YOUNG VOLCANISM OR EXTENSIVE MASS-WASTING COLLAPSE INSIDE WEST CANDOR CHASMA, MARS; B.K. Lucchitta, Northern Arizona University and U.S. Geological Survey, Flagstaff, Arizona 86001.

Anomalous color [1,2] as well as unusual erosional and depositional features [3] have been noted previously in west Candor Chasma. In this report I tentatively attribute strange stratigraphic, morphologic, and topographic relations to either relatively young volcanism or wholesale mass-wasting collapse of interior deposits.

West Candor Chasma occupies the westernmost part of the large west-northwest-trending trough of Candor Chasma. This section is about 150 km wide, not as wide as central Candor Chasma but significantly wider than east Candor Chasma. West Candor Chasma is bordered on the north and south by straight wall scarps, most likely faults, and on its west by two en echelon segments of north-northeast-trending scarps, nearly perpendicular to the northern and southern scarps. The north wall is dissected by landslide scars forming reentrants filled with landslide debris. The south wall shows spur-and-gully morphology and smooth sections. These configurations are similar to those of Ophir Chasma. Also similar to Ophir and east Candor Chasmata are the overall topography and stratigraphy, which show deeper troughs that are devoid of older interior deposits along the north side, and shallower regions that are filled with deposits in the center and on the south side. The northern trough floor lies as much as 8 km below the adjacent plateau rim; the southern region lies generally about 4 km below the rim but extends to 6 km locally [4]. The central part of the chasma is occupied by a stack of older, finely layered, interior deposits with a smooth, resistant caprock, similar to what is seen in mesas and benches elsewhere in the central troughs [2].

The high-standing central mesa, informally dubbed Red Mesa by Geissler et al. [1], has several curvilinear reentrants carved into the caprock. Geissler et al. [1] found the layers exposed in the reentrants to have anomalous colors, which they interpreted to be possibly caused by young hydrothermal alteration products. The caprock plunges steeply on two sides as much as 3 km down toward the valley floor [4], giving rise to an anticlinal structure. In two places the smooth caprock gradually changes its surface appearance; it develops vague longitudinal ridges and local knobs. Eventually this transformed unit merges with light-colored lobes that flow away from the top of the interior-deposit stack and then flow around and embay the same layered stack from which they originated. One of these apparent flow features is composed of at least two or perhaps even three huge, superposed, vaguely layered, very rugged, light-colored lobes as much as 100 km long, 20 km wide, and over 2 km thick.

The layered deposits below the caprock also merge with a different-looking unit. This unit borders the central mesa and its surface shows, in chaotic arrangement, small segments of plateau-like platforms and triangular hogbacks, parallel edges of apparently tilted layers, fluted outcrops, and small lobes. This unit also embays older interior deposits. Locally it has lobate fronts and overlaps landslide deposits. In this region, it appears that the older interior deposits are transitional with these younger deposits. However, the resolution of the images (about 80 m/pixel) leaves ample room for ambiguity in interpretation.

Finely hummocky material fills the southwesternmost region of west Candor Chasma and is perhaps as much as 3 km thick [3]. The material is slightly darker than the light-colored lobes and is similar in hue to wall rock and landslides [1, Fig. 2]. The material embays tributary canyons, apparently buries landslide deposits, and has a level surface suggesting emplacement as a fluid. The unit abuts the huge, light-colored flow lobes, but superposition relations are not clear. This unit, as well as the lobes and chaotically arranged material discussed above, was labeled "irregular deposits" in Lucchitta [3] and Lucchitta et al. [5,6].

Low areas show dark deposits of neutral color, most likely composed of mafic materials [7]. On the northern trough floor the dark deposits occur as a thin veneer on landslide deposits, as a rugged lineated unit with sharply defined boundaries, and as thick blankets of smooth material. Thick, smooth, dark blankets also occur in a central low reentrant on the east side of Red Mesa. The dark material appears to emanate from point sources along the lowermost northern trough walls, from a linear feature along the rugged lineated unit, and perhaps from source areas underneath the thick smooth blankets. Also conspicuously dark is a layer cropping out in the lower walls of a 3-km-wide, smooth-rimmed, steep-walled, fresh-looking crater without a well developed ejecta blanket. The crater has the appearance of some terrestrial maars. Dark material also lines the southern trough wall at its contact with interior deposits.

Young volcanism or mass wasting could explain the relations seen in west Candor Chasma. Support for either hypothesis will be presented below.

WEST CANDOR CHASMA: Lucchitta, B.K.

The light-colored lobes, chaotically arranged materials, and level, hummocky fill may be volcanic. In favor of this interpretation is the observation that they were apparently emplaced by flow. They are massive deposits of considerable thickness that do not have an obvious source area of missing material in another unit, suggesting an internal origin. The light-colored lobes come from a region dotted by knobs that could be volcanoes. The relatively high albedo would suggest that the volcanic material is either more felsic than common for materials on Mars, or, if mafic, that unusual emplacement mechanisms imparted the higher albedo. On the basis of spectral absorption bands seen in Phobos 2 ISM imaging spectrometer data, Murchie et al. [8] suggested that bright interior deposits elsewhere in Candor Chasma could be palagonites. Also, the dark materials and steep-rimmed, fresh-looking crater suggest young volcanic activity in the region. The anomalously colored deposits on the flanks of Red Mesa suggest hydrothermal alteration [1,2]. Dearth of impact craters on the lobes and on the hummocky fill indicate young age. However, a young volcanic origin does not explain the apparent transition of older interior deposits to younger irregular deposits.

The light-colored lobes, chaotically arranged materials, and hummocky fill may be mass wasting deposits. The transition of older interior deposits to younger irregular deposits would then be due to wholesale collapse of older interior deposits that flowed out and became transformed to the younger unit. The idea requires that the older interior layered deposits in this region were saturated with ice, perhaps from former lakes. However, if the layered deposits ever formed unconfined, free-standing mesas, the sedimentary structure inside the mesas must have been supported by grains in order to uphold steep scarps [9]. Eventually, increased heatflow combined with tectonic activity, as evidenced in young fault scarps [1], upset the delicate balance between ice in pores and supporting grains. Liquefaction ensued. This scenario would explain the deformation of the older interior deposits as well as the transition of older to younger materials. The younger materials did not come from the walls (i.e., are composed of reworked wall rock), as suggested by the observation that they bury landslides on the walls and that they locally show fluting, which is commonly developed on interior-deposit material but not on wall-rock material. More difficult to explain are the light-colored lobes that are as much as 2-km thick, have steep margins, and show some edges with multiple layers. These observations do not suggest rapid, chaotic collapse, but perhaps are compatible with successive waves of slowly creeping material. Also, the nature of the knobs on top of Red Mesa, in the source region of the lobes, is not explained, unless the knobs are erosional remnants. Furthermore, it is difficult to understand how the voluminous light-colored lobes could have emerged only from the top of the mesa. In addition, mass wasting generally does not occur on interior deposits elsewhere in the troughs, even though it is common on chasma walls [5]. (An exception are some peculiar flow lobes on interior layered deposits in far eastern east Candor Chasma [3, Fig. 15]). However, even if the young irregular deposits in west Candor Chasma were mass-wasting products, young volcanism and/or tectonism would be needed to melt, soften, or dislodge the ice and make the material flow. That such volcanism occurred is suggested by the dark deposits; the young, possibly volcanic crater; and the inferred hydrothermal alteration products [1,2,3] in this region.

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