tute of Technology with an instrument having a 30-cm radius and solid source (Table 1).

The first four gasoline samples (Table 1) showed a uniform lead isotopic composition within analytical error. Lead composition of the Shell regular gasoline differed slightly from the average, but this lead alkyl may have been manufactured by another chemical plant. Comparison of the isotopic composition of lead in the Los Angeles basin aerosols with that of the average gasoline lead indicates that these two kinds of lead are indentical within the limits of measurement error. The isotopic composition of such lead represents a typical "tertiary" age lead which is less radiogenic than that of the common "modern" lead. The average isotopic composition of the Pacific sediment lead which represents a "quaternary" age (*5*) is also listed in Table 1 for comparison.

The isotopic composition of lead in the 1963 winter rural snow (*1*) is also similar to that of the Los Angeles basin aerosols. The difference between the rural snow and the aerosols with respect to the ratio of Pb^{206} to Pb^{207} was about 0.8 percent. This could be due to the measurement error or to lead alkyls of slightly different lead isotopic composition.

The isotopic composition of lead in the tetraethyl lead manufactured by the Ethyl Corporation in 1947 is given in Table 1. This analysis was performed by Diebler and Mohler (*6*) on a gas source instrument with errors of about $\pm$ 1 percent for Pb^{206}, Pb^{207}, and Pb^{208}, and of about $\pm$ 5 percent for Pb^{204}. This antiknock additive which was manufactured 17 years ago had more radiogenic isotopes of lead than some present-day lead alkyls have; this suggests that the isotopic composition of the mixed pool of feed lead has changed slightly with time.

The average annual production of lead alkyls in the northern hemisphere is equivalent to about 2.7×10^{11} g of lead for recent years (*7*). If one assumes that this quantity of lead alkyls was combusted and uniformly distributed on the surface of the northern hemisphere, it would amount to an average of 1.1 mg of lead per square meter. The average precipitation at Lassen Volcanic National Park is about 1 m per annum (*8*). Thus, the lead contamination from the leaded gasoline alone at Lassen Park is calculated to be 1.1 μg per kilogram of precipitation. A slightly high value for contamination will be obtained because Lassen Park is situated near industrialized regions.

Since the advent of antiknock gasoline in 1923, more than 2.6×10^{12} g of lead in the form of lead alkyls have been marketed and combusted (*7*). Thus, the average cumulative contamination from industrial lead on the surface of the northern hemisphere is about 10 mg of lead per square meter from gasoline-burning alone. Within highly industrialized and motorized areas, such as the Los Angeles basin, the content of lead in the air should be several hundredfold higher than this average. Part of this lead has been discharging, directly or through runoff, into the oceans; and as pointed out by Tatsumoto and Patterson (*1*), only a short time span is required for the abnormal amount of lead now present in the surface sea water of the northern hemisphere to accumulate. Part of this contaminant has undoubtedly been incorporated into plants and animals (*7*). Because of the well-known toxicity of lead, the overall effect of lead pollutants in the air and on the ground cannot be ignored.

