(*12*). Some method of age trend correction was employed for all indices, except the Alaska, which is developed from trees having no or negligible age trend, a characteristic of some growth in this area previously noted by Giddings (*5*). I have corrected the two groups comprising the Labrador index by plotting Hustich's uncorrected values (*6*) and converting them to percent departures from an eye-fitted age trend curve as described by Schulman (*3*). Schove (*8*) noted that the chronologies comprising the Scandinavia index were corrected, but by differing methods which he did not specify. Adamenko (*12*) stated that his measurements were corrected "according to the method of Rudakov."

The climatic significance of these indices is similar in that they are believed to reflect temporal variations of growing season temperature, but the details of this relationship appear to vary somewhat according to the species and the geographical location. The indices used here are regarded as reflecting primarily June (*10*) or July (*6, 13*) temperatures.

A further relationship involving atmospheric pressure has been suggested. Schove (*14*) stated that his Scandinavia index is indicative of "probable (atmospheric) pressure patterns of individual summers" on the basis that summer temperature is closely related to wind and atmospheric pressure conditions. Adamenko (*9*) tentatively attributed the 25-year lag previously mentioned between the Scandinavia and Urals indices to "the same delay observed in frequency trends of the anticyclonic situations in western and central Europe, compared with those in eastern Europe." During my investigation of Alaskan timberline tree growth, however, I have not found a statistically significant relationship to any climatic parameter other than temperature.

The inference of similarities of major temperature trends based on tree ring indices can be supported by other evidence. Bray (*15*) found that periods of minimal forest growth in British Columbia during 1655–1723, 1799–1833, and, to a lesser extent, 1873–1913, corresponded to similar depressions in Adamenko's polar Urals index as well as to glacial maxima in northwestern North America. It appears that Bray's minimal forest growth periods correspond generally to the Alaskan as well as to the Urals indices. The interior Alaska index also correlates with glacial maxima in the nearby Alaska range, dated by Reger (*16*) as occurring in 1650, 1830, and 1875.

The intent of this paper has been to show that there is a significant degree of similarity in the major oscillations of tree ring indices representative of the circumpolar area. This is suggestive of similarities in long term trends of summer temperatures on a hemispheric basis.

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Sea-Floor Spreading near the Galapagos

Abstract. *Seismicity, volcanism, and a linear pattern of very large magnetic anomalies that show symmetry about a broad negative anomaly suggest that a type of sea-floor spreading occurs near the Galapagos Islands in the east-equatorial Pacific. This spreading results from the tensile stresses generated by different spreading directions of two adjacent segments of the East Pacific Rise, and it is suggested that the area be called the Galapagos Rift Zone.*

The hypothesis of spreading of the sea floor, advanced by Hess (*1*) and Dietz (*2*), proposes that the ocean basins have grown with the continued formation of new crustal material at the crest of the mid-oceanic ridge. Dramatic evidence to support this thesis has been presented by Pitman and Heirtzler (*3*) and by Vine (*4*) from analysis of the pattern of the magnetic anomaly observed over the axial zones of different portions of the mid-oceanic

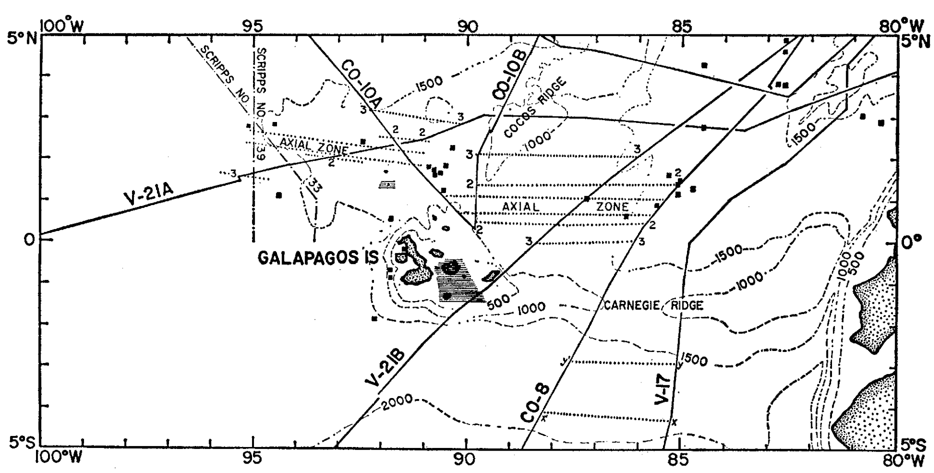

Fig. 1. Location map. Depth contours in fathoms are dashed. Epicenters as determined by Acharya (*7*) are indicated by solid squares. Hachured area indicates region in which Cox and Dalrymple (*8*) found reversely magnetized rocks. Dotted lines correlate magnetic anomalies shown in Figs. 2 and 4. Dot-dashed lines are approximate tracks for the Scripps Institution profiles shown in Fig. 2 (*11*). The west coast of South America appears on the extreme right.

