effect of electronegativity and ion radii as discussed by Jayaraman (*1*) could account for the two different types of high-pressure phases obtained for the structurally similar CdTe and HgTe.

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Cosmic-Ray Exposure Age of the Farmington Meteorite from Radioactive Isotopes

Abstract. *The cosmic-ray exposure age of the Farmington meteorite was found to be greater than 7000 years from the ratio of the carbon-14 and argon-39 present and less than 25,000 years from the ratio of the aluminum-26 and argon-39 present. This exposure age is about an order of magnitude smaller than was estimated previously.*

Cosmic-ray exposure ages of meteorites have been determined from the ratio of the amount of a cosmic-ray-produced stable isotope to a cosmic-ray-produced radioactive isotope. Exposure ages of meteorites have also been estimated from the amount of a cosmic-ray-produced stable isotope alone. Schaeffer (*1*), Anders (*2*), and Arnold (*3*) have recently reviewed this topic. For the Farmington meteorite we determined the exposure age from the radioactive isotopes alone.

Kirsten, Krankowsky, and Zähringer (*4*) measured an unusually low content of the spallation rare-gas isotopes He^3 and Ne^{21} in the Farmington meteorite. Anders (*5*) found the Al^{26} content of Farmington also to be low, 3.6 ± 2.5 disintegrations per minute per kilogram, consistent with He^3 and Ne^{21} values. He interpreted these results to indicate an exposure age of less than 1 to 2×10^5 years. It is also possible to interpret the low He^3, Ne^{21}, and Al^{26} contents on the basis of shielding from cosmic-rays while the meteoroid was in space. The shielding interpretation requires the mass of the meteoroid to be more than 5 tons (metric); this mass is certainly possible. In order to rule out the shielding interpretation it is necessary to measure a cosmic-ray-produced radioactive isotope of a comparatively short half-life. We measured Ar^{39}, H^3, C^{14}, and Al^{26}. From the contents of these radioactive isotopes it is not only possible to rule out the shielding interpretation for the low He^3, Ne^{21}, and Al^{26} contents but also possible to determine the exposure age.

For measuring H^3 and Ar^{39} and for extracting the carbon in the form of CO_2 (*6*), the sample is melted with carrier gas by a radio-frequency heater and the gas is removed from the sample. The hydrogen and argon, after purification, are put into Geiger counters with volumes of 80 cm³ and 0.7 cm³. The CO_2, after purification, is put into a proportional counter of 35 cm³ volume. The Geiger and proportional counters are operated in our low-level counting system (*6*). Since the Farmington meteorite fell in 1890 (*7*), there is a large uncertainty in the H^3 content, 550 ± 150 disintegrations per minute per kilogram. We found that the Ar^{39} content of a 35.3-gram sample obtained from C. Frondel was 7.3 ± 0.4 disintegrations per minute per kilogram, and a 35.7-gram sample obtained from B. Mason was 7.3 ± 0.3 disintegrations per minute per kilogram. This value of 7.3 disintegrations per minute per kilogram for Farmington is approximately the same as the content of Ar^{39} in ten other recently fallen meteorites that we have measured. We have measured the C^{14} content of only two meteorites, Farmington and Bruderheim; we obtained 47 ± 10 disintegrations per minute per kilogram for Farmington and 60 ± 10 disintegrations per minute per kilogram for Bruderheim. We determined the Al^{26} concentrations in two different samples of the Farmington meteorite by the nondestructive γ-γ coincidence method. This method is identical to that used by Anders (*5*). One sample was a 880-gram slice, 13 mm thick, obtained from C. Frondel. The other sample was 200 grams of powder from which the metal was removed; this powder was from a sample obtained from E. Olsen. We counted the 880-gram sample with a pair of crystal NaI(Tl) detectors of 6-inch diameter and 4-inch thickness; we counted the 200-gram sample with a pair of cylindrical 3 by 3 inch NaI (Tl) detectors. We prepared two calibration standards from a powdered mixture of NaCl and Fe with a known amount of Na^{22}. These standards contained 2.05 and 3.15 disintegrations per minute per gram and had the identical mass densities and electron densities as the meteorite samples. To duplicate the configuration of the slice we made an epoxy mold of the slice and poured the calibration powder in the mold. Background standards were prepared in the same way as the calibration standards. We measured 0.4 ± 0.4 disintegrations per minute per kilogram of Al^{26} in the 880-gram slice and 1.6 ± 1.6 disintegrations per minute per kilogram in the 200-gram powder. The errors given are one standard deviation in the counting statistics. These values are to be compared with an average value of about 54 disintegrations per minute per kilogram for chondrites (*8*). We have measured the Al^{26} content in nine chondrites and have found approximately the same average value. The chemical composition of the Farmington meteorite is similar to that of an average chondrite (*7*). Table 1 summarizes our measurements for Farmington.

