Years of magma intrusion primed Kīlauea Volcano for the 2018 eruption

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Description of supplementary spreadsheet

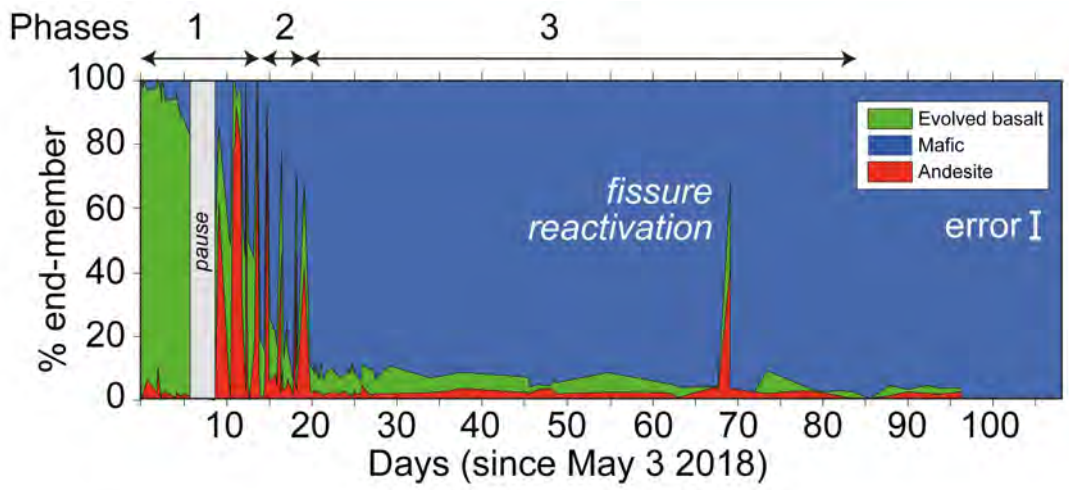
The supplementary spreadsheet contains:

- A description of the 2018 Kīlauea samples investigated.
- Mixing-to-eruption timescales obtained from 71 different olivine crystals. This sheet contains Fo core and rim composition, the temperature relevant to rim 1 ('rim 1' corresponds to the rim that formed at the Kīlauea summit before the olivine was transported to the lower East Rift Zone) calculated to be at equilibrium with the melt using a K_D^{Fe-Mg} = 0.33, the temperature for 'rim 2' (only recorded in some olivine that mixed with some evolved high-Ti basalt stored in the East Rift Zone). The uncertainties on temperature are calculated based on a variation in $K_D^{Fe-Mg} \pm 0.02$. The profiles orientation (a-, b- and c-axis) were obtained using Electron Backscatter Diffraction (EBSD) patterns. The timescales ('Fo' in the sheet) t_1 (mixing in the summit area) and t_2 (mixing in the East Rift Zone) with their uncertainties ('+' and '-' in the sheet) are reported for each olivine.
- Profile data for each olivine with a BSE image showing the location of the profile.
- The analytical precision and accuracy of major element analyses in olivine for each session.

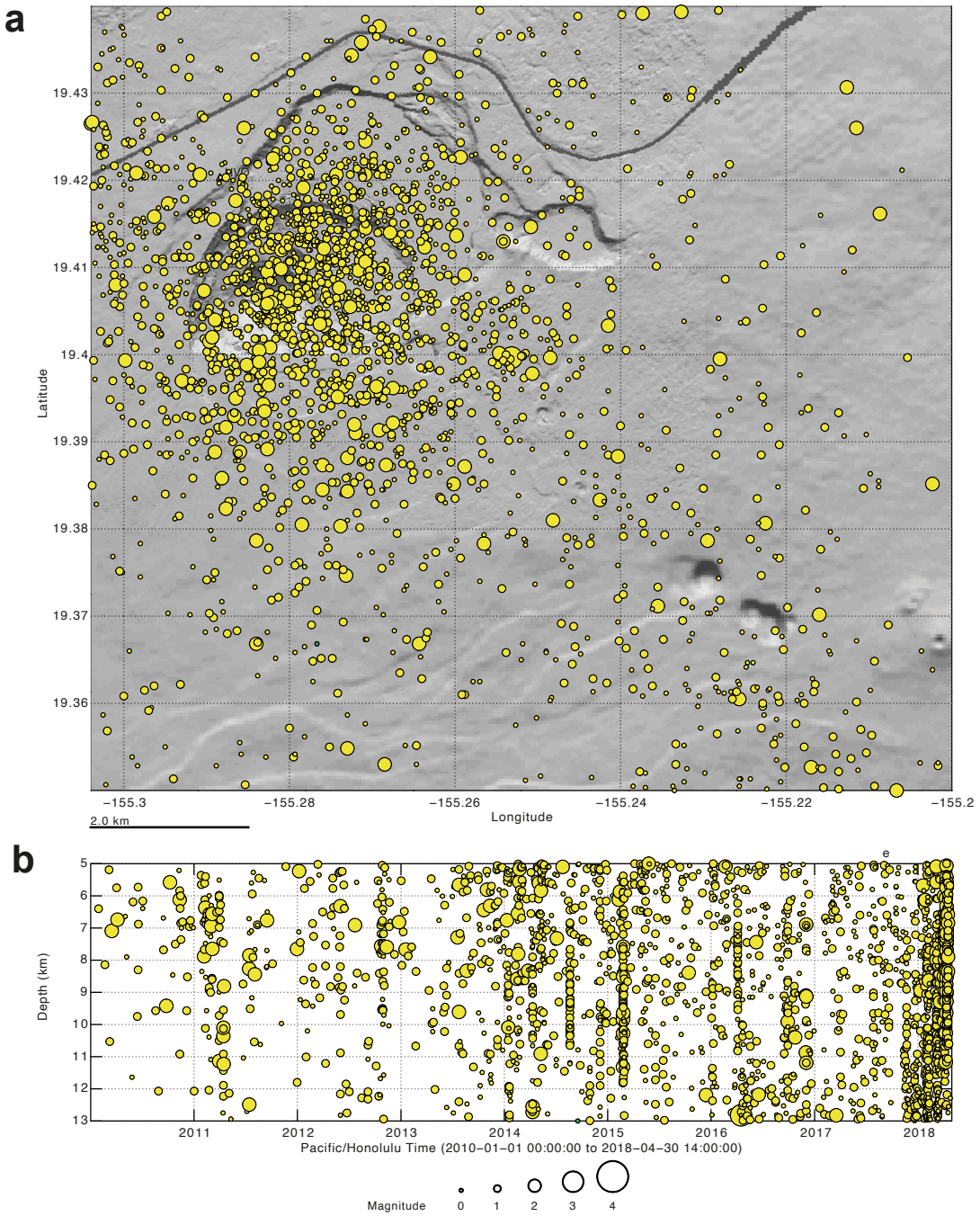
Summary of changes in lava chemistry during the 2018 Kīlauea eruption

The 2018 Kīlauea lower East Rift Zone eruption involved a mix of (1) older and colder stored magma (high-Ti basalt erupted during 'phase 1' with 54-55 wt.% SiO_2 in the matrix glass), (2) a basaltic-andesite to andesite magma (fissure 17) erupted between 13 to 25 May 2018, and (3) hotter magma (mafic magma, with 49-51 wt.% SiO_2 in the matrix glass during 'phase 2 & 3'). The colder magma erupted mainly in May. The fraction of 'cold' high-Ti basalt magma decreased from 90 vol.% (5 May) to 10 vol.% (23 May) after two weeks of eruption. Some of the initial fissures reactivated several times (e.g. fissure 13 on 15 May, fissure 18 late June, fissure 22 early July).

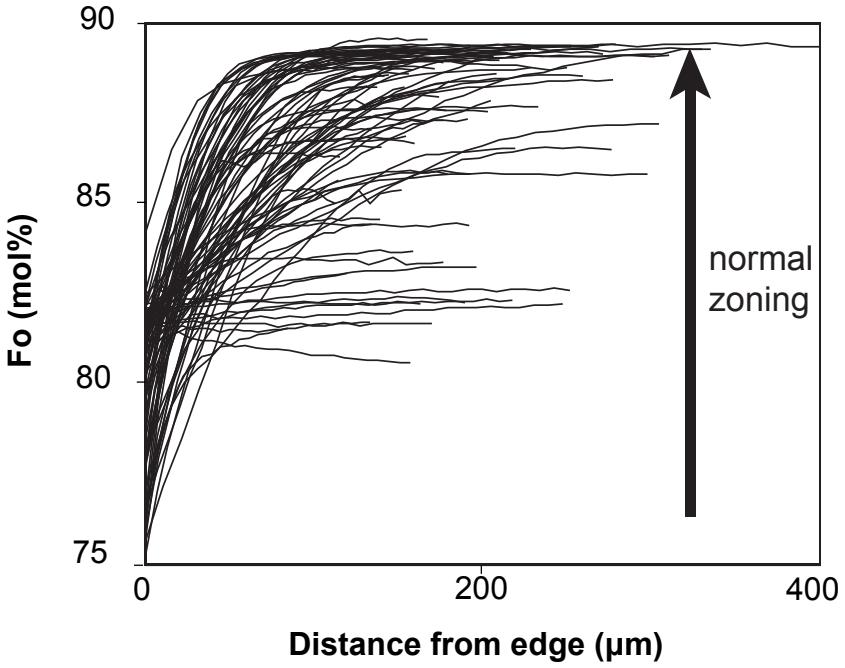
Supplementary figures



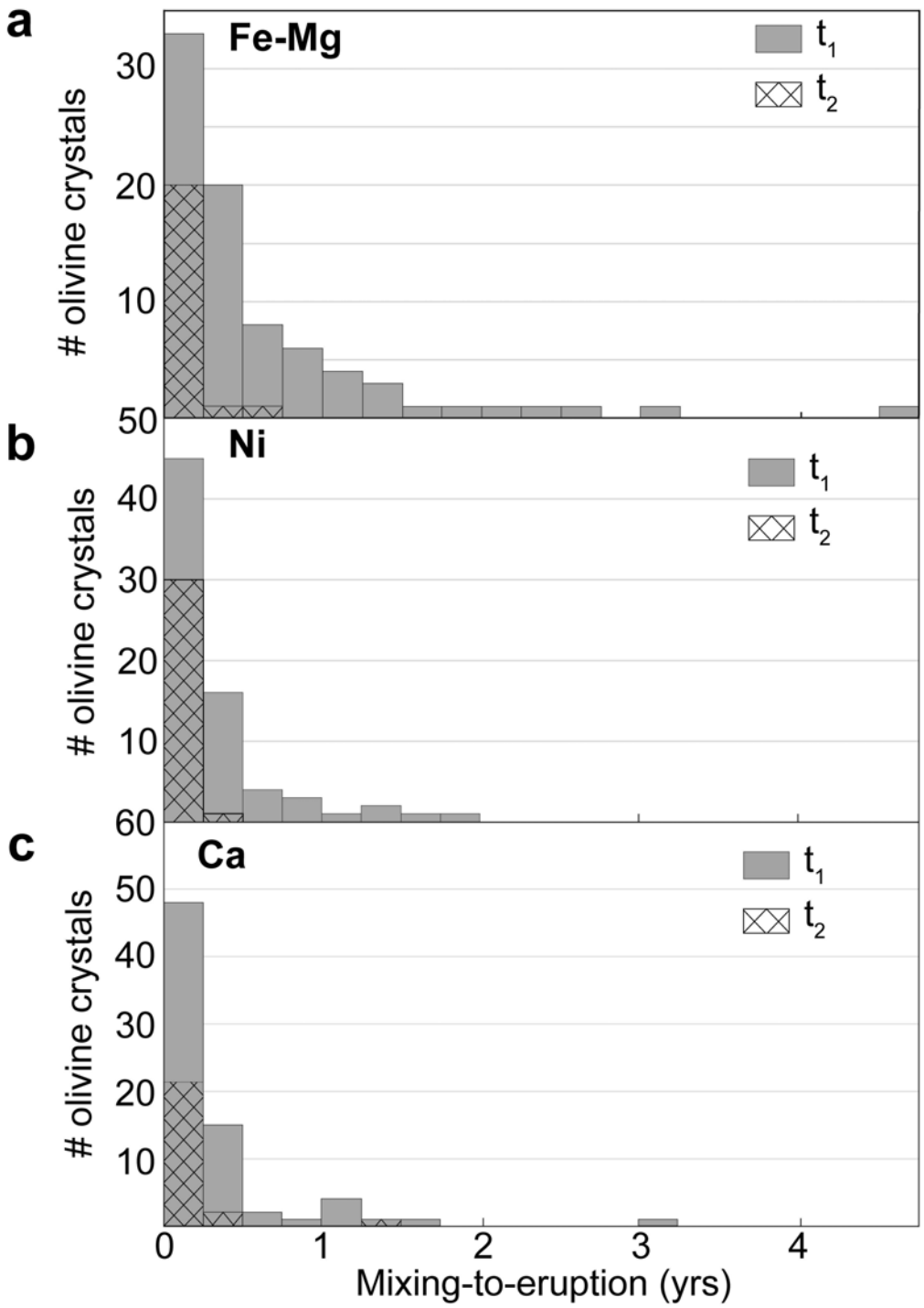
Supplementary Fig. 1: Contribution (by mass) of the three main magma end-members over the course of the eruption. Olivine basalt largely dominates during the phase 2 and 3. End-member percentage was calculated based on TiO_2 - K_2O relationships from whole-rock compositions.



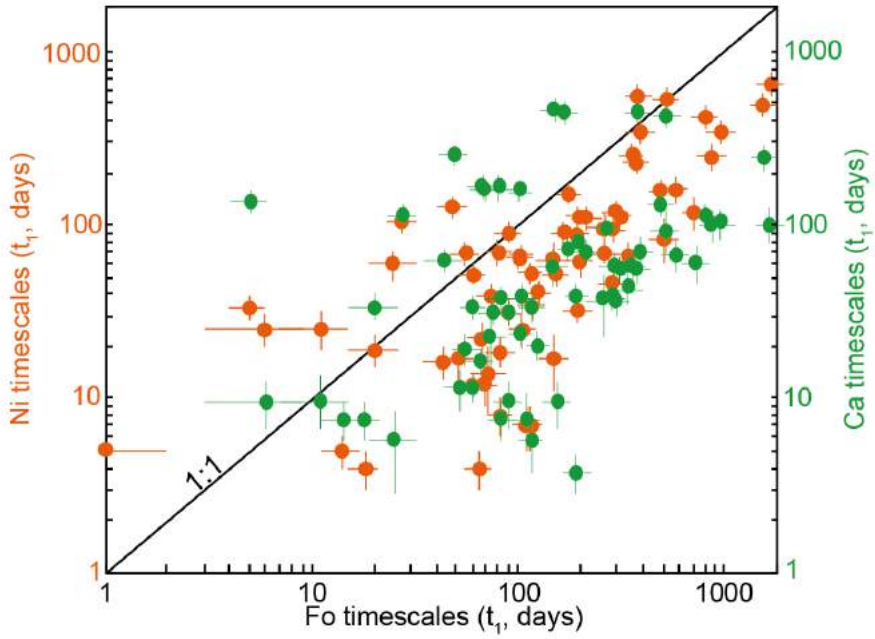
Supplementary Fig. 2: Seismicity (5-13 km depth) at the Kīlauea summit between January 2010 and April 27, 2018. a, Map of the Kīlauea summit with the East rift connector showing the location and magnitude of the earthquakes. **b,** Depth and magnitude of the earthquakes between January 2010 and April 27, 2018. Earthquakes between 5 and 13 km correspond to the seismicity below the South Caldera reservoir.



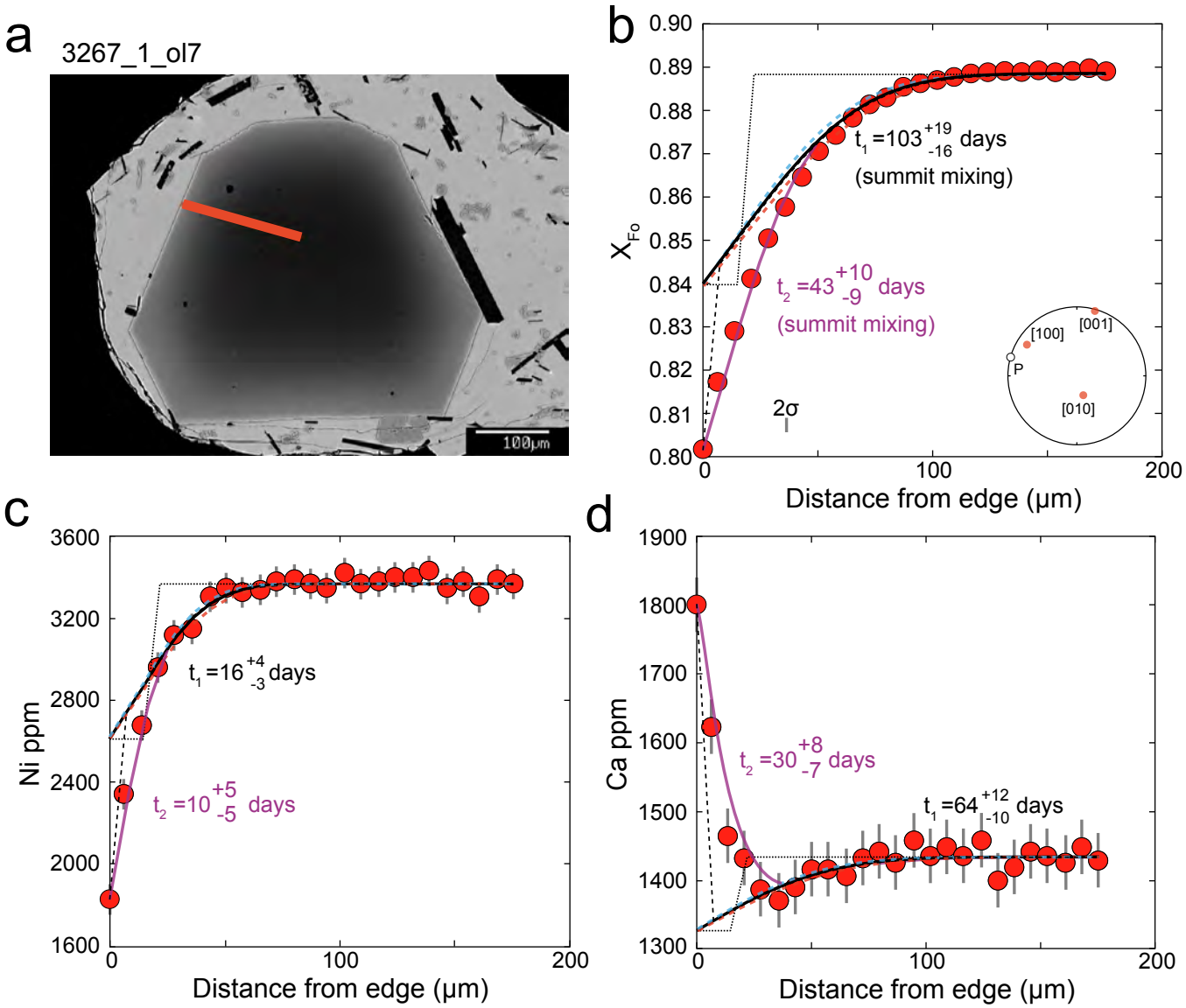
Supplementary Fig. 3: Olivine forsterite profiles grouped to highlight similar normal zoning patterns (except for one crystal with slight inverse zoning) found in samples investigated.



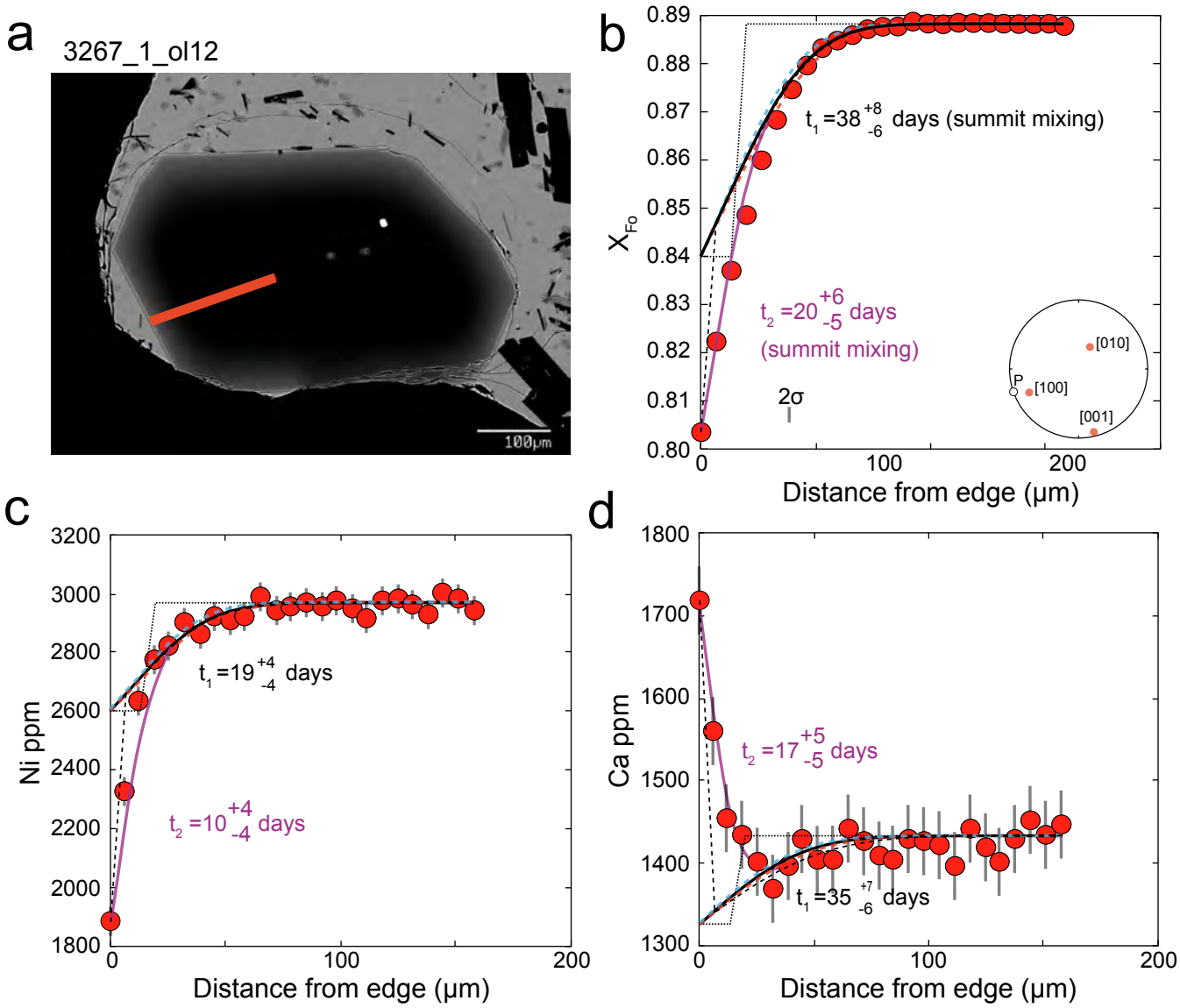
Supplementary Fig. 4: Mixing-to-eruption timescales from 1D diffusion modeling. a, Fe-Mg diffusion modeling. **b,** Ni diffusion modeling. **c,** Ca diffusion modeling. 't_1' represents pre-eruptive mixing and 't_2' is syn-eruptive mixing with stored magma at the lower East Rift Zone.



