Figures

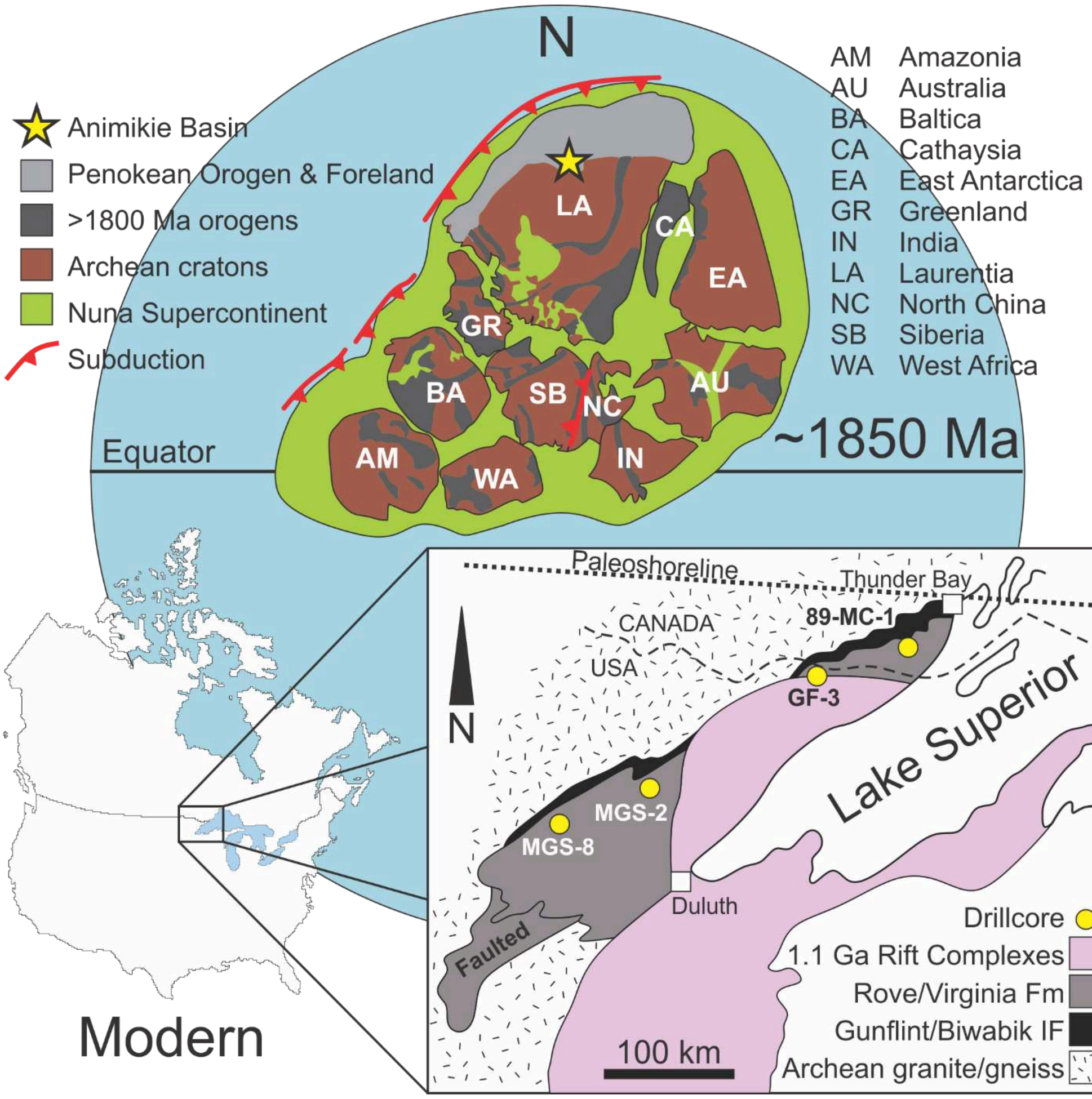

Figure 1. Paleogeography of the supercontinent Nuna at ~1850 Ma (after Wan et al., 2015; S. Zhang et al., 2012) *showing the Animikie Basin along the northern continental coast, and modern location of the Animikie Group preserved in central North America* (after Poulton et al., 2010) *. Paleogeographic configuration and age is approximate as Wan et al. (2015) and Zhang et al. (2012) mapped ~1820 Ma and ~1740 Ma, respectively.*

