predominantly 2 to 60 μm in diameter (*18*) and have not been visually resolved in this size range; if they are porous or have concave surfaces that can interlock, the above findings may not be valid.

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Fission Track Age of Magnetic Anomaly 10: A New Point on the Sea-Floor Spreading Curve

Abstract. *A portion of basaltic glass retrieved from an abyssal hill in the northeast Pacific has been dated by the fission track method. The sample location corresponds to magnetic anomaly 10 believed to have resulted from sea-floor spreading. The age of this sample is 35 ± 5 million years, which is in agreement with the previously proposed age of 31 to 32 million years based on linear extrapolation of measured recent spreading rates. This observation upholds the suggestions of other authors on the time variation of sea-floor spreading for the last 30 million years in various parts of the world ocean basin.*

Several kilograms of basalt of tholeiitic composition (*1*) have been recovered from an abyssal hill in the northeast Pacific near 32°25′N, 125°38′W. The sample was recovered during expedition Tow Más aboard the research vessel *Thomas Washington* of the Scripps Institution of Oceanography. The hill is elongate north-south, with a flat top and steep linear scarps for its sides. It resulted primarily from postdepositional faulting of the oceanic crust (*2*). The sample was dredged from depths of 4400 to 4300 m off a scarp 100 m high on the east side of the hill. Near-bottom seismic data showed that the scarps on the hillsides are devoid of sediment (*2*). The rock exposed on the scarp is either the original oceanic crust or volcanic outpourings that accompanied the faulting. This hill is located in an area of linear magnetic anomalies believed to have resulted from sea-floor spreading processes. The sample has been taken from the younger positive event of anomaly 10 (*3*) as defined by Pitman *et al.* (*4*).

The ages of the younger magnetic anomalies, up to anomaly 3, are known by comparison with potassium-argon dates of rocks of known magnetic polarity within the interval 0 to 4.5 million years (*5*). Based on these ages, the recent spreading rate of oceanic rises has been determined in many parts of the world ocean basin (*6*). However, because the ages of anomalies beyond number 3 (~4 million years) have not been determined, an estimation of the early Tertiary spreading rates is not possible. Heirtzler *et al.* (*7*) have done the opposite by using a marine magnetic profile from the South Atlantic (V-20, S.A.), which they suggest by a series of arguments represents a record of linear spreading. They dated the anomalies by extrapolating the measured recent rate back in time. The age of the younger positive event of anomaly 10 by their time scale is from 31.50 to 31.84 million years. It was decided to date the present sample to determine if its age was concordant with the linear extrapolation of Heirtzler *et al.* (*7*). If the rock turned out to be younger than about 30 million years it could be dismissed as a recent geologic event, such as a fragment of a lava flow which issued from the fault scarp. If it proved older than the proposed age, the long-term sea-floor spreading rate for V-20 S.A. could be interpreted as being lower than the proposed rate and nonlinear. Then the proposed ages of marine magnetic anomalies (*7*) would have to be revised upward. If the ages were in accordance, then the hypothesis is upheld in this one test, but it is not proved.

Petrographic examination of thin sections of the rock (*1*) indicated that it was unsuitable for potassium-argon dating. The samples possess a glassy crust, 1 to 7 mm thick, that is relatively unweathered. However, recent studies have shown that basaltic glass crusts from rocks dredged at this depth often show large amounts of excess argon (*8*), so that quenched glass is also unsuitable for potassium-argon dating. The fission track method is therefore uniquely applicable for the age determination of this sample.

Fission track dating of authigenic deep-sea glasses has been described previously (*9*). In the work described here, we isolated samples of the glass crust, 0.1 cm^2 in area, potted them in

Table 1. Fission track ages of the basalt glass.

