outside the known area of contamination as established in 1948. See Reports UCLA-32, 75 and 78.

The collection and assay of plant material and soil adhering to roots has been done as an attempt to establish the soil-plant relationship with respect to fission products. Collections outside the area of contamination have been made in an attempt to establish the naturally occurring "background" value for each species of plant sampled.

GENERAL DESCRIPTION OF LOCALITIES

Three of the four areas previously mentioned were studied in detail during the Radiological and Soil Survey. The location, topography, general soil description and vegetation for each of these three areas is presented.

Area 21: (28 miles roughly northeast of Zero), is situated just east of the Primary Transect Reference Line (see Fig. 1, p.10) on Lateral 21, Right, on the Chupadera Mesa. The major part of this 1.5 square mile area consists of ridges and valleys, lying in a general north-south direction with drainage generally to the southwest supplying several stock tanks on the Coker Ranch. The soils of the ridges and their slopes are coarse sandy loams, often with high gravel content and surface rock. In several locations in this area, long continued erosion has exposed the

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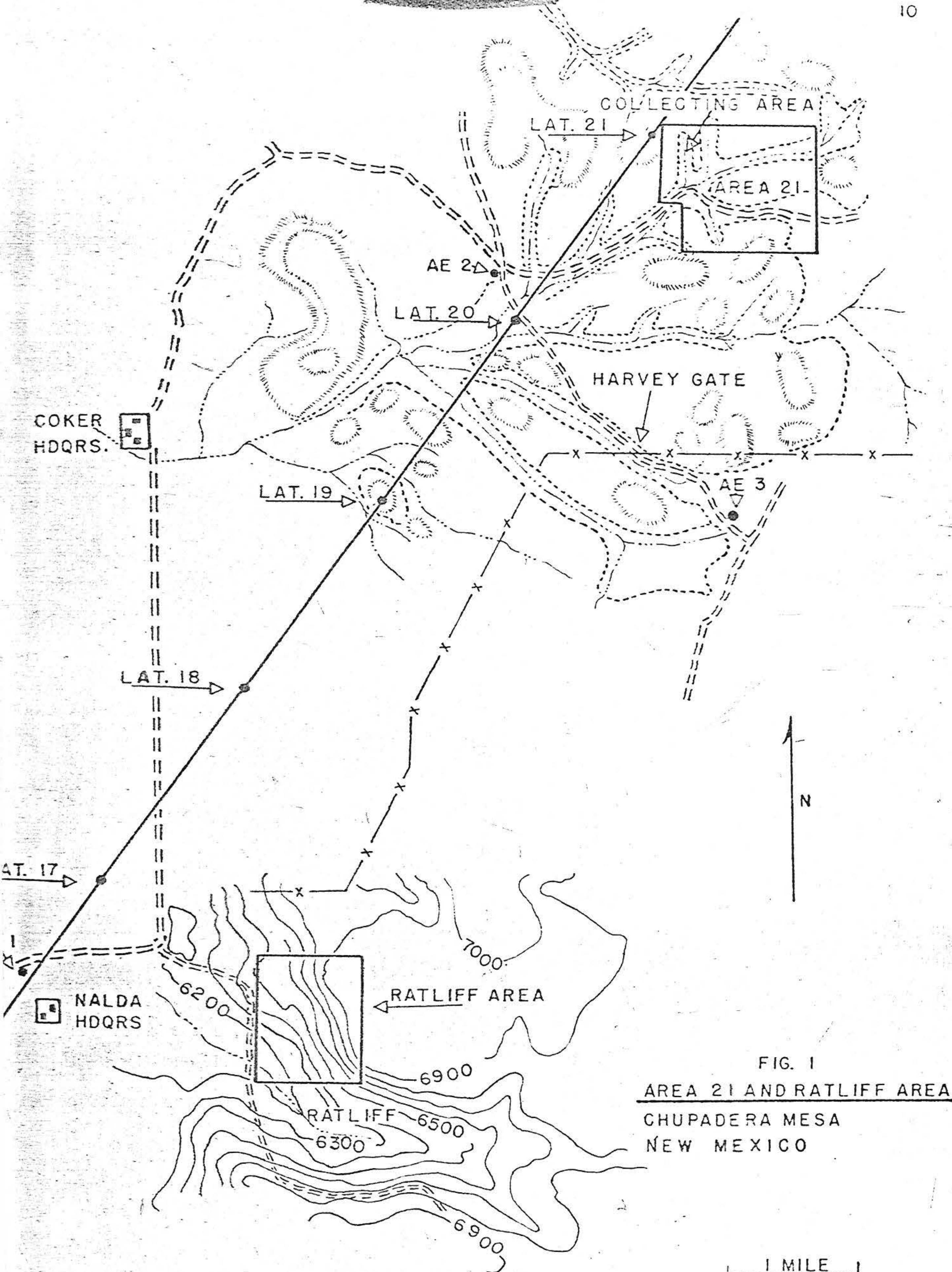

FIG. 1
AREA 21 AND RATLIFF AREA
CHUPADERA MESA
NEW MEXICO

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partially decomposed limestone-gypsum substratum which now appears as large hills or ridges. The soils of the valleys are usually loams of fairly high silt content and are calcareous.

In general, the ridges and their slopes in Area 21 are densely populated with juniper and pinon pine. The valleys have vegetation consisting mainly of grasses and scattered juniper. The northeastern section (approximately one-fourth of the area) is a broad open plain sloping gently (two to four per cent) to the east. The soil and vegetation here are similar to those of the valleys described above.

Ratliff Area: This region is located about one mile east of the Primary Transect Reference Line on Lateral 17, Right, (22 miles north of Zero, see Fig. 1, p. 10) on the Chupadera Mesa. It consists mainly of alluvial fans and terraces forming the southwestern slope of the mesa. The soils are generally coarse sandy loams with considerable gravel. A ridge rising 600 feet above the floor of the canyon forms the eastern boundary. The soils of this ridge are, in general, coarse sandy loams or loamy sands largely covered with rock, particularly on the eastern slope.

The vegetation of the Ratliff Area is grass with scattered juniper throughout, with the exception of the ridge where juniper and pinon pine form the main cover on the west and north slopes. The very rocky eastern slope (somewhat less than half of the total area) is almost barren with only a few yucca and scattered grass tufts.

In each of three years, soil profiles were taken at two locations in these areas, one in the Ratliff "Hot" Canyon the other, AE-1, at the section corner, one-half mile north of Nalda Headquarters and four miles east of Old Bingham. Additional profiles were taken in the valley of Area 21 and at the Harvey Gate location.

Hot Canyon

meter, with the probe being held four inches away from the stake and one inch above the ground.

The soil profile samples collected for beta-gamma radioactivity assay in the laboratory were processed in the same manner as the 1948 samples with one exception; all soil fractionating (sieving) was done for fifteen minutes on a Ro-Tap sieve shaker.

All of the laboratory data have been corrected for instrument and soil background (naturally occurring radioactivity) and self-absorption. Average soil background was determined to be 0.7 dis./sec./gm.(1). Additional data accumulated and repeated determinations in subsequent years has substantiated the validity and constancy of this average value. A self-absorption factor of 1.5 (approximate) was determined using the 1950 surface samples from Harvey Gate, as well as on soil samples from the Fenced Area. This value has been used throughout on the soil assays.

RADIOLOGICAL RESULTS AND OBSERVATIONS

Chupadera Mesa: The field data and information collected from the two areas, Area 21 and Ratliff Area in 1949, are presented in Tables I and II, and Figs. 3 and 4. Only one point was found in the two areas which had an average reading greater than 0.3 mr./hr. beta-gamma activity. (An average reading is the arithmetical mean of all mr./hr. values taken at any one location.) Several locations had individual readings between 0.3 and 0.6 mr./hr.

No significant differences were found on the ridges and the adjacent valleys in beta-gamma radioactivity. In general, the higher

(1) The 1948 Radiological and Biological Survey of Areas in New Mexico Affected by the First Atomic Bomb Detonation. Report UCLA-32, p. 21.

activities were found in grass tufts which had accumulated dust, silt and sand or under the juniper trees on decaying organic matter (dead needles and twigs). The lower activities occurred on heavily eroded rock and soil, especially that found on the ridges. The wood-rat nests investigated were only two to three times more than background.

In addition to the two areas surveyed in detail, nine other locations on the Mesa which has been measured in 1948 were checked for comparative purposes in 1949. These data are presented in Table III.

Table III

COMPARATIVE AVERAGE MR./HR. READINGS TAKEN IN 1948 AND 1949 ON THE CHUPADERA MESA AT SEVERAL LOCATIONS

Location	Mr./hr.- Beta-Gamma 1948	1949
Harvey Gate (H.G.)	0.26	0.17
Lateral 20	0.14	0.09
Miles from Coker House, northeast along State Highway 41		
0.0		0.008
1.0	0.009	0.004
2.0	0.042	0.005
3.0	0.080	0.014
4.0	0.290	0.029
5.0	0.160	0.113
6.0	0.220	0.091

Two other locations, the White Store and the Ratliff "Hot" Canyon Areas, on the Chupadera Mesa have been checked periodically since the bomb detonation in 1945. These data are of importance since they give an estimation of the overall rate of change of activity resulting from decay of fission products, erosion effects, translocation, and other influences. These data are presented in Table IV.

