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New characterization of the Early Sonoma Foreland basin (western USA) and its controlling factors using multi-scale integrated approaches

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Context and localization

In the aftermath of the end-Permian mass extinction (~252 Ma), the Sonoma Foreland Basin (SFB) provides excellent sedimentary and fossil records to describe and understand the Early Triassic biotic recovery. Nevertheless, despite its importance, the basin itself has been poorly constrained until now and most of its controlling factors remain unclear.

The SFB area roughly corresponds to a 600 x 1000 km rectangle encompassing Utah, Idaho, western Wyoming and eastern Nevada (Fig. 1). It displays a ~2Ga-long, complex geodynamical history marked by a succession of tectono-sedimentary events. During the Early Triassic, the SFB was a shallow marine basin, bordered by the Golconda Allochthon to the West, and by the remnants of the Ancestral Rockies (ARM) to the East (Fig. 1). Continental borders are still uncertain.

A multi-scale and multi-disciplinary work was conducted on ~50 sections from the literature and field-based data to characterize the paleoenvironmental parameters of the SFB, their 4D evolution as well as their associated controls.

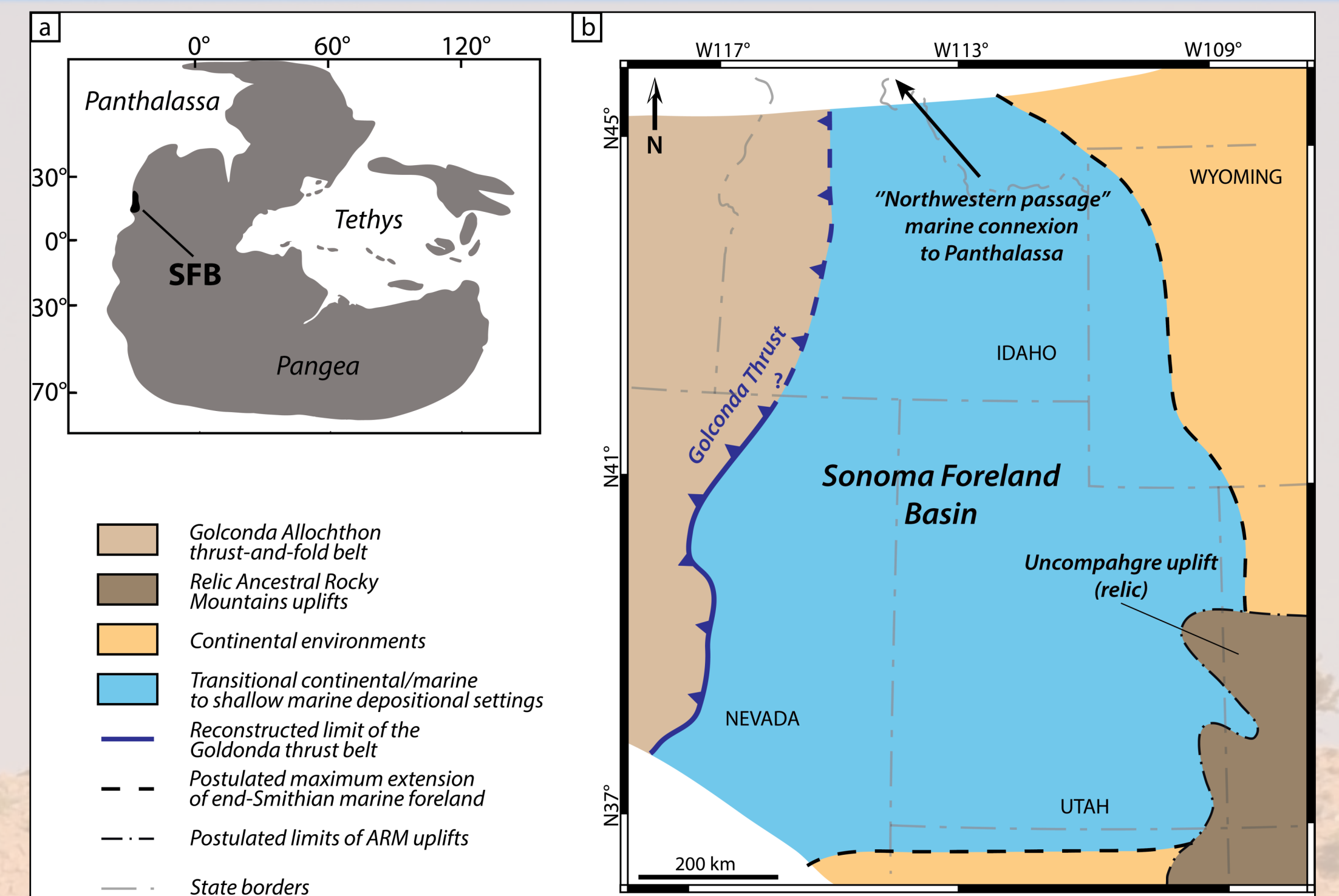


Figure 1: a) Early Triassic location of the Sonoma Foreland Basin (SFB); b) Simplified paleogeographic map of the SFB and bordering reliefs