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References and Notes

1. M. Tatsumoto and C. C. Patterson, *Nature* **199**, 350 (1963).
2. A comprehensive résumé of the isotopic composition of the major lead deposits was compiled by J. S. Brown, *Econ. Geol.* **57**, 673 (1962); and that of geochronologic important mineral lead was given by R. D. Russell and R. M. Farquhar, *Lead Isotopes in Geology* (Interscience, New York, 1960).
3. Private communication (1964) with J. Kozikowski of the Ethyl Corporation, Ferndale, Michigan. He stated, "Our records of March 1964 show that the national weighted average of tetraethyl lead content in premium gasoline was 2.49 ml TEL per gallon, and in regular grade gasoline, 1.82 ml TEL per gallon. One ml of TEL is equivalent to 1.057 grams of metallic lead. The ratio of premium-to-regular gasoline sales in the U.S. is about 30 to 70"; (TEL, tetraethyl lead). O. C. Blade [*U.S. Bur. Mines, Rept. Invest.* No. 4702 (1950)] gave the average content of 2.02 ml TEL per gallon of premium gasoline and 1.53 ml per gallon of regular gasoline, respectively. The averages were based on the analyses of 3659 samples from 135 companies. Evidently the lead alkyl content of gasoline has increased in recent years.
4. T. J. Chow and C. R. McKinney, *Anal. Chem.* **30**, 1499 (1958).
5. T. J. Chow and C. C. Patterson, *Geochim. Cosmochim. Acta* **26**, 263 (1962).
6. V. H. Diebler and F. L. Mohler, *J. Res. Natl. Bur. Stds.* **47**, 337 (1951).
7. C. C. Patterson, *J. Am. Med. Assoc.*, in press. We thank Dr. Patterson for making the statistical data available and also for his suggestions.
8. Based on the data of Manzanita Lake Weather Station, California, *U.S. Weather Bureau Climatological Data*, Washington, D.C. (1963).
9. Supported by the NSF and the ONR.

7 December 1964

Thermal Neutron Activation: Measurement of Cross Section for Manganese-53

Abstract. *The product of the thermal neutron activation cross section and half-life for manganese-53 is* $(350 \pm 100) \times 10^6$ *barn-years. If a value of* 2×10^6 *years is assumed for the half-life of manganese-53, then the cross section is 170 barns. This large cross section affords much greater sensitivity for the determination of manganese-53.*

The presence of Mn^{53}, produced by cosmic rays, in iron meteorites was predicted by Sheline and Hooper (*1*) and demonstrated by Honda *et al.* (*2*). It has since been measured in many iron and stone meteorites (*3*). Although the half-life of Mn^{53} has not been determined directly by combining counting data with mass-spectrometric data, Kaye and Cressy (*4*) have estimated it to be $(1.9 \pm 0.5) \times 10^6$ years on the basis of measurements made on an iron meteorite of old terrestrial age and a stone meteorite of short cosmic-ray exposure age. Goel (*5*) found a half-life of 3×10^6 years by similar measurements on a meteorite whose exposure to cosmic rays had been relatively short. At present these values are the best estimates of the Mn^{53} half-life.

Measurement of Mn^{53} in meteorites requires hundred-gram samples and low-level counting systems equipped with heavy shielding and anti-coincidence guard counters. Since Mn^{53} decays by pure orbital electron capture, only a soft x-ray is emitted, and the sample must be spread as thinly as possible to minimize self-absorption. If thermal neutrons are used to convert Mn^{53} to 300-day Mn^{54} according to the reaction Mn$^{53}(n,\gamma)$Mn^{54}, then the more easily measured 0.835-Mev Mn^{54} γ-ray is made available. The purpose of the present work is the determination of the cross section for this neutron reaction.

The fast neutron reactions Mn$^{55}(n,2n)$Mn^{54} and Fe$^{54}(n,p)$Mn^{54} also produce Mn^{54}. Interference from the second reaction can be minimized by purifying the manganese sample prior to irradiation; interference from the first reaction can be reduced only by using a well-thermalized neutron flux.

The Mn^{53} sample used for the irradiation was separated from the Odessa iron meteorite by Honda *et al.* (*2*). Their counting data for Mn^{53} were used to calculate the Mn^{53} activity in the irradiated sample. A check was made for Mn^{54} γ-activity, and it and samples of Mn_3O_4 and Fe_2O_3 were sealed in quartz ampules and irradiated in the isotope-tray position of the Argonne CP-5 Research Reactor for 1 week. The thermal neutron flux was 1×10^{12} n cm^{-2} sec^{-1}. After the irradiation, carriers were added, and manganese and iron separated from each sample. These elements were counted with a γ-counter and, in most cases, recycled and counted again. The Mn^{54} activity in the manganese from Odessa Mn sample was also determined by x-ray counting.