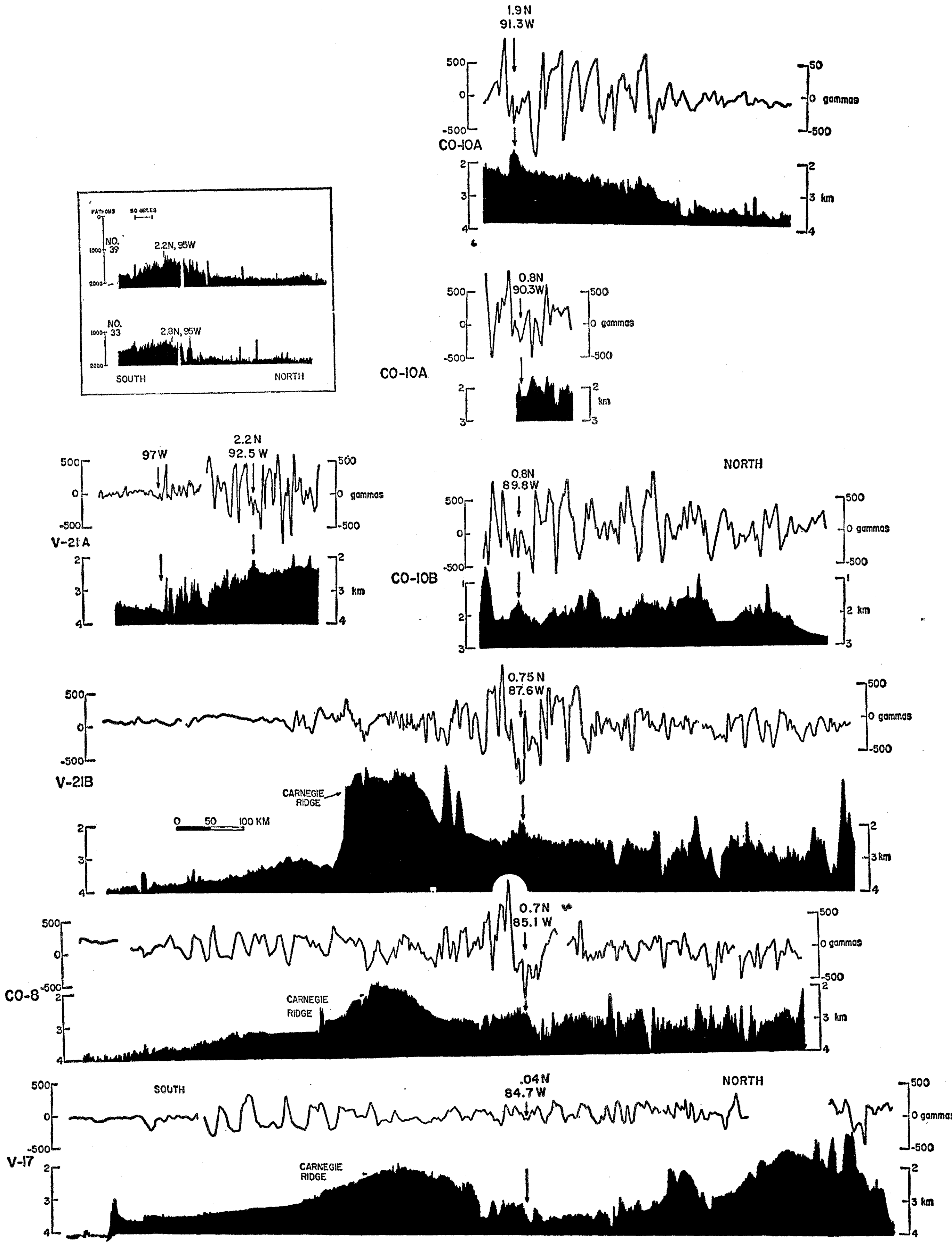

Fig. 2. Projected topographic and magnetic profiles obtained by Lamont vessels along the tracks shown in Fig. 1. The profiles have been projected along a great circle perpendicular to the assumed strike of the anomalous feature. Two topographic profiles (not projected) obtained by Scripps Institution of Oceanography near 95°W (*11*) are shown in the inset.

ridge in the Pacific, Atlantic, and Indian oceans. By analyzing the geophysical data, especially the data on marine magnetism available near the Galapagos, and by applying the hypothesis of spreading of the sea floor, it is possible to construct a history for the area near the Galapagos.