Table IV

BETA-GAMMA ACTIVITY (MR./HR.)
TAKEN AT TWO LOCATIONS PERIODICALLY
SINCE IMMEDIATELY FOLLOWING THE INITIAL FALL-OUT

Date of Reading	Time Elapsed Since Zero Hour	Mr./hr. Beta-Gamma White Store	Ratliff "Hot" Canyon
July, 1945*	5 to 8 hours	2500.	6000.
Dec., 1945*	3,336 hours	0.5	2.2
Aug., 1947	18,360 hours	---	1.3
Aug., 1948	27,000 hours	0.06	0.64
Aug., 1949	35,760 hours	---	0.07

* These values were reported by the Los Alamos Group.

The Crater Region - Fenced and Unfenced Areas: The portion of Trinity immediately outside the Fenced Area and that inside the fence, including the Crater, were resurveyed for beta-gamma and gamma radiation as in 1948. The mr./hr. readings of beta-gamma radioactivity obtained in 1948, 1949 and 1950 along the radials outside of the Fenced Area are summarized in Table V. Table VI summarizes the readings of gamma radiation obtained in 1947, 1948, 1949 and 1950 along the four principal radials within the Fenced Area.

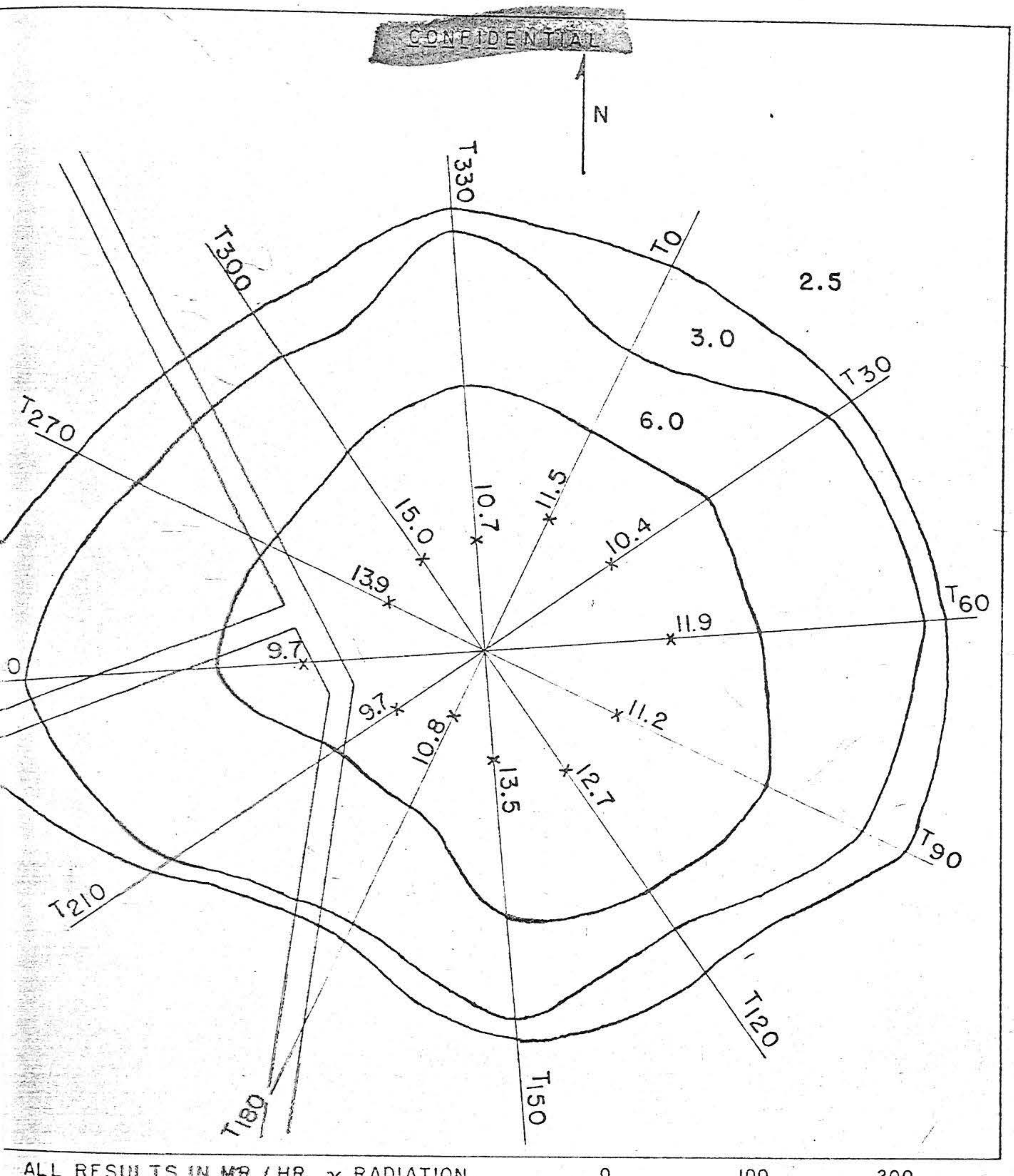
During the 1950 Survey, mr./hr. readings were also obtained along the other eight 30° radials within the Fenced Area. These data are summarized by the "isodose" maps of the Crater and the Fenced Area shown in Figs. 5 and 6.

Radioautographs were obtained in the Fenced Area in 1949 and 1950 with film packs (twenty square inches in area) supported one inch above the surface. Mr./hr. readings obtained with these films by densitometer techniques are summarized in Table VII. The high and low readings

Table V

BETA-GAMMA RADIOACTIVITY EXPRESSED AS MR./HR.
ALONG SIX RADIALS OUTSIDE OF FENCED AREA, 1948, 1949 AND 1950

Direction from Zero	Distance in Miles from Fence	Mr./hr. Beta and Gamma 1948	1949	1950
59° E of N	0.0	0.77	0.37	0.27
	0.1	0.26	0.21	0.007
	0.2	0.067	0.70	0.003
	0.3	0.031	0.43	0.013
	0.4	0.040	0.07	Bkgd
	0.5	0.034	0.045	---
	0.6	Bkgd	0.012	---
	0.7	---	0.012	---
	0.8	---	0.012	---
66° E of S	0.0	0.020	0.027	0.021
	0.1	---	0.008	Bkgd
	0.2	0.012	0.012	Bkgd
	0.3	---	0.016	---
	0.4	0.004	0.008	---
14° E of S	0.0	0.010	0.012	0.026
	0.1	---	0.010	Bkgd
	0.2	0.005	0.004	Bkgd
	0.3	---	0.012	---
	0.4	0.004	0.006	---
	0.5	Bkgd	0.002	---
38° W of S	0.0	0.061	0.032	0.080
	0.1	---	0.008	Bkgd
	0.2	0.010	0.008	Bkgd
	0.3	0.010	0.006	---
	0.4	0.010	0.008	---
	0.5	0.007	0.010	---
	0.6	0.010	0.008	---
	0.7	---	0.008	---
87° W of S	0.0	---	0.43	0.37
	0.1	---	0.22	0.013
	0.2	---	0.049	Bkgd
	0.3	---	0.51	0.003
	0.4	---	0.049	0.003
	0.5	---	0.032	Bkgd
	0.6	---	0.032	---
	0.7	---	0.016	---
	0.8	---	0.010	---
	0.9	---	0.004	---
	1.0	---	0.004	---
44° W of N	0.0	0.42	0.19	0.47
	0.1	0.26	0.049	0.19
	0.2	0.32	0.042	0.027
	0.3	0.13	0.004	Bkgd
	0.4	0.002	0.006	Bkgd
	0.5	---	Bkgd	---
	0.6	0.002	Bkgd	---



