also on the O atom. Approximate balance of charge is retained by an increase in the populations of the σ-orbitals. This effect, which is also observed in oxalic acid, would imply that in the crystal there is more concentration of charge in the molecular plane than the approximate calculation on the isolated molecule would predict. Net atomic charges are generally smaller than the calculated values, although the results obtained with the optimized Slater basis set are closer to the theoretical values for the C, N, and H atoms.

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Crustal Plates in the Central Atlantic

Abstract. *Various people have proposed that North and South America are a part of a gigantic crustal plate within which little differential movement is taking place. Considerations of the size of this postulated plate and the pattern of seismicity around the Caribbean indicate that it is in fact two plates, separated in the region between the Lesser Antilles and the Mid-Atlantic Ridge. Many of the offsets of the Mid-Atlantic Ridge opposite the Caribbean are the result of differential spreading rates and the westward continuations of the fracture zones extending from these offsets are active left-lateral faults.*

In the consideration of data regarding a portion of a fracture zone beyond a ridge offset Fox *et al.* (*1*) adhere to the related concepts of the ridge-ridge transform fault (*2*) and plate tectonism (*3–5*). According to these ideas the present configuration of the ridge preserves the shape of the original opening of the ocean basin, crust moves away from the ridge in gigantic unsheared plates, ridge offsets are transform faults that terminate at the ridge, and the topographic expression of the fracture zones outside of the ridge offsets results from the positive elevation of the side closest to the ridge.

Our work (*6*) has led us to an alternate explanation for the origin of some fracture zones. We began in an attempt to explain the structural and seismic asymmetry between the north and south boundaries of the Caribbean Sea. We concluded that left-lateral shear in the Atlantic to the east of the Caribbean (Fig. 1) was necessary to explain the relative lack, both of earthquakes, and also of evidence for strike-slip motion on the south boundary of the Caribbean Sea. This led us to question the assumption (*3–5*) that both North and South America together with the Western Atlantic act as a single plate.

We were initially impressed by the great size and extremely irregular shape of this plate with its narrow section between the Mid-Atlantic Ridge and the Caribbean. As Morgan points out (*4*), it is impossible to tell with his approach whether the Americas are parts of one or two plates. This is because the evidence which he obtained from the strikes of offsets of the Mid-Atlantic Ridge gives a pole of rotation that is poorly defined with regard to latitude. It is equally possible to choose two poles of rotation, the one for North America and Africa lying to the north of the one for South America and Africa.

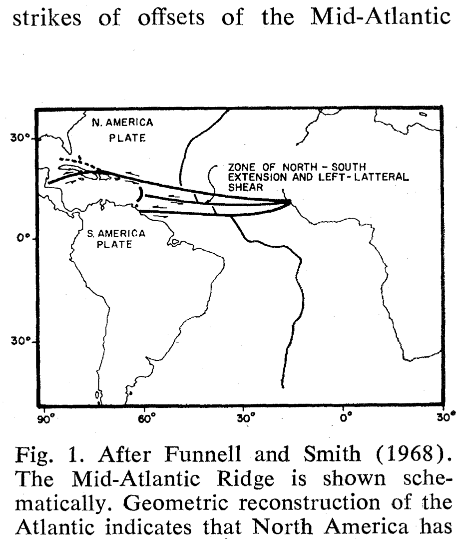

Fig. 1. After Funnell and Smith (1968). The Mid-Atlantic Ridge is shown schematically. Geometric reconstruction of the Atlantic indicates that North America has moved faster and slightly to the north relative to South America's movement away from Africa. The result of the relative movement between these plates has been the formation of a zone of north-south extension and left-lateral shear.

The evidence for a single pole from the variation of spreading rate with position on the ridge, used by Morgan, is equally inconclusive. The data points are clustered between 22° and 32°N and 24° and 44°S. The data are just as well explained as a result of North and South America acting as parts of different plates rotating away from Africa about different poles of rotation at different speeds.

Based on the geometrical reconstruction of the Atlantic (*7*), Funnell and Smith (*8*) came to the conclusion that the Caribbean region was formed because North America rotated away from Africa faster and with a more northerly component than South America. The Caribbean and that portion of the Atlantic to the east of the Lesser Antilles would accordingly be a region of north-south extension and left-lateral shear.

This region is the site of numerous offsets of the Mid-Atlantic Ridge. Based on the position of ridge segments the sense of shear on these offsets appears to be left-lateral. However, judging from first motion studies on the offsets the sense of shear is right-lateral (*9*). This paradoxical situation is resolved by consideration of the interaction of fracture zone faults and migrating ridges. The Mid-Atlantic Ridge must migrate westward from Africa because of the lack of a marginal trench system about this ridge-ringed continent (*10*). As a result of a faster spreading rate the migration has been more rapid to the north of latitude 5°N (Fig. 1). Fracture zone faults offsetting the ridge are the result of this incremental variation in ridge migration rate.

