Zeitschrift: Bulletin der Vereinigung Schweiz. Petroleum-Geologen und -Ingenieure
Herausgeber: Vereinigung Schweizerischer Petroleum-Geologen und -Ingenieure
Band: 55 (1989-1990)
Heft: 128

Artikel: Organic metamorphism : the effect of a burial event / likely residence time in the oil window under continuous burial
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DOI: https://doi.org/10.5169/seals-212657

Bull. Swiss Assoc. of Petroleum Geol. and Eng., v. 55, no. 128, April 1989 - p. 57-59

Organic metamorphism - The effect of a burial event / likely residence time in the oil window under continuous burial

Geological Note

by P.E. GRETENER[1]
with 2 figures

The following two points are made in principle and any numerical values are to be taken as guidelines rather than rigid predictions. It is for this reason that the simple oleum method (Canadian Lopatin scale, GRETENER & CURTIS, 1982) can be used. It has been pointed out that the Lopatin scale does not make allowance for the different types of kerogen maturing at variable rates. This is correct but it is also true that kerogen type is only one of many uncertainties afflicting maturation modeling. Even such a trivial error as an uncertainty of +/− 3°C in the present source rock temperature introduces a variation of about +/− 20% in the final computation, let alone the many other assumptions that are always part of any thermal history match. The Lopatin scale has served us well over the past years to give estimates within reasonable tolerances and detect obviously ill conceived models. Thus it seems permissible to use this highly simplified but easily managed and transparent method to make the following points.

The effect of a burial event

The use of a burial event is a favorite with organic modelers in order to match any observed vitrinite reflectances (HOUSEKNECHT & MATTHEWS, 1985, p. 342, Fig. 10; RAHMAN et al., 1985, p. 398, Fig. 2). The effect of such an event is shown in **Figure 1**. Before the burial event a source rock will mature linearly with time at the rate corresponding to the residence temperature. During burial the conversion rate will increase exponentially and double for every 10°C temperature increase (Lopatin). During the subsequent erosion the same curve will be followed in reverse and return to the original slope once exhumation is complete. The non-linear part of the curve will be centrosymmetric about T_{max}, i.e. the point of maximum burial. The amount of additional metamorphism will be identical for the downward and the upward leg of the burial event.

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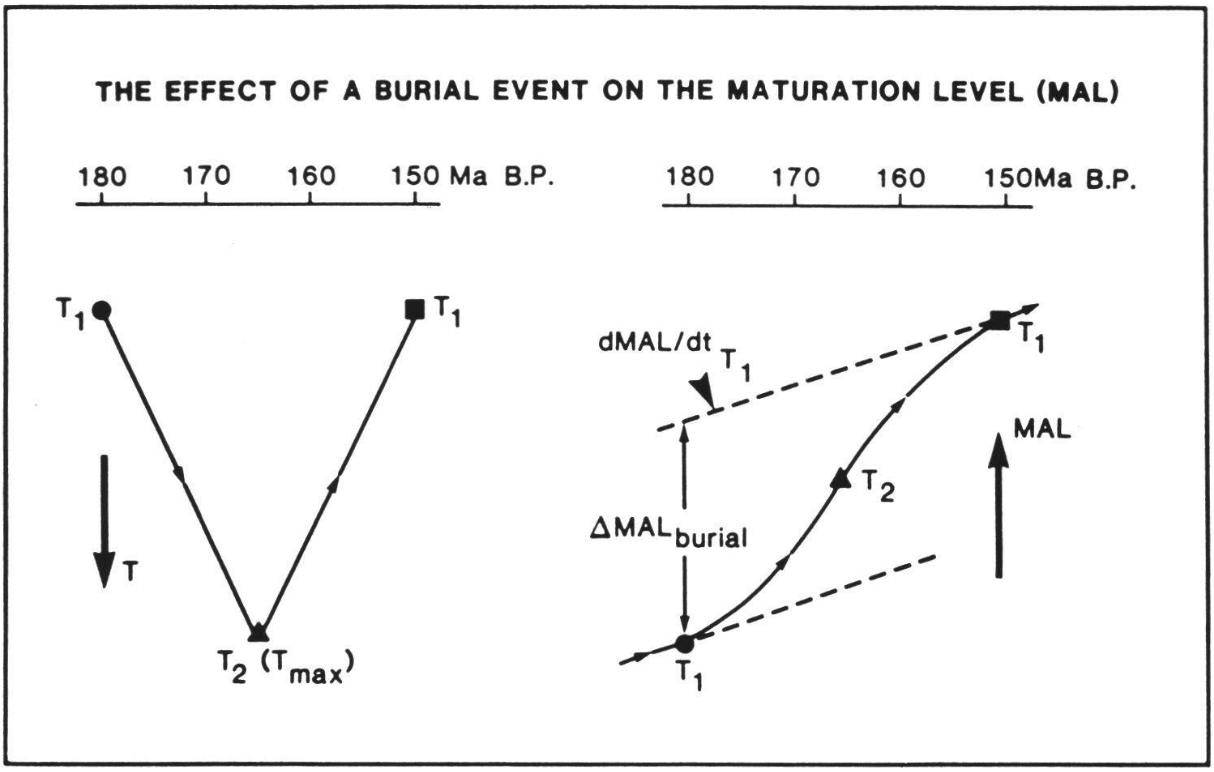

Figure 1: For the initial residence temperature (T_1) the maturation level rises linearly with time. During the burial (heating) event maturation increses exponentially until maximum burial is reached (T_2). During subsequent uplift (cooling) maturation decreases exponentially until the original temperature level (T_1) is reached, after which it proceeds linearly at the original rate. A burial event produces a step in the maturation level of magnitude MAL.