ALL RESULTS IN MR./HR. γ RADIATION.
READINGS TAKEN 1 INCH ABOVE SURFACE
WITH 263A-VICTOREEN SURVEY METERS
AUGUST, 1950

FIG. 5 ISODOSE MAP OF GAMMA RADIATION IN THE CRATER

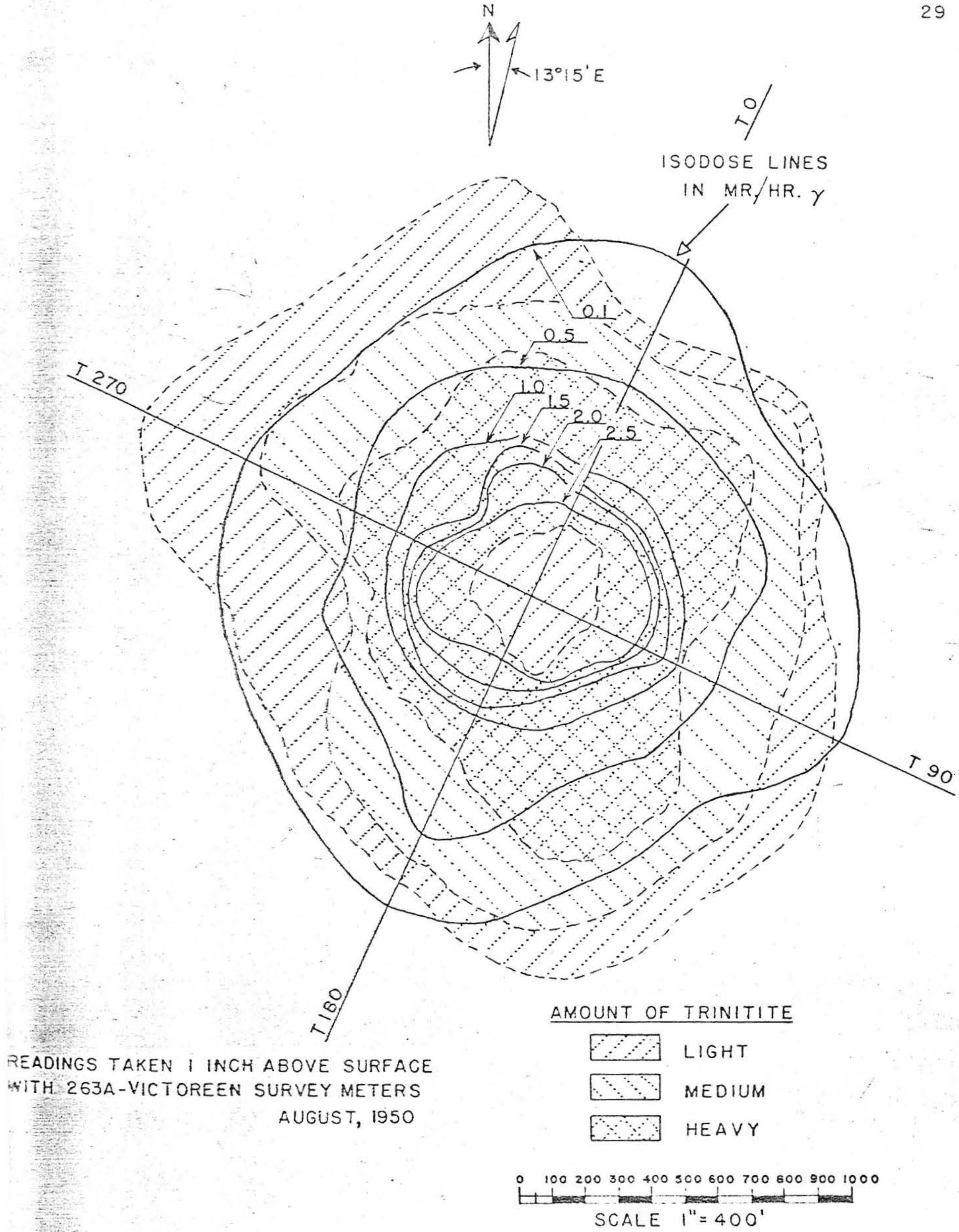


FIG. 6 ISODOSE MAP OF GAMMA RADIATION IN THE FENCED AREA

recorded are given to indicate the variations that are possible on the ground surface due to the variable pattern of the present disposition of Trinitite.

Weir Area: The beta-gamma activity survey measurements that were taken north, south, east and west of each reference point established in August, 1949 were repeated during 1950. A few random readings were taken during the first week in July, 1950 and two complete surveys of the area were made about three weeks apart during late July and August, 1950. A heavy rain (cloudburst) and several windstorms occurred between these last two surveys in 1950. Representative data for the two years are presented in Table VIII. Table IX shows the average mr./hr. readings around each stake as determined August 22, 1949 and August 22, 1950. These average readings are plotted in Fig. 2, inside back cover.

The four radioactivity readings taken around each stake were quite variable in many instances. This variation can be ascribed in part to the particulate nature of the radioactive material and in part to the variation in distribution and density of the original Fall-out. The particulate nature of radioactive material on the surface of the soil in this area is clearly illustrated by typical radioautographs reproduced in Fig. 7. The high readings were invariably observed over loose sand and in many cases small "glass beads" were visible in those spots. The differences between readings at the various stakes in 1949 and 1950 and between the three surveys in 1950 point out the shifting of the radioactive contamination from its original point of deposition by the effects of the erosional factors, wind and runoff, in the area.

The 1949 surface readings in the central sector, both in the channel bottoms and on the steep heavily eroded headlands, were extremely low. This suggested that the contamination was possibly being removed from the area by the action of water.

Wind Erosion in the Weir Area and Crater Region: When the Weir Area was first visited on July 8, 1950, the main drainage channel and the Weir proper had been filled with wind-blown sand to a depth of six inches in eleven months. Surface activity readings were uniformly quite low over this material. Soil profiles designated W_I and W_{II} were cut through the drift material eighteen inches up from and thirty-six inches down from the Weir in the channel. Analysis of the depth increments, Table XI, do not show a uniform distribution of radioactivity throughout this deposit. This observation indicates that wind is of great importance in the lateral migration of radioactive contamination from this area.

Table XI

BETA-GAMMA RADIOACTIVITY OF WIND-BLOWN DEPOSITS IN WEIR CHANNEL, PROFILES W_I AND W_{II}, 1950

Depth in Inches	Dis./sec./gm. of Soil or Sand W_I	W_{II}
0.0 - 0.5	0.6	0.3
0.5 - 1.0	0.3	0.3
1.0 - 1.5	Bkgd	0.8
1.5 - 2.0	0.6	0.6
2.0 - 2.5	0.3	0.4
2.5 - 3.0	0.1	0.3
3.0 - 3.5	0.2	0.7
3.5 - 4.0	0.6	1.4
4.0 - 4.5	0.7	Bkgd
4.5 - 5.0	0.7	0.7
5.0 - 5.5	0.1	---
5.5 - 6.0	Bkgd	---
6.0 - 7.0	Bkgd	---
7.0 - 8.0	Bkgd	---

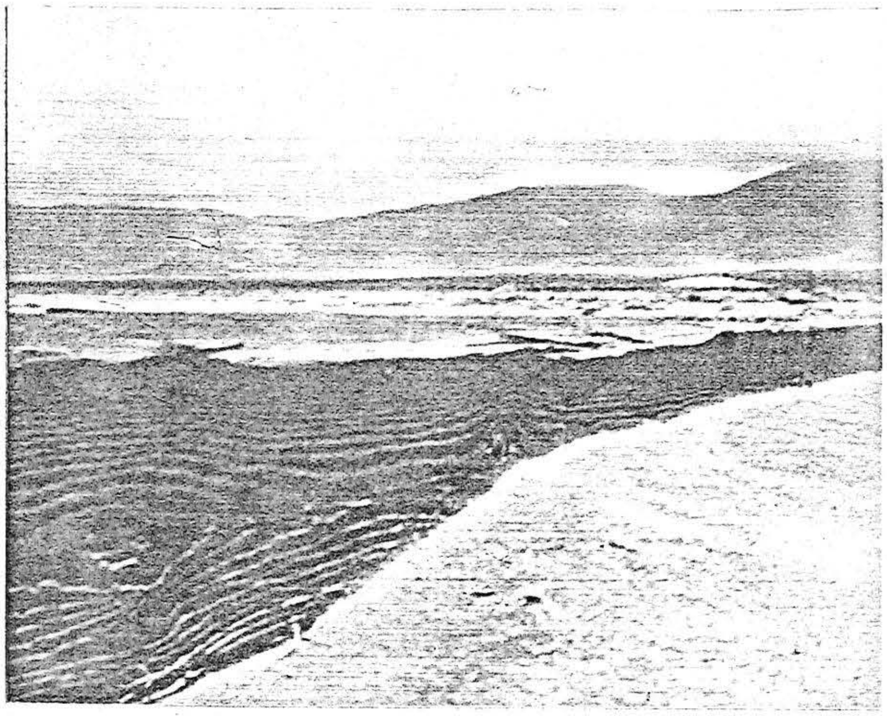


Fig. 8

A "timber" (14" x 14" x 24' long) lying several hundred feet out from the Fenced Area along T-270 showing the wind-blown material deposited. Note the sandblast effects which removed the softer wood.

The two sets of data presented above suggest that appreciable amounts of radioactive material are being carried from the Crater by wind. The absence of any other concentrations of contaminants outside of the Fenced Area as a result of the wind erosion suggests that the wind-borne material ordinarily is redeposited over a wide area and is thereby diluted to the extent that it is not detectable with survey instruments.

