Plate 1. Overview over the four formation hypotheses.

	A. Mantle downwelling	B. Mantle upwelling	C. Pulsating continents	D. Lava pond and bolide
References	Bindschadler and Parmentier 1990 Bindschadler 1995 Bindschadler et al 1992	Hansen and Phillips 1998 Phillips and Hansen 1998 Hansen and Willis 1998	Romeo and Turcotte, 2008	Hansen 2006
Short definition	Crustal accretion due to sub-solidus flow or lithospheric accretion.	Massive partial melting at shallow depths caused by plumes or diffuse upwelling.	Periodic subduction events lead to thickening of crustal plateau terrain driven by tectonic compression and extensional collapse. Tessera terrain represents continental crust which survived global subduction events.	Progressive solidification and deformation of a large lava pond of similar size to a crustal plateau
Primary driving mechanism	Convective down flow within the mantle or sinking of a portion of colder, dense lithosphere	Rising mantle plume with magmatic underplating	Cyclic compression and global subduction	Formation and solidification of a lava pond
Involved layers	Crust and mantle	upper crustal material and shallow mantle fed by plume from core boundary	Crust and lithosphere	Topmost layer and upper mantle
Initial setting	Layered structure with brittle elastic upper layer, ductile lower crust, strong upper mantle and weaker substrate. Including a early thin lithosphere	Early thin lithosphere, prolific magmatism, and a undeformed or annealed crust	Low density crust with relatively thick lithosphere which survived global subduction. Thickness ratio between lithosphere and crust is key	Globally thin lithosphere, hot environment
Starting mechanism	• Convective flow within the mantle leads to thinning of the crust	• Focused plumes rise from the core mantle boundary • Extensive partial melting in the upper mantle • Internally heated convection drives large volumes of melt up	• Initial contractional tectonic stress creates shortening of a continental low density area and creates a wide range of structural wavelength features	• Impact of a large bolide with enough velocity to create a 200-300km diameter crater • Creating partial melt in the upper mantle which rises to the surface through fracture surfaces
Stages: How does it evolve over time?	• Downwelling causes a initially downward flexed surface with small radially distributed contractional features • Ductile lower crust material is pulled toward the downwelling region • A region of thickened crust starts to form • As thickening continues contractional structures form • The center spot above downwelling represents a weak zone within the lithosphere and a barrier between mantle flow and • Contractional structures are then focused on the edges of the crustal plateau creating a ring of high topography • The center of thickened crust tends to spread under its own weight and extensional structures are created in a radial pattern • Additional local extension can be attributed to local relaxation of the material	• During upwelling of a mantle plume the crust heats up • Partial melting at the plume head occurs • Mechanical annealing of the crust (BDT near the surface) • Uplifts creates ribbon fabrics (rifting) while BDT is shallow and tensile stresses are high • Massive basalt flows • Then thickens by magmatic underplating while BDT deepens • Folding • Cooling and subsidence lead to local shortening • Topography subsides during further cooling • Graben form during late stage by relaxation of fold crests • Existing plateaus suggest formation late in thin lithosphere environment	• Crustal thickening by concentric thrusting occurs • Compression end when equilibrium between forces is reached • Rising of plateau by isostasty leading to thrusts and folds • A gravitational instability of the cold lithospheric mantle under the center of the plateau develops (similar to downwelling) • Radial graben and fractures are generated along the margins. The center experiences basin and dome interference pattern • This extensional stage widens the plateau by compressing the surrounding plains forming folds and thrusts • Intratessera volcanism is created during late stage extension by partial melting of the plateau driven by decompression • During deformation and thickening the crust becomes decoupled from lithosphere which allows delamination during the next global subduction event. Buoyant crust is surrounded by hot mantle and new lithosphere grows by heat conduction	• RTT represents lava pond scum, solidifying over time • Shortening and amplification lead to formation of folds • Extensional fabric forms normal to fold crest • Magma leaks to the surface & fills local lows • Layer thickening over time due to: ○ Deformation ○ Cooling ○ Lava flooding and solidification in structural lows • Longer wavelength fold and extensional structures form due to increased layer thickness • in the mantle where material was extracted a large solidified residuum remains (more buoyant and stronger) • Isostatic adjustment results in uplift, raising the solidified pond • Since residuum is in ductile mantle it could be stripped away by mantle convection. Which could lead to subsidence of the plateau. • If lithosphere thickens due to secular cooling before the root is swept away, the residuum would remain in place and retain the elevated shape.
Effects on the model	Size of the area initiating the downwelling and conditions of the cold spot	Lithospheric thickness Size of upwelling plume	After global subduction the ratio between crustal and lithospheric mantle thickness.	1. Venus's supercritical CO_2 atmosphere could affect solidification. Allowing longer ductility 2. Higher surface temperatures
Deformation mechanisms (stresses)	Downwelling creates contractional stresses	Upwelling creates tensional stresses	Initial ratio between lithospheric and crustal thickness determines collapse or rising of plateau.	Ductile and brittle modes of deformation all over the entire crustal plateau

Final crustal plateau

Spatial (areal) distribution & strain	Distribution of structures is covering a similar area to initial surface Higher ratio of contractional and extensional features in center of the plateau Margins are dominated solely by contractional structures	Structures exceed the initial upwelling surface Mostly extensional structures Disorganized shortening (folds) over the surface	Size of plateau depends on initial size of low density continental material that gets compressed Volcanism at all levels (post compression) Concentric thrusts and folds	Areal extend depends on size of lava pond High continuity of patterns, but widespread structures of the entire terrain Continuous deformation causes flow like patterning
Temporal Evolution	Early stage contractional structures Followed by radial patterns of extension	Early extensional (ribbons) Folds Graben Caused by an increase in BDT	Early contractional (until equilibrium) structures Late extensional features Accompanied by late stage flooding	Early short-wavelength Contractional structures (Fold) & Extensional structures (ribbons) Progressive increase in wavelengths Flooding occurs throughout deformation (basin fill)
Wavelengths	All wavelengths present	All wavelengths present	All wavelengths present	Large intermediate and short wavelengths
Distribution of impact craters	N/A	Craters on plateaus undeformed or only affected by late graben. Therefore ribbon and fold formation predate cratering on plateaus. Previous craters would have been wiped out by annealing.	Approximately equal to lowlands, which means crustal plateau formation and lowland volcanic plains are linked.	Some older craters might remain but most of them will be overprinted by lava pond