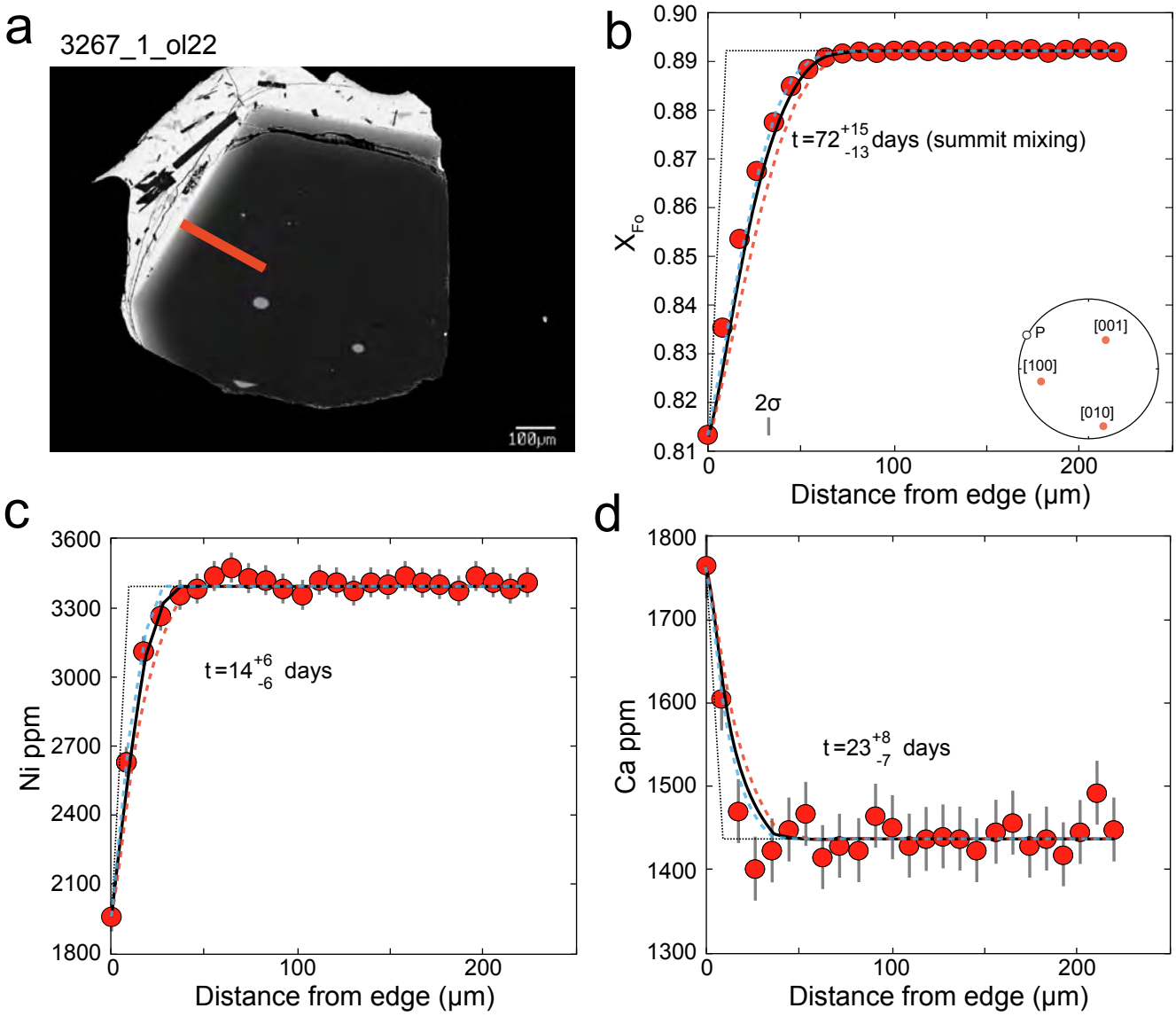
Supplementary Fig. 5: **Timescales results for Fo vs. Ni or Ca. The error bars correspond to the uncertainty on the timescales.**



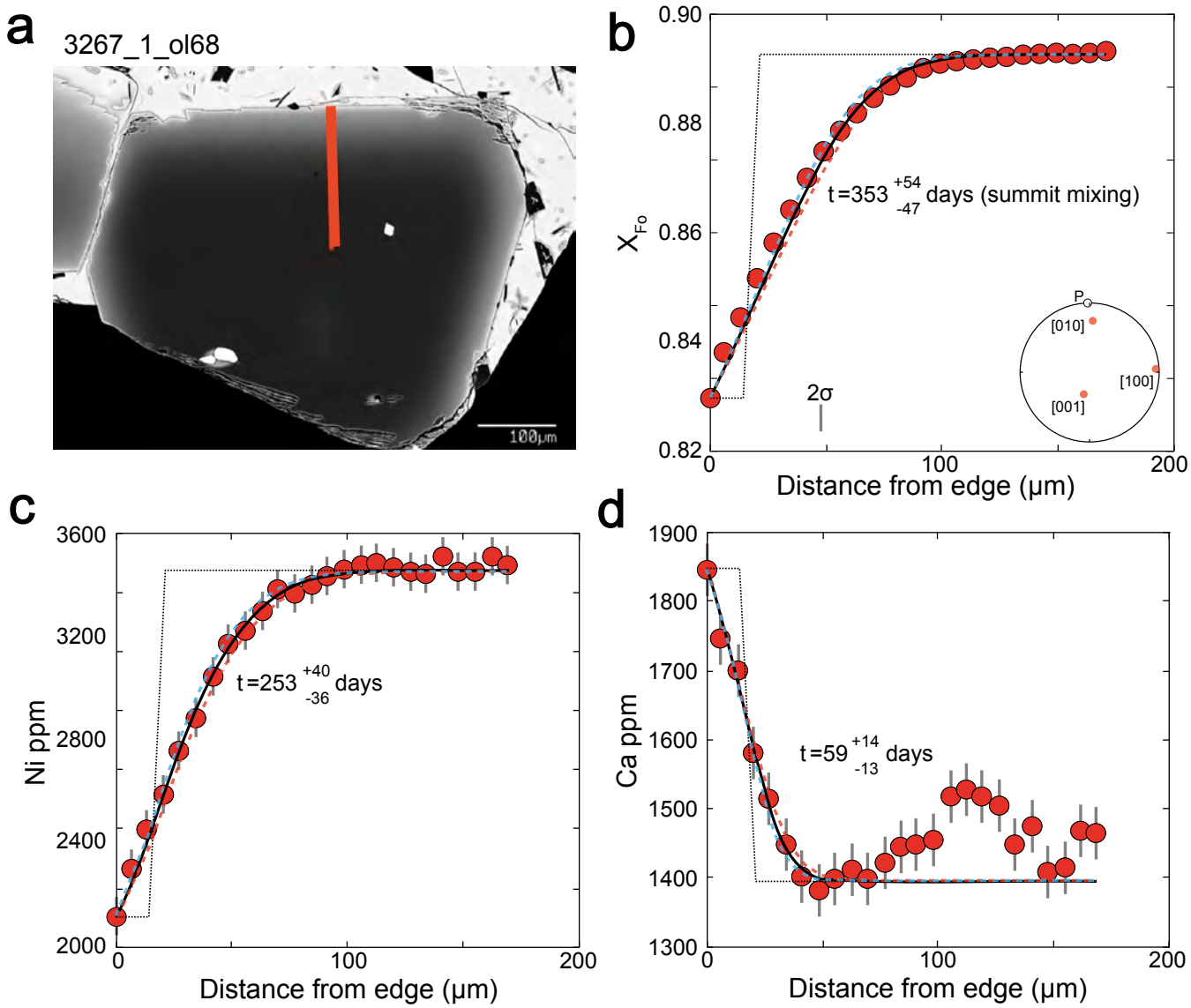
Supplementary Fig. 6: **Data, initial conditions and model fits for olivine crystal '3267_1_ol7'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit.



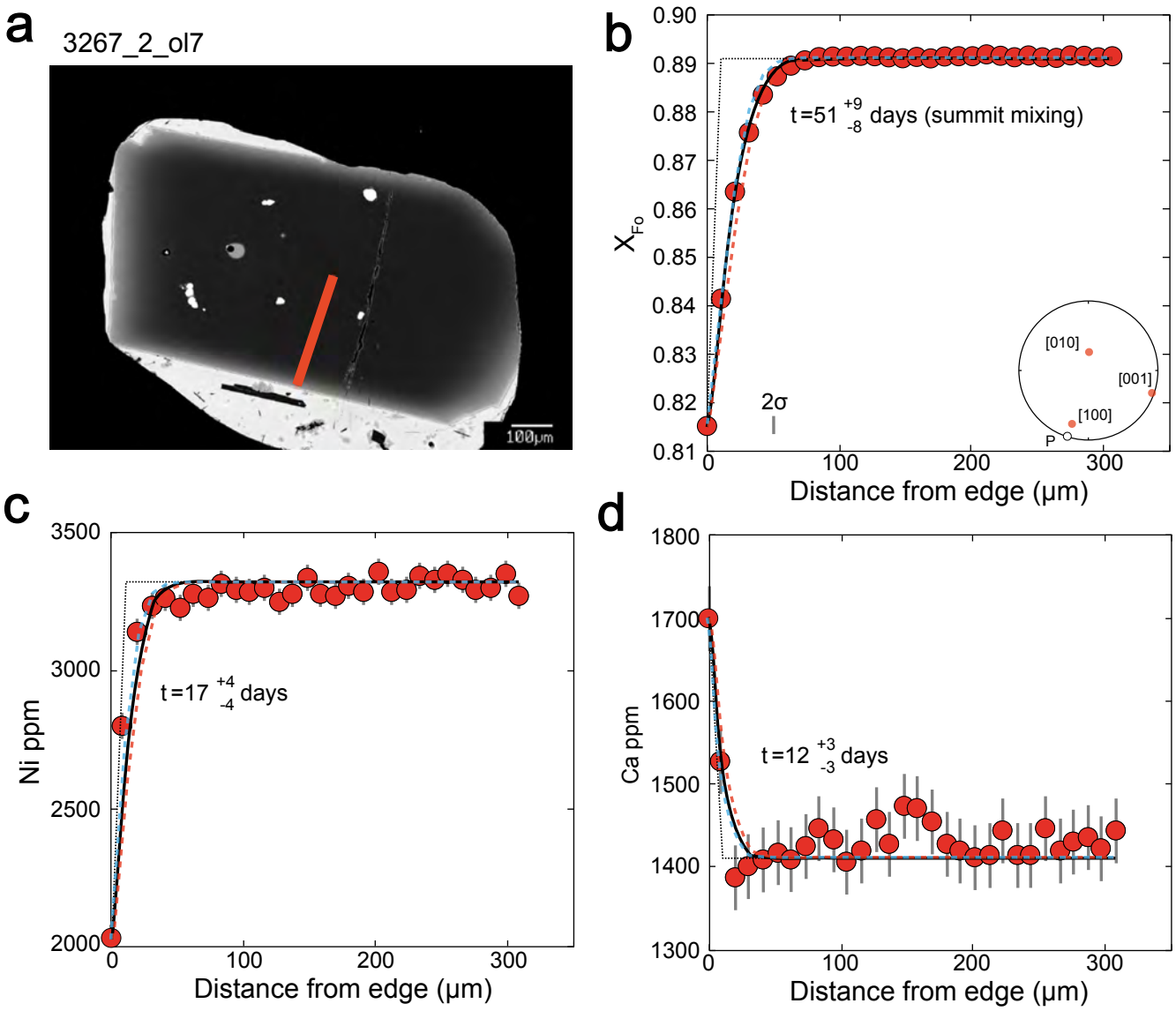
Supplementary Fig. 7: **Data, initial conditions and model fits for olivine crystal '3267_1_ol12'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit.



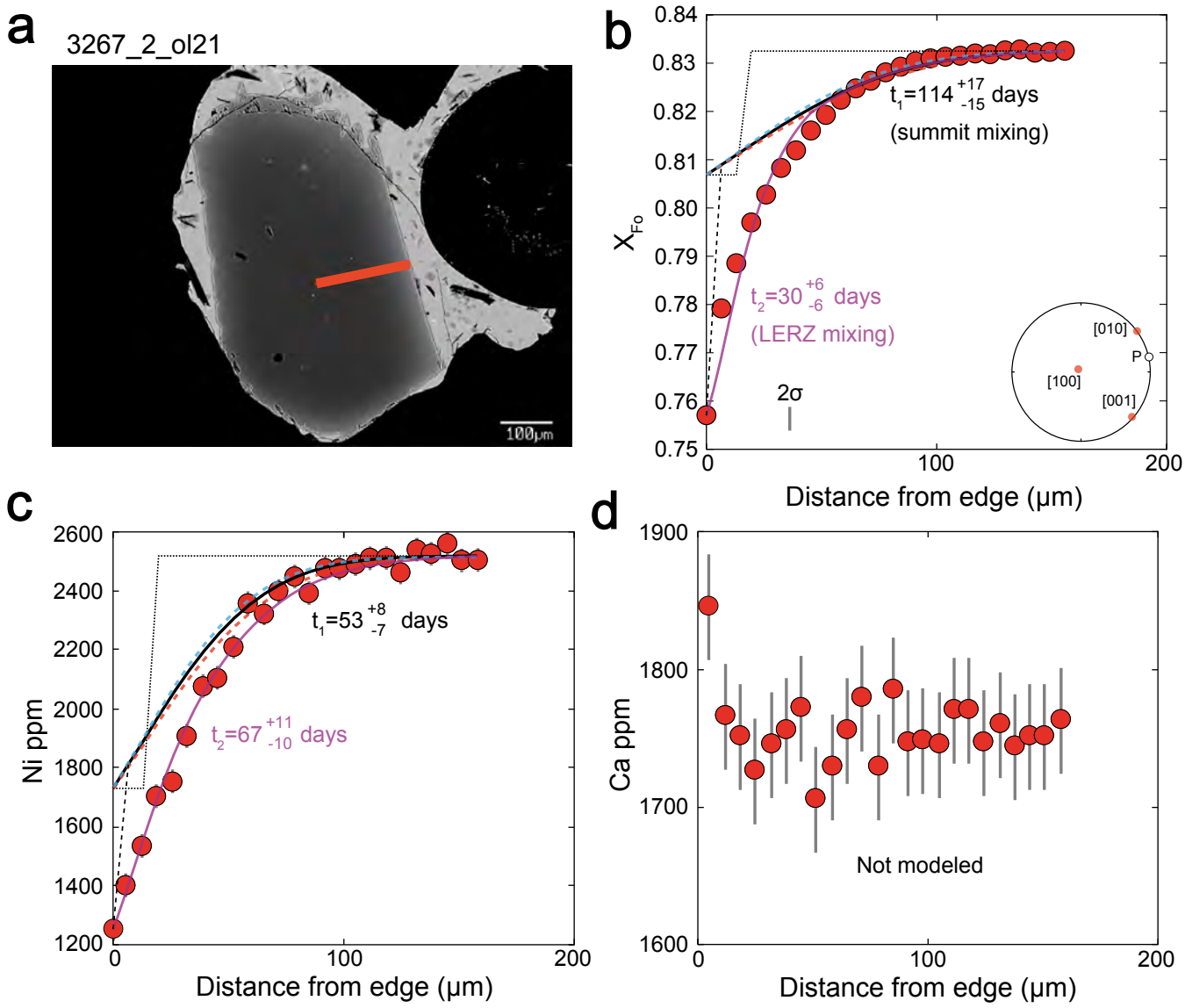
Supplementary Fig. 8: **Data, initial conditions and model fits for olivine crystal '3267_1_ol22'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



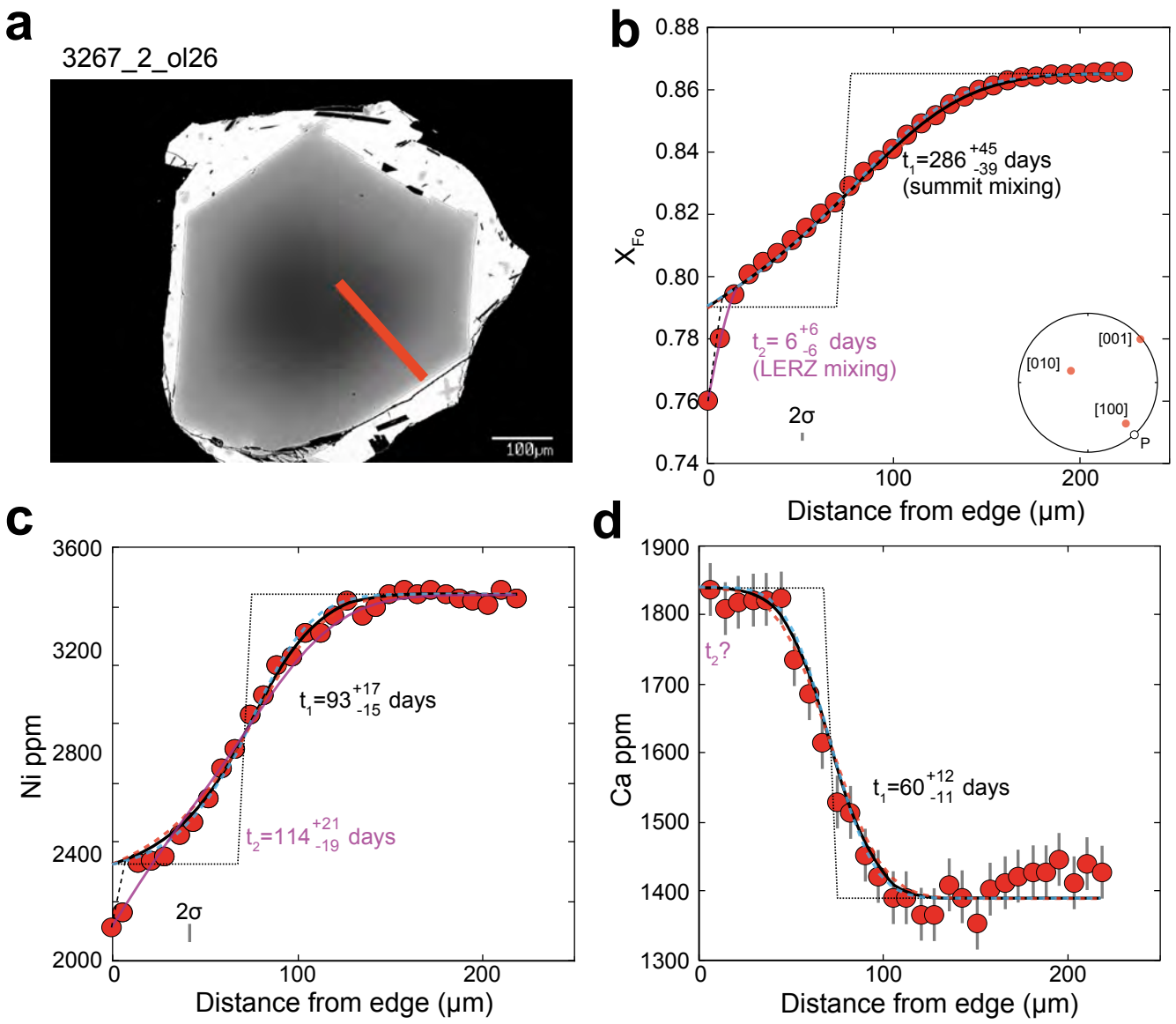
Supplementary Fig. 9: **Data, initial conditions and model fits for olivine crystal '3267_1_ol68'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



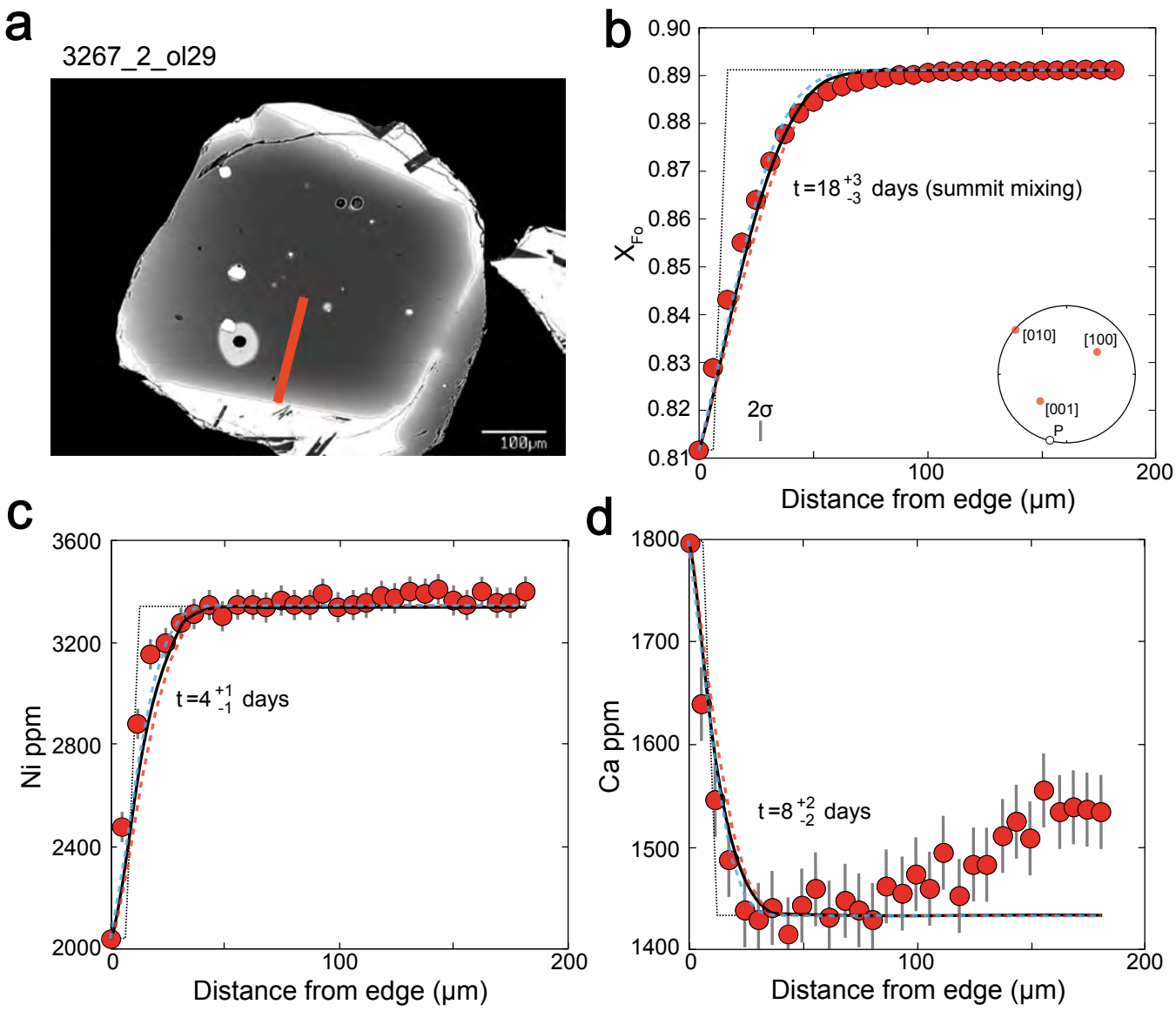
Supplementary Fig. 10: **Data, initial conditions and model fits for olivine crystal '3267_2_ol7'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



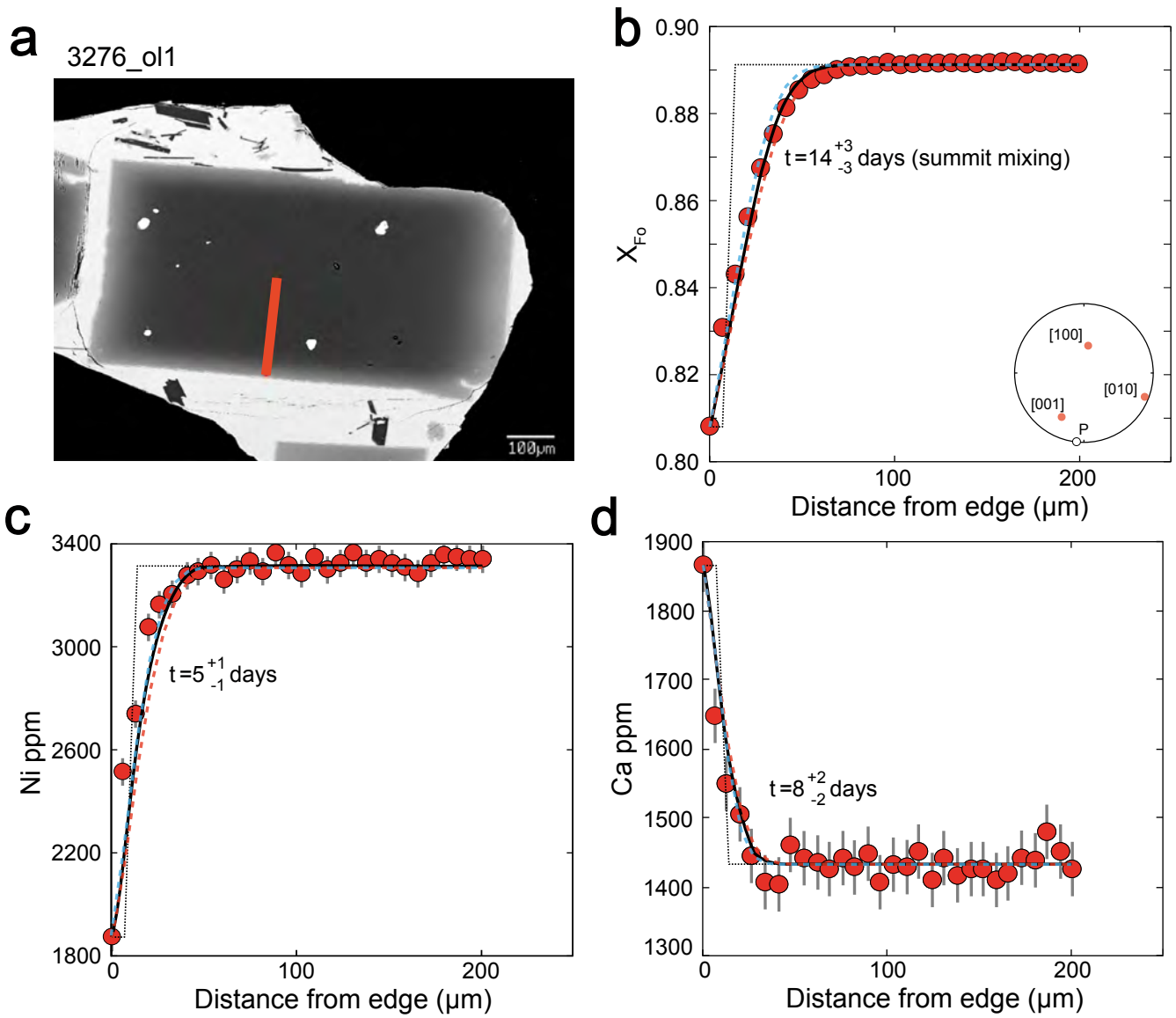
Supplementary Fig. 11: **Data, initial conditions and model fits for olivine crystal '3267_2_ol21'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit. LERZ = lower East Rift Zone.



