clusion that satellites were numerous and commonplace until Herculina's confirmed satellite observation. The fact that the 23 secondary events reported for eight minor planets (*2*) were observed by very sparse observer networks only serves to strengthen the conclusion.

In summary, I still consider that the existing observational data are reliable and support the conclusions drawn in (*2*). Nevertheless, I endorse Reitsema's call for additional observations by observers placed to provide redundancy. This idea has apparently already borne fruit during the occultation by 216 Kleopatra on 10 November 1980. Two visual observers spaced 2000 feet (0.6 km) apart parallel to the asteroid's ground track, but several hundred kilometers outside it, each observed essentially simultaneous total occultations of 1/2-second duration, which would correspond to a 5-km satellite.

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Geothermal System at 21°N

In his report on the geothermal system at 21°N, Bischoff (*1*) argued convincingly that the maximum subsurface temperature of the geothermal fluid should be higher than 350°C. He further demonstrated that the maximum temperature could be estimated from the pressure-volume-temperature (*PVT*) properties of seawater and suggested that it should be less than 420°C. However, he assumed that the *PVT* relations for seawater are the same as those for pure water and used pure water data for his arguments. This assumption is indeed valid in most cases, but should be used with caution.

For instance, it is well known that the existence of sea salts depresses the temperature of maximum density of water in the low-temperature range (*2*). On the other hand, sea salts raise the critical temperature of water in the high-temperature range (*3*), although little is known of the salinity dependence of the critical temperature of seawater. As a first approximation, I assume that the critical temperature of the deep Pacific seawater (34.7 per mil in salinity) is the same as that of a 0.615 molal NaCl solution. The resulting critical temperature is approximately 40°C higher than that for pure water (*3*).

Bischoff argued that the pressure limits for the circulating hydrothermal water are confined between 250 and 500 bars. He further argued that buoyancy is the driving force and thus the limiting factor for the maximum temperature the hydrothermal fluid acquires (*1*, *4*). Next he showed that a plot of the specific volume of pure water against temperature (his figure 7, redrawn as dashed lines in Fig. 1) indicates that water at 250 bars expands rapidly at temperatures above 380°C and water at 450 bars expands markedly above 420°C. Judging from the rapidity of water expansion above 420°C at 450 bars, Bischoff concluded that the maximum possible temperature cannot be much above 420°C.

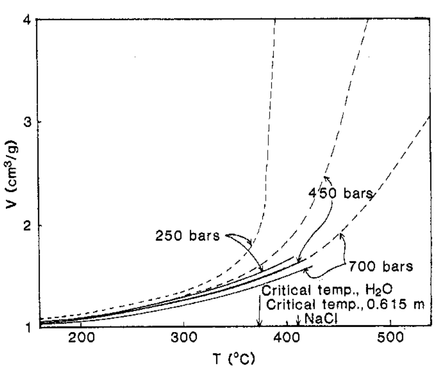

Fig. 1. Specific volumes of pure water and 0.615 molal NaCl solution versus temperature at 250, 450, and 700 bars.

The arguments of Bischoff are basically right, but he probably underestimated the maximum temperature. I have plotted in Fig. 1 the specific volumes of a 0.615 molal NaCl aqueous solution (solid lines) at various pressures (*5*). The curves are similar to those for pure water below 320°C, but are distinctively different once the critical temperature for pure water is approached.

At 250 bars, for instance, the specific volume of pure water increases drastically above 370°C, whereas that of the NaCl solution increases steadily to about 400°C. Presumably the NaCl specific volumes would start a rapid increase above the NaCl critical temperature, but no data are available. At 450 bars, the specific volume increase for the NaCl solution also lags behind that for pure water by about 40°C. In other words, it may be possible to heat the circulating hydrothermal seawater (NaCl) to near 460°C instead of only 420°C as suggested by Bischoff. This seemingly small difference in temperature could mean a significant difference in mineral solubility, and metal transport and deposition mechanisms (*1*) thus should not be neglected.

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