At approximately the same supersaturation, the growth steps moved much faster than they did in crystals grown from pure ammonium dihydrogen phosphate solutions, so much so that it was difficult to photograph the spirals with the light available. As would be expected, the steps appeared to be shallower than those observed under other conditions. Figure 6 shows an enlargement made from 16-mm cine film. At the same supersaturation the number of dislocation sites was markedly increased. The number of single spirals was greater than with crystals grown from pure solution, although some combinations of spirals of opposite hands, forming closed loops, were found. The step heights were more uniform than were those in crystals grown from pure solution, and there was less dominance by one particular spiral. The observation of more dislocation sites in the chromium-contaminated crystals agrees with our observation of higher dislocation densities, as revealed by x-ray diffraction topography in crystal portions contaminated with chromium (*6*).

We also investigated the effect of growing pure ammonium dihydrogen phosphate crystals, observing the typical elliptical growth spirals, and then suddenly introducing a solution contaminated with chromium. This had a startling effect. The surface momentarily became inactive and then was quickly reactivated, with rectangular spirals. This suggests that the habit modification caused by the chromium proceeds by selective adsorption along the one-dimensional growth fronts rather than by adsorption on certain crystal planes, and, further, that the changes in crystal habit are secondary to the changes in the morphology of the growth spirals. If the contaminated solution was replaced by pure solution, the spirals reverted to their original elliptical shape.

By slightly raising the temperature of the cell so that the solution becomes unsaturated, etch pits can be observed and recorded photographically. Etch pits on the {100} face of ammonium dihydrogen phosphate are elliptical in shape, the short axis of the ellipse being parallel to the *c*-axis of the crystal. Therefore, they have a distinct relation to the spiral growth form on that face. Figure 6 illustrates dissolution at a Frank-Read source. The etch pattern is strikingly similar to the growth pattern of Fig. 2. Fewer etch pits are produced on the {101} face; again they have a distinctive pattern resembling that of the growth morphology, being triangular in shape.

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"Trinitite": Cobalt-60, Cesium-137, and Europium-152

Abstract. *Cobalt-60, cesium-137, and europium-152 have been identified in "trinitite," an artifical mineral produced in the first nuclear explosion at Alamagordo, New Mexico, in 1945. Cesium-137 is an expected fission product, but the origin of the other two radionuclides is not certain.*

Operation Trinity, the first nuclear detonation, was a 19-kiloton plutonium device set off on a 30-m steel tower at Alamagordo, New Mexico, 16 July 1945 (*1*). The debris found around the site, consisting of fused soil, materials of construction, and parts of the device, has been named "trinitite." Larson and co-workers reported on investigations of plutonium and fission products in "trinitite" and other environmental materials at the test site

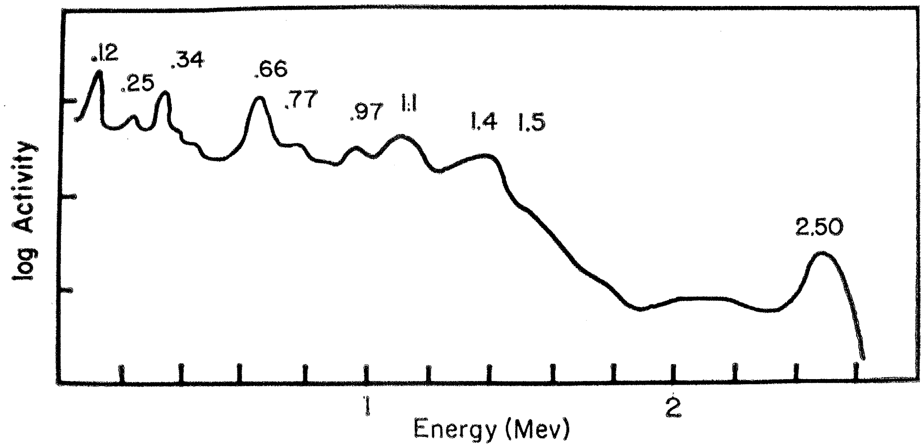

Fig. 1. Gamma-emission spectrum of trinitite.

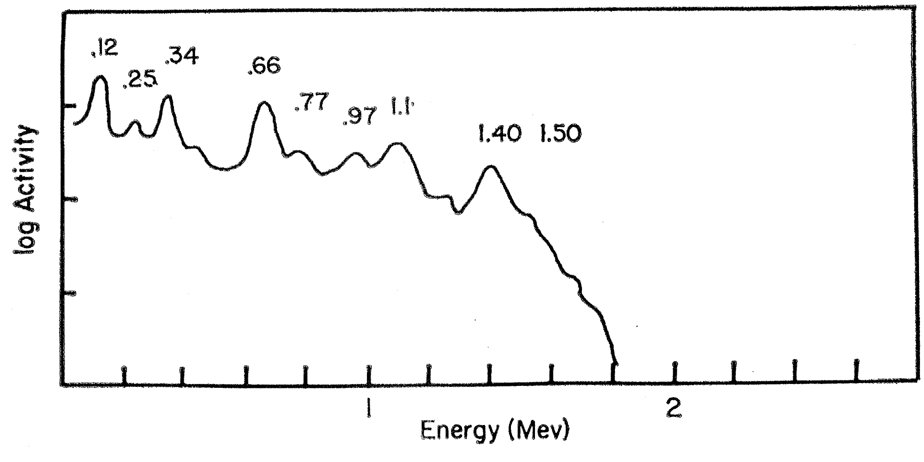

Fig. 2. Gamma-emission spectrum of trinitite with cobalt-60 subtracted.

studied up to 6 years after the test (*2*).