Water Erosion or Runoff in the Weir Area and Crater Region: Rain showers of sufficient intensity have not fallen on the Weir Area at any time when observations could be made on the volume of runoff. Consequently, there have been no samples of runoff water collected. However, a flash flood resulting from a rain of cloudburst proportions falling on

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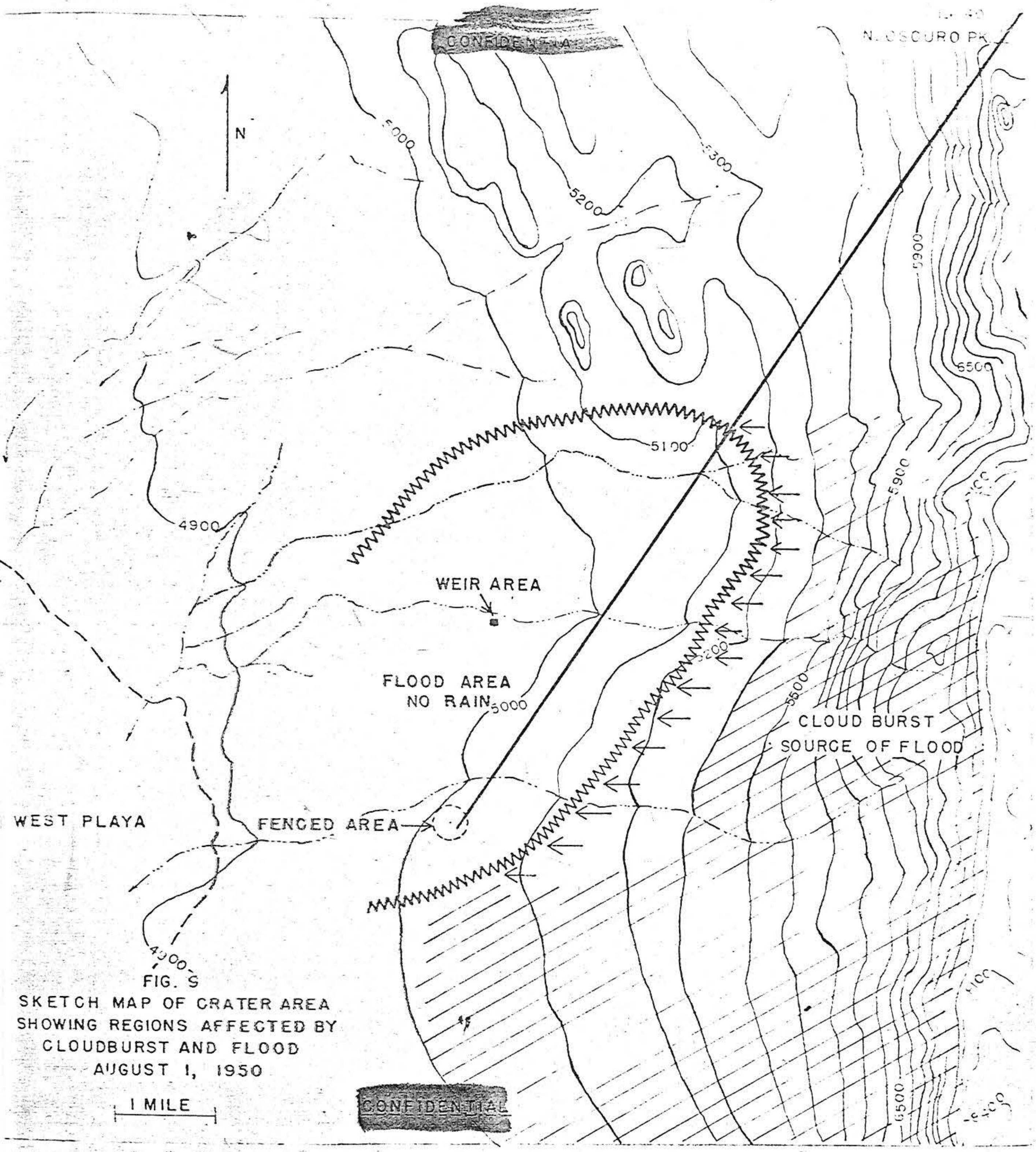

FIG. 9
SKETCH MAP OF CRATER AREA
SHOWING REGIONS AFFECTED BY
CLOUDBURST AND FLOOD
AUGUST 1, 1950

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Table XVII

INDICATION OF DOWNWARD MOVEMENT OF
BETA AND GAMMA RADIOACTIVITY OF THE PROFILES COLLECTED IN
AREA 21, HARVEY GATE, LATERAL 20 AND AE-2 IN 1949 AND 1950

Results are given as disintegrations per second per gram of soil

Location	21-A		21-B		21-C		Harvey Gate		Lateral 20		AE-2
Depth in Inches	1949	1950	1949	1950	1949	1950	1949	1950	1949	1950	1950
0.0 - 0.5*	6.1	1.0	2.8	4.5	5.1	4.2	6.0	9.4	---	2.4	3.6
0.5 - 1.0*	3.1	Bkgd	0.6	3.0	1.6	0.4	Bkgd	2.2	---	0.4	5.4
1.0 - 1.5*	---	Bkgd	---	0.6	---	Bkgd	---	Bkgd	---	Bkgd	Bkgd
0.0 - 1.0	---	3.9	---	8.5	---	5.7	---	7.2	3.9	3.0	4.8
1.0 - 2.0	0.4	Bkgd	Bkgd	1.0	Bkgd	0.4	Bkgd	1.8	Bkgd	Bkgd	0.4
2.0 - 3.0	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd	0.4
3.0 - 4.0	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd
4.0 - 5.0				ALL INCREMENTS BELOW THIS LEVEL WERE BACKGROUND							
5.0 - 6.0											
6.0 - 7.0											
7.0 - 8.0											
10.0 - 12.0											Bkgd
13.0 - 15.0								Bkgd			H.P.
14.0 - 17.0								H.P.		Bkgd	
18.0 - 20.0		Bkgd		Bkgd						H.P.	
20.0 - 22.0		H.P.**		H.P.		H.P.					

* The half inch increments were collected so that a study could be made of the dilution factors when compared to the one inch increments.

**H.P. (Hard Pan) in this area is the characteristic layer of partially lime-cemented clay accumulation that occurs at various depths.

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Soil Profile Studies within the Fenced Area: Six soil profiles were taken each year from within the Fenced Area along the line T-90 - T-270 which bisects the Crater in a southeast-northwest direction. These profiles were located 200, 600, and 1000 feet from Zero in either direction. Table XVIII presents representative data, a comparison of beta-gamma activity with respect to depth obtained from the 1947, 1948 and 1949 profiles at T-90, 600 feet and T-270, 600 feet. Analysis of the 1950 Fenced Area profiles have not been completed at this time. The data are consistent in indicating the absence of any factors other than isotopic decay acting to reduce the radioactivity below the first inch. This is to be expected since the normal annual rainfall in the area is slight, and consequently little leaching by water can take place.

In 1950 two soil profiles were taken within the Crater proper, 75 feet northeast of Zero and 25 feet west of Zero. Only the former has been assayed for activity. The data, shown in Table XIX, show a very significant amount of beta-gamma activity present down to at least two feet below the surface.

Since the radioactivity in the lower levels of the soil profiles within and at 200 feet from Zero can be attributed in part, at least, to neutron induction, the soil profile collected in 1947, 135 feet from Zero under the asphalt road was partially rerun to determine the approximate half-life of the neutron induced activity. Table XX presents these data from which an approximate half-life of 740 days was calculated.

Soil Clays and their Fixation Capacities: Since the chemical combinations of the radioactive fission products contaminating the Chupadera Mesa are not known by this laboratory at this time, it is impossible to completely evaluate the influence of soil clays upon the observed distribution of radioactivity. However, preliminary investigations involving the fixation of soluble isotopes on clays in acid suspension, pH 4-5, indicate that many factors are involved.

The most apparent factor is the different degree of fixation characteristic of each specific isotope. Fixation of comparable concentrations of Cs^{137} and Sr^{90} + Y^{90} at levels far below the fixation capacities of the several clays tested reveals that Cs^{137} is fixed almost quantitatively in some cases while Sr^{90} + Y^{90} is not. At most concentrations Cs^{137} is fixed more completely and in no case less completely than Sr^{90} + Y^{90}.

Investigations of the effects of clay type on fixation were limited to the < 20 micron fraction of several normal soils, commercial kaolin and a Utah bentonite. Kaolinite and montmorillonite, the primary mineral constituents of kaolin and bentonite, respectively, are normally found in soils in varying proportions; they represent the high (montmorillonite) and low (kaolinite) extremes in fixation capacities of the major soil clays. Bentonite adsorbs both Cs^{137} and Sr^{90} + Y^{90} more completely than does kaolin, while the adsorption of either isotope by the soil clays tested is generally as great as, or in excess of that of bentonite. As an example of a Chupadera Mesa soil, the < 20 micron fraction of the four to five inch depth increment of Profile 21B was used. This soil was found to exceed bentonite in the adsorption of Cs^{137} but is exceptional in having a lower fixation capacity for Sr^{90} + Y^{90}. Greater adsorption by the natural soil clays can probably be ascribed, in large part, to the presence of organic matter and the amount of hydrated iron which is absent in bentonite.

In general, the degree of fixation of a given isotope by a soil reflects an equilibrium of that isotope between the solid (clay) and liquid (soil solution) phases. The particular equilibrium established is a function of type, concentration and state of oxidation of isotope, type of clay mineral, particle size distribution, nature and amount of naturally adsorbed cations, nature and amount of organic matter, etc. Consequently, a complete understanding of the role of the fixation capacity of the Chupadera Mesa soils with regard to the distribution of radioactivity in that region depends upon the evaluation of these numerous factors. This is under investigation in this laboratory and will be reported at a later date.

