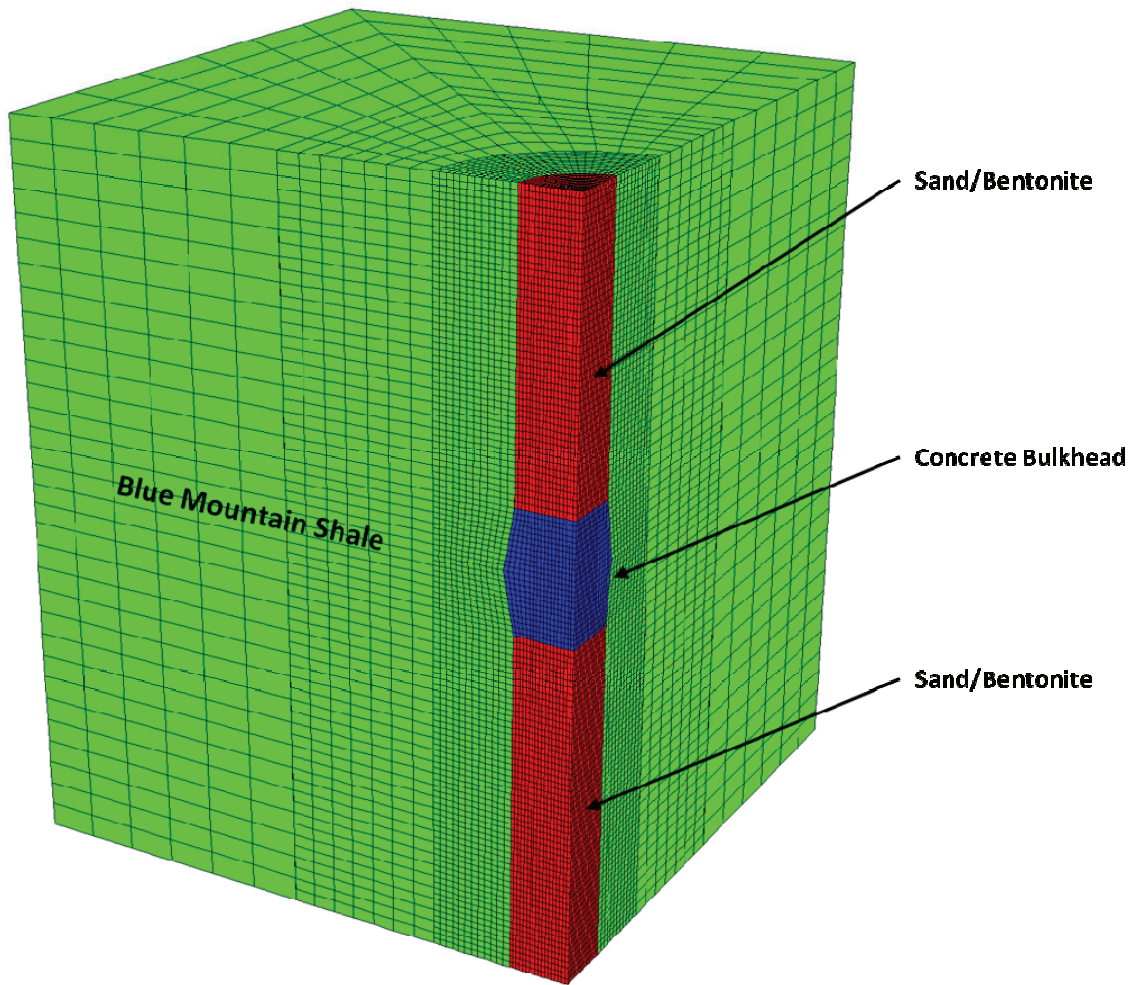


**APPENDIX B. SUPPLEMENTAL FLAC3D RESULTS FOR CONCRETE BULKHEAD  
IN BLUE MOUNTAIN SHALE**

This appendix includes the plots with the results for concrete bulkhead (B1') in Blue Mountain shale. The summary plots show yielded zones in the model, contours of the shear and the volumetric strains in the isometric view but also in the horizontal cross-sections 22.4 m above the middle of the seal, in the middle of the seal and 22.4 m below the middle of the seal. The results are shown at the characteristic times, including: (1) time after shaft excavation, (2) 100 years (pre-closure), (3) 200 years (post-closure), (4) 100,000 years and (5) 1,000,000 years. The included results are for: (1) time-dependent strength degradation, (2) time-dependent strength degradation and glacial load, (3) time-dependent strength degradation, glacial load and pore pressure, and (4) time-dependent strength degradation, glacial load and seismic load applied after 100,000 years.



**Figure B.1** Layout of Quarter-symmetrical FLAC3D Model of Over-excavated And Backfilled Main Shaft for Bulkhead in Blue Mountain Shale

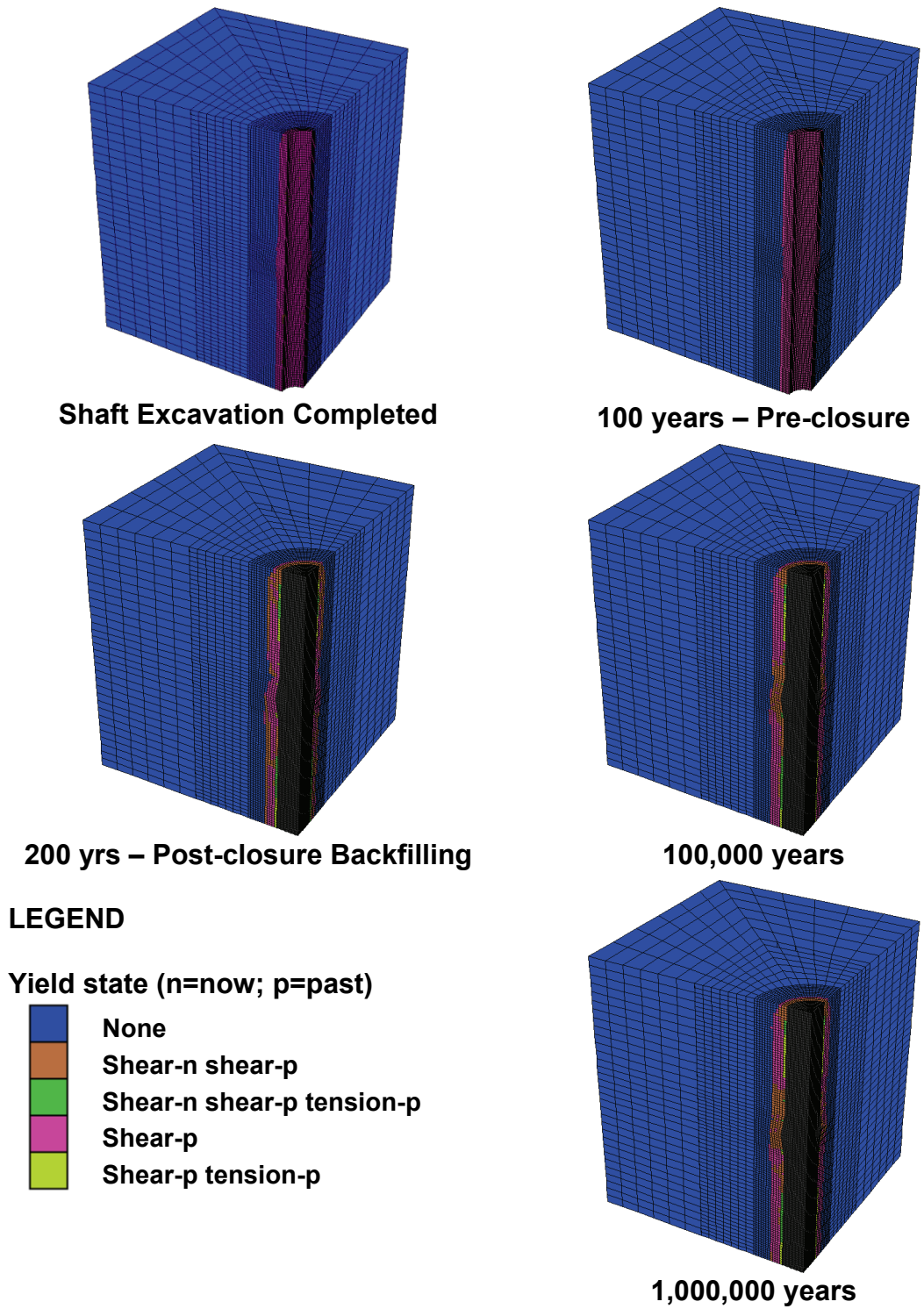
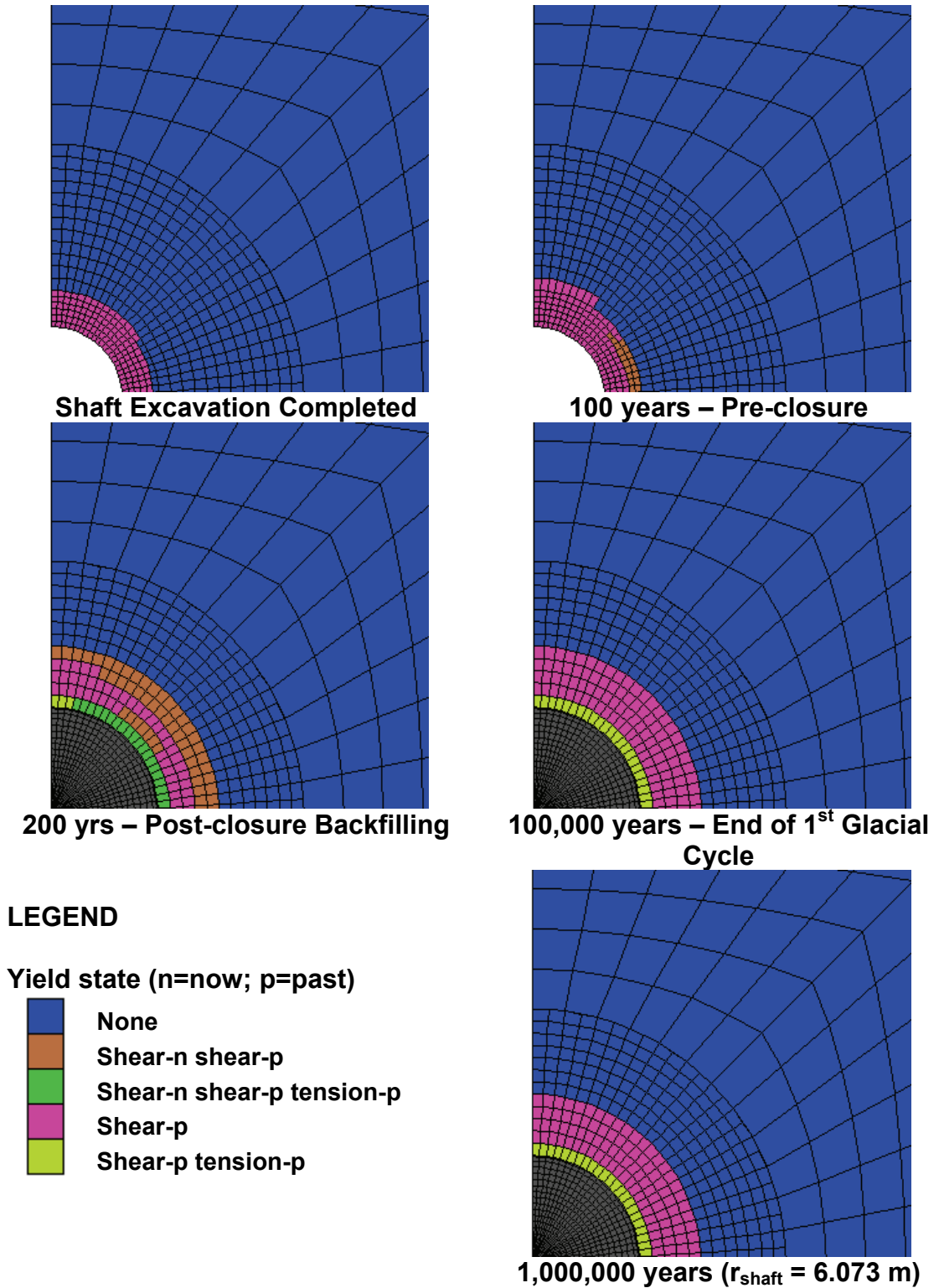
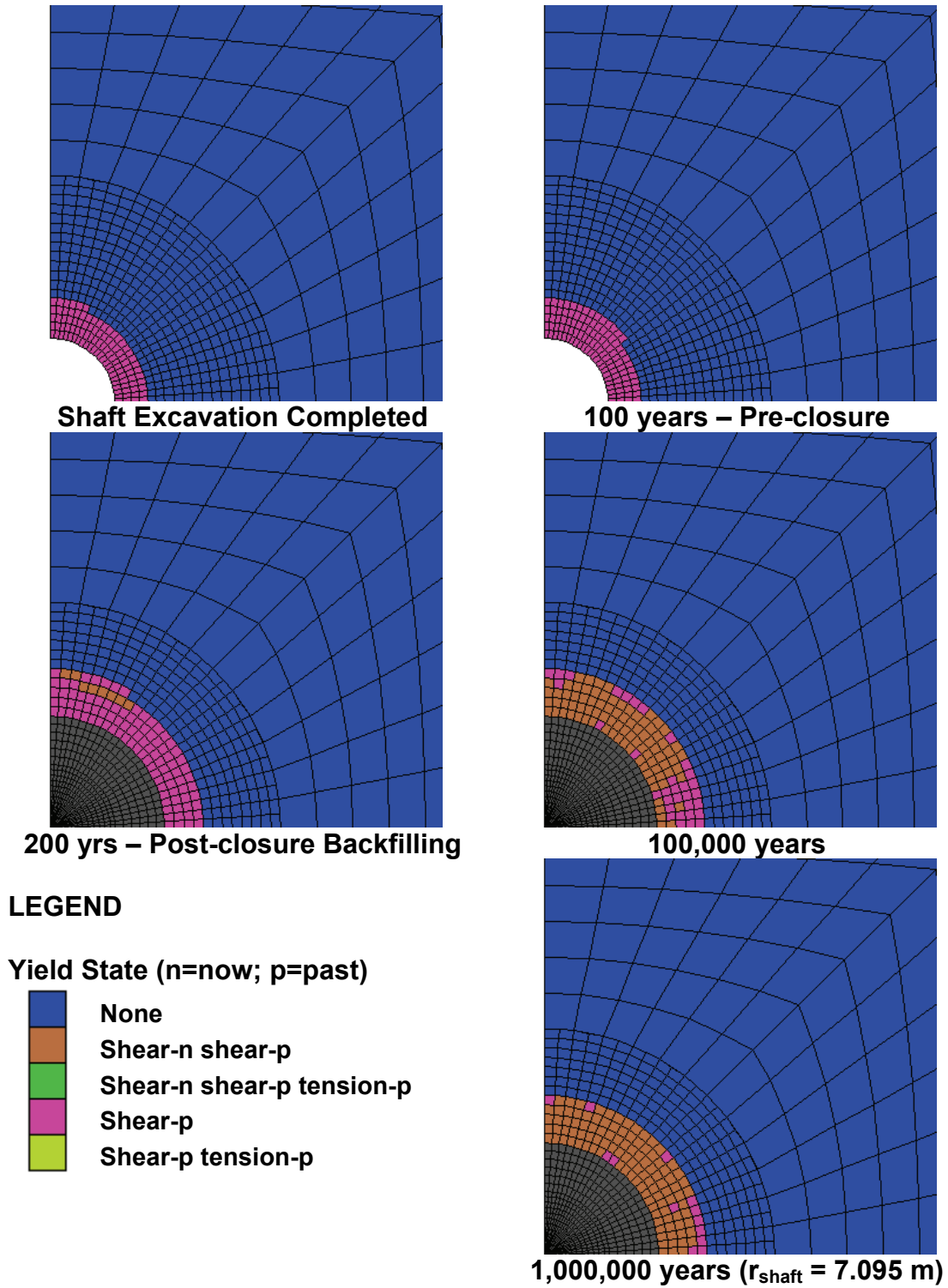


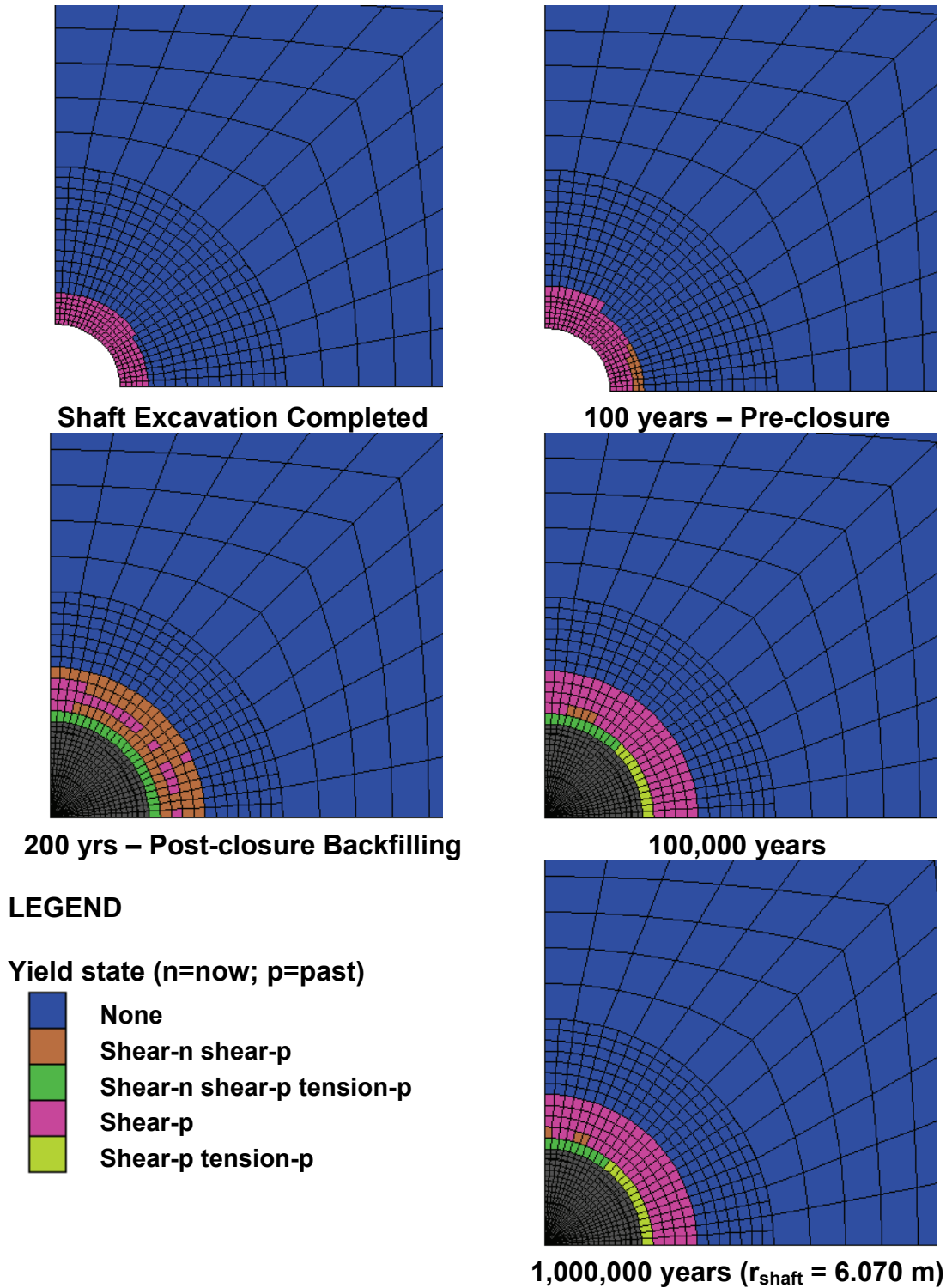
Figure B.2 Yield State – Concrete Bulkhead B1': Time-dependent Strength Degradation



**Figure B.3 Yield State – 22.4 m Above Concrete Bulkhead B1': Time-dependent Strength Degradation**



**Figure B.4 Yield State – Middle Concrete Bulkhead B1': Time-dependent Strength Degradation**



**Figure B.5 Yield State – 22.4 m Below Concrete Bulkhead B1': Time-dependent Strength Degradation**

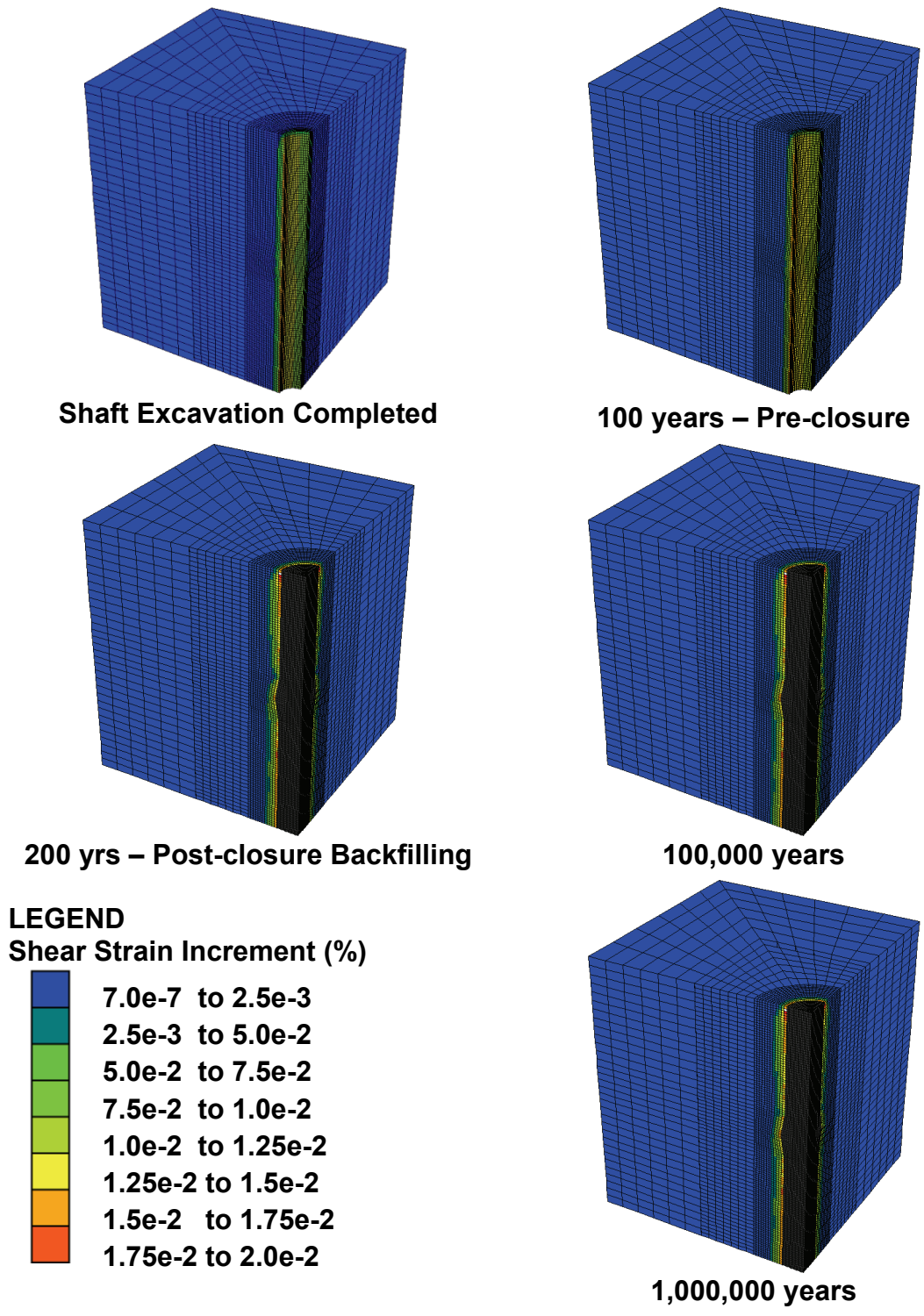


Figure B.6 Shear Strain – Concrete Bulkhead B1': Time-dependent Strength Degradation

