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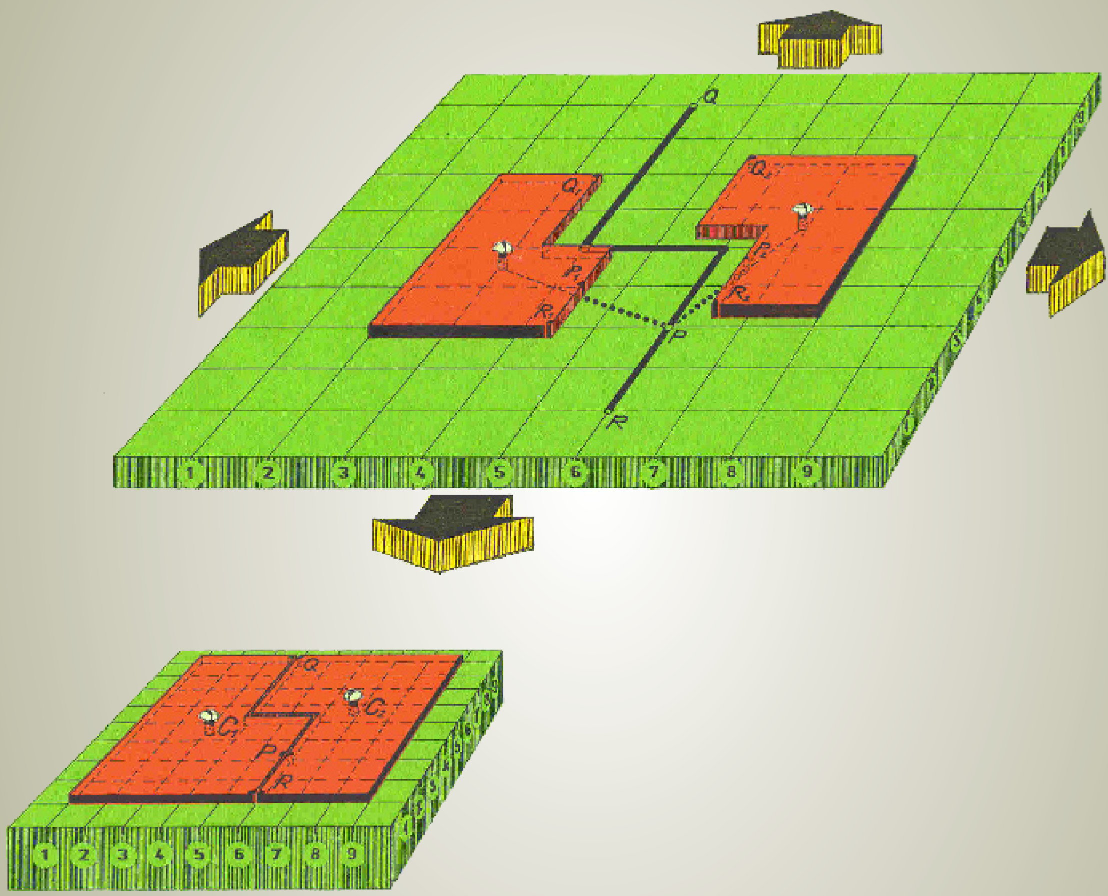

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PRINCIPLES OF PLATE MOVEMENTS ON THE EXPANDING EARTH

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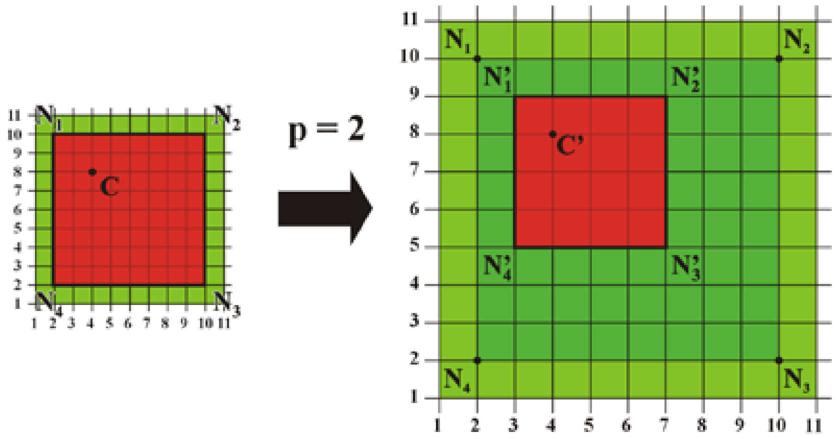
INTRODUCTION

