Geologic Overview of the Turkey Creek Caldera, by Ed du Bray (USGS)

Written in reference to Geologic Map of the Turkey Creek Caldera,
Chiricahua Mountains, Cochise County, Arizona
(USGS Map I-2544, du Bray and others, 1997)

The Turkey Creek caldera, in the center of the map area, is a mid-Tertiary (27 Ma) volcanic depression that formed during eruption of the Rhyolite Canyon Tuff and partial evacuation of an underlying rhyolitic to dacitic magma chamber (Marjaniemi, 1969; du Bray and Pallister, 1991). Caldera evolution involved three distinct phases: (1) eruption of 500-1,000 km^3 of Rhyolite Canyon Tuff and attendant caldera collapse, (2) emplacement of a dacite porphyry intrusion and lava flows, and (3) renewed eruption of high-silica rhyolite as lava flows. The caldera is deeply eroded; volcanic and shallow plutonic levels are exposed.

The majority of the rocks that host or form the topographic margin of the Turkey Creek caldera are older, middle Tertiary volcanic rocks, principally rhyolite ash-flow tuffs, although the northeast sector of the caldera's topographic margin is formed by interlayered Mesozoic sedimentary and volcanic rocks. These Mesozoic rocks are underlain by Paleozoic marine sedimentary rocks, which in turn were deposited on basement composed of Middle Proterozoic granitoid rocks; the geology of these pre-Cenozoic rocks is more fully described in Drewes (1982) and in Drewes and others (in press). Sources for the ash flows that predate the Rhyolite Canyon Tuff are unknown, but these tuffs crop out extensively in the Pedregosa Mountains, south of the map area. Andesite lava flows, present throughout the map area, were erupted at the onset of middle Tertiary volcanism in this area but became less abundant as ash flow eruptions became more voluminous. The distribution of intermediate-composition lavas, probably erupted from overlapping stratovolcanos throughout the map area, is highly irregular and probably reflects the topographic surface onto which they were erupted. Two other areas, Cave Creek and the area east of the mouth of Tex Canyon, are dominated by voluminous, aphyric, high-silica rhyolite lava flows that represent pre-caldera, coalesced dome fields. A third dome field is indicated by thick accumulations of relatively crystal-rich, low-silica rhyolite lava in the Erickson Ridge area.

One of the thickest and most complete sections of the outflow facies of Rhyolite Canyon Tuff is present in Chiricahua National Monument, in the northern part of the map area; ash flows also ponded within the subsiding caldera to form a thick section of the intracaldera facies of Rhyolite Canyon Tuff. Thick accumulations of Rhyolite Canyon Tuff in the Monument and near Bruno Peak, in the southern part of the map area, are presumed to represent filled paleovalleys.

The southwest sector of the intracaldera facies of Rhyolite Canyon Tuff includes a large mass characterized by lava-flow-like textural features. The lava-flow-like phase, which is younger than the remainder of the intracaldera facies of Rhyolite Canyon Tuff and is interbedded with dacite porphyry lava at one locality near the head of John Long Canyon, locally appears to be rheomorphic tuff; however, many exposures are distinguished by the presence of flow laminations, unbroken sanidine phenocrysts, and few, if any, lithic fragments. The lava-flow-like phase is compositionally indistinguishable from the remainder of the intracaldera Rhyolite Canyon Tuff. These features suggest that the lava-flow-like phase was erupted by fire fountaining, following the explosive caldera-forming eruption, and formed lava flows in the intracaldera environment.

Immediately after and overlapping in time with the final eruptions of Rhyolite Canyon Tuff, the central part of the caldera was intruded and domed and the structural margin was intruded by dacite and monzonite porphyry. Dacite porphyry was erupted from a ring dike within the structural margin and accumulated as a series of thick lava flows within the caldera moat (du Bray and Pallister, 1991). The facts that (1) rocks having compositions intermediate between those of dacite porphyry lava and intracaldera tuff are rare in the Turkey Creek caldera and (2) the lava-flow-like phase is interbedded with dacite porphyry lava flows indicate that the magmas represented by these rocks were present simultaneously in a magma reservoir beneath the Turkey Creek caldera and that eruption conduits alternately tapped different parts of a layered chamber characterized by a pronounced compositional interface (du Bray and Pallister, 1991).

Following eruption of dacite onto the floor of the caldera moat, a series of rhyolite lava flows, small-volume tuffs, and sedimentary rocks were deposited during the final phase of activity associated with the Turkey Creek caldera. Subsequently, erosion modified the topographic expression of the caldera; the former topographic high of the caldera margin is located within what is now Pinery and Red Rock Canyons, whereas erosion-resistant moat lavas now form topographic highlands.