Now, 20 years later, we have obtained the γ-ray spectra, over the energy range 0.1 to 3 Mev, of random pieces of trinitite from three independent sources, with a NaI(Tl) crystal (20 by 10 cm). Samples from the three sources gave similar γ-ray spectra (Fig. 1). Moving the sample away from the face of the crystal lowered the peaks at 1.5 and 2.50 Mev relative to the peaks at other energies, an indication that the peaks at 1.5 and 2.50 Mev are due to sum effects.

The peak from the long-lived fission product Cs^{137} (30.5-year half-life) at 0.662 Mev is readily recognized in the spectra. As expected, other significant γ-emitting fission products have decayed so that they are now undetectable. We therefore investigated the long-lived neutron activation products to account for the presence of the other peaks in the spectra.

Cobalt-60 (5.27-year half-life) emits 1.17 and 1.33 Mev photons in cascade with a sum peak at 2.50 Mev. These energies appear in the trinitite spectra. By subtracting an appropriate Co^{60} spectrum from the spectrum shown in Fig. 1, we obtained the net spectrum shown in Fig. 2. This removed the 2.50-Mev peak and improved the resolution of the two peaks at 1.10 and 1.40 Mev. These appear broad in the original spectrum (Fig. 1) as they are distorted by the 1.17- and 1.33-Mev photons from Co^{60}.

The seven major unidentified peaks in the net spectrum (Fig. 2), 0.12, 0.25, 0.34, 0.77, 0.97, 1.10, and 1.40 Mev, are identical with the most abundant photons listed for Eu^{152} (12.4-year half-life) (*3*) and indicate the presence of this radionuclide. Europium-152 has a sum peak at 1.53 Mev also, which accounts for the sum peak we obtained at 1.5 Mev.

Using appropriate radioactive standard sources we estimated the present concentrations (disintegrations per minute per gram—dpm/g) of the major γ-emitting constituents in a sample of trinitite as follows: Co^{60}, 0.4×10^3 dpm/g; Cs ^{137}, 1×10^3 dpm/g; Eu^{152}, 2×10^3 dpm/g. In addition, analysis of the beta activity indicated substantial amounts of the Sr^{90}, Y^{90} pair.

The composition of this local debris is not unique, since we found a similar spectrum for comparable material from one of the early detonations at the Nevada Test Site. No evidence exists for the formation of either Co^{60} or Eu^{152} in fission. They may be products of the neutron activation of stable Co^{59} and Eu^{151}, respectively. Although Co^{60} resulting from nuclear weapons tests was noted previously (*4*), the presence of Eu^{152} in worldwide fallout has not been reported (*5*). If present, it is not of interest with respect to plant or animal metabolism, but could contribute to the external dose of γ-radiation from fallout.

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5. Concurrent measurements made by personnel at the White Sands Missile Range confirm the presence and general amounts of Eu^{152} in this material. We thank them for making their findings known to us.

1 February 1965 ■

Radioactive Strontium: Estimation of the Amount Accidentally Ingested

Abstract. *If radioactive strontium is accidentally ingested or inhaled, the amount absorbed may be calculated with reasonable accuracy from the amount of calcium and strontium excreted in the urine in a single day. The amount retained by the body initially may be calculated from the amount of radiostrontium excreted in the feces in the first few days.*

Considerable work has been done on the metabolism of radioactive strontium (*1, 2*) both because of the risks inherent in the presence of Sr^{90} in fallout and because of the hazards that may result from exposure to large amounts of this radioisotope when it is used industrially. Several accidents have already occurred (*3, 4*) and it is important in such cases to know how much Sr^{90} has been absorbed and how its retention in the body can be decreased.

If, soon after the administration of radiostrontium, ammonium chloride is given orally at the same time as calcium gluconate is given intravenously, the amount of strontium retained in the body is appreciably reduced (*5*). However, in cases of accidents it has been difficult to estimate the amount of Sr^{90} retained. Bradley *et al.* (*4*) obtained estimates of the radioactivity retained by counting the secondary x-rays produced by Sr^{90} with a whole-body counter, by using a formula developed by Bishop *et al.* for use in conjunction with data on radiostrontium excretion (*6*) and by determining the Sr^{90} activity of plasma. To make some of these estimates, the methods of Bradley *et al.* require the accumulation of considerable data (*4*).

The object of this report is to show how a minimum of data can be used to calculate the amount of Sr^{90} absorbed and the amount retained.

The retention and excretion of Sr^{85} were studied in 45 patients, each of whom received an intravenous injection of Sr^{85} (0.1 to 0.4 μc per kg of body weight). Most of the patients were maintained under controlled conditions and their calcium intake was kept constant. Table 1 gives the ranges of urinary calcium, of urinary Sr^{85} for the first day, and of cumulative urinary Sr^{85} for 12 days following administration of the dose. As reported

Table 1. Ranges of Sr^{85} and stable calcium excreted in urine of patients injected intravenously with Sr^{85}, on the first day after administration of the dose and the totals for 12 days. The values are for groups of five patients.

Calcium (mg/day)	Sr^{85} 1st day (% of dose)	Total Sr^{85} excretion for 12 days (% of dose)
6– 33	1.30– 3.96	5.21–17.44
35– 45	3.20– 6.05	14.17–25.15
46– 62	1.10–10.19	5.10–39.32
67– 75	5.05– 8.63	25.17–39.63
85–100	5.97–15.91	21.89–48.69
110–130	3.33–17.06	9.88–48.50
141–158	10.29–23.16	38.38–67.37
166–212	10.85–23.39	26.54–61.28
215–326	14.38–28.00	47.74–68.65