normal practice: (1) overconstrained case in a perfectly resolvable model is generated with squares fitting the data, (2) underconstrained case the data can be fitted perfectly, but there is resolution.

inverse theory for three models of interest successful, one of which includes a low-veloc- Three important points to be noted are: (1) as four iterations are required for resolving parameters even when the data contain noise, (2) high-paramater resolution can be when small perturbations on parameters substantial perturbations on data, and (3) pa- resolutions are improved when the elements system matrix are within several orders of tude. These observations result from the exami- of deltaness of the resolution and information matrices.

Environmental Seismology? A Challenge

ndell V. Mickey

physicists can take positive action and make tant contributions toward a better understand- the environment as it is influenced by earth- and other sources of induced seismic energy. ensive seismic systems are available which could by field crews (seismic, gravity, geomagnetic, to monitor seismic activity as it affects commu- from which the crews operate. A more sophisti- approach would include three systems: (1) -frequency response for micro-earthquake activ- (2) Intermediate response systems for the study regional earthquakes; (3) Strong-motion instru- for evaluating destructive earthquakes. The ben- are many: Local seismicity information, possi- effects of secondary oil recovery from water flood- or underground waste disposal, determining daries of geothermal activity, soil dynamics for planning, evaluation of ground motion as it re- to the potential for vibration damage from blasts, even the evaluation of sonic booms. Many seis- active areas with the likelihood of destructive quakes are along the faulted boundaries of oil . Environmental seismology can be dually prof- by contributing to the science and providing services.

Use of Geophysical Methods to Explore Solution Susceptible Bedrock—Davis-Besse Nuclear Power Station

Douglas C. Moorhouse and Richard A. Millet

Three geophysical methods (compression-wave ve- city, resisttivity, and gravity measurements) were , together with direct exploratory methods, to roughly examine the bedrock at the Davis-Besse Nuclear Power Station for significant solution activity.

All three methods were successfully used even though various phases of site preparation construction work were taking place simultaneously with the making of the geophysical measurements. The cross-hole method of obtaining compression-wave velocities was found to be limited in its ability to detect solution activity in bedded rock conditions because of the potential refraction of seismic waves to high-velocity beds. The seismic up-hole method of obtaining compression-wave velocities appeared to circumvent this problem. The resistivity method proved to be an inexpensive rapid procedure that can be used to detect solution activity if the effects of topography and groundwater conditions are properly evaluated. For the site conditions, the gravity method was judged to be the most reliable method of detecting solution activity because of its ability to directly measure mass deficiencies in the underlying bedrock. This method was also the least influenced by extraneous topography and groundwater conditions.

In conclusion, the authors feel that the three geophysical methods described can be very useful in the exploration of solution susceptible bedrock. However, all the geophysical methods require direct corroborating data obtained in borings, probes, etc., and they should not be relied upon without such data. In addition they cannot accurately define the dimensions of cavities formed by solution activity but they can indicate suspect areas that can then be efficiently explored by detailed direct methods. To use geophysical methods successfully the subsurface conditions of the site must be reasonably uniform in highly folded, faulted, or complex bedrock conditions; the prognosis for successful use of any of these three methods is poor.

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Geothermal Research in the U.S. Geological Survey

L. J. P. Muffler

Geothermal research in the U. S. Geological Survey has four major goals:

(1) To establish a reliable body of knowledge of the principles that control the occurence, size, temperature, energy content, producibility, and economic life of geothermal fields.

(2) To develop, refine, and test geophysical, geochemical, geologic, and hydrological techniques for finding and evaluating geothermal areas.

(3) To monitor the environmental effects of geothermal development, particularly with respect to subsidence, ground-water pollution, and seismic hazard.

(4) To provide data needed to evaluate the geothermal resources of the public domain.

A large part of the USGS Geothermal Research Program is currently focused on two "type" areas:

the Long Valley Caldera in eastern California (a hot-water geothermal system) and the Clear Lake area of northern California (which includes The Geysers, a vapor-dominated geothermal system). A thorough understanding of the nature and extent of the geothermal resources in these two areas will provide a firm base for extrapolation to other areas and for regional exploration and assessment of geothermal resources.