The existence of rigid lithospheric plates resting on a plastic asthenosphere, allow us to build a quantitative model of their movement on the expanding Earth. Such a model relates the kinetics with dynamics, and binds the lithosphere with its basement as a general reference frame. These features do not exist in the plate tectonics model. The expanding earth model explains the observed scheme of development of the lithosphere, together with some relations incomprehensible within plate tectonics.

THE PINNED PLATE

Let us start with considering a rigid plate of a constant shape which rests on the basement with a grid of coordinates, being isotropically extended (Figure 1a).



1 a 1 b

C (4,8)	→	C' (4,8)
N_1 (2,10)	→	N'_1 (3,9)
N_2 (10,10)	→	N'_2 (7,9)
N_3 (10,2)	→	N'_3 (7,5)
N_4 (2,2)	→	N'_4 (3,5)

1 c

Figure 1. *Transformation of plate corners' coordinates of the plate pinned to expanding basement at the point C.*

Let us also assume that the plate is pinned to the basement at the point *C*, and that the basement enlarges its line dimension by extension, at the rate $p = 2$ (Figure 1b). The transformation of coordinates of the plate's corners is shown in the table (Figure 1c).

Among all the points of the plate, only the point C does not change its coordinates and so we may call it „the stable point of transformation” (*SPT*). General algebraic transformation of coordinates of any point of the plate is described by formulas:

$$x' = x_0 + \frac{1}{p}(x - x_0) \qquad y' = y_0 + \frac{1}{p}(y - y_0) \tag{1}$$

where (x_0, y_0) are the coordinates of *SPT*, while *(x, y)* and *(x', y')* are coordinates of any point of the plate, respectively, before and after the extension of the basement at the linear rate *p*.

STABLE POINT OF TRANSFORMATION OF NON-PINNED PLATE

Non-pinned plates, resting loosely on the basement (the lithospheric plates are like this) have their *SPT*s as well. In order to find such a point, we must analyze the friction forces between the plate and the basement. Let us consider first the force acting on an area element Δ*S* of a plate pinned at the point *C*, (Figure 2). This force will be everywhere directed outwards from the point *C*.

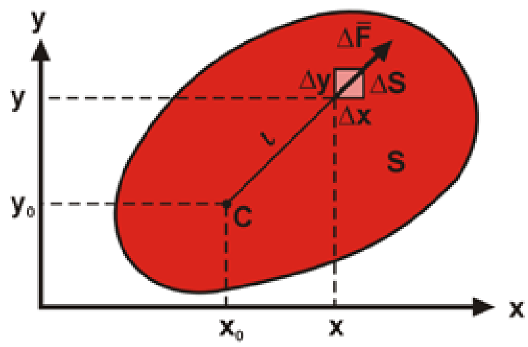


Figure 2. *Friction force acting on an element ΔS of the plate (an area element) pinned to the expanding basement at the point C.*

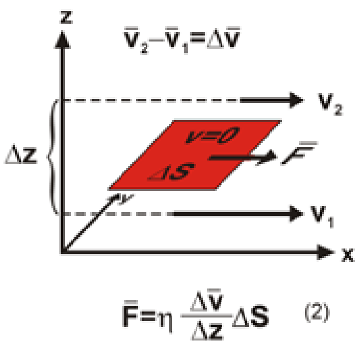


Figure 3a. *Friction exerted by flowing viscous fluid on the fixed area element ΔS, where η - coefficient of internal friction of the fluid, Δv/Δz - velocity gradient of fluid's laminar movement.*

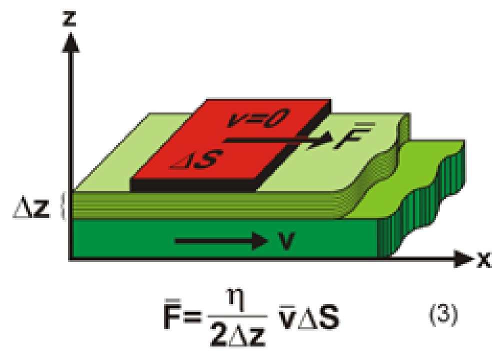


Figure 3b. *Single-sided friction force exerted by the expanding basement on the plate's element ΔS.*