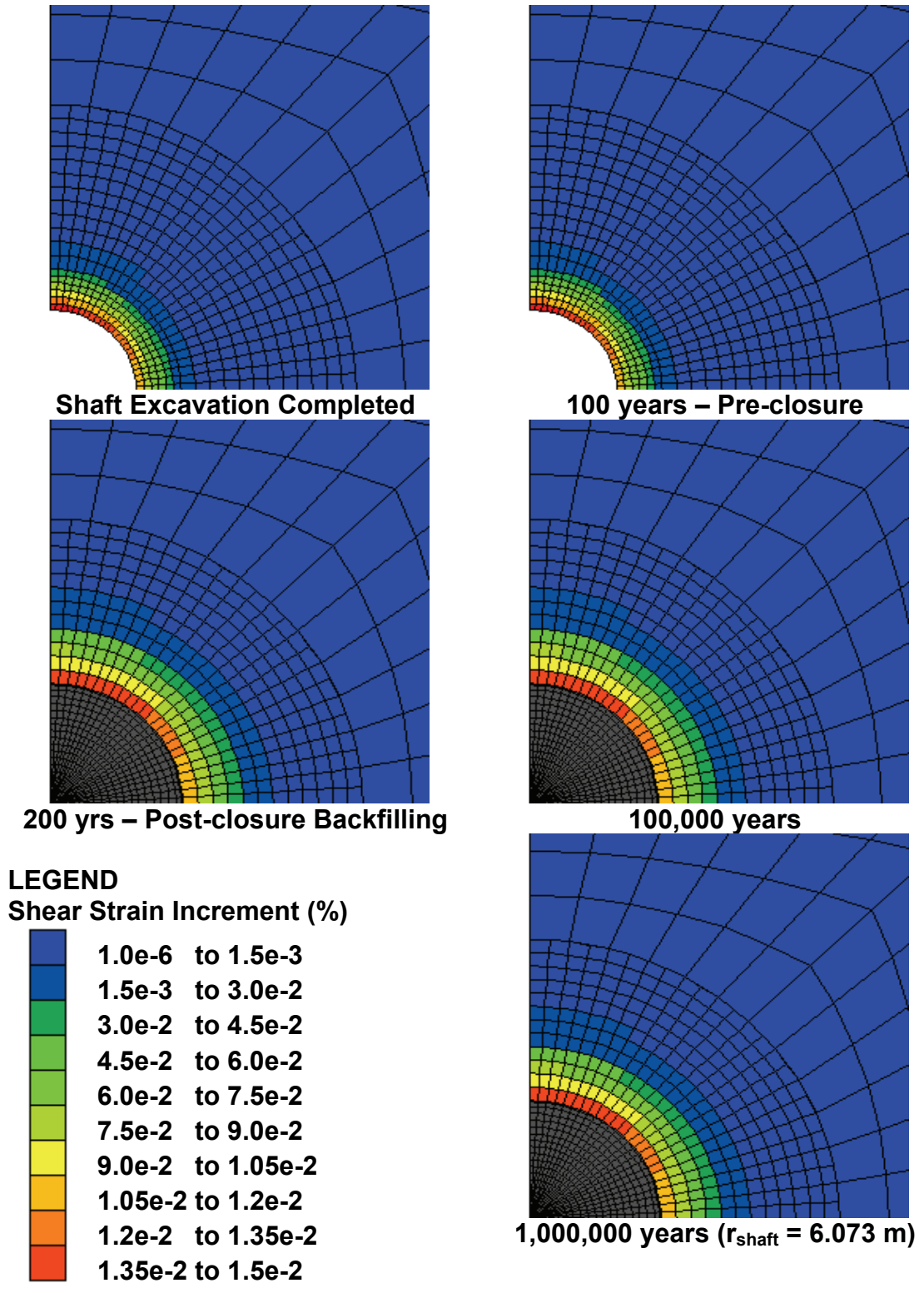


Figure B.7 Shear Strain – 22.4 m Above Concrete Bulkhead B1': Time-dependent Strength Degradation



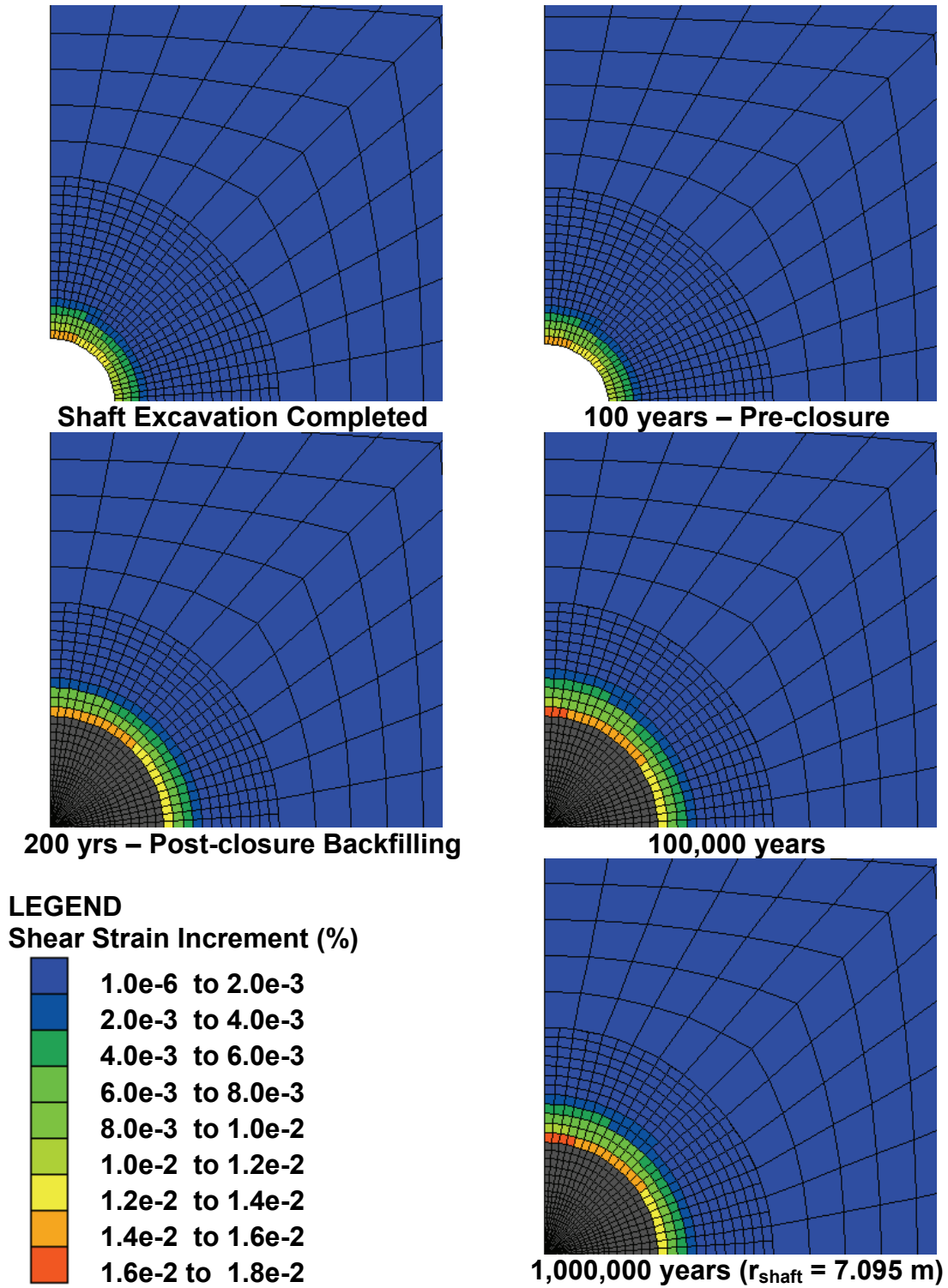
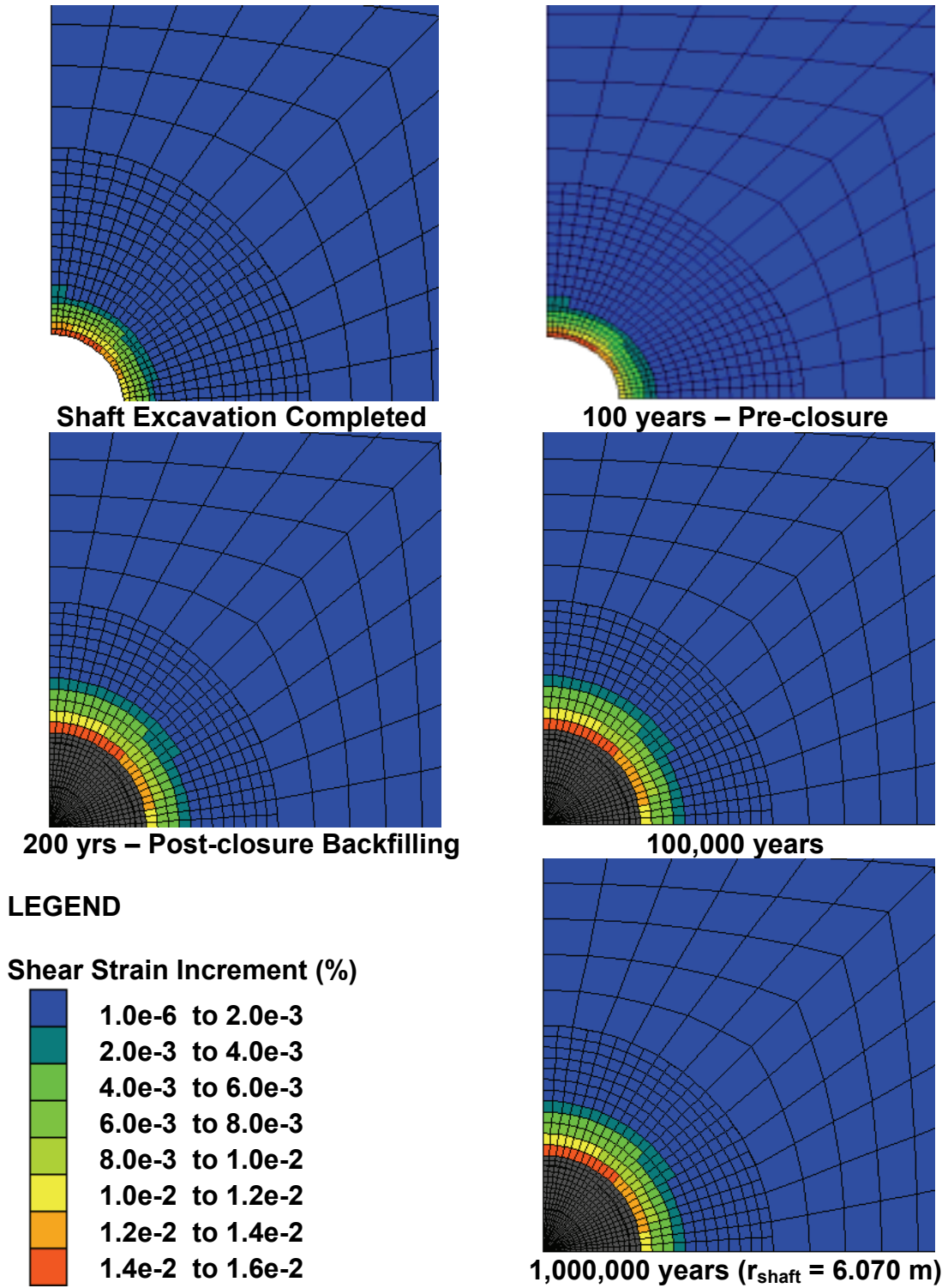


Figure B.8 Shear Strain – Middle Concrete Bulkhead B1': Time-dependent Strength Degradation



**Figure B.9 Shear Strain – 22.4 m Below Concrete Bulkhead B1': Time-dependent Strength Degradation**

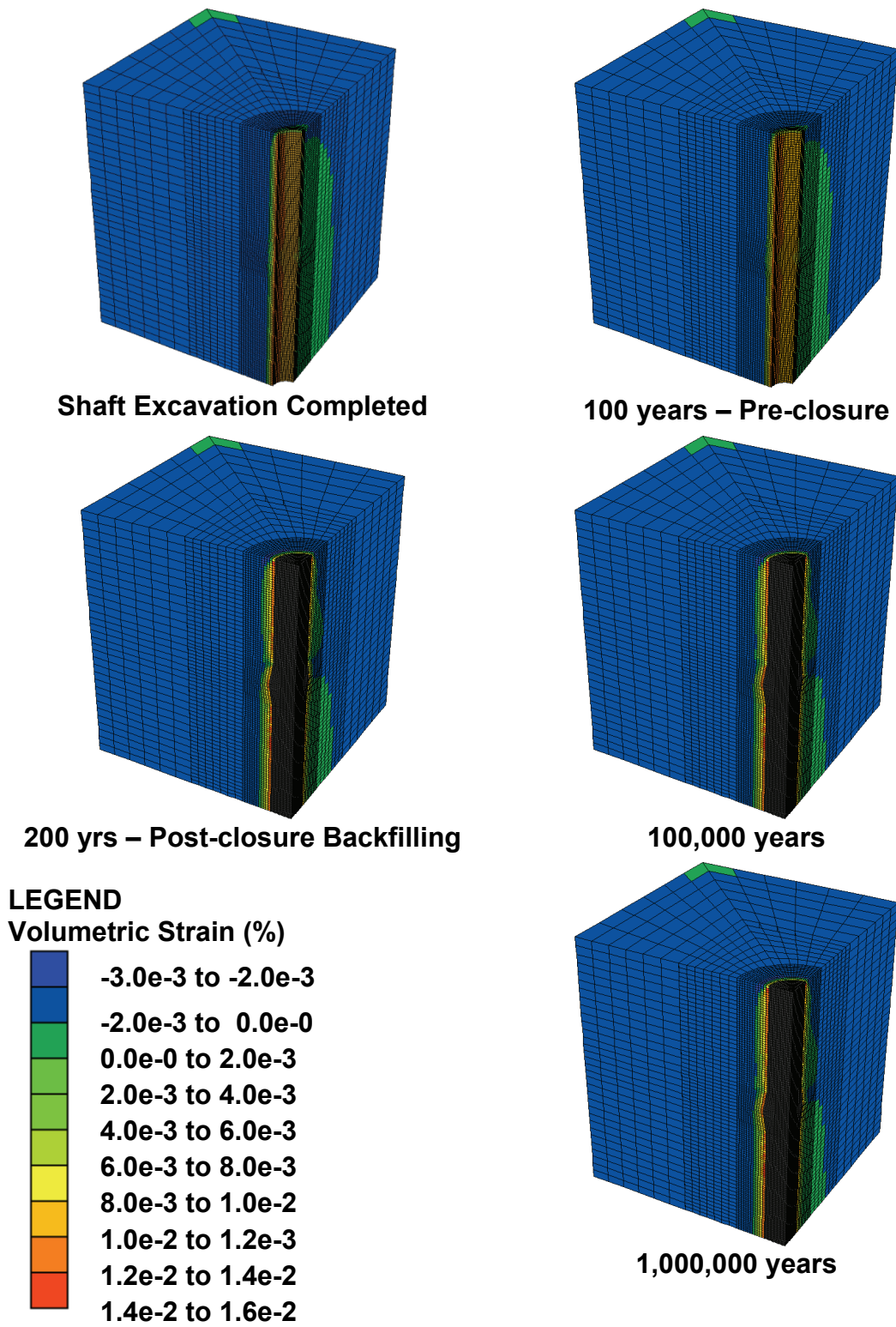
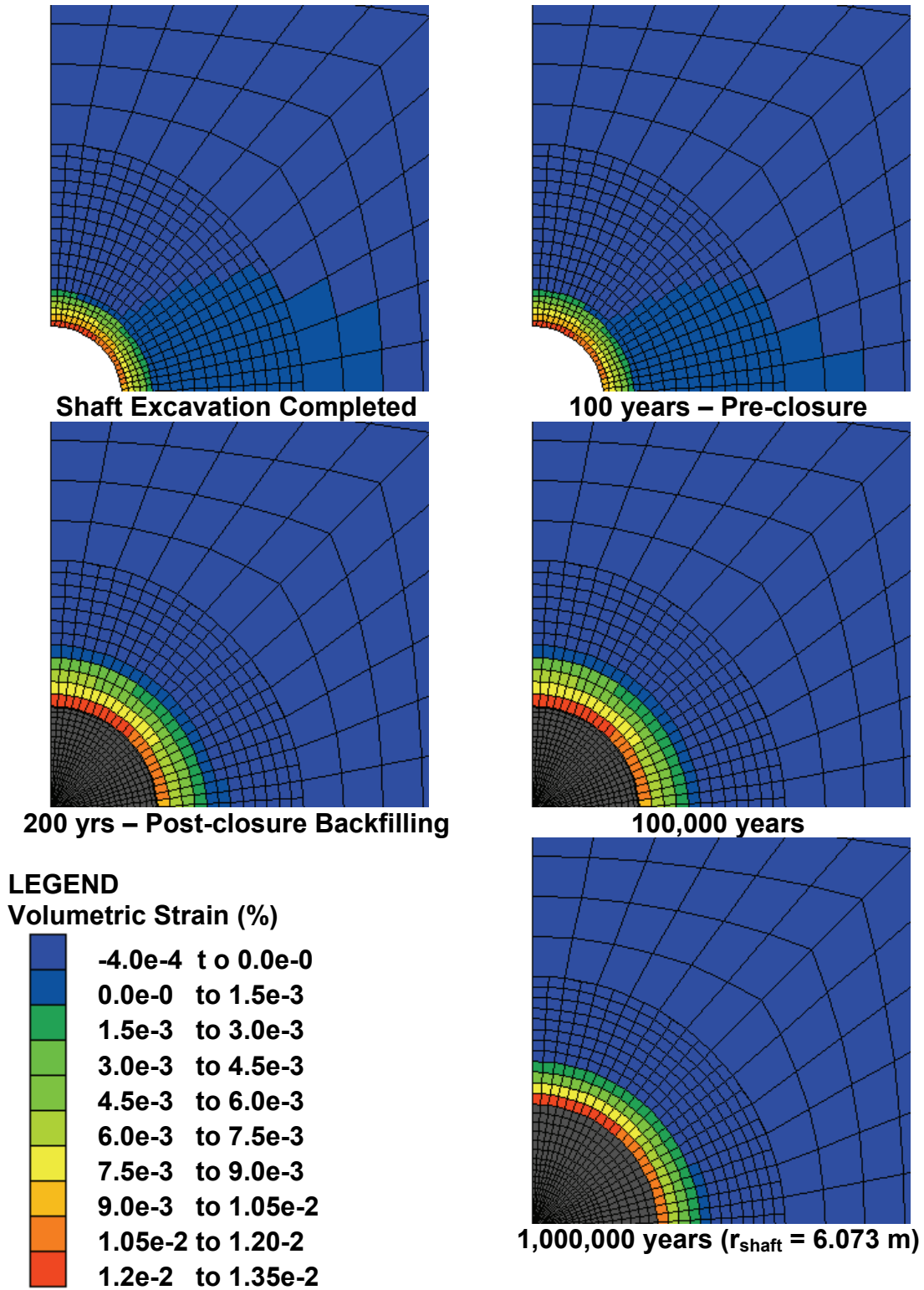


Figure B.10 Volumetric Strain – Concrete Bulkhead B1’: Time-dependent Strength Degradation



**Figure B.11 Volumetric Strain – 22.4 m Above Concrete Bulkhead B1':  
 Time-dependent Strength Degradation**

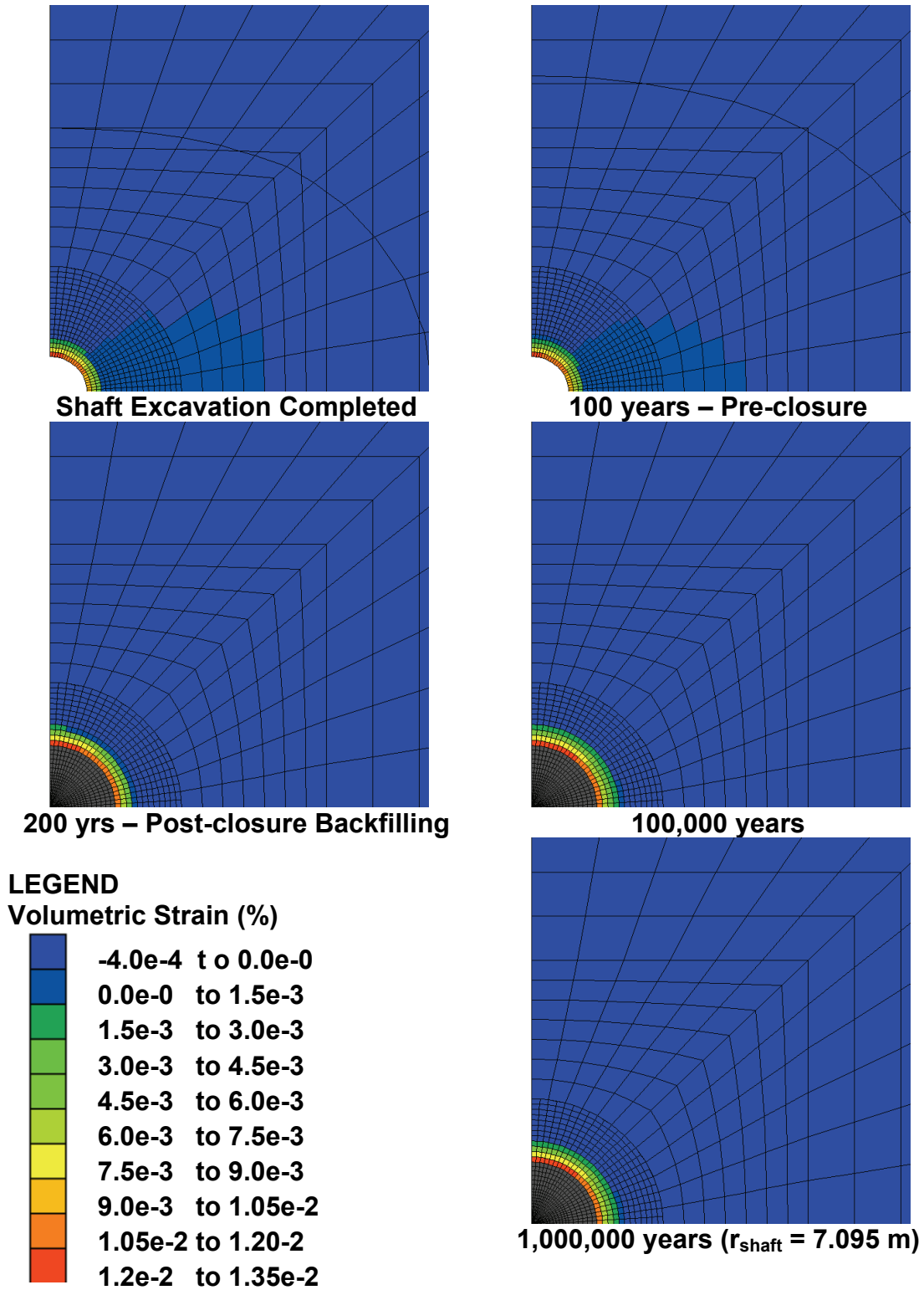
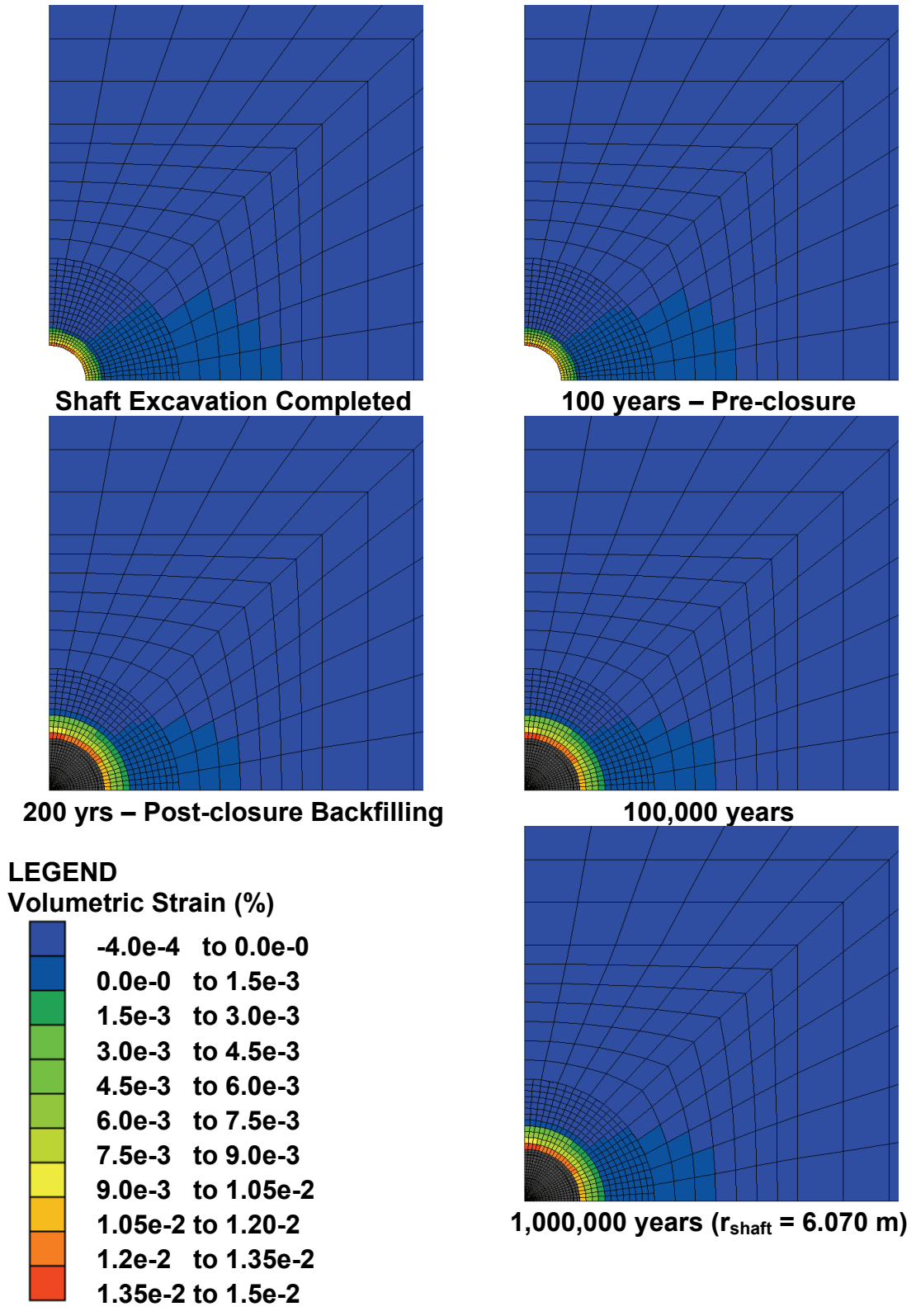


