Reports

Paleotemperatures and Chronology at Archeological Cave Site Revealed by Thermoluminescence

Abstract. *Contrasting values of remnant thermoluminescence of limestone samples from Jaguar Cave, eastcentral Idaho, reveal temperature differences attributable to position within the cave microenvironment. Absence of recorded temperature change during cave-filling by rock and human debris indicates brevity of human occupation, which was near the end of Wisconsin (Pinedale) time.*

Previous work has shown that the magnitude of the 230°C glow-curve peak, which is present in the natural thermoluminescence glow curves of a limestone sample, is a usable indicator of the previous mean high temperature of that sample (*1*). The time during which this relationship remains valid varies with absolute temperature from a few thousand years in a hot environment, such as that of Death Valley, to more than a million years in Antarctica. Studies just completed show that thermoluminescence can reveal synchronous minor temperature differences within a restricted though diverse environment. These microenvironmental differences can in turn be interpreted in terms of past climatic regimes for purposes of geochronology, which can be applied directly to the solution of certain problems in archeology.

On the western slope of the Beaverhead Mountains about 30 km north of the Snake River Plain in eastcentral Idaho is Indian Head Canyon. The most outstanding result of archeological excavations made on the northern side of this canyon by Sadek in 1961–62 was the discovery of a cave behind an accumulation of rubble at the base of a low cliff (*2*). This cave, now called Jaguar Cave, has a roughly rectangular floor, 8 by 11 m. Bedrock is the Carboniferous Brazer Limestone.

When the cave was discovered, it was largely filled with pieces of rock from the ceiling, interstitial dirt, and several tens of thousands of fragments of animal bones, most of which were split in such a way as to indicate that they had been deliberately broken as part of the food supply of humans. Although occurring outside in some profusion, no chipped stone artifacts were found during exploration of the cave proper nor in subsequent searches in the excavated material. However, a few pieces of bone from the cave show clear evidence of human workmanship (*3*).

Age determinations have been made on two samples of charcoal obtained during the excavation. These samples came from near the center of the cave both horizontally and vertically so that they record a point intermediate in the span of human occupation and debris accumulation. The stratigraphically higher of the two samples yielded a radiocarbon age of 10,370 ± 350 years, the slightly lower one 11,580 ± 250 years (*4*).

Although the duration of human occupancy of Jaguar Cave is not bracketed by radiocarbon dates, it is apparent that the cave was open to Indian Head Canyon at least 12,000 years ago, and that the accumulation of rock and bone debris began to fill the cave at that time or somewhat earlier and continued until something less than 10,000 year ago. Analysis of the thermoluminescence of samples of limestone from various parts of the cave presents more definite evidence of the duration of the cave-filling period. Because the broken animal bones were distributed throughout the fill, which indicated at least sporadic human occupancy while the debris was accumulating, analysis of the thermoluminescence also provides information of archeological importance.

Samples of the limestone bedrock were collected from the cave in 1964 (Fig. 1) and have been subjected to thermoluminescence analysis. The amount of thermoluminescent radiation produced by a specimen of calcite, or of reasonably pure limestone, increases irregularly as the specimen is heated, and reaches peaks at about 230° and 315°C. The 230°C glow-curve peak is affected by temperatures within the range of terrestrial climates. The previous mean high temperature of a sample is indicated by the percentage of possible thermoluminescence that still remains at 230°C. Inasmuch as electrons escape from traps in the crystal lattice more rapidly as the temperature increases, and the naturally occurring thermoluminescence therefore declines, higher percentages of remnant thermoluminescence indicate lower mean high temperatures. In specimens from Jaguar Cave the percentage of available electron traps actually filled varied from 36.5 to 43.0 percent.

Sample 1 (remnant thermoluminescence, 36.5 percent), from the original floor of the cave, records the highest temperature. It was covered by rock debris mixed with rotting bones and flesh that served as a local source of heat and raised the temperature of the contiguous bedrock above that affected only by the geothermal flux from below or by such climatic warming from outside as could reach the spot through the cave opening.

Sample 2 (remnant thermoluminescence, 39.6 percent) came from the domed ceiling that trapped warm air rising from lower in the cave. This heated air originated from body heat of the human occupants, from their fires, and from the rotting of their organic debris. It was sufficient to noticeably raise the rock temperature.

Sample 3 (remnant thermoluminescence, 40.2 percent) came from just above the level to which the cave was filled with debris. It was cooled by circulation of exterior air until debris accumulation sealed the cave.

Sample 4 (remnant thermoluminescence, 40.5 percent), taken from the bottom of a hole excavated in the bedrock floor by the archeologists, records the coldest temperature within the cave. This is the true bedrock temperature fixed at the time the cave was open and unfilled. After debris accumulation had formed an insulating layer on the floor of the cave the bedrock temperature was not appreci-

ably affected by subsequent variations in climate. Heating of the floor surface by oxidation of overlying debris did not affect bedrock temperature at the depth from which this sample was obtained.

Sample 5 (remnant thermoluminescence, 43.0 percent), with a temperature lower than any within the cave, came from the cliff above the cave entrance. This cliff faces south and would be expected to have a relatively high temperature caused by lengthy, direct insolation. However, the location is protected from morning sun by a high ridge on the southern side of Indian Head Canyon, and during summer afternoons the cave is commonly shielded from sunlight by an extensive development of clouds to the southwest over the Lemhi Mountains.