PLANT OBSERVATIONS AND RESULTS

Background Samples: Whenever possible samples of the grass *Bouteloua gracilis*, the predominant grass species in the contaminated area, especially on the Chupadera Mesa, were collected. The only other grass species of which at least five samples were collected in either 1949 or 1950 was *Poa interior*. Typical data showing beta-gamma radioactivities of the "tops" and "old stubs" of *B. gracilis* along with the uncorrected soil radioactivities are presented in Tables XXI and XXII. A partial summary of other background data, including *Salsola pestifer* (Russian thistle) which is at present the predominant plant species in the Fenced Area, is presented in Table XXIII.

Other plant samples obtained on the Chupadera Mesa in 1949 and 1950 consisted of twenty samples of juniper bark from various locations and ten samples of yucca leaves collected in Area 21. The mean beta-gamma radioactivity of the juniper bark was 4.64 dis./sec./gm. of dried material. This is about forty-five times the average background value (0.11 dis./sec./gm.) for this material. The high values obtained with the juniper bark are most likely attributable to particles of radioactive material adhering to the rough surface of the bark. These may well have been deposited on the bark during the Fall-out from the radioactive cloud.

45 Times in Bark

*

The yucca samples had a mean activity of 0.30 dis./sec./gm. dried material compared to 0.30 dis./sec./gm. for the background samples. Yucca being a deep rooted plant has not taken up any of the soil activity which is restricted to the upper two inches of soil.

<u>Plants from the Crater Region</u>: At present the only plant growing within the Fenced Area in sufficient numbers to permit systematic sampling is the Russian thistle, <u>Salsola pestifer</u>. Samples of this plant were collected in 1948 and 1950 along the four principal radials within the Fenced Area. Only a few of the 1948 samples were assayed at that time, but the complete 1948 series was assayed in 1950 along with the 1950 samples. The complete data are presented in Table XXV. Direct comparison of the data is difficult due to the isotopic decay occurring during the two years between sampling and the radiological assays of the 1948 samples. The few cases where samples were collected and assayed in 1948 serve to point out that the plants growing in the Crater Region in 1950 were as radioactive as the same species in 1948, even though the soil activity has decreased markedly in that time. The decrease in activity between 1948 and 1950 in

Thistle

the plant samples collected in 1948 show that the radioisotopes taken up by the plant had an apparent average half-life of about 300-400 days. See Discussion, p. 75.

Root soil samples were not obtained with these plants, hence no exact evaluation of the ratio of soil-plant radioactivity is possible. Some indication of the soil activity at the various sampling locations can be obtained from the mr./hr. data obtained adjacent to these radials (Table VI and from the soil profile data (Tables XVIII and XIX).

Laboratory and Greenhouse Studies on Soil-Plant Interrelationships: The data presented herein come from a desert area where only native or naturally occurring vegetation was sparsely available. Interpretation of the foregoing soil-plant data in terms of soil-plant interrelationships in agricultural areas requires supplementary data. Greenhouse experiments are currently in progress on the uptake of soluble radioisotopes from various soils by several economically important crops to bridge the gap.

Five crops, barley, beans, carrots, lettuce and radish are being grown on a California soil, Sorrento. In addition, barley is being grown on three other California soils: Aiken, Yolo and Hanford and on a mixed desert soil (Mojave and Karro types) typical of the Trinity Region in New Mexico collected near Deming, New Mexico. The soils were sieved to remove the <150 micron fraction. The soluble isotopes, $Sr^{90} + Y^{90}$ and Cs^{137} were fixed on this fine fraction and the soils reconstituted. All soil activities are between 94 and 108 dis./sec./gm. of reconstituted soil. The controls are the same soils with no contamination.

In addition to the soluble isotope being used in the present studies, barley and radish are being grown in soil to which powdered Trinitite has been added to give activities of about 100 dis./sec./gm. of reconstituted soil. In one set of pots the Trinitite is thoroughly mixed with the total quantity of soil and in another set it is spread over the surface of the potted soil forming a layer one half inch deep.

Tables XXVI and XXVII present some of the data obtained to date. Especially noteworthy is the wide variation in uptake of the two isotopes, and the lack of uptake of radioactive material from the Trinitite which presumably contains both Cs^{137} and $Sr^{90} + Y^{90}$ as fission products of the New Mexico Bomb Test, but in insoluble form.

Table XXVI

AMOUNT OF UPTAKE BY BARLEY OF $Sr^{90} + Y^{90}$ AND Cs^{137} FROM SEVERAL CONTAMINATED SOIL TYPES IN 4 WEEKS

Soil Type	Aiken	Hanford	Mixed Desert	Sorrento	Yolo
	Dis./sec./gm. Plant Dry Material				
Leaves					
Control	2.43	1.96	0.93	2.41	1.46
Cesium	3.27	8.47	2.60	2.88	2.18
Strontium	181.0	208.0	102.0	143.0	72.2
Stems					
Control	3.86	2.56	1.56	2.99	2.45
Cesium	3.82	4.00	2.30	3.85	2.60
Strontium	137.0	149.0	85.7	111.0	62.1
Soil Activity	Dis./sec./gm. of Reconstituted Soil				
Cs^{137}	102.0	104.0	97.0	99.0	107.0
$Sr^{90} + Y^{90}$	108.0	94.0	97.0	95.0	97.0

DISCUSSION

Radiological Survey: The radiological survey data gathered from the Chupadera Mesa, particularly that from Area 21 and the Ratliff Area in 1949 and Area 21 in 1950, show that measurable amounts of radioactive fission product contamination resulting from the First Atomic Bomb Detonation on July 16, 1945 still are present throughout the hundreds of square miles previously described, Report UCLA-32. The detailed surveys of Area 21 and the Ratliff Area show that relatively small changes in elevation (300 feet or less) had no detectable effect evident at this late date on the distribution of the Fall-out. The highest mr./hr. readings were observed in clumps of grass, on fallen and partially decayed pinon and juniper needles, or wherever accumulations of organic matter occur. There is little evidence of lateral migration of the contaminants in these areas except from the barren rocky slopes which gave the lowest readings. As previously indicated the average readings in these two areas were generally below 0.3 mr./hr. Individual readings ranged from 0.006 to 0.5 mr./hr. with most of the individual locations reading about 0.2 mr./hr.

In the Crater Region surface mr./hr. readings outside the Fenced Area are decreasing year by year, and the area showing measurable amounts of radioactive contamination is decreasing in extent. Only along the line of drift are readings of more than twice the instrument background encountered outside of the Fenced Area. Within the Fenced Area the radioactivity is decreasing year by year with a resultant reduction of the area constituting a direct radiation hazard. As of August 1, 1950 the area for 50 mr./24 hrs., gamma radiation, has shrunken to a diameter of approximately 700 feet. Over a period of four years this diameter has decreased 700 feet, i.e., from approximately 1400 feet to the present 700 feet.

Erosional Factors in the Crater Region: The Weir Area which is located about two miles north northeast of the site of detonation was originally selected and laid out for the purpose of studying the effect of the erosional agents, wind and water, in removal of fission product contaminants from the areas of original Fall-out. While the data accumulated from this area to date consist primarily of surface mr./hr. readings, they indicate that several factors enter into the overall erosional picture. The relatively high surface radioactivity readings in the northern sector of the Weir Area, which is comparatively densely covered with shallow rooted plants, points out the great effect that plant cover has in reducing erosion. The southern sector is only sparsely covered by deep rooted plants which offer little resistance to the lateral migration of the radioactive contamination and surface activity readings are consequently lower in this sector.

In 1949 the drainage channels in the Weir Area showed very low mr./hr. readings, both in the channel bottoms and on the steep, heavily eroded headlands. This is evidence that water runoff is effectively removing some of the contamination from the area of Fall-out. During the eleven months intervening between August, 1949 and July, 1950 wind-blown soil filled the main channel to a depth of six inches. Depth increments of profiles cut through this material indicate erratic distribution of radioactivity throughout the deposit, Table XI, p. 36. When the large amount of material involved is taken into account the total activity represented by this deposit is great.

1. Wind Erosion: Further opportunity to study the effect of wind as an erosional factor in the Crater Region was found in wind-blown soil accumulations several inches deep at the Crater Fence and adjacent to a

WIND

The drift material collected along the timber and I-beams northwest of the Fenced Area is known to have accumulated during the early part of 1950, as the beams were placed there during January or February of that year. This is based on information furnished by Mr. D. MacDonald, co-owner of the land on which the detonation took place. Beta-gamma radioactivity in this wind-blown material ranged from 4.2 to 6.3 dis./sec./gm. This material not being in the Fall-out area must have come from within the Fenced Area and is conclusive evidence that radioactive material is being transported from the Fenced Area by wind. This is quite feasible since no vegetation was growing in the Fenced Area July 7 and hence accelerated wind erosion was possible for at least three months. See Fig. 17.

