Reports

Molokai Fracture Zone: Continuation West of the Hawaiian Ridge

Abstract. *The Molokai Fracture Zone is one of the principal east-west (striking) fracture zones between California and the mid-Pacific. On the basis of bathymetry alone, it has been assumed that the zone ended abruptly east of the Hawaiian Islands. Use of correlation techniques between bathymetric features and their magnetic anomalies in the vicinity of the islands now show that structural elements of the zone cross the islands and continue westward for at least 130 kilometers. Recent volcanism and deep rift zones of the islands parallel the zone, suggesting structural correlation between the strike of the zone and the origin of recent volcanism in the islands.*

The longest linear structural features on the earth's surface are the east-west fracture zones of the northeast Pacific Ocean. Horizontal displacements of many hundreds of kilometers have been postulated along these zones (*1*) on the basis of matching of magnetic anomalies across such structures. The large-scale horizontal mass transport that this feature implies raises the question of what takes place at the ends of the zones. To better understand the cause of the zones it is important to know the location of the terminations. Because of large-scale cross-cutting structures associated with the continental margin, the eastern terminations are difficult to define; extensions of the zones for varying distances eastward across the North American continent have been postulated (*2*), but all are somewhat conjectural.

Of the western terminations, Menard (*3*) states that those of the Murray and Clipperton fracture zones, as defined bathymetrically, have been discovered in the mid-Pacific; that of the Molokai Fracture Zone can be traced westward as far as the oceanic deep lying to the east of the Hawaiian Ridge. West of the ridge, however, the zone is obscured by the volcanic structures, and there is no bathymetric evidence of reemergence to the west of the Hawaiian Ridge; thus on the basis of bathymetry alone, the Molokai Fracture Zone could be said to end against the Hawaiian Ridge.

However, despite the lack of bathymetric expression, immediately to the east and west of the Hawaiian Ridge there existed before 1963 indications that the Molokai Fracture Zone probably continued across the Hawaiian Ridge as a structural feature. Unpublished magnetic work (*4*) demonstrated that to the east of the Hawaiian Swell, where the bathymetric expression of the Molokai Fracture Zone is prominent, the zone also exhibited distinctive linear magnetic anomalies in the form of closed elongate ellipses, forming dipole and single-pole magnetic anomalies that trended (taking the strike of the major axis of the ellipse) approximately eastward, paralleling the bathymetric features. Similar linear magnetic trends were also found southwest of the Hawaiian Ridge (*5*) by the Naval Oceanographic Office. However, considerable uncertainty existed in correlation of the magnetic trends between these two areas, because (as Fig. 1 shows) the trends to the southwest of the ridge appear to turn sharply southward at their eastern ends; moreover, to the east of the ridge the magnetic anomalies have a somewhat different trend from those of the Molokai Fracture Zone.

During the last half of 1964 and early 1965, the major Hawaiian islands and the shallows immediately surrounding them were aeromagnetically surveyed (*6*). Additional magnetic surveys were made aboard the vessels *Surveyor* (USCG) and *Teritu* (Hawaii Institute of Geophysics). The magnetic trends resulting from this work appear in Fig. 1.

The results we present demonstrate that the magnetic trends of the Molokai Fracture Zone pass continuously across the Hawaiian Ridge. Indeed, much of the volcanism on the major islands is localized along the magnetic trends. The implications of this fact on the structure of the ridge will be discussed elsewhere in greater detail; we point out, however, that these magnetic results effectively rule out the hypothesis of Wilson (*7*) that the ridge was formed by eruption from a single eruptive center, located in the position of the present island of Hawaii, and spread from this center by convectively induced motion of the ocean floor.

Several important conclusions and conjectures can be based on the existence of the continuity and extension of the magnetic trends of the Molokai Fracture Zone:

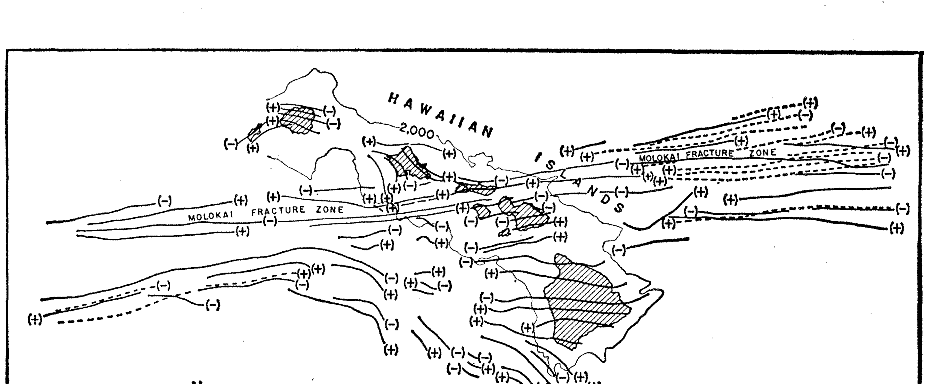

Fig. 1. Magnetic and topographic trends over the Hawaiian Swell.

