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Development of Cost-Effective Geothermal Probes for Use in Offshore Exploration and Environmental Work

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Geothermal measurements are important in various aspects of offshore oil and gas exploration. For example, hydrocarbon maturation is largely controlled by the thermal history of the sediments (Lerche, 1992), and the measurement of the heat flow through the seafloor is probably the most important direct information available to deduce the thermal history, and to infer a hydrocarbon maturation history. Underwater heat flow probing has been recognized as an effective method in detecting oil and gas seeps (Anderson, et al., 1991) and in investigating the sub-salt structures in the Gulf of Mexico (Nagihara, et al., 1992). Geothermal measurements are also important in understanding the heat budget in estuaries and lakes.

Although geothermal data are useful in many aspects, their acquisition tends to be costly and time consuming. The probes previously available for underwater measurements were mainly designed for operations in very deep (> 1000 m) water (Hyndman, et al., 1979; Jemsek, et al., 1985; Nagihara, et al., 1996). The equipment is quite heavy (one ton), and its deployment requires a

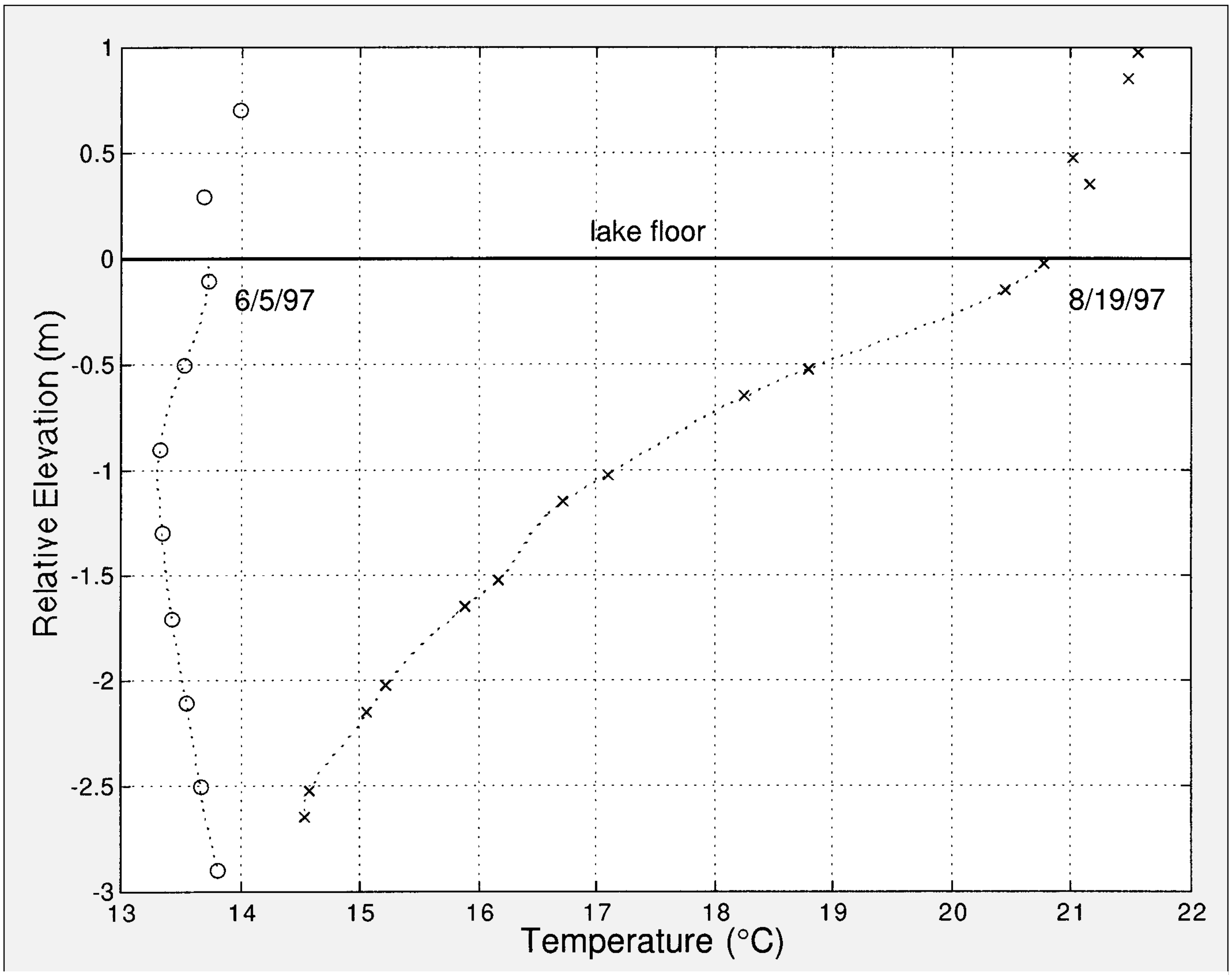

Figure 1. Subbottom sediment temperature profiles of Lake Travis, Texas, obtained during the two instrument tests in 1997.

large ship equipped with a heavy-duty winch and good station-keeping capability for which operational costs are high. These requirements preclude collecting data making measurements in small inland lakes where there is no means of transporting and deploying such heavy gear.

In this study, we have developed a new type of geothermal probe that has significant logistical and economical advantages over the previous ones for deployment in shallow (< 500 m) seas and lakes. The new probe utilizes a thin (2.54-cm or 1-inch diameter), long (~7 m) steel tube which contains a number of thermistors. It can be easily transported and deployed from a very small (i.e., inexpensive) ship with a small number of people because it weighs less than 50 kg. Once deployed, the probe free-falls through the water column and, with its momentum, penetrates into the sediments. In the current design, the probe transmits the temperature data to the surface through a thin electrical-mechanical cable. A maximum of 12 thermistors can be placed inside the metal tube. The internal electronics yields temperature resolutions of 2 to 3 millidegrees-K. Because of its simple design, the new probe costs much less to build and operate than the previous probes.