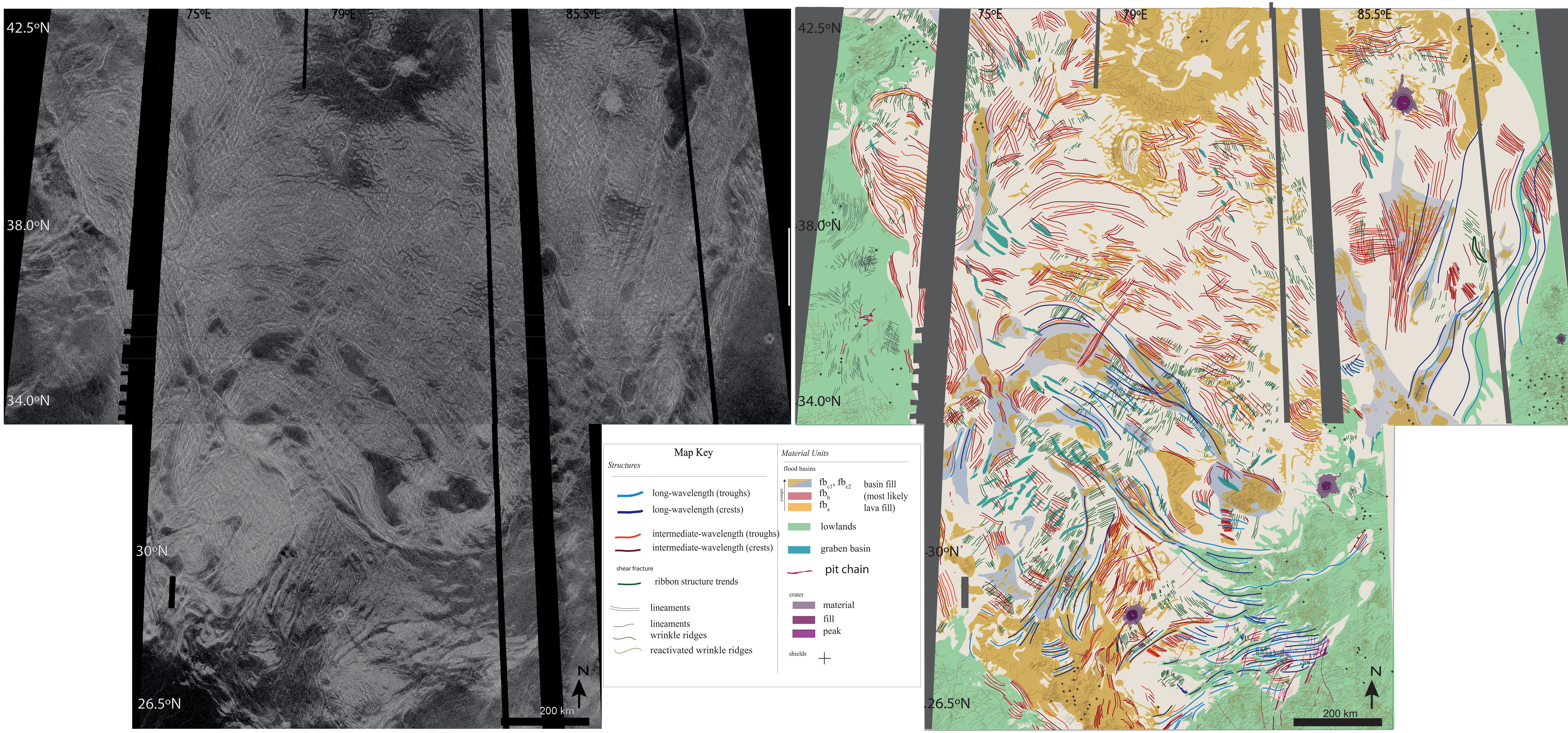


Plate 2. Left-look SAR image and geologic map of southern Tellus Regio. Long-wavelength folds dominate the plateau margin and southern area, parallel intermediate-wavelength folds extend across the entire terrain, depicting some structural fluidity. Generally ribbon structures and graben trend NE in the southern portion and NW in the northern portion of the plateau. Intratessera basins dominate the plateau, filling topographic lows of structural elements with low viscosity deposit material. Wrinkle ridges occur in intratessera basins and surrounding lowlands. Four impact craters occur in the southern and eastern margin of the plateau. Intermediate- and short-wavelength folds (not depicted due to resolution), and ribbons occur on the crests, limbs and troughs of long-wavelength folds. Graben generally postdate all previous structures.