We can find its value from the formula (2) describing the friction of viscous fluid acting on the area element Δ*S*, (Figure 3a). Because the friction acts only on the bottom side of the area element, so it is twice weaker, (Figure 3b), and since the layer of the laminar movement has an unknown but constant thickness Δ*z* then (2) takes the form (3). The basement velocity relative to the element Δ*S* is expressed by the formula (4)

$$\bar{v} = \frac{\Delta \bar{l}}{\Delta t} = \frac{(p-1)\bar{l}}{\Delta t} = h\bar{l} \tag{4}$$

where h is a formal equivalent of the known parameter of an expanding Universe, which we may call, in general sense, the „Hubble factor" (in distinction from the „Hubble constant"). This factor can change with time, but at given time it is constant for the whole plate. In connection with the former statements, the formula for ΔF (Figure 2) appears as:

$$\Delta \overline{F} = \frac{h\mathrm{h}}{2\Delta z}\bar{l}\Delta S = k\bar{l}\Delta S \tag{5}$$

where $k = \frac{h\mathrm{h}}{2\Delta z}$ is an unknown but constant parameter for the whole plate.

Now we will calculate the resultant friction force acting on the whole plate. To do that, we must display the components of the force's element ΔF :

$$\Delta F_x = k(x - x_0)\Delta S \qquad \Delta F_y = k(y - y_0)\Delta S \tag{6}$$

and integrate them over the whole area S of the plate:

$$F_x = k\iint_S (x - x_0)dS \qquad F_y = k\iint_S (y - y_0)dS \tag{7}$$

The resultant friction force, exerted by the basement on the plate, will be in general different from zero. Thereby, this force will tend to tear off the postulated physical connection between the plate and its basement at the point C. However, if this resultant force equals zero, then the removing of the ties changes nothing, and point C will be a stable point of transformation as before, but this time – of the loosely resting plate (non-pinned). Then, in order to find this point, we must equate the right sides of (7) to zero:

$$k\iint_S (x - x_0)dS = 0 \qquad k\iint_S (y - y_0)dS = 0 \tag{8}$$

and by solving the equations (8) we will find the coordinates (x_0, y_0). Since $k \neq 0$, the equations take the form:

$$\iint_S (x - x_0)dS = 0 \qquad \iint_S (y - y_0)dS = 0 \tag{9}$$

Their solution is:

$$x_0 = \frac{\iint_S x dS}{S} \qquad y_0 = \frac{\iint_S x dS}{S} \tag{10}$$

These are the formulas for the coordinates of the barycentre of the plate.

THE CRACKING PLATE

Now, let us demonstrate the case of a loosely resting plate which is cracking to smaller pieces during the expansion of the basement, (Figure 4).