Figure B.12 Volumetric Strain – Middle Concrete Bulkhead B1': Time-dependent Strength Degradation



**Figure B.13 Volumetric Strain – 22.4 m Below Concrete Bulkhead B1':  
 Time-dependent Strength Degradation**

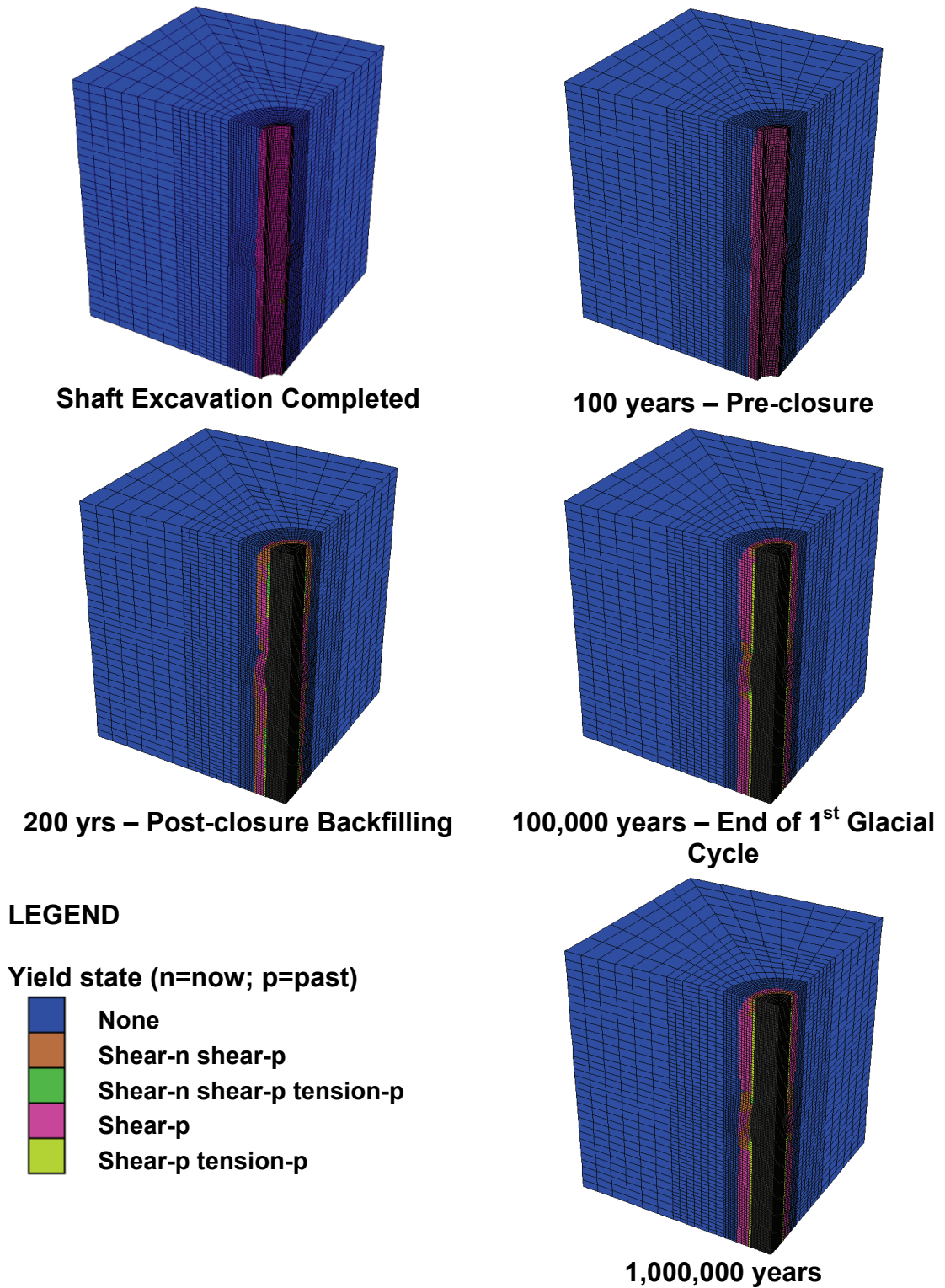


Figure B.14 Yield State – Concrete Bulkhead B1': Time-dependent Strength Degradation + Glacial Load

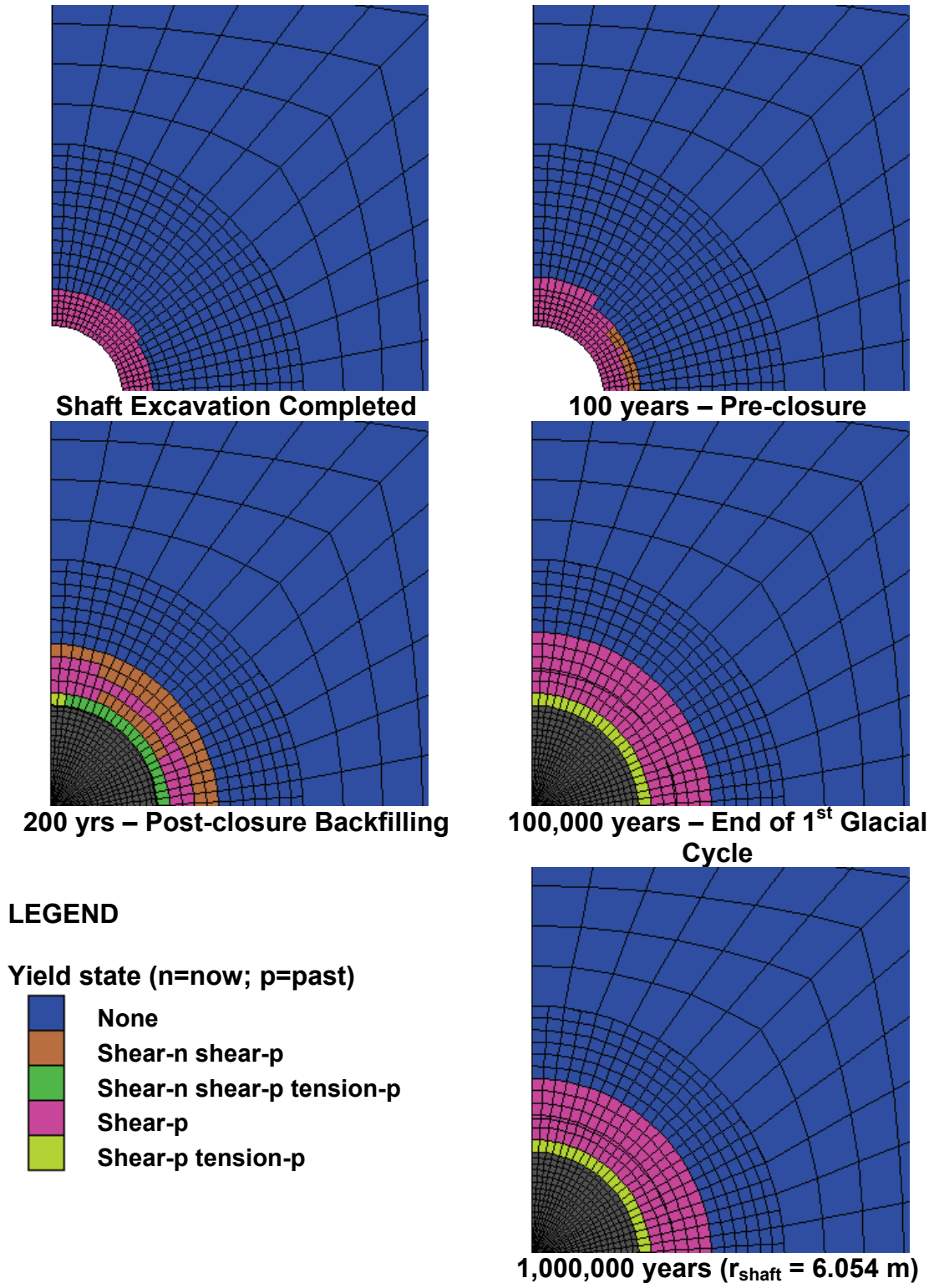


Figure B.15 Yield State – 22.4 m Above Concrete Bulkhead B1': Time-dependent Strength Degradation + Glacial Load



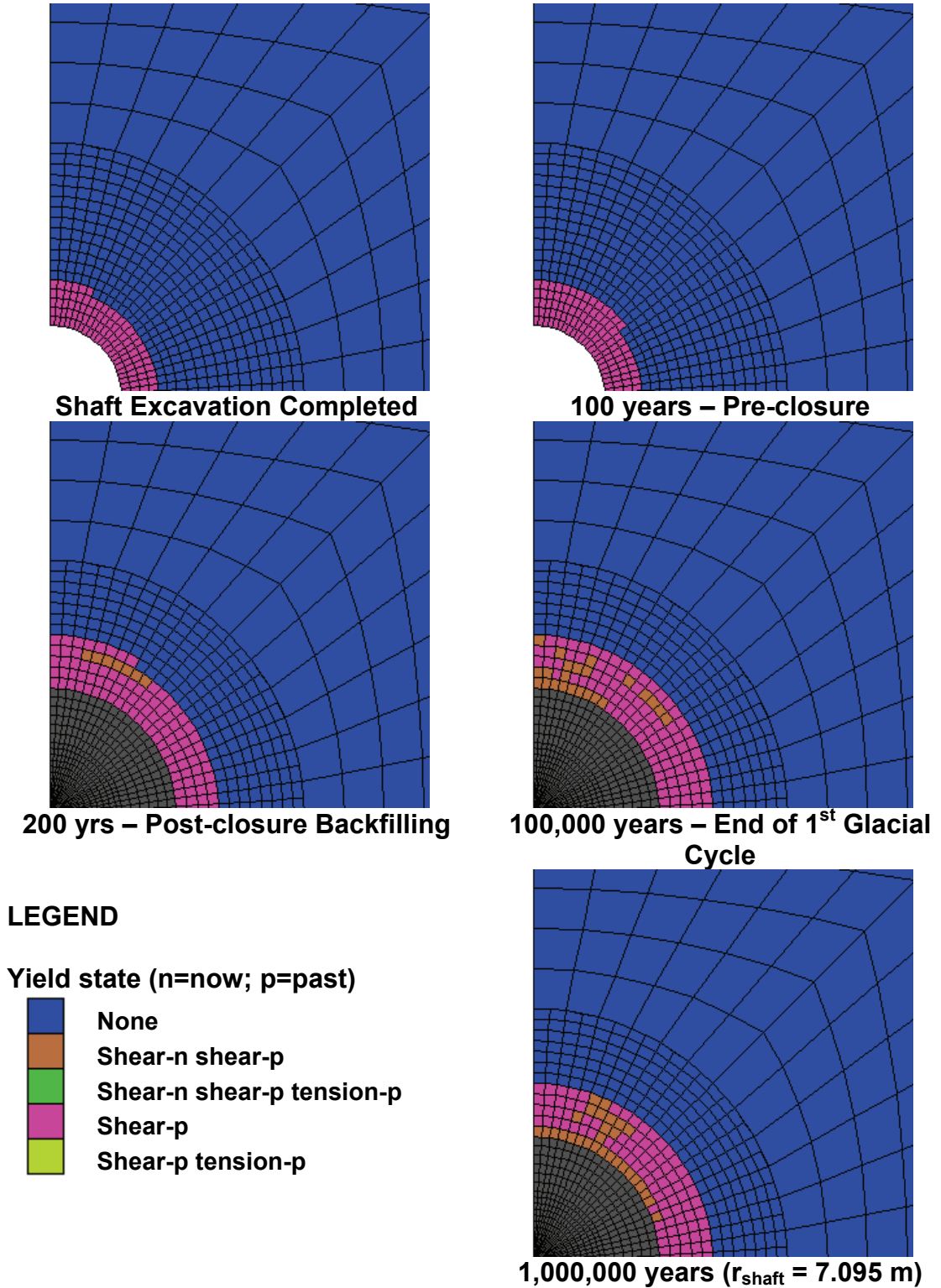


Figure B.16 Yield State – Middle Concrete Bulkhead B1': Time-Dependent Strength Degradation + Glacial Load

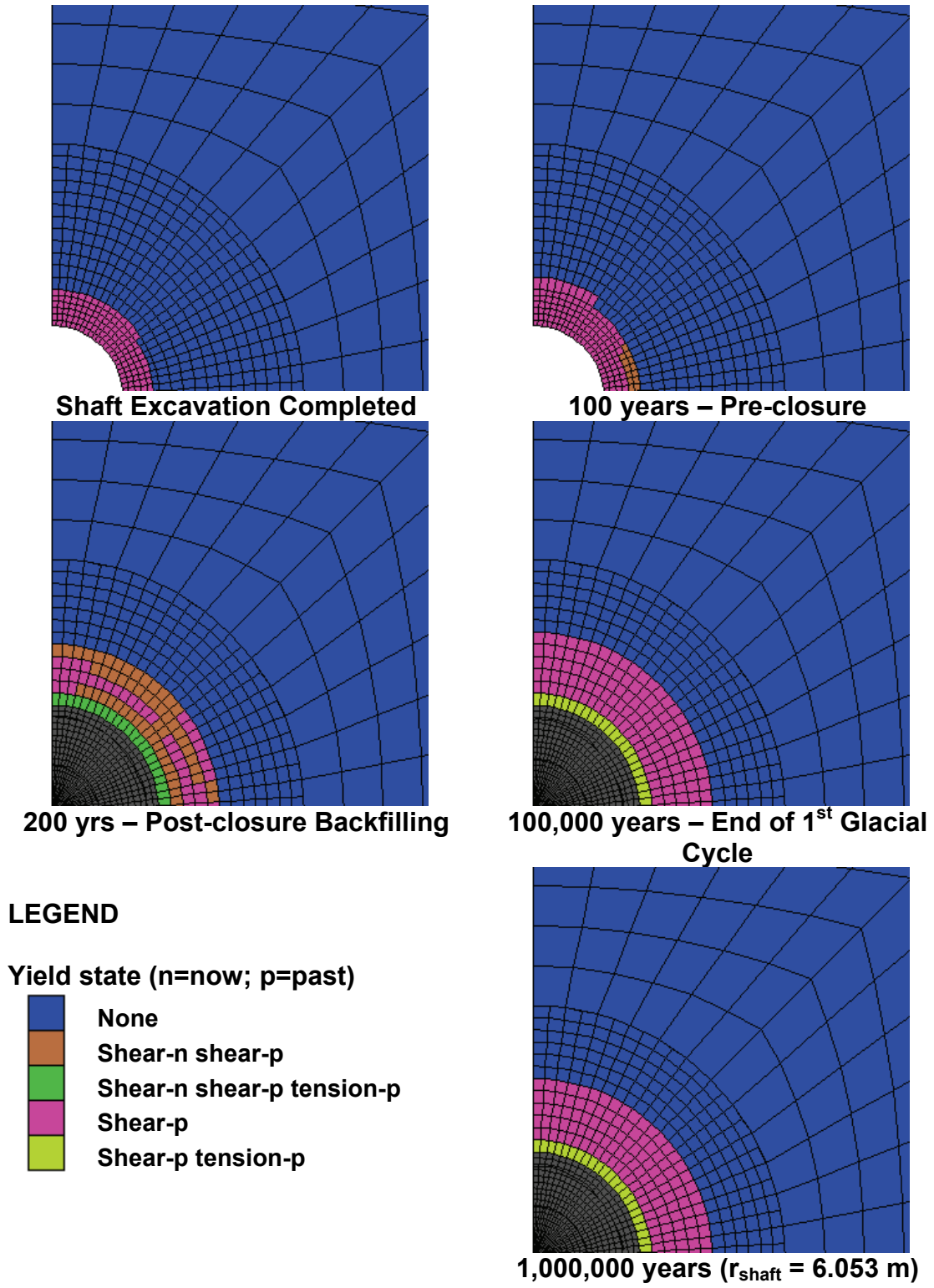


Figure B.17 Yield State – 22.4 m Below Concrete Bulkhead B1': Time-dependent Strength Degradation + Glacial Load