Residence time in the oil window

On the Lopatin (WAPLES, 1980) or Oleum (GRETENER & CURTIS, 1982) scales the oil windows fall in the following range:

Onset of oil generation	15 TT1	100 oleum
End of oil generation	160 TT1	1000 oleum
End of oil preservation	1500 TT1	10000 oleum

Within the generative window organic metamorphism increases 10 fold, for the preservative window the increase is 100 fold. Thus for the first instance the time interval corresponds to $3.322 \bullet t_a$. GRETENER & CURTIS (1982) have shown:

$$T_a = \frac{10}{dT/dt}$$

Where t_a is the doubling time for the Lopatin scale and:

$$dT/dt = dT/dz \times dz/dt \quad \text{or:}$$

heating rate = geothermal gradient times burial rate.

Using reasonable values for the geothermal gradient and the burial rates one arrives at the following limitations:

$$10°C/km \geq dT/dt \geq 1°C/km$$
$$10 Ma \geq t_a \geq 1\ Ma$$

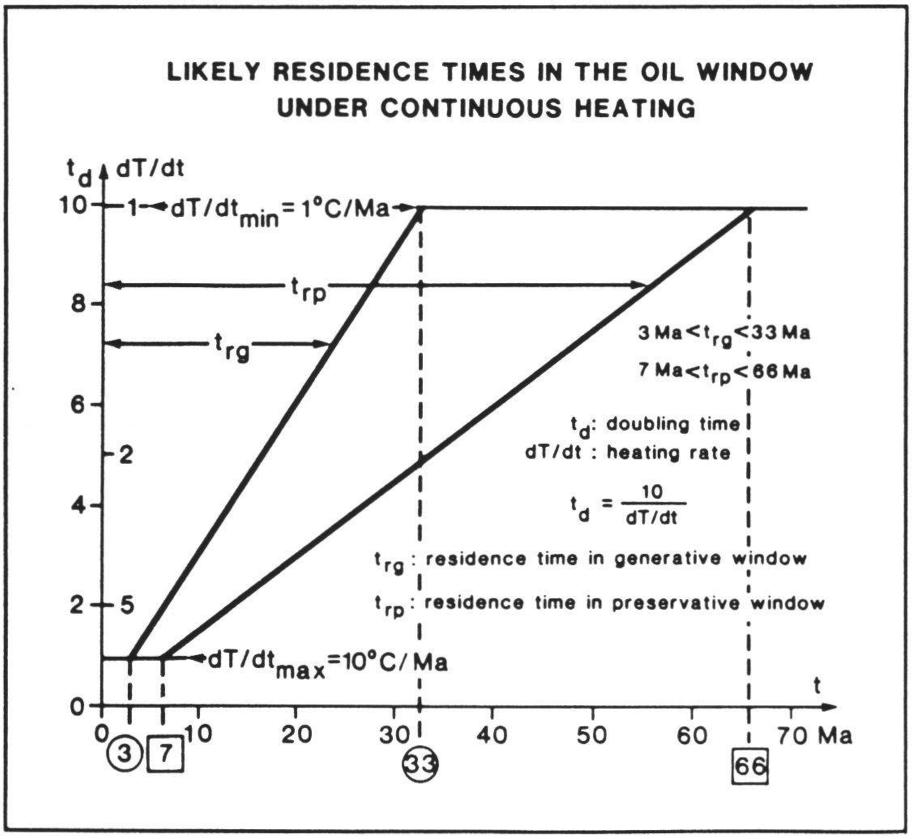

Figure 2: Here the likely residence times in the oil window are given for conditions of continuous heating (burial). It should be noted that the residence time in the generative window (t_{rg}) and in the preservative window (t_{rp}) can be rather short in what must be considered a normal geothermal environment.

From the above follows that the residence times for the generative oil window (t_g) and the preservative oil window (t_p) under conditions of continuous burial lie within the following limits:

$$33\text{Ma} \geq t_g \geq 3\text{Ma}$$
$$66\text{Ma} \geq t_p \geq 7\text{Ma}$$

The details of this relationship are given graphically in **Figure 2.**

The above considerations demonstrate that full oil generation may take less than 10 Ma in many cases. This leads us to anticipate temporary geopressures in maturing rich source rocks. Source rocks in overthrust belts that are subject to rapid heating may thus act as decollement horizons, provided tectonic pulses and thermal maturation are synchronous.

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