The temperatures of samples 1 and 2 were strongly influenced by sources of heat within the cave, as was that of sample 3 to a lesser degree. These samples record the high temperatures that were present within the cave during human occupation while the fill debris was accumulating or shortly after the rising fill surface had sealed the cave, but rotting of the organic material was still producing heat. Sample 4 records the temperature at the time the cave was completely open to atmospheric circulation, and before filling with the debris of human occupation had begun.

Sample 5, from outside the cave, records the lowest temperature of all. The fact that this exterior temperature is lower than that preserved within the cave by its filling, and recorded in sample 4, might be interpreted as indication that occupation and consequent filling of the cave began during a climatic regime somewhat warmer than that of the present. However, glow-curve peaks record previous mean high temperatures and that record would be preserved through a subsequent short cold interval. Therefore, the temperature contrast recorded by samples 4 and 5 is interpreted as an indication that the cave interior, even before debris accumulation restricted circulation of air from the outside, was measurably warmer than the outside temperature.

The close similarity of the glow curves for samples 3 and 4 indicates that the cave was effectively sealed by the rising accumulation of debris at a time when the climate was essentially the same, at least in terms of temperature, as when filling began. Because the sealing of the cave also effectively blocked human ingress, except possibly through a cleared crawlway in an emergency, it is apparent that human occupation was limited to the duration or part of the duration of one climatic regime.

The radiocarbon dates correlate with the final retreat of the Wisconsin ice sheet in the Mississippi Lowland (interrupted by the minor Two Creeks advance) and of Pinedale valley glaciers in the Rocky Mountains, which include many glaciers on the slopes of the Lemhi Mountains as close as 16 km from Jaguar Cave. This correlation in turn suggests that the cave was occupied, filled, and sealed shortly before or at the beginning of the Anathermal climatic interval. Human occupation and the resultant filling of the cave must have been restricted to little more than two millennia because climate was changing rapidly at that time; yet the close similarity of temperatures recorded by samples 3 and 4 indicates that the cave was sealed and unaffected by the warmer and drier Altithermal climate that followed soon afterward.

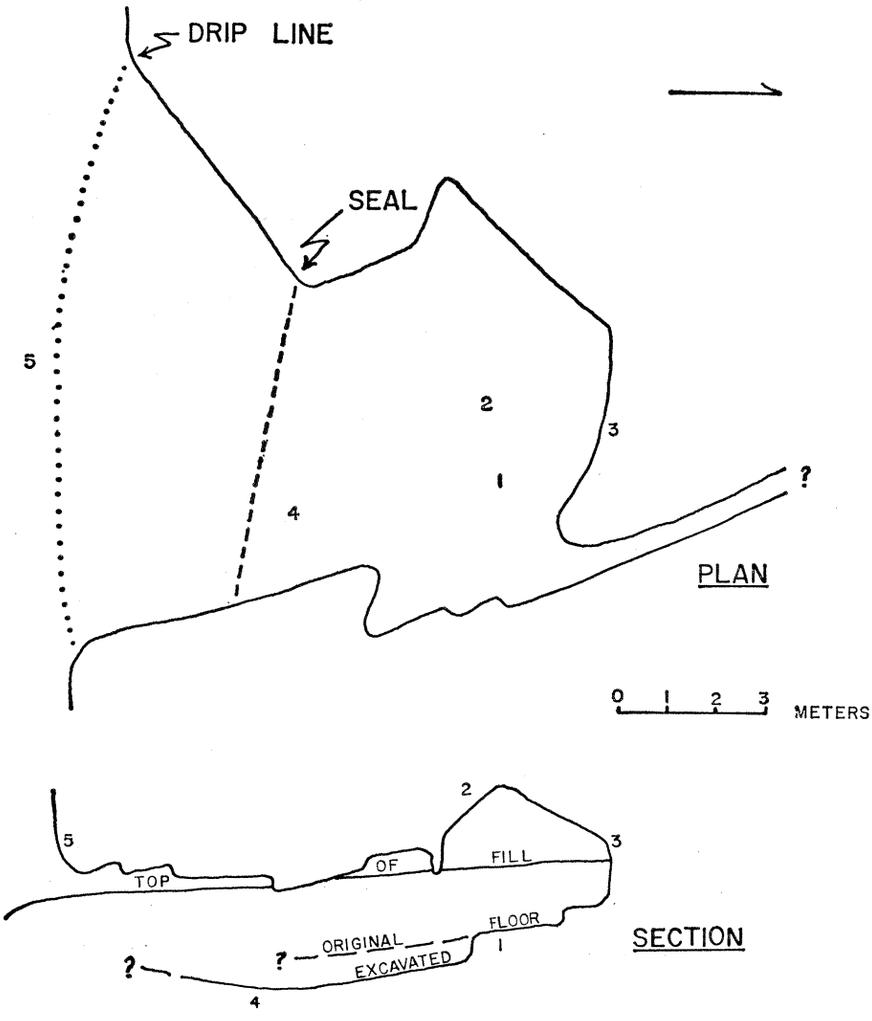

Fig. 1. Plan and section of Jaguar Cave, eastcentral Idaho, showing locations from which limestone specimens were obtained for thermoluminescence analysis.

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References and Notes

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