Introduction: Long lava flows (taken here to be flows longer than 50 km) are distinctive features on all terrestrial planetary surfaces where volcanism is evident. The emplacement of long lava flows has generated controversy, particularly with regard to the rate and style of emplacement. Long lava flows on several planetary surfaces were investigated recently in an attempt to understand their overall geometry, to provide constraints on modes of emplacement [1]. Geometric information about flows derived from remote sensing data alone usually is of insufficient precision to provide strong constraints on flow volume and modes of emplacement. We made a preliminary examination of the Carrizozo basalt flow in central New Mexico to assess the utility of detailed topographic information as an aide for interpreting flow characteristics using remote sensing data, and here we present our preliminary observations and results. We believe that a more complete assessment of the detailed topography of the Carrizozo flow will provide valuable insight into interpretations of long flows on other planetary surfaces.

Background: Two models for emplacement of long lava flows within the Columbia River Basalt (CRB) group represent the extremes in the flow emplacement debate. Turbulent flow powered by the hydraulic head produced by the gently sloping upper surface of massive flows leads to emplacement times of days to weeks for flows hundreds of km in length [2]. In contrast, observations of inflation of active Hawaiian basalt flows [3] led to the interpretation of several CRB flows as inflated pahoehoe flows emplaced over periods of years [4, 5]. Compound flows on planetary surfaces can provide additional examples of long flows for testing these modes of emplacement [1]. The Carrizozo flow provides a unique opportunity to obtain detailed information about a long basalt flow that should be very helpful in assessing the emplacement of compound flows on other planetary surfaces.

Topography: The Carrizozo flow (N 33°50’ to 15’, W 105°55’ to 106°20’) is an excellent example of a young, 75-km-long, compound tube-fed pahoehoe flow field located in south-central New Mexico [6]. The flow covers 330 km$^2$ to an estimated depth of 10 to 15 m, for a total erupted volume of ~4.3 km$^3$ [7]. The flow is Quaternary in age and has well preserved surface morphology in the semi-arid conditions of the high desert. The northern portion of the flow is cut by U.S. Highway 380, which provides excellent access for a topographic traverse across one of the wider sections of the flow. We used a Trimble 4800 base station and roving receiver to make two Differential Global Positioning System (DGPS) surveys with vertical and horizontal precision of ~2-4 cm. The first profile is parallel to the north side of Hwy 380 along a 4.6 km traverse, ~10 km down flow from the vent (Figs. 1&2).

Figure 1. Northern section of the Carrizozo lava flow. White line is location of DGPS profile in Fig. 2. The survey followed the north side of U.S. Highway 380 across the flow. From geo-referenced false-color TM image; grid lines are spaced 1 km.

Figure 2. DGPS profile across the northern portion of the Carrizozo lava flow (see Fig. 1). Lines connect 86 surveyed points. Vertical axis is altitude (m) above 1590 meters. “3” is on the west side of a large tumulus, as shown in Fig. 3.

flow surface is primarily pahoehoe, with numerous ropes and plates. The dominant relief consists of numerous tumuli with up to 10 m of relief, both as isolated ridges and as compound ridges parallel to the flow direction (Fig. 3). Road cuts through several of the tumuli clearly showed dense, mostly non-vesicular basalt to a level equivalent to their outer margins.
The highway profile (Fig. 2) reveals a topographic change perpendicular to the flow direction; the western 1.7 km of the flow has an eastward dip toward a 1.4 km central ridge, while the eastern 1.5 km is on relatively level terrain. We infer these variations are related to the sequence of flow segment emplacement.

The distal (southern) half of the flow, on the White Sands Missile Range, has restricted access. Through the efforts of Robert Myers (Environment and Safety Directorate, National Range), we were granted access to this part of the flow. Restrictions did not allow us to use the DGPS base transmitter, but through post-processing we still obtained excellent data for the narrow central portion of the flow (Figs. 4 & 5). This second traverse, ~40 km from the vent, shows relief still dominated by basaltic tumuli (~3 m high), with the exception of one 6-m-high tumulus comprising a ridge several km long (see arrows, Fig. 4). A medial crack on this tumulus reveals dense basalt to a depth of ~4 m; we saw no evidence that this unique ridge was the surface expression of a lava tube, as has been previously suggested [6]. We did see evidence that the eastern margin of the flow is buried by sediment from the nearby Bull Gap Ridge; it is apparent that the present visible flow surface does not represent the entire flow width at this location.

The distal end of the flow, ~75 km from the vent, expands to a width comparable to that of the northern section. Here we manually measured selected margin flow thicknesses of 1 to 2 m, which were on small outbreaks from the main flow. We found a large tumulus with ~10 m relief on the eastern edge of the main flow; here the top of the tumulus corresponds to a surface that appears flat over the entire flow width (although with numerous collapse depressions). We infer that the margin tumulus height likely represents the inflated thickness of the flow, which appears to be relatively uniform over the distal portion of the flow.

Clearly the tumuli are crucial keys to the thickness that likely relates to conditions during emplacement. We intend to make additional DGPS measurements in the future to document more completely the complex topography and probable thickness of the flow during its emplacement. [This work was supported by NASA (PG&G) grant NAG5-4164]