The USGS Geothermal Research Program also includes reconnaissance investigations in Oregon, Nevada, and Alaska that are designed to develop techniques and methodology for geothermal exploration and to assess the geothermal potential of these large areas.

These field investigations are complemented by laboratory experiments that provide the theoretical models and experimental data needed to understand geothermal phenomena. Laboratory investigations include research on hydrogeothermometers, rock-water interactions, isotopic relations, interpretation of resistivity data, and digital modeling of geothermal systems.

USGS environmental monitoring activities include subsidence studies, microearthquake monitoring, and water chemistry studies in several geothermal areas.

Gravity Gradiometer Experiments

Marjorie M. Mullins, James W. Parker, Robert L. Holland, and Harvell P. Williams

Gradiometers of the static and dynamic type which are currently under development measure from 1.0 to 0.01 Eötvös units over 5 to 30 sec, and are described with respect to their principles of operation, sensitivities, and resolution. These include gradiometers which measure in-line and cross gradients. The dynamic type includes those which are based on sensing the rotation of a proof mass, and the static type includes those which are based on sensing the translation of a proof mass. Specific dynamic-type gradiometers include rotating resonant instruments which sense torques and differential torques. Specific static-type instruments sense the tension in a spring or the capacitance between two proof masses; thus, a differential acceleration is detected.

An experimental laboratory test program which is currently in progress to establish designs and calibration procedures is described with respect to the site, equipment, instrumentation, and procedures. This includes a system whereby simulations of gradiometer responses in an orbiting spacecraft can be performed at the exact distances and velocities anticipated in actual flight.

A concept is given for utilizing gradiometers to complement existing guidance and navigation systems. This is discussed only from a theoretical point of view. The apparent advantages and limitations are summarized.

Results of the experiments thus far indicate [illegible] instruments with a 1 Eötvös unit sensitivity [illegible] 10-sec time constant can be built and calibrated in the 1-g environment on the surface of the [illegible]

Data from an orbiting or airborne gradiometer [illegible] offer global and local data independent in form [illegible] accuracy, thereby offering a new source of scientific information. This type of data provides, for the [illegible] time, measurements in accessible as well as inaccessible areas and totally outside the gravitating source. [illegible] latter is a requirement for the validity of certain mathematical techniques. In addition the possibility [illegible] obtaining consistent and complete measurements [illegible] points about the earth is unique. This will serve [illegible] criterion for evaluating the boundary value problem [illegible] combining independently made measurements into a continuous map. Some of the benefits of the data [illegible] geodesy and geophysics are discussed.

An instrument capable of detecting the density variations, or gravity anomalies, of the earth would [illegible] invaluable to many fields of study. In this paper [illegible] theoretical, as well as actual test results are given. These results demonstrate and verify the feasibility [illegible] detecting gravitational anomalies with a gravity gradient sensing instrument.

The gravitational field of a primary is discussed [illegible] terms of the spherical harmonic series and the problem of terminating this series. Also, the application [illegible] the coefficients of this series to the interpretation [illegible] the reference ellipsoid, moments of inertia, and [illegible] oidal undulations is considered.

The Analytic Signal of Magnetic Bodies of Polygonal Cross-Sections

Misac N. Nabighian

A procedure for automatic resolution of magnetic profiles can be followed under two assumptions: [illegible] Uniform magnetization and (2) Magnetized bodies have cross-sections which can be represented by [illegible] polygon. The concept of analytic signal is introduced and applied to both theoretical and field data. All operations are easily accomplished in frequency domain. The solution is shown to be quite general, being applicable to a wide range of problems.

Numerical Modeling of the Gradient IP Method

Misac N. Nabighian, Geoffrey O. Dickson, and John R. Parry

The finite-difference method has been used to investigate the gradient resistivity and IP problem of [illegible] dike located beneath a conductive layer. The computations are done for point electrodes, the overburden is assumed to be a flat layer, and the dike is assumed to be vertical with plane boundaries. The remaining geometry and electrode relationships, however, [illegible] general.