1) A large-scale, linear, westward-trending, bathymetric feature lying immediately to the west of the ridge (Fig. 1) may be considered an additional extension of the Molokai Fracture Zone; thus one may extend the zone almost to a point of juncture with the Marcus-Necker Ridge.

2) The direction of the magnetic trend is altered somewhat, as it crosses the Hawaiian Ridge, from almost exactly eastward east of the ridge to east-northeastward west of the ridge; this change is in line with the much sharper southward bending of the Murray and Mendocino fracture zones to the north. At the point where the Molokai Fracture Zone magnetic trend encounters the ridge (Fig. 1), the other major structural direction, as defined by major rift zones having associated gravity and magnetic anomalies, is northwestward; this trend may be seen on the islands of Oahu, Molokai, Lanai, and Kauai. The same trend may also be seen in magnetic anomalies to the southwest of the islands, in the bathymetry south of the island of Hawaii, and in the trend of submarine volcanoes running northwestward from the island of Oahu. Apparently this northwestward trend represents a basic fracture zone and a discontinuity in the crust across which the major east-west fracture zones experience a discontinuous change in direction.

3) The tremendous length of the Molokai Fracture Zone, reaching as it does from the East Pacific Rise to the postulated "Darwin Rise" of Menard, strongly suggests that the fracture zones are not genetically related to the East Pacific Rise as has been suggested. Perhaps the greater vertical displacement along the fracture zones in the vicinity of the East Pacific Rise may well reflect the action of the forces forming the rise on the fault structures already existing.

The fact that the magnetic trend of the Molokai Fracture Zone can be traced for hundreds of kilometers, where there is little or no bathymetric expression, suggests that the western ends of the Murray and Clarion fracture zones also should be examined magnetically to determine whether they also extend farther westward than has been suspected.

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Radiation Absorption between the Ultraviolet and X-ray Bands

Abstract. *The recent initial exploration of photoabsorption in a previously unmapped portion of the spectrum, photon energies between approximately 20 and 500 electron volts or wavelengths between 20 and 600 angstroms, is reviewed.*

While the comparative capacity of matter to absorb electromagnetic radiation of various spectral characteristics has been regarded as an important subject of investigation, the absorption by single atoms or small molecules over a broad spectral range between photon energies of approximately 20 to 500 ev or wavelengths of 20 to 600 Å has remained essentially unmapped until the last few years. This gap in our knowledge is now being bridged, if only in a preliminary way.

I now attempt to describe the absorption of photons by atoms as provided by data from several laboratories. The data pertain primarily to inert gases. Dependable surmises concerning other elements could probably be derived from it, but no serious effort appears to have been undertaken to this end.

The development of absorption spectroscopy covering the range between the ultra violet and x-ray wavelengths has been delayed by the lack of suitable radiation sources and by the strongly disturbing influence of any extraneous matter that might come across the optical path. However, among those who contributed to recent progress are Lukirskii and co-workers (*1*) who extended x-ray techniques down to 60 ev and Tomboulian *et al.* (*2*), as well as Samson (*3*), who extended the application of line sources from sparks. The development by Madden and Codling of a spectrograph which utilizes the National Bureau of Standards synchrotron as a light source has permitted continuous coverage of the spectra and brought out fine structures over photon energies up to 150 ev (*4*). Progress toward a general theory has been made by Cooper (*5*), and particular calculations by others (*6*). The emphasis in our laboratory, reflected in this paper, has been on identifying the major properties of the spectra and the underlying physical mechanisms.

Prior to 1960, tentative expectations concerning absorption coefficients in our range of interest were based on extrapolation to lower photon energies of the hydrogen-like behavior observed in the x-ray range. The dashed line in Fig. 1 shows this behavior for argon, with the characteristic linear drop toward higher energies, on the logarithmic scale. The drop is interrupted now and then by the familiar "edges" which mark the onset of absorption by the electrons of the successive internal shells or subshells. The argon data are emphasized here because they exhibit many novel features. The inset on the right shows the fine structure of the *K*-edge; this structure consists of lines which correspond to excitation from the *K*-shell to outer discrete orbitals and which are broadened by autoionization (Auger effect) so that they merge into one another. The experimental data fit the dashed line on the right side of Fig. 1 rather well, but large, qualitative departures occur at lower energies.

Departures are not unexpected here, as the hydrogen-like approximation to atomic mechanics breaks down for lower photon energies. These photons are absorbed by electrons in the outer portions of atoms, where the average electric field varies far more sharply than the Coulomb field does within the hydrogen atom. Two other effects that also become more important in the outer shells are (i) deviations from the average field at each point, which are due to correlations between electron positions and which cause effects of "configuration interaction"; and (ii) electron-exchange effects.

The inset on the left of Fig. 1 shows the fine structure associated with the M_1 threshold. Not only does this struc-