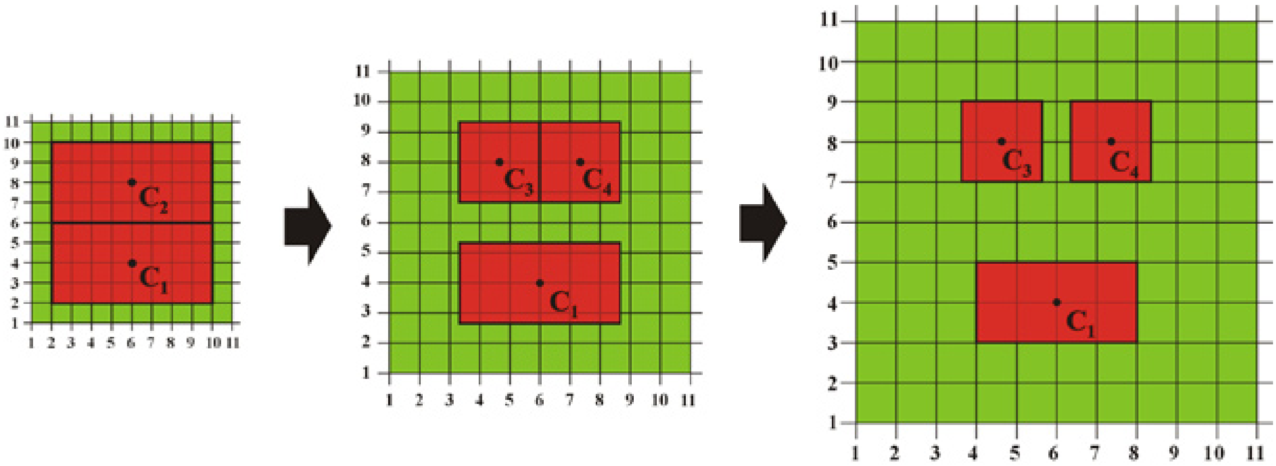


Figure 4. *The cracking plate on the expanding basement.*

As we see, the offshoot plates are carried away from themselves but, at the same time, they are tied to their basement at their *SPT*s. Then, the presented model solves the contradiction between fixism (stabilism) and mobilism, which is insoluble on a non-expanding earth.

If the cracking plate leaves a split's trace on the basement, then this trace undergoes enlargement relative to relevant edges of the offshoot plates (Figure 5).

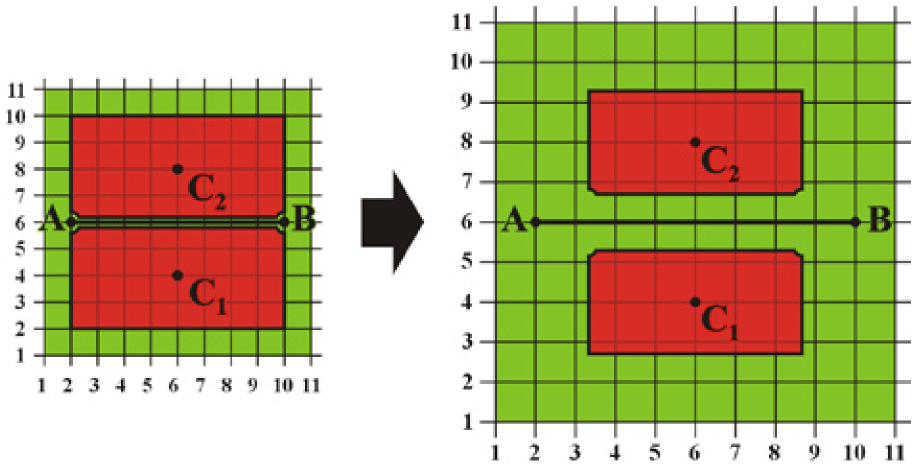


Figure 5. *The trace of the cracking of the plate left on the expanding basement (an oceanic ridge)*

Such traces of the plate's splitting are in fact the oceanic ridges. Their enlargement relative to relevant contours of continents and the signs of their lengthwise extension are most important geotectonic features, not explained by plate tectonics.

The *SPT*s and traces of the plate's cracking (oceanic ridges) fix the general reference frame which is the deep basement. In plate tectonics, at most, one plate can be fixed, and it is not known which one. Recently, it was proved by seismic tomography (Woodhouse and Dziewoński, 1984) that plates and oceanic ridges are authochthonous, which confirms the presented model.

THE GROWING PLATE

In reality, the lithospheric plates not only crack, but also grow as a result of spreading. We can prove, that if the growth of plates is regular i.e. if their borders are motionless in relation to the basement (oceanic ridges remain authochthonous), then their *SPT*s are stable.

At regular growth, the translation of every point of the plate's contour is proportional to its former distance from the *SPT*. Let us consider the area *S* and *S'* which has developed from *S* by regular growth, (Figure 6).