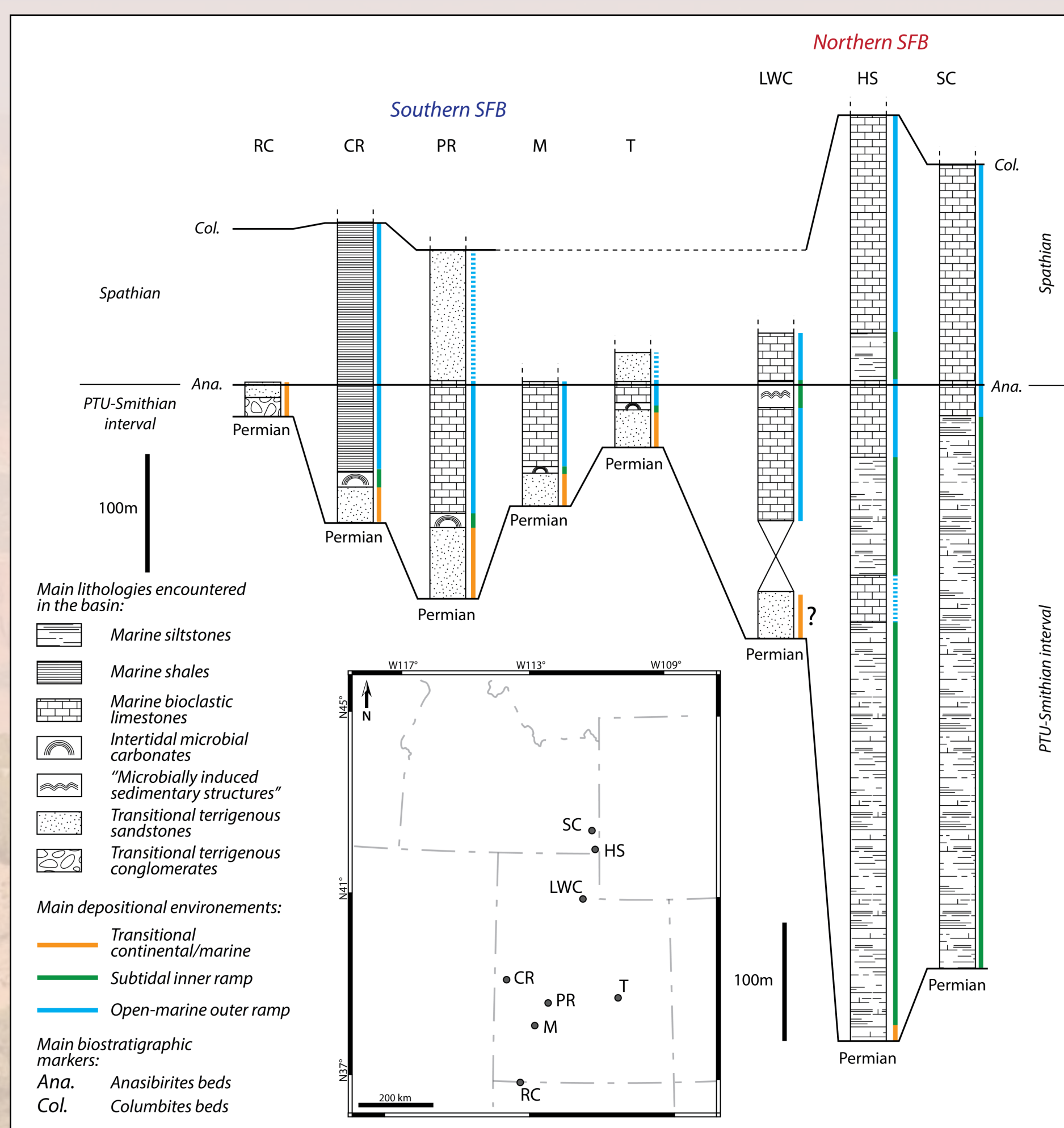


Figure 2: Lithostratigraphic columns, associated main general depositional environments and biostratigraphic correlations for 8 selected sections of the SFB. These columns illustrate local succession of environments within each outcrop, but also regional to larger scale similarities and discrepancies in dominant lithologies and thicknesses (cf. Fig. 3) of the sedimentary record of the SFB. CR: Confusion Range; HS: Hot Springs; LWC: Lower Weber canyon; M: Minersville; PR: Pahvant Range; RC: Rock Canyon; SC: Sheep Creek; T: Torrey.

