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TRITIUM STUDIES, SOCORRO SPRING

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INTRODUCTION

The major water supply for the city of Socorro is a spring located in Tertiary breccia three miles west of the city. The recharge to the spring is probably through joints and fissures from the Snake Ranch Flats area west of the Socorro Mountains. A minor portion of the recharge to the spring is probably derived from local precipitation. The storage time for the waters in the aquifer which recharges the spring has not been known. In an attempt to determine the time for precipitation water to move from the outcrop area to the discharge point, a study is being made of time of passage through the reservoir of tritium peaks derived from the hydrogen bomb series of detonations beginning in the early 1950's.

TRITIUM PROPERTIES AND APPLICATION TO GROUND-WATER STUDIES

The radioactive isotope of hydrogen, H^3, commonly known as tritium, is produced continuously by natural processes in the earth's stratosphere. Secondary neutrons are first produced by collision between particles in the atmosphere and cosmic particles from outer space. Subsequent capture of these neutrons by nitrogen-fourteen nuclei is followed by disruption of the nitrogen atom into atoms of carbon-twelve plus tritium. The H^3 atoms so produced have a short half life of 12.6 years and decay into atoms of helium-three through the emission of low-energy electrons.

The tritium naturally resident in the earth's stratosphere, then, is the balance of production by cosmic radiation against removal by (1) decay into helium-three and (2) by mixing into the earth's troposphere. There results a constant reservoir of radioactive hydrogen which feeds into the water vapor in the atmosphere at a steady rate. Removal of this naturally tritiated water from the moisture pattern of the earth by precipitation provides means by which the age of underground waters can be determined. Once surface waters have disappeared into the ground, their source of supply of tritium is lost and the tritium that remains in the water decays continuously to a smaller and smaller percentage of the total amount of hydrogen isotope present. The ratio of the tritium concentration in underground waters to the normal background concentration of surface waters affords a determination of the time elapsed between entrance into the ground and reemergence in springs and wells.

The normal balance of tritium in meteoric waters has been grossly distorted since 1950 by the several series of hydrogen bomb tests. Each test series provides an anomalous peak in the tritium concentration in the moisture pattern that vitiates most age determinations for underground waters. The tritium bomb peaks do, however, serve as tracers for following the point-to-point migration of the underground waters in an aquifer through the discharge from wells or from seepage. Additional information on rate of flow can be deduced when time correlation of tritium peaks in waters at a discharge point in the aquifer can be made against tritium peaks in the precipitation over the outcrop area of the aquifer.

ANALYSIS OF SOCORRO SPRING WATERS

The tritium laboratory of the Research Division of the New Mexico Institute of Mining and Technology has attempted to determine the storage time for the underground reservoir which supplies the city of Socorro, New Mexico, from a correlation of H-bomb-induced tritium peaks between precipitation and spring waters. Figure 1 illustrates the relation between Socorro spring and the rain and snow waters for the years 1957 to 1960. The tritium concentration in water is expressed in T units. One T unit represents a ratio of 10^{-18} tritium atoms per hydrogen atom. The top curve shows the tritium peaks present in the precipitation data. Other major peaks not shown by the Socorro data occurred in midyear of both 1954 and 1956. The 1959 peak probably represents fallout from the high-yield Russian shots in October 1958. The continuously high level of activity throughout the years of 1957-59 represents continuing activity in bomb testing for that period and compares to a value of less than 10 T units for the period preceding the first major bomb test year of 1954. Correlation of each peak in the Socorro precipitation with peak yield from the bomb detonations is complicated by the scanty rainfall in the Socorro area. As a further complication, rains