The Galapagos, a group of volcanic islands near the coast of Ecuador in equatorial Pacific, lie at the intersection of the east-west trending Carnegie Ridge and the northeast trending Cocos Ridge (*5*). Menard *et al.* (*6*) have proposed the existence of an east-west-striking Galapagos fracture zone west of the islands. Earthquake epicenters in the area, relocated by Acharya (*7*), show three seismically active areas centered near 1°N85°W, 2°N91°W, and near the west coast of the largest island, Isabela. Figure 1 shows bathymetry with epicenter locations, as determined by Acharya.

Paleomagnetic and radiometric studies of basalts on the islands by Cox and Dalrymple (*8*) showed that all the rocks examined belonged either to the present Brunhes normal epoch or to the Matuyama reversed epoch. The oldest date obtained by the potassium-argon method was 1.5 million years. The older dates and the reversely magnetized specimens were found on the southeastern islands and on Wolf Island in the extreme northwest of the group. The hachured area in Fig. 1 locates the area in which the older rocks were found. Cox and Dalrymple interpreted this pattern in terms of Wilson's (*9*) theory that with sea-floor spreading the age of islands that are formed at the crest of the ridge increases with distance from the crest. If one applies this hypothesis, the Galapagos would be moving toward South America. However, Cox and Dalrymple noted the close association of both old and young lavas on the same islands.

Recent magnetic surveys by Lamont ships *Vema* and *Conrad* have revealed a band of anomalies, with very large amplitudes and short wavelengths, north of the main group of islands. Amplitudes of individual anomalies exceed 1000 gammas, in sharp contrast to the 200-gamma amplitude of the axial anomaly of the East Pacific Rise at the same latitude. Examination of these profiles indicated a linear pattern trending east-west between 85° and 95°W along a line north of the Carnegie Ridge. Accordingly, the Lamont

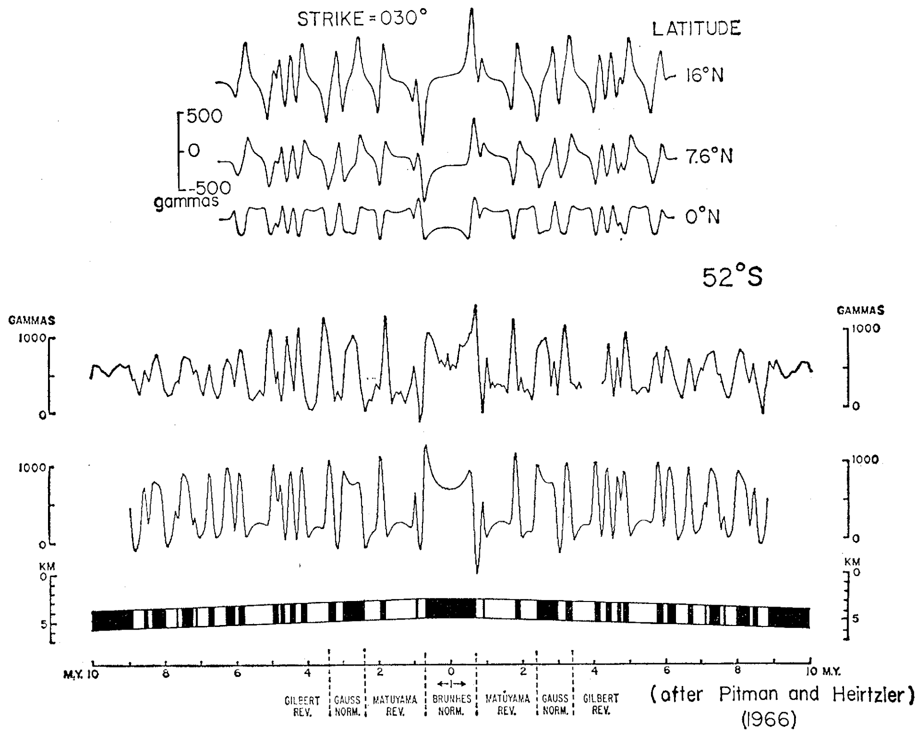

Fig. 3. Computed anomalies for the same structure at different magnetic inclinations. The magnetic profiles have been computed by use of a two-dimensional structure which strikes 30°. For comparison, the *Eltanin*-19 profile of Pitman and Heirtzler (*3*) is shown below. The block structure used in the axial zone of the *Eltanin* model is identical with that used for the anomaly patterns at lower latitudes.