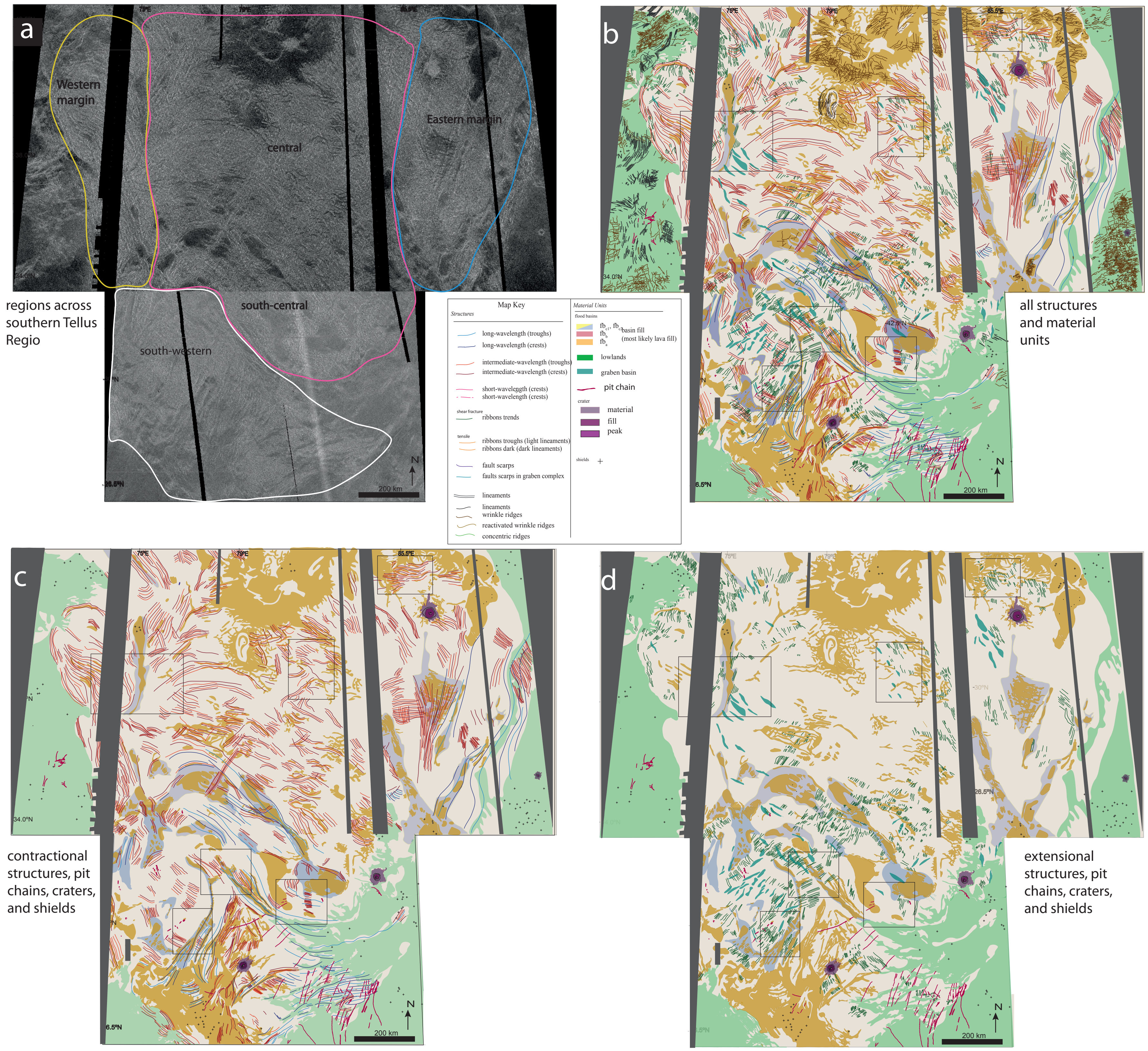
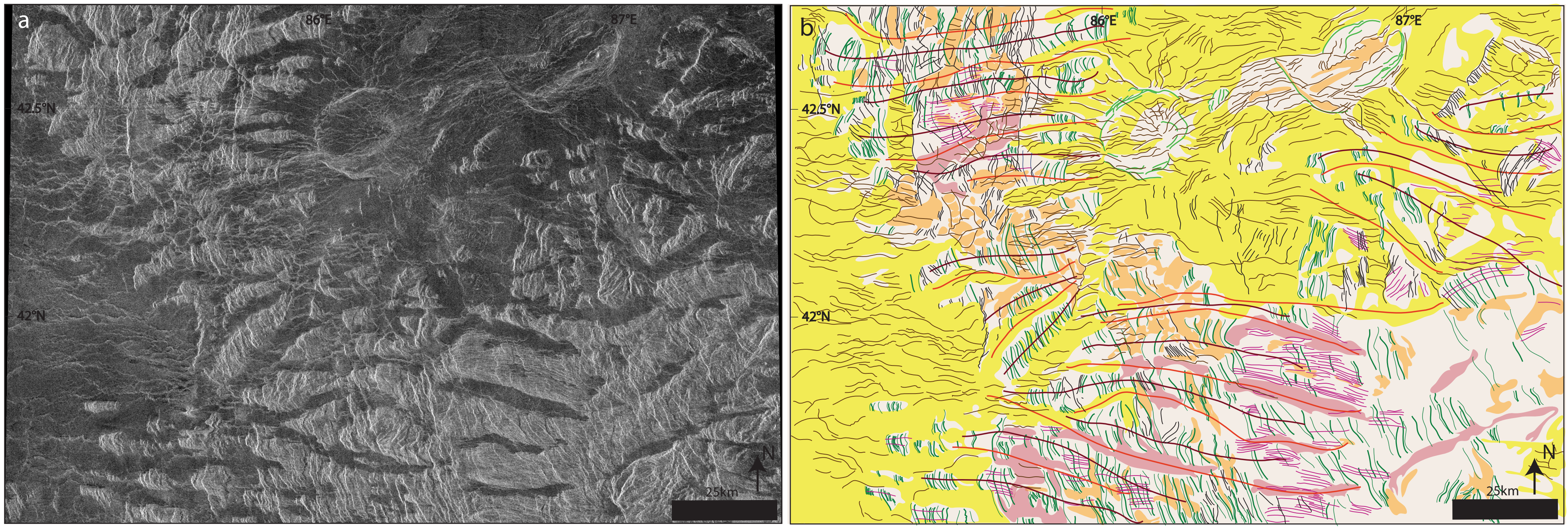
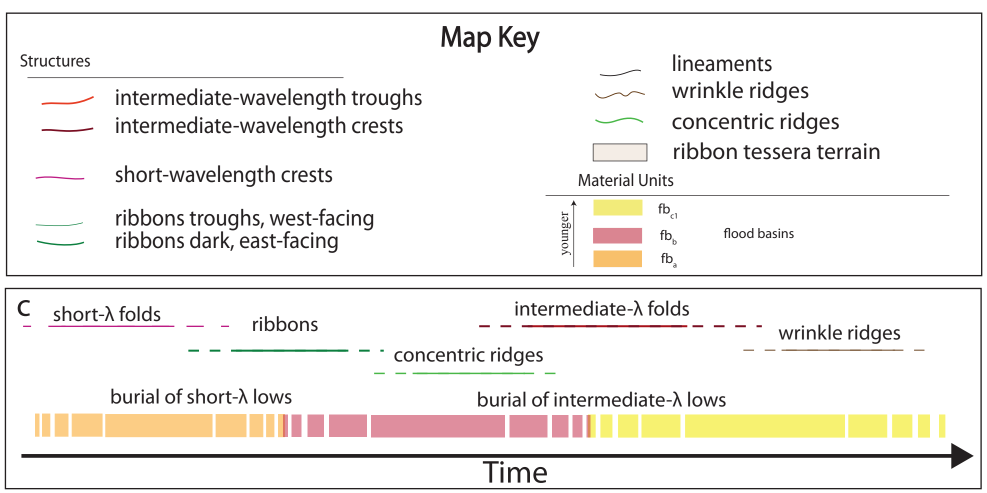


Plate 3. Overview over southern Tellus Regio structural suites. Map a depicts southern Tellus Regio left-look SAR with the divisions that are discussed: central, south-central, and the eastern and western margins . Map b highlights all structural elements and material units across the map area, map c highlights structural features, such as intermediate- and long-wavelength folds, intratessera basins, pit chains in the south-eastern portion, craters and shields throughout the lowlands. Map d focuses on: ribbon structure trends, graben complexes, intratessera basins, pit chains, and craters.