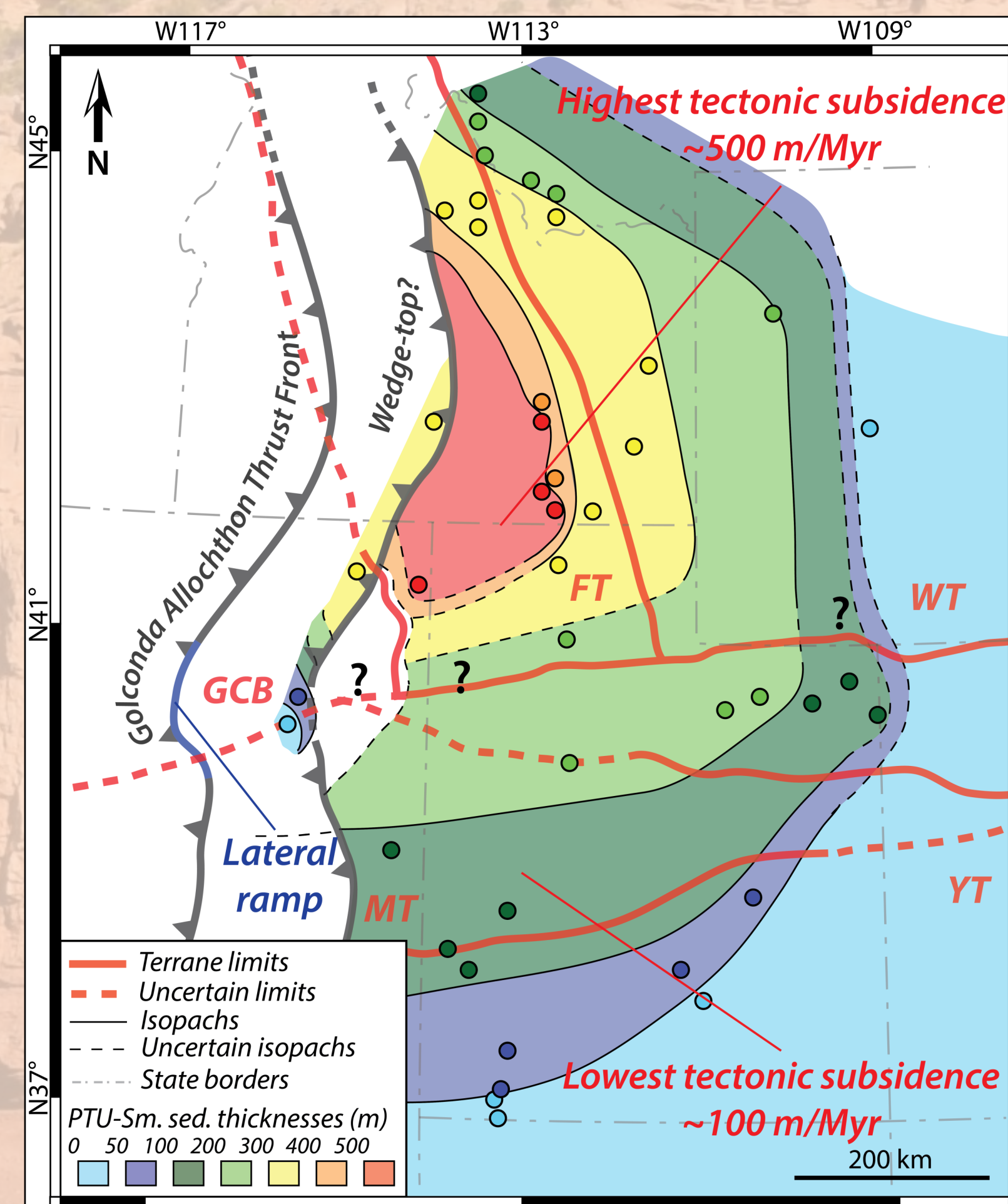


Figure 3: Isopach map of the SFB showing the spatial repartition of the sedimentary thicknesses for the Early Triassic up to the Upper Smithian. Difference in tectonic subsidence rates can be observed between northern and southern parts of the SFB. Red lines indicate the limits of the Archean to Mesoproterozoic lithospheric terranes that compose the basement of the SFB; GCB: Archean Grouse Creek Block; WT: Archean Wyoming Terrane; MT: Paleoproterozoic Mojave Terrane; YT: Paleoproterozoic Yavapai Terrane; FT: Mesoproterozoic Farmington Terrane (mobile belt).

Local-scale approaches

Sedimentology (Fig. 2)

- Fine and detailed study of each individual sections allowed to characterize main lithologies, sedimentary structures and facies to determine local depositional settings and their vertical/lateral evolutions.

Paleontology (Fig. 2)

- Fossils were crucial for high-resolution framework and biostratigraphical correlations, and to decipher the paleoenvironments associated with sedimentary data.

Geochemistry

- Fluctuations of the paired carbon isotopes and trace & major elements concentrations gave info about the composition of the water column and its oxygenic state. Secondary processes (diagenesis) impact was also addressed.

Basin-scale approaches

Geodynamical framework (Fig. 3)