We tested the new geothermal probe successfully in Lake Travis, Texas, in early June and mid-August of 1997 (Fig. 1). It was deployed in the deepest (~55 m) part of the lake and recorded temperature profiles down to 3 m subbottom. The penetration was limited because the soft sediment cover of the man-made lake was thin. On each penetration, the probe was left in the bottom for about 45 minutes during which each thermistor was logged every 2 seconds. The equilibrium temperature at each sensor was determined by the extrapolation method previously established by Bullard (1954).

The two sets of geothermal records show the warming trend of the lake bottom water from the spring to summer. Detailed history of the temperature change, heat input from the surface and the greater depth are currently analyzed using mathematical modeling of the heat conduction process.

REFERENCES

Anderson, R.N., L.M. Cathles III, and H.R. Nelson Jr., 1991, ‘Data cube’ depicting fluid flow history in Gulf Coast sediments: Oil and Gas Journal, v. 89, p. 60-65.

Bullard, E.C., 1954, The flow of heat through the floor of the Atlantic Ocean: Proc. Royal Soc. London, A, v. 222, p. 408-429.

Hyndman, R.D., E.E. Davis, and J.A. Wright, 1979, The measurement of marine geothermal heat flow by a multipenetration probe with digital acoustic telemetry and in situ thermal conductivity: Mar. Geophys. Res., v. 4, p. 181-205.

Jemsek, J., R.P. Voh Herzen, and P. Andrew, 1985, In-situ measurement of thermal conductivity using the continuous-heating line source method and WHOI outrigger probe. Woods Hole Oceanographic Institution, WHOI-85-28.

Lerche, I., 1992, Oil Exploration: San Diego, Academic Press, 178 p.

Nagihara, S., J.G. Sclater, L.M. Beckley, E.W. Behrens, and L.A. Lawver, 1992, High heat flow anomalies over salt structures on the Texas continental slope, Gulf of Mexico: Geophys. Res. Let., v. 19, p. 1687-1690.

Nagihara, S., J.G. Sclater, J.D. Phillips, E.W. Behrens, L.A. Lawver, Y. Nakamura, A. Maxwell, T. Lewis, and J. Garcia, 1996, Heat flow in the western abyssal plain of the Gulf of Mexico: implications for thermal evolution of the old oceanic lithosphere: Journal of Geophys. Res., v. 101, p. 2895-2913.