support this description. Incompletely etched tracks can also be seen optically in thin, annealed sheets of mica. Acid proceeds from both surfaces but stops when it meets a healed-up portion of track, leaving a constriction.

From the curves in Fig. 1 we deduce that either or both the number and length of healed-up regions increases with increased annealing temperature and probably also with increased time.

In order to date samples accurately, it is necessary for the track densities not to have been lowered by past thermal treatments. These results show that densities are not affected by temperatures of 450°C or less for times of up to 1 hour. The stability of tracks for longer times is not yet known but we may estimate it by comparison with data on tracks in another material. It was found (*7*) that tracks in tektites were stable for 1 hour at temperatures below 500°C (which is comparable to our observation in muscovite of a decrease in number between 450°C and 510°C). If the tracks in mica anneal out under the same conditions, then the extrapolated tektite results would apply to muscovite also. We then calculate that tracks would be stable over the entire age of the earth at approximately 145°C, but would anneal out in only a million years at about 200°C.

The annealing data on lepidolite are less extensive than on muscovite because of the problem of long-lived radioactivity induced in a reactor irradiation. We have found that tracks begin to shorten after a 1-hour anneal at temperatures as low as 200°C. No data are available on track densities.

Let us now compare the relative effects of high temperatures on the reliability of dates derived from K-Ar measurements and those from fission track dating. In K-Ar dating, the measurements cease to be reliable if argon is able to escape. A reasonable value for the activation energy for argon diffusion appears to be $E_{Ar} \approx 1.1$ to 1.2 ev (*9*), and in typical samples the diffusion distance is of the order of millimeters. In contrast, the annealing out of fission tracks occurs at activation energies (E_t) of 2.0 to 2.5 ev in cases so far examined (*6*, *7*) but requires atomic motion of only a few atom spacings. These numbers imply that above some critical temperature, which is a function of $E_{Ar} - E_t$ and the ratio of the two diffusion distances involved, fission tracks will disappear more rapidly than will argon. This critical temperature is estimated to be 100°C when $E_t = 2.5$ ev.

In conclusion, fission-track dating provides a simple and usually accurate method of geochronology for micas less than a few hundred million years old. Although for older micas correct results are sometimes found, track fading appears to be common and may be due to a high ambient temperature over geological times or to a transient period at higher temperature. The extent of this fading may become a useful indicator of thermal history.

The most probable means of extending the technique of fission-track dating to older samples appears to require finding tracks in minerals with higher activation energies for track fading. Recent experiments show that fossil tracks in hornblende are more resistant to annealing than tracks in mica. Other minerals also have been found to contain fossil tracks and annealing and dating studies are in progress.

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Geomagnetic Polarity Epochs

In June of 1963 we published paleomagnetic results from six radiometrically dated volcanic flows from the Sierra Nevada of California (*1*) and 4 months later two additional studies appeared almost simultaneously, one by us on more material from the Sierra Nevada (*2*) and one by McDougall and Tarling (*3*) on volcanic rocks from the Hawaiian Islands. All of the data from these three studies are consistent with the geomagnetic field's having had normal polarity back to about 1 million years (eight radiometric dates from normal flows) and having had reversed polarity between 1 and 1.8 million years (19 radiometric dates from reversed flows). In rocks older than this several discrepancies appear between the results from California and those from Hawaii. In an attempt to account for these discrepancies, we have reexamined all of our data and have found no reason to distrust any of our paleomagnetic or radiometric results, but we have discovered errors in our geologic correlations which remove two of the discrepancies.

The radiometric dates of the rocks in our studies were all obtained in the geochronometry laboratory of Curtis and Evernden at the University of California. Curtis, Evernden, James, Lipson, and Savage (*4*) obtained the dates for our data points *S*1, *S*3, and *S*4, and the others were determined by Dalrymple (*5*). The dates were obtained for reasons other than their paleomagnetic interest, and collections of oriented samples for paleomagnetic study were made subsequently on the basis of published locality descriptions and unpublished field notes. The strength of this approach is that the petrographic criteria used to determine whether samples are suitable for dating were based solely on internal stratigraphic consistency and consistency with mammalian paleontology. These criteria were developed prior to and independently of the paleomagnetic studies. Because of this, the excellent consistency between the paleomagnetic and radiometric data back to 1.8 million years constitutes a strong, independent verification of the accuracy of the techniques developed at Berkeley for the dating of young volcanic rocks.

The weakness of working independently on previously dated material lies in the possibility of errors in geologic correlation. In reviewing our 16 data

points we found that for *S*12, *S*13, and *S*14, all from the Lake Tahoe area, it was conceivable that the paleomagnetic and radiometric samples came from different flows. To check this we have made a joint field trip to the collecting area and have found that in comparing our previous field notes for *S*13 we erred and sampled different flows only a few meters apart, one of which is normal and the other is reversed.

