nating torques at the spin frequency. The gravity gradient field, however, induces alternating torques at *twice*, the spin frequency, and they are preferentially selected by the mechanical resonance. The alternating torques are converted by a piezoelectric transducer into easily measured ac voltages.

Three versions of this sensor have been built and tested: (1) A lab protoype which demonstrated the feasibility of the concept; (2) An earth orbital flight prototype; and (3) A brassboard demonstration model of an airborne version. Most of the paper will describe our present work under ARPA–AFCRL sponsorship to produce a prototype moving base gradiometer capable of measuring horizontal and vertical gravity gradient components to an accuracy of one Eötvös Unit in a ten-second integration time.

2/216 *Review of Geochemical Techniques in Geothermal Exploration*

R. O. Fournier and D. E. White

Geochemistry has many applications to different stages of geothermal exploration and exploitation. Chemical and physical characteristics of thermal springs are critical in the early discrimination between the two major types of hydrothermal convection systems: the more common hot-water system and the rare, but especially attractive, vapor-dominated system (dry steam). Low-chloride waters, relatively rich in sodium bicarbonate or acid sulfate, indicate vapor-dominated systems. No reliable methods of predicting temperatures of vapor-dominated systems are yet proven, but isotopic fractionation of C^{13} between CO_2 and CH_4 is promising.

In hot-water systems, the silica contents and Na/K ratios (recently refined by adding a calcium correction) of hot-spring waters have, under favorable conditions, been utilized to give quantitative prediction of subsurface temperatures. Siliceous sinter and natural geyser activity provide evidence of high reservoir temperatures ($\geq 200°C$). Travertine deposits, in contrast, are generally indicative of relatively low subsurface temperatures because solubility of $CaCO_3$ increases with decreasing temperature.

Geochemical principles are essential in evaluating and attempting to solve many exploitation problems, including the understanding of vapor-liquid relations in produced fluids, corrosion and scaling in wells and surface pipes, disposal of unwanted effluents by reinjection or other means, and possible economic recovery of selected constituents of the produced fluids.

Combined Geoelectrical and Bore-Hole Investigations for the Detection of Fresh-Water Aquifers in Northwestern Missouri

Reinhard K. Frohlich

The northwestern part of Missouri has been under intense geologic investigation for the detection of fresh-water aquifers. The bedrock water in the Pennsylvanian limestone is not potable because of its high salinity. Fresh water is confined to glacial gravel deposits, which occur in small amounts near the surface and in a greater distribution at the bottom of glacial stream channels with thicknesses between 200 and 300 ft. Knowledge of the course of the stream channels and an estimation of the distribution of gravel and sand deposits is a prerequisite of water quality and quantity for household, irrigation, and industrial use.

Depth soundings after Schlumberger were carried out and compared with drillhole observations. Results of the investigation showed that within the glacial deposits, a distinction between yellow and gray clay can be made, where the latter shows consistently a lower resistivity. Below the clay is the aquifer consisting of water-saturated coarse sand with some gravel. It shows higher values of resistivity between 40 and 50Ωm. Surprisingly in no case was it possible to find a geoelectrical boundary at the depth of the bedrock. An increase to higher resistivities between 200 and 600Ωm, however, was found below its surface. This result is in agreement with geologic evidence that the upper part of the bedrock contains saline water in fissures. Its formation resistivity is similar to that found for the basis of the glacial deposits.

The glacial deposits under investigation show a rather complex composition of clay, sand, and gravel with strong lateral changes. The resolving power of the geoelectrical method is discussed for different possible layer cases. Recommendations are made for a combined geoelectrical investigation and drilling program to reduce the extensive drillhole observations.

The Correlation of Seismic Noise in Seismic Arrays

Anthony F. Gangi

The average crosscorrelation function as a function of separation between seismometers is important in the design of seismic arrays. Simple, straightforward array processing methods such as summing (or stacking or beam-steering), are efficient and optimum methods of improving the signal-to-noise ratio if the noise signals are decorrelated over the array. By their nature, noise signals in seismometers decorrelate as the distance between the seismometers is increased. The expensive, time-consuming process of experimentally determining the average crosscorrelation function for an array can be eliminated by taking advantage of the propagating nature of seismic noise. Under this assumption, the average crosscorrelation function can be simply derived from the average autocorrelation function at a single sensor. If the seismic noise is predominantly time and space stationary propagating noise, the average crosscorrelation function for a linear array is the convolution of the average autocorrelation function with the average angular distribution function of the propagating noise. For a planar array, there is an additional convolution over the angular distribu-