Both ridge segments are migrating to the left in order to accommodate new crust formed by spreading (Fig. 2). The northern segment migrates faster as a result of its greater spreading rate. This shears and offsets the ridge. Shear is no longer active on the part of the fracture zone between the ridge and the fixed continental margin; however, the pattern of magnetic anomalies will record the progressive left-lateral offsetting of the ridge on this dead fault. Between the portions of ridge crest, the north side of the fracture zone is fixed relative to the conti-

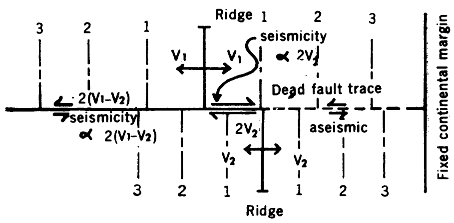

Fig. 2. Interaction of a migrating ridge and a fracture zone fault. The symbols V_1 and V_2 are spreading rates for the north and south ridge segments respectively. The continental margin is fixed so the ridge segments migrate to the left at the spreading rates. Right of the ridge offset, the apparent sense of faulting is left-lateral and there is no active shear. On the offset, the north side of the fracture zone is stationary, but the south side moves left at twice the spreading rate. This results in right-lateral shear and seismicity proportional to twice the spreading rate. Left of the offset, both sides of the fracture zone move to the left at twice their respective spreading rates; but, since this rate is greater for the northern ridge segment, there is active left-lateral shear proportional to twice the difference between spreading rates. The lines numbered *1* to *3* represent isochrons based on correlation of magnetic anomalies.

nental margin but the south side moves left at twice the spreading rate. Thus, the offset is a zone of very active right-lateral shear and attendant seismicity. To the left, beyond the offset, both sides of the fracture move left at twice the spreading rate. Because the northern segment has the greater spreading rate, this portion of the fracture zone is an active left-lateral shear. However, this activity only stems from the difference in spreading rates, and so the seismicity is much less than on the offset.

According to our model, one would expect some earthquakes outside the ridge offsets between the Mid-Atlantic Ridge and the Lesser Antilles. There are only a few such quakes noted in the data of Sykes and Ewing (*11*) and Sykes (*9*). An explanation for this lack of seismicity is suggested by comparison of the Caribbean-Atlantic shear zone to the Azores-Gibraltar Ridge, another fracture zone where our model applies (*12*). The Azores ridge is apparently the position of a transcurrent fault separating Eurasia from Africa and has rather sparse earthquakes along it (*3*). The differential movement calculated between the two sides of the Azores ridge is about 1.7 cm/year (*5*). Choosing positions for poles of rotation and rates for the movements of North America and South America away from Africa which are consistent with Morgan's data and calculating a rate of movement between North and South America, we arrive at a rate of about 0.5 cm/year in the region between the Lesser Antilles and the Mid-Atlantic Ridge. Furthermore, in the case of the Azores Ridge, all the movement is concentrated on a single fracture while in the Caribbean-Atlantic shear zone it is distributed among a number of fractures. Therefore, we should expect there to be far fewer earthquakes on individual fractures at the boundary between the North and South American plates than there are marking the contact between the Eurasian and African plates.

Thus, it appears that some fracture zones are strike-slip faults that result from variation of migration rates from one ridge segment to the next. For these fractures, faulting occurs and progressively widens the ridge offset. Offsets are not ridge-ridge transform faults that terminate at the ridge segments, and the topography on strike extensions of the offset is not simply a result of relative positive elevation of that side of the fracture nearest the ridge.

It appears to us that the portion of fracture zone studied by Fox *et al.* (*1*) may not be the fossil trace of a transform fault within a single plate. For, according to transform fault dogma, the south sides of their profiles 1 to 3 and the north sides of their profiles 5 through 24 should have been higher (*13*). These predicted relationships occur on less than half the profiles. Furthermore, if the fracture zone beyond the offset were nothing more than the fossil trace of a transform fault, one would expect its relief to diminish away from the ridge due to the combined effects of regional slope, normal faulting and infilling by sediments. The profiles do not reveal any such decrease in relief. Perhaps the appropriate scale for application of the concept of plate tectonism is that of continental blocks rather than individual fracture zones.

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Image-Formation Technique for Scanning Electron Microscopy and Electron Probe Microanalysis

Abstract. *A technique is described for producing improved topographic images on the scanning electron microscope and the scanning electron probe microanalyzer. In this technique, the brightness of the oscilloscope is modulated by a signal obtained by mixing the signal (from secondary electrons or target current) with its first derivative. This enhances minor topographic features which are poorly reproduced in the conventional technique.*

Kelly, Lindqvist, and Muir (*1*) recently published a report concerning image formation on the scanning electron microscope with Y-modulation of the signal. They described the improvement in the registration of surface details on the scanned specimen when the electron beam of the oscilloscope is modulated in the vertical direction by

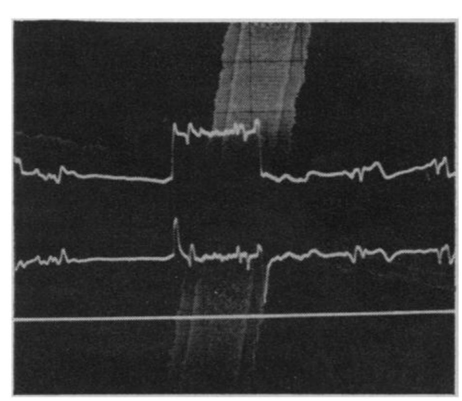

Fig. 1. Target current scan of a gold grid on a brass surface (× 400). Lower trace: position of a single line scan. Upper trace: target current signal obtained during this line scan. Middle trace: derivative target current signal from the same scan.