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P. W. Kasameyer
L. W. Younker
R. L. Newmark
A. G. Duba

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DRILLING INVESTIGATIONS OF CRUSTAL RIFTING PROCESSES IN THE SALTON TROUGH, CALIFORNIA.

MASTER

P. W. Kasameyer, L. W. Younker, R. L. Newmark and A. G. Duba
Lawrence Livermore National Laboratory, Livermore, California 94550

Introduction - Drilling provides access to the interior of the continental crust, allowing the direct observation of active processes and the collection of relatively undisturbed samples of the materials resulting from those processes. Unfortunately, the drillhole is myopic, and these observations and samples are valuable only if they can be viewed in context and provide insights into more general applications. In this talk we describe the results of CSDP activities in the Salton Sea Geothermal Field (SSGF), concentrating on a shallow heat-flow survey, but also considering preliminary results from the Salton Sea Scientific Drilling Program (SSSDP). These studies are providing significant insights into the nature of this specific hydrothermal system. By examining the thermal budget for the hydrothermal system, we argue that these studies are also telling a great deal about the nature of the rifting of the continental crust by oblique spreading throughout the Salton Trough.

Salton Trough Models - The Salton Trough is a large sediment-filled rift valley that represents a zone of tectonic transition between the oceanic-style ridge-transform activities of the Gulf of California to the southeast and the San Andreas continental transform fault system to the northwest. Authors with differing interests perceive that this spreading is occurring on different scales. The thermal zones, perceived by many as the locus of spreading, are less than 10 km in extent. The zones of seismicity suggest that a larger area, perhaps 30 km long, is deforming whereas tectonic models require basalt intrusion into a diffuse zone of deformation 150 km long. The local thermal zones produce only a small portion of the total heat flux of the valley. Does this mean that they contribute only a relatively insignificant amount to the rifting processes?

In this talk we explore how CSDP activities can be used to test the hypothesis that localized thermal zones are the source of all the heat for the Salton Trough. If this hypothesis is shown to be true, then it follows that, over the last few million years, the hot spots must have migrated around the Trough, producing the relatively uniform heat flow that is observed.

To maintain the observed average rate of heat influx, which is required to keep the Salton Trough near sea level (Lachenbruch, et al, 1985)1, the heat input rate to the hydrothermal systems must be larger than the heat flow out, by a factor of four or more. Thus, by examining the ratio of heat flux out to heat accumulation rate, we can test whether it is possible that all the spreading takes place at these zones.

The hydrothermal system and young volcanoes at the SSGF have been studied by many techniques but temperature profiles in deep and shallow wells have, to date, provided the most useful information about the circulation patterns in system. The reinterpretation of a simple conceptual model of the flow in the sampled portions of this

1. Lachenbruch, A. H., J. H. Sass and S. P. Galanis, Jr., Heat flow in southern-most California and the origin of the Salton Trough, J. Geophys. Res. 90, 6709-6736, 1985.

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field (Kasameyer, et al, 1984)[2] shows that to fit the observations from the SSGF, the ratio of heat input into the system by advection to heat flux from the top of the system by conduction is somewhere between 2.8 and 10. If this model is valid, and if the same ratio applies to all the other fields, then the heat influx rate for these fields is large enough to account for the steady-state heat flux from the Salton Trough.

Recent Continental Scientific Drilling Activities at the Salton Sea Geothermal Field are adding constraints to these models. The LLNL-Sandia thermal gradient survey, supported by DOE-OBES, completes the coverage of the top of the hydrothermal system at the SSGF, detecting asymmetry in its shape and lateral extent. The SSSDP deep hole is contributing important information to the definition of the thermal budget for the circulating hydrothermal system, in addition to providing the opportunity for extensive sampling and other studies.

The total area and heat flux coming from the field, the thickness of the circulating zone, and the abruptness of the transition from high to low gradients are the principal data constraining the rate of heat influx into the SSGF. The results from these experiments will feed back into thermal models and lead to conclusions about the thermal budget for this field, and about the importance of the local hot-spots in crustal rifting. If we become convinced that all the spreading takes place at hot-spots, then the chemical and petrologic studies at the SSGF provide insight, not only into hydrothermal alteration in geothermal systems, but also to the manufacture of new continental crust by the interaction of energy and materials from the mantle with continental sediments.

Future Drilling Investigations in the Salton Trough - There are many possibilities in the Salton Trough for future CSDP activities designed to understand the regional thermal and tectonic processes. The highest priority in this regard is to obtain deep temperature data which bear on the relationship between the thermal structure of the localized geothermal anomalies and the regional thermal regime. The present SSSDP hole reached approximately 10,500 feet, and a proposal has been sent to DOE to deepen it to 14,000 feet. A simple argument indicates that the proposed deepening is likely to reach the bottom of the well-studied hydrothermal circulation zone, providing a solid constraint on the thermal budget. There are many other ideas that, analyzed and justified, might make attractive CSDP projects in the Salton Trough. An intermediate depth (3000 foot?) hole could be drilled at the northwest boundary of the SSGF, to understand the cause of the asymmetry in the geothermal anomaly, and to test the validity of the lateral flow model. This hole could be complemented by a reflection profiling study focused on the nature of the localized spreading center at depth (Henyey, personal communication). A drill hole into the seismically active zone, but between the geothermal fields, could be targeted to identify the rock properties and state of stress in order to develop a seismo-tectonic model of deformation. Additional constraints on the regional heat budget could be provided by filling in the gaps in the heat flow coverage with measurements in the western part of the valley and to the south and east of the Salton Sea (Lachenbruch, Sass, and Galanis, personal communication). Heat input rates from other geothermal fields throughout the Salton Trough need to be evaluated in order to more effectively assess whether the heat input to the localized geothermal systems is sufficient to drive the rifting process.

2. Kasameyer, P. W., L. W. Younker, and J. M. Hanson, Development and application of a hydrothermal model for the Salton Sea geothermal field, Geol. Soc. Am. Bull, 95, 1242-1252, 1984.