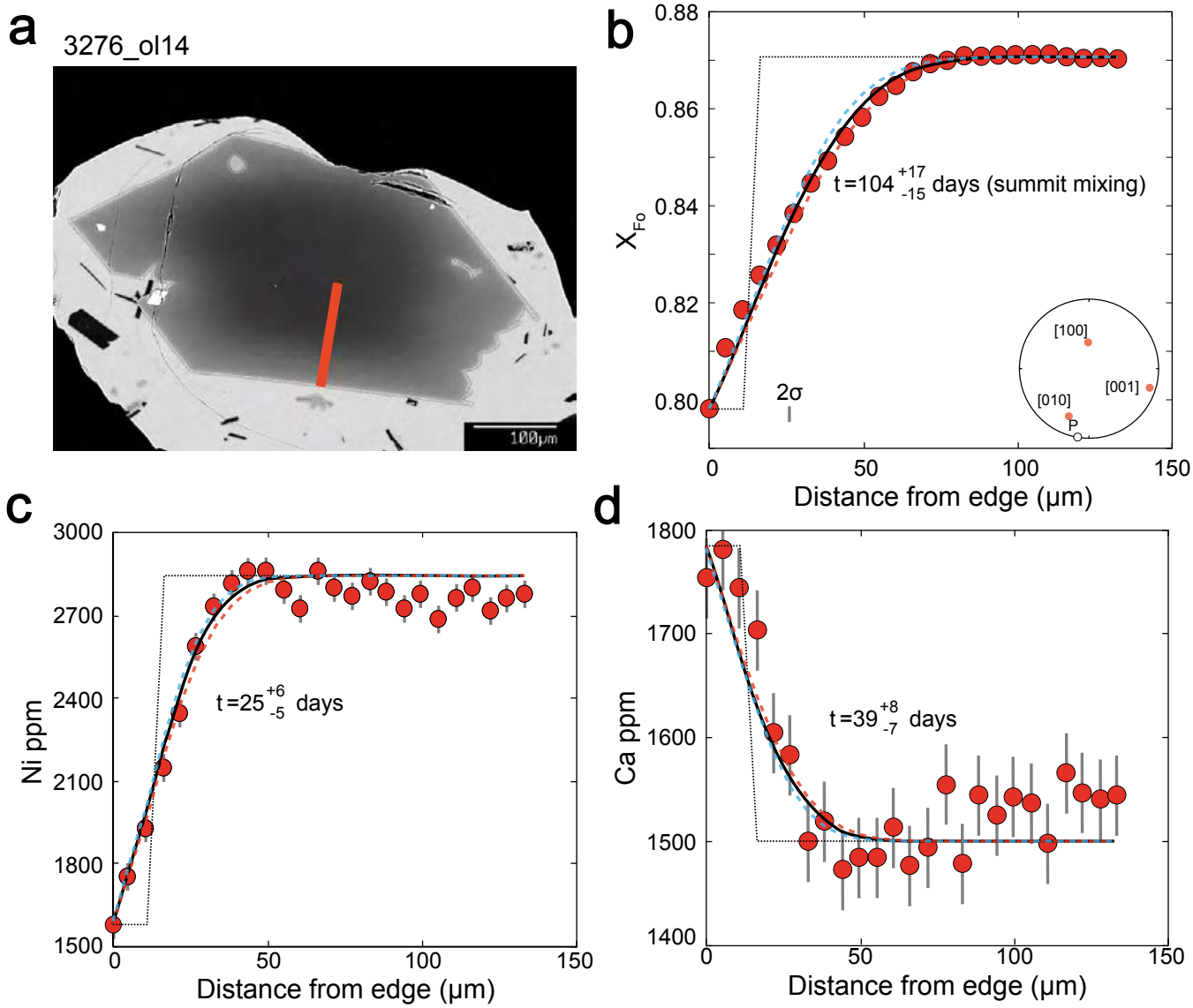
Supplementary Fig. 12: **Data, initial conditions and model fits for olivine crystal '3267_2_ol26'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit. LERZ = lower East Rift Zone.



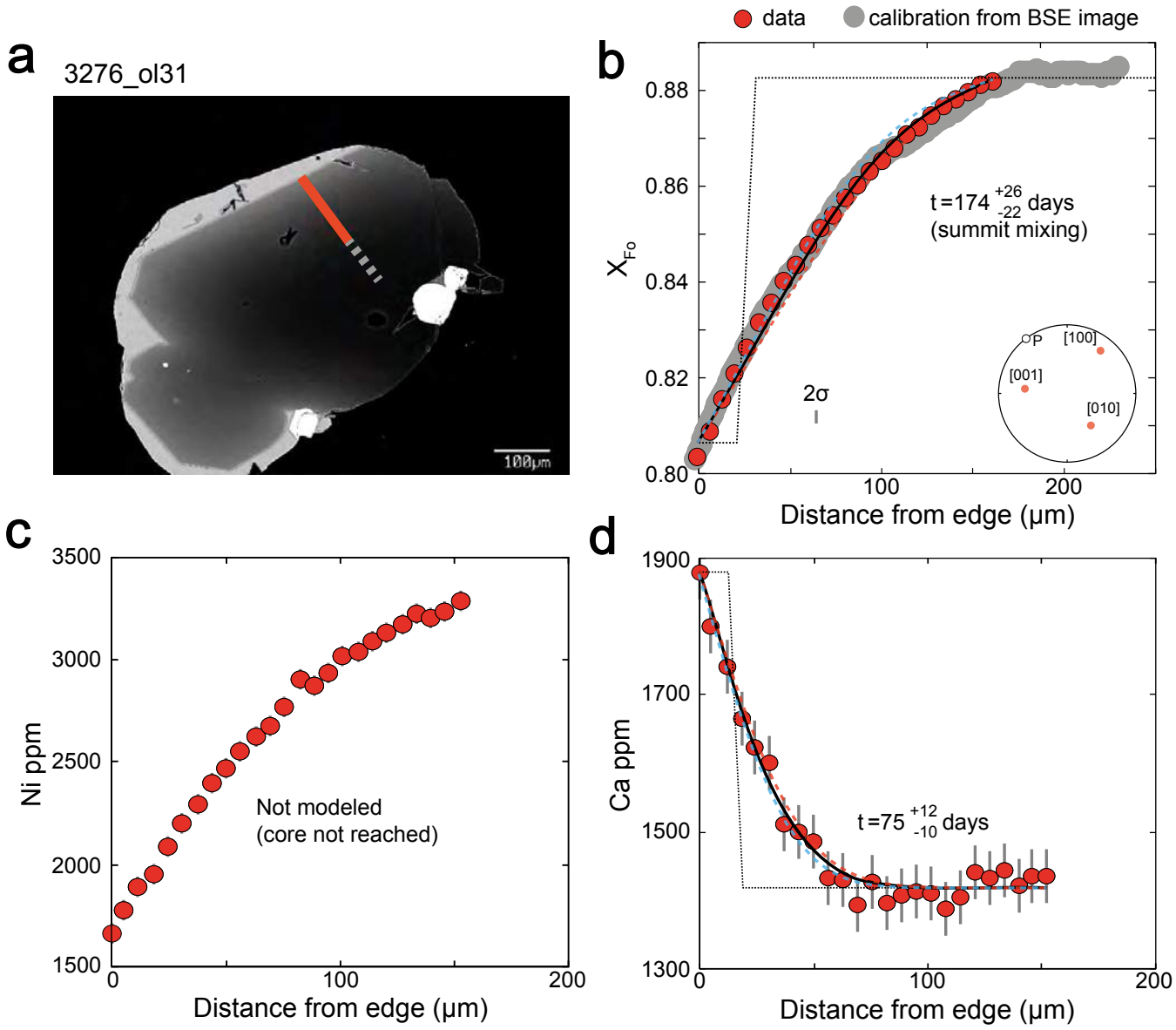
Supplementary Fig. 13: **Data, initial conditions and model fits for olivine crystal '3267_2_ol29'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



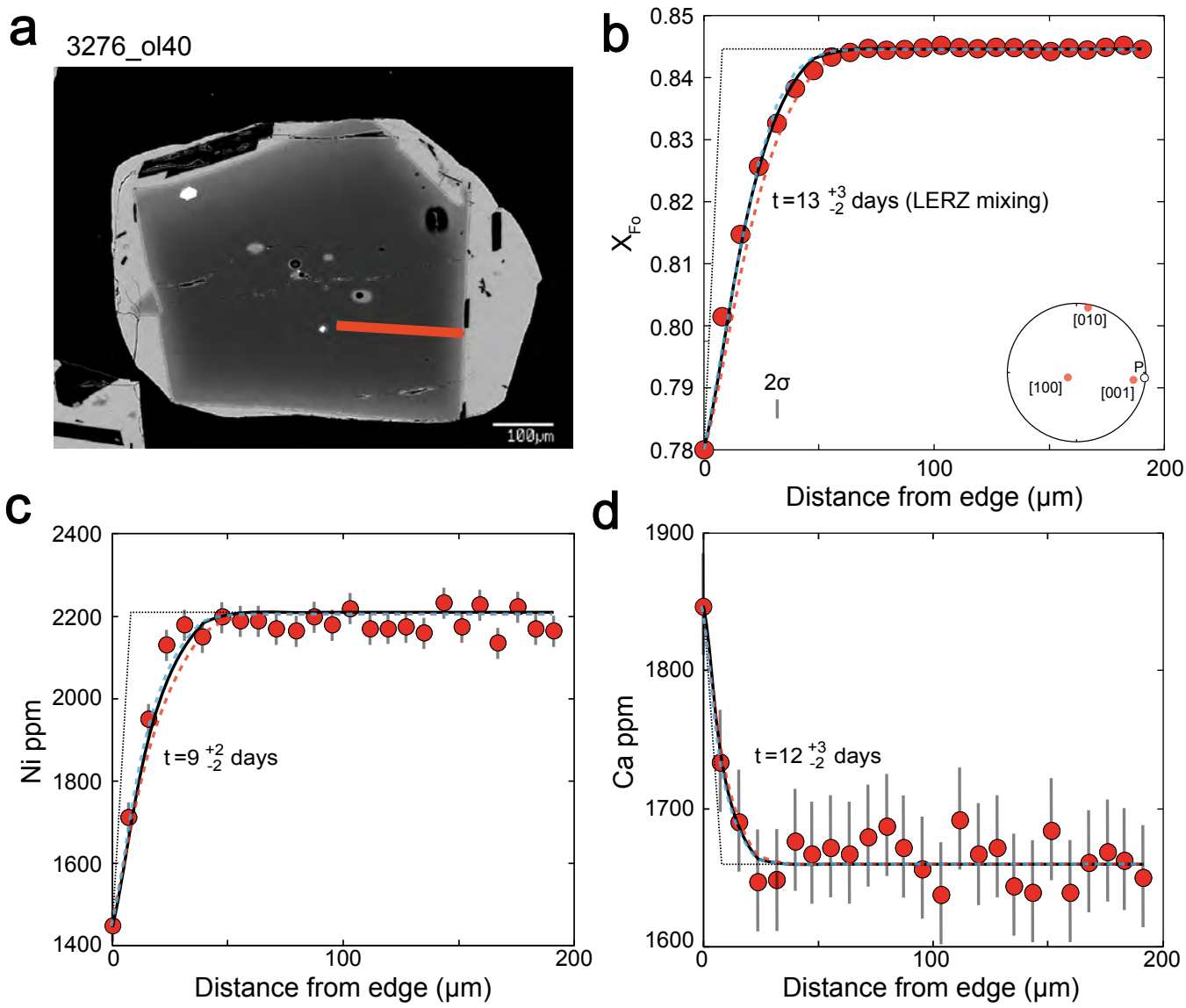
Supplementary Fig. 14: **Data, initial conditions and model fits for olivine crystal '3276_ol1'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



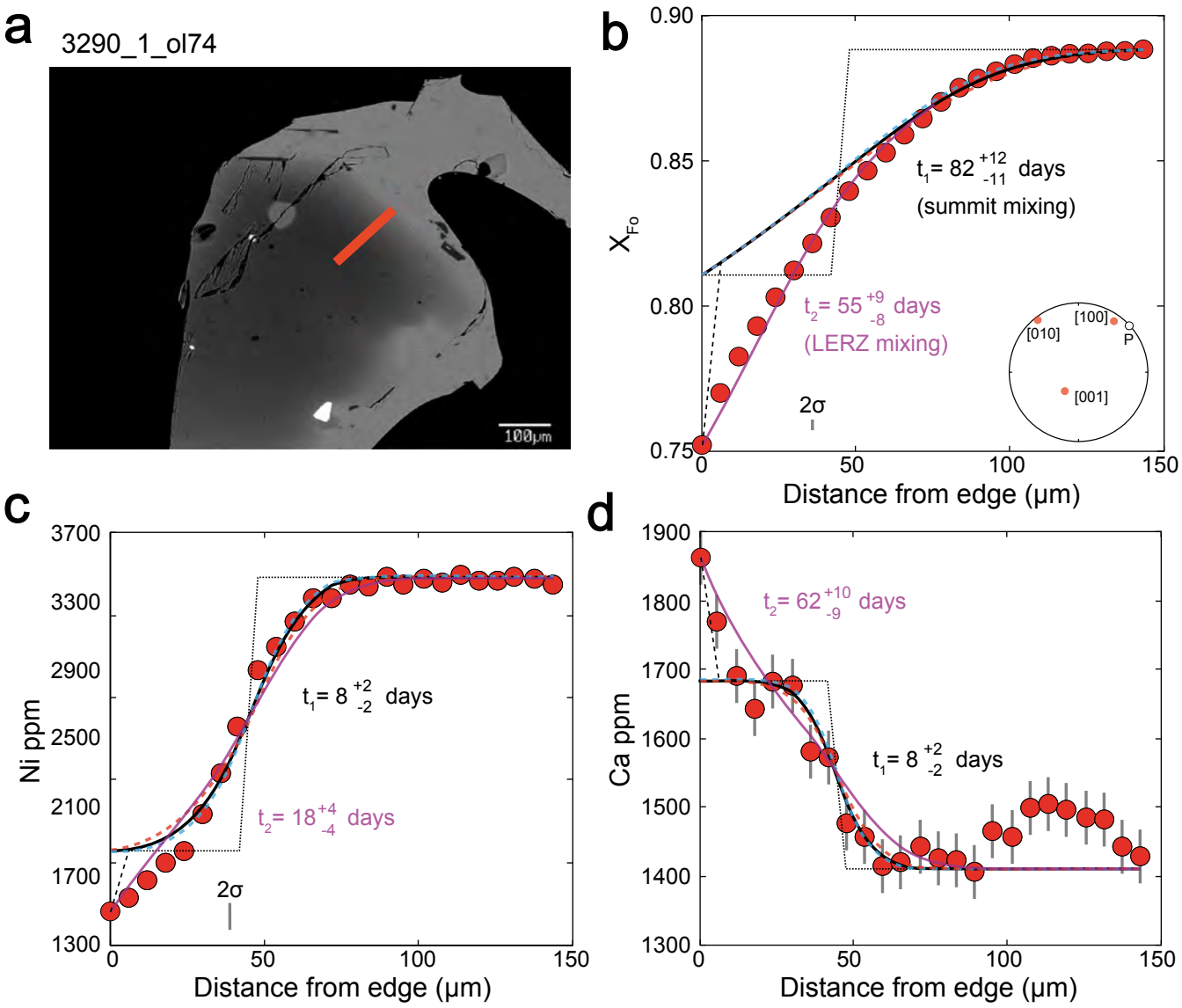
Supplementary Fig. 15: **Data, initial conditions and model fits for olivine crystal '3276_ol14'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



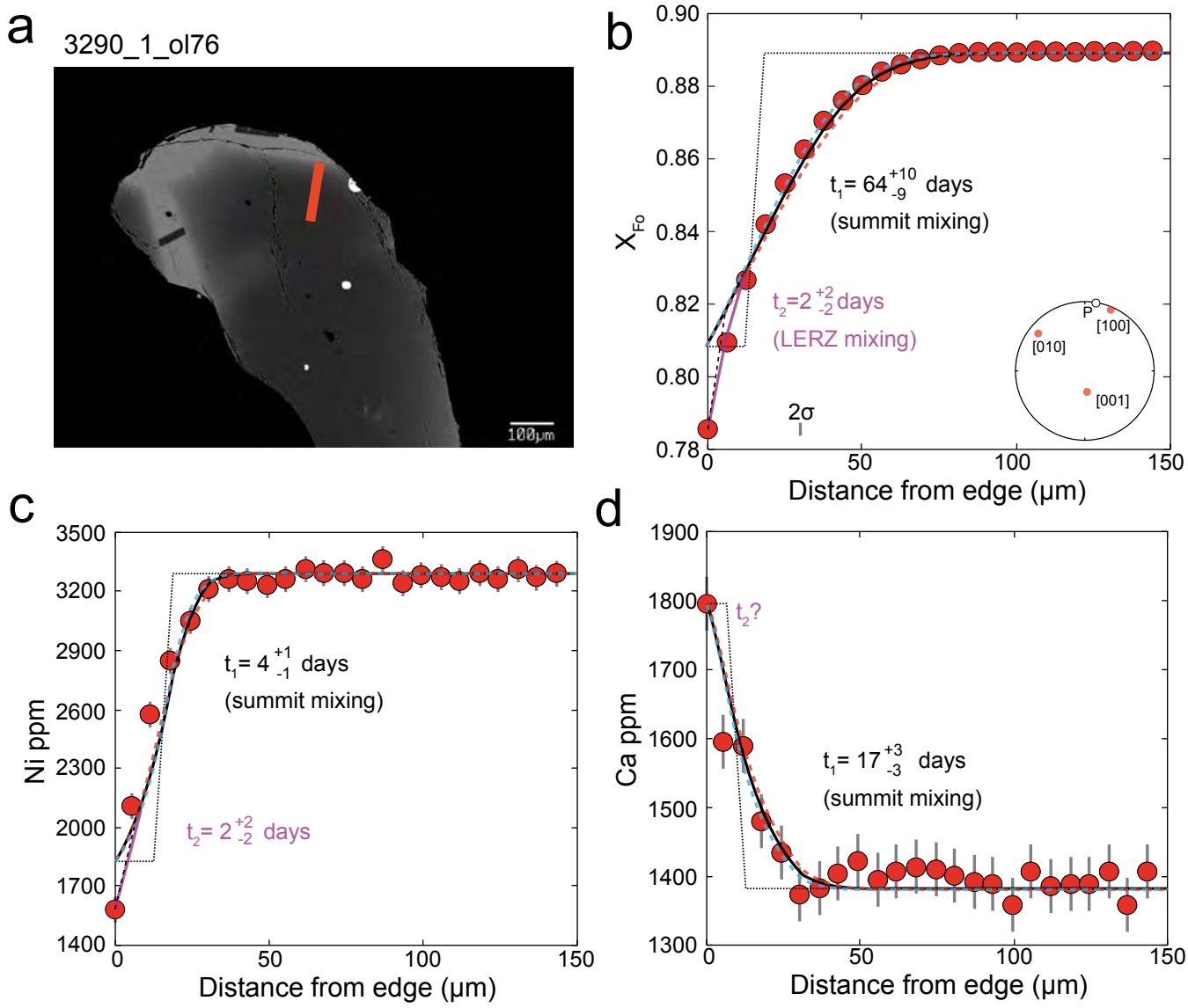
Supplementary Fig. 16: **Data, initial conditions and model fits for olivine crystal '3276_ol31'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



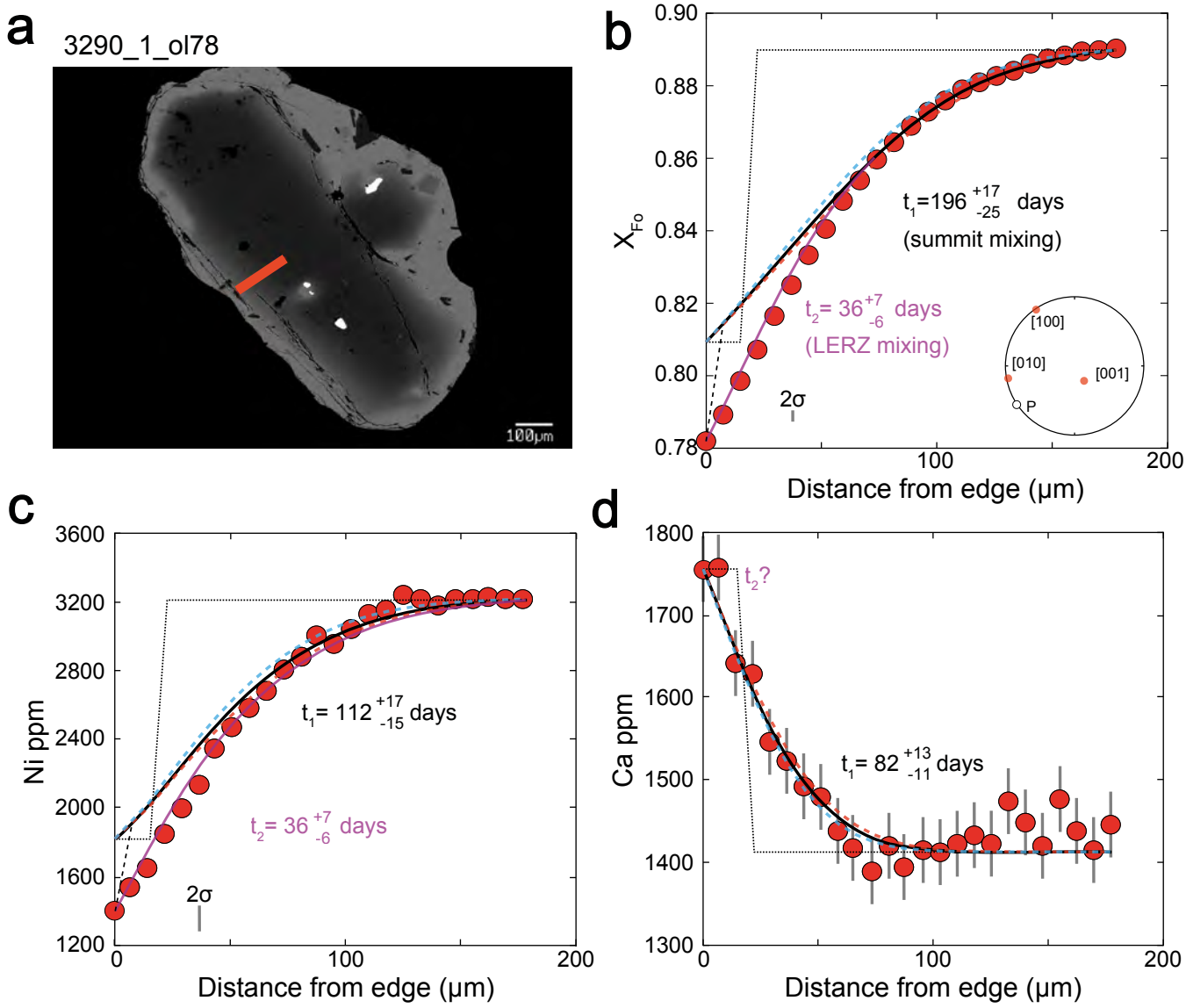
Supplementary Fig. 17: **Data, initial conditions and model fits for olivine crystal '3276_ol40'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. LERZ = lower East Rift Zone.