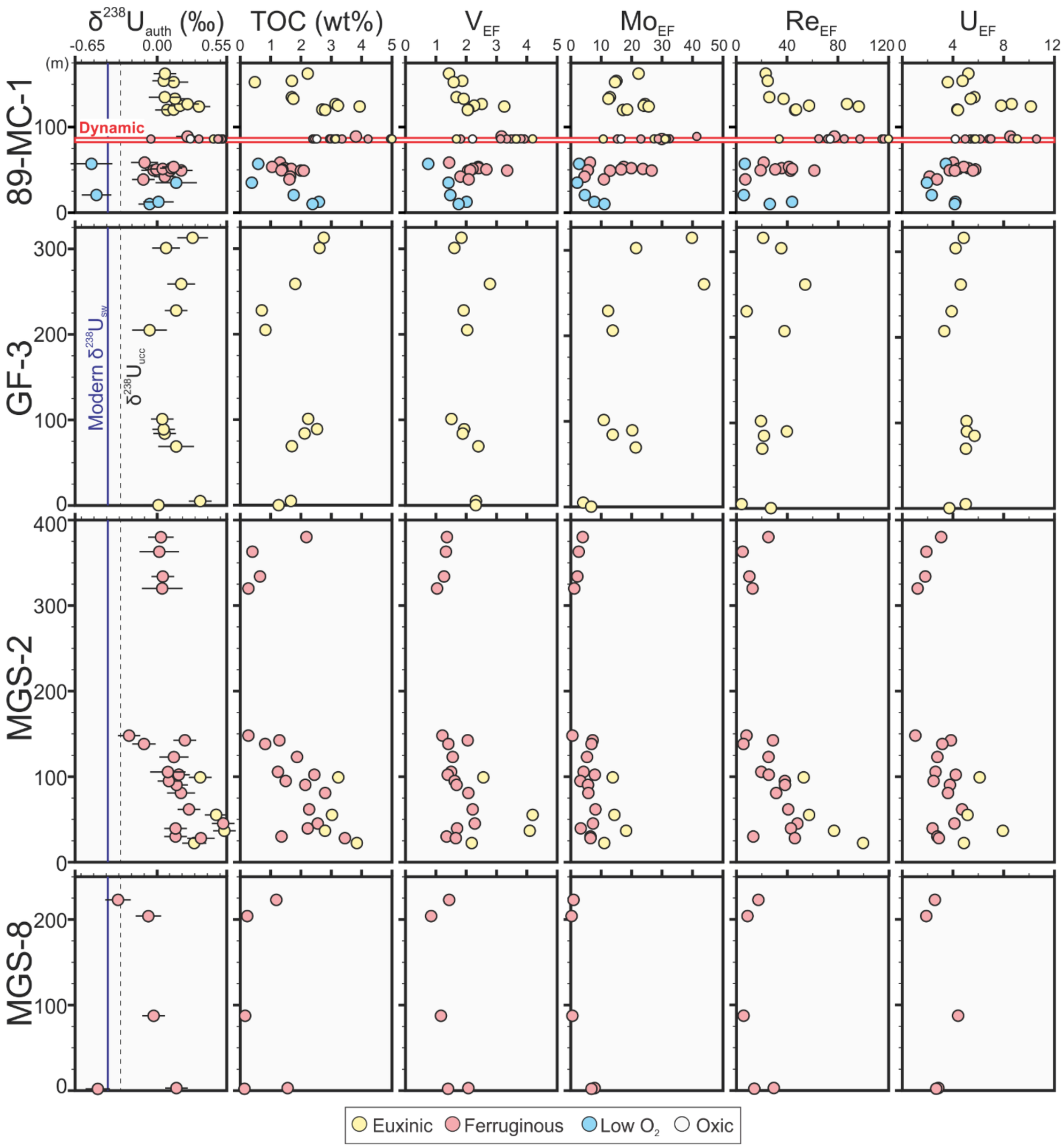

Figure 2. Geochemical profiles for Rove/Virginia cores. Yellow markers are euxinic, red markers are ferruginous, and blue markers are suboxic based on Fe speciation (after Poulton et al. 2004, 2010). Total organic carbon (TOC) content is from Poulton et al. (2010). One oxic sample (white marker) may be present in the dynamic interval of 89-MC-1. Dashed vertical line in uranium isotope profiles is upper continental crust isotope composition and solid blue line is seawater. Error on isotope compositions is long term reproducibility of ±0.09‰ or ±2σ on replicate measurements, whichever is larger. Vertical axis is height (metres) above the contact with the Gunflint/Biwabik iron formations.