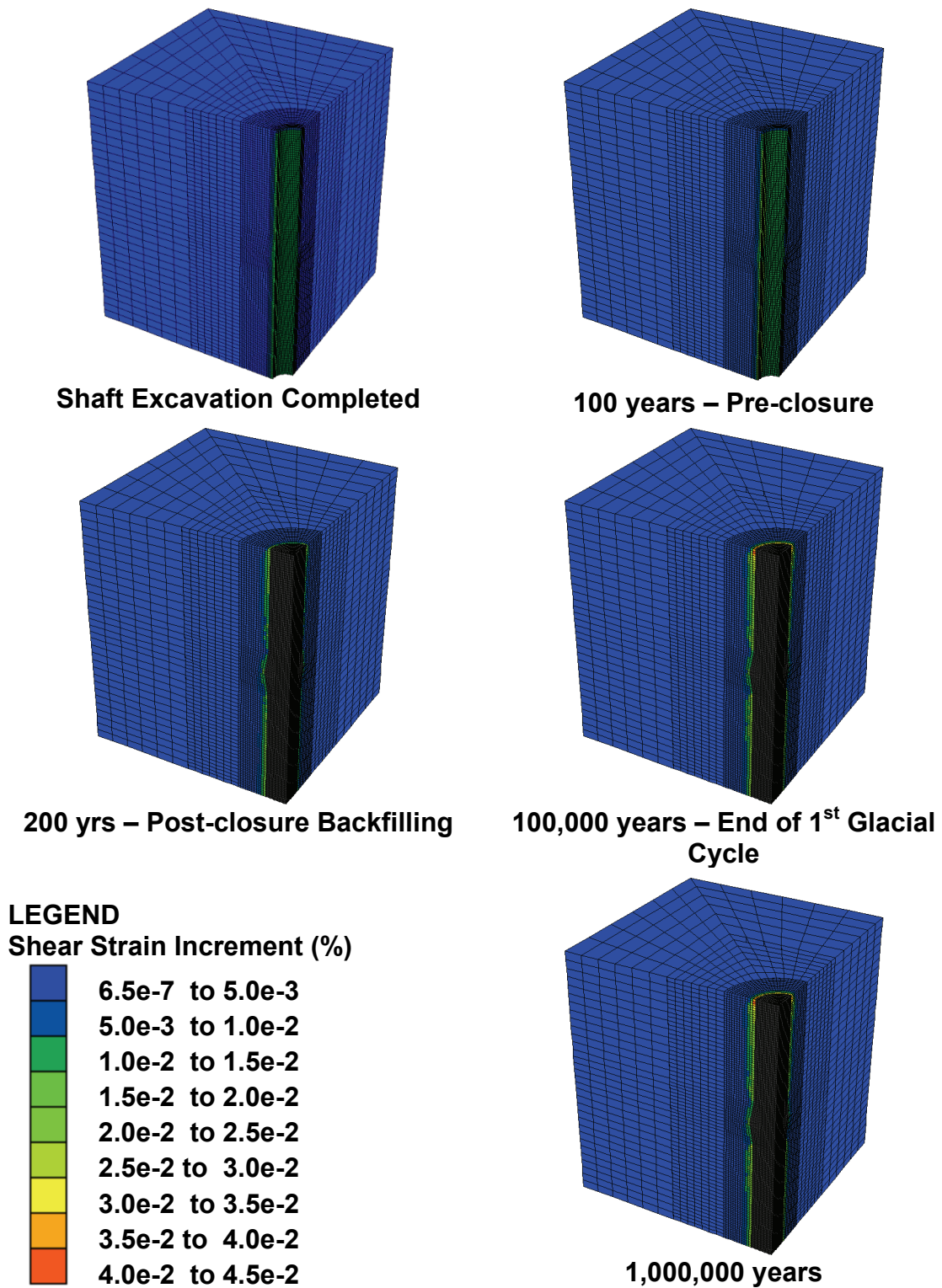
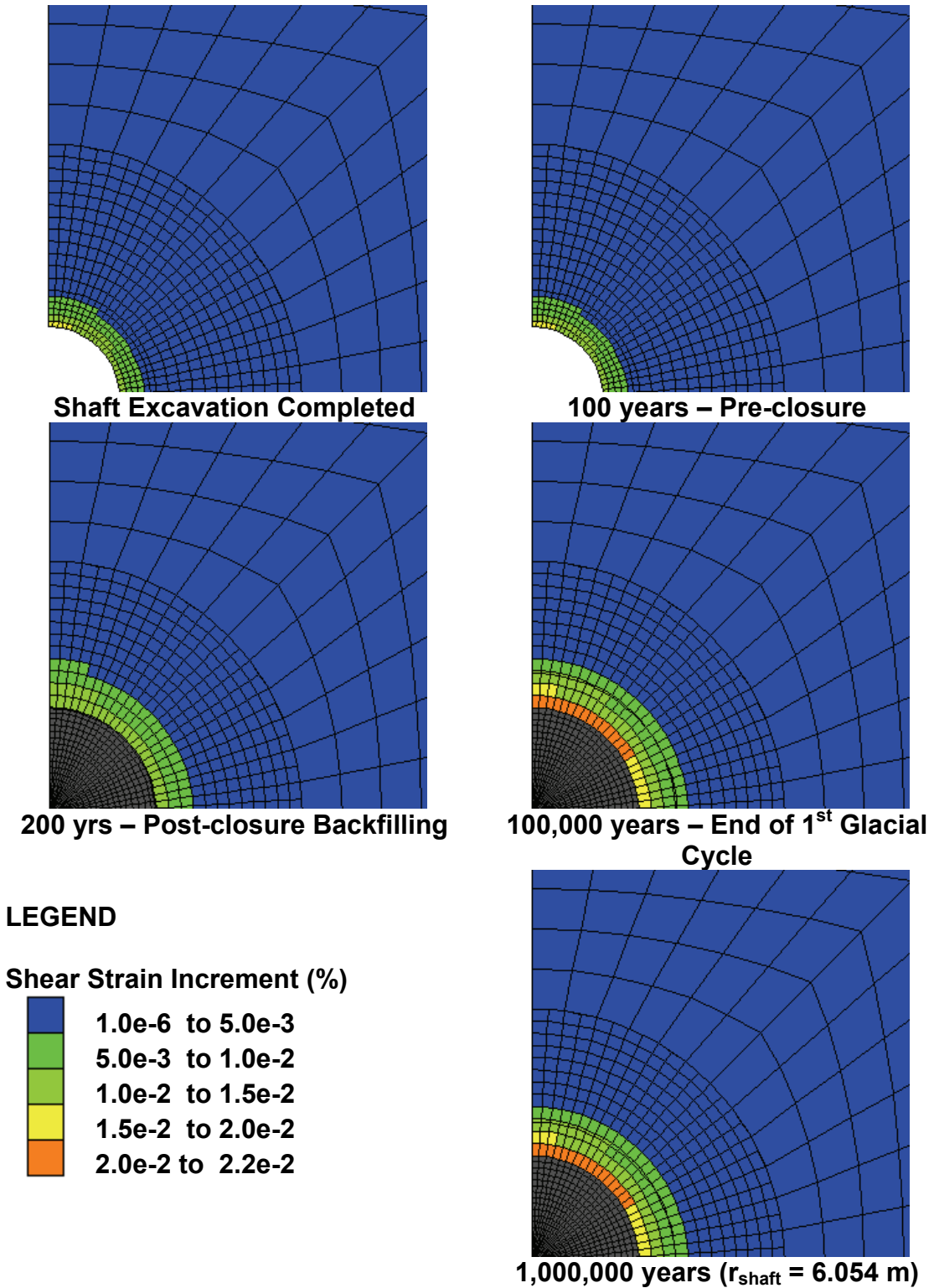
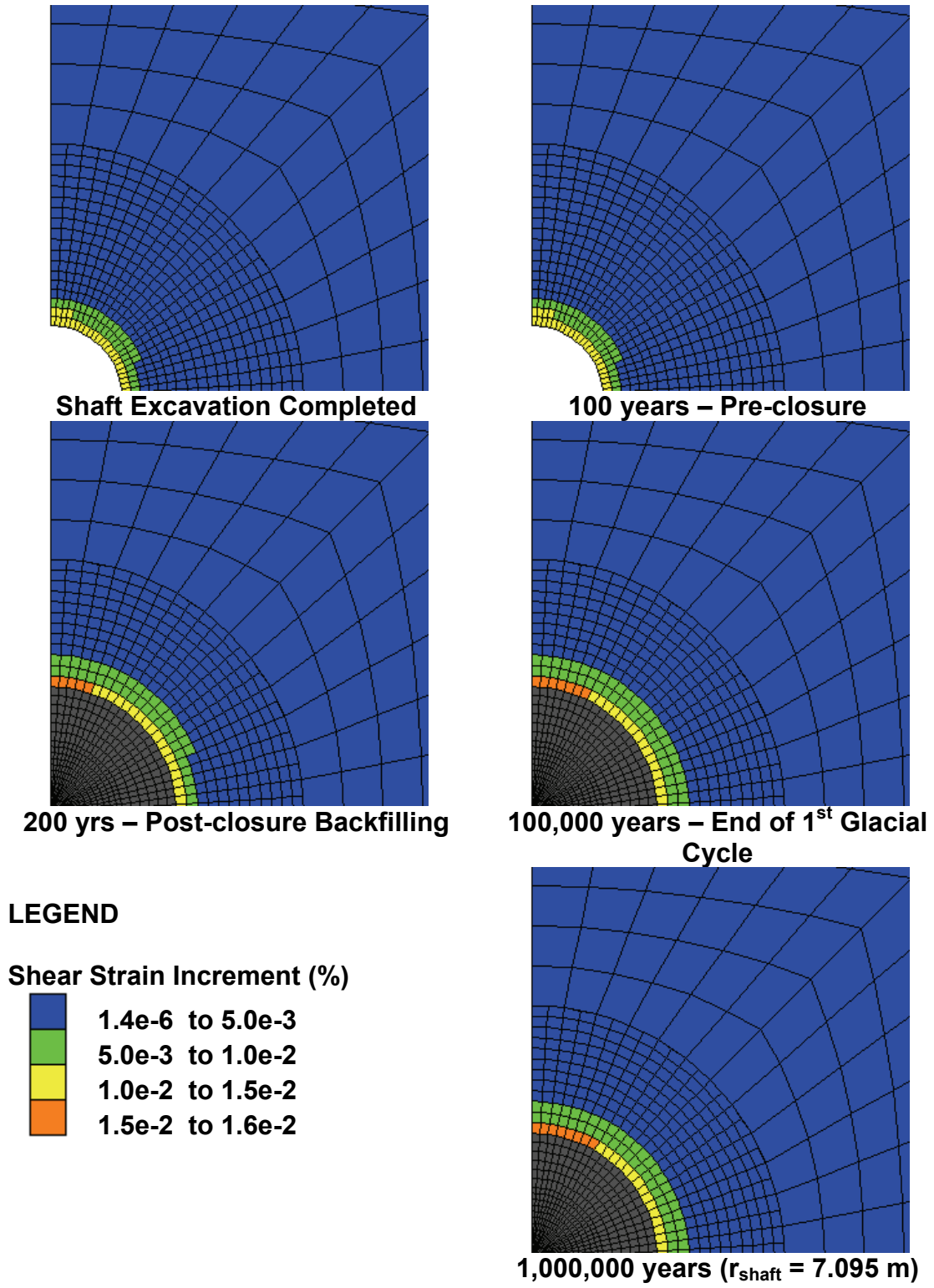


Figure B.18 Shear Strain – Concrete Bulkhead B1': Time-dependent Strength Degradation + Glacial Load



**Figure B.19 Shear Strain – 22.4 m Above Concrete Bulkhead B1': Time-dependent Strength Degradation + Glacial Load**



**Figure B.20 Shear Strain – Middle Concrete Bulkhead B1': Time-dependent Strength Degradation + Glacial Load**

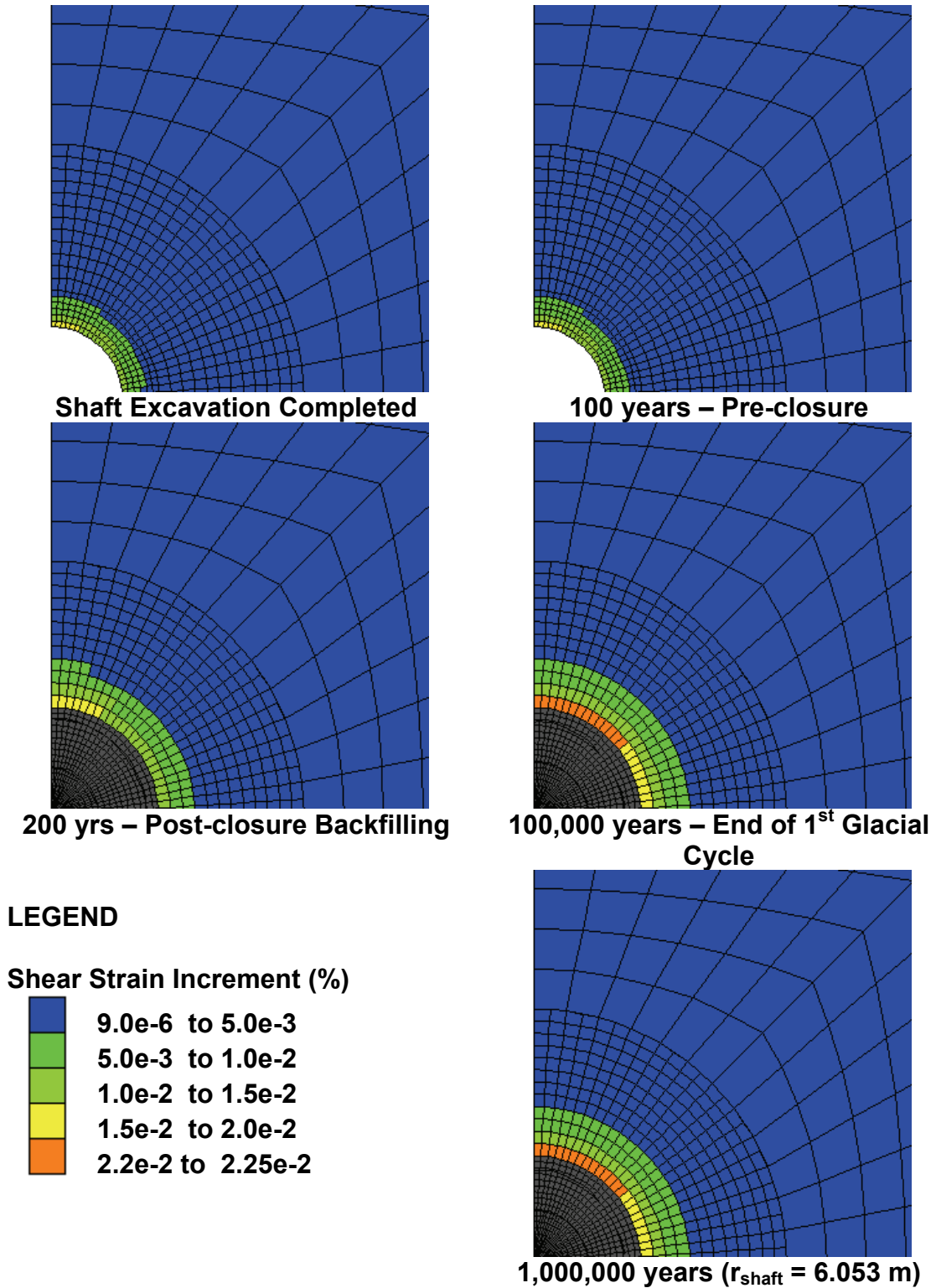


Figure B.21 Shear Strain – 22.4 m Below Concrete Bulkhead B1': Time-dependent Strength Degradation + Glacial Load

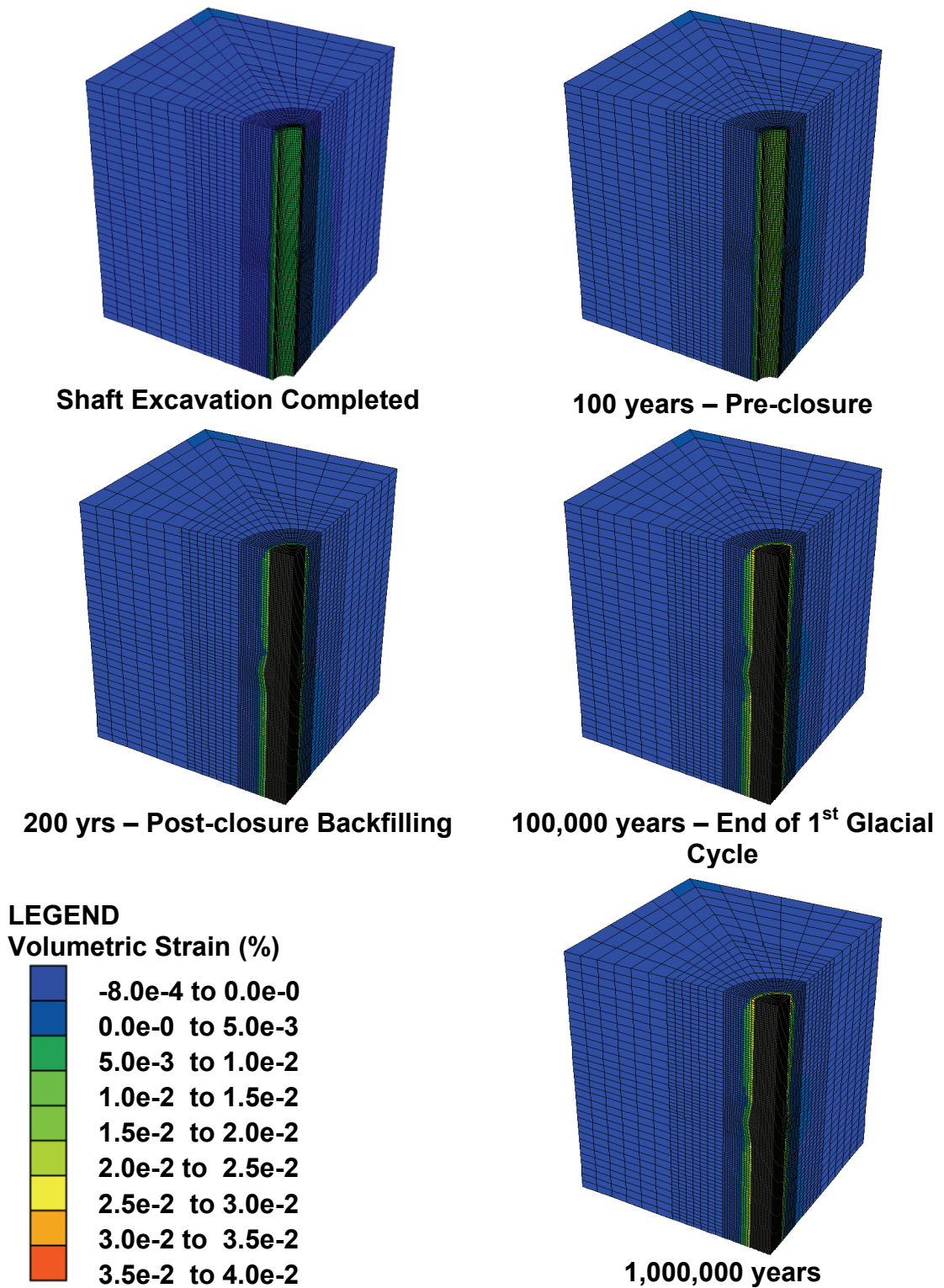
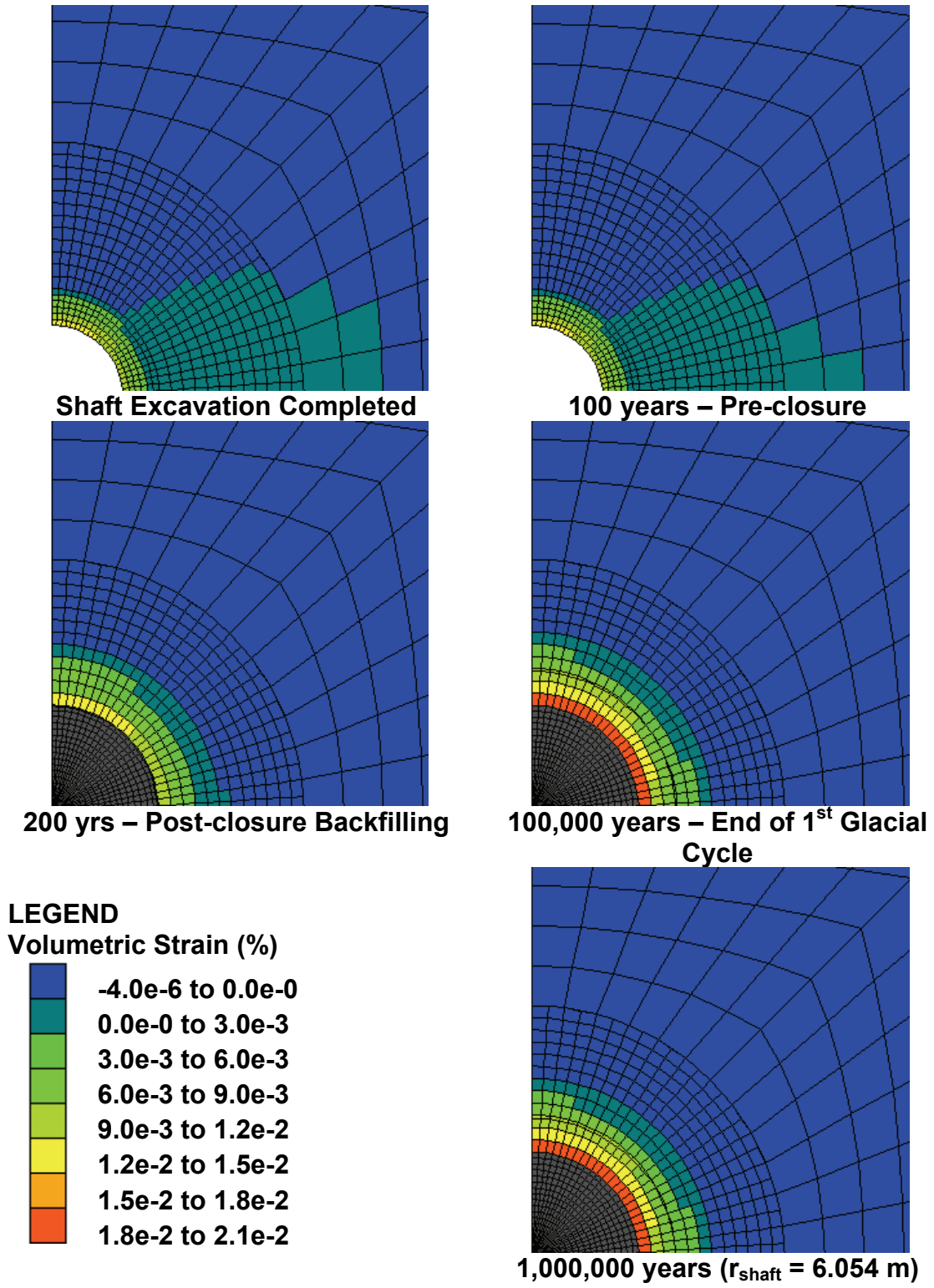


Figure B.22 Volumetric Strain – Concrete Bulkhead B1': Time-dependent Strength Degradation + Glacial Load



**Figure B.23 Volumetric Strain – 22.4 m Above Concrete Bulkhead B1':  
 Time-dependent Strength Degradation + Glacial Load**



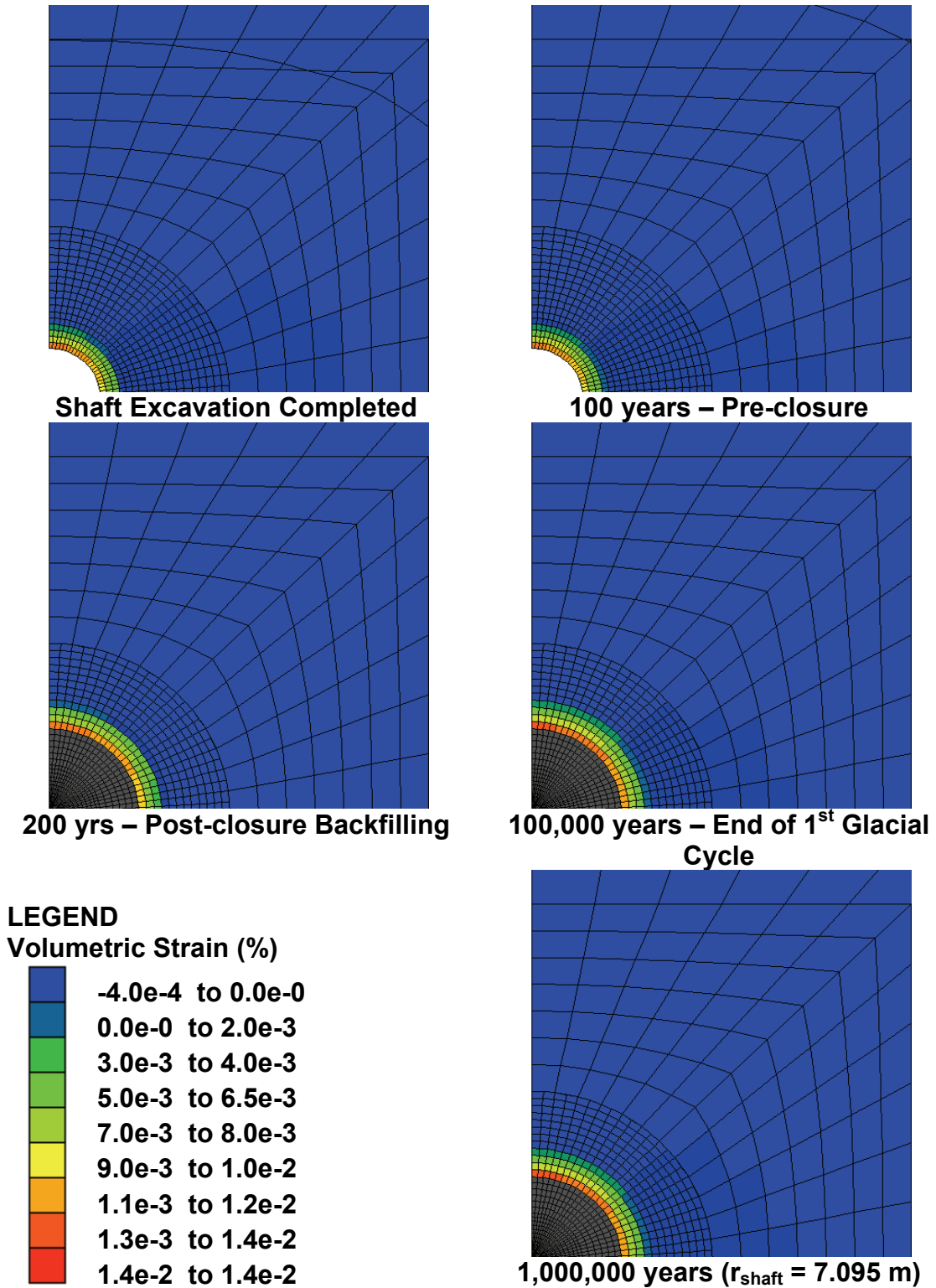


Figure B.24 Volumetric Strain – Middle Concrete Bulkhead B1': Time-dependent Strength Degradation + Glacial Load

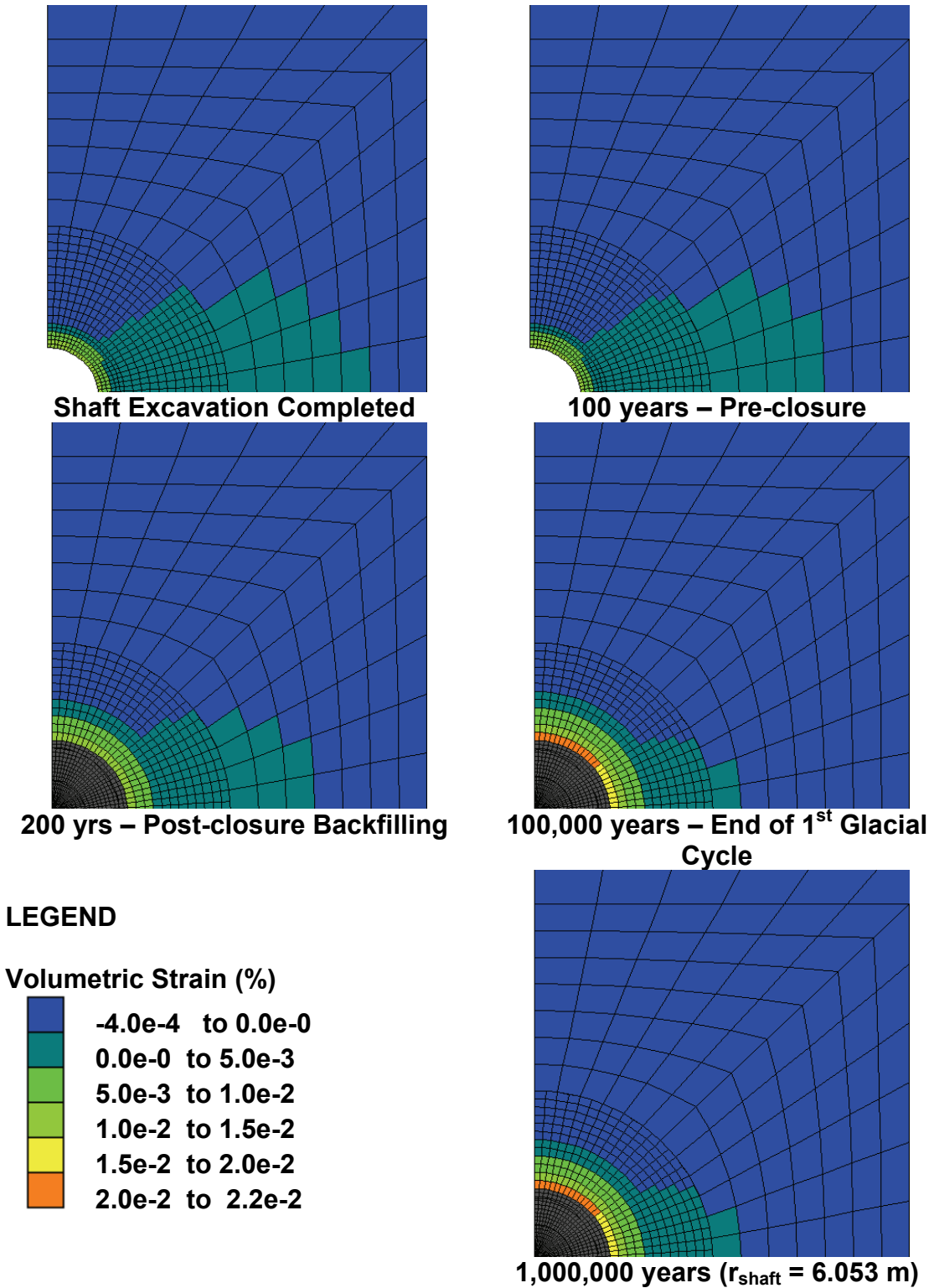


Figure B.25 Volumetric Strain – 22.4 m Below Concrete Bulkhead B1':  
Time-dependent Strength Degradation + Glacial Load