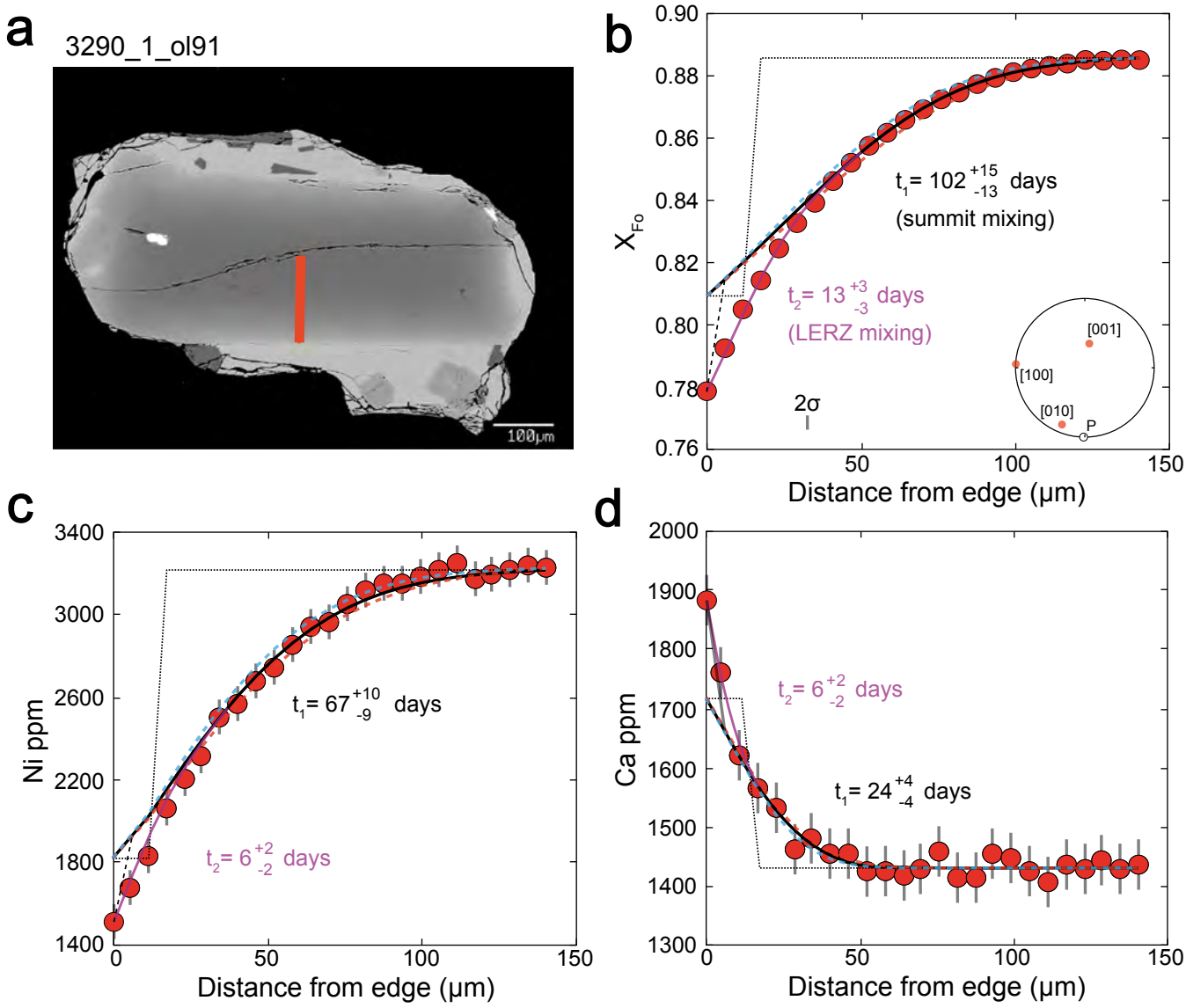
Supplementary Fig. 18: **Data, initial conditions and model fits for olivine crystal '3290_1_ol74'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit. LERZ = lower East Rift Zone.



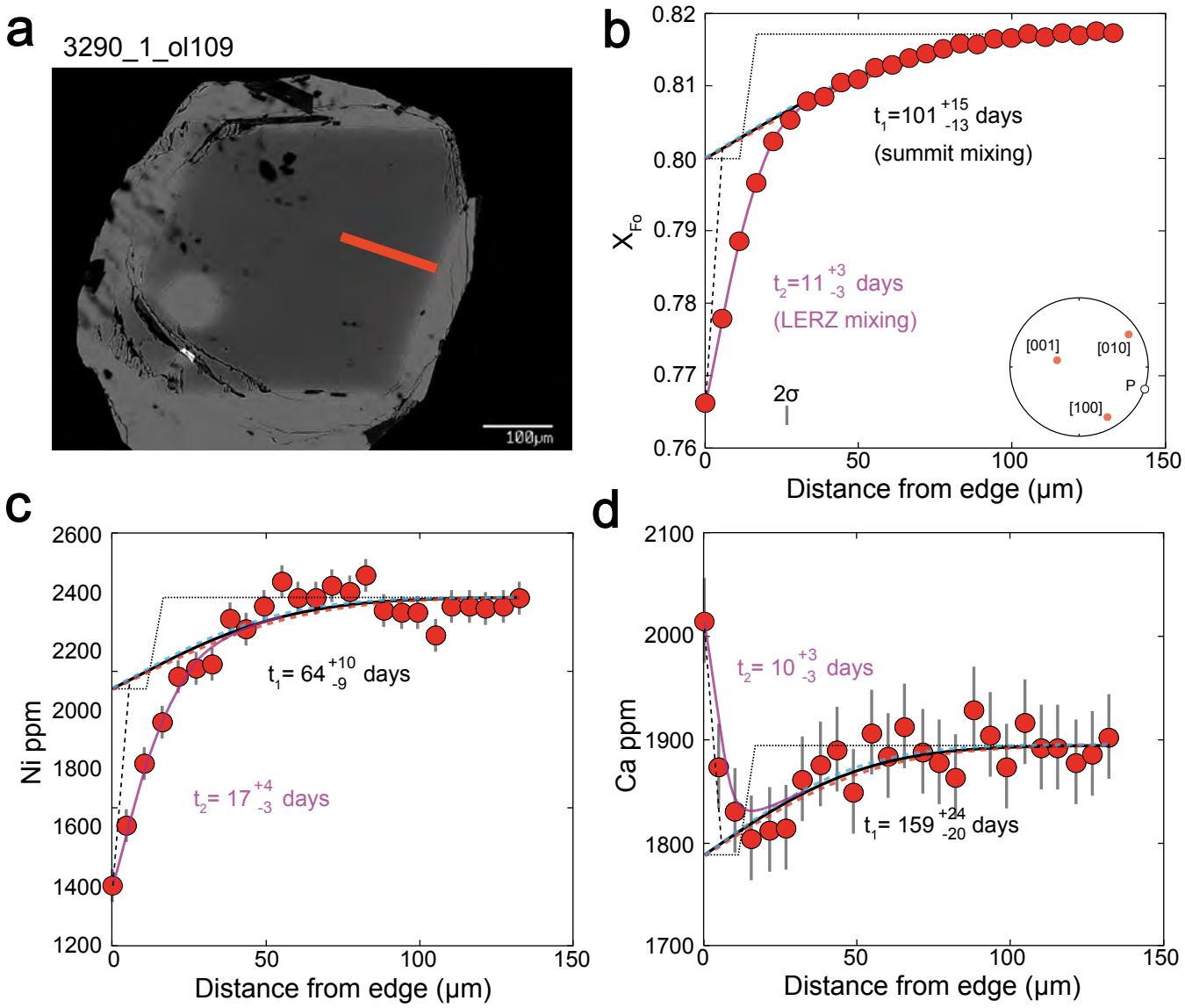
Supplementary Fig. 19: **Data, initial conditions and model fits for olivine crystal '3290_1_ol76'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit. LERZ = lower East Rift Zone.



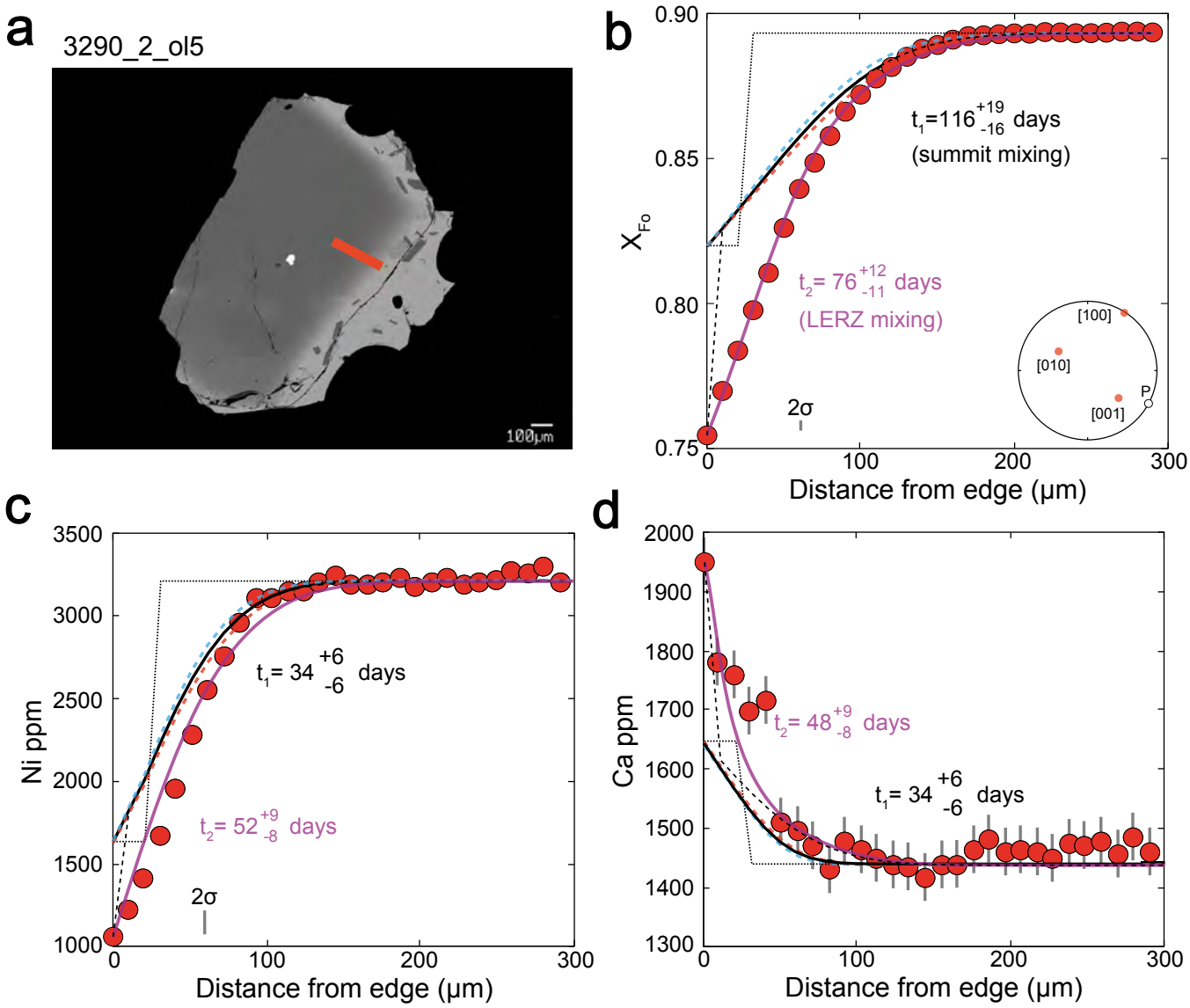
Supplementary Fig. 20: **Data, initial conditions and model fits for olivine crystal '3290_1_ol78'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit. LERZ = lower East Rift Zone.



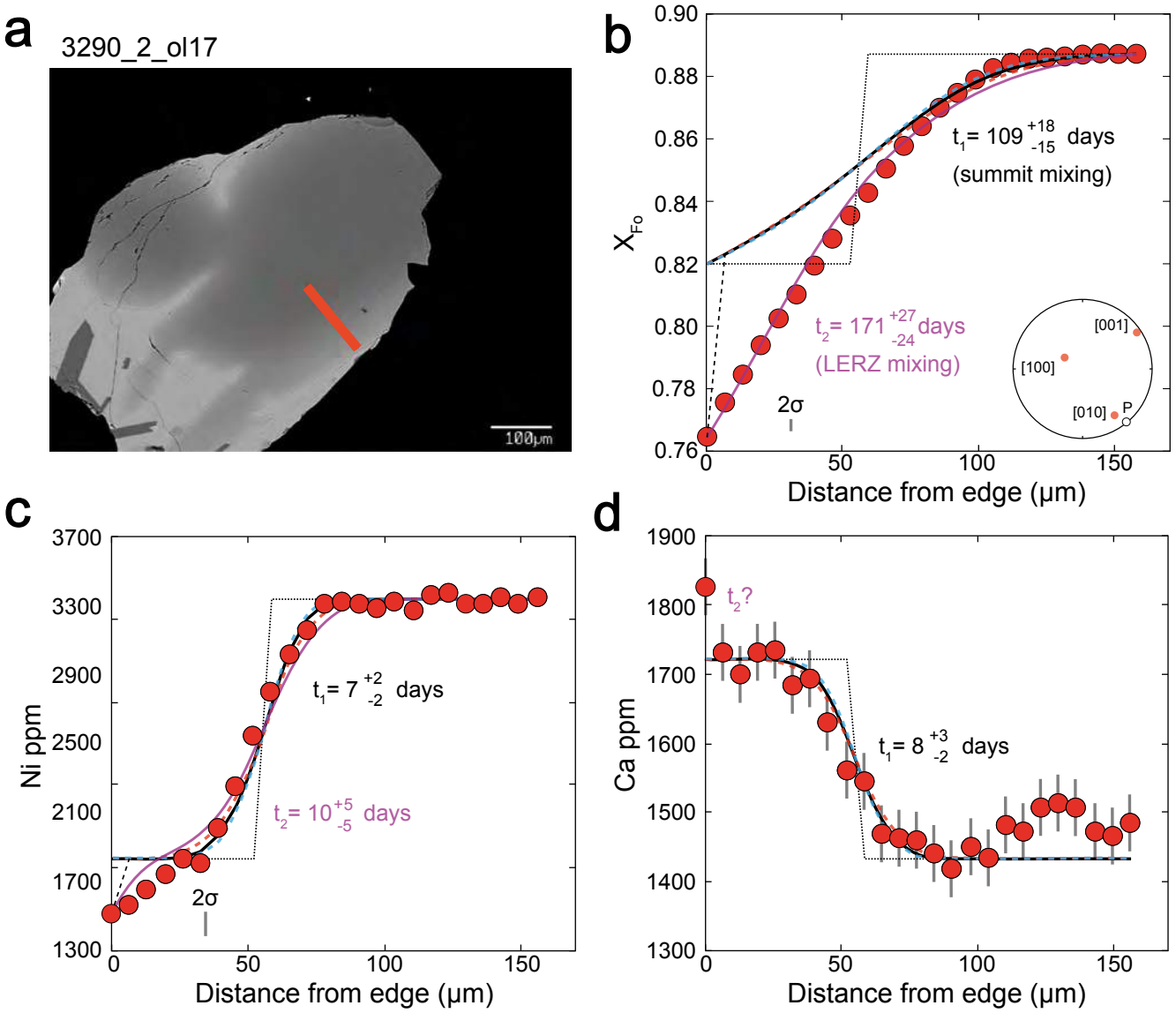
Supplementary Fig. 21: **Data, initial conditions and model fits for olivine crystal '3290_1_ol91'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit. LERZ = lower East Rift Zone.



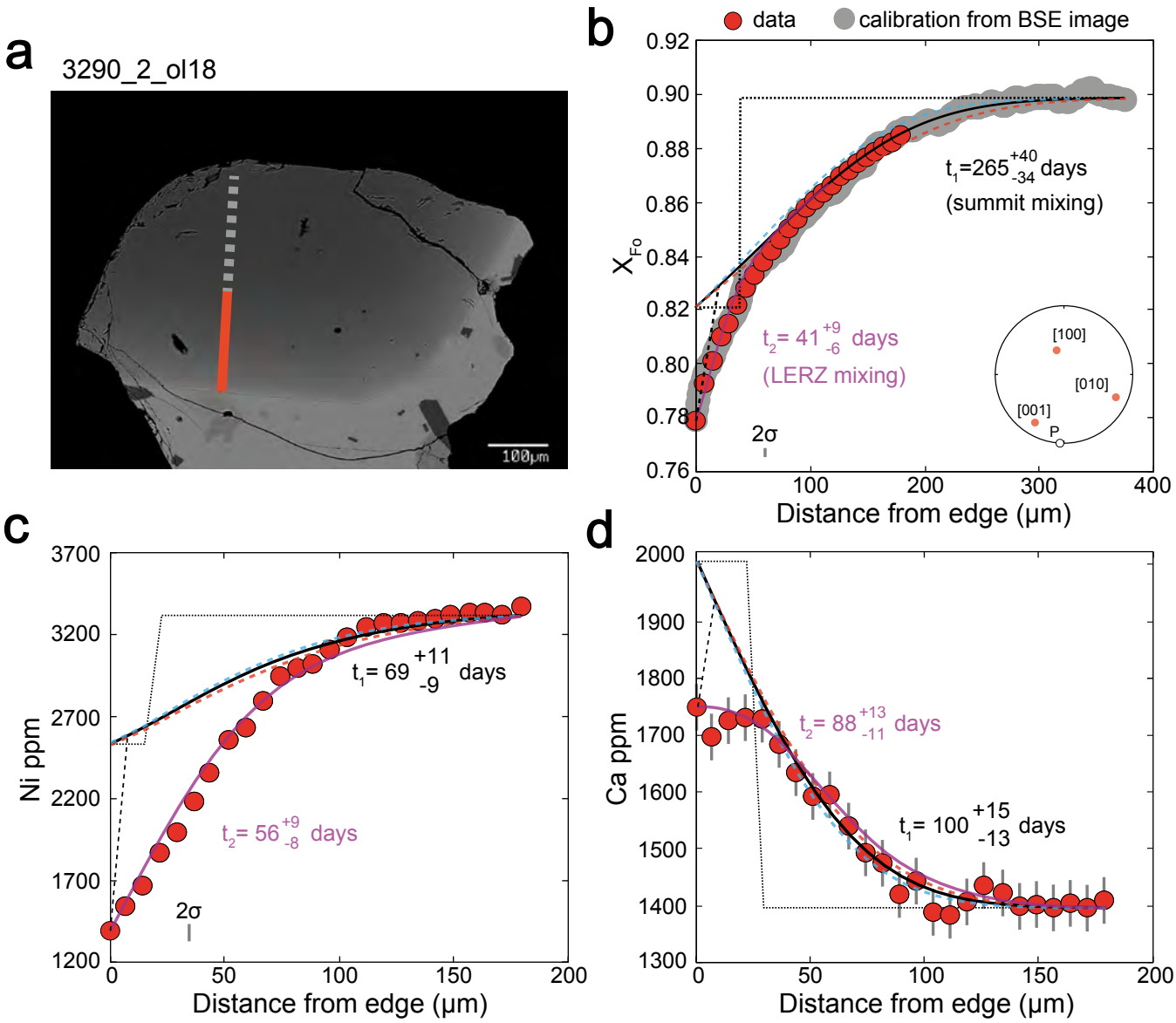
Supplementary Fig. 22: **Data, initial conditions and model fits for olivine crystal '3290_1_ol109'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit. LERZ = lower East Rift Zone.