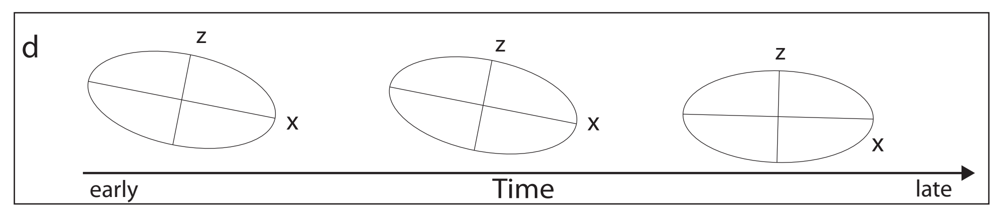
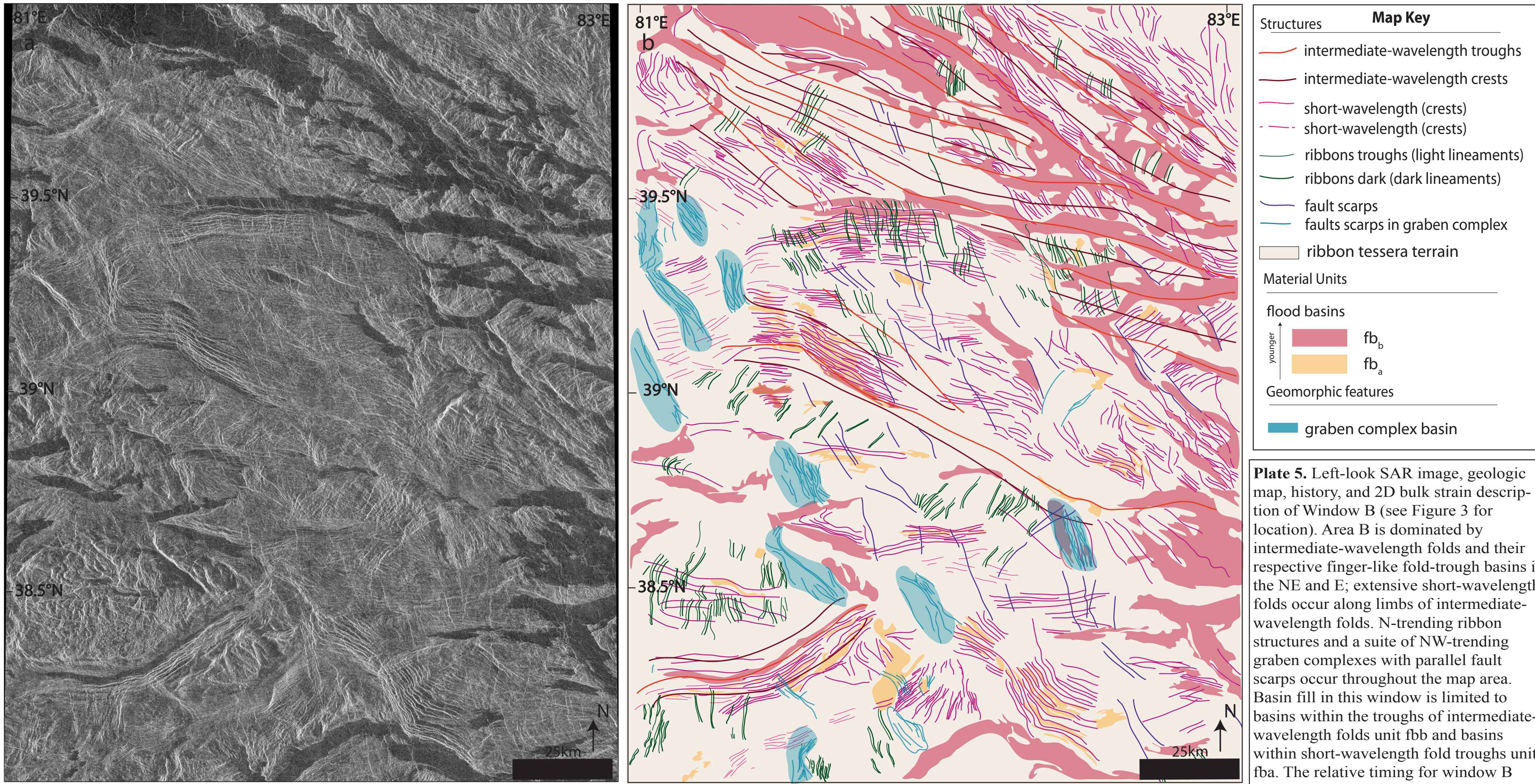


Plate 4. Left-look SAR image, geologic map, history, and 2D bulk strain description of window A (see Figure 3 for location). Area dominated by two basins, host to parallel short- and intermediate wavelength folds, trending generally W. NNW-trending ribbon structures are orthogonal to folds. Flood deposit material occurs in troughs of short- and intermediate-wavelength folds, ribbons and extend as finger-like embayments towards the larger basin fill. Wrinkle ridges and circular ridges deform the basins. The interpreted history (Plate 4c) begins with early short-wavelength fold formation, followed by, or coinciding with ribbon formation. Concentric ridges predate intermediate-wavelength folds and are followed by wrinkle ridge formation. Plate 4d depicts the 2D bulk strain over window A, indicating only little variation over time. See text for discussion.



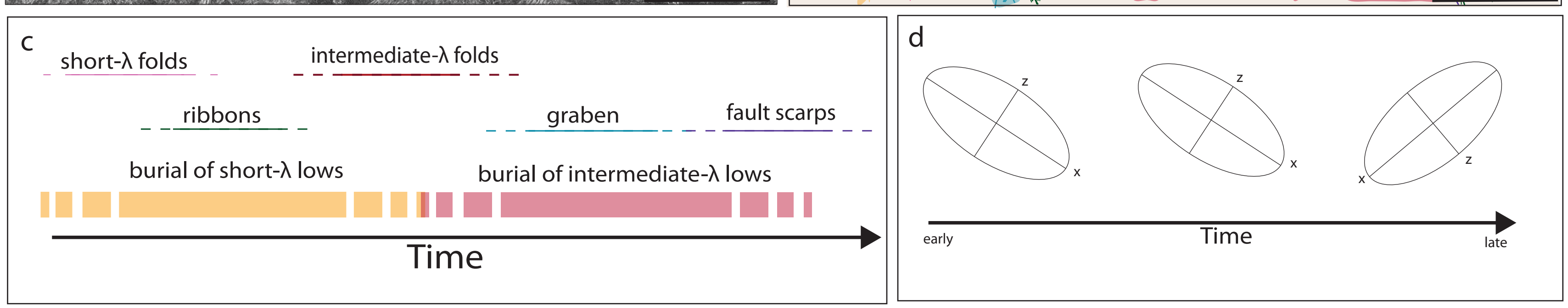
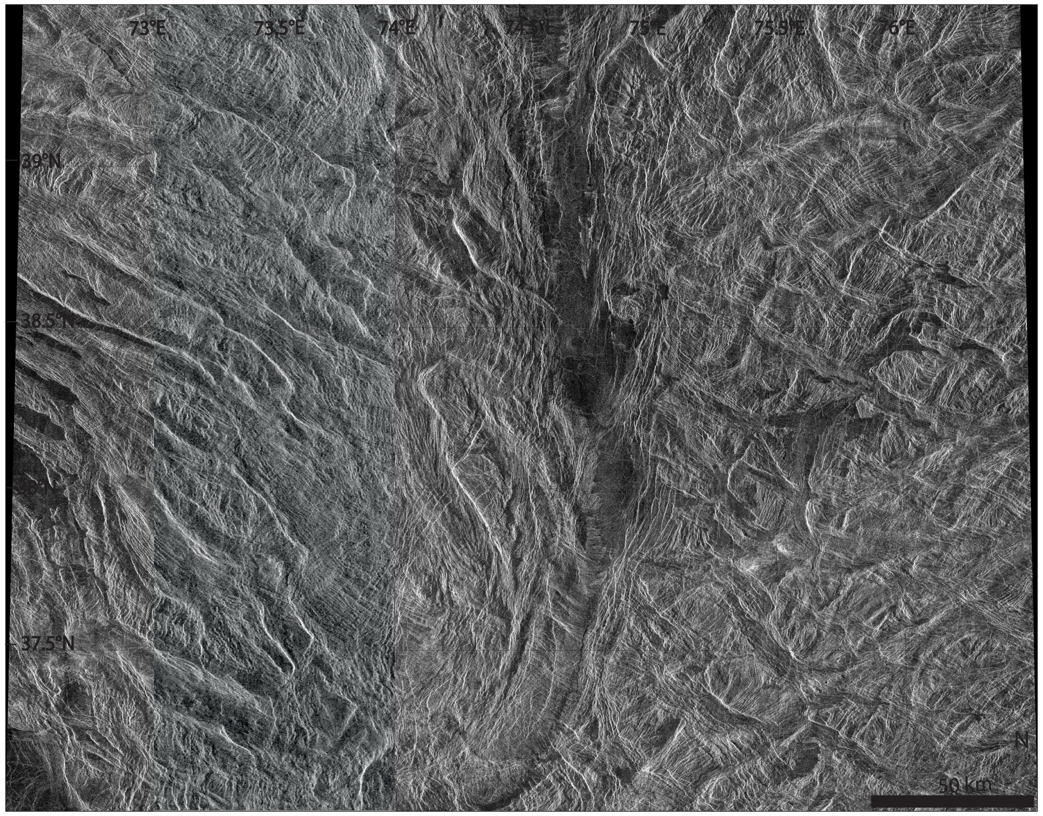