Sample No.		Fossil fission tracks	Induced fission tracks	Neutron flux ($\times 10^{15}$/cm^2)	(million years) Age
109		37	244	4.0	37 ± 6
91		13	200	8.4	34 ± 8
95		9	70	4.0	32 ± 10
	Total	59	409*		35 ± 5†

* Normalized to flux $= 4.0 \times 10^{15}$. † Standard deviation based on standard deviation of number of tracks.

plastic, and polished the surface. They were etched for 6 minutes with 10 percent hydrogen fluoride, and fossil fission tracks were counted in transmitted light. The samples were etched again, 1 minute at a time for three more times, and tracks were counted after each etch. In all cases the track density remained the same within statistical error. The samples were then sent to a nuclear reactor for neutron irradiation. The neutron flux was calibrated both by beta-counting a 0.1 percent gold wire and by counting fission tracks induced in a calibration glass slide. The two methods agreed with each other within 10 percent. After the irradiation, the samples were again etched for 6 minutes and induced fission tracks were counted. The 6-minute etch dissolved more than 10 μm of surface glass, so that we were looking at what had been an internal surface during the neutron irradiation. To check on this, the samples were etched again twice, for 2 minutes each time, and the induced tracks were counted. In all cases the track count was the same within statistical errors. The data are shown in Table 1. Ages are calculated for each sample from the equation:

$$T = 6.21 \times 10^{-8} (N_f/N_i)F$$

where N_f is the number of fossil tracks; N_i, the number of neutron-induced tracks; and F, the neutron flux (*10*). The error in the ratio of fossil to induced tracks is the statistical limitation. This is the error that is listed in Table 1. Because all the ages are in agreement within the statistical limit set by the observed number of tracks, it is legitimate to sum these observations and then apply the above equation. This gives an age for the glass of 35 ± 5 million years. This fission track age is probably a very good approximation to the age of eruption of the rock since annealing of tracks (which is sometimes a serious problem in terrestrial materials) has been shown to be completely negligible for this time interval at ambient ocean water temperatures of near 0°C (*9*). The three samples were taken at various distances from the surface within this crust. There was no correlation of either fossil or induced fission track density with distance, which shows that there have been no serious weathering effects.

The present sample probably represents the age of the original oceanic crust in the area for the following reasons: (i) It was recovered from a fault scarp that seismic evidence shows to have exposed the acoustic basement, or volcanic second layer, through vertical movement; and (ii) evidence of later volcanic activity on the fault scarp is meager at the dredge site, although postdepositional activity is significant in the vicinity (*2*).

The age determined for this sample is in agreement with that extrapolated by Heirtzler *et al.* for profile V-20 S.A. in the South Atlantic. According to the experimental error, the true age of the sample may be as young as 30 or as old as 40 million years. Taking the extrapolated age as 31.75 million years, the implied maximum deviation from linearity in the spreading rate for that profile is +5.5 and −26 percent. Taking the true age as 35 million years the deviation is around −10 percent.

Heirtzler and his colleagues have written a series of papers (*4, 7, 11, 12*) in which they speculate on the probable temporal history of spreading in the world's ocean basin based on the assumption that profile V-20 S.A. is the result of continuous and linear seafloor spreading. Our date generally upholds the proposed anomaly time scale of Heirtzler *et al.* (*7*) for the last 35 million years and the suggestion of other authors of significant time-variation in the spreading rate in various parts of the ocean basin (*4; 11–13*).

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Strontium-90 Concentration Factors of Lake Plankton, Macrophytes, and Substrates

Abstract. *The ratio of concentration of strontium-90 in living and inert lake components to that in lake water (concentration factors) was determined for plankton, macrophytes, and substrates in eutrophic, mesotropric-eutrophic, and dystrophic Latgalian lakes. Concentration factors of strontium-90 in aquatic organisms and substrates are higher in a dystrophic lake than in the other types.*

Among environmental factors caused by man, the effects of man-made radionuclides are unique (*1*). Despite previous work on radioecology of aquatic organisms (*1, 2*), accumulated knowledge is insufficient for solving hydrobiological problems resulting from the use of atomic energy. One such problem involves the role of living and inert lake components in the cycling of strontium-90. Concentration factors (CF), that is, the ratio of a radionuclide in a lake component to that in water, of ^{90}Sr have been studied in the laboratory in planktonic crustacea from Lake Bolshoe Miasovo (*3*). Accumulation of ^{90}Sr by unicellular and filamentous algae (*4*), by *Cladophora* sp. and *Myriophyllum* sp. in English lakes (*5*), and by some freshwater plants (*6*) has been studied. We have now