Table 1. Radioactivity in the Farmington meteorite corrected to the date of fall. The half-life (in years) is given in parentheses.

Wt. of sample (g)	Isotope			
	H^3 (12.4)	Ar^{39} (320)	C^{14} (5770)	Al^{26} (7.5×10^5)
	(disintegration min⁻¹ kg⁻¹)			
35.3	550±150	7.3±0.4	47±10	
35.7		7.3±0.3		
880				0.4±0.4
200				1.6±1.6

The Ar^{39} activity shows that the Al^{26} and C^{14} production rates in the Farmington meteoroid for approximately 1000 years prior to its fall were similar to other chondrites. If the production rates were constant for time, *t*, then *t* is the cosmic-ray exposure age. The Al^{26} and C^{14} activities are related to *t* in years by the equations

$$Al^{26} = 54\,[1 - \exp(-t/1.06 \times 10^6)]$$

$$C^{14} = 60\,[1 - \exp(-t/8.33 \times 10^3)]$$

In the Farmington meteorite the Al^{26} is less than 1 disintegration per minute per kilogram and the C^{14} is within 10 disintegrations per minute of the value

47; therefore, the cosmic-ray exposure age, *t*, is between 7000 and 25,000 years.

If the measurements of rare-gas isotope by Kirsten *et al.* (*4*) are correct, the discrepancy between the content of rare-gas isotope and radioactive isotope implies that the Farmington meteorite might have been shielded by approximately 3 m of material until 25,000 years ago when a collision exposed the material. Three meters of shielding reduces the isotope production by a factor between a hundred and a thousand. If the material is in this shielded state for many million years, the Al^{26} radioactivity only builds up to saturation which is between 0.05 and 0.5 disintegrations per minute per kilogram. However, for the stable isotopes there is no saturation, and He^3, Ne^{21}, and Ar^{38} continually build up with time. The amounts of the stable isotopes produced during the many million-year period can exceed the amounts produced during the last 25,000 years. If the measurement of the Ar^{38}/Ne^{21} ratio of Kirsten *et al.* is correct, it would indicate that Ar^{38} production is greatly enhanced in relation to Ne^{21} production under 3 m of shielding by the action of secondary neutrons on calcium (*9*).

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Binding Capacity of Reductively Fragmented Antibodies to the 2,4-Dinitrophenyl Group

Abstract. *Mild reductive cleavage of the polypeptide chains of antibodies to the 2,4-dinitrophenyl group has been carried out according to the methods of Porter and co-workers. The addition of ε-2,4-dinitrophenyllysine permitted almost complete retention of the antibody binding capacity upon transfer to 1*M *propionic acid. Fractionation of the chains showed that the hapten was specifically bound to the A and not the B chains, and that about 30 percent of the B chains were bound to A in the presence of the bound hapten. The results confirm the conclusion of Porter and co-workers that the A chain is the principal component of the antibody site, but suggest that the B chain may also contribute to the site.*