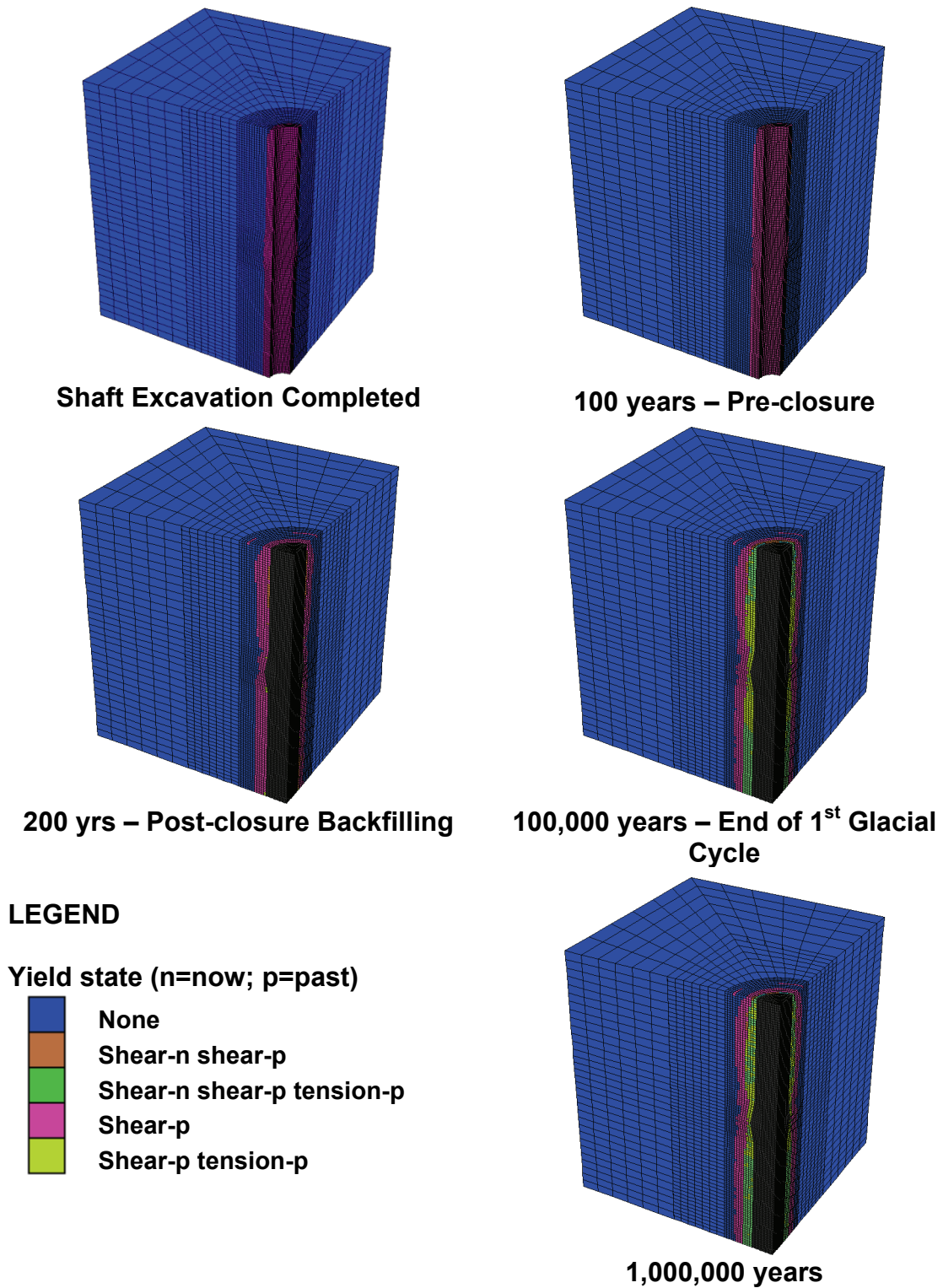
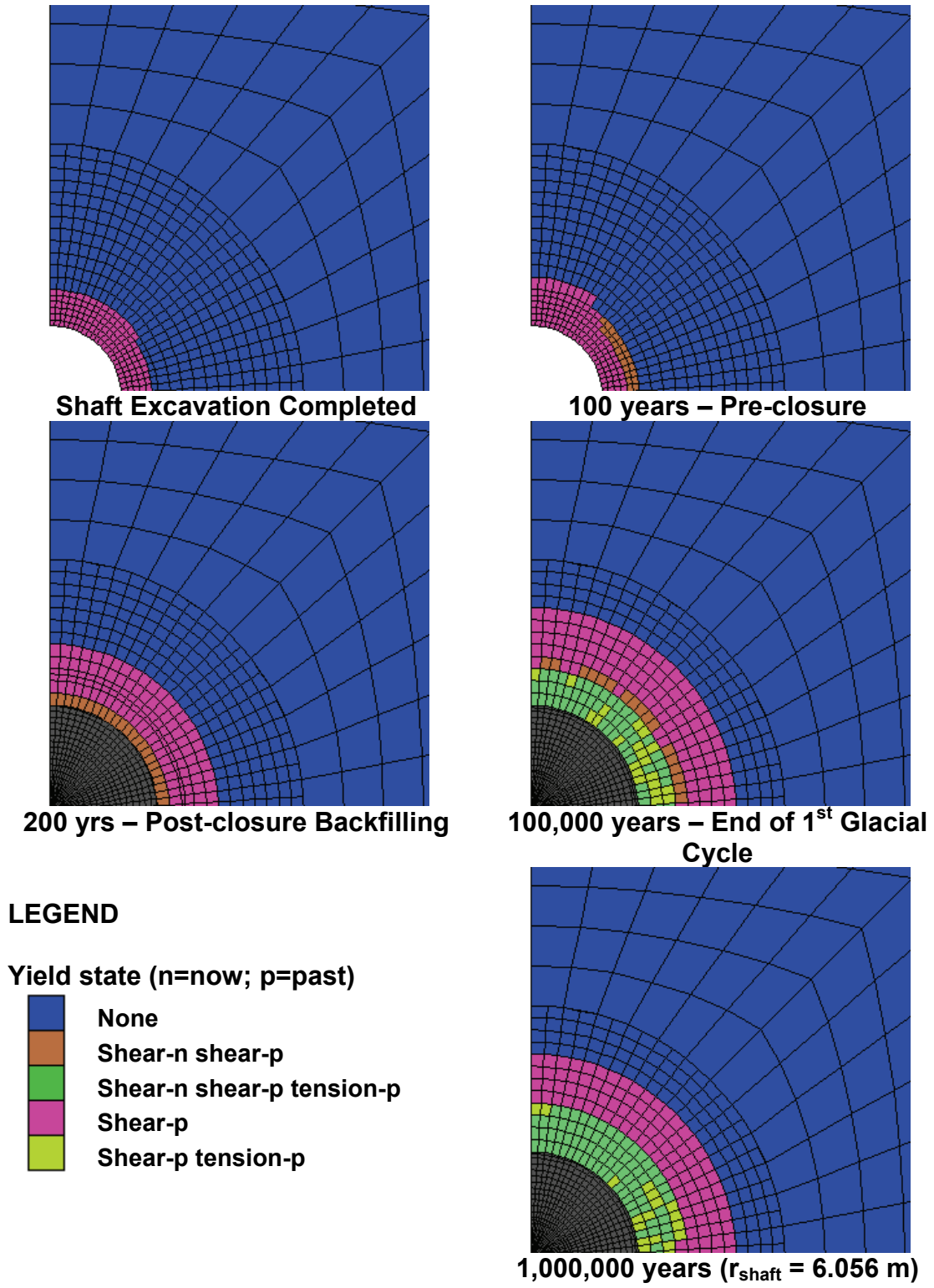
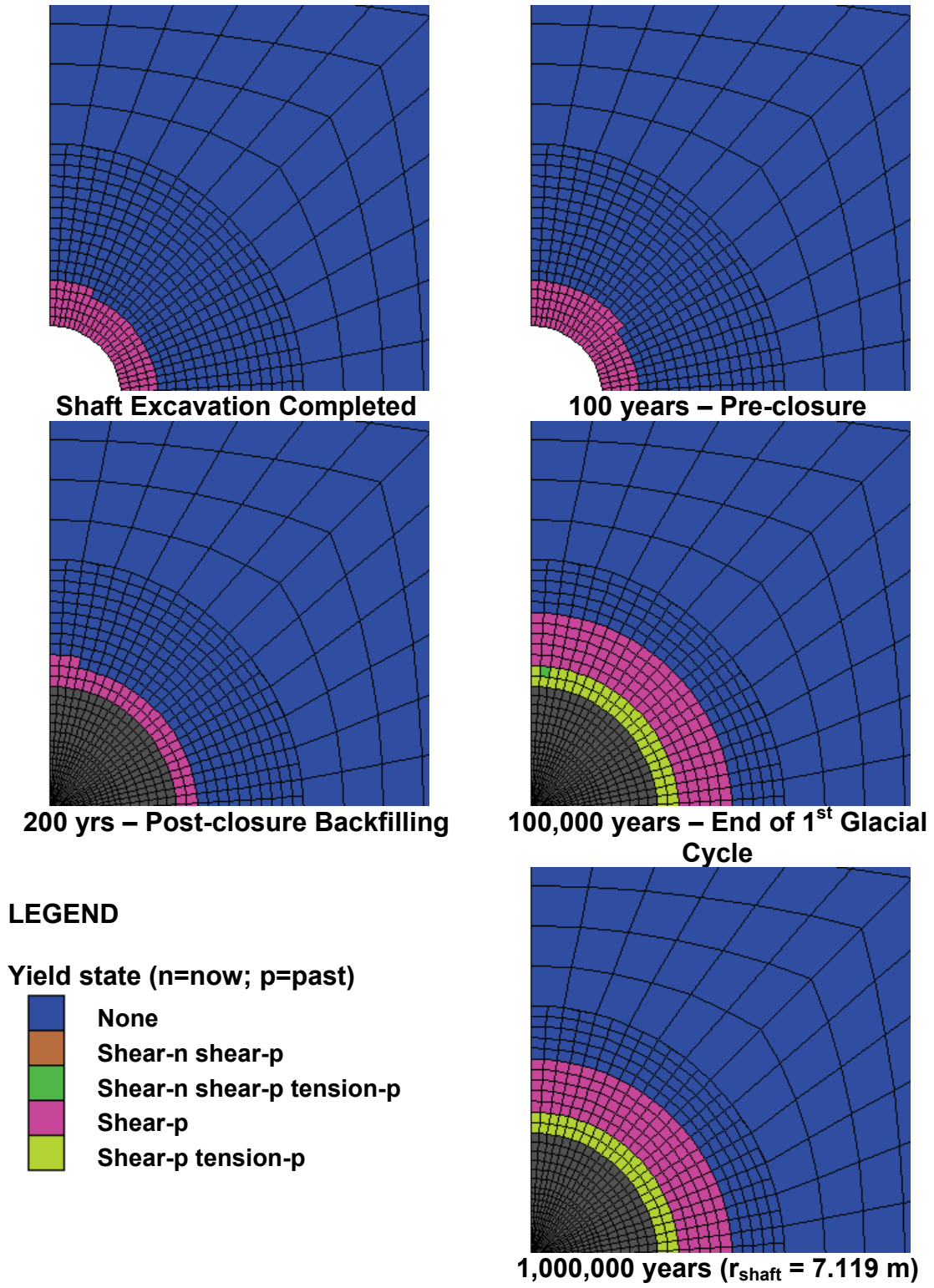


Figure B.26 Yield State – Concrete Bulkhead B1': Time-dependent Strength Degradation + Glacial Load + Pore Pressure



**Figure B.27 Yield State – 22.4 m Above Concrete Bulkhead B1': Time-dependent Strength Degradation + Glacial Load + Pore Pressure**



**Figure B.28 Yield State – Middle Concrete Bulkhead B1': Time-dependent Strength Degradation + Glacial Load + Pore Pressure**

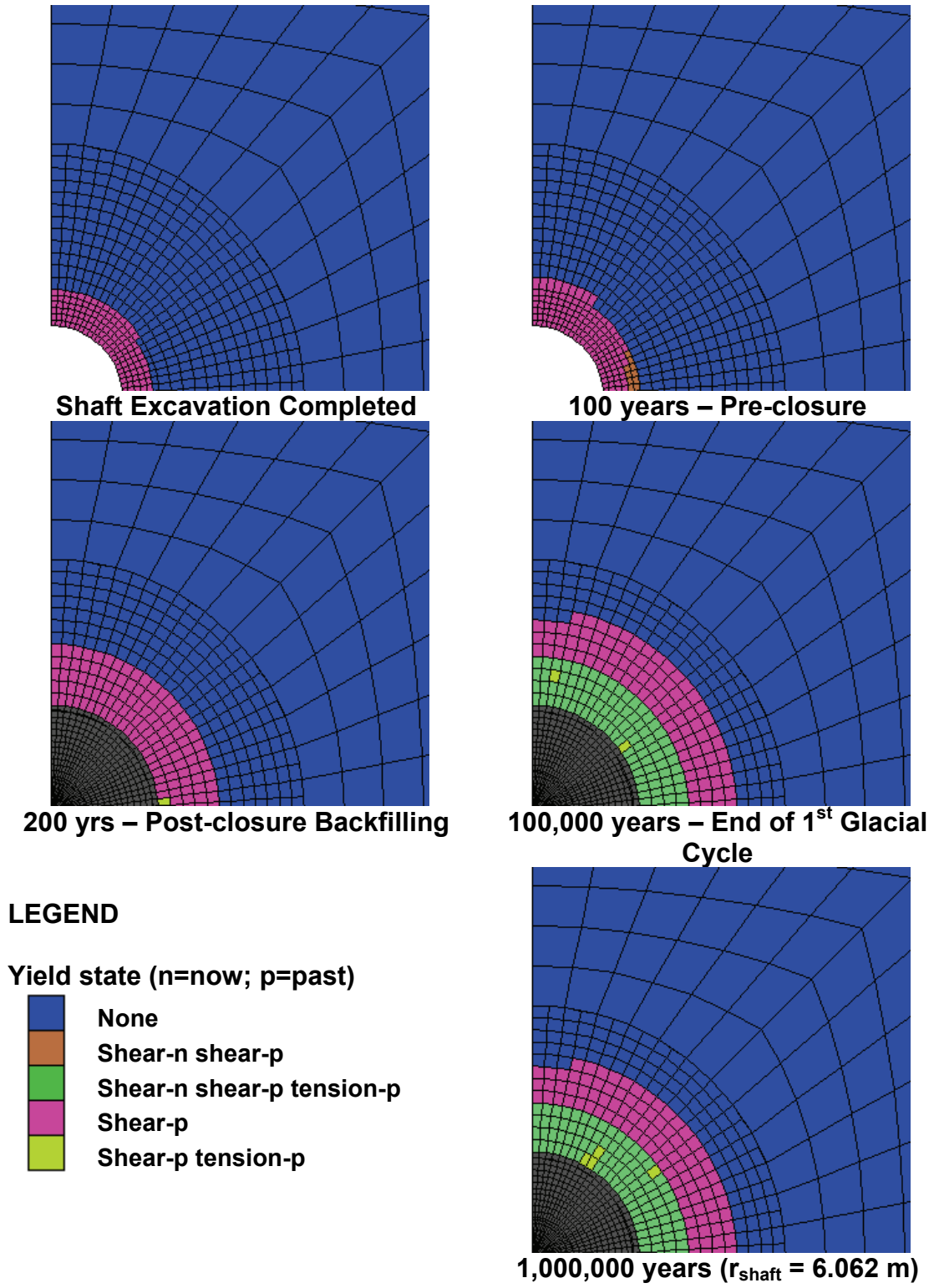
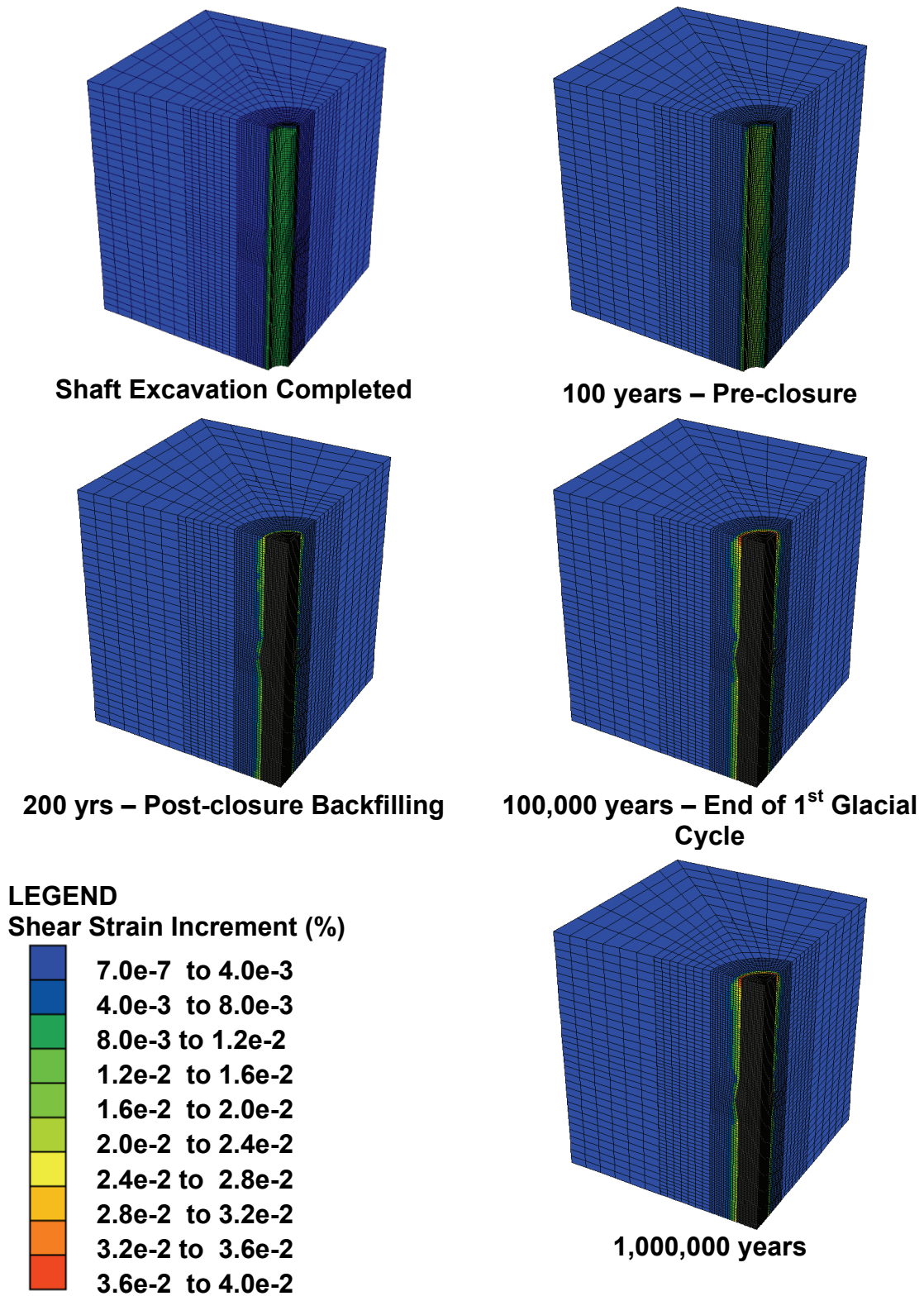


Figure B.29 Yield State – 22.4 m Below Concrete Bulkhead B1': Time-dependent Strength Degradation + Glacial Load + Pore Pressure