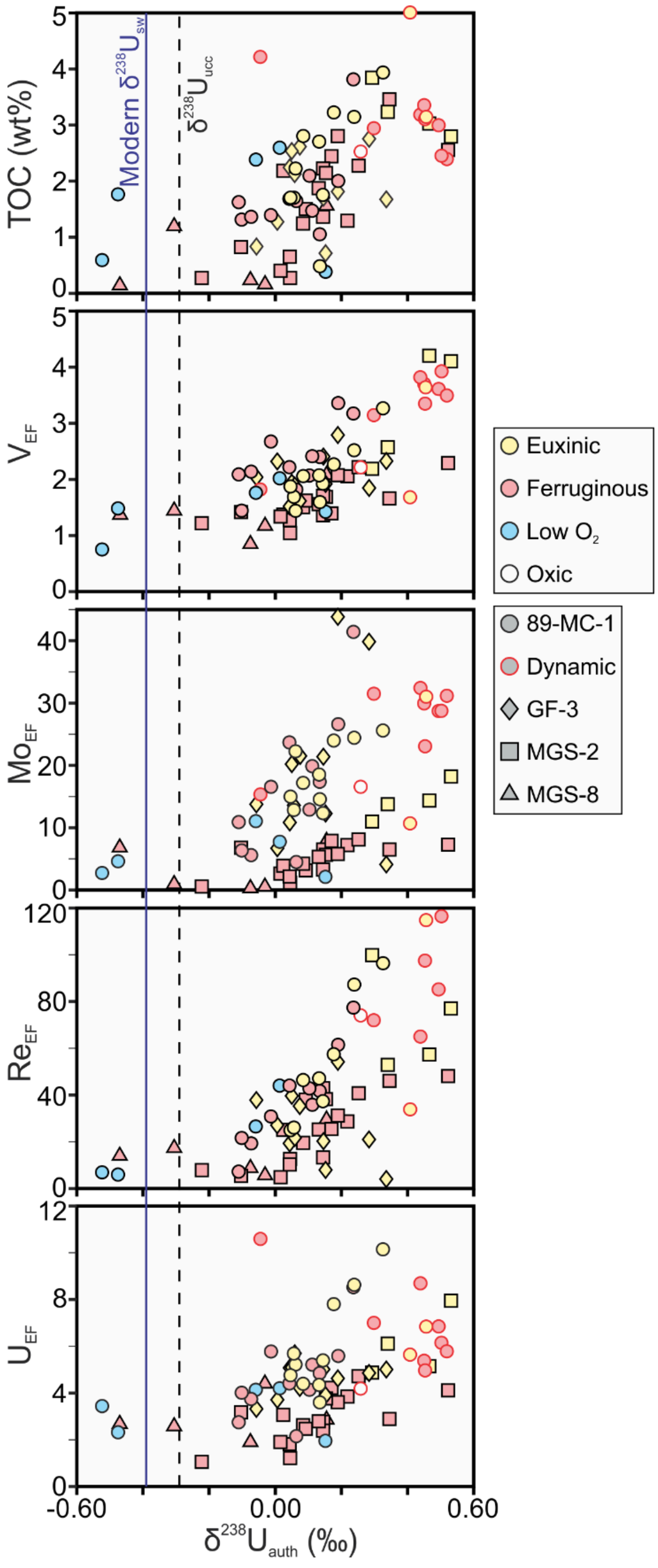

Figure 3. Covariations between select redox sensitive trace metal enrichment factors (EF) and TOC versus $\delta^{238}U_{auth}$ in Rove and Virginia samples. Solid blue line is modern seawater $\delta^{238}U$ and the dashed black line is modern $\delta^{238}U$ input to the oceans from rivers (derived from upper continental crust, UCC).