- Lithospheric heritage and rheological behavior of the SFB basement were of paramount importance to determine the first order control over subsidence and sedimentary accumulation. 2D numerical modeling of the basement was performed to this end.

Sedimentology (Fig. 3)

- Spatial repartition of the Early Triassic sedimentary thickness was mapped.

Geochemistry

- Geochemical signals and secondary alteration processes were used to highlight locally- or globally-driven (exogenic) forcing on the SFB water column chemistry.

Paleontology

- The spatio-temporal evolution of marine communities was investigated.

Data integration and basin-wide interpretations

Integration of these multi-scale data allowed to confirm the foreland nature of this basin.

We also distinguished two parts within the basin: North-SFB and South-SFB (Fig. 4). This previously unrecognized spatial subdivision is highlighted by a central “transitional” part, potentially a topographic high that is yet to be thoroughly detailed (Fig. 4).

This subdivision had major consequences through locally-controlled forcing parameters over the sedimentary systems of the entire SFB. 7 facies associations (Fig. 5) were therefore defined to decipher the paleoenvironmental evolution of the entire SFB during the Early Triassic.

Conclusion

Using this multi-scale integrated method, we were able to better reconstruct the Early Triassic Sonoma Foreland Basin and to decipher previously unknown structures and the controls of this long-lost basin.

