Art. N° 89
Contribution COB N° 83

Geophys. J. R. astr. Soc. (1972) **29**, 43–46.

Comments on 'Thermal Effects of the Formation of Atlantic Continental Margins by Continental Break up' by N.H. Sleep

J. P. Foucher and X. Le Pichon

(Received 1972 February 29)

– Sleep (1971) has presented some very interesting observations on the exponential decrease of the subsidence rate in coastal basins. He shows that the time constant of this exponential decrease is of the same order of magnitude that the thermal time constant of a lithospheric plate. He then makes calculations with a physical model combining erosion and thermal contraction. The purpose of these comments is to show that his physical assumptions are invalid and that consequently his calculations are grossly in error. –

Starting with an initial elevation E_0, at time $t = 0$, Sleep defines the law of variation of the elevation E by

$$kE + \frac{dE}{dt} = -aE_0 \exp(-at) \tag{1}$$

where $aE_0 \exp(-at)$ is the thermal contraction term, a^{-1} is the thermal time constant, $-kE$ is the erosion term and k^{-1} is the erosion time constant.

Sleep also defines

f_c as the isostatic multiplying factor;

ρm, ρc as the mantle and crust density;

D as the total denudation by erosion from $t = 0$ to the time T where the elevation is zero.

$$f_c = \rho m/(\rho m - \rho c) \tag{2}$$

$$D = \int_0^T kE(t)\,dt. \tag{3}$$

Sleep then assumes that $a = k$, solves (1) and computes D with (3). He gets

$$E = E_0(1-at)\exp(-at) \tag{4}$$

by integration of (1) but without taking into account the isostasy which applies at all times. He then computes

$$D = af_c \int_0^{1/a} E\,dt = E_0 f_c \exp(-1) \tag{5}$$

applying the isostatic correction after a time of 50 My which has no physical meaning.

Actually, (1) should be

$$\frac{kE}{f_c} + \frac{dE}{dt} = -aE_0 \exp(-at). \tag{6}$$

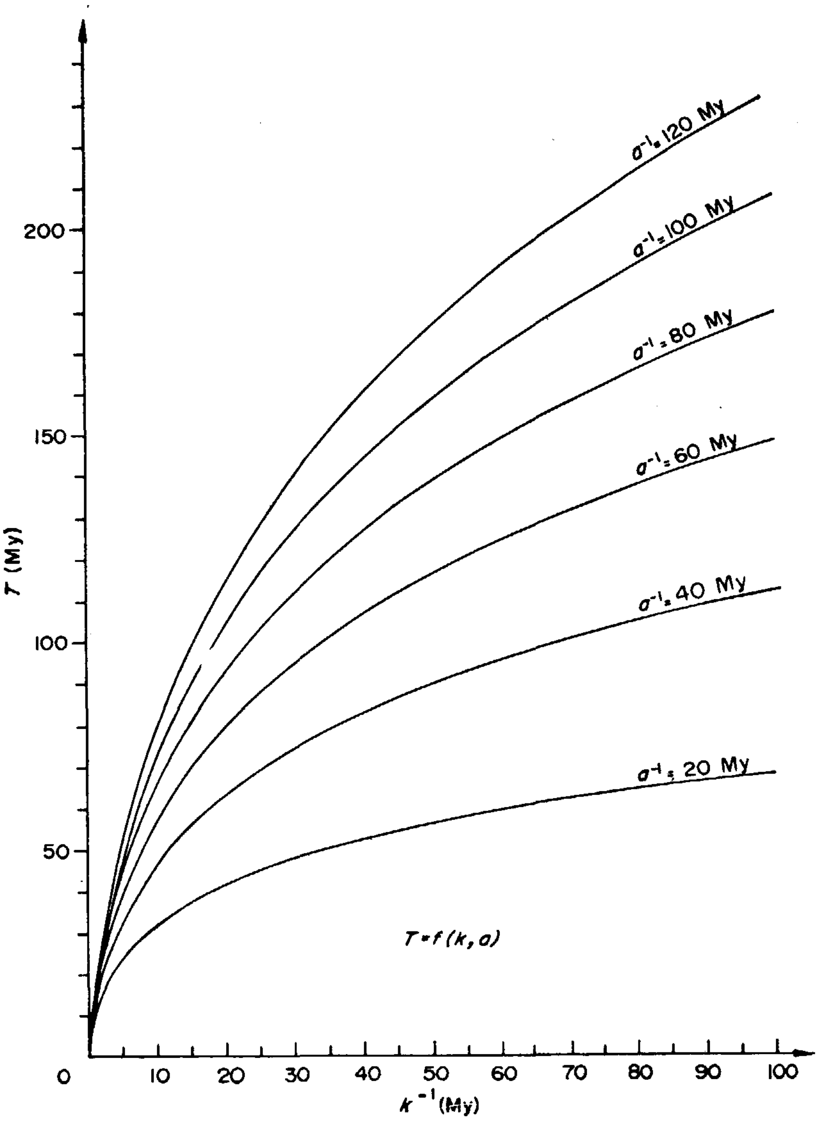

FIG. 1. Variation of the total time of erosion T as a function of the erosion time constant k^{-1} and thermal time constant a^{-1}.