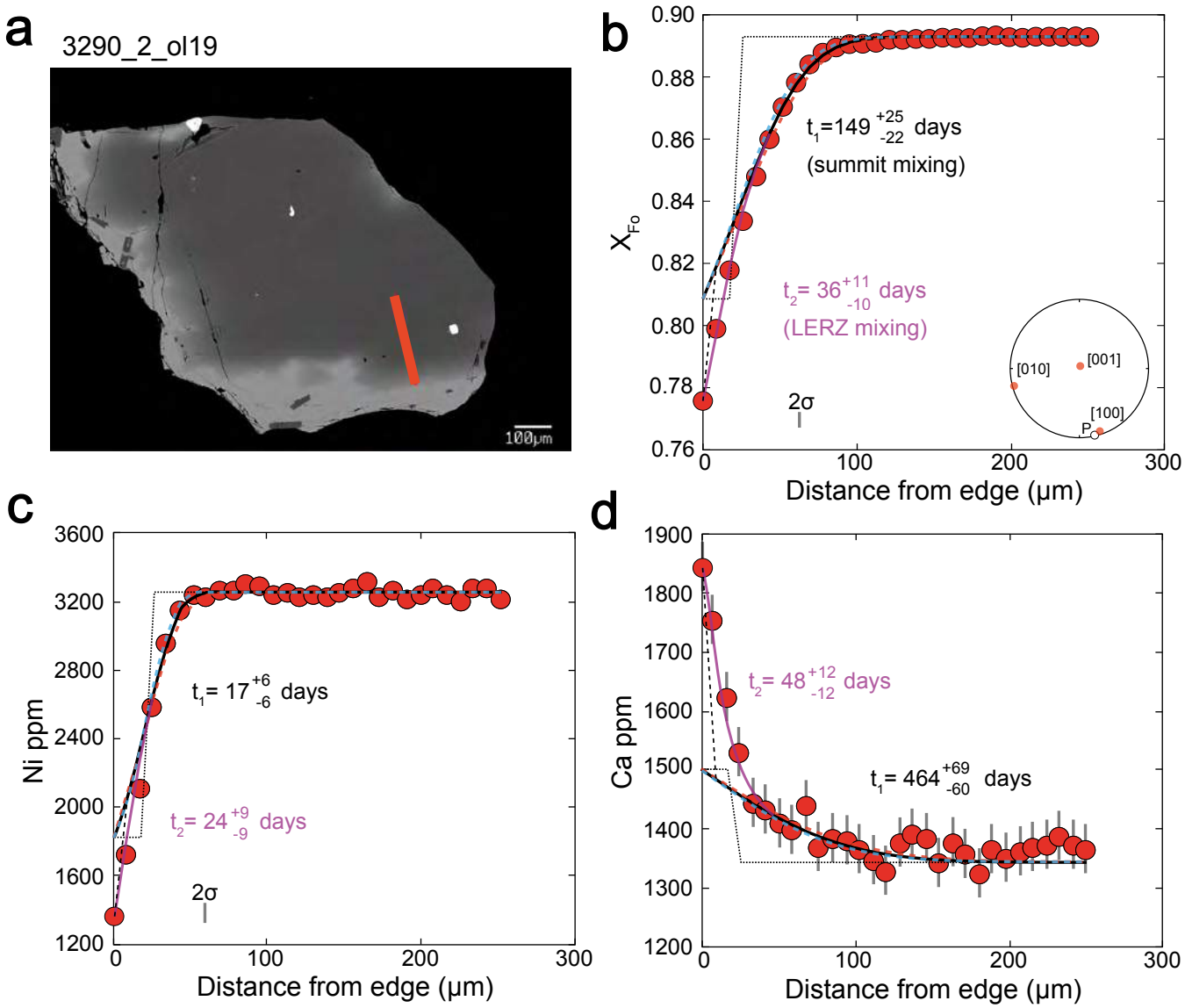
Supplementary Fig. 23: **Data, initial conditions and model fits for olivine crystal '3290_2_ol5'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit. LERZ = lower East Rift Zone.



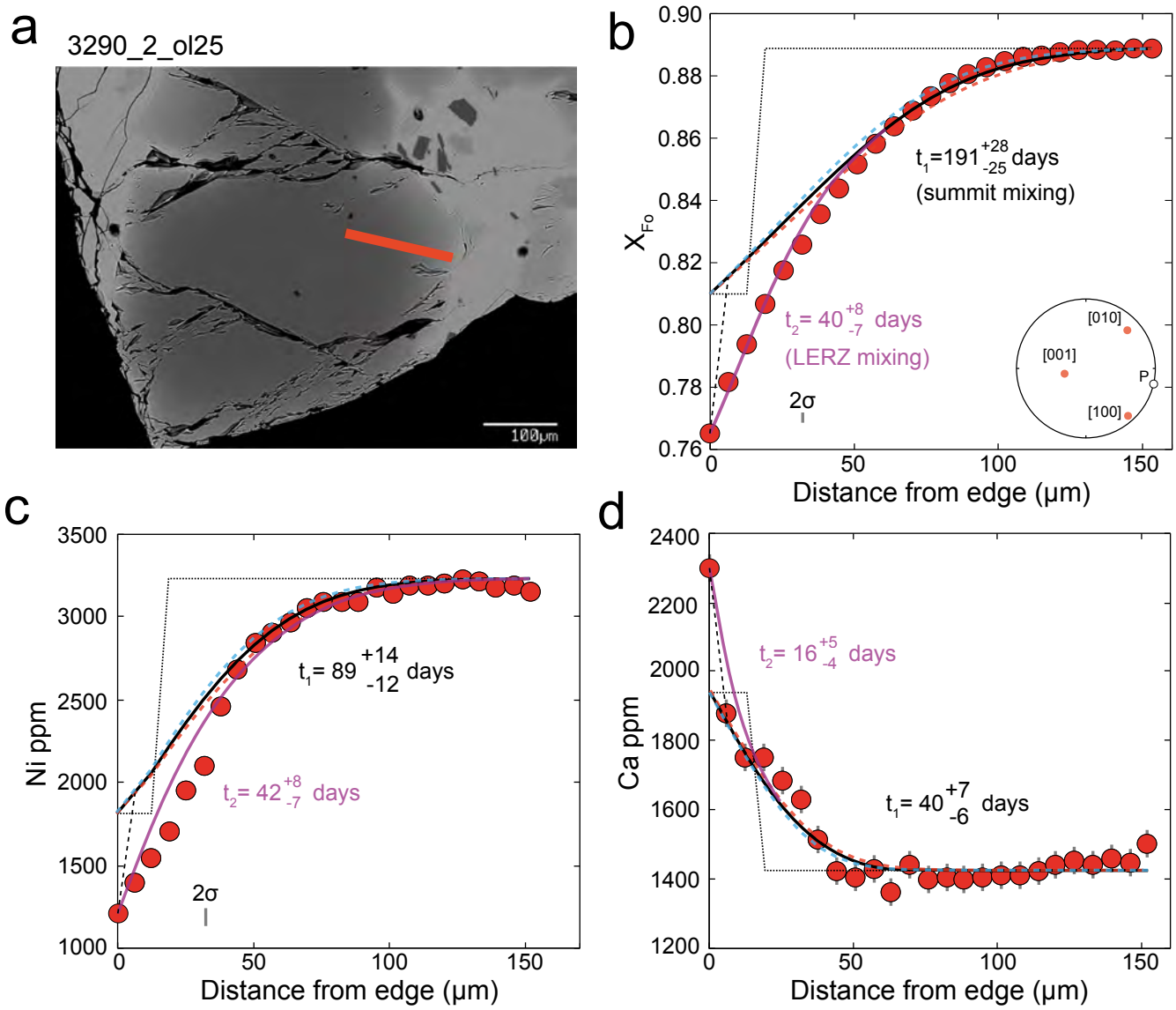
Supplementary Fig. 24: **Data, initial conditions and model fits for olivine crystal '3290_2_ol17'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit. LERZ = lower East Rift Zone.



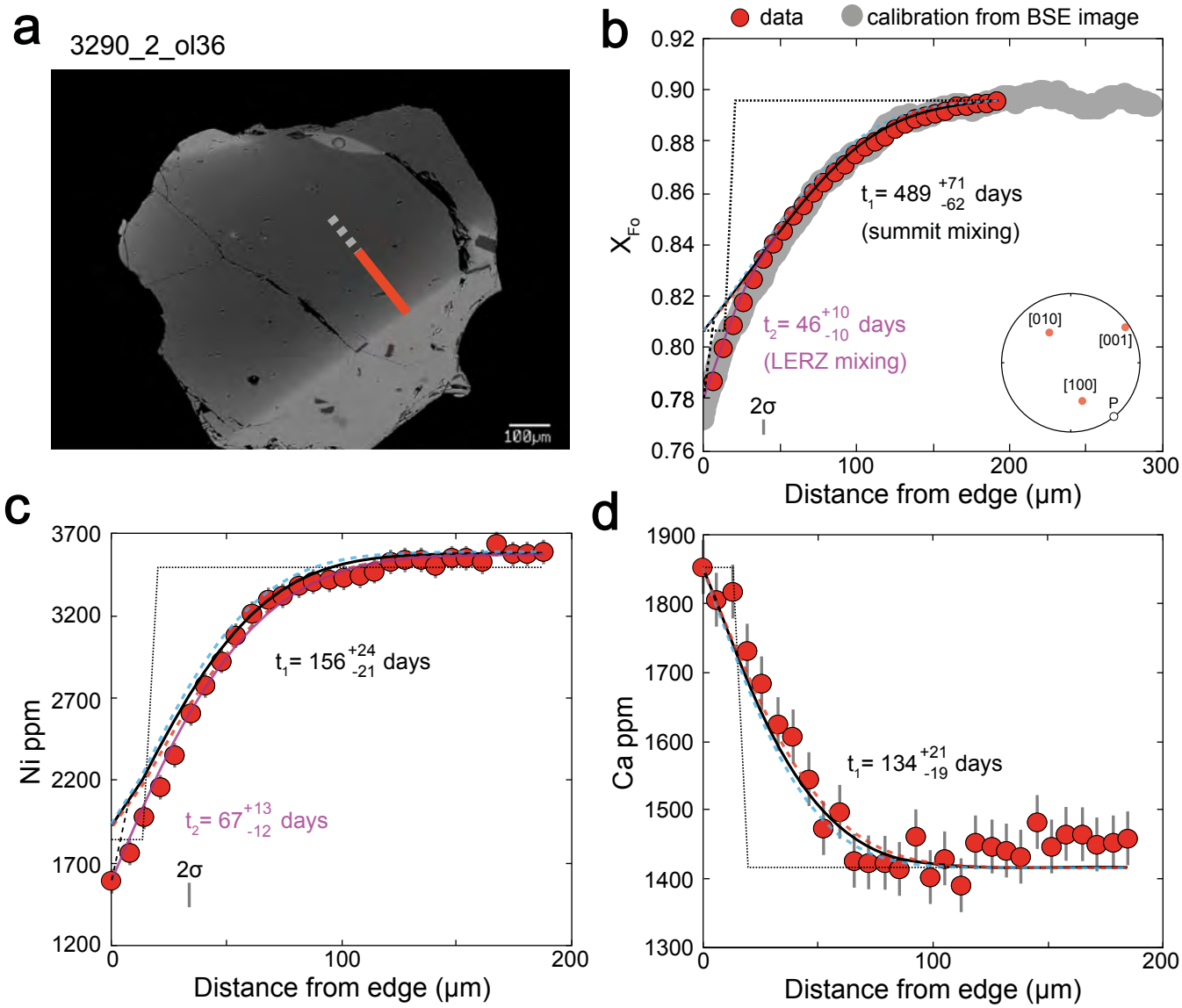
Supplementary Fig. 25: **Data, initial conditions and model fits for olivine crystal '3290_2_ol18'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit. LERZ = lower East Rift Zone.



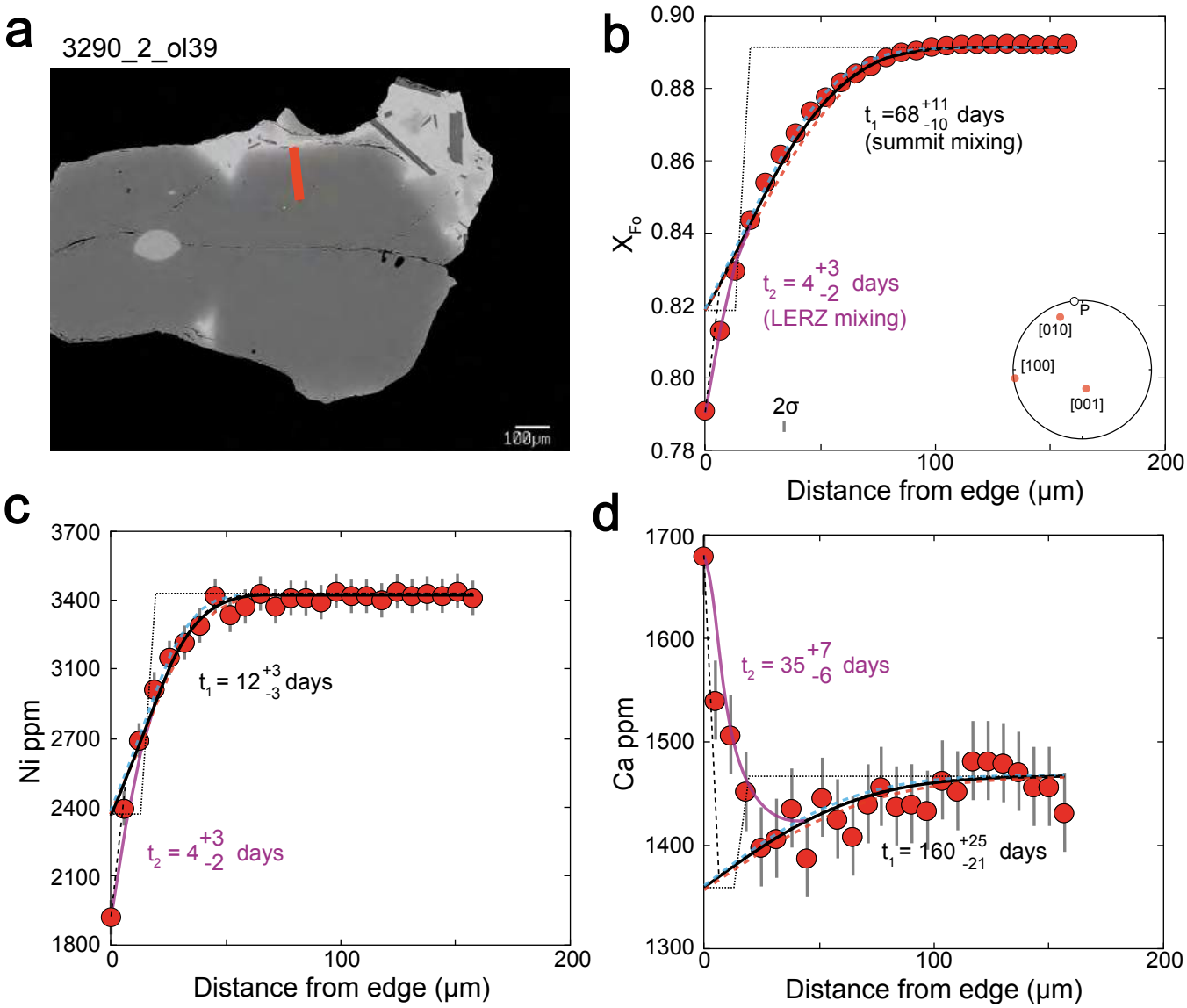
Supplementary Fig. 26: **Data, initial conditions and model fits for olivine crystal '3290_2_ol19'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit. LERZ = lower East Rift Zone.



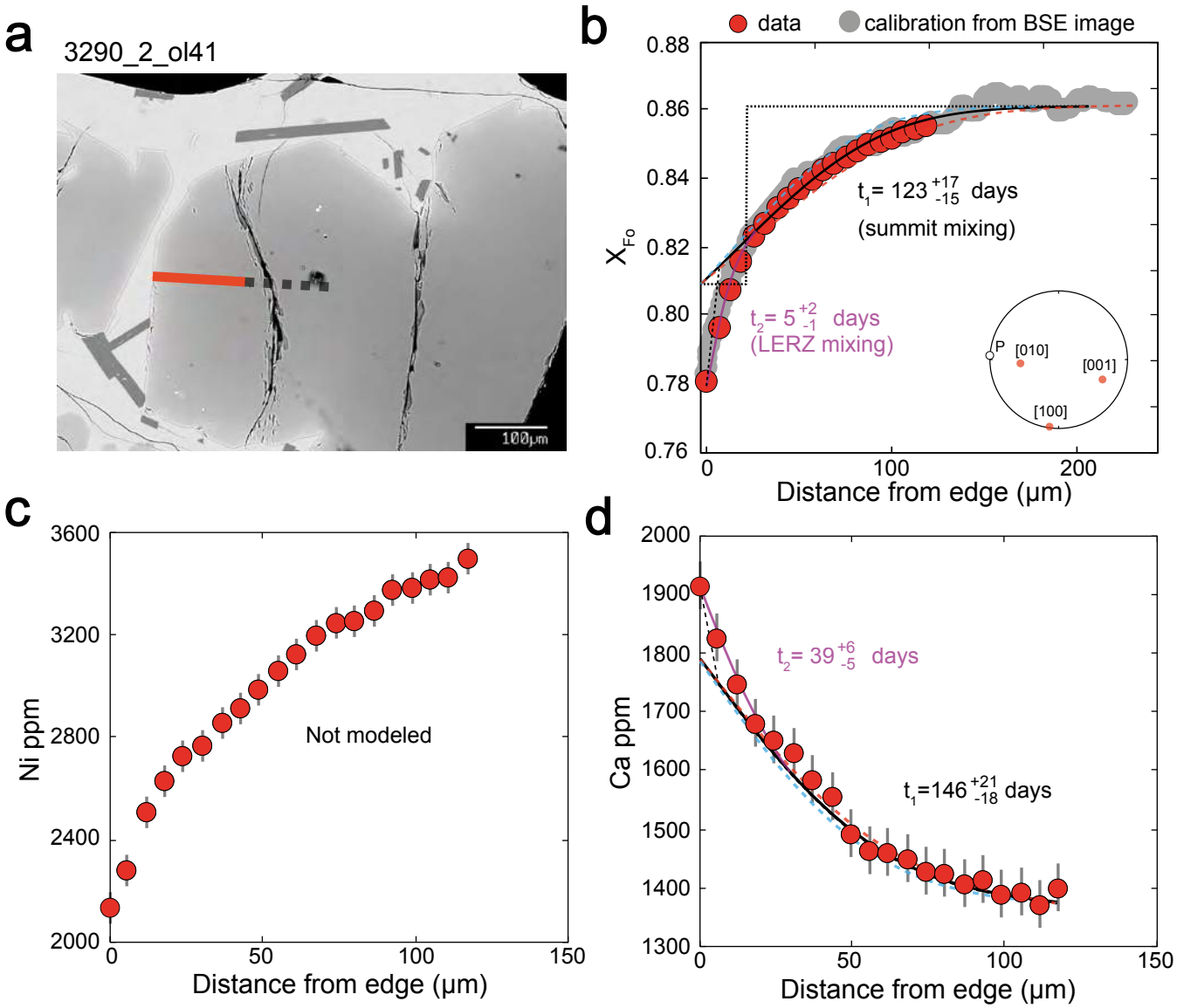
Supplementary Fig. 27: **Data, initial conditions and model fits for olivine crystal '3290_2_ol25'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit. LERZ = lower East Rift Zone.



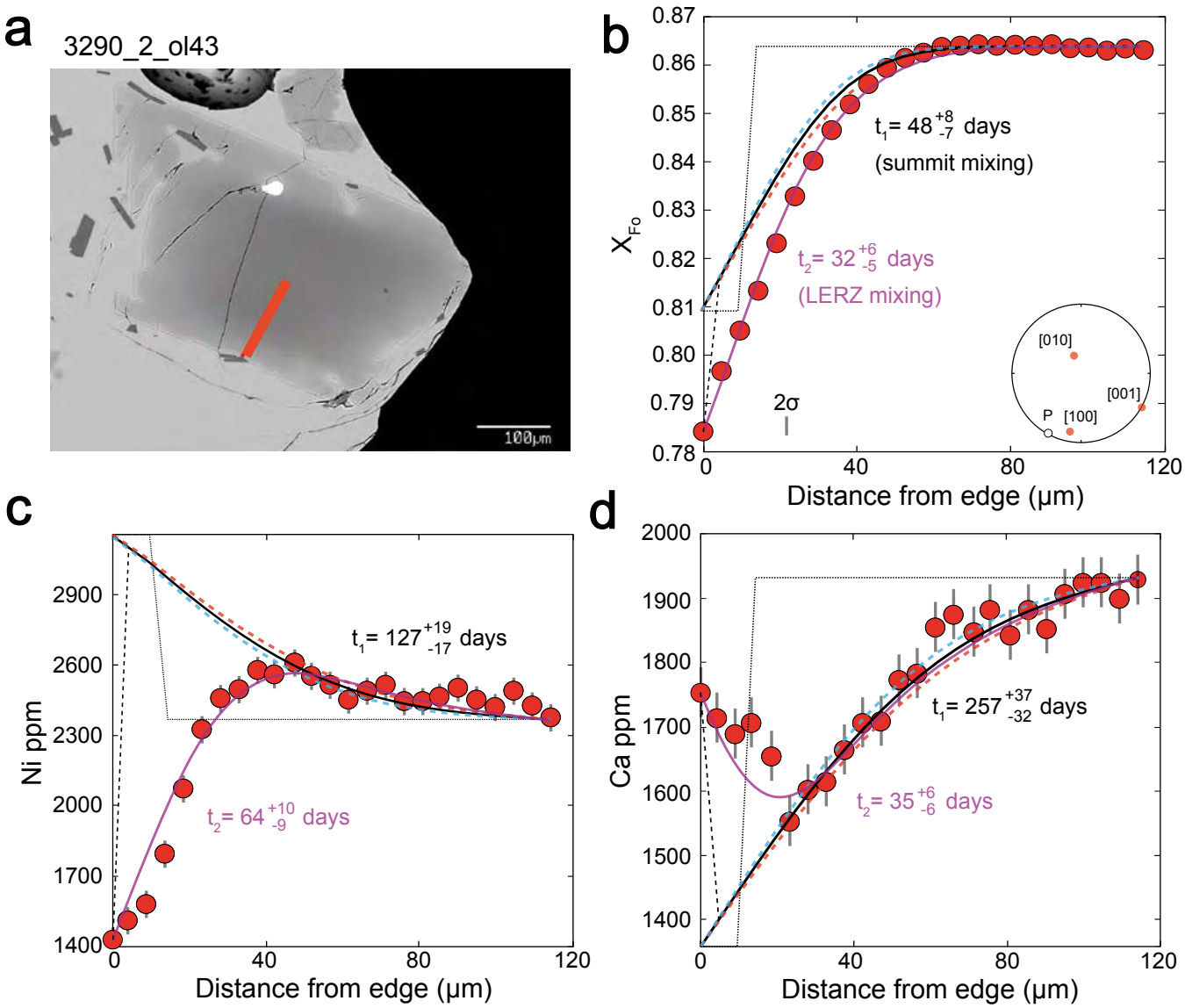
Supplementary Fig. 28: **Data, initial conditions and model fits for olivine crystal '3290_2_ol36'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit. LERZ = lower East Rift Zone.



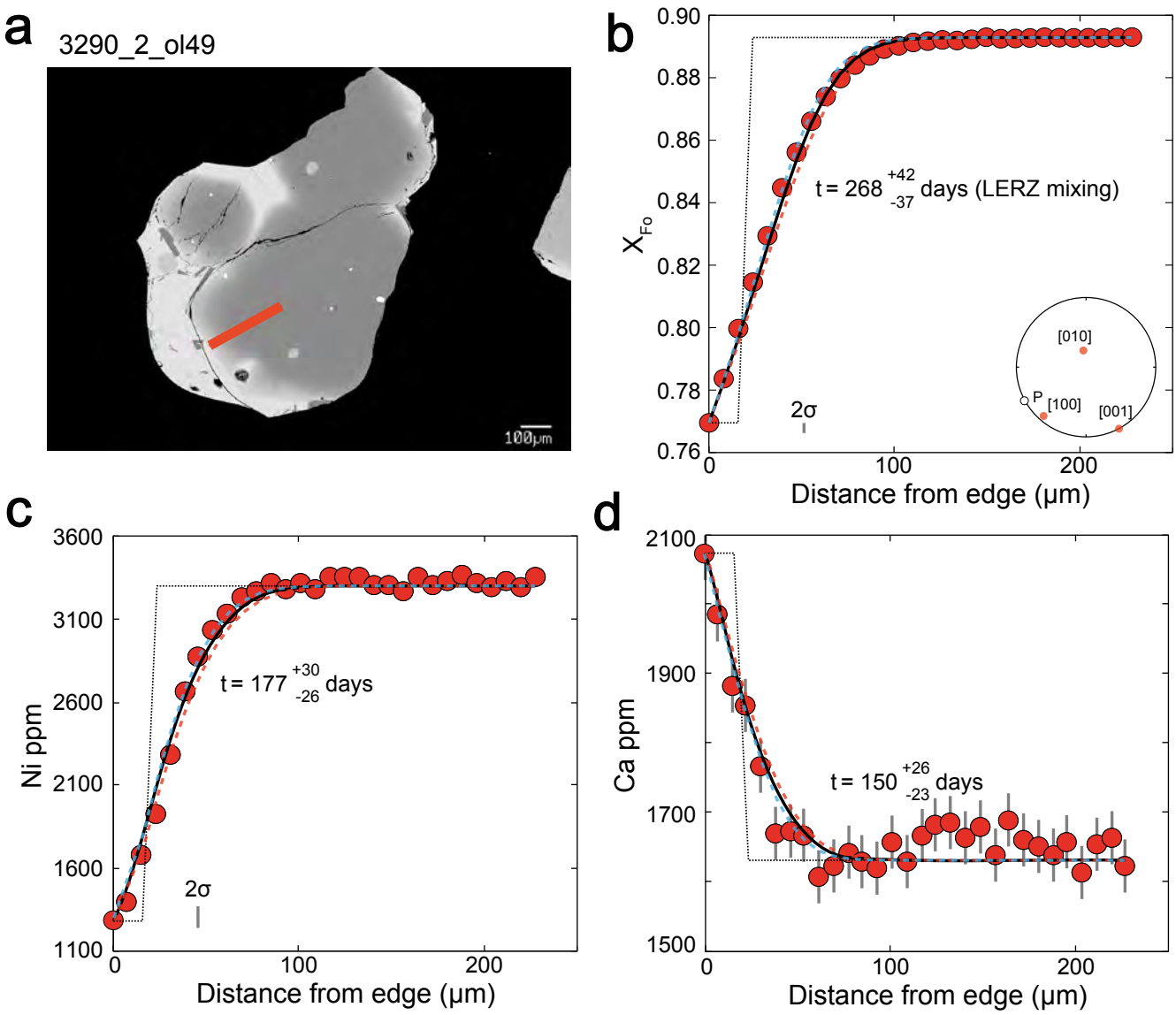
Supplementary Fig. 29: **Data, initial conditions and model fits for olivine crystal '3290_2_ol39'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit. LERZ = lower East Rift Zone.