profiles shown in Fig. 2 have been projected along a great circle striking due north, perpendicular to the trend of the lineations. This magnetic pattern is symmetric about a broad, deep negative anomaly that is flanked on both sides by a series of positive anomalies that decrease in amplitude and wavelength with distance from the axis of symmetry.

Topography in the region of the large anomalies is characterized by the absence of sediments and general roughness (*10*). A very small but characteristic bulge is coincident with the magnetic trough axis. Sediments appear on the southern flank of the Carnegie Ridge and to the north of the area near Cocos Ridge. The broad inverted V-shape shown on the two Scripps topographic profiles (*11*) near 95°W resembles a typical cross section of the East Pacific Rise.

The clusters of epicenters found by Acharya at 85° and 91°W are reflected in the magnetic pattern (Fig. 1). East of the eastern cluster, the large anomalies disappear, as shown in Fig. 2 by the *V-17* profile. In the central region between the two clusters, the magnetic axis and topographic bulge can be traced along an east-west line at 0.8°N. At the western cluster of epicenters, the axis is offset to the north; the *CO-10A* profile crosses the axis twice. West of this cluster, the magnetic lineation may trend west-northwest. The topographic axis observed on the two Scripps crossings lies along this trend.

High seismicity near an offset of the mid-oceanic ridge axis was noted by Tolstoy and Ewing (*12*). Recent work by Sykes (*13*), who used very accurately determined epicenters, has shown that nearly all earthquakes located on a fracture zone occur between the offset portions of the ridge axis. If sea-floor spreading occurs in this area, the two zones of high seismicity at 85°W and 91°W may reflect the intersection of offset portions of ridge axis along a fracture zone. The epicenters on the west coast of Isabela Island suggest that the western fracture zone trends northeast along the line joining this area with the group of epicenters clustered about 2°N91°W.

From a study of both topography and magnetics, it would seem reasonable to assume spreading along the axis of magnetic symmetry and to test this hypothesis with the pattern of the model anomaly computed by Pitman and Heirtzler (*3*) for the South Pacific.