Our results highlight a complex interplay of local- to basin-scale controlling factors, responsible for the spatial distribution and migration through time and space of the depositional settings present in both northern and southern parts of the SFB (Fig. 6).

We are therefore able to track the 4D evolution of the paleoenvironments and the multi-scale controlling factors of the Sonoma Foreland Basin.

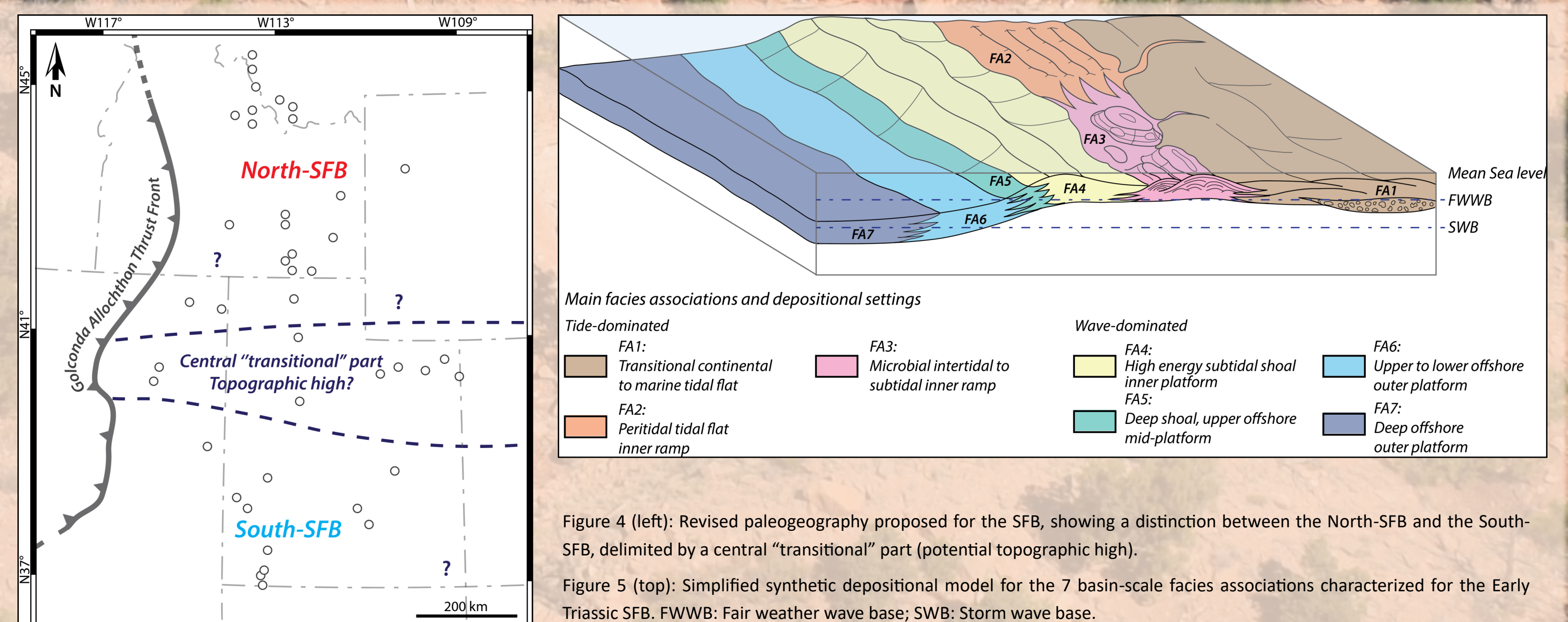


Figure 4 (left): Revised paleogeography proposed for the SFB, showing a distinction between the North-SFB and the South-SFB, delimited by a central “transitional” part (potential topographic high).

Figure 5 (top): Simplified synthetic depositional model for the 7 basin-scale facies associations characterized for the Early Triassic SFB. FWWB: Fair weather wave base; SWB: Storm wave base.

