The Glass Buttes volcanic complex consists of many domes and individual vents that erupted both rhyolitic and basaltic lavas during the late Miocene to early Pliocene. The east half of the complex, in the vicinity of Little Glass Butte, contains interfingering, finely flow-banded rhyolite and black obsidian flows. The youngest unit, an obsidian, has been dated at 4.9 m.y. East of Little Glass Butte lie two northwest-trending ridges, Antelope and Cascade Ridges, composed of two or more overlapping exogenous domes that formed along northwest-trending faults.
The Brothers fault zone dominates local structure. Fault trends observed are northwesterly, and northeast trends may be conjugate fractures. The concentration of volcanism at Glass Buttes may be due to intersection of the Brothers fault zone with a west-northwest-trending silicic volcanic zone. Ensuing volcanism was bimodal, including glassy rhyolite, and the igneous body fostered a hydrothermal system.

Rhyolites are peraluminous, and silica ranges from 73 to 79%. Growth of spherulites occurred during devitrification of the glassy rhyolites, with slight silica-enrichment during vapor-phase alteration. Hydration and groundwater leaching depleted soda, alumina and silica in the glass. The plateau surrounding the buttes consists of olivine basalt, and a feldspathic basalt interfingers with rhyolite flows within the complex.

Hydrothermal alteration of rhyolite flows and glass was concentrated along faults in the eastern Glass Buttes. Massive cinnabar-bearing opalite was deposited from rising silica-rich geothermal waters accompanied by mercury-bearing vapors. Silicification occurred into footwall material, and irregular argillic alteration resulted from downward-percolating acidified groundwater.

The hydrothermal system has since cooled off or been plugged by opalite deposits. Eruption of lavas continued after alteration, further sealing the system. Late-stage fumarolic alteration indicates limited escape of gases occurred through faults in the opalite.
The geothermal reservoir is 600 m or more below the surface. Repeated fracturing and resultant boiling of fluids suggests the potential for precious metal deposits. Low temperature fluids producing surface alteration could not transport most epithermal elements, that subsequently were concentrated below the opalite cover. The steeply inclined zones of alteration imply a deep hydrothermal system, and great depths to potentially economic mineral deposits.