The magnetic pattern at the Galapagos bears no resemblance to the pattern

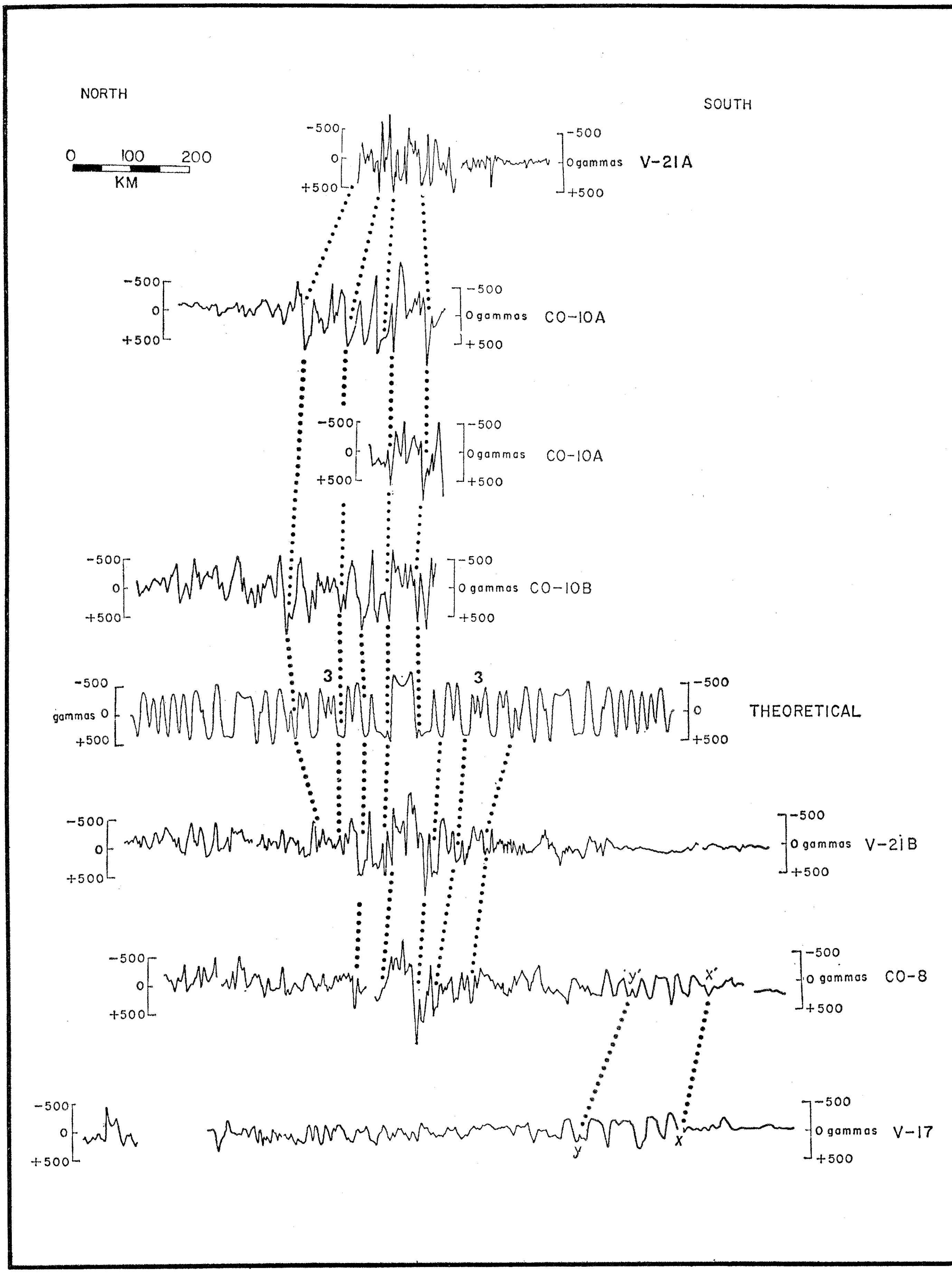

Fig. 4. Observed magnetic profiles and a theoretical profile which assumes a spreading rate of 3.0 cm/year. All the profiles are shown upside down for ease in comparison with anomaly patterns at higher latitude.

over the crest of the East Pacific Rise at 52°S, as shown in Fig. 3. However, the shape of a magnetic anomaly is a function of the latitude and strike of the body; therefore, dissimilarity of shape between these two patterns does not preclude the possibility that both patterns are caused by the same sequence of magnetized crustal blocks. Figure 3 shows the anomaly pattern for identical sets of crustal blocks with the same strike but at different latitude. The *Eltanin*-19 profile of Pitman and Heirtzler is presented for comparison. Both the axial model anomalies for the latitude of the *Eltanin*-19 profile and at low latitudes result from the same set of normal and reversely magnetized blocks.

Paleomagnetic studies of ancient pole positions have shown that the average position of the magnetic pole over a long period of time approaches that of the geocentric axial dipole. The axis of magnetic symmetry lies at 0.8°N in the central region, corresponding to an axial dipole field of +1.6° (down). The anomaly pattern shown in Fig. 4 has been computed with the use of the same set of bodies as were used for the South Pacific axial zone (Fig. 3) but with a spreading rate of 3.0 cm/year. Since the high-latitude profiles are more familiar to the observer and since the equatorial profiles are inverted with respect to those at high latitudes in both northern and southern hemispheres, both the computed and the observed profiles have been plotted upside down. The similarity between observed and theoretical profiles is best shown by the *V-21B* profile from the central region, but it is possible to trace anomalies as far as No. 3 by using the nomenclature of Pitman and Heirtzler on all profiles except the *V-17*. Anomaly No. 3 corresponds to an age of 5 million years. The spreading rate is quite constant in the central zone; it may decrease to the west, as shown on the *V-21A* profile. The abrupt change in topographic slope, and the sudden increase in amplitude of the magnetic anomalies at 97°W shown on this profile in Fig. 2, suggest that this zone of magnetic anomalies does not extend to the crest of the East Pacific Rise.