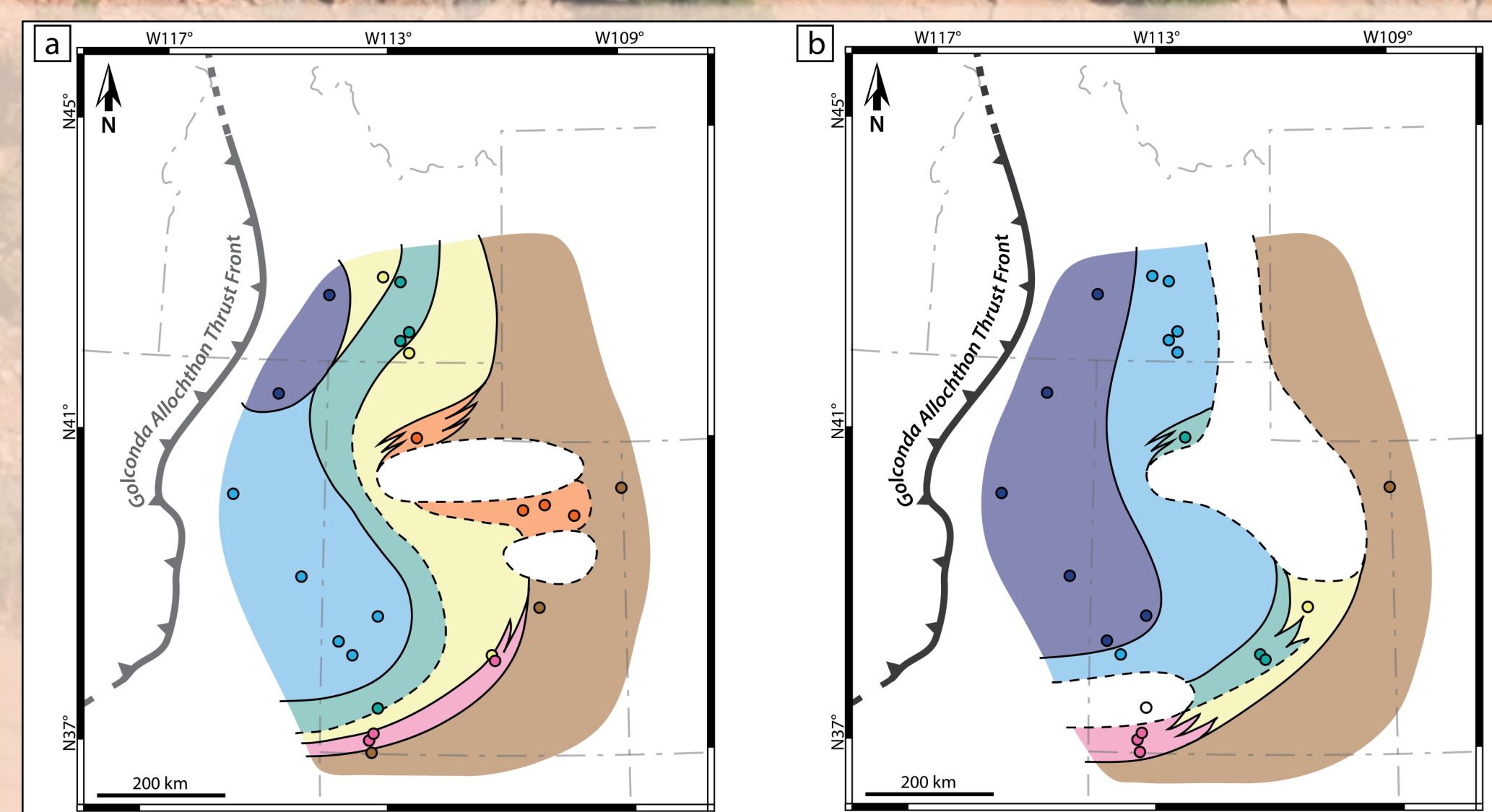


Figure 6: Illustration of the basin-wide spatial distribution of the main depositional settings in the SFB during the a) Middle Smithian (Owenites beds), and during the b) Upper Smithian (Anasibirites beds). For depositional settings, refer to Fig. 5.