Organic compounds as thermal sensors for sediment alteration

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Molecular stratigraphy utilizes specific organic compounds (biomarkers) with distinct biological origins to characterize sedimentary sequences (e.g., Brassell et al., [1986]). One such class of biomarkers is a group of long-chain (C_{37} to C_{39}) alkenones which are widespread in Quaternary marine sediments and preserve a record of past sea-surface temperature [*Brassell et al.,* 1986]. They are derived primarily from prymnesiophyte algae such as *Emiliania huxleyi* (e.g., Volkman et al., [1980]), where the degree of alkenone unsaturation, expressed as an index (U^{K}_{37}=[37:2]/([37:2] + [37:3])), is linear versus the growth temperature determined by laboratory culture experiments and field correlations [*Prahl and Wakeham,* 1987; *Sikes and Volkman,* 1993].

These alkenones were found in sediments from the Middle Valley hydrothermal system recovered by ODP Leg 139 [*Davis et al.,* 1992; *Simoneit et al.,* 1994]. The molecular identity of these compounds was confirmed by mass spectrometry and a temperature scale assigned to the U^{K}_{37} index. The thermal stability of these compounds was evaluated versus sub-bottom depth in the hydrothermal system so that they may be used as geothermal probes.

The C_{37} alkenones present in the shallow sections of most ODP Leg 139 holes indicate a range of temperatures during prymnesiophyte synthesis of 7˚-15˚C, average 10.7˚C within surface waters.

The sub-bottom depth of a 200˚C isotherm, i.e. the depth where the *in situ* temperature could have approached 200˚C for a brief time, was estimated for each hole based on the disappearance of the alkenones (e.g., Fig. 1). The present measured temperatures at these depths are <80˚C, indicating that alkenone alteration may also be tied to lower temperatures over longer time. At Site 855, the recharge zone of the hydrothermal system with the reference holes, this depth correlates well with the distance from the fault scarp (recharge zone), i.e., Hole 855B 30-40 mbsf, Hole 855A >60 mbsf, and

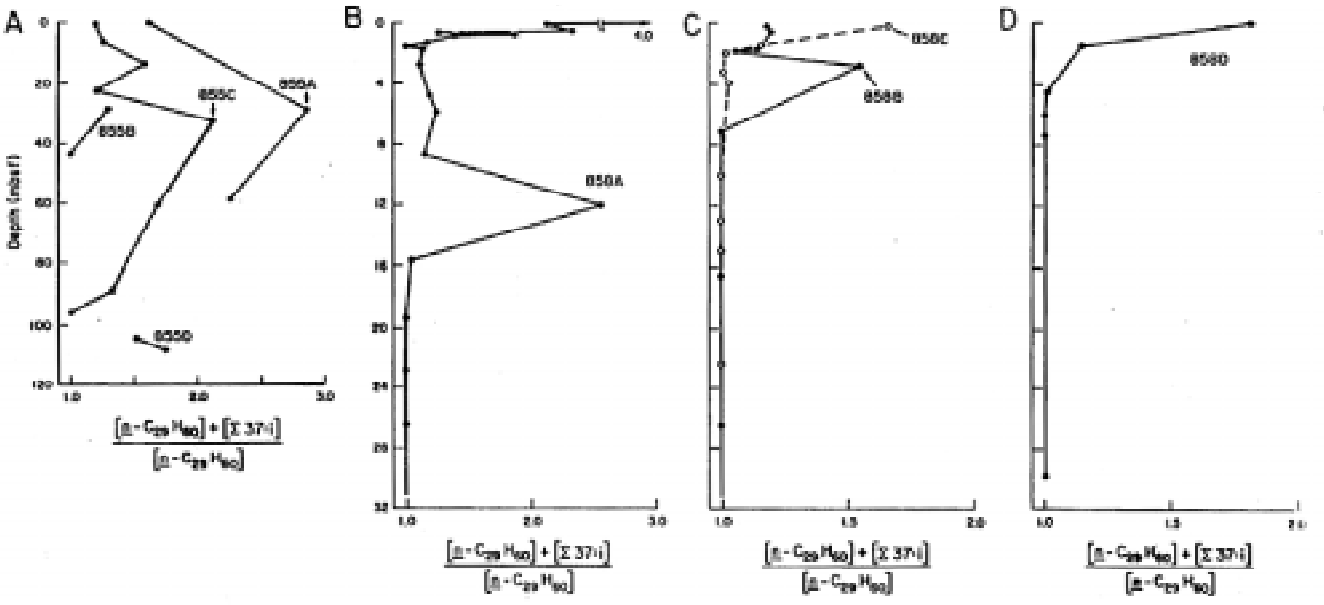

Figure 1. Alkenone concentration parameter, $\left(\frac{[n-C_{29}H_{60}]+[\Sigma 37:i]}{[n-C_{29}H_{60}]}\right)\left(\frac{[n-C_{29}H_{60}]+[\Sigma 37:i]}{[n-C_{29}H_{60}]}\right)$, versus sub-bottom depth: (A) Site 855, (B) Hole 858A, (C) Holes 858B and 858C, (D) Hole 858D.

Holes 855C and 855D 96 and 110 mbsf, respectively (Fig. 1A). At Site 856 on Bent Hill, only one hole had alkenones confirming the relict high temperatures at this site. In Holes 857A and 857C the alkenones disappear at 85 mbsf, indicating horizontal isotherms across the 200 m distance between the holes. This is consistent with the interpretation of a hydrothermal reservoir under this site, although the surface heat flow is different between the two holes. Site 858 is in the active vent area. Hole 858A, located ~200 m off center, had a hot fluid incursion at 1.5 mbsf and the 200°C isotherm is at about 26 mbsf (Fig. 1B). Hole 858C is at the edge of the vent area and the alkenones disappear in the 4-10 mbsf interval (Fig. 1C). Holes 858B and 858D are in the center of the vent area and the alkenones are depleted at the shallowest depths, i.e., 3-7 and 5 mbsf, respectively (Fig. 1C, D). The consistent fit of the disappearance of the alkenones with the observed heat flows makes these alkenones useful thermal probes.

References

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