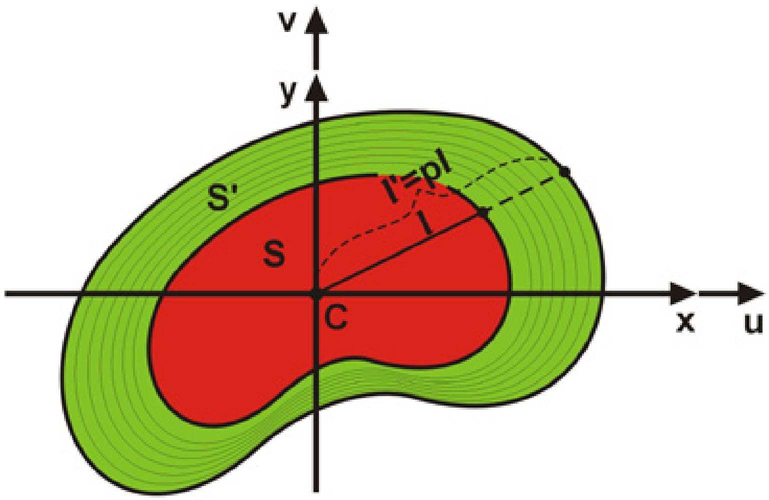


Figure 6. *The regularly growing plate.*

For simplicity, let us assume that the center of the reference frame lies at *SPT* of the area *S* (point *C*). Then:

$$\iint_S x dS = 0 \qquad \iint_S y dS = 0 \tag{11}$$

Then, let us transform the area *S* of *(x, y)* coordinates, to the *S'* area of *(u, v)* coordinates, according to the following formulas:

$$u = px \qquad v = py \tag{12}$$

This transformation corresponds with the radial enlargement of the area *S* relative to point *(0, 0),* at the rate *p*. Then, it corresponds with the regular growth defined above. Let us now change the variables in formulas (11) according to the transformation (12). Since the jacobian of this transformation is $\frac{1}{p^2}$ then equations (11) take the form:

$$\frac{1}{p^3}\iint_{S'} u dS' = 0 \qquad \frac{1}{p^3}\iint_{S'} v dS' = 0 \tag{13}$$

Since $\frac{1}{p^3} \neq 0$, then

$$\iint_{S'} u dS' = 0 \qquad \iint_{S'} v dS' = 0 \tag{14}$$

We have proved in this way, that the *SPT*s of the areas *S* and *S'* are the same.

It is self-evident that the junction and disjunction of areas with the same *SPT*s, give areas also with the same *SPT*s (the analogy to physical barycentres). Then, if we exclude the area *S* from the area *S'*, the *SPT* of the obtained ring *(S' - S)* lies at the *SPT* of the area *S*. We have shown in this way, that if growing ring *(S' - S)* has different friction coefficient relative to the basement (e.g. because of smaller thickness of the lithosphere), then it has no influence on the position of *SPT* of the whole growing plate.

HOT SPOTS

Now let us think about the effects of hot spots activity. The volcanic chains produced by hot spots (mantle plumes) which are tied with the expanding basement, are divergent. We can demonstrate this first for the case of two intraplate hot spots (Figure 7).

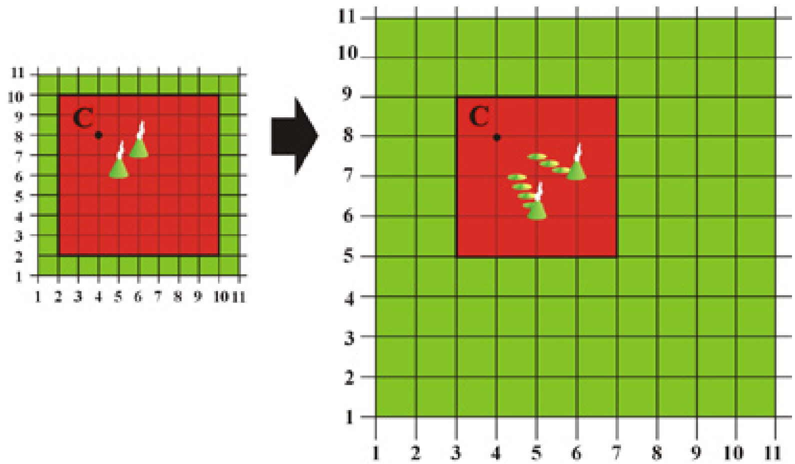


***Figure 7**. Divergence of the volcanic chains produced by intraplate hot spots.*

A similar situation is in the case of interplate hot spots tied with oceanic ridges (Figure 8). Such hot spots do not pierce the plates but add swelling to their borders, which produces, in the course of spreading, also the volcanic chains.