For *S*14, because of dislocations by frost riving at the radiometric sampling site, we collected samples at an undisturbed outcrop 2 km away. The two outcrops had previously been assigned to the same geologic formation (*6*) and they appeared to us to be from the same flow. On checking the radiometrically dated outcrop, we found that the directions of magnetization of multiple samples, although scattered as expectable from disturbance by frost, are all reversed. The polarity of *S*12 is of doubtful paleomagnetic significance because of its tendency toward self-reversal (*2*) and therefore this flow was not investigated further. For both *S*13 and *S*14 it is now clear that the paleomagnetic samples came from flows with normal polarities, whereas the radiometrically dated ones came from nearby reversed flows.

Even after these two data points are corrected, none of the published time scales (*1–3*) is consistent with all of the published data. Despite the remaining discrepancies, the main conclusions of our previous article still appear to us to be valid: the internal consistency of the data, especially among the younger flows, confirms the field reversal hypothesis and the younger polarity epochs are of the order of 1 million years long, although not of equal duration. Whether the remaining discrepancies are due to inaccurate dates, self-reversal, bad geologic correlation, or short polarity epochs can only be resolved by additional work.

The fact that independent investigations in California and Hawaii have enabled us to promptly identify an error of the type here described may serve as a convincing, though embarrassing, demonstration of the usefulness of paleomagnetism for precise world-wide stratigraphic correlation.

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High-Pressure Metallic Indium Telluride: Preparation and Crystal Structure

Abstract. *The metallic high-pressure form of indium telluride may be prepared under high pressure at 150°C and retained at ambient conditions without low-temperature quenching. It has the NaCl (type B1) structure with a cell edge of 6.160 ± .005 Å and a calculated density of 6.887 g/cm³. The density increase relative to the low-pressure polymorph is 15.6 percent.*

At 23 kb and ambient temperature, indium antimonide transforms to an electrically conducting polymorph (*1*, *2*) with the white tin structure (*2*, *3*, *4*). No direct evidence for the ordering of In and Sb in the white tin structure has been obtained because of the similar x-ray scattering power of In and Sb. Darnell and Libby (*3*) prepared the white tin form of InSb for study at ambient pressure by heating to about 100°C at pressures slightly greater than 23 kb, cooling with liquid nitrogen, and then releasing the pressure. The thermal metastability limit for metallic InSb at ambient pressure was reported to be −63°C. Darnell, Yencha, and Libby (*5*) subsequently prepared a high-pressure metallic polymorph of InTe above 32 kb by the same technique used for the preparation of InSb and found that it could be retained metastably at ambient pressure below 125°C. The reported large difference between the thermal metastability limits of metallic InSb and InTe led us to attempt the preparation of metallic InTe without subambient quenching. Finely powdered (−325 mesh) tetragonal InTe was subjected to 50 kb at 150°C in a belt-type apparatus (*6*) for 1 hour. The sample was quenched to ambient temperature while under pressure and the pressure was then released. Essentially complete conversion to the cubic blue metallic phase described by Darnell, Yencha, and Libby (*5*) was obtained. The product was a compact cylinder 0.96 cm in diameter and 0.85 cm high. After 3 days at ambient conditions, the metallic InTe was ground in a mortar to −325 mesh. X-ray powder-diffraction data showed that there was no transformation to the low-pressure form. The high-pressure form of InTe may thus be readily prepared and retained for laboratory study.

Indium arsenide and InP are transformed under pressures of 100 and 125 kb, respectively, at ambient temperature to electrically conducting high-pressure polymorphs with the NaCl structure (*4*, *7*). In addition, the ambient-pressure forms of SnTe and SnSb and of several rare-earth tellurides and antimonides (for example, NdTe, NdSb, PrTe, and PrSb) are reported to have the NaCl structure with cell edges between 6.14 Å and 6.36 Å (*8*). At ambient temperature, SnSb has a slightly deformed NaCl structure and is rhombohedral with $\alpha = 89°38'$ (*9*). Metallic InTe gives an x-ray powder diffraction pattern which may be indexed on a simple cubic cell with $a_0 = 3.07$ Å (*5*). Doubling of this cell permits indexing of the pattern as face-centered cubic and the relative intensities of the reflections are compatible with the NaCl structure (Table 1). The reflections for which the indices are all odd (111, 311, 331, and 511), however, are missing because of the similar scattering power of In and Te. Goryunova, Radautsan, and Kiosse (*10*) have studied the ambient-pressure phases in the In-Sb-Te system by x-ray powder-diffraction methods. They confirmed that InSb has the sphalerite structure with $a_0 = 6.47$ Å as reported by earlier workers (*11*) and concluded that (i) the composition range (3 InSb·In-Te-InSb·3 InTe) is a two-phase region composed of a cubic phase with the sphalerite structure and a cubic phase with the NaCl structure and that the percentage of the latter increases as the Te-rich composition is approached, (ii) the composition (InSb·3 InTe) is a single phase with the NaCl structure and $a_0 = 6.13$ Å, and (iii) InTe has a relatively low-symmetry structure. Their interplanar spacings for [InSb·3 InTe] are essentially coincident with those of the high-pressure form of InTe and reflections with all indices odd are absent. Their x-ray data for the ambient-pressure form of InTe are in agreement