By integrating (6), (4) is replaced by

$$E = [E_0/(-af_c+k)]\left[k \exp\left(-\frac{k}{f_c}t\right) - af_c \exp(-at)\right] \tag{7}$$

$$T = [f_c/(-af_c+k)] \log\left(\frac{k}{af_c}\right) \tag{8}$$

$$D = [kf_c E_0/(-af_c+k)]\left[\exp(-aT) - \exp\left(-\frac{k}{f_c}T\right)\right]. \tag{9}$$

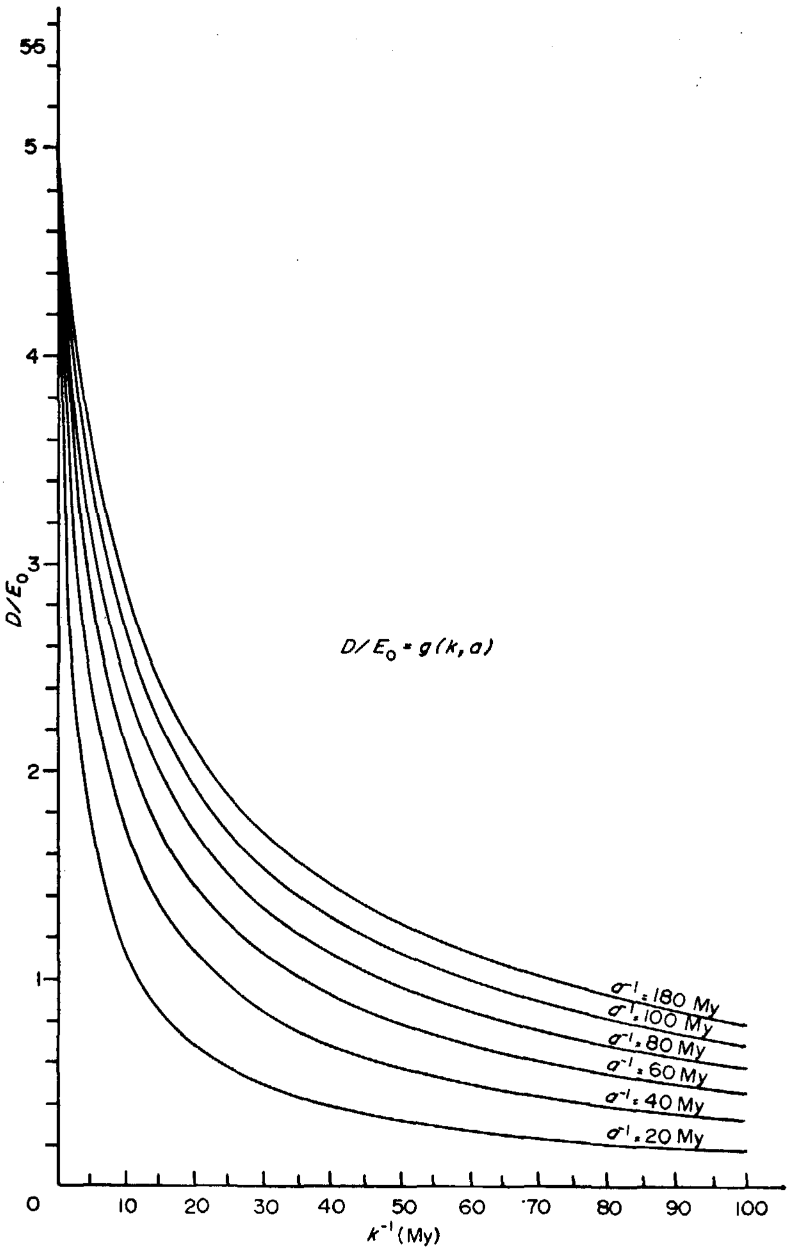

FIG. 2. Variation of the ratio of total eroded thickness D over the initial elevation E_0 as a function of the erosion time constant k^{-1} and thermal time constant a^{-1}.

For $E_0 = 1{\cdot}5$ km, and with $a = k = 50\,\text{My}^{-1}$, $D = 1{\cdot}0$ km and not 3 km as proposed by Sleep.

Fig. 1 shows the variation

$$T = f(k, a)$$

and Fig. 2 the variation

$$D/E_0 = g(k, a).$$

Fig. 1 shows that to have a period of erosion lasting 50 My the value of the erosion time constant k^{-1} is 5 to 10 My. The ratio D/E_0 changes very rapidly with k around such a value (see Fig. 2). It is thus clear that there is considerable arbitrariness in the choice of the constant k and yet the choice of this value dominates the result one obtains. In addition, the law of erosion chosen is quite arbitrary. Finally, the influence of loading of the adjacent oceanic plate with sediment and consequent flexural bending is not considered (Walcott 1972, in press).

Centre Océanologique de Bretagne.

References

Sleep, N. H., 1971. Thermal effects of the formation of Atlantic continental margins by continental break-up, *Geophys. J. R. astr. Soc.*, **24**, 325.

Walcott, R. I., 1972. Gravity, flexure and the growth of sedimentary basins at a continental edge, *Bull. geol. Soc. Am.*, in press.