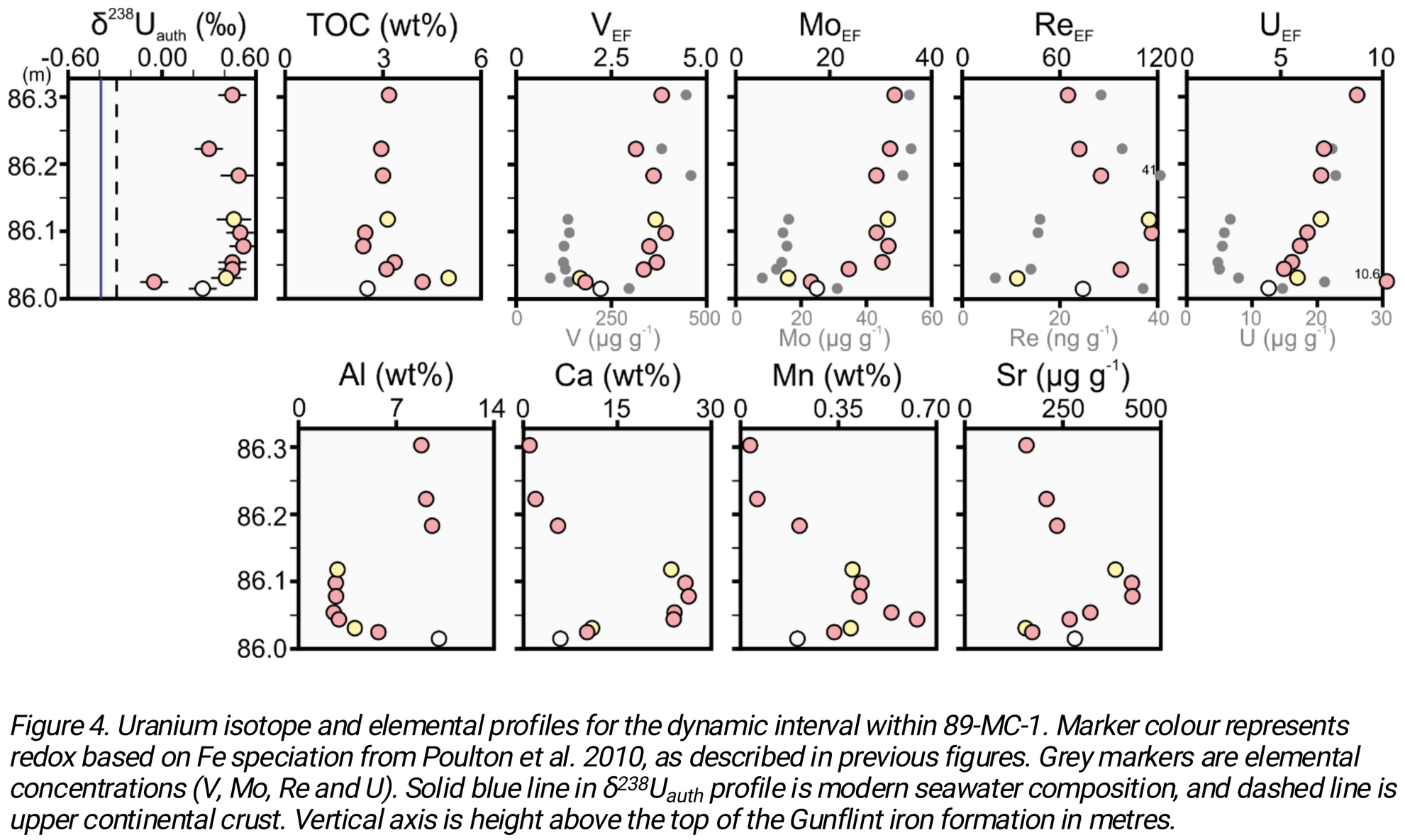

Figure 4. Uranium isotope and elemental profiles for the dynamic interval within 89-MC-1. Marker colour represents redox based on Fe speciation from Poulton et al. 2010, as described in previous figures. Grey markers are elemental concentrations (V, Mo, Re and U). Solid blue line in $\delta^{238}U_{auth}$ profile is modern seawater composition, and dashed line is upper continental crust. Vertical axis is height above the top of the Gunflint iron formation in metres.