The Mn^{54} activity produced by the irradiation was referred to the 2.58-hour Mn^{56} activity produced in the reaction Mn^{55} $(n,\gamma)Mn^{56}$. The two activities are given by the conventional irradiation equations

$$A_{56} = \sigma_{55}N_{55}f(1 - e^{-\lambda_{56}t_1})e^{-\lambda_{56}t_2} \quad (1)$$
$$A_{54} = \sigma_{53}N_{53}f(1 - e^{-\lambda_{54}t_1})e^{-\lambda_{54}t_2} \quad (2)$$

where A = activity, σ = cross section, N = number of atoms, f = thermal neutron flux, λ = decay constant, t_1 = irradiation time in the reactor, and t_2 = decay time after removal from the reactor. Dividing Eq. 2 by Eq. 1, substituting $N_{53} = A_{53}T_{53}/0.6931$ (where T_{53} = half-life of Mn^{53} and A_{53} = activity of Mn^{53} measured prior to irradiation), and solving for $\sigma_{53}T_{53}$ yields the relation

$$\sigma_{53}T_{53} = \sigma_{55}N_{55}\frac{0.6931}{A_{53}} \times \frac{A_{54}(1 - e^{-\lambda_{56}t_1})e^{-\lambda_{56}t_2}}{A_{56}(1 - e^{-\lambda_{54}t_1})e^{-\lambda_{54}t_2}} \quad (3)$$

If t_1 = 1 week, t_2 = 0, and σ_{55} = 13.2 barns, then

$$\sigma_{53}T_{53} = (566 \text{ barns})\frac{N_{55}A_{54}}{A_{53}A_{56}} \quad (4)$$

The activity in the 0.835-Mev gamma peak was measured shortly after the removal of the irradiated material from the reactor to obtain the counting rate for Mn^{56} and again after the Mn^{56} had decayed to obtain the counting rate for Mn^{54}. The counting rate for the 0.84-Mev Mn^{56} peak was corrected for contributions from the Compton regions of the 1.81- and 2.13-Mev gammas and the counting rate for Mn^{54} was corrected for Mn^{54} from Mn^{55} or Fe^{54}.

The results are presented in Table 1 along with the specific activity or composition calculated from these data. In the case of the Odessa Mn sample the contributions to the Mn^{54} activity made by the reactions Fe^{54} $(n,p)Mn^{54}$ and Mn^{55} $(n,2n)Mn^{54}$ are respectively ≤ 0.013 disintegrations per minute (dpm) and ≤ 42 dpm. These activities are much smaller than the 1.19×10^4 dpm for Mn^{54} activity found and may therefore be neglected. The value for $\sigma_{53}T_{53}$ calculated from these data by Eq. 4 is $(350 \pm 100) \times 10^6$ barn-years. The error on this number was estimated from the uncertainty in the specific activity of Mn^{53} in the Odessa Mn sample and is much larger than the error based on the counting statistics after activation. If a half-life of 2×10^6 years is assumed, then σ_{53} is 170 barns. An increase in specific activity by a factor of 320 is achieved under these irradiation conditions. This large amplification will greatly facilitate the detection and measurement of Mn^{53} in the future.

Table 1. Counting results for Mn^{56} (half-life = 2.58 hours), Mn^{54} (half-life = 300 days), and Fe^{59} (half-life = 45.0 days). The errors shown are standard deviations based on counting statistics only.