WIND

no vegitation 1950 in CRATER

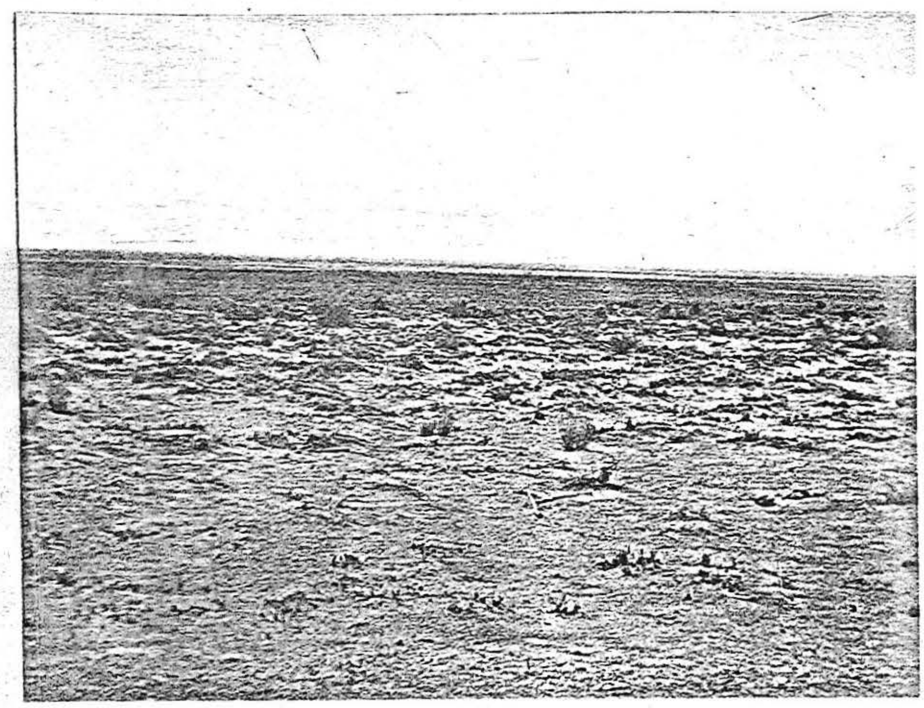

Fig. 17

Crater, July 7, 1950, showing no growing vegetation.

larger timber and a steel I-beam located 300-500 feet northwest of the Fenced Area along T-270.

The depth increments of profile samples collected in the drift material along the fence showed a significant amount of beta-gamma radioactivity throughout, with some increments showing as much as 12 dis./sec./gm. of silt and clay. Such a level of activity could only have originated from well within the Fenced Area. No estimate is possible of the exact time at which this material was deposited, but significant accumulations were first observed in 1948. It has no doubt been accumulating at varying rates during the years since the detonation, especially after the 1948 crop of thistle (the first significant plant cover since July, 1945) accumulated at the fence. In many locations accumulations of wind-blown plants reached the top of the fence. See Fig. 16.

thistle crop in 1948

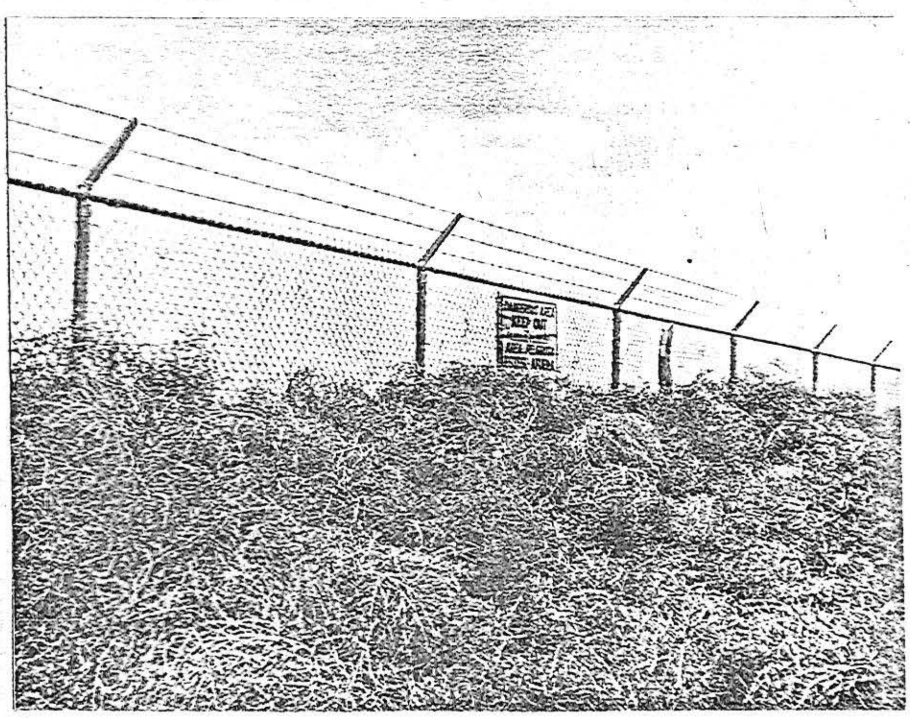

Fig. 16

Thistle accumulation at the Crater Fence-south side.

2. Water Erosion or Runoff: The first rain of the 1950 season fell on July 6th. From observations* made in the Field two days later, it was clear that this rain did not result in any appreciable runoff from the Crater Region. There was no evidence of runoff from that area having occurred between the time of this observation and July 26 when the survey proper was started. Several light showers fell on the area during the following days, none of which resulted in runoff. The heavy rain of August 1, 1950 along the west face of the Oscuro Mountains resulted in a flash flood covering the area from Lateral 2 southward and including the Crater. See Fig. 9.

The data obtained on samples of water, silt and sand collected during the flood from and adjacent to an arroyo draining the area between Laterals 1 and 2 (Table XIII) indicate that radioactive material is carried by runoff water from the areas of lesser contamination. The most active material on a comparative weight basis were the dissolved solids, which probably include small amounts of non-filterable clay particles of sub-micron size. The water-borne silt and freshly deposited silt were of low activity as was the "normal" soil of the area. See footnote, p. 42.

After the flood had receded and the ground had dried out, several samples of freshly deposited silt and the underlying sandy soil were collected in and around the Fenced Area. Silt deposits within the Crater itself, although showing beta-gamma radioactivities as high as 22.5 dis./sec./gm. were always several times less active than the underlying soil or sand. Silt and soil samples collected on the east side of the Fenced Area

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*Observations made by K.H. Larson, during a three-day reconnaissance preliminary to the Biological Survey of August, 1950.

at the point of major breakthrough of water entering the Crater showed background activity. Comparable samples collected at the point of major breakthrough on the west side of the Fenced Area had beta-gamma activities of 2-3 dis./sec./gm.

To supplement the information to be gained from the water-borne samples collected, a survey was made of several small washes north and west of the Fenced Area, and of a large arroyo originating 1.5 miles west of the fence to which the bulk of the observed runoff funnels. See Fig. 18. No evidence was found of measurable concentrations of radioactive material in any of these drainage channels or on the playa on which the entire drainage of the area terminates(1).

Comparison of Wind and Water Erosion: Comparison of the two sets of data on erosional factors in the Crater Region indicates that wind has been the more important erosional factor in spreading the contamination from the area originally affected by the detonation. The much higher activity associated with the wind-blown drift materials, compared to silt deposits at the perimeter of the Fenced Area is in itself conclusive evidence of the greater effect of wind. The conclusion is further strengthened by other observations in the field and by laboratory studies on the solubility of Trinitite.

According to information furnished by Mr. D. MacDonald the months of May and June, 1950 were particularly dry and windy with almost daily severe desert storms affecting the entire valley in which the detonation

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(1) The large arroyo which originates 1.5 miles from the west side of the Fenced Area started four years ago according to Mr. D. MacDonald. At the present rate of recession, this arroyo could conceivably come to have its origin somewhere within the Fenced Area in a few years. It is not uncommon for deeper arroyos to form during one rain due to excessive runoff.

took place. Evidence for this was apparent in the wind-blown soil deposits in the Weir Area, along the I-beams northwest of the Crater and in fresh wind-blown deposits along the various "black-top" roads around the Fenced Area. During the five weeks of the 1950 Field Survey seven dust storms were observed with winds of from 35-55 miles an hour. No two of these storms came from the same direction. Dust clouds were observed rising from fifty to several hundred feet above the floor of the valley. See Report UCLA-108, p. 11.

