INTRATESSERA FLOOD-LAVA BASINS (ITBs) CONSTRAIN TIMING OF CRUSTAL PLATEAU STRUCTURES.

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Introduction: Crustal plateaus on Venus are broad plateau-shaped regions of thickened crust on the order of 1000 to 3000 kilometers wide standing 1 to 4 kilometers above surrounding radar dark volcanic plains. Although the typical crustal plateau surface appears bright in radar images, conspicuous patches of radar dark material up to 250 kilometers in width occur where low viscosity lava has flooded local topographic lows. These lava flooded areas are thus termed 'intratessera flood-lava basins', or 'ITBs' for brevity [1].

Despite recent advances in our understanding of crustal plateaus, the debate of crustal plateau evolution continues. In determining the origin of crustal plateaus it is particularly important to establish temporal relationships between their various structural elements. We have studied the geology of ITBs within Tellus Regio at the F-MIDR scale and have determined that ITBs postdate short-wavelength (~2-10 km) extensional and contractional features. Radar and altimetry evidence further suggests that initiation of some ITBs occurred prior to the formation of broad-wavelength (25-60 km) marginal folds. Our research corroborates previous investigations concluding that widespread crustal plateau extension occurred prior to contraction at plateau margins [2,3,4].

Background: Radar images of crustal plateaus appear brighter on average than surrounding low-lying plains, indicating that crustal plateaus have high surface roughness which is attributed to deformation accrued during crustal plateau development. There are, however, numerous radar dark areas, termed ITBs, within crustal plateaus that appear relatively smooth and undeformed, much like plains material. The surface of ITBs commonly lack a dense concentration of intersecting lineaments that constitute surrounding crustal plateau structural fabric, termed tessera. With few exceptions radar dark material of ITBs lies within local topographic lows, though not necessarily within regional lows. The smooth nature of this material combined with its occurrence within surface lows suggests that radar dark ITB material represents low viscosity flood lava constrained by gravity and topography such that it was deposited within local lows existing at the time of volcanism.

ITBs, recognized in Pioneer-Venus, Venera, and Magellan data, have been referred to as "intratessera plains" [5,6,7,8,9,10], "inter-tessera plains" [11], and "intratesseral plains" [12]. The term "plains", with reference to Venus, usually implies the vast expanse of lowland volcanic plains that cover much of Venus' surface. Although some workers group intratessera basin units with plains units, it is important to note that ITB volcanism need not be genetically related to plains volcanism.

There exist two end-member types of ITBs distinguished by shape and associated structures [1]. Regularly shaped "structural basins" are quasi-circular to long and narrow in planform and most commonly occur within crustal plateau marginal fold domains. Basin-bounding normal faults largely define the shape of structural basins and provide a buttress for intrabasin lava such that lava flows are mostly contained within basin margins. Structural basins are subdivided into basins with and without major late-stage interior graben. Irregularly shaped "embayment basins" lack boundary-defining normal faults and are characterized by digitate margins that trend with pre-existing crustal plateau topographic lows as a result of passive flooding. Embayment basins commonly exist juxtaposed with structural basins within marginal fold terrain. However, seemingly isolated embayment basins also occur within crustal plateau interiors. Many ITBs exhibit characteristics of both endmember types and are thus transitional forms.

Temporal Relations: Bindschadler and Head [5] reason that because boundary lineaments appear sharp and continuous and crosscut other tessera structures, ITBs and their associated boundary structures postdate tessera deformation. Other workers agree that ITBs are a late-stage event with respect to crustal plateau deformation [9,13,1]. At first glance lava-flooded basins appear significantly less deformed than surrounding tessera; many bright lineaments exist in tesserae whereas basins are mostly radar dark and characterized by a lack of numerous interior lineaments. ITB boundaries display lava flow embayment of tessera structures suggesting that the majority of tessera deformation occurred prior to basin lava flooding.

We examined geologic relations at ITBs within Tellus Regio with respect to crustal plateau structures described by Hansen and Willis [2,3] and Ghent and Hansen [4] including ribbons, graben and folds of interior basin-and-dome terrain, broad-wavelength margin-parallel folds, and late complex graben. Ribbons do not deform entire basins implying that initial ribbon formation predated ITB volcanism. Embayment basins are common within basin-and-dome terrain. Lava flooding in these basins embay graben and interference folds there, thus postdate them. An ITB along a fold crest within Tellus' eastern marginal fold belt appears to have influenced local fold physiography suggesting that the ITB existed during that episode of contraction. This particular example proves extremely important in documenting the relative timing between broad wavelength folds at crustal plateau margins and ITB development. It is described in more detail below. Late complex graben that crosscut ITB lava flows indicate localized extension after ITB lava flooding. However, lava flows also embay some late complex graben indicating that volcanism continued into late stages of crustal plateau evolution.

The ITB centered at approximately 37.8 N latitude and 87.2 E longitude, termed waffle basin due to its appearance, is located on a regional topographic high, one of the highest points in Tellus. It sits along the crest of a broad fold within the marginal fold belt. The waffle basin is an embayment-type basin whose shape takes on trends of pre-existing tessera structures. Geologic relations at this location give robust timing constrains of the four sets of tessera structures that occur in this area. Early-formed structures include north-trending, short-wavelength (~2-5 km) folds and east-trending, short-wavelength (~2-10 km) graben. These two sets of structures are grouped together because their timing relations cannot be determined in this area. They may have formed simultaneously since their orientations are consistent with the same overall bulk strain regime. The fact that their structural wavelengths are similarly narrow indicates that they deformed a similarly thick layer. ITB lava embays and thus postdates both north-trending folds and east-trending graben. It is likely that these two sets of structures record deformation from early stages of crustal plateau formation.

As mentioned above, broad wavelength (~25-60 km) folds of the marginal fold belt appear to bend around the location of flooding within the waffle basin. This suggests that the ITB (or its source at depth) existed prior to formation of these folds. Fold wavelengths increase dramatically in the vicinity of the embayment basin indicating the existence of strong material at depth during contraction. Volcanism may have continued during and prior to fold formation.

Conclusions: Geologic relationships suggest that the sequence of deformation at the waffle basin in Tellus is as follows: 1) North-trending folds and east-trending graben, both with narrow wavelengths, deformed a thin boundary layer. 2) ITB volcanism subsequently flooded topographic lows created by earlier deformation. 3) Regional contraction of a thick boundary layer created marginal folds trending approximately north.

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