Occurrence and environmental significance of long-chain alkenones in Tibetan Zabuye Salt Lake, S.W. China

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Abstract. Long-chain alkenones, a group of sensitive organic molecular indicators of water temperature, have been rather extensively studied in marine environments. However they have never been systematically examined in lacustrine environments, despite reports of their occurrence in lake sediments. Here, we report on a recent study of long-chain alkenones in a sedimentary core from a high altitude (5400 m) salt lake, Zabuye Salt Lake (ZSL), Tibet. This is a critical location for global climate studies, especially of the atmospheric circulation of the North Hemisphere. C37–C39 methyl and/or ethyl alkenones, usually dominated by components with tetra- and tri-double bounds, are commonly the major components of the polar fraction of the extracted organic matter from most sections. Down-core (vertical) variation of alkenone indices, the measure of molecular unsaturation, is compared primarily with other environmental signals, including lithology, elemental and mineral compositions, and stable carbon isotopes of hydrocarbon biomarkers of this core. Down-core profiles of alkenone climatic indices (U37 and U38) suggest ZSL had two warm periods, one during 20–30 ka (Jabula Interglacial Optimum) and another at 8–5 ka (Middle Holocene Optimum), and a severe cold period from 18–11 ka (Last Glacial Maximum). The proposed warmer intervals are generally characterized by higher contents of carbonate, organic carbon, alkenones and heavier δ13C values of n-alkanes.

Key words: long-chain alkenone, climate, carbon isotope, Quaternary, Tibet Plateau

Introduction

Long-chain alkenones in sedimentary organic matter have become the focus of numerous investigations of paleoclimate (Marlowe et al., 1984; Brassell et al., 1986; Prahl and Wakeham 1987; Prahl et al., 1988; Brassell, 1993; Sikes and Volkman, 1993) based on measurement of variations in their distribution that represent a response to temperature. These biomarkers consist of a series of C17–C39 di-, tri-, and tetraunsaturated methyl and ethyl ketones that are constituents of the coccolithophorid alga Emiliania huxleyi and a few other species of prymnesiophytes (Volkman et al., 1980). Field studies and labora-
tory culture experiments have been performed to establish the relationship between alkenone unsaturation, with higher proportions of the more unsaturated components (i.e. C_{37:3} and C_{37:4}) at lower temperatures (e.g. Brassell et al., 1986; Prahl and Wakeham 1987; Prahl et al., 1988). The alkenone climate index (U_{37}^k) has been established (Brassell et al., 1986). An extensive database of alkenone indices from various marine settings, ranging from tropical to polar waters, has also been developed (reviewed in Brassell, 1993).

Our understanding of climatic signals from lacustrine sedimentary organic matter is less advanced. Sensitive molecules have to be explored to obtain climatic information from continental lacustrine sediments. Alkenones are not restricted to marine environment and also known from temperate freshwater lakes in England (Cranwell, 1985) and in an Antarctic saline lake (Volkman et al., 1988). More recently, they have been reported in modern lacustrine sediments from the saline Lake Qinghaihu (Li et al., 1996). However, no satisfactory systematic study has been performed on continental environments, despite these reports. Such systematic studies are necessary to explore the potential of using these molecular tools in lacustrine environments. To compare oceanic and continental with regard to global climate change, these fossil compounds may play a critical role. Hence, investigations of alkenone climatic records, especially from climatically significant lacustrine environments, are of great importance.

This paper reports on our recent study of long-chain alkenones in a sedimentary core from a high altitude salt lake, Zabuye Salt Lake, Tibetan Plateau. As the highest plateau in the world and positioned in a location critical for studies of the global environment and climate (e.g. Gasse et al., 1991), the Tibetan Plateau merits attention in efforts to study global change (Flohn, 1957, 1965, 1968, 1981; Hahn and Manabe, 1975; Zheng and Liu, 1985; Zheng et al. 1989; Thompson et al., 1990; Shi et al., 1993; Gasse and Van Campo, 1994; Gasse et al., 1991, 1996; Gasse and Derbyshire, 1996).

Zabuye Salt Lake

_Zabuye Salt Lake_ (ZSL, Figure 1) is a small (~ 250 km²), oligotrophic (nutrient input is very limited from the semi-desert drainage basin) salt lake located in the Gandise-Himalayan fold belt, amid Cretaceous and Tertiary intermediate-acidic volcanics and purplish-red sandy argillites. A summary of its principal features (Table 1) indicates present size and water properties, especially salinity, and documents the evaporation/precipitation ratio (E/P) as ~ 12. ZSL lies about 500 m above the tree-line, and this effectively excludes any significant direct inputs from vascular plants. Halophilic algae, including _Chlamydomonas_ and _Dunaliella_ species and various bacteria, including