New Tools for Science

Microcalorimeter

Some of nature's most intriguing scientific mysteries often lie just beyond our grasp because we cannot measure properly. Recently, however, Seed Money researchers developed a new, highly sensitive heat measuring instrument, called a microcalorimeter, which has begun to shed light on these mysteries and provide the means by which their underlying processes may be revealed.

Take for example the origin of man's most valuable mineral deposits, including those of iron, manganese, copper, zinc, silver, and gold. It is now believed that these deposits, mined on land near the surface, were once formed at great depths on the ocean floor near volcano-like hot springs, or so-called ocean thermal vents. A better understanding of how these mineral deposits were formed may lead to significant advances in our ability to locate and mine new deposits.

Unraveling this and other mysteries requires, in part, a basic understanding of the behavior of dissolved minerals in sea water at extreme temperatures and pressures. Yet, the underlying thermodynamic properties of mineral laden solutions in such regimes, cannot simply be extended from current data or more common experiences. Even normally stable properties are known to vary widely under such conditions and, until recently, could not be measured for lack of a reliable instrument.

In 1978 researchers funded by the Seed Money program embarked upon an uncertain path toward the development of such an instrument. The goal was nothing less than a device capable of the complete characterization of the most important thermodynamic properties, at temperatures up to 900°F and pressures up to 700 atmospheres, for a full range of solutions, including highly corrosive ones, such as strong acids and bases.

Their work made use of the fact that under special circumstances, if one could measure very precisely the faint amount of heat (energy) either given off or absorbed by a mixing reaction involving two highly dilute solutions or liquids, then everything else would fall into place. The special circumstances required, as a minimum: exact knowledge of the temperature, pressure, chemical composition, and amounts of the two liquids to be mixed; a carefully controlled mixing process to ensure completeness of the reaction; total absence of any gas or vapor phase in order to simplify the equations and eliminate extra variables; and a means of correcting for any outside influences that might adversely affect the data during the experiments.

If these conditions could be achieved under exacting standards, then the so-called "heats of dilution" could be measured precisely. This information, combined with other existing data, the well known laws of thermodynamics, and the equations of physical chemistry, could then enable the researchers to derive the remaining thermodynamic properties of the solutions in question.

The technical challenge was essentially one of building a device that could both withstand the extreme corrosiveness, temperatures, and pressures of the solutions envisioned, while simultaneously achieving levels of precision in measurement never before attempted. At the time, it was considered a high risk venture.

Within a year, the Seed Money researchers had built their device and demonstrated its powerful capabilities. They were enormously successful. Their device had circumvented a number of longstanding technical difficulties and produced results with high accuracies in previously unexplored regimes.

Moreover, the device was efficient and economical. Because of its simplicity, many tests could be run per day, heralding the collapse into months of what otherwise would have taken years of difficult and expensive research using