Table 1. Potassium-argon ages and polarities of six volcanic units from the Valles Caldera, New Mexico.

Unit No.	K-Ar age (millions of years)	Polarity
4D049	0.71	Reversed
3X122	.72	Reversed
4D074	.73	Reversed
4D057	.88	Intermediate
3X187	.89	Normal
3X194	1.04	Reversed

reversal, several petrographic, thermomagnetic, and other paleomagnetic "reliability" investigations were made on these rocks. We have not found any evidence that might be construed as indicating self-reversal, and, in fact, these rocks all have quite similar intrinsic magnetic properties. Finally, we note that a self-reversal hypothesis for these data cannot explain the intermediate direction of magnetization for 4D057.

Because polarity intervals of short duration are known in other parts of the polarity epoch time scale—the Olduvai normal event at 1.9 million years and the Mammoth reversed event at about 3.0 million years, during the Matuyama reversed and Gauss normal epochs, respectively (*5*)—the third of the three hypotheses appears most likely. Thus, these data and those previously published suggest the sequence for the more recent polarity changes shown in Fig. 1.

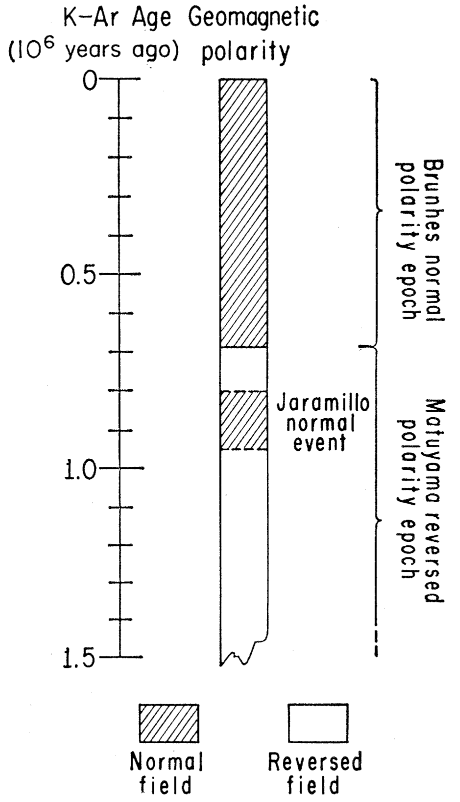

Fig. 1. Suggested sequence of the most recent changes in polarity of the earth's magnetic field.

The placement of the Brunhes-Matuyama boundary is more or less arbitrary in view of the present data. It could be placed between 0.9 and 1.0 million years ago, in which case the three reversely magnetized domes with ages between 0.71 and 0.73 million years would represent a reversed polarity event in the Brunhes normal epoch; or the boundary could be placed at 0.7 million years ago with 4D057 and 3X187 representing a normal event in the Matuyama reversed epoch at about 0.9 million years. For purposes of stratigraphic correlation, the last transition of polarity will undoubtedly be the most useful, and we therefore prefer to assign the epoch boundary at 0.7 million years. Accordingly we here name the normal event near 0.9 million years the "Jaramillo normal event," after Jaramillo Creek, which is approximately 3 km south of the locality of unit 3X187. From the present data it is not possible to tell whether the intermediate direction represents the transition to or from the Jaramillo normal event, nor, therefore, whether the event occurred just before or just after 0.9 million years ago.

Details of these studies as well as those on the other 13 units investigated in this region will be published shortly. Meanwhile, stratigraphers and other scientists making use of the geomagnetic polarity epoch time scale for geological correlation or other purposes may find these recent data valuable and timely.

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2 February 1966

Color Center in Amethyst Quartz

Abstract. *Treatment with x-rays increased the intensity of color of natural amethyst up to fivefold, and an electron paramagnetic resonance spectrum was detected. The intensity of the spectrum was proportional to the intensity of the optical absorption near 545 mμ. The EPR spectrum of the color center corresponded to a positive hole trapped on a substitutional* Fe^{3+} *ion in the quartz structure. We ascribe the color to a charge-transfer transition,* $Fe^{4+} + O^{2-} \rightarrow Fe^{3+} + O^{1-}$.

Studies of electron paramagnetic resonance (EPR) and optical spectra of amethyst have revealed several different Fe^{3+} centers: a substitutional center, S_1, charge-compensated by an interstitial alkali ion (*1*); substitutional centers, S_2, charge-compensated by a proton (*2*); and an interstitial center, I_1 (*3*). Of these, center S_1 appears to be the precursor of the actual color center, which could be formed from it by x- or γ-irradiation. However, the EPR spectrum of the color center itself has not hitherto been identified.

Prolonged irradiation of a natural amethyst with x-rays caused a five-fold increase in the intensity of its color (measured in the 545-mμ band) (*4*). At the same time the intensity of the EPR spectrum of the S_1 center decreased to about one-third of its initial value. An increase in intensity of the S_2 spectrum accounted for about half the decrease in S_1. The residual decrease in intensity of precursor was assumed to be due to conversion to the color center.

Examination of the EPR spectrum at 93°K revealed an intense resonance line, without hyperfine structure, having a minimum width of 7.5 gauss. This line is shown in Fig. 1 for a rotation around the *c*-axis. Its intensity is proportional (within ± 15 percent) to that of the optical absorption at 545 mμ.