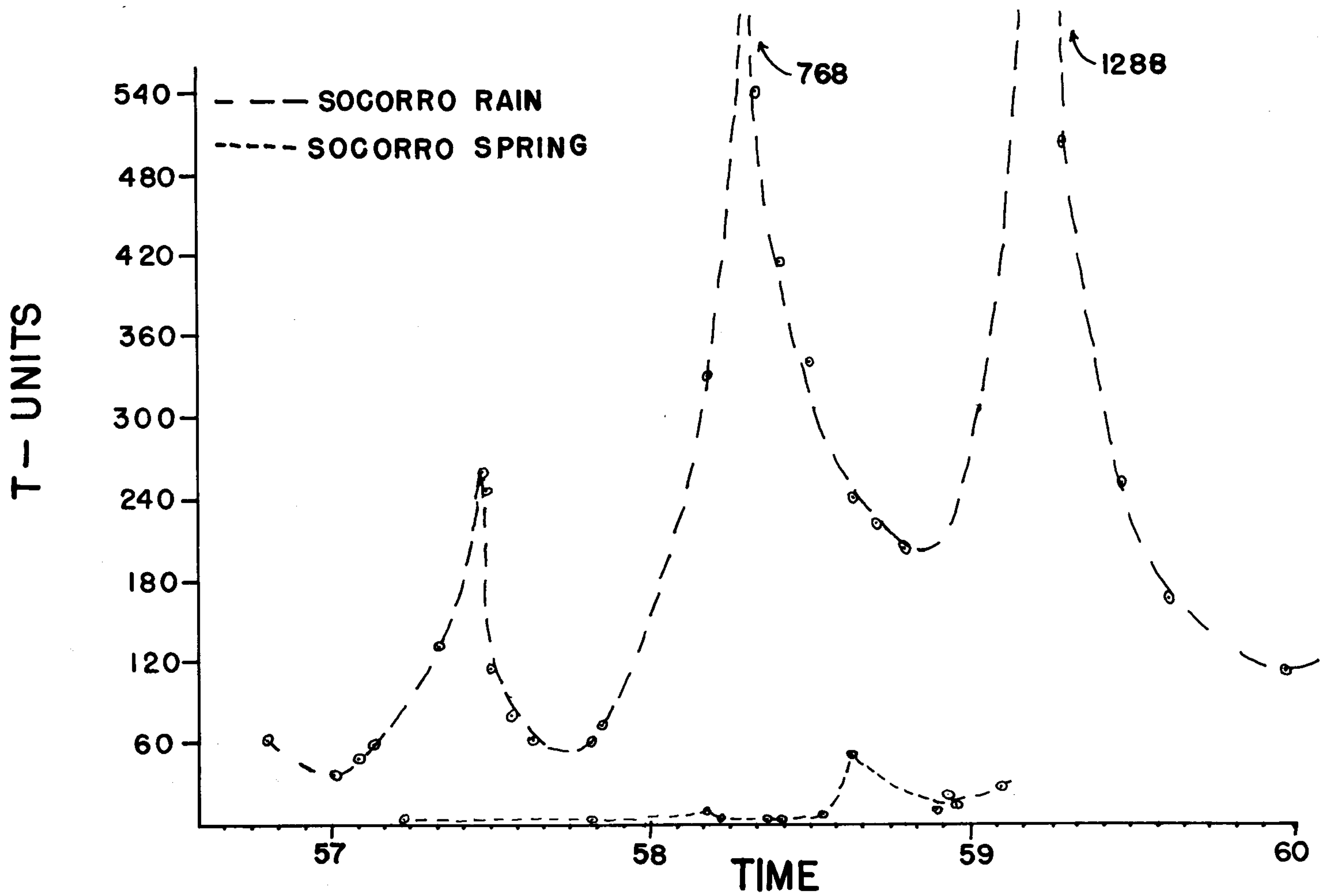

FIGURE 1
Tritium concentration in Socorro precipitation and spring waters.

occurring at Socorro represent a mixture derived from ocean waters and re-evaporated rain water which has fallen earlier.

The lower of the two curves shown in Figure 1 represents the level of tritium activity in the Socorro spring waters. The average value of the concentration was less than 5 T units for the period prior to midsummer 1958 and compares (after radioactive decay) to the low level found for precipitation waters prior to 1954. The first large rise in the tritium concentration in the spring waters occurred in August 1958. For the rest of the year, the activity remained at a level of about four times that obtained for the period prior to August. Stored samples for the remainder of 1959 were lost and no data are available for this period.

Although the data are scanty, consideration of Figure 1 suggests that the storage time for the spring water is at least four years. The first nuclear test series large enough to raise significantly the level of tritium concentration in precipitation waters was the Castle series beginning early in 1954. The August 1958 tritium peak in the spring water is believed to represent water entering the reservoir from that series. If the peak in the spring water represents any of the peaks in precipitation waters shown in Figure 1, it would have had to have been preceded by another peak on the spring-water graph, as the time interval between the precipitation peaks is less than a year. The August 1958 spring-water peak is not believed to represent the precipitation peak from the 1956 bomb test series. For if it does, a previous peak representing the 1954 (Castle) series should have been observed. A number of samples of Socorro tap water for the period 1956-1957 showed consistently low values of less than 10 T units. The major portion of the water of the municipal supply is derived from the Socorro spring. If there were any significant levels of activity for the spring for 1956, this would have been evident in the values obtained for the Socorro tap water. One sample of Socorro spring water analyzed for the summer of 1960 shows a value of 180 T units and probably represents precipitation waters derived from the 1956 bomb test series. The minor peak shown on the Socorro spring-water graph for March 1958 has a value of 10 T units and probably represents precipitation waters derived in local recharge from the tritium peak in the precipitation from the 1958 bomb test series.

If the tritium peak shown on the spring-water graph represents the 1954 precipitation peak, then the reservoir has an average storage time of 4.3 years. Assuming that the distance from the spring to the recharge area in the Snake Ranch Flats is about ten miles, the rate of flow through the reservoir is less than 35 feet a day.

A large number of samples obtained for the period 1961-63 are now being processed and other samples are being collected at monthly intervals. From the results of the analyses of these samples, we hope to be able to confirm the analysis based on the data presently available.