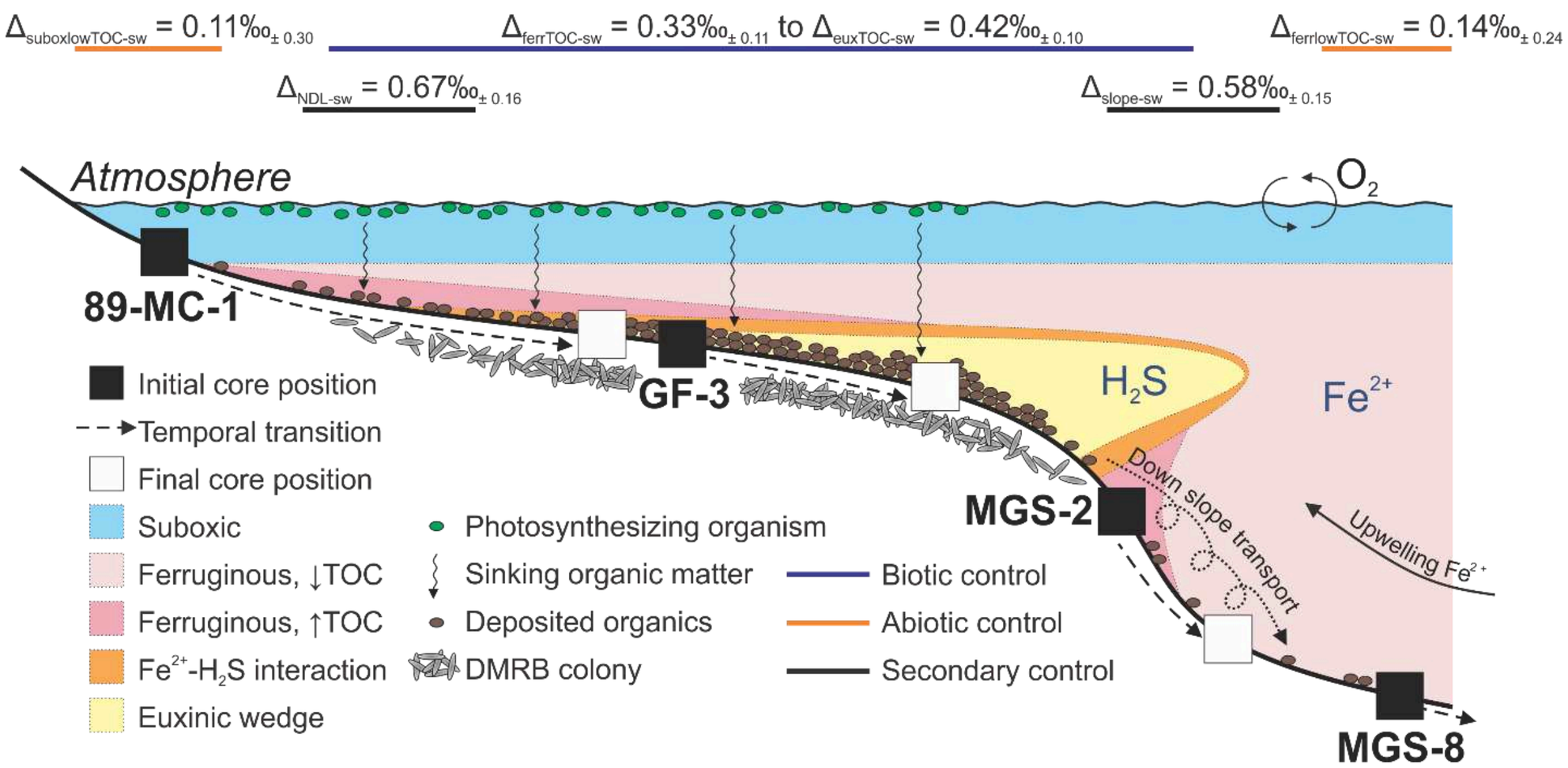

Figure 5. Model of Animikie Basin unifying controls on uranium isotope offsets during fractionation from seawater (Δ_{sed-sw}). Offsets represent average (±1σ) $\delta^{238}U_{auth}$ from the Rove and Virginia cores less the modern $\delta^{238}U_{riv}$ (−0.29‰), thus these represent minimum offsets for the average sample in the interval. Maximum offsets can be determined using the minimum $\delta^{238}U_{sw}$ for the Proterozoic of −0.73‰, which will increase each Δ_{sed-sw} value by 0.44‰. The blue bar represents the approximate lateral extent where TOC is elevated and microbially mediated reduction may be the dominant control on U isotope fractionation. Orange bars represent low TOC areas where abiotic reduction and fractionation processes are thought to dominate. Lateral extent of secondary processes like non-diffusion-limited (NDL) conditions and down-slope redeposition ("slope") are represented by black bars. Black squares are the initial positions of the four drill cores and white squares are their final positions. Note that these represent temporal, rather than spatial transitions as sea level transgressed and bottom water conditions at each location migrated landward. Diagram not to scale.