Plate 5. Left-look SAR image, geologic map, history, and 2D bulk strain description of Window B (see Figure 3 for location). Area B is dominated by intermediate-wavelength folds and their respective finger-like fold-trough basins in the NE and E; extensive short-wavelength folds occur along limbs of intermediate-wavelength folds. N-trending ribbon structures and a suite of NW-trending graben complexes with parallel fault scarps occur throughout the map area. Basin fill in this window is limited to basins within the troughs of intermediate-wavelength folds unit fbb and basins within short-wavelength fold troughs unit fba. The relative timing for window B (Plate 5c) is interpreted as: short-wavelength fold and ribbons structures formed early, followed by intermediate-wavelength formation and formation of late graben complexes and fault scarps. Plate 5d depicts 2D bulk strain for the map area, showing early similar orientations during formation of short- and intermediate-wavelength folds and ribbons, but near-opposite 2D bulk strain during formation of late graben complexes. See text for discussion.



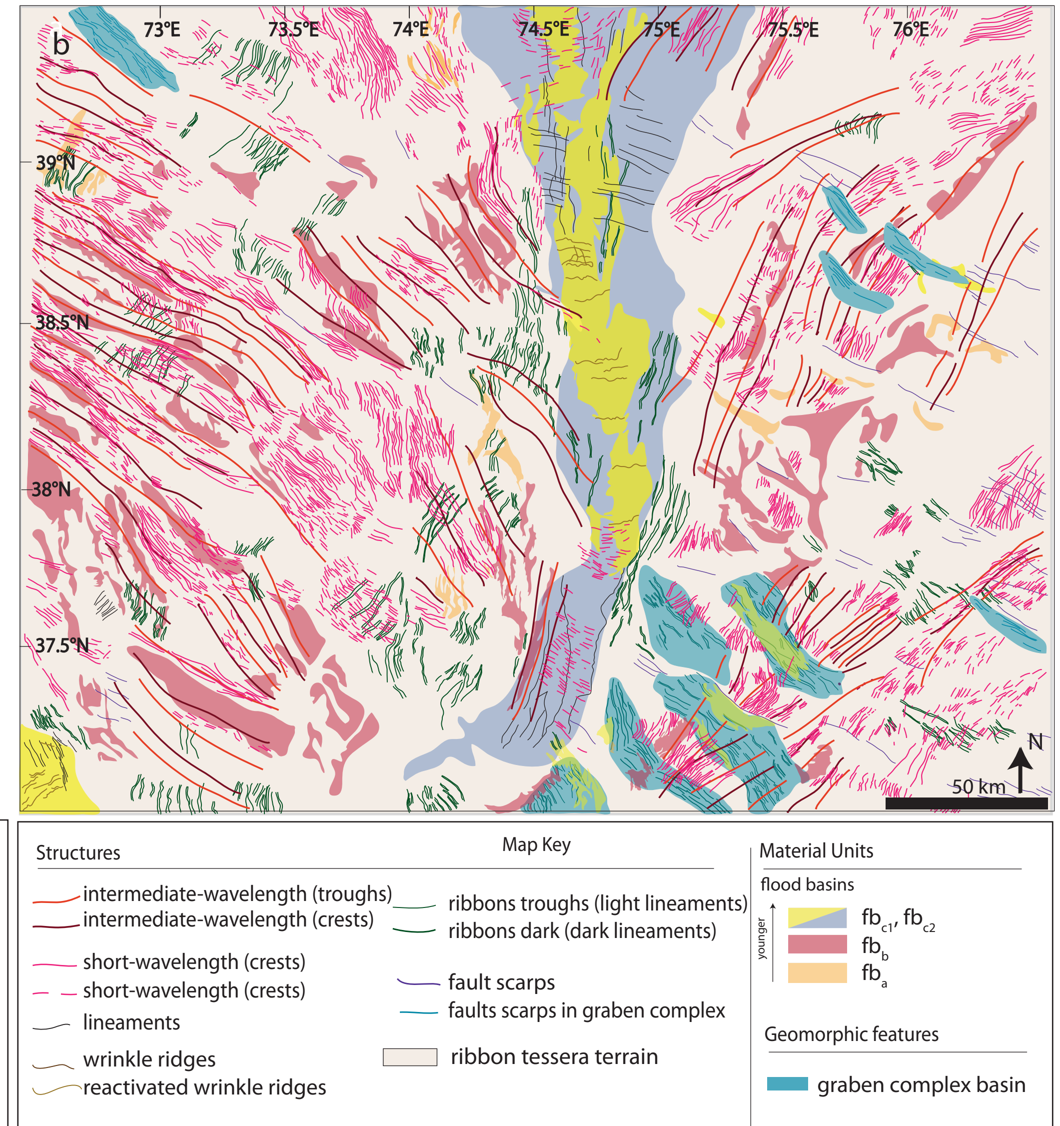
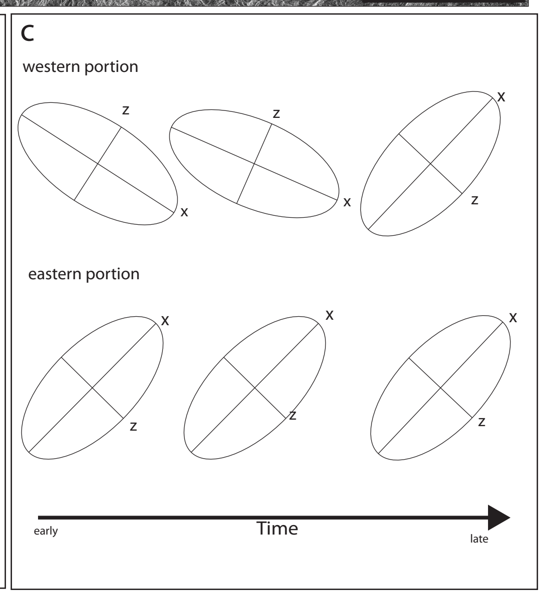
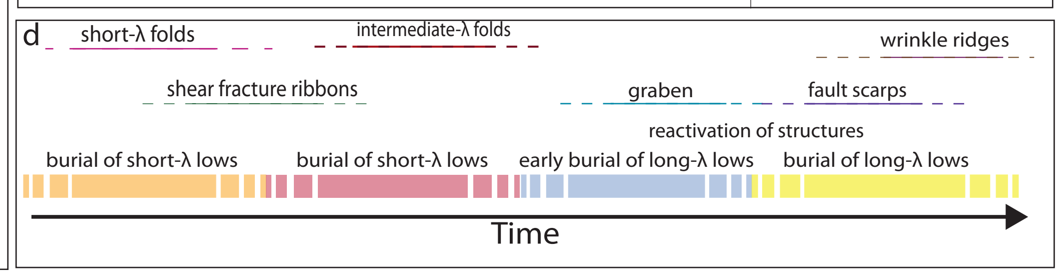
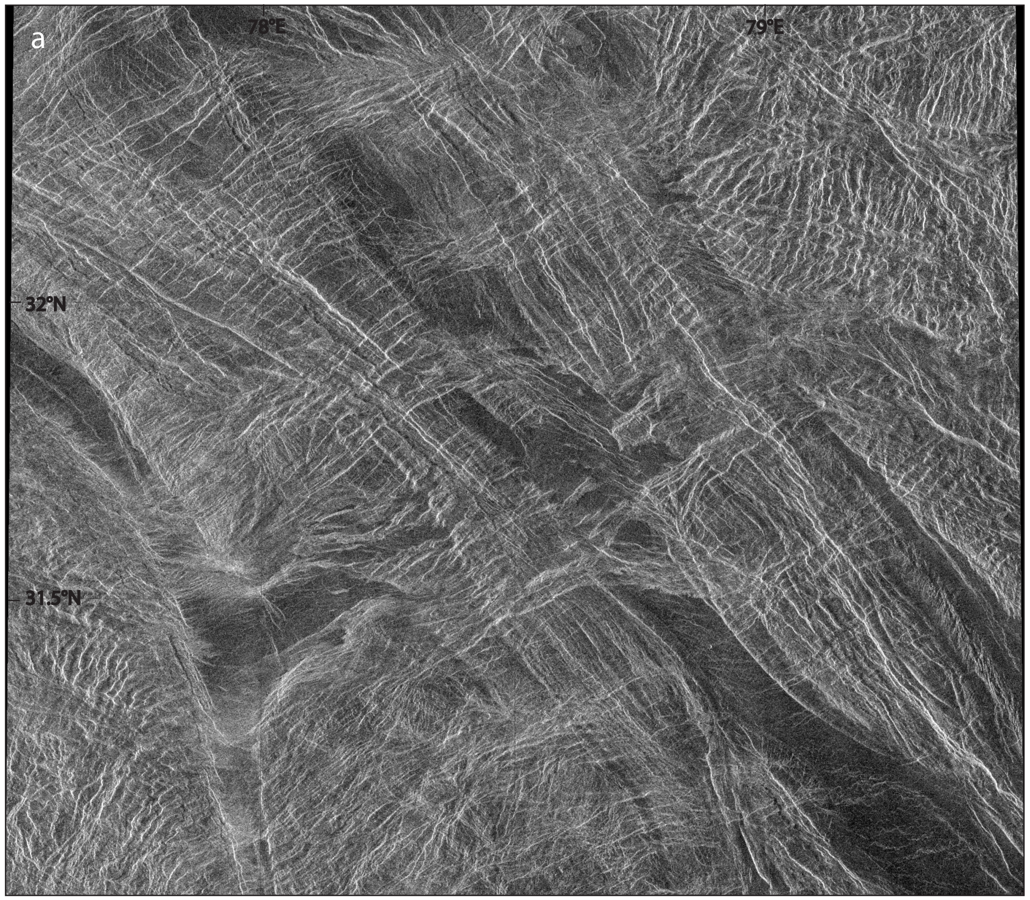
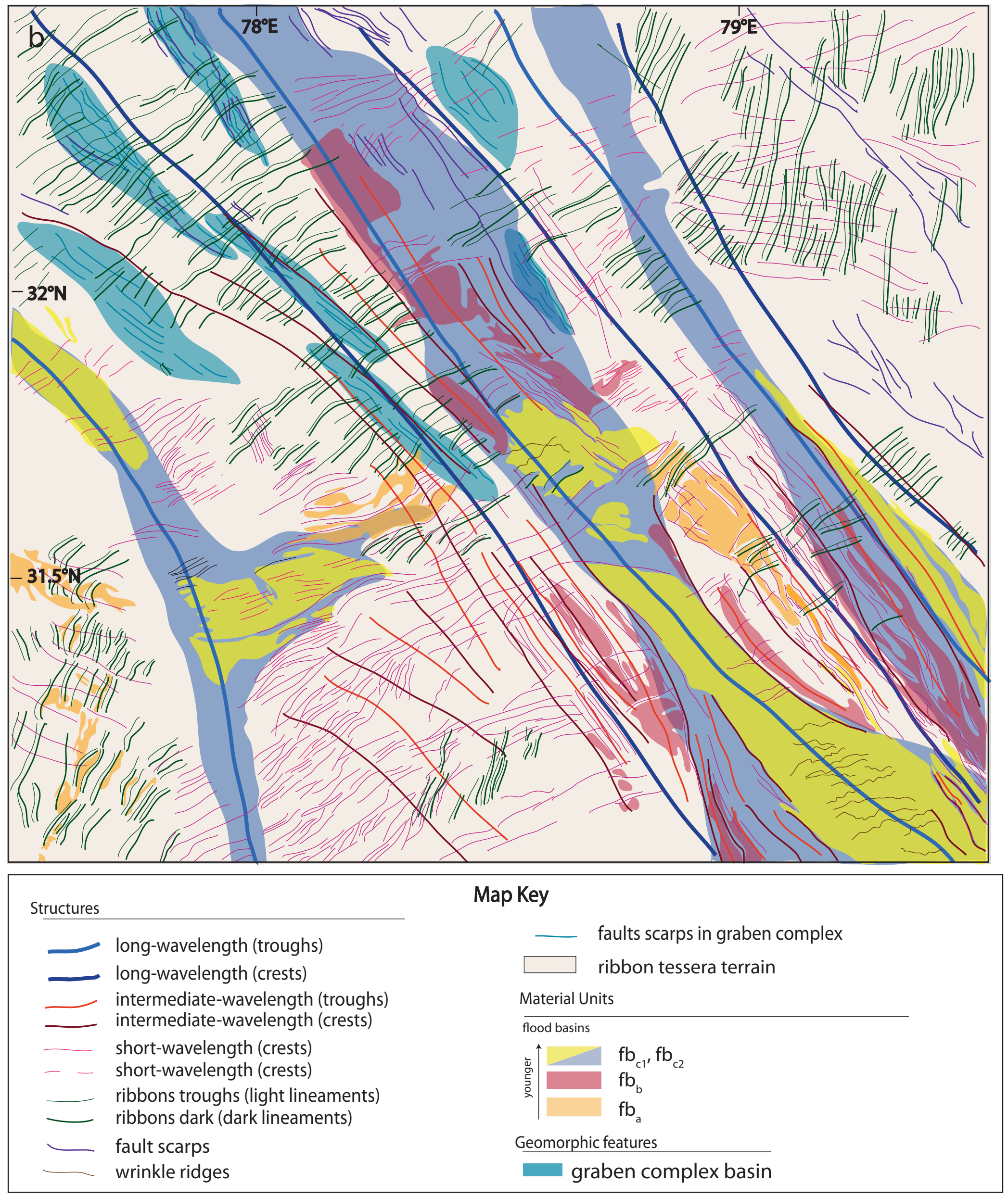