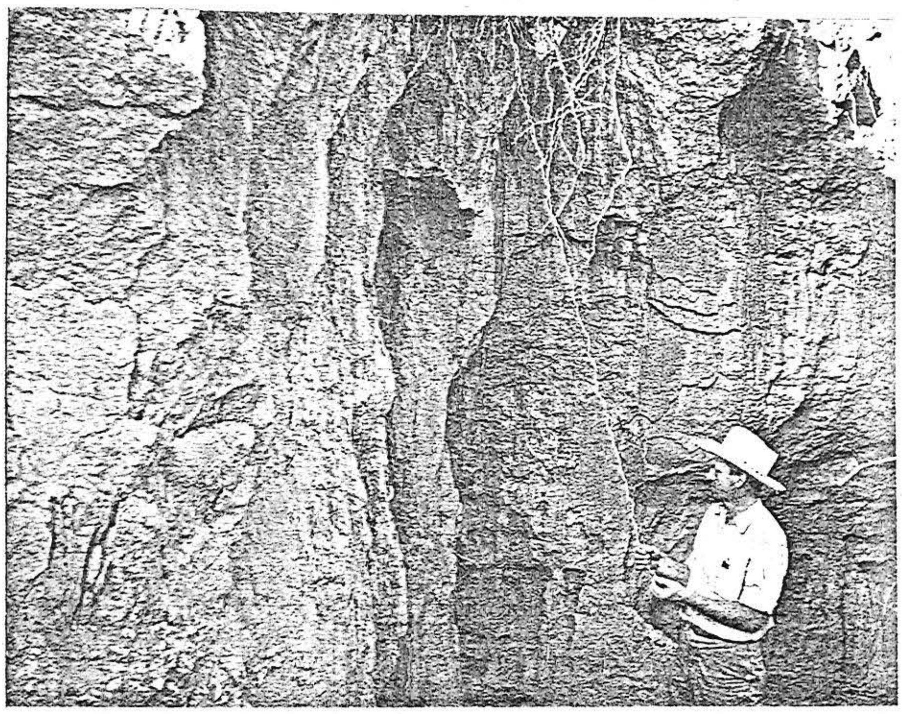

Fig. 18

A wide and deep arroyo near its origin, 1.5 miles west of the Fenced Area. This also illustrates a deep rooted plant.

The wind drifted material sampled, although representing a large total amount of activity, by no means gives a complete measure of the total activity being carried by this medium from the area. The wind-blown material deposited in the vicinity of the Fenced Area consists mainly of the coarser fraction. No estimate is possible as to how much activity is carried away with extremely fine particles to be distributed over an indeterminate but extensive area. Inability to detect concentration of wind-borne contaminants by the usual survey or laboratory procedures away from the Crater Region is due merely to the dilution attributable to the wide scattering. However, it has been demonstrated that even on the calmest days air-borne dust in the Crater Region contains significant amounts of alpha emitters, presumably plutonium. See Report UCLA-108, pp. 11-28. Future detection of plutonium activity may well become the best measure of the extent of contamination now that suitable procedures have been developed for its assay.

In contrast to the great frequency of dust storms in the Crater Region, flash floods are a very rare occurrence. In the four years that the area has been under observation by this group, only two flash floods have been observed, one in 1947 and the other in 1950. The surveys have all been conducted during the season of greatest rainfall in the region, the month of August.

There are several fortunate local conditions preventing the spread of material from the Crater Area by water. All drainage from the region is to a playa approximately four miles west of the Fenced Area. Any contamination carried from the Crater Region by water would be found in that relatively small area. Complete absence of detectable amounts of radioactive materials in this area clearly indicates that no significant amount of contamination has been spread from the Crater Region by this erosional agent. This is not surprising in view of the virtually complete insolubility of Trinitite in water or weak alkali. It is very unlikely that any particulate material would be carried directly from the Fenced Area to the playa when one considers that the duration of these floods is a matter of minutes and that the load of suspended material carried by the water is in the process of being deposited as the floods fan out. In addition, there has never been an observed cloudburst directly over the Fenced Area and consequently no floods have originated in the Area.

Soils: Analysis of the depth increments of the soil profiles collected on the Chupadera Mesa show that the radioactive contamination is still concentrated in the upper one to two inches of soil. However, there is some indication from the 1950 data that downward migration of the radioactive fission products may be taking place. For example, the depth increment from one to two inches at Stations 21-B, 21-C and Harvey Gate showed background activities in 1949 and 1.0, 0.4 and 1.8 dis./sec./gm. of soil respectively in 1950. This is the first indication of any such downward migration of fission product activity. Further investigation is required to definitely establish whether this is actually taking place or if these values are an artifact. If borne out by future studies, this can mean that the contaminants, which are considered to have been insoluble up to this time are becoming more readily soluble due to weathering and thus probably are becoming more available to forage plants growing in the area. It is only through future surveys of the Chupadera Mesa and correlated laboratory studies that the ultimate answers to the many problems involved can be found.

The existing levels of beta-gamma radioactivity in the surface inch of soil on the Chupadera Mesa, ranging from 1 to 9.4 dis./sec./gm. of soil may not at first appear to carry much significance. However, if one assumes that the density of the soils of that area is 2.65, the commonly accepted figure, and calculates the activity per square foot of a soil layer one inch deep, the activity on a per gram basis is magnified approximately 6,250 times. This means that an activity of 6 dis./sec./gm. corresponds to 37,500 dis./sec. or approximately one microcurie per square foot.

per sq foot

As yet no evidence has appeared to indicate any downward migration of the radioactive materials in the Crater Area. Profile depth increments show decreasing activity from year to year at all levels where activity is present. Eventually this picture will change as weathering of the Trinitite progresses further and the resultant material becomes more soluble. The small amount of annual rainfall in the area could then bring about some leaching action. On the basis of present knowledge it appears that several decades might be required before this occurs.

need several decades of studies

The foregoing discussion has been based on the assumption that the radioactive contaminants have remained on or near the surface of the soil purely by virtue of being soluble in water. It is conceivable that even now the bulk of the fission product contamination on the Chupadera Mesa is in a soluble form, and that it remains near the surface as a result of being strongly adsorbed or fixed on the clay particles in the soil. Preliminary laboratory studies on the fixation of Cs^{137} and $Sr^{90} + Y^{90}$ indicate that these two isotopes are independently fixed by different clays and in different amounts. Cs^{137} is almost quantitatively fixed by the clay fraction of the soil from Area 21 while $Sr^{90} + Y^{90}$ are fixed to a much lesser degree by the same clay. This makes it possible to predict that in that particular area soluble Cs^{137} would remain at or very near the surface of this type of soil, whereas $Sr^{90} + Y^{90}$ would be expected to migrate downward by the leaching action of water. This has been observed in the present soil-plant laboratory studies. $Sr^{90} + Y^{90}$ is leached from the pot when excessively watered while Cs^{137} is not. The important

why on surface

clays

soils

implication of this is that certain radioisotopes on or very near the surface are not readily available to plants, whereas they can be taken up and assimilated when present at the depth of the major portion of the root system of the plants, especially so if weakly adsorbed on the clay present in the soils.

IMPT

Soil-plant Relationships and their Fission Product Equilibrium: The background studies of plant samples from New Mexico areas outside of the known area of contamination, conducted to date, have indicated a relatively wide range of natural radioactivity within a plant species. See Report UCLA-75. Even greater variation among species has been observed. The *Bouteloua gracilis* samples collected in 1949 had beta-gamma activities ranging from 0.05 to 0.44 dis./sec./gm. of dried plant material. The root soils from the two extremes had activities of 0.35 and 0.64 dis./sec./gm. of soil. Similar variations were encountered in 1950. In general, comparable variations were observed in the other control species sampled. Agreement between naturally occurring soil and plant radioactivity has been poor, based on the information obtained so far; development of better sampling techniques is perhaps the answer to this problem.

It is impossible at this time to assign any definite reliable value for normal background radioactivity to any plant species studied to date. Further study of the subject may enable reasonable limits to be fixed for a given plant species. Definite differences between species and genera have been observed. Grasses in general have much lower activities than, for example, *Salsola pestifer* or various shrubs. The lack of agreement between plant and soil beta-gamma background radioactivities indicate factors other than specie differences play a major role in determining the radioactivity of plants growing in any particular area.

Mean beta-gamma radioactivities of fission product origin of the Bouteloua gracilis samples collected in Area 21 in 1949 and 1950 were 0.488 and 0.332 dis./sec./gm. or 2.8 and 1.8 times the mean background values for the species respectively. Root soil samples for the two years averaged 12.67 and 5.94 dis./sec./gm. or 18.1 and 8.5 times average soil background. Comparison of the ratio of soil to plant radioactivity reveals that in 1949 the activity of a gram of dried plant material was 3.85% of the activity in a gram of soil. In 1950 this value was 5.59%. This indicates that the remaining soil activity is apparently becoming more available to the plants growing in the area. The fact that any activity whatsoever is being taken up by the plant is a significant observation. The relatively greater uptake observed in 1950, compared to 1949, points out that as a potential biological hazard the remaining of fission product contamination of the Chupadera Mesa is relatively greater now than in the past. The need for further investigation of the Chupadera Mesa in the matter of soil-plant relationships is indicated, since only by field observation and correlated laboratory research can the equilibrium values be established in this or any other contaminated area.

Salsola pestifer (Russian thistle) growing within the Fenced Area in 1950 was as radioactive as was the same species in that area in 1948, based on the few strictly comparable assays. This is an indication that the thistle uptake is at equilibrium with the remaining fission product contamination in the Crater Region (Table XXV, p. 60). Further, the estimated half-life in this plant material is 300-400 days whereas the estimated half-life in certain soil samples from this area is approximately 700 days. The difference may be accounted for by the soil-plant relationships. Within 600 feet of ground zero, which is the present approximate detectable limit of neutron induced radioactivity, there is the added possible complicating factor that the total amount of available radioisotopes (neutron induced) is great enough so that availability of fission products is no longer the factor limiting uptake. From the limited data available at this time on the uptake by plants of radioactive fission products from finely powdered Trinitite (Table XXVII, p. 63), it is highly improbable that any of the activity in the plants growing in the Crater comes directly from the macroscopic fragments of this material. It would appear that in order for Trinitite to become an available source of radioactive material for plants the particles would have to be in the sub-micron size range.

