

Geology. — “*Fractures and Faults near the Surface of Moving Geanticlines. III. The Horizontal Movement of the Central-Atlantic Ridge*”. By Prof. H. A. BROUWER.

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Many explanations that have been given for tectonic structures are unsatisfactory on account of the geometrical treatment of the problems and a preference to vertical movements. The geometrical treatment draws attention to the change in position of parts of the earth's crust, while the velocity of the movement receives no further consideration. Because of the predilection for vertical movements we often explain the observed facts by vertical movements, until it is proved that faulting must have been effected in another direction.

In regions, which are not accessible to direct observation, i.e. the parts of the earth's crust covered by the sea, the existing morphology is explained by rising and by subsiding movements, while the factor time is neglected. Subsidence of continents and subsidence of “land-bridges” are common expressions in geological literature. Velocity and direction of the movement are hardly or not at all considered in these inadequate interpretations of dynamic phenomena. The reason is obvious, the forces causing the movement are unknown, and the velocity of the movement cannot be measured.

Another way of studying these problems is the comparative-tectonic method. Our object in this paper is to consider the results achieved by applying this method to the movement of a region, which is almost entirely covered by the sea, of which the morphology is known in broad outlines, and which is still moving, as we know from numerous earthquakes. It is the S-shaped ridge, of which the existence has been proved by numerous soundings and parts of which emerge from the sea, as e.g. the Azores and the islands of St. Paul and Tristan da Cunha. In previous papers¹⁾ we pointed to the significance of the bending-points of the horizontal projection of a geanticlinal axis for a judgment upon the horizontal movement of geanticlines. Transverse fractures, which may be more or less

¹⁾ These Proceedings XXIII, p. 570; XXV, p. 327.

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gaping are the surface expression of velocity-differences in a horizontal direction; horizontal transverse faults prevail at greater depth, while with increasing plasticity deformation takes place without fracture-movements. If these tectonic zones of different depths are all visible at the surface, they enable us to trace the movement for a considerable space of time, because then the different phases of the movement are observable. If the movements are still going on, the epicentra of earthquakes will be accumulated near the places with considerable velocity-differences and may be disposed along more or less transverse fractures. In this connection we point to the region in the neighbourhood of Sunda Strait between Java and Sumatra, to the earthquake lines near the bending-point between the Alps and the Carpathian mountains, to Cook-strait between the Northern and the Southern island of New Zealand and to many others.



Zuid Amerika = South America. Romanche diep = Romanche Deep.
 Afrika = Africa Azoren = Azores

Fig. 1. 2978 etc. Depths of the sea in meters on the Central-Atlantic Ridge.

If a submarine ridge has a bending-point, the strongly curved shape of the ridge may have been developed from an originally simpler form by velocity-differences in a horizontal direction. Where the velocity-differences are greatest, the epicentra of earthquakes will be numerous, and from an accumulation of epicentra near a

bending point it may be concluded that velocity differences in a horizontal direction are a characteristic of the present movement.

In the Central Atlantic Ridge there is a distinct bending-point between the island of St. Paul and the Romanche Deep, while quite close to it there is a zone of strong seismic activity. Further application of the comparative method would lead to the conclusion that the Central Atlantic Ridge is not only moving now, but has been moving for a long time, with velocity-differences in a horizontal direction. The tectonic structure of the ridge is not accessible to observation. However, there are indications that a further application of the comparative method is possible. The morphology is still little known, but the soundings have proved the existence of very great depths, viz. in the Romanche Deep, where a depth of 7370 m. has been sounded.

This depth has been considered as a remarkable phenomenon for the Atlantic Ocean. The situation *close to the bending-point* points to an origin such as already previously suggested by us with regard to abnormally deep straits near the bending-points of rows of islands. Just as is the case in Manipa Strait between Ceram and Boeroe. The Romanche Deep can be explained by difference in velocity of horizontal movements for neighbouring parts of the ridge along the axis.

We only find the results of the *differences* in velocity in a horizontal direction, the absolute horizontal movement cannot be inferred from the surface characters with the comparative method. We do not know whether the Central Atlantic Ridge originally had a more rectilinear form. Neither do we know whether the bending of the strong curve between the Azores and the island of St. Paul is still increasing, or whether the southern portion with Ascension and Tristan da Cunha is moving with less velocity than the northern in a western, or in an eastern direction, or whether it has become stationary now.

Many widely different views have been brought forward concerning the origin of the Central Atlantic Ridge. Some authors¹⁾ look upon it as a rising geanticline, as a mountain range in statu nascendi. Up to now these authors never considered the horizontal movements, which as evidenced before often are much more important than the vertical movements in rising geanticlines. Another explanation²⁾ has been afforded representing the ridge as the filling of an originally

1) E. HAUG, *Traité de Géologie* I, 1907, p. 164.

2) A. WEGENER, *Die Entstehung der Kontinente und Ozeane*. 1922, p. 42.

narrow gaping fracture, which opened to the present Atlantic Ocean by horizontal movements of continental areas.

In either view regarding the origin of the ridge the movements can take place with velocity-differences in a horizontal direction. Other explanations, such as the ridge being of volcanic origin or the highest parts of a subsided continent (horst), do not consider horizontal movements. Vertical movements may occur and may have occurred in some places perhaps in an upward, in other places in a downward direction, and varying at different periods, because no movement of the earth's crust will have exactly a horizontal direction for a long time, just as it will never have exactly a vertical direction.

The comparative method does not enable us to trace out the movement of the Central Atlantic Ridge down from its earliest development. It proves, however, that the simple explanations by upward and downward vertical movements, which have been suggested, cannot be maintained.