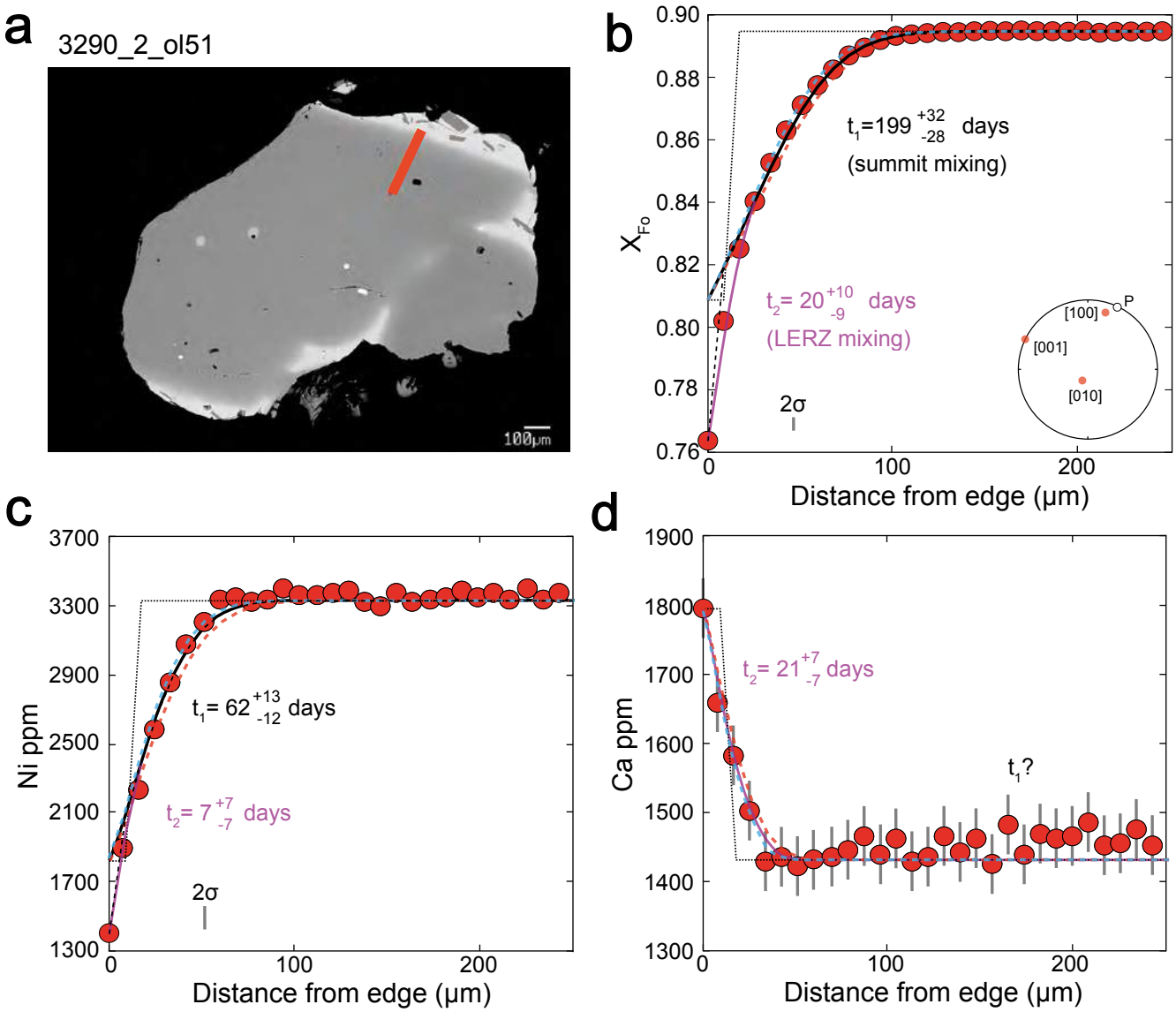
Supplementary Fig. 30: **Data, initial conditions and model fits for olivine crystal '3290_2_ol41'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit. LERZ = lower East Rift Zone.



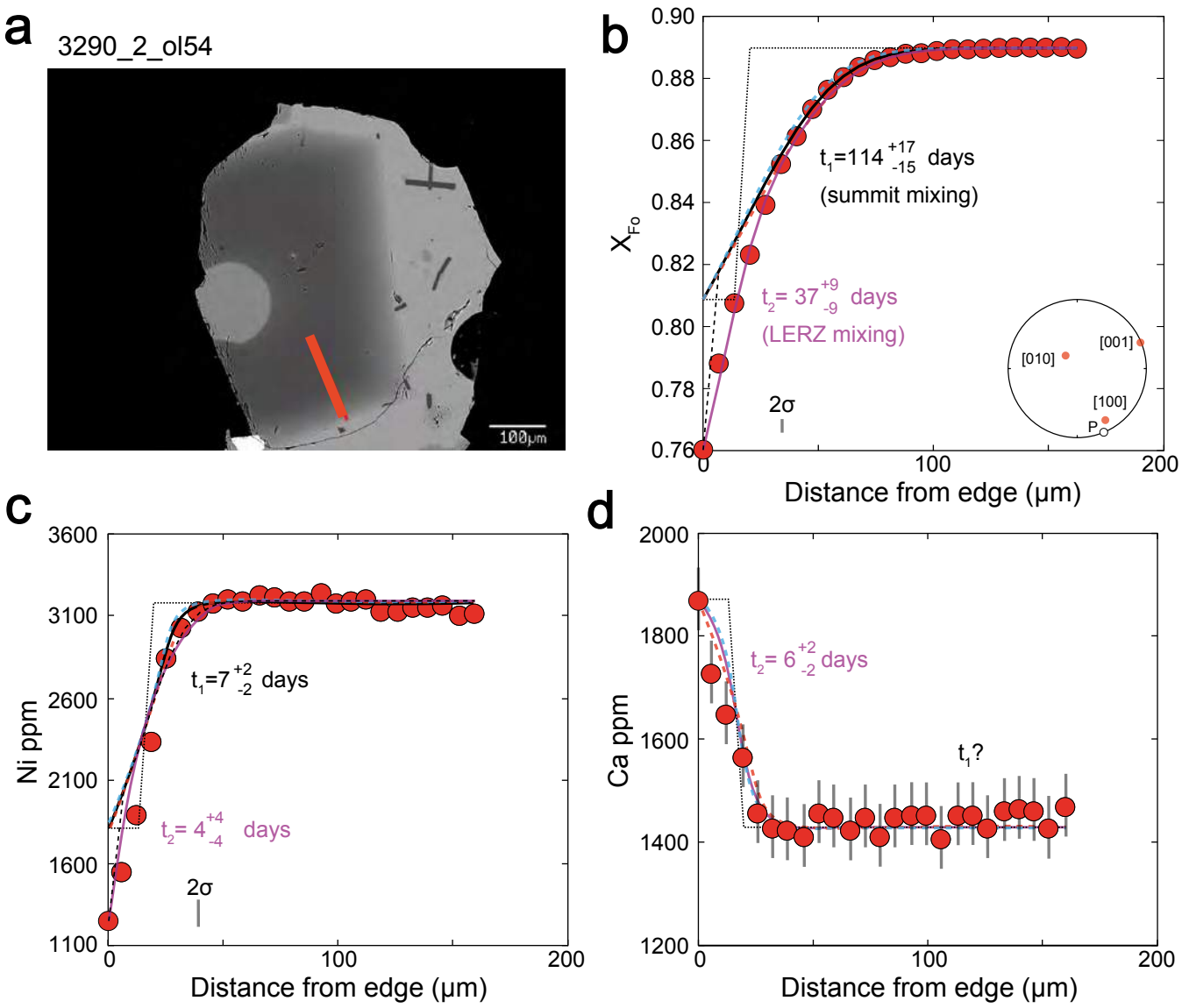
Supplementary Fig. 31: **Data, initial conditions and model fits for olivine crystal '3290_2_ol43'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit. LERZ = lower East Rift Zone.



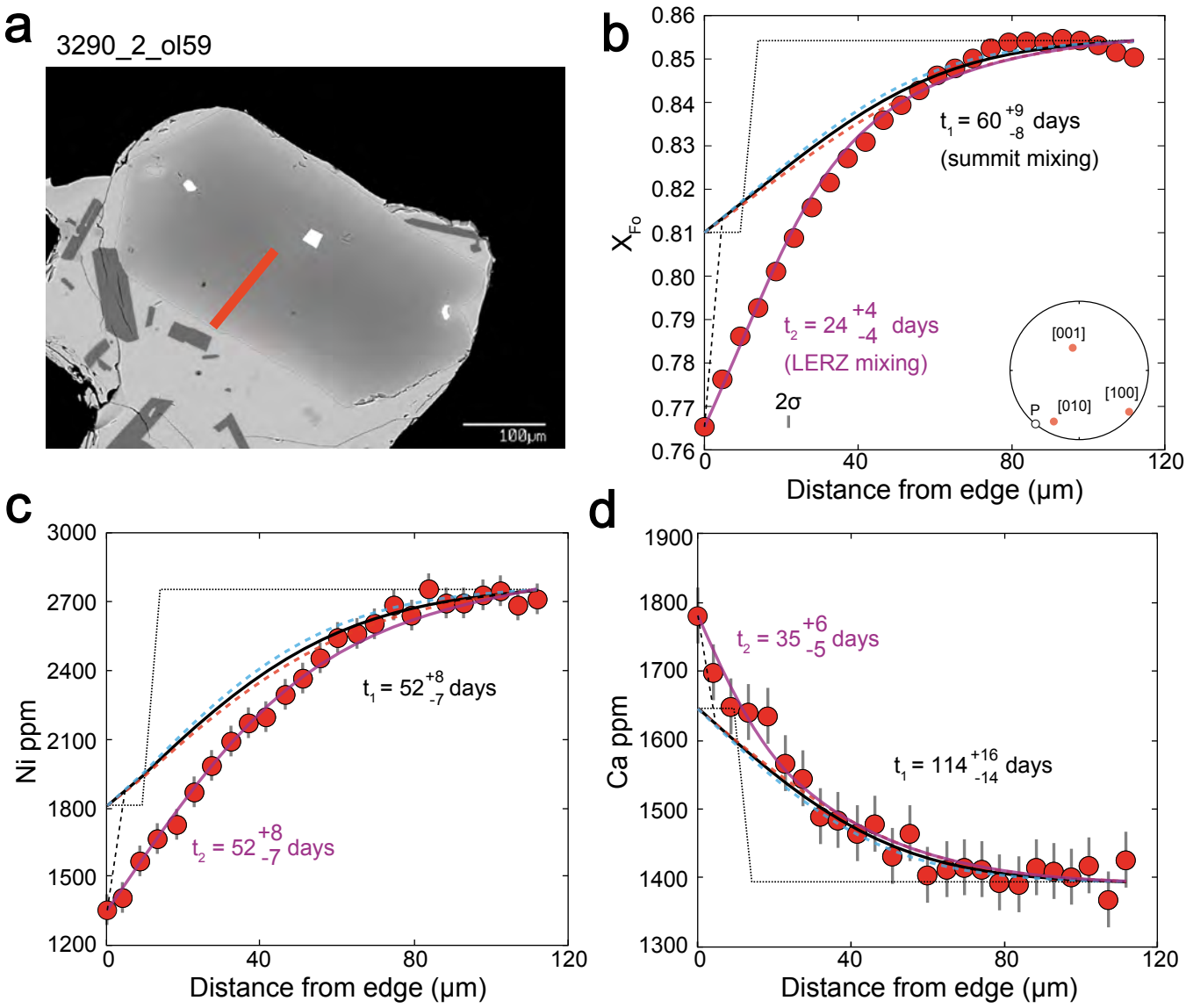
Supplementary Fig. 32: **Data, initial conditions and model fits for olivine crystal '3290_2_ol49'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. LERZ = lower East Rift Zone.



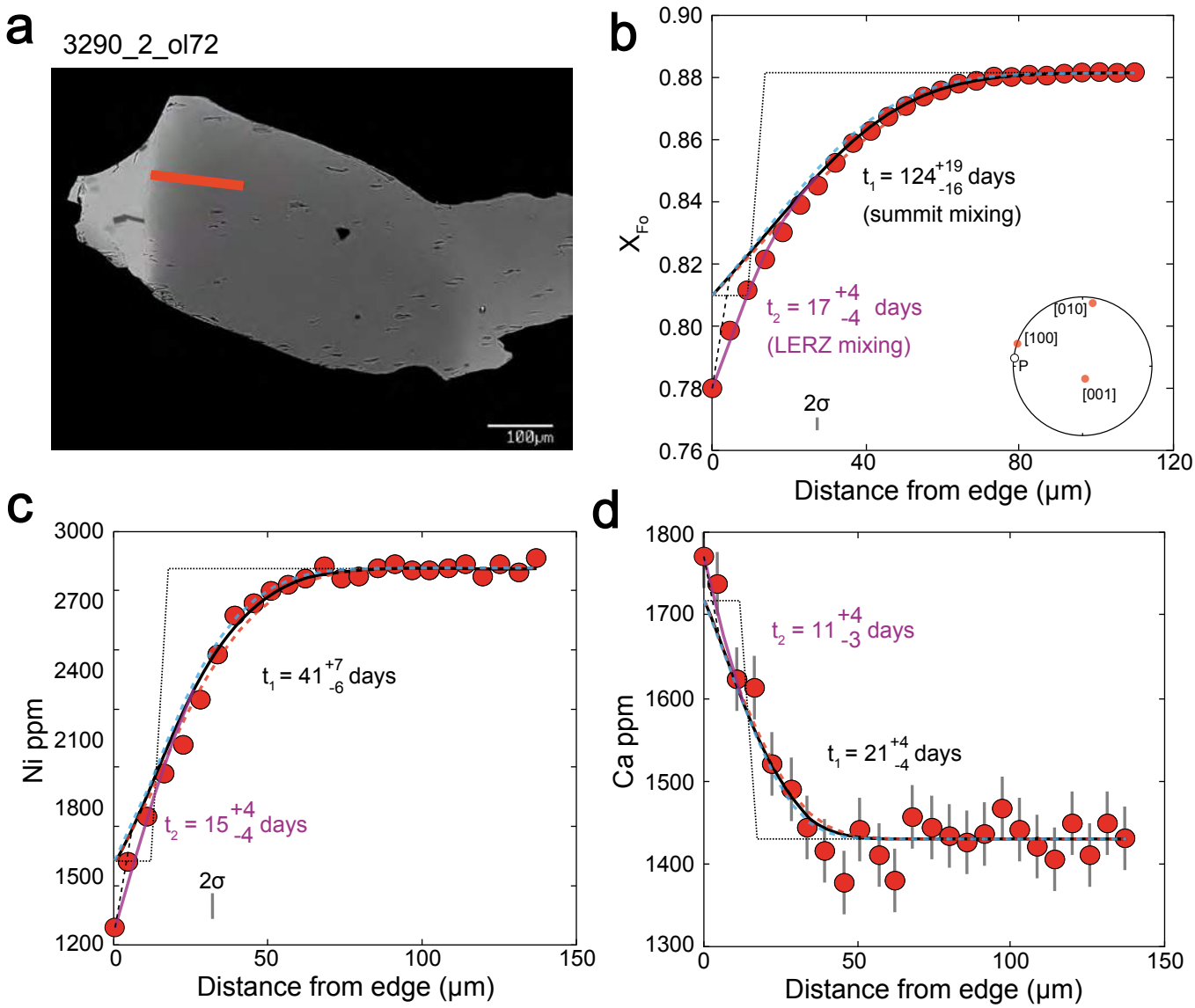
Supplementary Fig. 33: **Data, initial conditions and model fits for olivine crystal '3290_2_ol51'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit. LERZ = lower East Rift Zone.



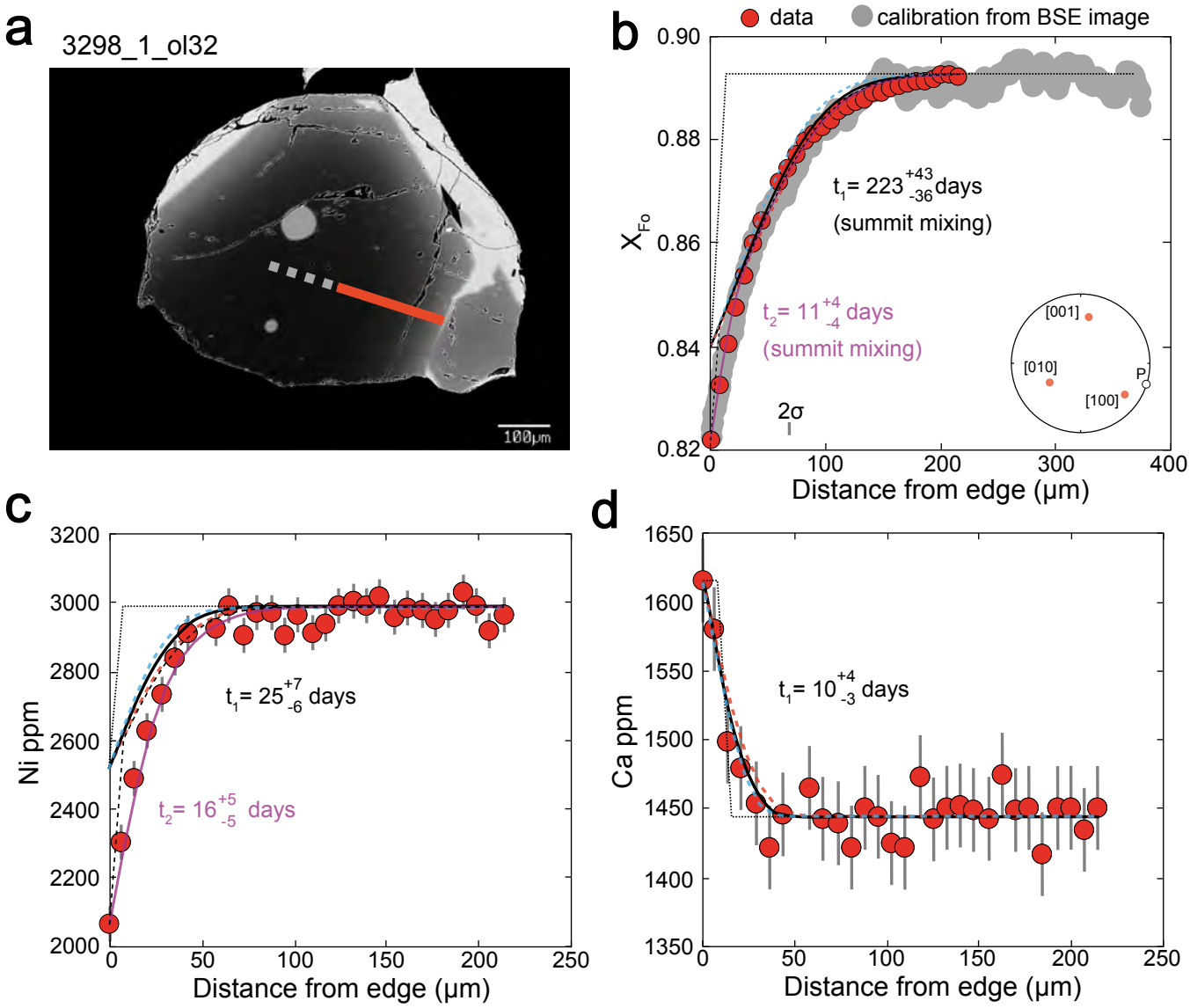
Supplementary Fig. 34: **Data, initial conditions and model fits for olivine crystal '3290_2_ol54'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit. LERZ = lower East Rift Zone.



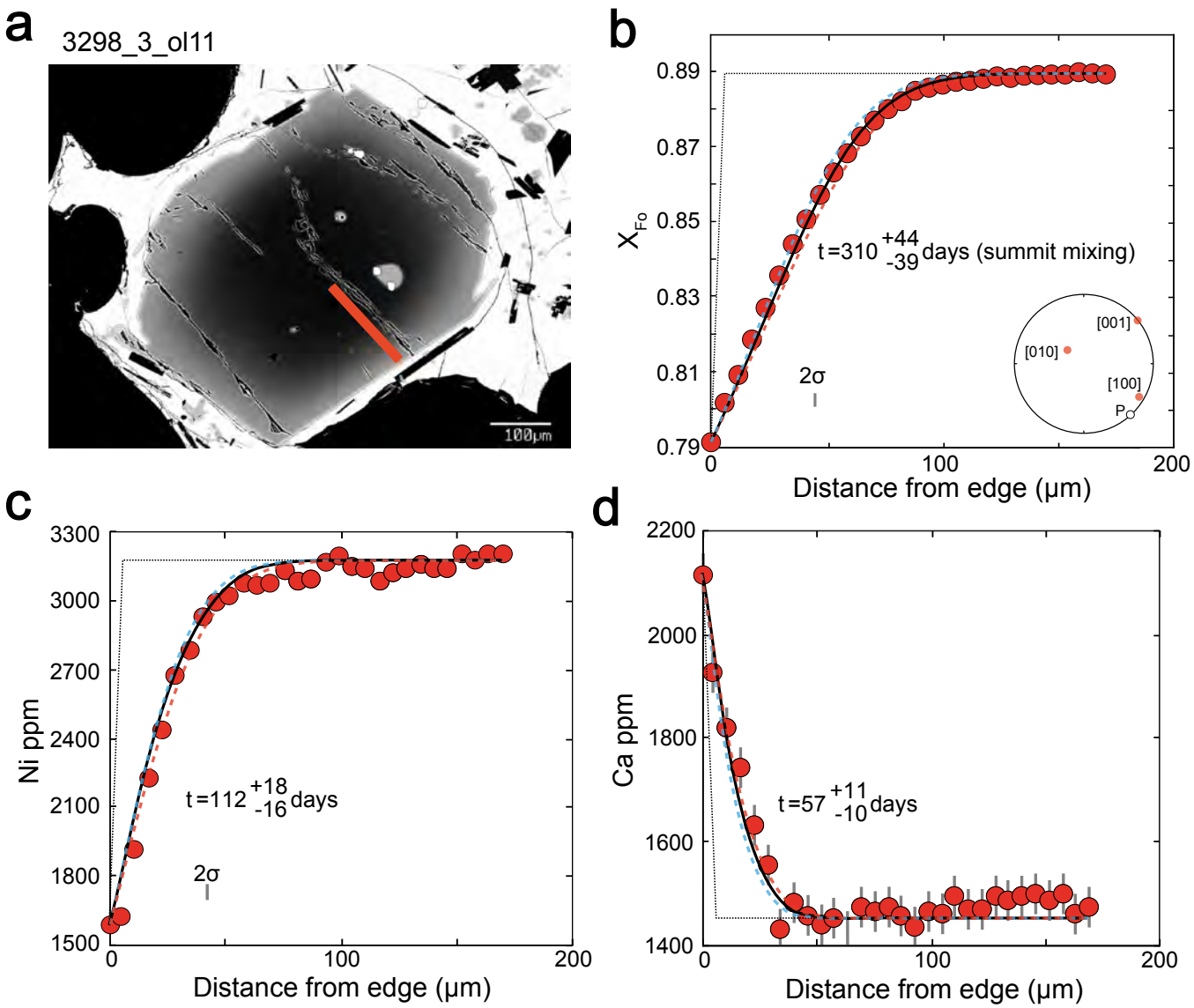
Supplementary Fig. 35: **Data, initial conditions and model fits for olivine crystal '3290_2_ol59'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit. LERZ = lower East Rift Zone.