A comparison of its maximum intensity with a 1 percent pitch standard (both at 93°K) gave a value for free spins per unit volume of $N = 1.7 \times 10^{18}$ cm^{-3}. This figure is equal to almost one-third of the number of iron atoms present in the sample, as determined by spectrographic analysis. This value of N can be used in the Smakula formula (*5*), together with the intensity of the optical absorption band near

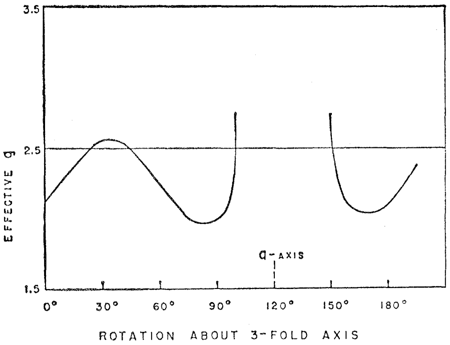

Fig. 1. Electron paramagnetic resonance line of amethyst color center measured at 9.28 Gc/sec.

545 mμ, to compute the oscillator strength f.

$$Nf = 1.29 \times 10^{17} \frac{n}{(n^2+2)^2} \alpha_M \omega \text{ cm}^{-3}$$

With α_M (5.97 cm^{-1}) the maximum absorption coefficient, ω (0.64 ev) the half-width of the transition, and n the refractive index (1.55), the resultant value of f is 2×10^{-2}.

This oscillator strength is much larger than values typical of crystal-field absorption spectra, which may be as low as 10^{-8}. It is of the same order of magnitude as f for the most intense absorptions in $MnO_4{}^{1-}$, which have been explained as transitions of the charge-transfer type (*6*, *7*). We therefore suggest that the amethyst color is due to a charge-transfer transition, which may be written (*8*):

$$O^{2-} + Fe^{4+} \rightleftharpoons O^{1-} + Fe^{3+}$$

The large anisotropy of the effective g value and the intensity of the EPR line indicate that the quadrivalent iron rather than the hole on oxide ion (which should be delocalized) is the ground state of the center. The close relation between axes of pleochroism in amethyst and magnetic axes of the S_1 precursor center also support this assignment (*1*).

An Fe^{3+} ion in a constricted substitutional site should be more readily oxidized. The only other known compounds of quadrivalent iron, however, are the ferrates (*9*) and the complex ion (*10*)

$$\left[Fe^{IV}[o\text{-}C_6H_4(As(CH_3)_2)_2]_2Cl_2\right]^{2+}$$

The complex is green in very dilute solutions, dark red in moderate concentrations, and black in solid salts.

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Lead-210 and Polonium-210 in Biological Samples from Alaska

Abstract. *The naturally occurring concentrations of lead-210 and polonium-210 in certain biological samples from Alaska are unusually high. The concentration processes are similar to those observed for artificially produced radioactive fallout. Concentrations of these nuclides are greater in Alaskan natives than they are in other United States residents.*

In the past two decades research workers in the radiological sciences have increased their efforts to identify and measure the natural radiation levels to which man is subject. These investigations have been prompted in large measure by the introduction of radioactive material into the environment by nuclear weapons and by the high natural radiation levels in various parts of the world (*1*).

More recently, the concentrating of fallout radionuclides in some ecosystems, such as that observed in the arctic regions for ^{137}Cs (*2*) and ^{55}Fe (*3*), has prompted research in the area of "natural fallout," notably the concentrations in the environment of the naturally occurring radioisotopes ^{210}Pb (half-life, 22 years) and ^{210}Po (half-life, 138 days). We now consider the levels of these two isotopes in certain biological samples from Alaska.

The most extensive investigation of natural ^{210}Pb concentrations in man is that of Holtzman (*4*), who also found relatively high concentrations of this isotope in arctic lichens, caribou bone, and antler. This ^{210}Pb undoubtedly derives from the decay of ^{222}Rn in the atmosphere. The high levels of ^{210}Pb in caribou result from concentration by lichens; the process is similar to one observed for ^{137}Cs. We have extended these measurements to include a variety of biological samples from the Alaska region and have analyzed not only ^{210}Pb content, but also ^{210}Po content.

To determine ^{210}Po, samples were first wet-ashed in concentrated nitric and perchloric acids and 30 percent hydrogen peroxide; chemical electrodeposition of the polonium from a dilute hydrochloric acid solution, by the method of Black (*5*), followed. Polonium-208 was used to measure radiochemical yield through the dissolution and plating procedure, the polonium finally being determined by alpha energy analysis with a silicon diode detector and a 400-channel pulse-height analyzer. Since lead is not lost in this procedure, ^{210}Pb was determined in the residue from the polonium plating by the procedure of Sill and Willis (*6*). Lead-212 was used to measure radiochemical yield, and the ^{210}Pb activity was determined by low background beta counting through aluminum absorbers following decay of the ^{212}Pb and the attainment of partial equilibrium between ^{210}Pb and its daughter, ^{210}Bi.

The identification and origin of the caribou samples which were analyzed and the levels of ^{210}Pb and ^{210}Po observed are shown in Table 1. The values listed for caribou are the concentrations existing at time of slaughter and show the relative concentrations in the various organs. Since isotopic tracers were used as determinants of yield, the probable errors in the determinations are due almost exclusively to counting statistics. Care was taken to insure that probable errors from this source were less than 10 percent for the measurements of both isotopes at the 90-percent confidence level.

Table 2 contains the results of the ^{210}Po analysis of a composite lichen sample and certain foodstuffs used by Eskimos living on the western coast of Alaska. Analyses of ^{210}Pb are not included in these particular samples since they are used here only as an indication of the relative levels of ^{210}Po to which these particular in-