It is generally accepted that a 6.6*S* γ-globulin molecule consists of two principal types of polypeptide chains linked by disulfide bridges (*1, 2*). These two types are designated H and L by one group of investigators (*2*), and A and B by another (*3*). We will use the A and B designations. The question arises concerning the relationship of these chains to the specific activity of 6.6*S* γ-globulin antibody molecules. Because discrete bands of the B chains, but not of the A chains, of pure antibodies were produced by electrophoresis in starch gels in urea, and because the nature of the band patterns varied with the specificity of the antibodies. Edelman *et al.* (*4*) inferred that the B chains were probably associated with antibody activity. Under the conditions they used to prepare them, however, the separated A and B chains were both inactive. Fleischman *et al.* (*3, 5*), working with γ-globulin preparations containing antiprotein antibodies, separated the A and B chains by methods sufficiently mild to permit the retention of a substantial part of the original antibody activity in certain systems. While neither the A nor B chains retained the capacity to precipitate with the specific protein antigen, the A chain and not the B would coprecipitate with the specific antigen-antibody precipitate. Antibody activity is difficult to measure quantitatively by this method. It is desirable to perform related experiments with pure anti-hapten antibodies whose specific activity can be unambiguously measured. Such experiments have been performed by Utsumi and Karush (*6*), and also in our laboratories.

In our experiments, we used purified rabbit antibodies to the 2,4-dinitrophenyl determinant (anti-DNP) (*7*). These antibodies are characterized by an unusually large affinity for the homologous hapten ε*N*-2,4-dinitrophenyllysine (DNP lysine) (*8*); this was considered advantageous for the retention of antibody activity under adverse conditions. The inter-chain disulfide bridges of anti-DNP and normal rabbit γ-globulin were reduced with 0.2*M* mercaptoethanol in 0.55*M* tris buffer at *p*H 8.2 and the free sulfhydryl groups were alkylated with iodoacetamide exactly according to the procedure of Fleischman *et al.* (*3, 5*). In each of two sets of experiments a portion of anti-DNP and of normal γ-globulin were treated in parallel. In the first set, after dialysis overnight against 0.16*M* NaCl, the reduced, alkylated proteins were dialyzed against 1*M* propionic acid, and 50 mg of each protein was applied successively to a column 75 × 2.8 cm of Sephadex G-75 equilibrated with 1*M* propionic acid. The results of the fractionation are shown in Fig. 1*A*. Absolute yields were, within experimental error, 100 percent of the protein applied. In these, and a substantial number of similar experiments, the relative yields under peaks A and B were 75 ± 1 and 25 ± 1 percent, respectively, entirely consistent with the observations of Fleischman *et al.* (*3*).

In the second set of experiments, the anti-DNP and normal γ-globulin samples were also reduced, alkylated, and dialyzed against 0.16*M* NaCl. However, at this point, the dialysis bags were opened; 2 moles of DNP lysine per mole protein were added to each bag, and the solutions were then dialyzed against 1*M* propionic acid containing $6 \times 10^{-6}M$ DNP lysine. By thus adding the specific hapten to the reduced anti-DNP before exposing the protein to 1*M* propionic acid, appreciable binding capacity could be retained upon subsequent exposure to the acid. From absorbance measurements made at 280 and 360 mμ against the dialyzate as a blank, with the extinction coefficient, $E_{1cm}^{1\%} = 14.6$ at 280 mμ for the protein and $E_{360m\mu} = 0.89 \times 10^4$ for antibody-bound DNP lysine (*9*), *r*, the number of moles of DNP lysine bound per mole of antibody protein, was calculated to be 1.65 at a protein concentration of 0.93 mg/ml in the 1*M* propionic acid containing $6 \times 10^{-6}M$ DNP lysine. The normal γ-globulin sample, on the other hand, after correction for the small protein absorbance at 360 mμ, had the same absorbance at 360 mμ as the dialyzate, and there-