**Figure B.30 Shear Strain – Concrete Bulkhead B1': Time-dependent Strength Degradation + Glacial Load + Pore Pressure**

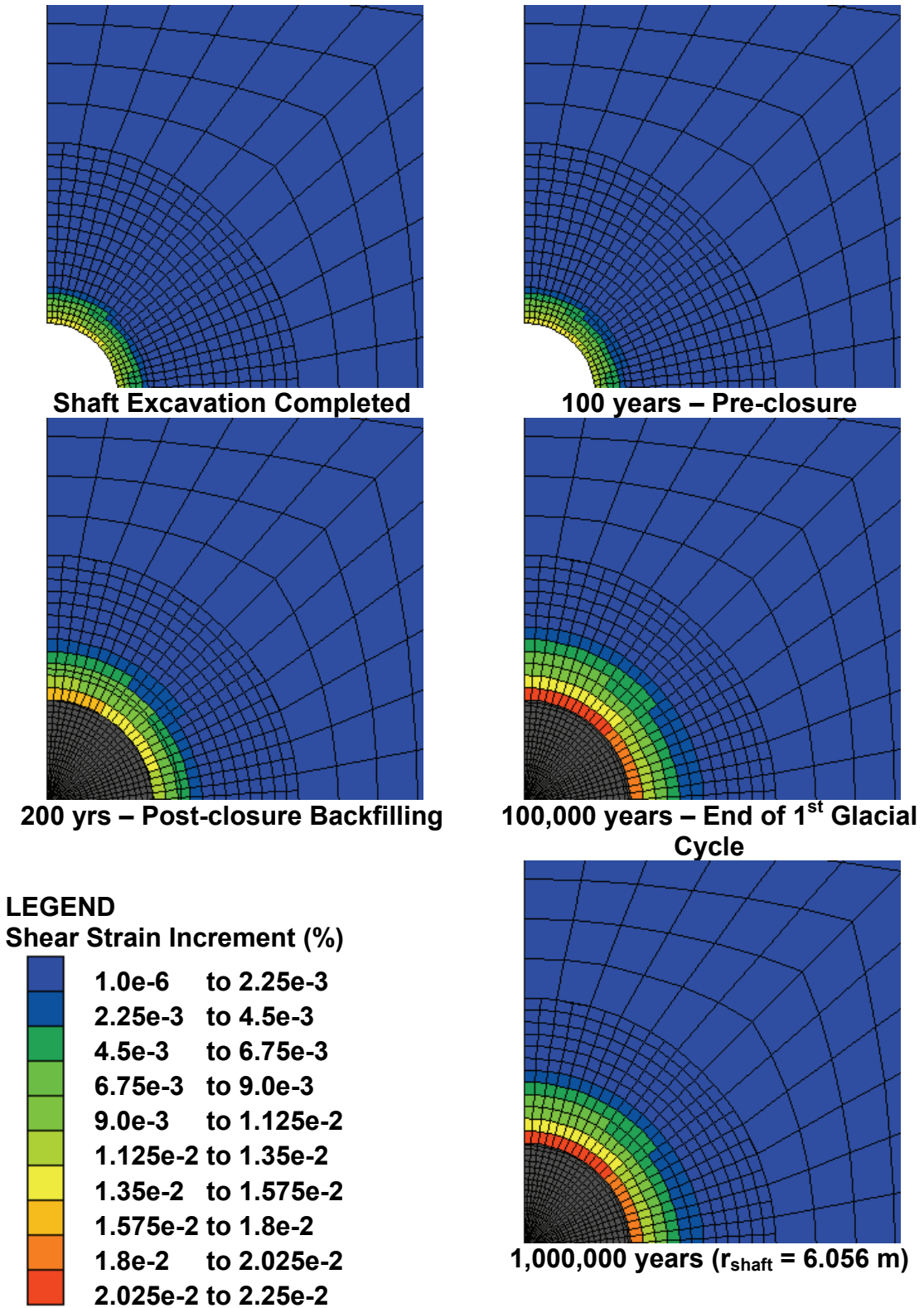
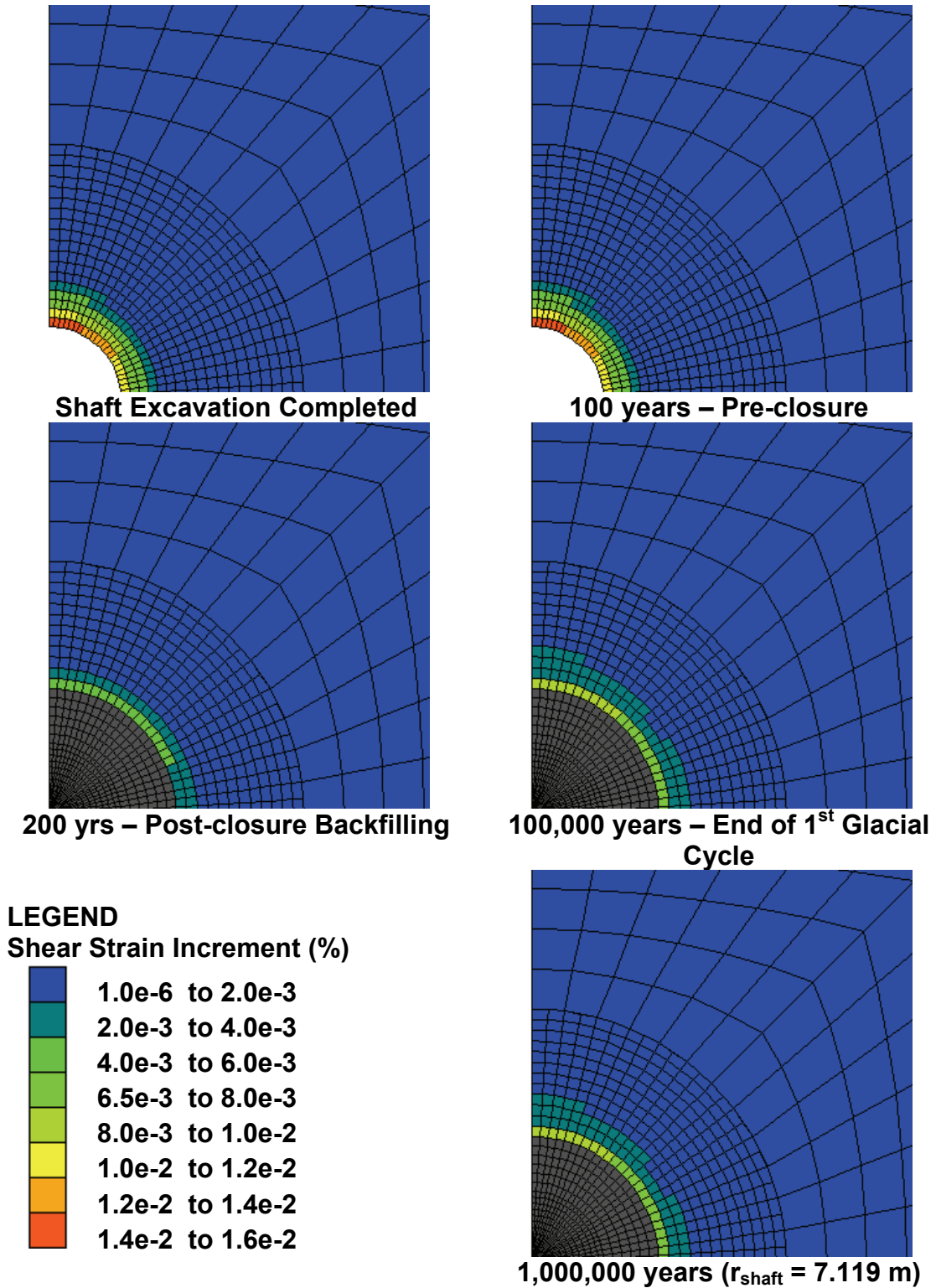


Figure B.31 Shear Strain – 22.4 m Above Concrete Bulkhead B1': Time-dependent Strength Degradation + Glacial Load + Pore Pressure





**Figure B.32 Shear Strain – Middle Concrete Bulkhead B1': Time-Dependent Strength Degradation + Glacial Load + Pore Pressure**

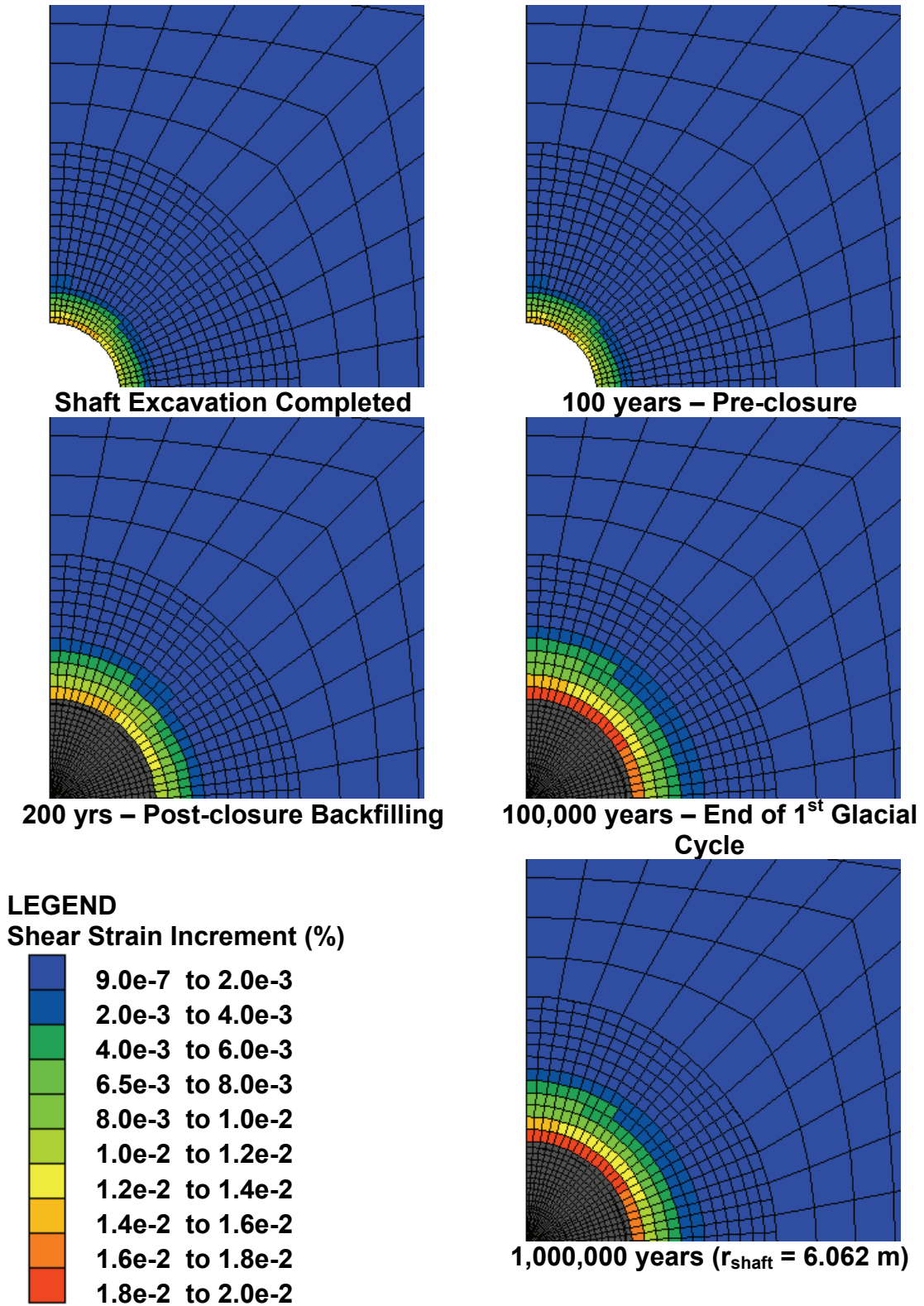


Figure B.33 Shear Strain – 22.4 m Below Concrete Bulkhead B1': Time-dependent Strength Degradation + Glacial Load + Pore Pressure

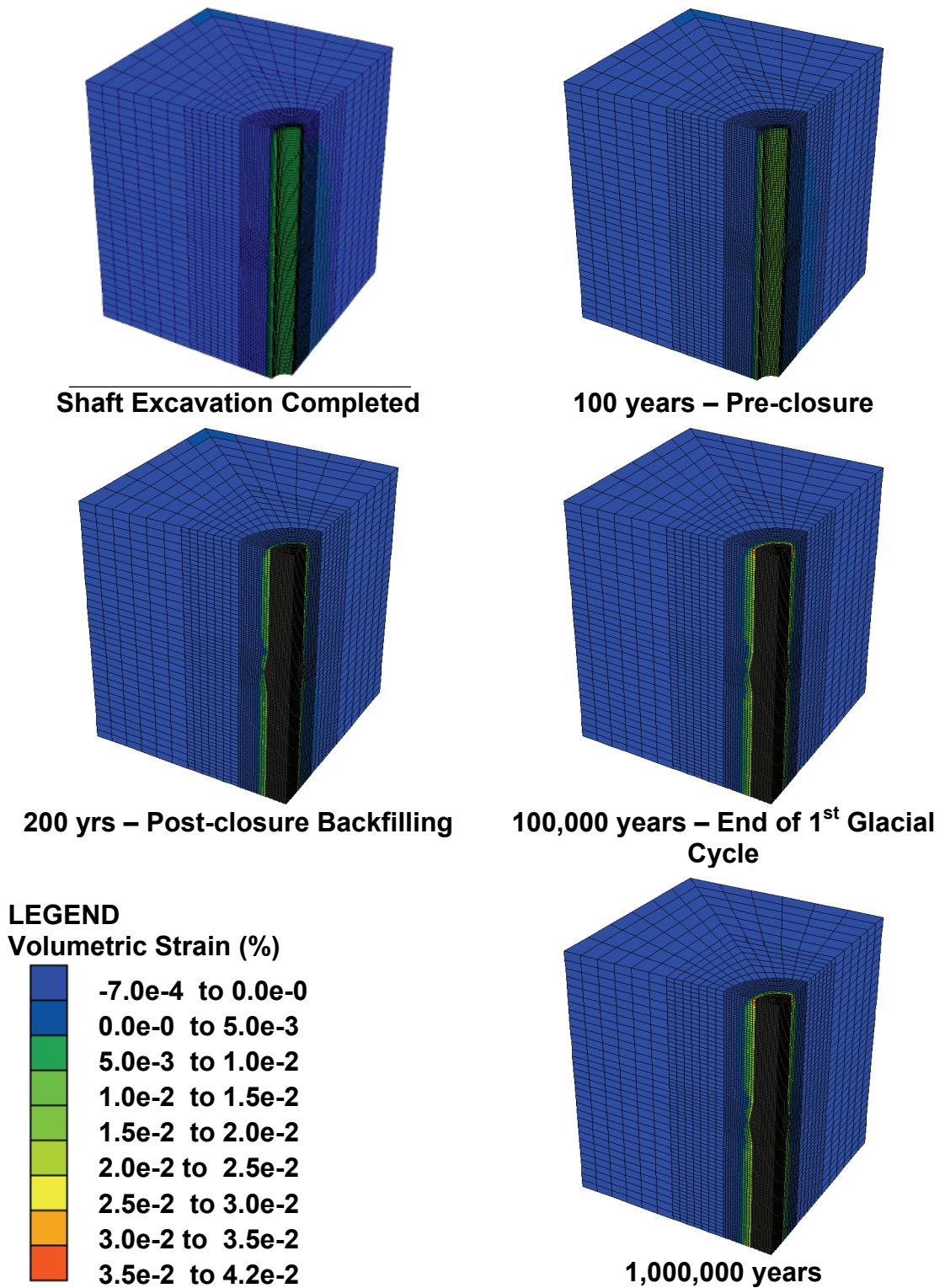


Figure B.34 Volumetric Strain – Concrete Bulkhead B1': Time-dependent Strength Degradation + Glacial Load + Pore Pressure

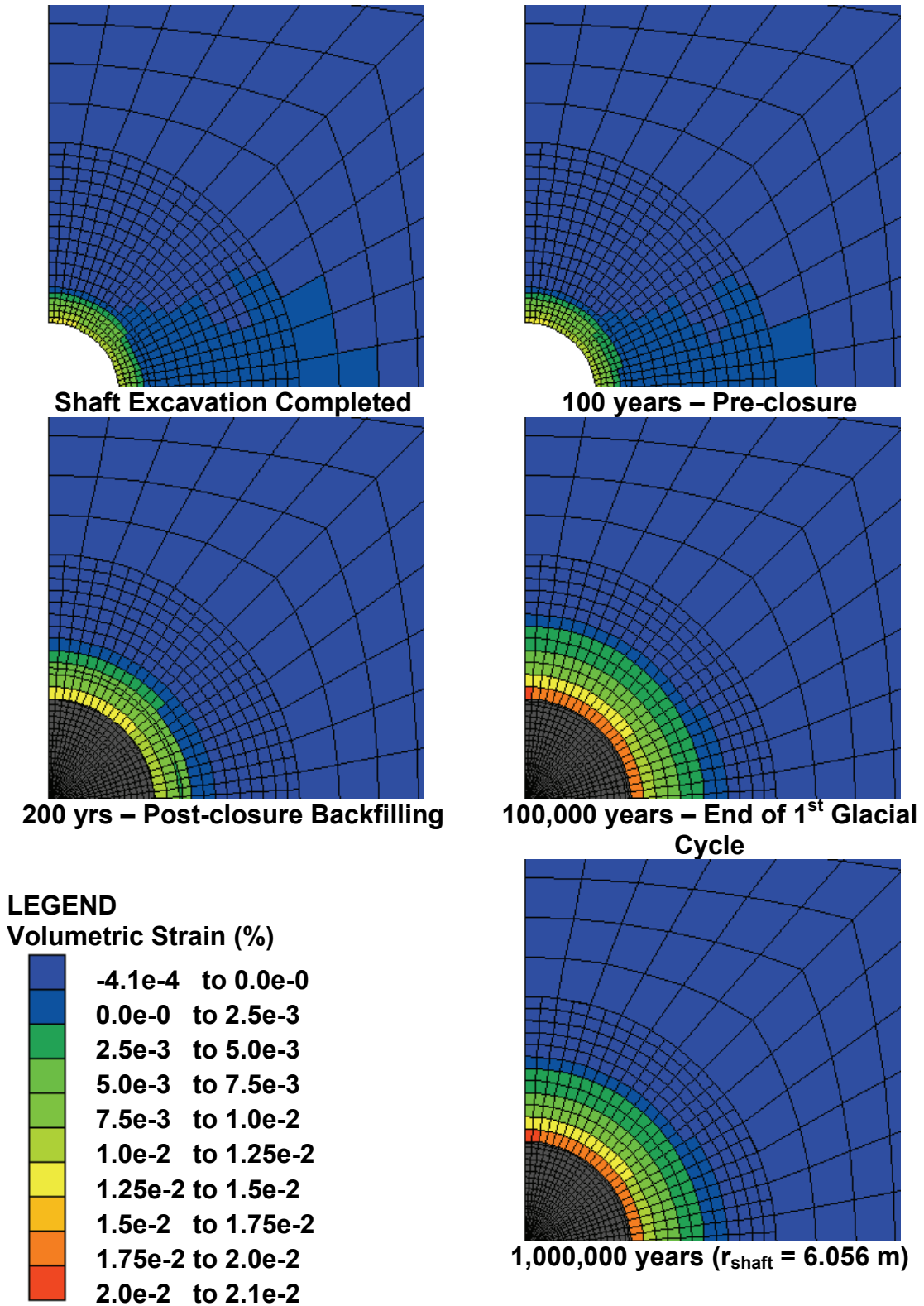
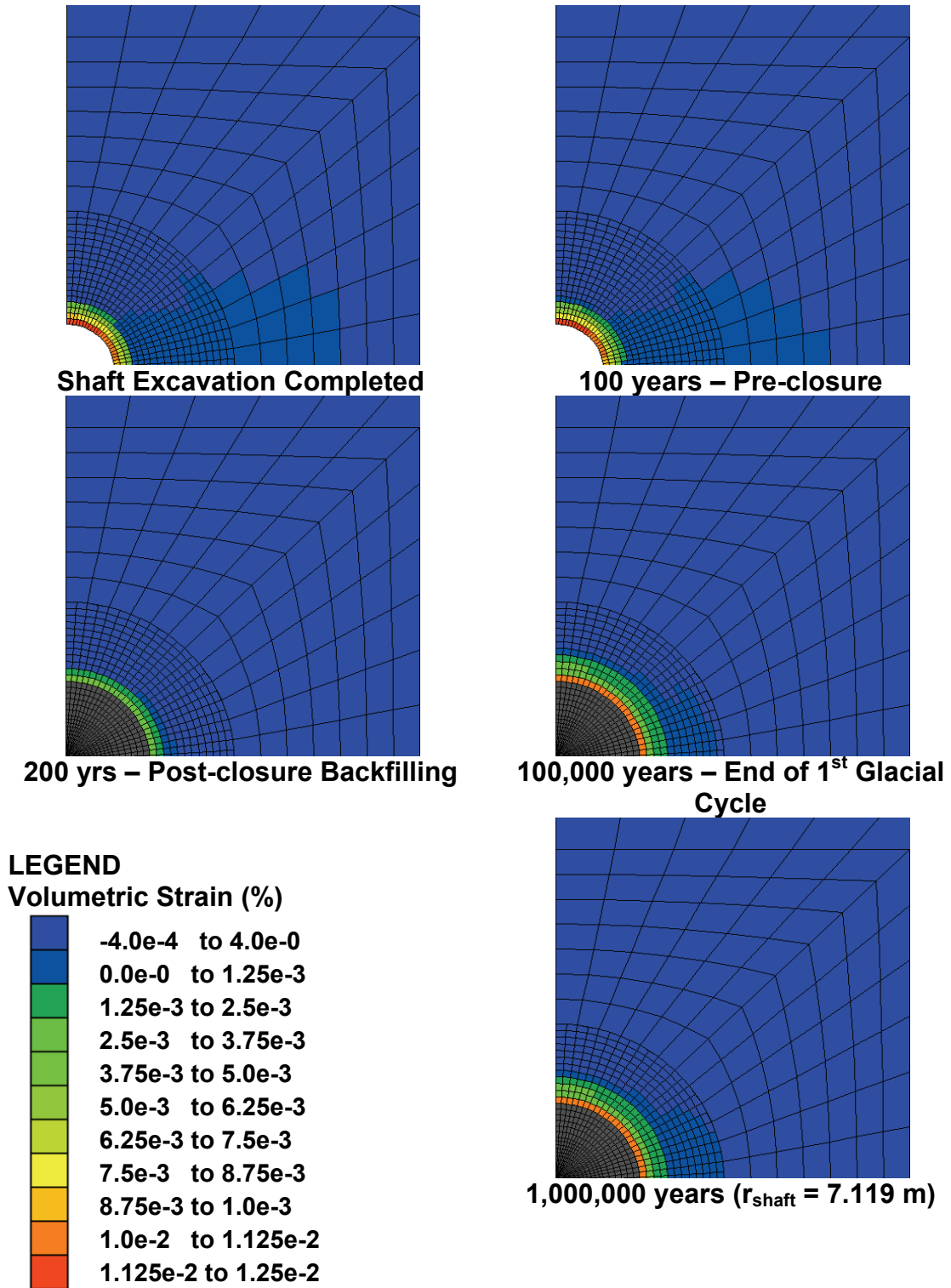


Figure B.35 Volumetric Strain – 22.4 m Above Concrete Bulkhead B1’: Time-dependent Strength Degradation + Glacial Load + Pore Pressure



**Figure B.36 Volumetric Strain – Middle Concrete Bulkhead B1': Time-dependent Strength Degradation + Glacial Load + Pore Pressure**

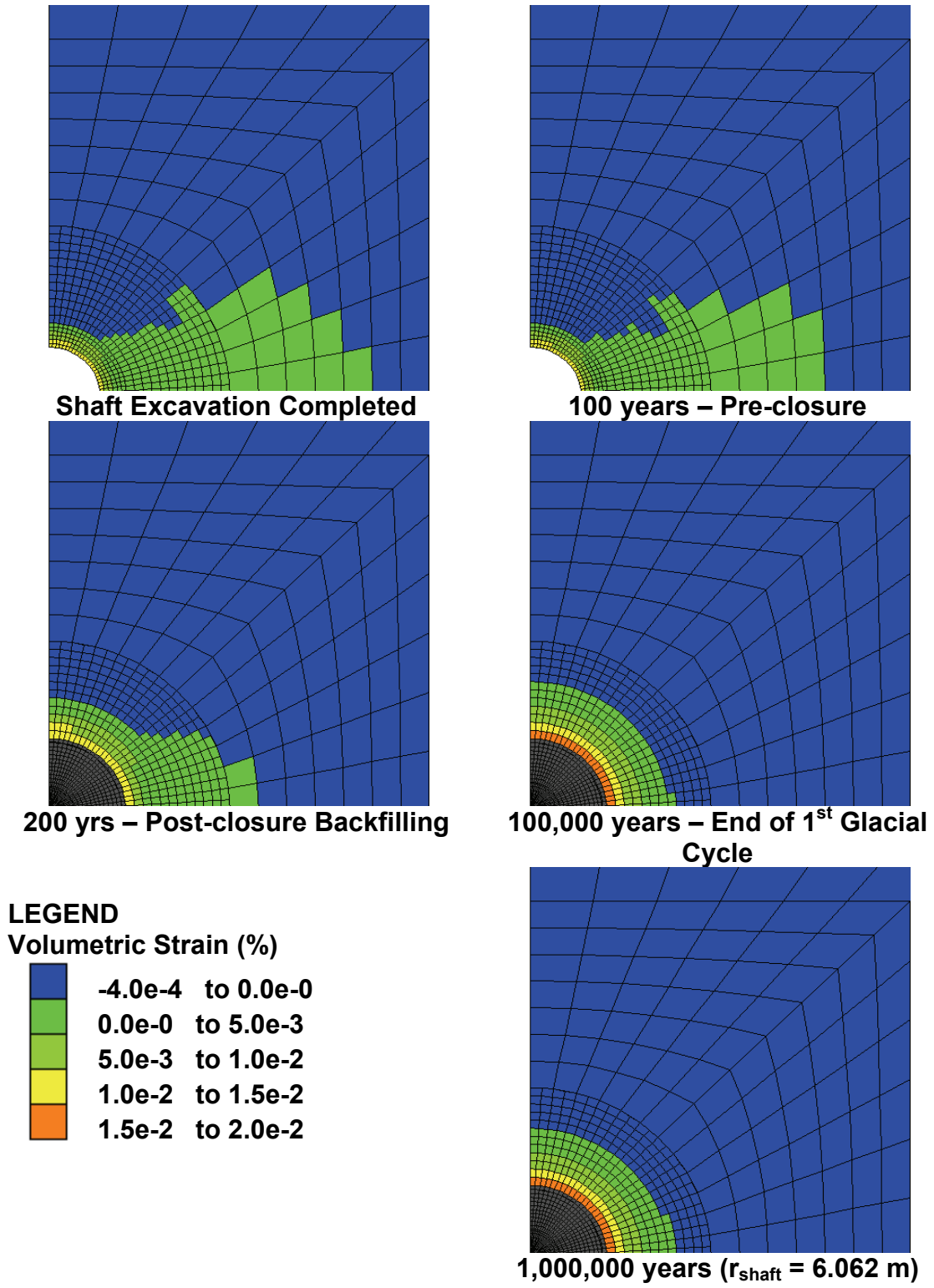


Figure B.37 Volumetric Strain – 22.4 m Below Concrete Bulkhead B1’: Time-dependent Strength Degradation + Glacial Load + Pore Pressure