The preliminary greenhouse data presented in this report serve to point out some of the many factors influencing fission product uptake by plants with potential subsequent transfer to animals and man. Although incomplete, these data indicate that the identity and chemical form of the isotopes, differences in soil composition and its chemistry, climatic factors, and inherent differences in plant species all play important roles in the overall picture.

It is apparent from the data presented that no hazard from external total body exposure to penetrating ionizing radiation (gamma rays) exists any place outside of the Fenced Area. Although this has been pointed out many times previously, we can not assume at this time that no hazard exists outside the Fenced Area from the widespread fission product contamination. The problem outside of the Fenced Area is entirely different for there are many potential long term insidious hazards from the present low level contamination which is the focal point of these studies. Evidence is beginning to accumulate from these annual Biological Surveys that such hazards exist. See Reports UCLA-108 and 111).

Cond

Continued study of Trinity, Alamogordo Area, in New Mexico, especially the Chupadera Mesa in conjunction with continued laboratory and greenhouse studies on soil-plant relationships could furnish much valuable information on what may be expected to result following a detonation anywhere in the United States. Only from actual field studies and correlated laboratory research can we hope to gather and correlate information which takes into account all of the major factors which will determine in time the equilibrium reached with respect to radioactive fission products in the total biological system. As our knowledge of this equilibrium increases so must our ability to predict the presence or absence of potential long term hazards to man become possible and logical.

SUMMARY AND CONCLUSIONS

This report presents a greatly compressed summary of additional radiological observations and some consideration of the soil-plant interrelationships due to the residual radioactivity of the Fall-out from the First Atomic Bomb Detonation of July, 1945 in New Mexico. The 1949 and 1950 Biological Surveys were, in part, concerned with the determination of the fourth and fifth year distribution of remaining fission products in soils and plants and their relationships with respect to biological cycling.

Radiological Survey: The radiological survey data from the Chupadera Mesa, twenty to thirty-five miles from ground-zero, in 1949 and 1950, show the continued presence of measurable amounts of radioactive fission product contamination throughout the hundreds of square miles delineated in 1948. Relatively small changes in elevation (300 feet or less) have no detectable effect evident at this late date on the distribution of the

Fall-out. There is little evidence of lateral migration of the contaminants in the areas surveyed by this method, except from the barren rocky slopes.

In the Crater Region, surface mr./hr. readings outside the Fenced Area are decreasing year by year. Within the Fenced Area the radioactivity is decreasing with a resultant reduction of the area constituting a direct external total body radiation hazard. As of August, 1950 the area for more than 50 mr./24 hours, gamma radiation, has decreased in diameter from approximately 1400 feet to the present 700 feet in four years.

Erosional Factors in the Crater Region:

1) Wind Erosion: The depth increments of profile samples collected in drift material along the Crater Fence show a significant amount of beta-gamma radioactivity throughout, with some increments showing as much as 12 dis./sec./gm. of silt and clay. These levels of radioactivity could only have originated from within the Fenced Area. No estimate is possible of the rate of accumulation of wind-borne material; however, significant amounts were first observed in 1948, especially after that year's crop of thistle accumulated at the fence.

Beta-gamma radioactivity was found 300 to 400 feet outside the Fenced Area in seven to ten inches of wind-blown material known to have accumulated within the first seven months of 1950.

Vegetation is the most important influence in decreasing the removal of wind-borne material. This is particularly evident in the Weir Area, a repeatedly studied area two miles north northeast of the Fenced Area.

2) Water Erosion or Runoff: Data obtained from samples of water, silt, and sand collected during a "flash flood" from the area between

Laterals 1 and 2, Left, indicate that radioactive material is transported by water runoff from areas of lesser contamination. Silt deposits within the Crater, although showing beta-gamma activities as high as 22.5 dis./sec./gm. were always several times less radioactive than the underlying soil or sand. This observation is in accord with the well-known physical laws governing erosion and sedimentation and the characteristic pattern of flooding of the Fenced Area thus far observed.

Surveys were made of several washes and a large arroyo north and west of the Fenced Area. No evidence was found of measurable concentrations of radioactive material by the field survey methods employed in any of the drainage channels or on the west playa. Apparently the dilution factors caused by the large amounts of non-contaminated soil transported by the several floods and mixed with Fall-out material have concealed the contamination in the terminal deposits.

Trinite

Studies of the solubility of Trinitite indicate that even finely powdered Trinitite is only sparingly soluble in water and dilute alkali solutions and only slightly more soluble in dilute acids. This factor of insolubility, coupled with the initial deposition of Trinitite as particulate material over a great part of the area contaminated, must be taken into consideration as a partial explanation of the lag of several years before fission products or alpha emitters appear in the biological systems.

Comparison of Wind and Water Erosion: Data on erosional factors in the Crater Region indicate that wind has been more important than water in spreading contamination. This is due to the continued effect of wind during the long dry periods of more than ten months of the year in this semi-arid area. Vegetation protects the surface from the wind effect; however, this is of importance only during the maximum growth period which is determined by the amount and duration of rainfall.

Wind-borne deposits containing a large total amount of radioactivity, do not afford a complete measure of the total activity being carried by this medium. The velocity of the wind varies from time to time and the particle size carried is dependent to a great extent upon the velocity. There are, of course, other controlling factors too, such as surface phenomena, moisture content, etc. Gentle winds would tend to carry only fine material, thus acting as another leaching out process of a specialized nature. No accounting can be made of wind conditions for a great part of the year so that many assumptions must be drawn from the limited observation period, which may or may not be characteristic of the rest of the year.

WIND

fine material

Soils: There is some indication from the 1950 data that downward migration of radioactive fission products in the soil is taking place on the Chupadera Mesa. The existing levels of beta-gamma radioactivity in the surface inch of soil from Area 21 on the Mesa range from 1.0 to 9.4 dis./sec./gm. or an average of approximately one microcurie per square foot one inch deep (6.0 dis./sec./gm. of soil). As yet no evidence has appeared to indicate any downward migration of the radioactive materials in the Crater Area. The predominance of large particles and chunks, coupled with the general insolubility of the Trinitite are probably important factors in the delay of downward migration.

DOWNWARD migration?

The importance of considering individual isotopes with respect to fixation and vertical migration is emphasized by preliminary laboratory studies on clay fixation. Cs^{137} is almost quantitatively fixed by the clay fraction of the soil from Area 21 while Sr^{90} + Y^{90} are fixed to a much lesser degree by the same clay.

Soil-plant Relationships and their Fission Product Equilibrium: It is not possible at this time to assign a reliable value for normal background radioactivity to any plant species studied to date. However, differences between species and genera have been observed. The normal background activity in grass samples (Bouteloua gracilis) collected outside the known area of contamination ranged from 0.05 to 0.44 dis./sec./gm. of dried plant material. The soil associated with the grass roots had background activities ranging from 0.35 to 0.64 dis./sec./gm. of soil.

The ratio of soil to plant beta-gamma radioactivity of residual fission products in Area 21 reveals that in 1949 the activity of a gram of dried plant material was 3.85% of the radioactivity in a gram of soil. In 1950 this value was 5.59%. Thus, the residual soil contamination is apparently becoming more available to the grasses growing in Area 21, twenty-eight miles from ground-zero.

The potentiality of an increasing biological hazard is pointed to by this annual increase in fission product uptake by grass. No sound prediction, or even an estimate, of the equilibrium which must eventually be reached on the Mesa can be made from the facts available at present.

* grass
no estim equilibrium

There is an indication that the uptake of remaining beta-gamma radioactivity by Russian thistle (Salsola pestifer), in the Fenced Area, has reached an equilibrium. This is based on comparative assays of a small number of samples collected from the Fenced Area in 1948 and 1950. The estimated half-life in this plant material is 300-400 days whereas the estimated half-life in certain soil samples in this area is approximately 700 days. Judging from the limited laboratory data available at this time

Here is one

on the uptake by plants of fission products from finely powdered Trinitite, it is improbable that any of the radioactivity in the plants growing in the Crater (five years after the detonation) comes directly from the macroscopic fragments of this material. It may be several years yet before fission products become available to plants in the Crater Area.

Preliminary greenhouse data presented from research in progress, indicate that the identity and chemical form of the isotopes, differences in soil composition and its chemistry, climatic factors, and inherent differences in plant species are all important factors in determining the behavior of the fission products in the overall biological cycle.

It is apparent from the data presented that no hazard from external total body exposure to ionizing (gamma) radiation exists any place outside the Fenced Area. Although this has been pointed out many times previously, we can not assume at this time that no other radiological hazard exists there. It is abundantly clear that the entire area is in a state of flux with respect to distribution and biological availability of radioactive fission products and unfissioned material. Evidence is accumulating from the annual Biological Surveys and correlated laboratory studies that many years may pass before a biological equilibrium with respect to residual contamination is reached. Only when we are in a position to predict with some degree of certainty what this equilibrium will be, can we assess the absence, presence, or magnitude of the biological hazard.