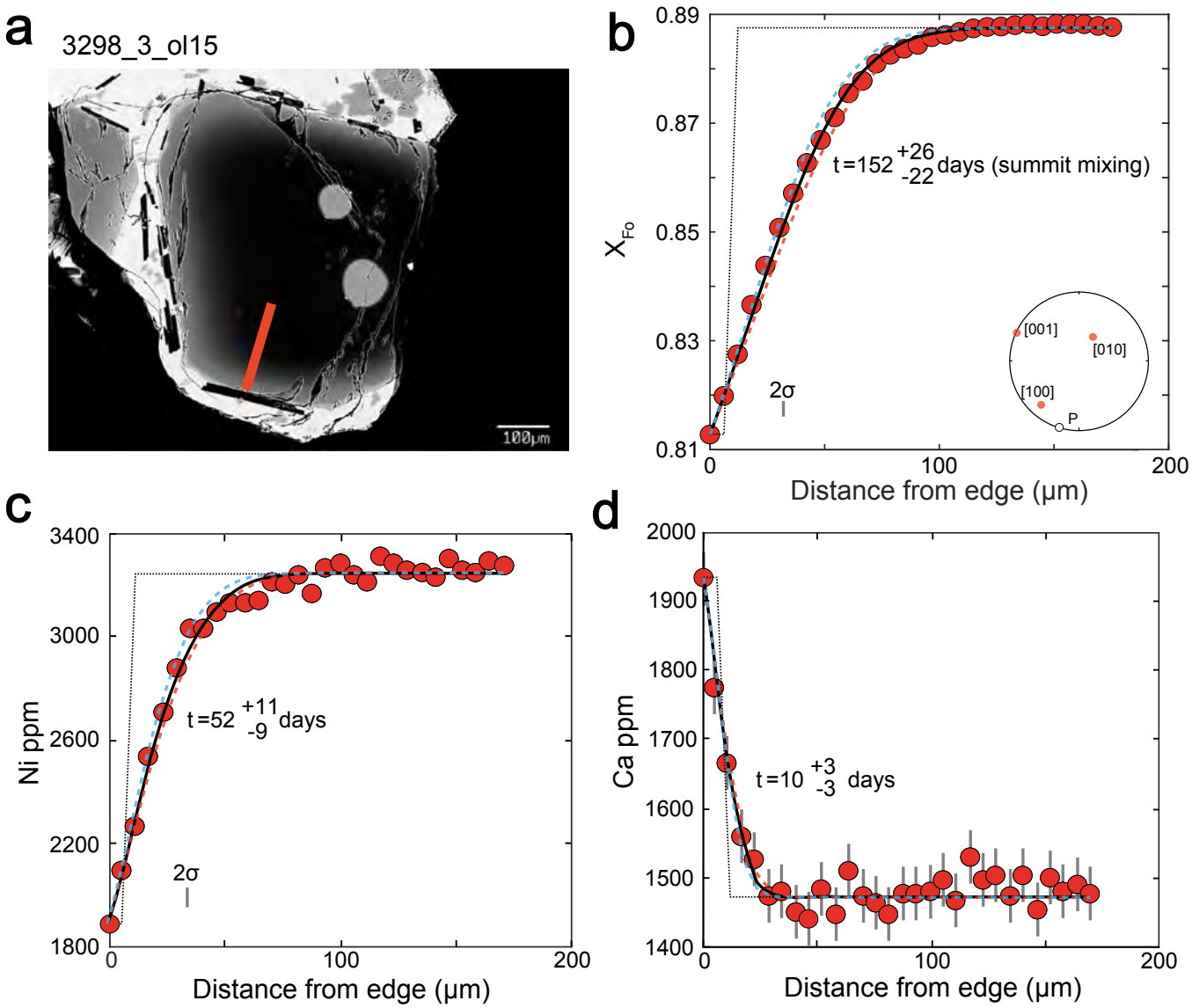
Supplementary Fig. 36: **Data, initial conditions and model fits for olivine crystal '3290_2_ol72'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit. LERZ = lower East Rift Zone.



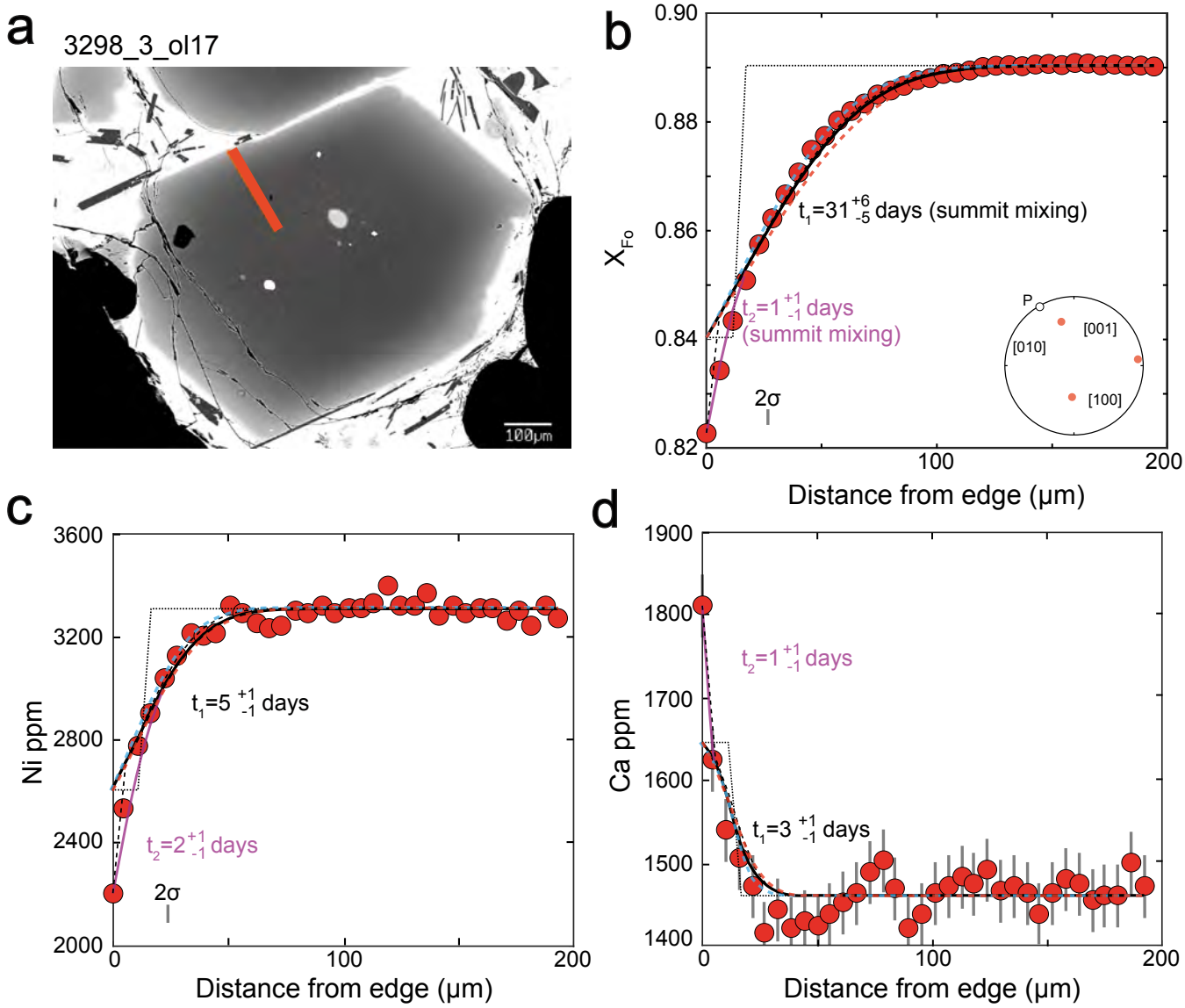
Supplementary Fig. 37: **Data, initial conditions and model fits for olivine crystal '3298_1_ol32'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit.



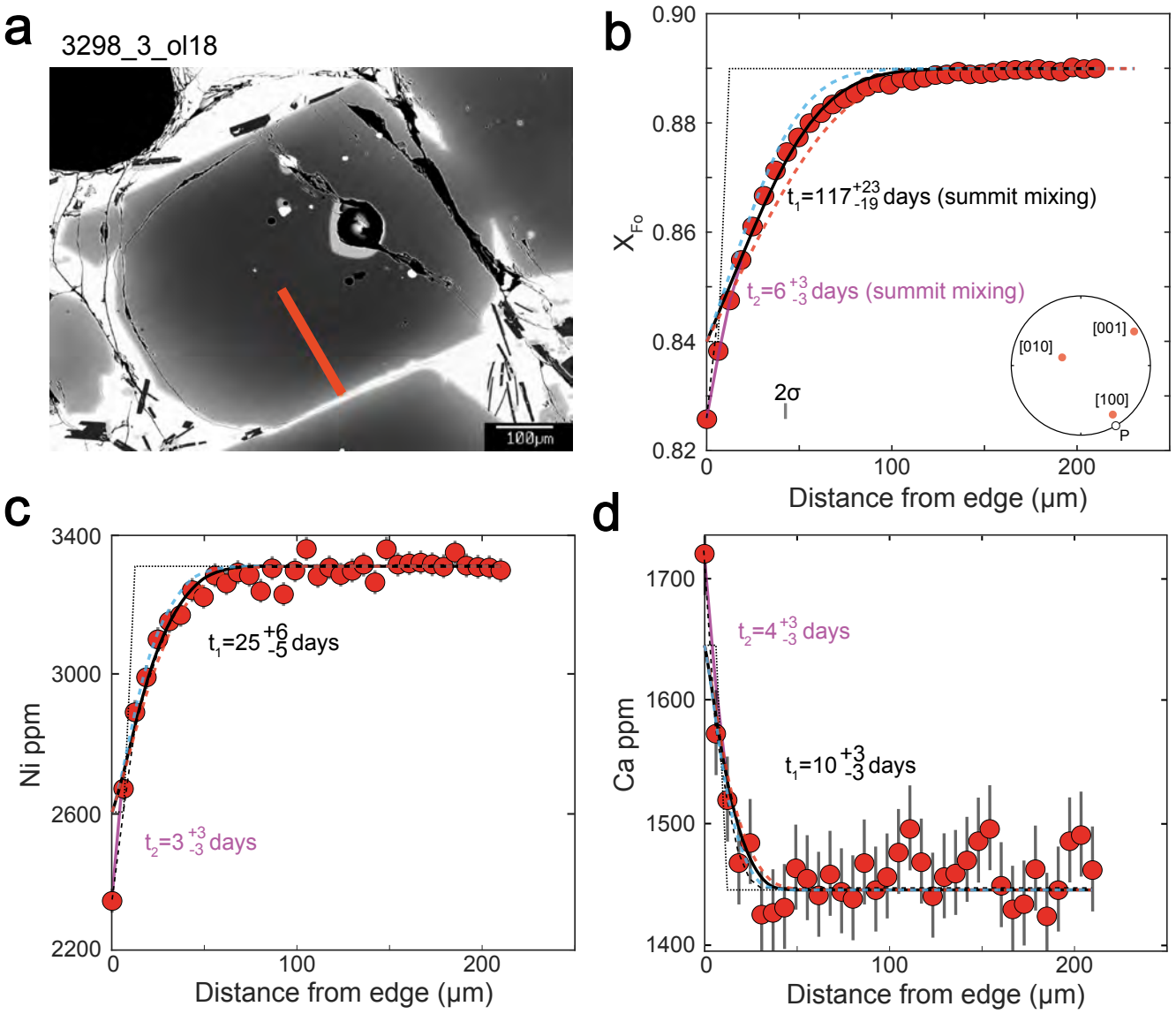
Supplementary Fig. 38: **Data, initial conditions and model fits for olivine crystal '3298_3_ol11'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



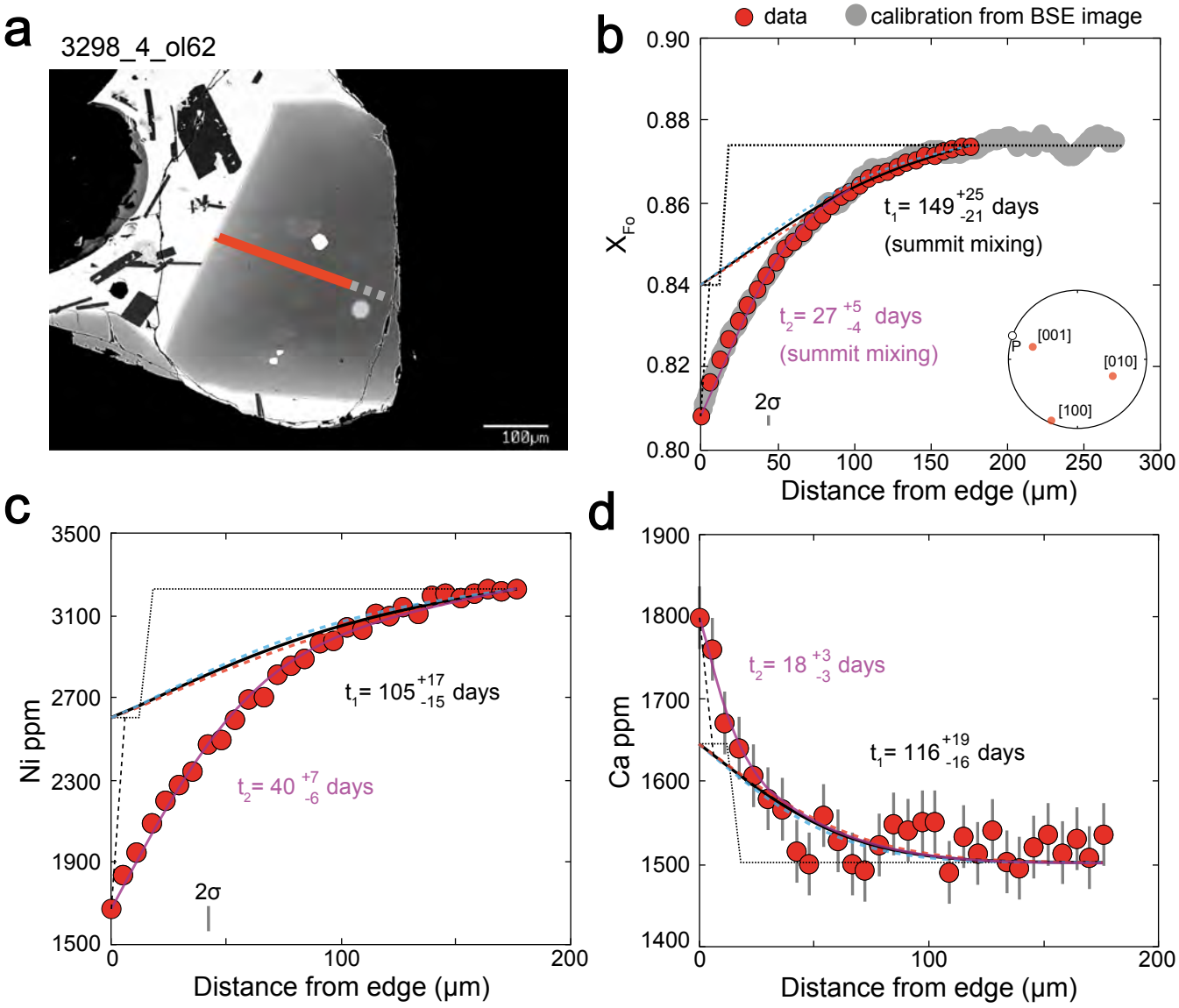
Supplementary Fig. 39: **Data, initial conditions and model fits for olivine crystal '3298_3_ol15'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



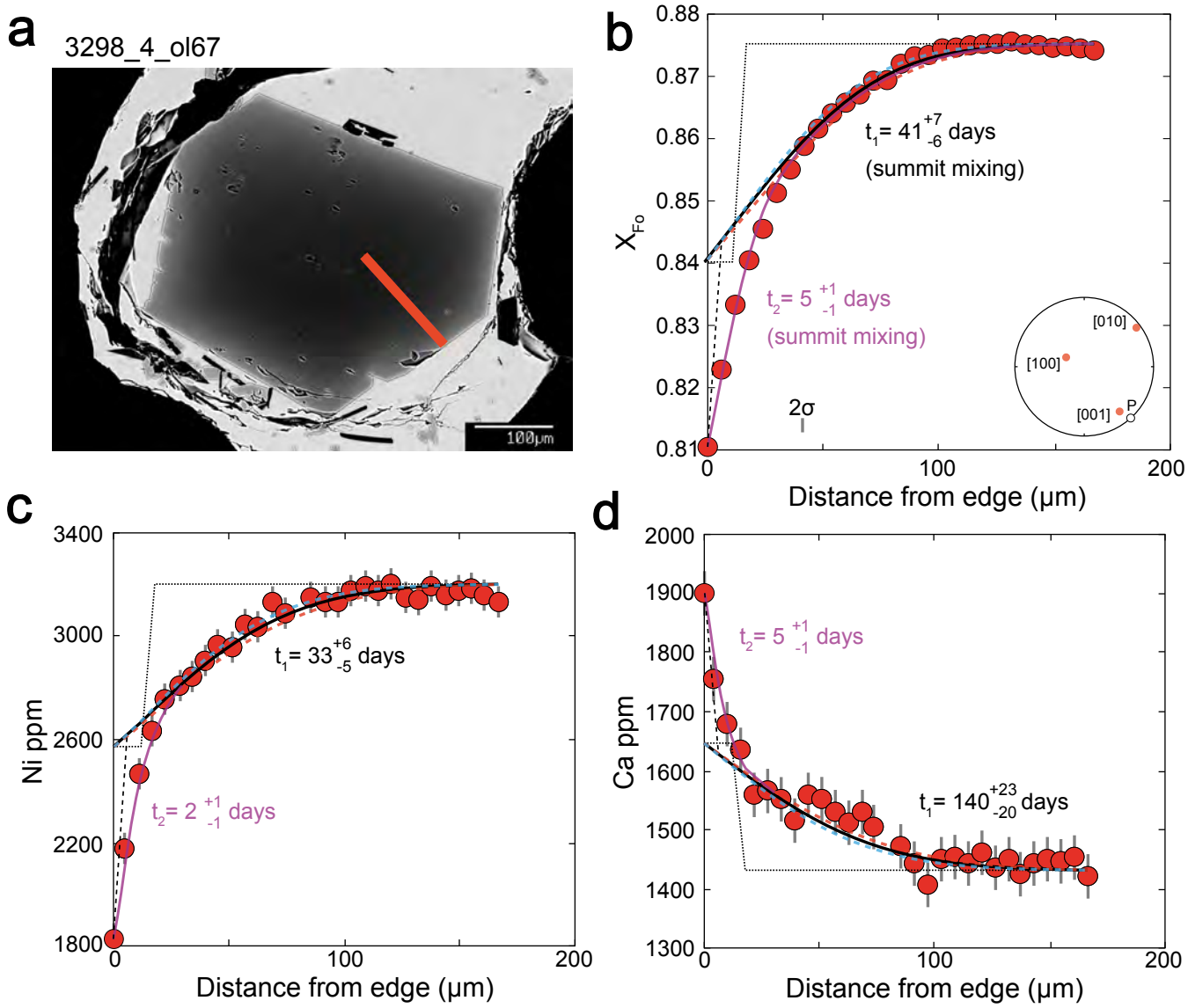
Supplementary Fig. 40: **Data, initial conditions and model fits for olivine crystal '3298_3_ol17'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit.



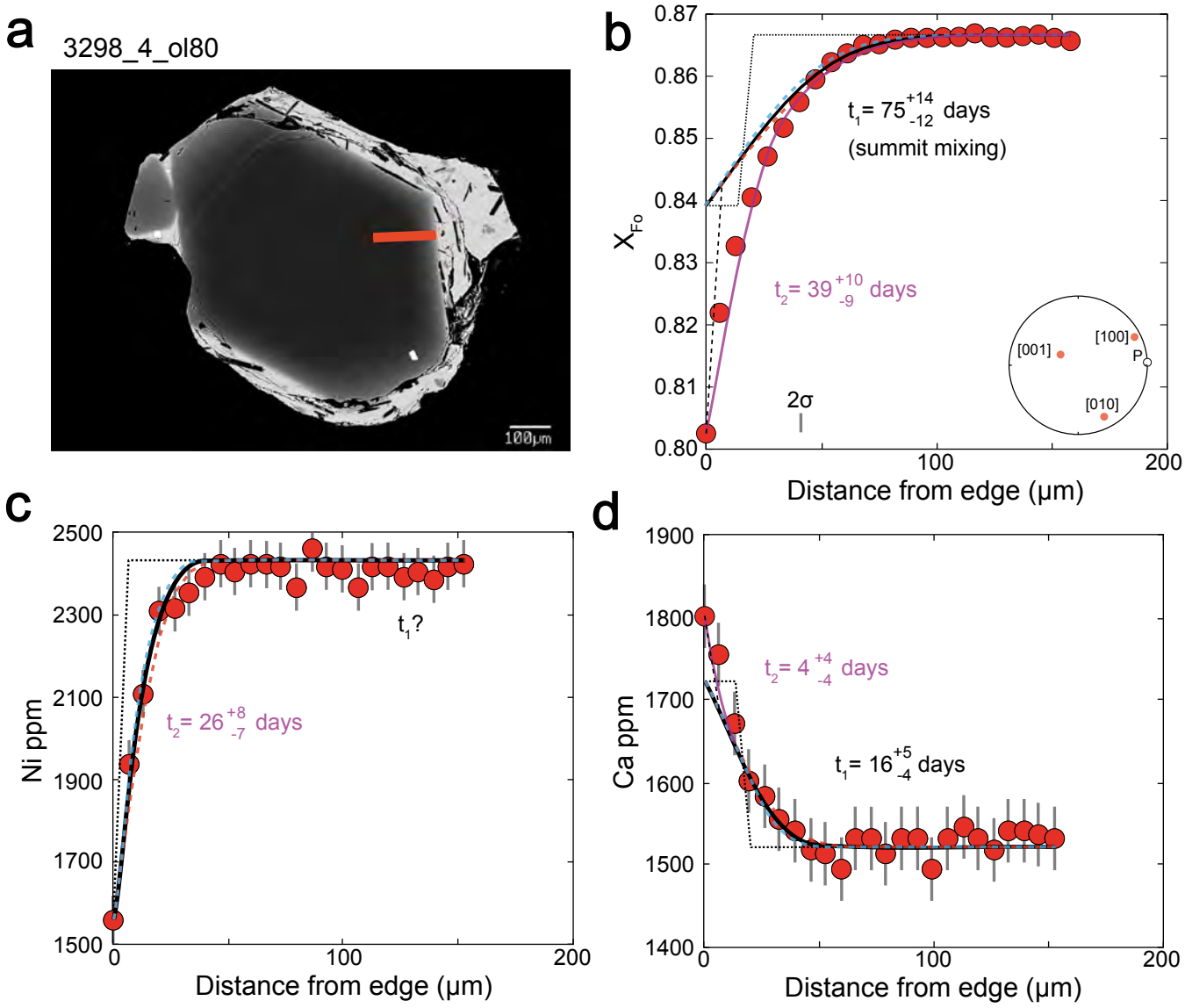
Supplementary Fig. 41: **Data, initial conditions and model fits for olivine crystal '3298_3_ol18'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit.