Separated element	Radioactive nuclide	Activity in total sample (dpm)	Computed specific activity or composition
		Before irradiation of Odessa Mn	
Total sample	Mn^{54}	$\leq 4.2 \pm 3.4$	
After irradiation of Odessa Mn (sample wt. = 3.5 mg; Mn = 1.63 mg; Mn^{53} = 37 ± 11 dpm)			
Mn	Mn^{56}	$(1.79 \pm .09) \times 10^{10}$	$(1.10 \pm .06) \times 10^{10}$ Mn^{56} dpm/mg Mn
Mn	Mn^{54}	$(1.29 \pm .02) \times 10^4$	
Mn recycle	Mn^{54}	$(1.19 \pm .01) \times 10^4$	$(0.73 \pm .01) \times 10^4$ Mn^{54} dpm/mg Mn
Mn recycle	Mn^{54} (x-ray)	$(1.47 \pm .03) \times 10^4$	
Fe	Fe^{59}	$\sim 6.5 \times 10^3$	
Fe recycle	Fe^{59}	$\sim 6.0 \times 10^3$	3.2 μg Fe/mg Odessa Mn sample
	After irradiation of Mn_3O_4 (sample wt. = 10.0 mg; Mn = 6.60 mg)		
Mn	Mn^{56}	$(7.29 \pm .41) \times 10^{10}$	$(1.10 \pm .06) \times 10^{10}$ Mn^{56} dpm/mg Mn
Mn	Mn^{54}	$\leq 168 \pm 7$	$\leq 26 \pm 1$ Mn^{54} dpm/mg Mn
Fe	Fe^{59}	$\leq 420 \pm 25$	
Fe recycle	Fe^{59}	$\leq 450 \pm 25$	$\leq .08$ μg Fe/mg Mn_3O_4 sample
	After irradiation of Fe_2O_3 (sample wt. = 6.2 mg; Fe = 4.3 mg)		
Mn	Mn^{54}	$\leq 19.2 \pm 5.3$	$\leq 4.5 \pm 1.2$ Mn^{54} dpm/mg Fe
Fe	Fe^{59}	$(2.56 \pm .02) \times 10^6$	
Fe recycle	Fe^{59}	$(2.33 \pm .01) \times 10^6$	$(5.42 \pm .01) \times 10^5$ Fe^{59} dpm/mg Fe

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References and Notes

1. R. K. Sheline and J. E. Hooper, *Nature* **179**, 85 (1957).
2. M. Honda, J. P. Shedlovsky, J. R. Arnold, *Geochim. Cosmochim. Acta* **22**, 133 (1961).
3. M. Honda and J. R. Arnold, *ibid.* **23**, 219 (1961); M. Honda, S. Umemoto, J. R. Arnold, *J. Geophys. Res.* **66**, 3541 (1961); M. M. Chakrabartty, P. J. Cressy, P. S. Goel, J. H. Kaye, J. P. Shedlovsky, *Nuclear Chemical Research at Carnegie Institute of Technology, 1961–1962, Progress Report* (1962), p. 49; J. H. Kaye, *ibid., 1962–1963* (1963), p. 62; P. J. Cressy, *USAEC Report No. NYO-8924* (1964).
4. J. H. Kaye and P. J. Cressy, personal communication.
5. P. S. Goel, personal communication.

16 December 1964

Brain Tumors (Gliomas) Induced in Hamsters by Bryan's Strain of Rous Sarcoma Virus

Abstract. *Gliomas and choroid plexus papillomas were induced by intercerebral inoculation of Rous sarcoma virus, Bryan's strain, in newborn hamsters. Of five pools of virus tested, four were effective when used at high dose.*

After the original isolation of a filterable agent responsible for the chicken myxosarcoma (*1*), a number of strains of Rous sarcoma virus (RSV) with different biological properties have been described. These variants differ with respect to antigenicity (*2*) and host range (*3, 4*). They also show varying pathological effects in chicken fibroblasts grown in vitro (*5*). Differences occur in the morphology of the pock-like lesions produced on the chorioallantoic membrane of embryonated hen's eggs and in the cell comprising the infective foci in chicken embryo tissue culture (*6*).

Whether these variants occur naturally or whether the original strain has been undergoing antigenic or mutational changes as a result of varying techniques for the preparation of virus stocks in different laboratories is not clear at present. The RSV is not species specific (*3, 7*). However, the demonstration that some strains of RSV are capable of inducing neoplastic lesions in rats (*4, 8*) showed that the virus is not class specific.