Tables

Table 1. Authigenic uranium isotope compositions ($\delta^{238}U_{auth}$) for Rove (89-MC-1, GF-3) and Virginia (MGS-2, MGS-8) formation cores in the Animikie Basin. Redox conditions are based on Fe speciation (Poulton et al. 2004, 2010). 'Dynamic' 89-MC-1 is an interval from 86.00 to 86.303 m that contains coarse pyrite grains and fluctuating redox. All other samples are considered steady state with respect to redox conditions. Bracketed values are sample counts.

	Dynamic	**Steady State**				
	89-MC-1	**89-MC-1**	**GF-3**	**MGS-2**	**MGS-8**	**All Cores**
Euxinic	0.43 ± 0.03‰ (2)	0.14 ± 0.09‰ (10)	0.12 ± 0.12‰ (11)	0.41 ± 0.11‰ (4)		0.17 ± 0.15‰ (25)
Ferruginous	0.39 ± 0.19‰ (8)	0.05 ± 0.12‰ (11)		0.12 ± 0.16‰ (18)	−0.15 ± 0.24‰ (5)	0.02 ± 0.18‰ (34)
Low Oxygen	*Oxic*: 0.26‰ (1)	−0.18 ± 0.30‰ (5)				−0.18 ± 0.30‰ (5)
AVERAGE	0.38 ± 0.16‰ (11)	0.04 ± 0.19‰ (26)	0.12 ± 0.12‰ (11)	0.18 ± 0.19‰ (22)	−0.15 ± 0.24‰ (5)	0.09 ± 0.20‰ (64)