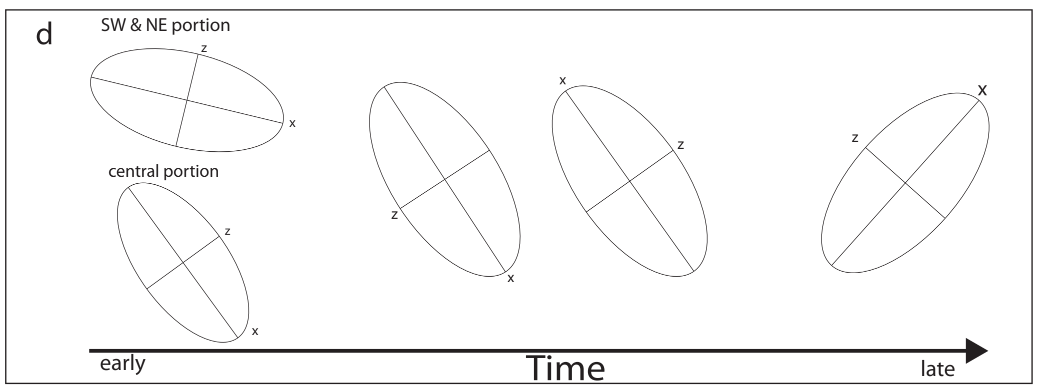
Plate 6. Left-look SAR image, geologic map, history, and 2D bulk strain description of window C (see Figure 3 for location). Window C is split into two regions (Plate 6b), western and eastern region which are separated by a N-trending basin. Both regions are dominated by parallel short and intermediate-wavelength folds, and orthogonal ribbon structures, however both regions show near-opposite orientations. NW-trending graben complexes and fault scarps cross the entire region. Basin fill material occurs in troughs of all structural wavelengths and in the central basin. The relative timing for window C (Plate 6c) is interpreted as: early short-wavelength fold and ribbon structures formation, followed by intermediate-wavelength formation and formation of late graben complexes and fault scarps. Plate 6d depicts 2D bulk strain for the map area, depicting early opposite 2D bulk strain between both regions, and later more coherent bulk strain across the map area, indicating early structural fluidity that ceased over time. See text for discussion.











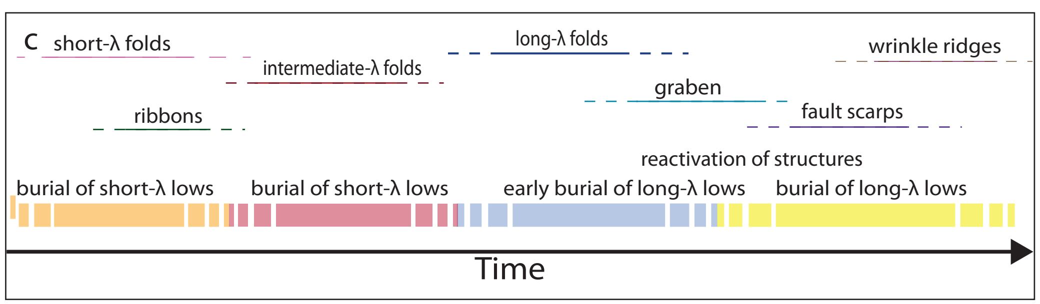
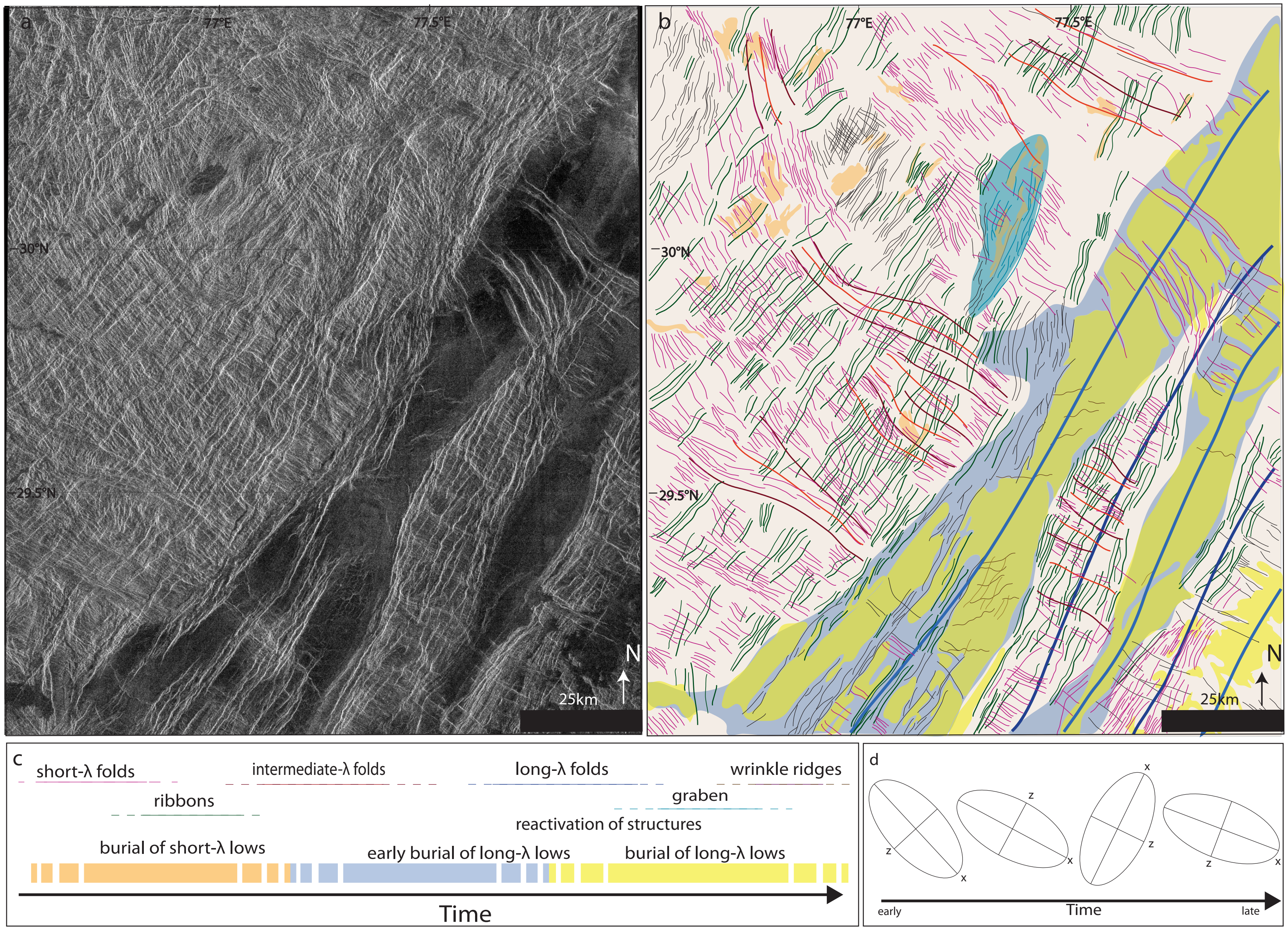


Plate 7. Left-look SAR image, geologic map, history, and 2D bulk strain description of window D (see Figure 3 for location). Window D is divided into three regions (Plate 7b), NW, central and NE.The central region hosts NW-trending long-wavelength folds with intermediate-and short-wavelengths preserved on crests and limbs and long and narrow basins in the long-wavelength fold troughs and parallel graben complexes; the SW and NE regions are host to W-trending short-wavelength folds and orthogonal ribbons of similar orientation. The relative timing for window D (Plate 7c) is interpreted as: early short-wavelength fold and ribbon structures formation, followed by intermediate- and long-wavelength formation and late formation of graben complexes, fault scarps and wrinkle ridge formation in the basins. Plate 7d depicts 2D bulk strain for the map area, depicting early variable 2D bulk strain for all regions for short-wavelength and ribbon formation, more coherent bulk strain across the map area for intermediate-and long-wavelength formation, followed by nearly-opposite bulk strain during graben complex formation, indicating early structural fluidity that ceased over time. See text for discussion.