The positions of the caldera's structural and topographic margins are noted on the map. The structural margin, as defined here, consists of the inferred position of the ring fault system along which the floor of the developing caldera collapsed during the eruption of Rhyolite Canyon Tuff. Caldera collapse caused development of a deep central depression in which intracaldera ruff accumulated to a thickness of at least 1.5 km. The structural margin (ring fault system) is either concealed by younger deposits or has been intruded by dacite porphyry throughout most of its extent; a west-trending segment of the structural margin is exposed about 1.5 km south of Turtle Mountain, in the southwestern part of the map area, and the ring fault coincides with the floor of nearby John Long Canyon. In other areas, the position of the structural margin is inferred to be outboard of the greatest thicknesses of intracaldera tuff and inboard of the topographic margin.

The topographic margin, as defined here, is denoted by the unconformity between caldera fill (intracaldera tuff, wall breccia, or moat deposits) and any older rock. The topographic rim retreated away from the structural margin by landsliding into the depression that developed during caldera collapse. In this process, large amounts of older rock exposed in the walls of the depression calved off and were redeposited as breccia beds on the caldera wall (unit Twb). Syn-eruptive landslides mixed with ash and pumice to form lithic-rich intracaldera tuff, and meso- and mega-breccia at deeper levels within the caldera. As eruption and collapse waned, a thin (<1 km) accumulation of tuff was deposited on older rock that formed the runout surfaces and headwall scarps of the landslides. The headwall scarps represent the topographic margin of the caldera and are located outboard from the structural margin. Resurgent emplacement of dacite porphyry magma, presumably as a laccolith, uplifted the center of the caldera and caused development of a caldera moat that was initially flooded with dacite porphyry lava flows and then filled with new high-silica rhyolite moat lavas.

In places, outflow tuff preserved at the lip of the caldera forms the topographic margin. Moat lavas ponded against this outflow tuff overfilled the moat and locally flowed out on top of the outflow tuff. In particular, moat deposits located along the northeast-trending ridge of Sage Peak, in the upper reaches of Price Canyon, on the ridge south of Baker Canyon, and on the east ridge of Dobson Peak, all in the southeastern part of the map area, are interpreted as moat deposits that flowed across the topographic margin after the moat depression in this area was filled by earlier moat deposits.

On the north wall of Red Rock Canyon, Rhyolite Canyon Tuff changes dip abruptly from 5°-10° to 43° and becomes rheomorphic and brecciated at the exposed topographic margin of the caldera. This area represents the headwall of a landslide into the caldera that formed during the final stages of caldera collapse. Angular blocks of Rhyolite Canyon Tuff were shed from the landslide scarp and accumulated to form steeply dipping beds of wall breccia (Twb), as exposed on the north-facing slopes between Red Rock and Rucker Canyons. Similarly, along the southern edge of the caldera, seven erosional remnants just inside the topographic margin are composed of monomictic breccia. Clasts in these breccias range from 0.1 to 2 m in diameter. Three of the breccia deposits contain clasts of Jesse James Canyon Tuff, and four contain clasts of outflow facies Rhyolite Canyon Tuff. Flow foliations indicated by flattened pumice blocks in the ash-flow tuff clasts in these deposits are randomly oriented; incomplete and rubbly exposures preclude observation of the matrix between clasts. These areas are interpreted as landslide breccias derived from headwall scarps along the topographic margin of the caldera. The composition of clasts contained in each of the breccias indicates the rock type of the topographic margin in the source region for each of the landslide deposits. The monomictic nature of these breccias indicates that source regions for these landslide deposits were relatively restricted and that the slide masses themselves did not move far.

Besides the Turkey Creek caldera, the most prominent structural feature in the area is a north-northwest-trending horst in the southern part of the map area. Features that suggest that this basement block was high-standing both during and following caldera collapse include nearby exposures of wall breccia (Twb) that are rich in Bisbee Group clasts. Last motion on the fault bounding the east side of the horst postdates caldera collapse and predates earliest moat magmatism because these faults cut intracaldera tuff but are buried by moat deposits. The northern edge of the horst, 1.5 km south of Turtle Mountain and north of Brushy Creek, coincides with an exposed segment of the structural margin (a growth fault) of the caldera along which intracaldera Rhyolite Canyon Tuff was deposited. The northern extension of the basement horst is present within the caldera as two fault blocks. The eastern (Turtle Mountain) block is a horst that exposes deep levels of intracaldera Rhyolite Canyon Tuff (Trci). High-silica rhyolite lava (Tmr_1) was erupted following resurgent uplift of this block and ponded against the high-standing block of intracaldera tuff. The graben block to the west exposes basal dacite porphyry lava that appears to be interlayered with a lava-flow-like phase of intracaldera Rhyolite Canyon Tuff, which is interpreted as the last Rhyolite Canyon Tuff magma to be erupted. Offset on the horst- and graben-bounding faults indicates a minimum pre-moat lava (Tmr_1) offset of at least 245 m based on the relative elevations of the top of intracaldera Rhyolite Canyon Tuff.