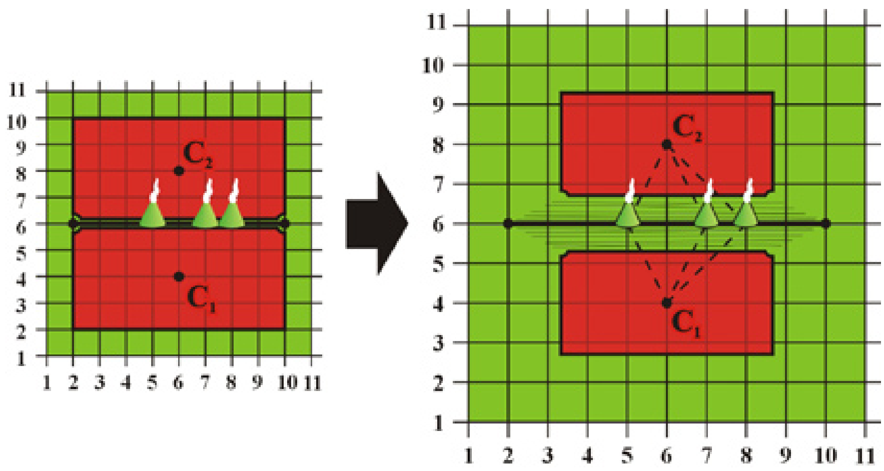


***Figure 8.** Divergence of the volcanic chains produced by interplate hot spots*

Mutual moving away of the Mid-Atlantic Ridge's hot spots (that is tantamount after all, with the lengthwise enlargement of the ridge) was already pointed at by Burke et al. (1973), but without connecting this phenomenon with the earth expansion. On the contrary, the divergence of the hot spot volcanic chains was noticed by Stewart (1976) and interpreted as a manifestation of the earth expansion.

DEVELOPMENT OF THE CENTRAL AND SOUTH ATLANTIC OCEAN

The described rules can be used to model the development of the Central and South Atlantic (Koziar 1985, 1993), as shown in Figure 9.

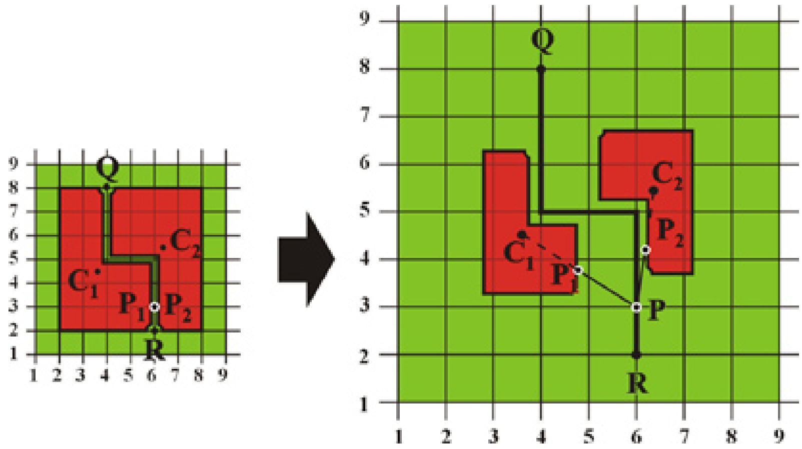


Figure 9. *Development of the Central and South Atlantic Ocean on the expanding basement.*

The two lines – P_1P and P_2P are, respectively, Rio Grande and Walvis ridges, produced by the interplate hot spot situated near Tristan da Cunha Island (point *P*). The arrangement of both ridges was noticed by Dietz and Holden (1970), who tried to explain the southward translation of the point *P* by the same translation of the deep basement. However, such interpretation does not explain similar, but northward translation of the Azores region *Q*, neither the general enlargement of the Mid Atlantic Ridge.

PHYSICAL MODEL

We can give a physical form to the geometrical model demonstrated above, in the shape of a radially extended rubber slice (Koziar 1980, 1993). We can put different configurations of plates on it. Using such a device, it is possible to model (demonstrated above in a geometrical way) the development of the Central and South Atlantic (Koziar 1980, 1993), and the radial growth of oceanic lithosphere around Africa and Antarctica (Koziar 1980, 1993), which indicates straightforward to the earth expansion. For the first time this relationship was pointed out by Carey (1958), and later by Heezen (1962). The devices can also be used to model the development of triple junctions and tearing off of island arcs from continental margins (Koziar 1993). The tensional development of the latter structures is described elsewhere (Koziar and Jamrozik, 1991, 1994).

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