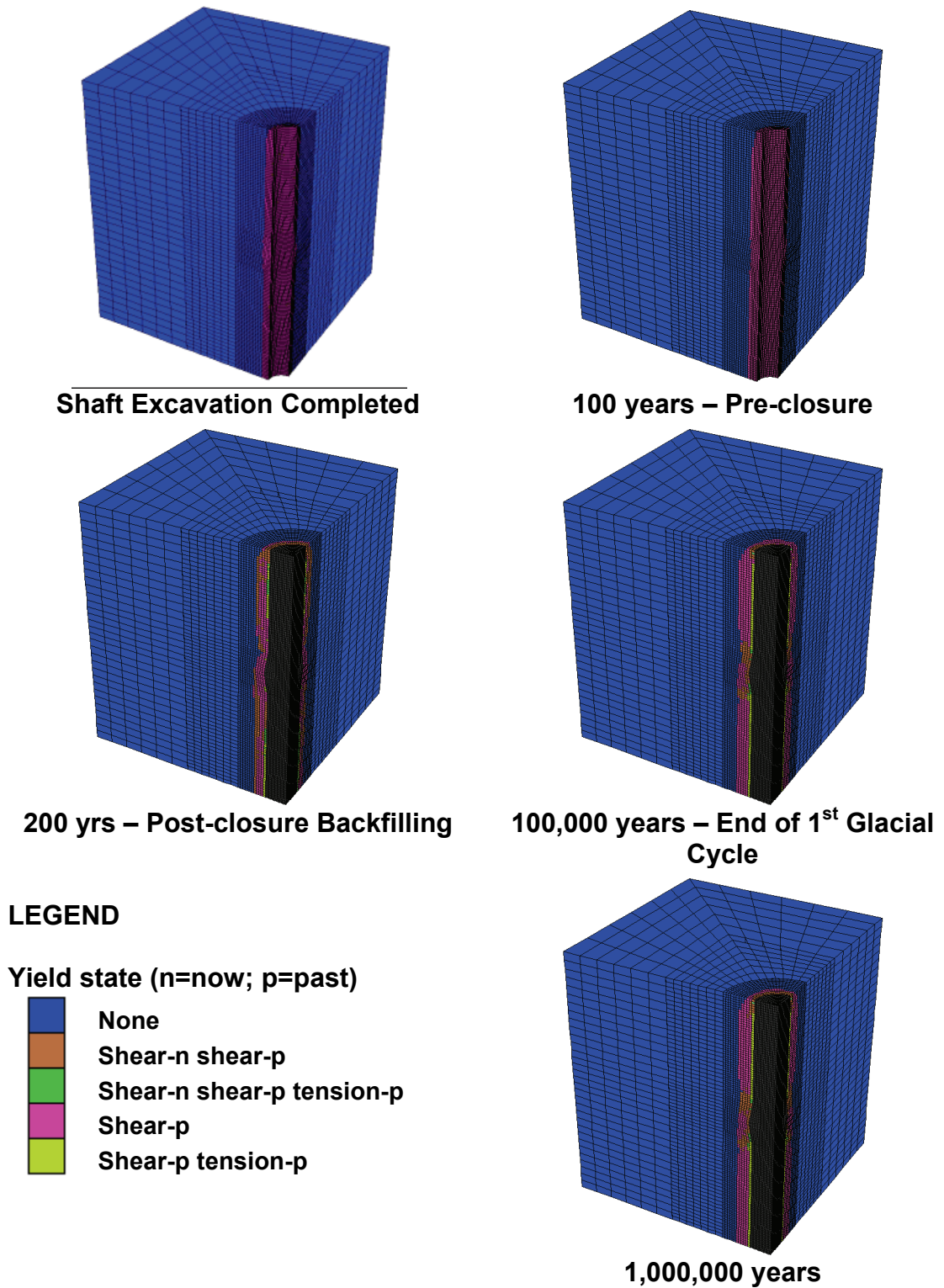
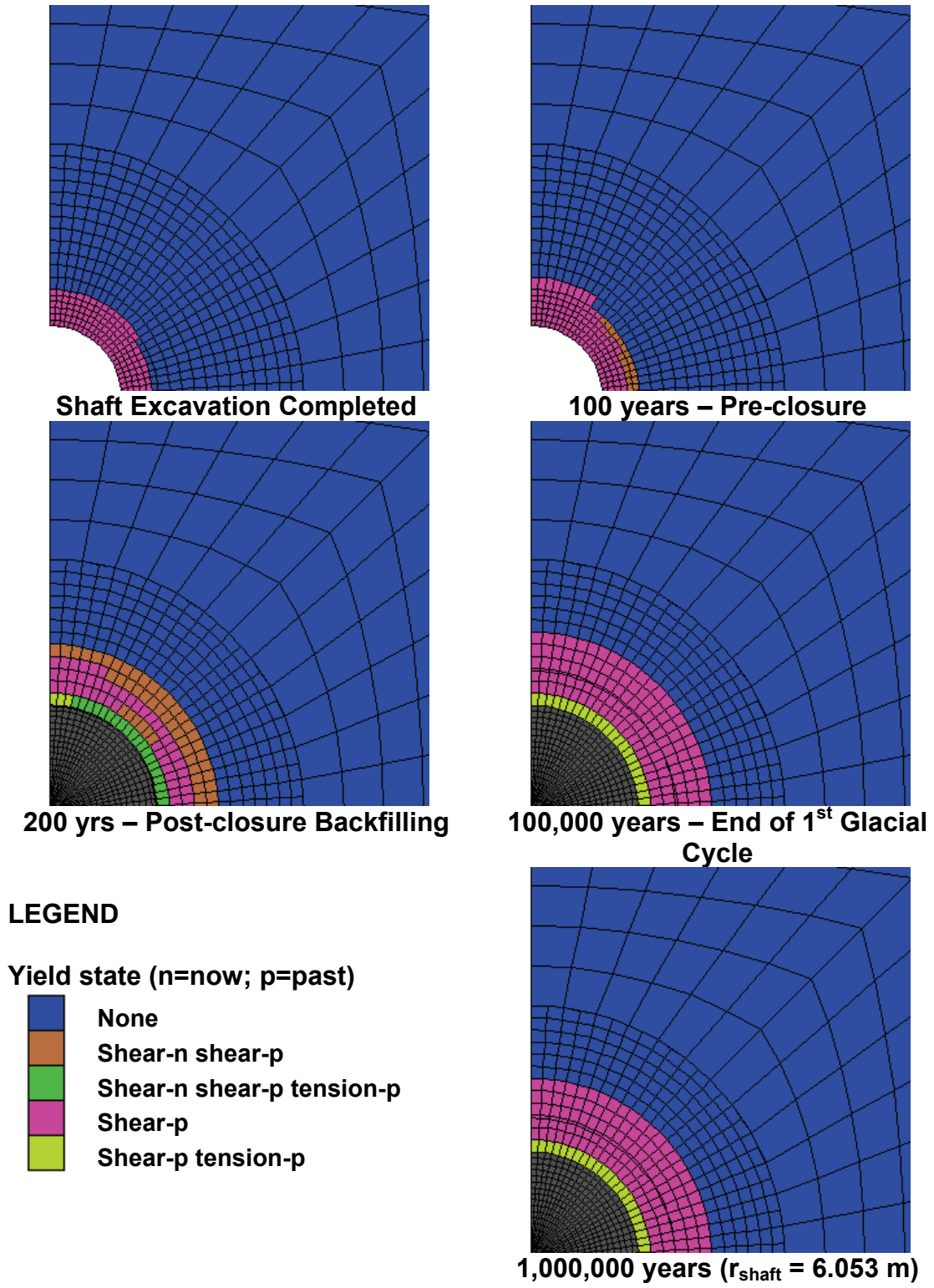


Figure B.38 Yield State – Concrete Bulkhead B1': Time-dependent Strength Degradation + Glacial Load + Pore Pressure + Seismic Loading



**Figure B.39 Yield State – 22.4 m Above Concrete Bulkhead B1': Time-dependent Strength Degradation + Glacial Load + Pore Pressure + Seismic Loading**



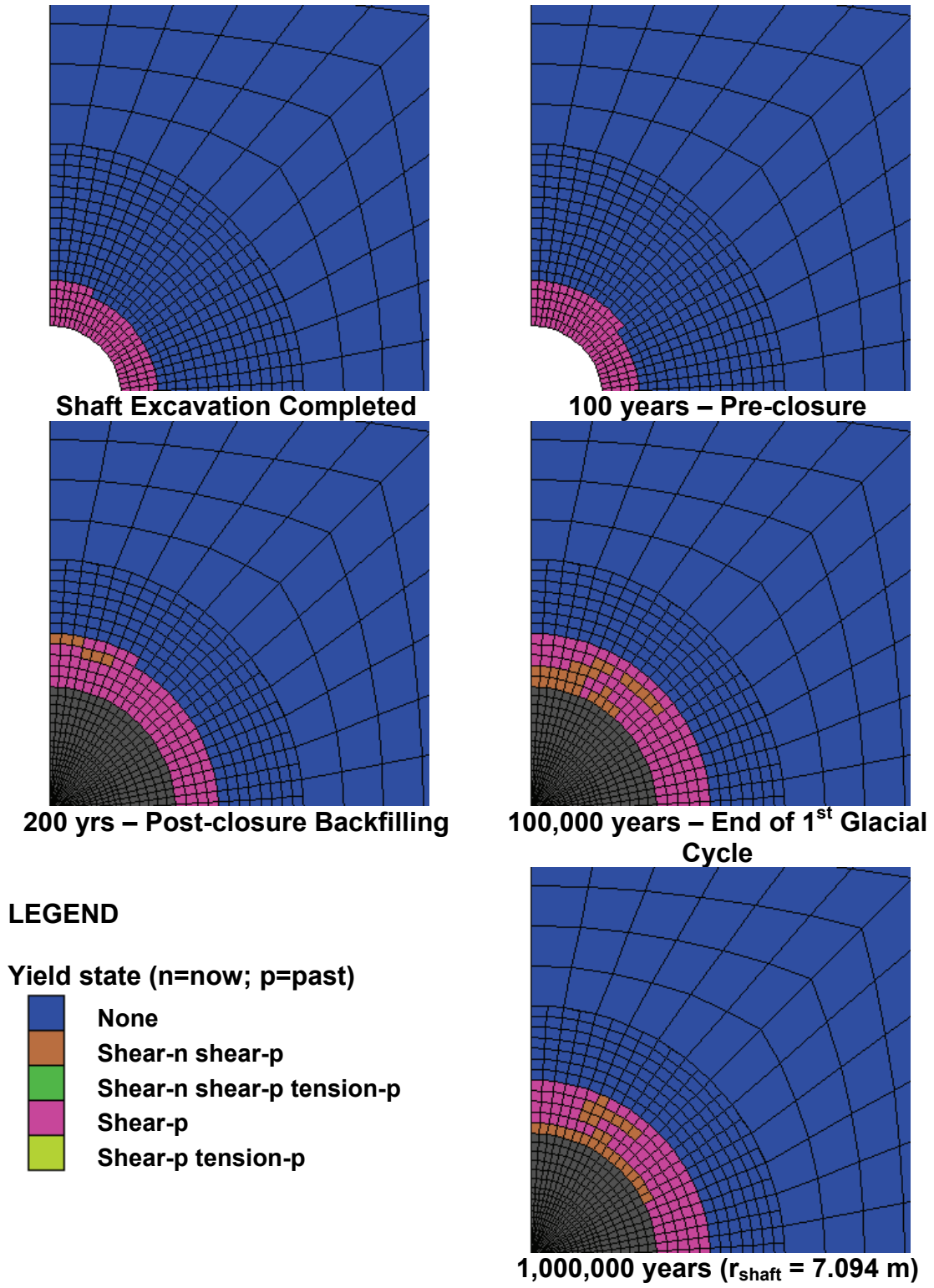


Figure B.40 Yield State – Middle Concrete Bulkhead B1': Time-Dependent Strength Degradation + Glacial Load + Pore Pressure + Seismic Loading

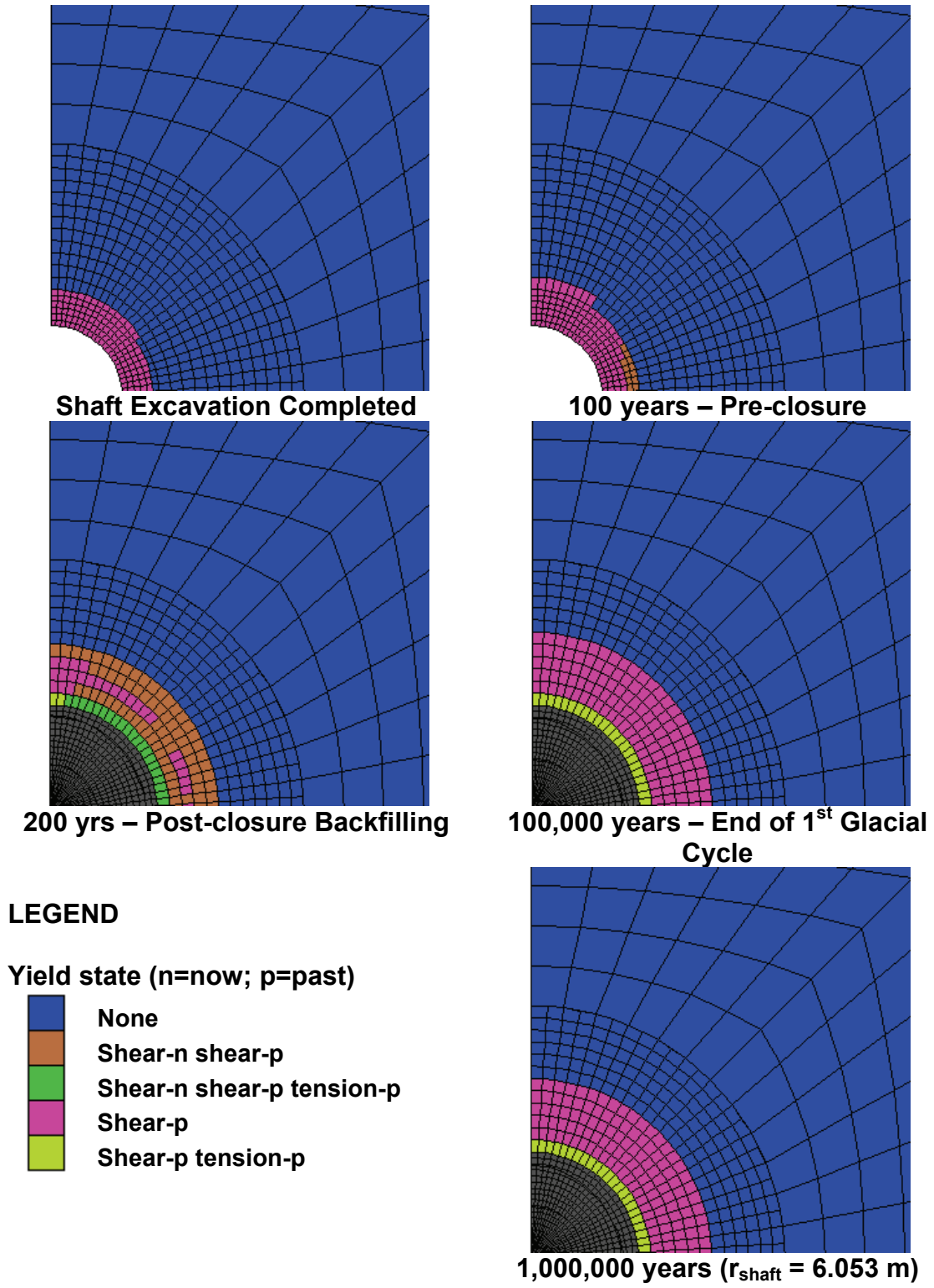


Figure B.41 Yield State – 22.4 m Below Concrete Bulkhead B1': Time-dependent Strength Degradation + Glacial Load + Pore Pressure + Seismic Loading

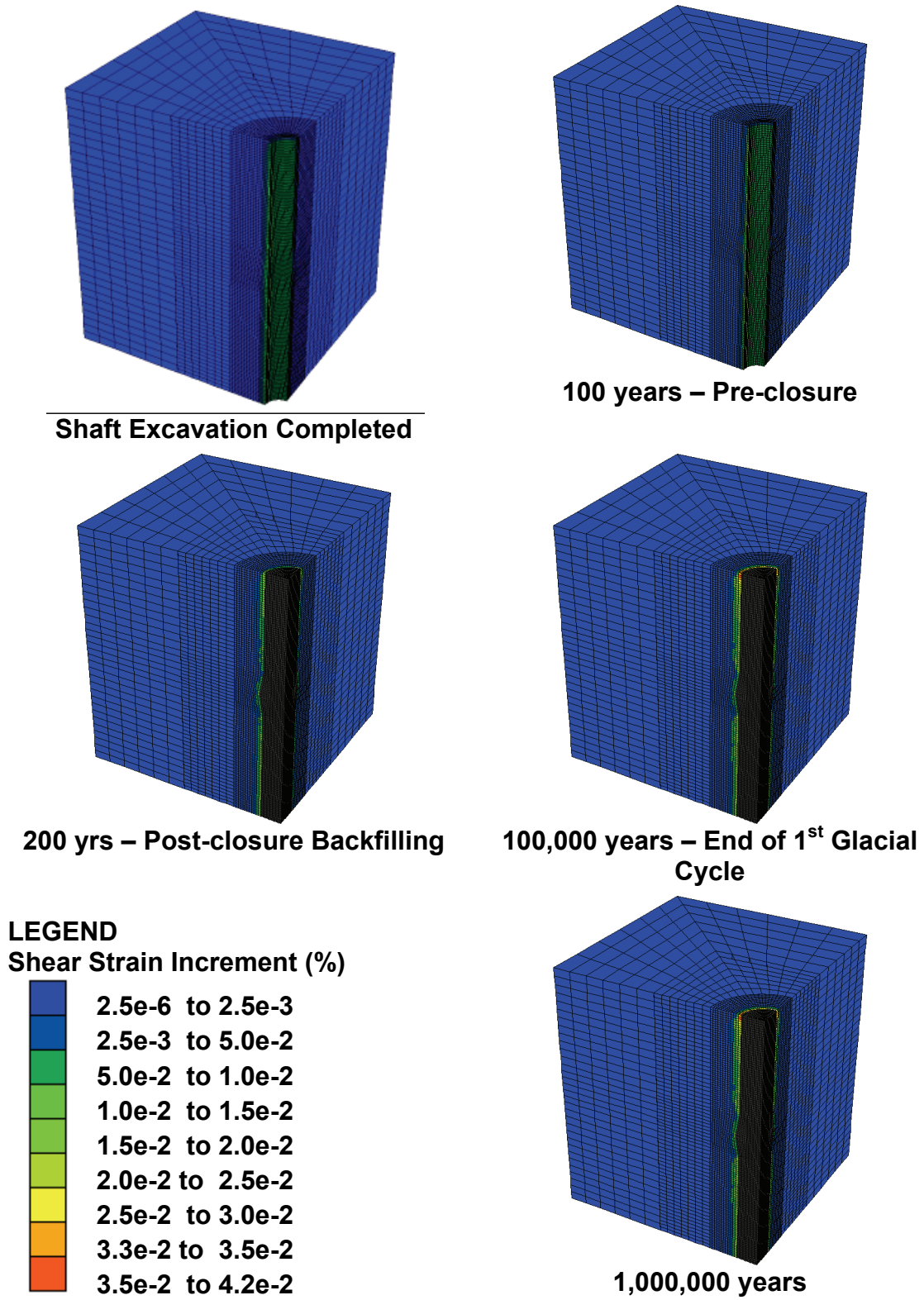


Figure B.42 Shear Strain – Concrete Bulkhead B1': Time-dependent Strength Degradation + Glacial Load + Pore Pressure + Seismic Loading

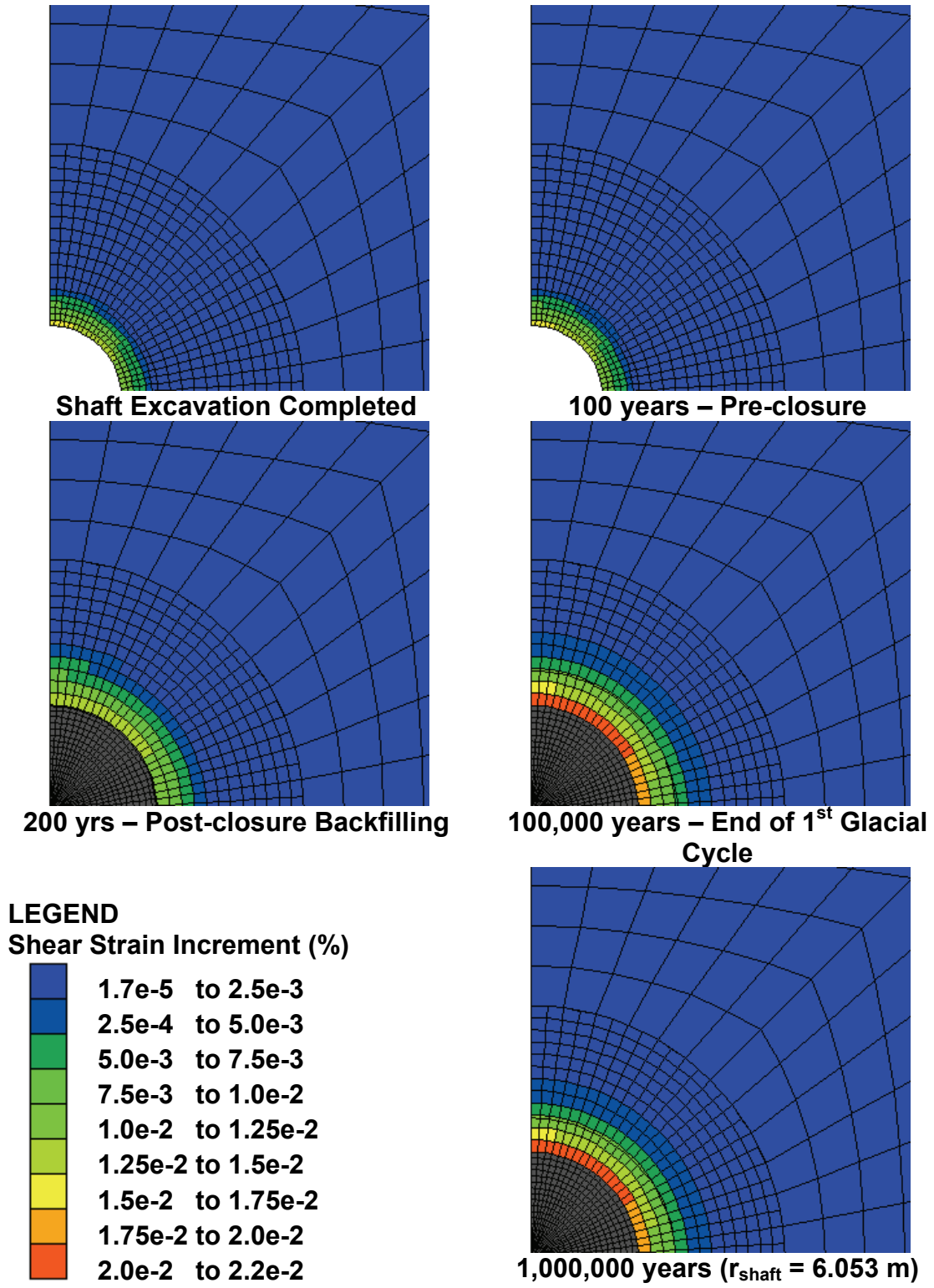


Figure B.43 Shear Strain – 22.4 m Above Concrete Bulkhead B1': Time-dependent Strength Degradation + Glacial Load + Pore Pressure + Seismic Loading