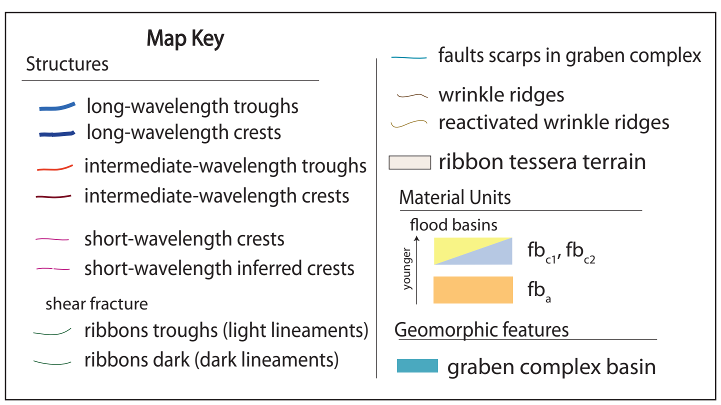


Plate 8. Left-look SAR image, geologic map, history, and 2D bulk strain description of window E (see Figure 3 for location). The area is dominated by a suite of NE-trending long-wavelength folds with respective troughs filled with flood deposit material. Long-wavelength fold crests are host to orthogonal short-wavelength folds and parallel ribbons along the long-wavelength fold crests. Short- and intermediate-wavelength folds also occur in the NW region. One graben complex trends parallel to long-wavelength folds. The relative timing for window E (Plate 8c) is interpreted as: early short-wavelength fold and ribbon structure formation, followed by intermediate- and long-wavelength formation and late formation of graben complexes and wrinkle ridge formation in the basins. Plate 8d depicts 2D bulk strain for the map area, depicting variable 2D bulk strain for regions of short-, intermediate-, and long-wavelength and ribbon formation. The late graben complex shows a similar bulk strain to other regional maps. See text for discussion.

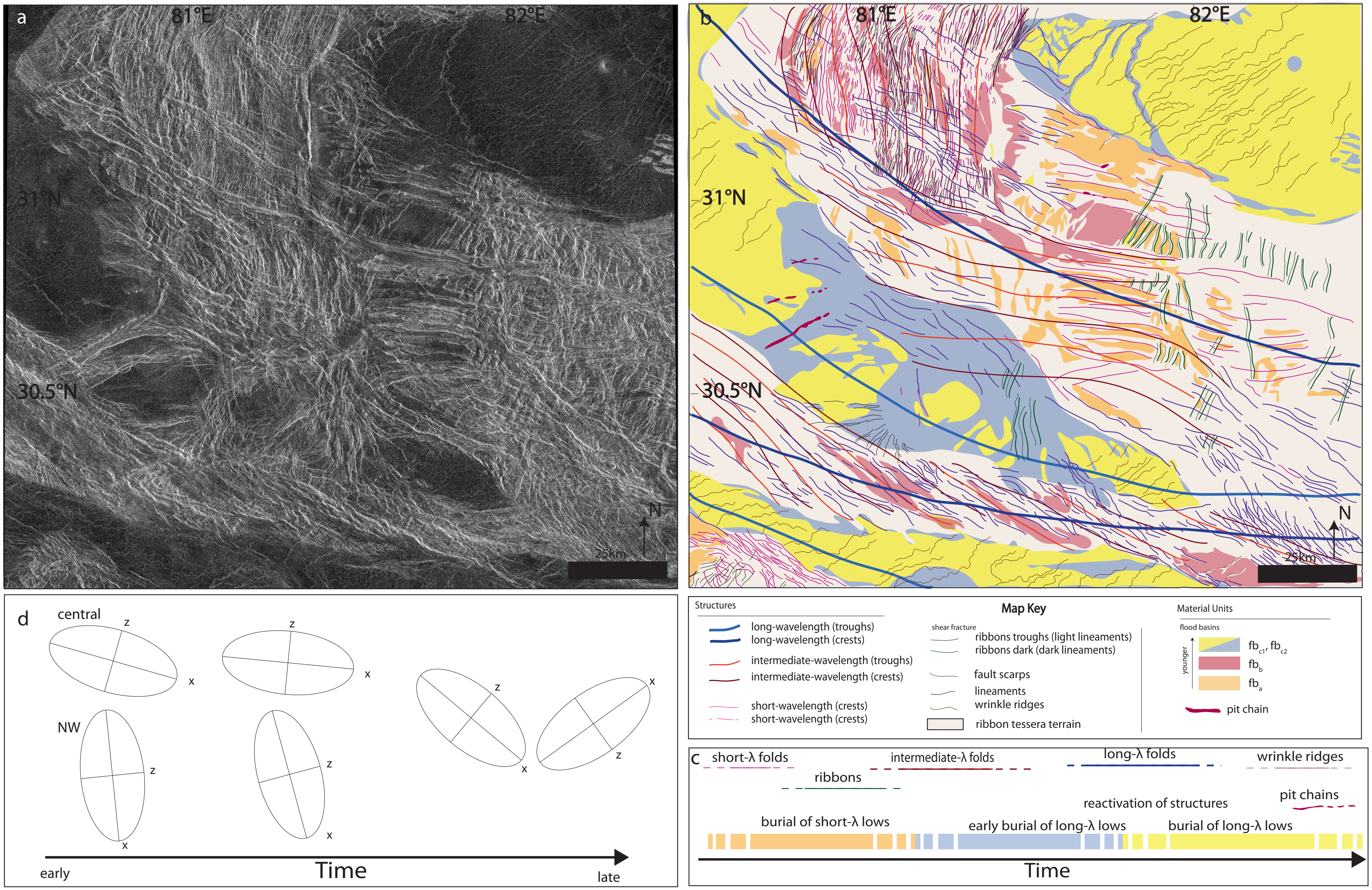


Plate 9. Left-look SAR image, geologic map, history, and 2D bulk strain description of window F (see Figure 3 for location). Window F is dominated by three major basins, creating regions dominated by deformation and regions that lack deformation (in the basins) (Plate 9b). NW-trending long-wavelength folds are host to parallel intermediate-, short-wavelength folds and orthogonal ribbons. Basins are host to wrinkle ridges and few pit chains. Suites of short- and intermediate-wavelength folds occur with variable trend. The relative timing for window D (Plate 9c) is interpreted as: early short-wavelength fold and ribbon structures formation, followed by intermediate- and long-wavelength formation and late formation of graben complexes, fault scarps and wrinkle ridge and pit chain formation in the basins, accompanied by flood material deposition. Plate 9d depicts 2D bulk strain for the map area, depicting early variable bulk strain for all regions for short- and intermediate-wavelength fold and ribbon formation, more coherent bulk strain across the map area for long-wavelength fold formation, followed by nearly-opposite bulk strain during graben complex formation. See text for discussion.