Menard (*14*) and Smith *et al.* (*11*) have called the topographic high to the west of the islands the Galapagos fracture zone and show it continuing to the coast of South America near the Carnegie Ridge. However, the consistently large magnetic anomalies observed over this area, their linearity, and their symmetry are atypical of fracture zones. It is possible that the pattern is due to dyke intrusion, but the presence of symmetry, although not perfectly displayed, is difficult to explain by this hypothesis.

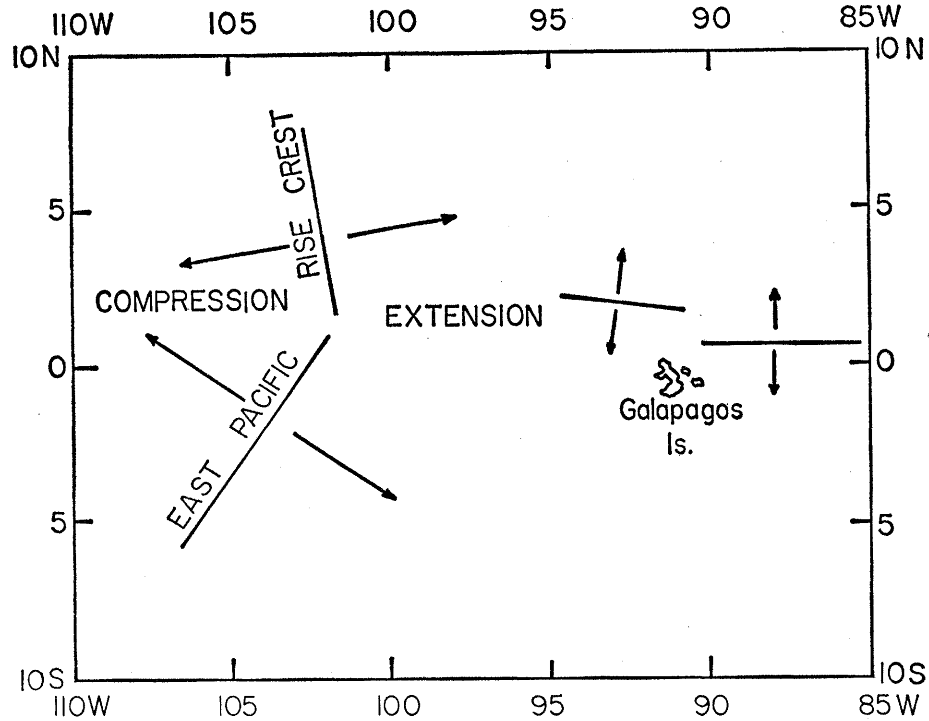

Fig. 5. Possible explanation for the rift zone near the Galapagos. Spreading directions are schematic. Axes of the rise and of the Galapagos Rift are shown by the solid lines.

An alternative explanation for the origin of the anomalies is shown in Fig. 5. The East Pacific Rise changes from a northeast to a northwest trending feature just north of the equator. If both northern and southern sections of this ridge are spreading at the present, as indicated by the high seismicity of the fracture zones between offset sections of the rise axis (*14*), the Galapagos area should be subject to tensile stress as a result of the spreading. This stress would result in fracturing along an east-west line in the Galapagos area. Fracturing would be followed by infilling of lava that would be magnetized in the direction of the earth's field as it cooled below the Curie point. The disappearance of the magnetic pattern east of the central area may indicate a change in the stress pattern caused by the proximity of the continent.

If this hypothesis is correct the area west of the crest of the East Pacific Rise should show compressional features. However, the concept of spreading of the sea floor does not require that both sides spread at the same rate, and the compressional stress on the western flank could be less than the tensile stress on the east.

The Galapagos Islands may have developed with the growth of the fracture zone on the western slope of the largest island. Continued volcanic activity on the islands supports the hypothesis of a growing fracture zone trending northeast near Isabela Island.

Ewing and Ewing (*15*) studied the distribution pattern of sediment in the equatorial Pacific and suggested that a change in the spreading rate occurred about 10 million years ago. Only about 5 million years have been recorded magnetically in the crustal rocks in this area, and this apparent youth may be due to the change in the spreading pattern 10 million years ago.

The presence of a symmetric pattern of very large-amplitude magnetic anomalies and the relation of this pattern to the seismicity and volcanism of the area suggest that spreading of the sea floor occurs near the Galapagos Islands. However, this particular type of spreading is the result of the stresses generated by spreading of the much larger and older East Pacific Rise.