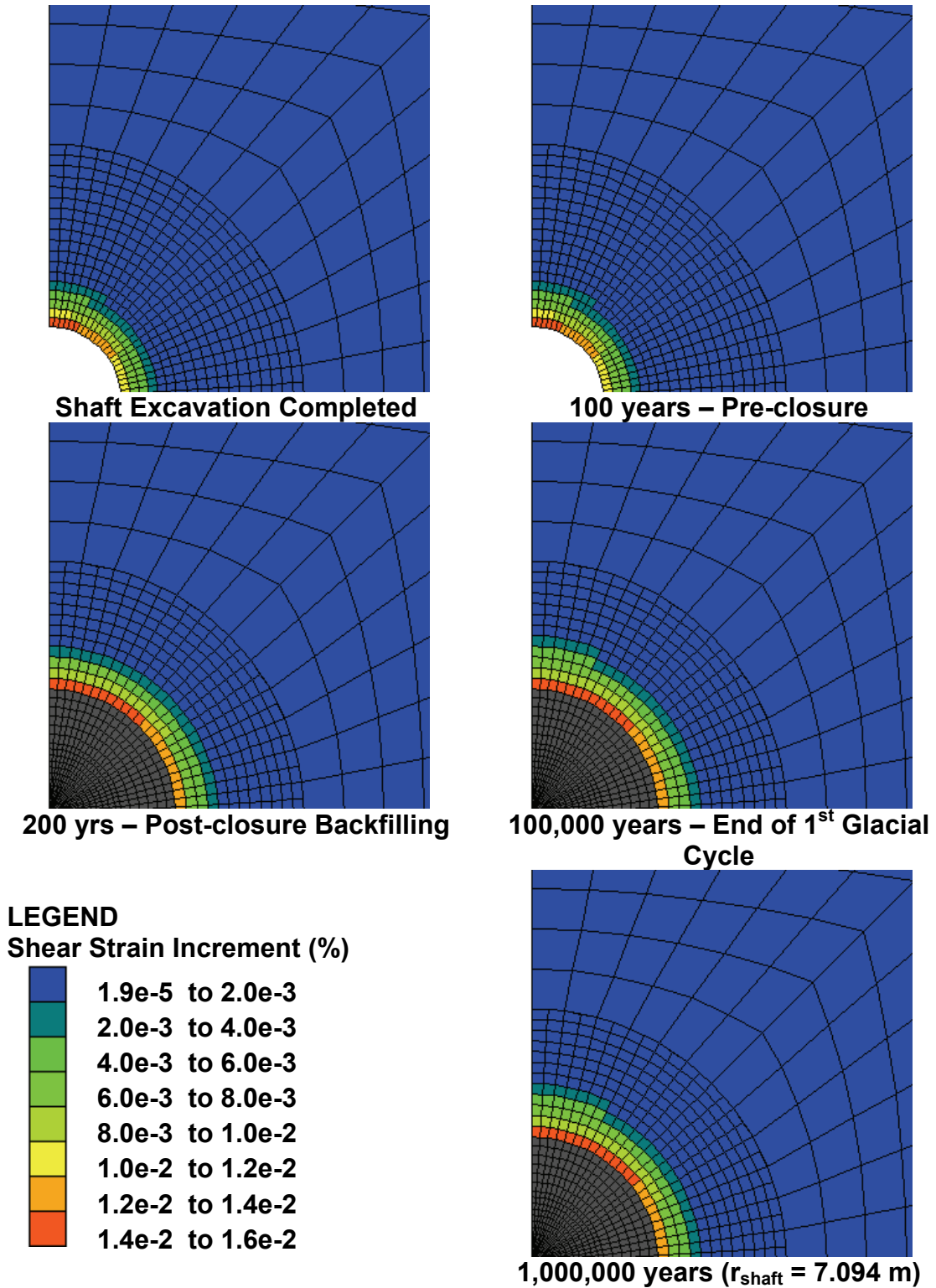


Figure B.44 Shear Strain – Middle Concrete Bulkhead B1': Time-dependent Strength Degradation + Glacial Load + Pore Pressure + Seismic Loading

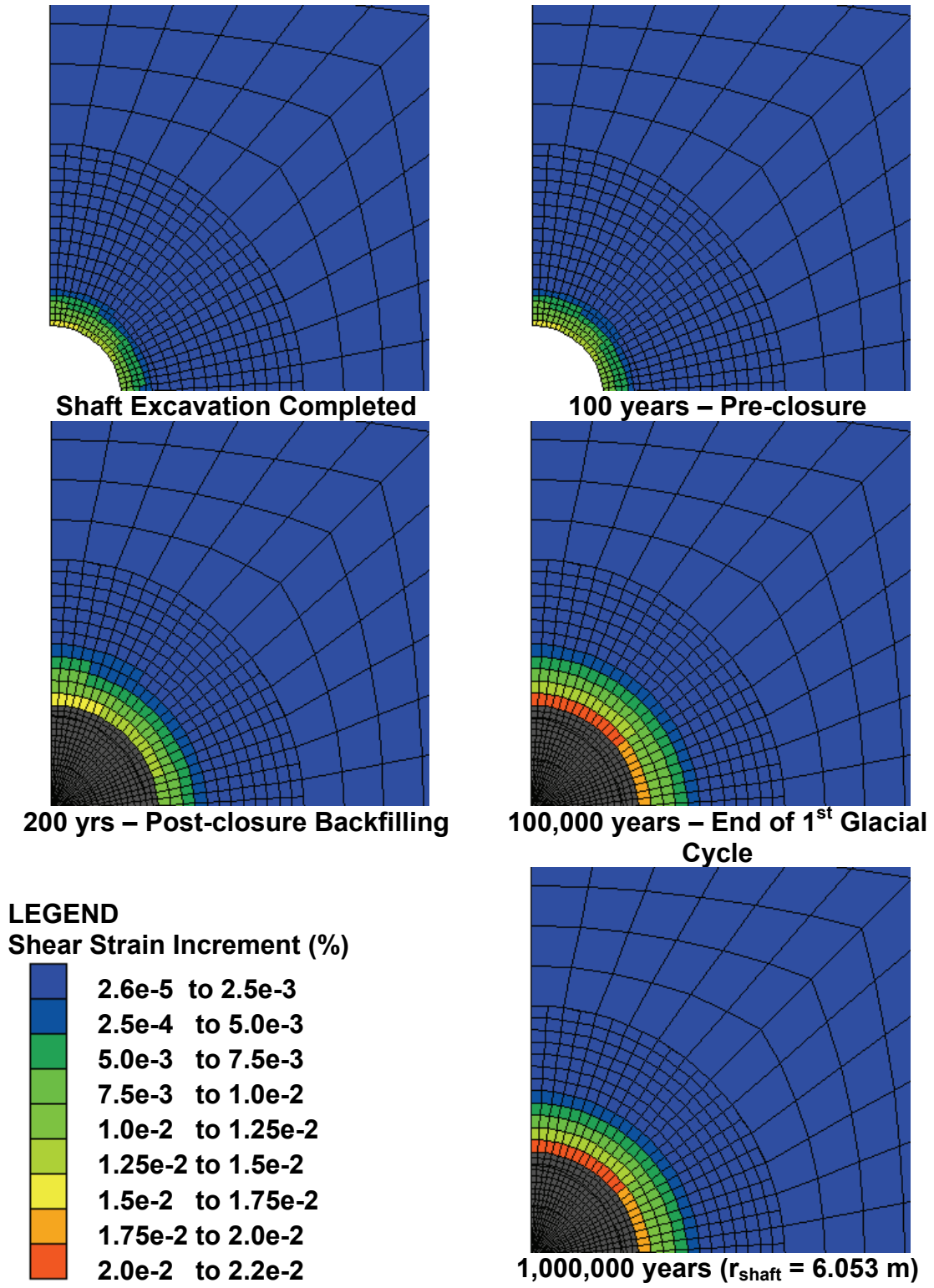


Figure B.45 Shear Strain – 22.4 m Below Concrete Bulkhead B1’: Time-dependent Strength Degradation + Glacial Load + Pore Pressure + Seismic Loading

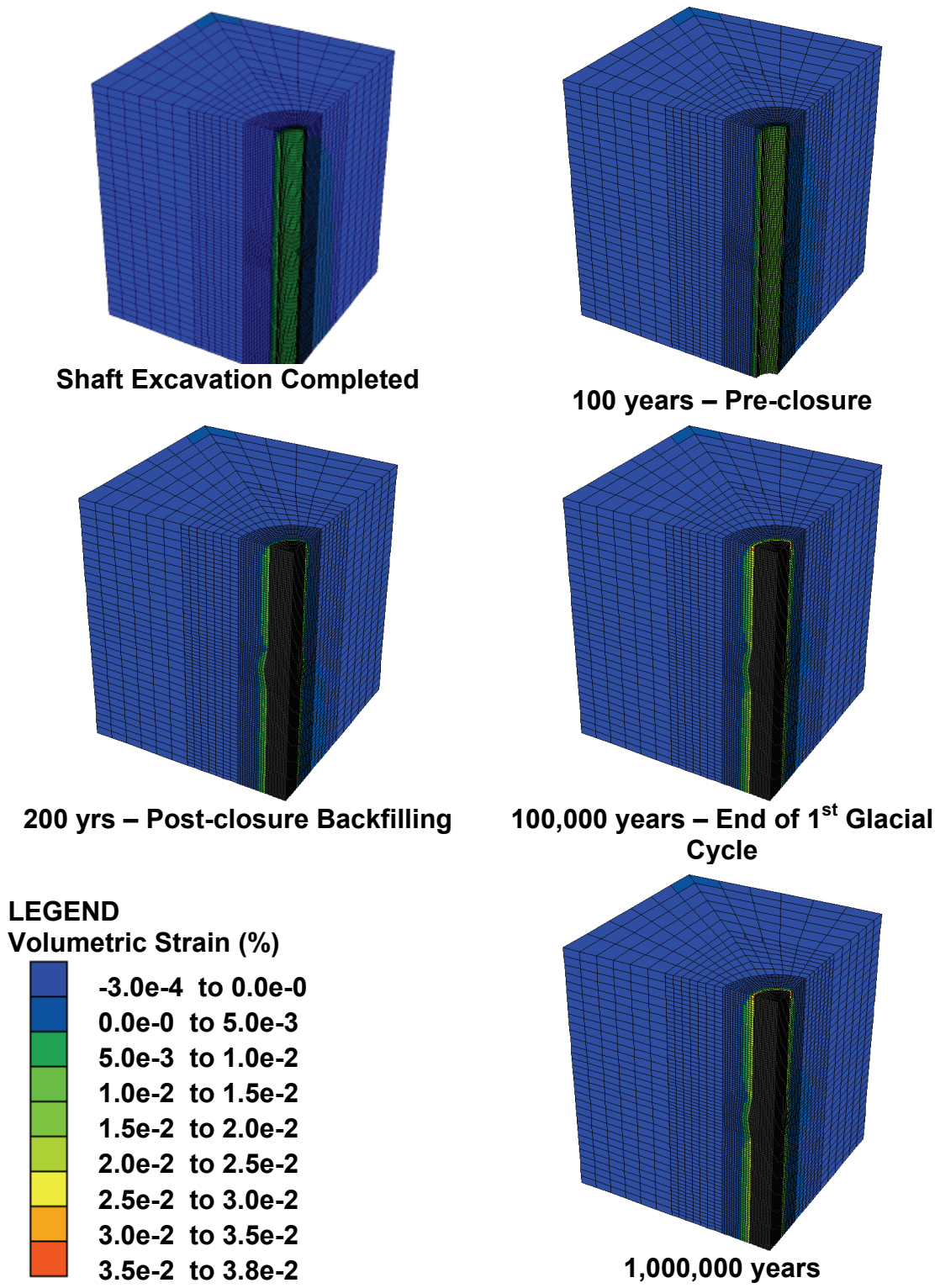
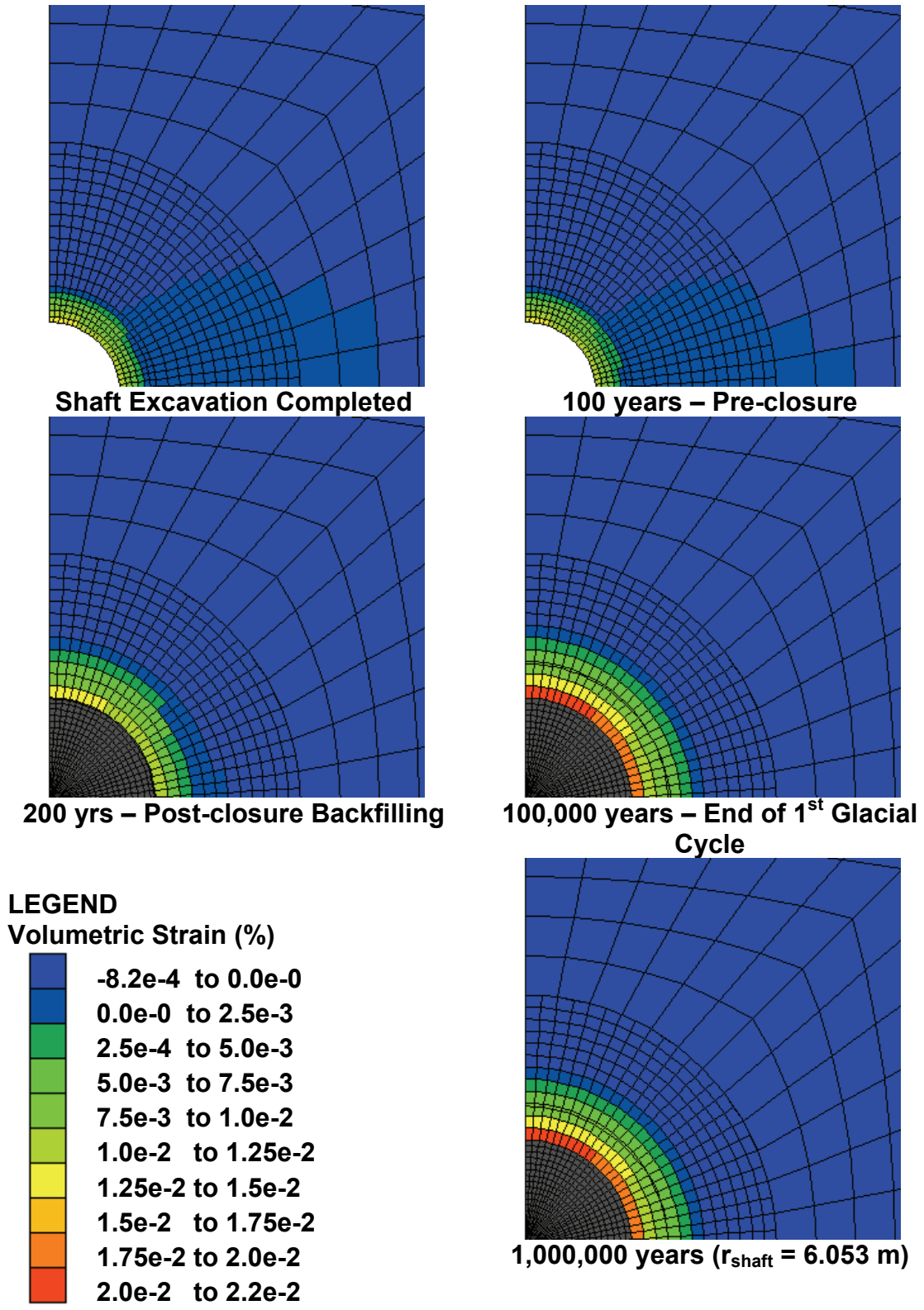
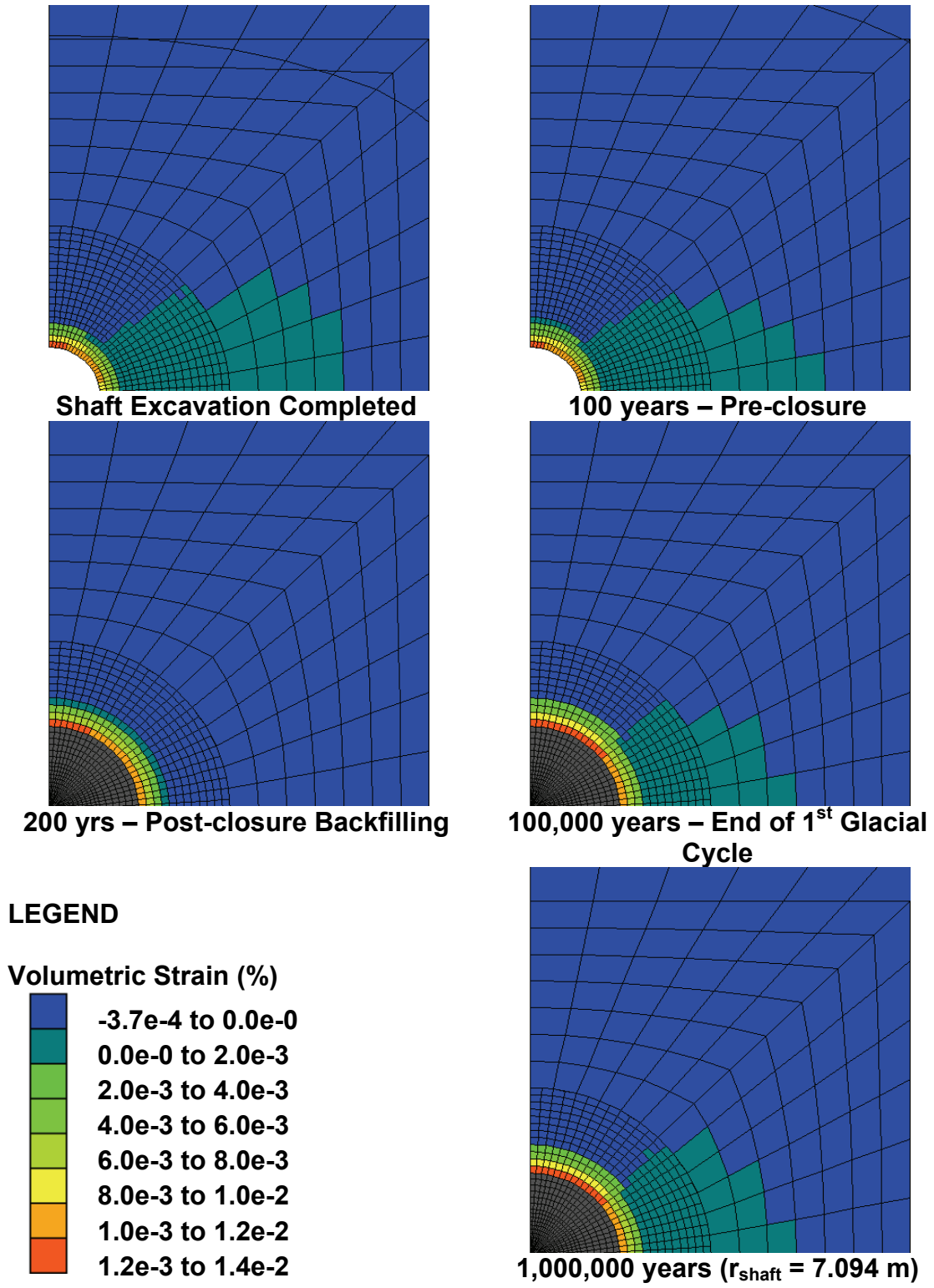


Figure B.46 Volumetric Strain – Concrete Bulkhead B1': Time-dependent Strength Degradation + Glacial Load + Pore Pressure + Seismic Loading

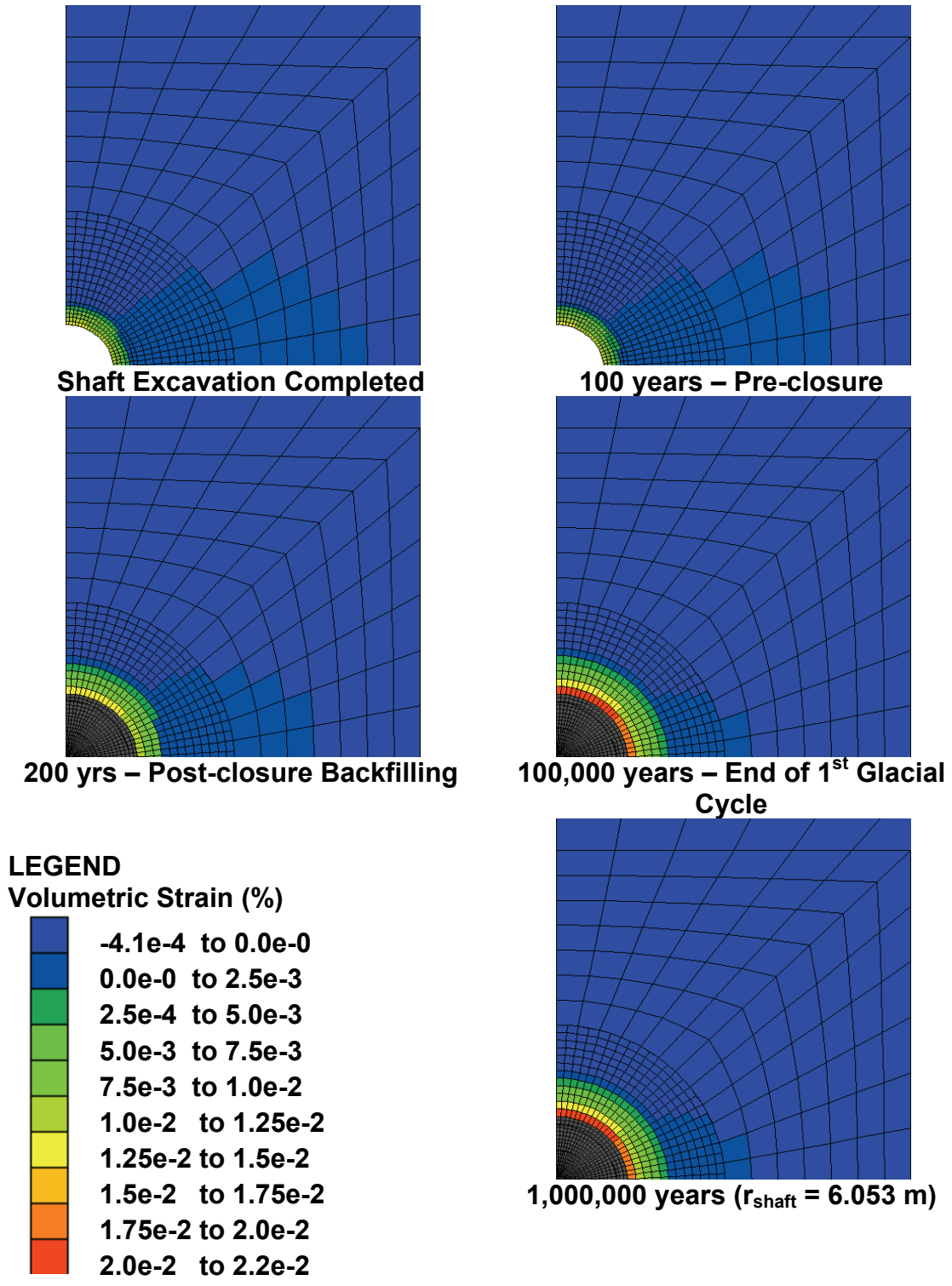


**Figure B.47 Volumetric Strain – 22.4 m Above Concrete Bulkhead B1': Time-dependent Strength Degradation + Glacial Load + Pore Pressure + Seismic Loading**





**Figure B.48 Volumetric Strain – Middle Concrete Bulkhead B1': Time-dependent Strength Degradation + Glacial Load + Pore Pressure + Seismic Loading**



**Figure B.49 Volumetric Strain – 22.4 m Below Concrete Bulkhead B1': Time-dependent Strength Degradation + Glacial Load + Pore Pressure + Seismic Loading**