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Quishqui Puncu: A Preceramic Site in Highland Peru

Abstract. *The complete campsite industry from this early site includes crude chopping tools, microblades, and numerous scraper and projectile point types. A square-based variant of the Ayampitín point is distinctive of the earliest occupation, but the incidence and distribution of other types indicate that seasonal use persisted into agricultural and ceramic periods.*

The preceramic archeological sites of Andean South America date from at least 7500 B.C. until the widespread adoption of pottery-making during the second millennium B.C. (*1*). In the central Andes of Peru, preceramic sites occur at very high elevations (over 4000 m) and near sea level on the desert coast, but they are rarely found at intermediate elevations or in valley bottoms where intensive agriculture and dense settlement have destroyed or obscured them during the last few thousand years.

Quishqui Puncu lies at an elevation of 3040 m in a major intermontane valley (the Callejón de Huaylas) between the coastal range (the Cordillera Negra) and the Cordillera Blanca, which forms the continental divide. The Community of Vicos, in which the site is located, extends from the right bank of the Río Marcará up into a glacial valley and pass 4750 m high over the Cordillera Blanca. The Quishqui Puncu site mantles the upper terrace of the Marcará at the point where it is met by a low ridge. The ridge rises as a convenient pathway from the site to the glacial trough and pass above. During the dry summer months, hunters in the Callejón de Huaylas would surely have utilized the green upper reaches of such side valleys, which provided seasonal pasture and browse for the Andean camelids and deer hunted in preceramic times. Quishqui Puncu is ideally situated where a hunting party would leave and regain the river for a trip to the high pastures, and, furthermore, its slight eminence would provide an excellent view of the surrounding countryside and game movements.

The excavated stone tool industry, as full and varied as any collected from a central Andean site, also indicates that Quishqui Puncu was a campsite. The artifacts associated with hunting and butchering are present, but so are cobble tools, borers, and thin-edged scrapers—implements for which it is easier to construe a use in camp than at a kill site. Soil conditions are not favorable for preservation of bone, but it is unlikely that Quishqui Puncu, with its topographic advantages as a campsite, ever served as a kill or butchering station. Moreover, the excavations yielded far more stone-chipping waste than one would expect at such a site. Considerable workshop activity took place at Quishqui Puncu. Large primary flakes and cores are few, so it seems that this effort was directed mainly to production of small tools and finishing and sharpening others. Moderately fresh quartzite might sometimes have been found in the Río Marcará as cobbles, but most of the favored metamorphosed volcanics, at least, must have come in unweathered workable condition directly from the zones of contact metamorphism in the mountains. Considering the situation of the site and the nature of its stone industry, it is impossible to argue that Quishqui Puncu was primarily a quarry or workshop site, as has been done in the case of the river terrace sites of Ambo (Department of Huánuco) and those discovered by Cigliano along the Río Ampajango in northwestern Argentina (*2*).

One of the best indicators of a campsite is a predominance of projectile point bases over tip fragments. This is supposed to reflect the repair of projectiles at camp after a hunt, the basal sections accumulating at the campsite while the broken tips remain at the place where the projectiles were used. Following Quishqui Puncu's original service as a campsite, thousands of years of agricultural disturbance must have caused an unknown number of complete projectile points to be broken, yielding an equal number of bases and tips to dilute the original contrast. In spite of this, and in spite of the fact that the men found tip fragments easier to recognize than the simple notchless and stemless bases, I have cataloged only 149 tips against 232 bases.

Test pits and trenches at Quishqui Puncu were distributed over an area about 100 m deep by 200 m long, at the edge of the terrace. Surface finds did not end abruptly, except at the terrace edge, and I have been unable to exactly delimit the site, especially as it extends up the ridge and away from the river. Multiple occupation campsites are not walled cities; it is unlikely that each successive camp would exactly overlie the refuse of the camp which preceded it. Thus, it is completely expectable that the intensity of use and archeological finds resemble a shotgun pattern.

About two-thirds of Quishqui Puncu now lies in agricultural terraces, frequently surrounded by fieldstone walls and brush, thorn, and agave fences from which the site takes its name. The effects of terrace building, obvious in the stratigraphy of a large part of the site, are illustrated here in trench R (Fig. 1). Loose boulder and angular rock fill (the lowest stratum shown on the profile) directly overlies culturally sterile, yellow boulder clay. Excavators