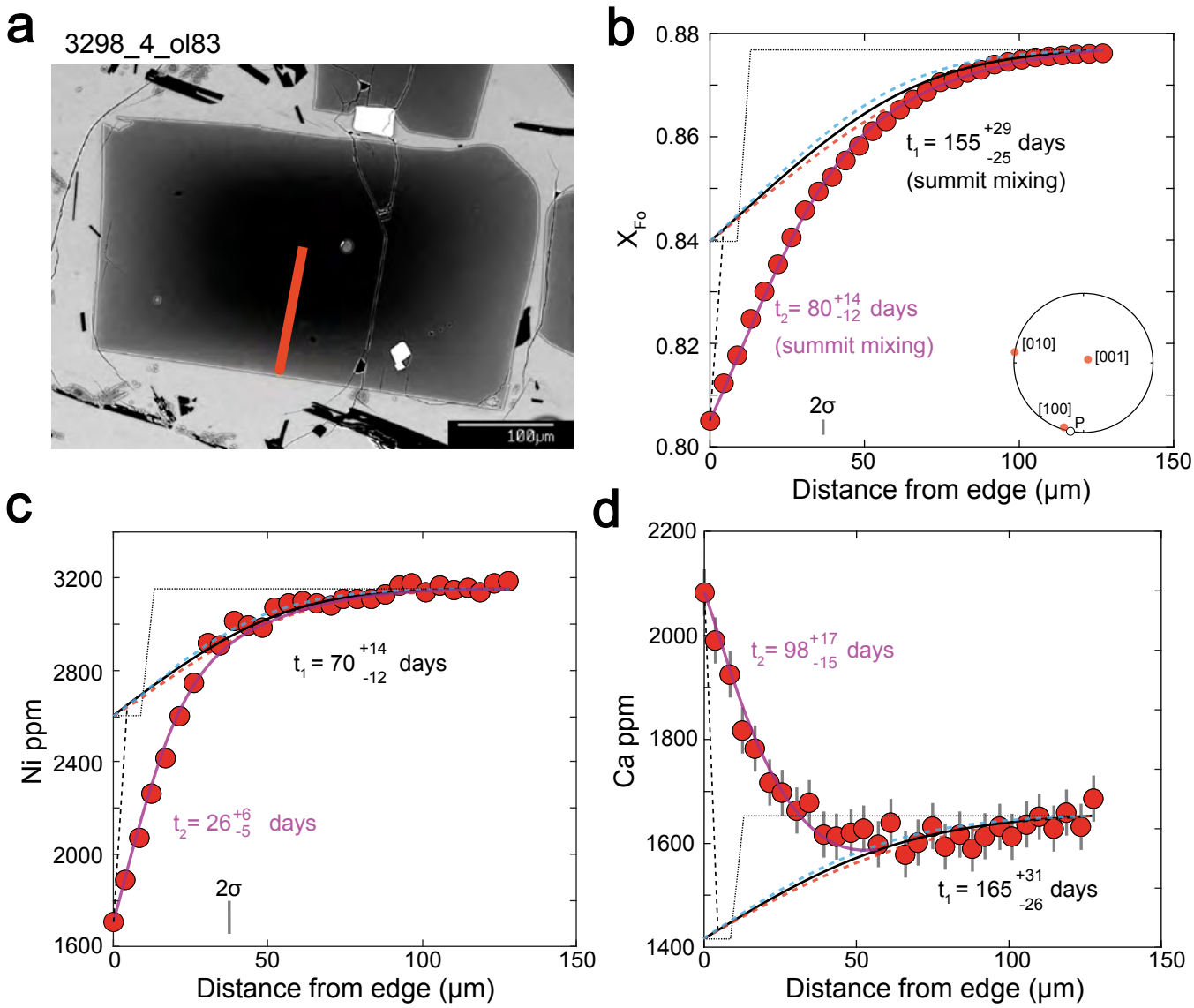
Supplementary Fig. 42: **Data, initial conditions and model fits for olivine crystal '3298_4_ol62'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit.



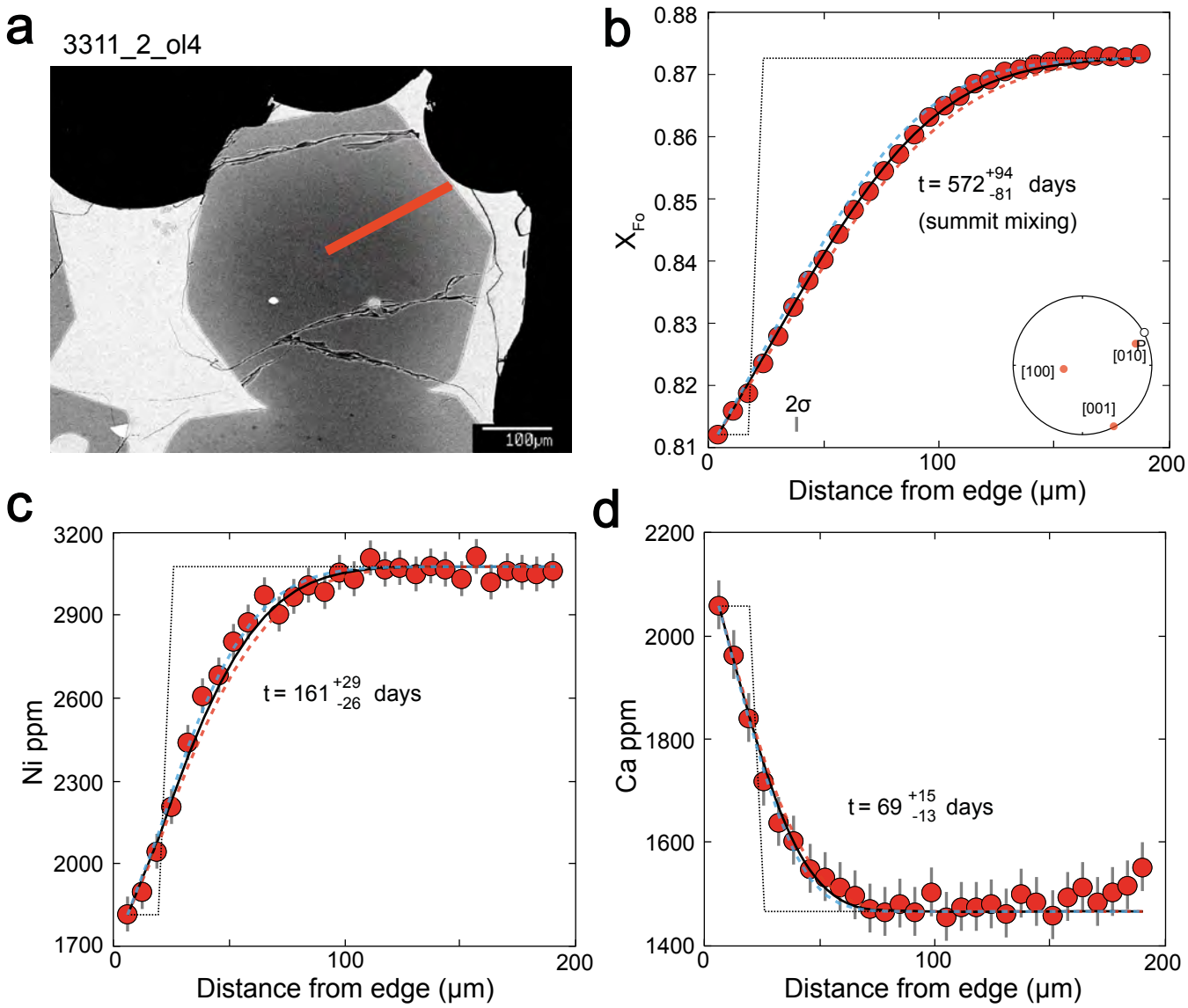
Supplementary Fig. 43: **Data, initial conditions and model fits for olivine crystal '3298_4_ol67'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit.



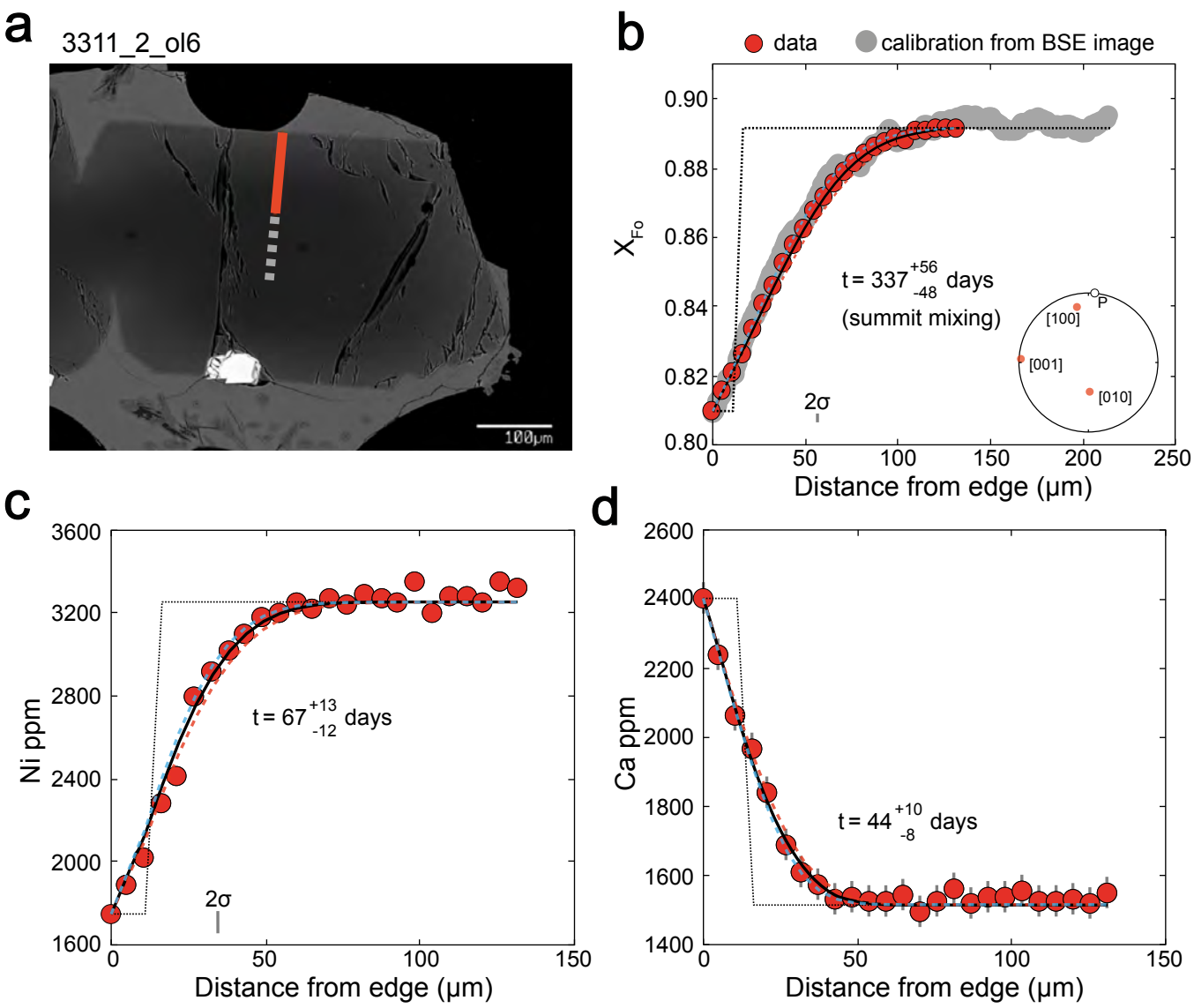
Supplementary Fig. 44: **Data, initial conditions and model fits for olivine crystal '3298_4_ol80'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit.



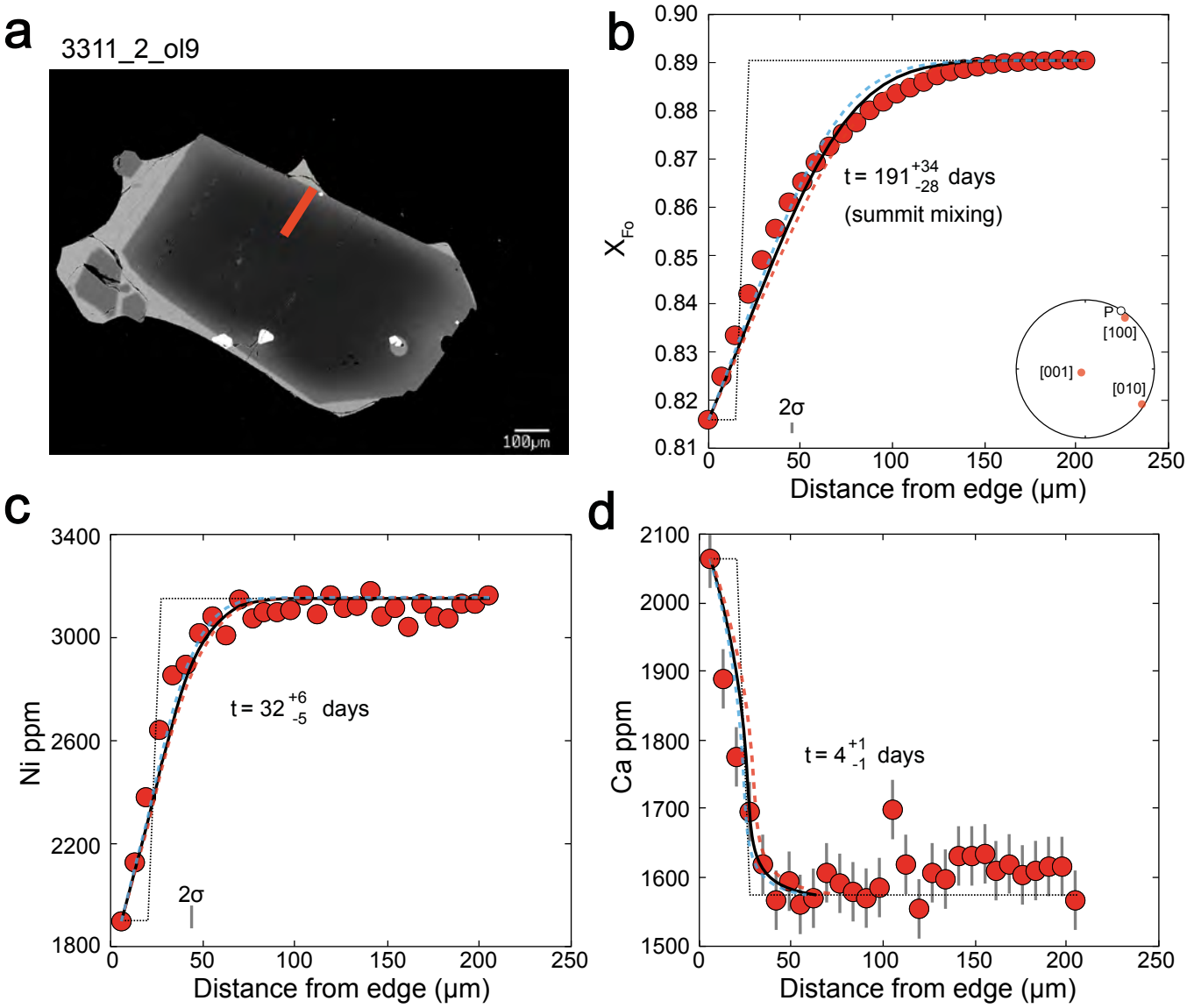
Supplementary Fig. 45: **Data, initial conditions and model fits for olivine crystal '3298_4_ol83'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit.



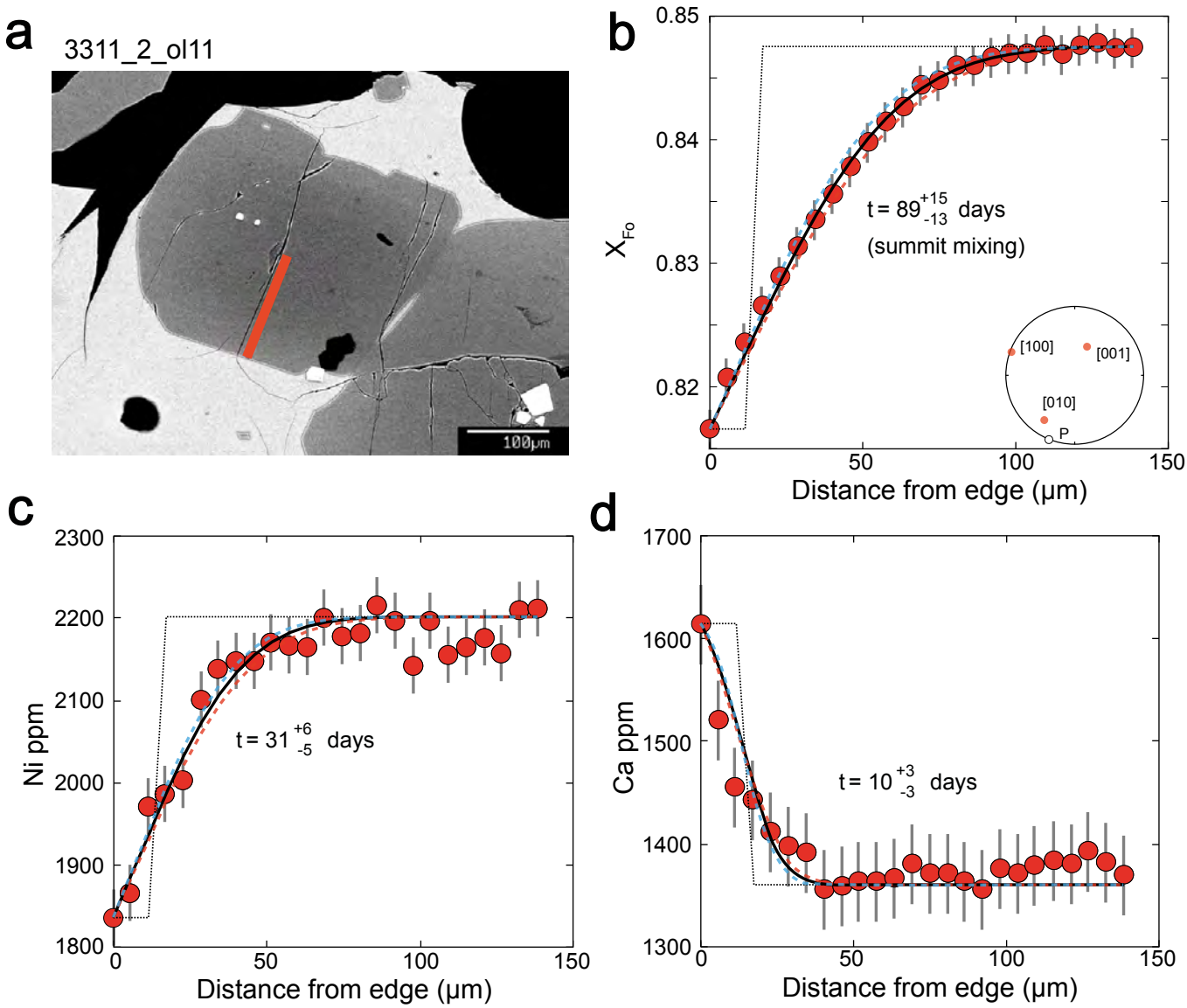
Supplementary Fig. 46: **Data, initial conditions and model fits for olivine crystal '3311_2_ol4'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



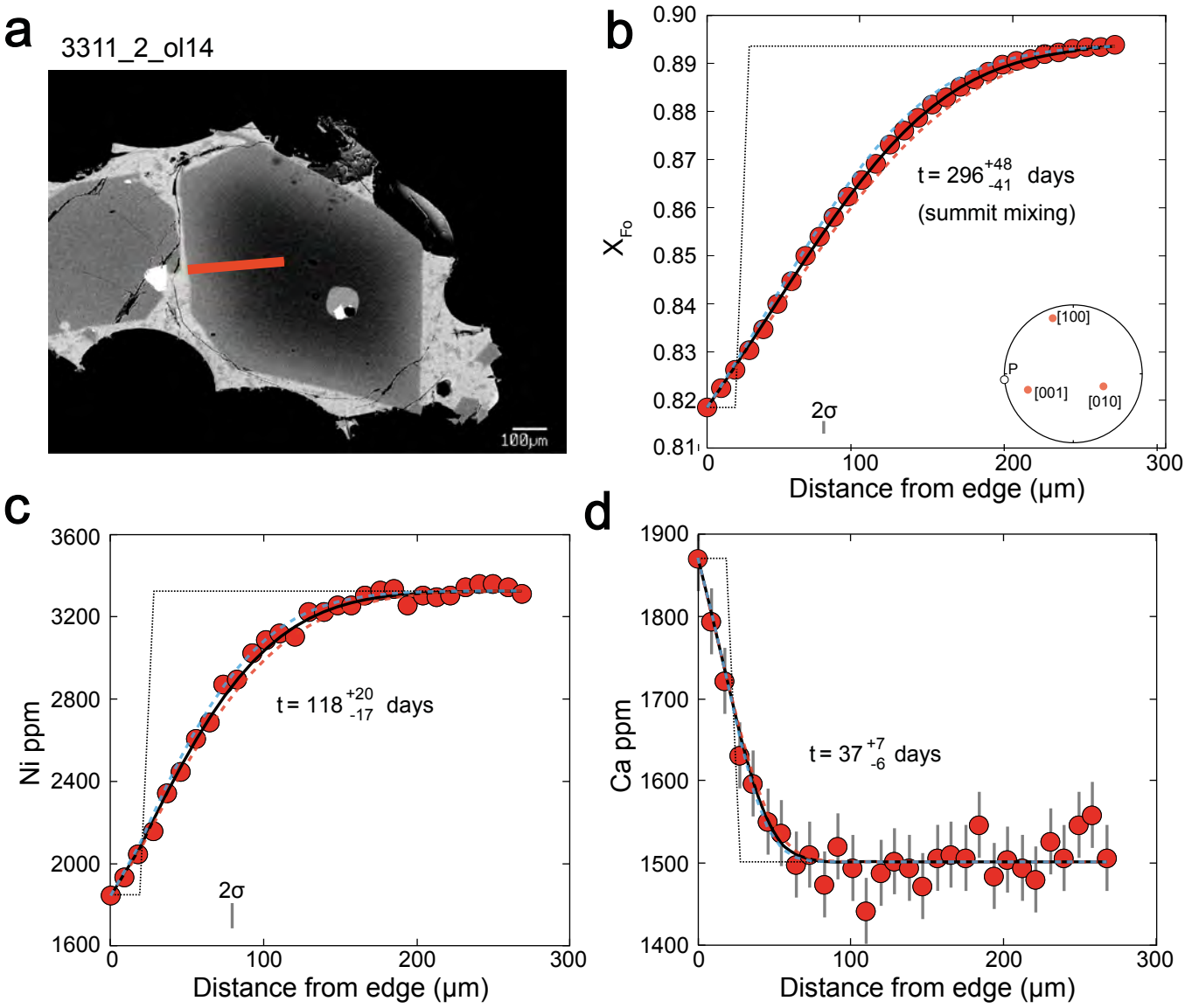
Supplementary Fig. 47: **Data, initial conditions and model fits for olivine crystal '3311_2_ol6'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



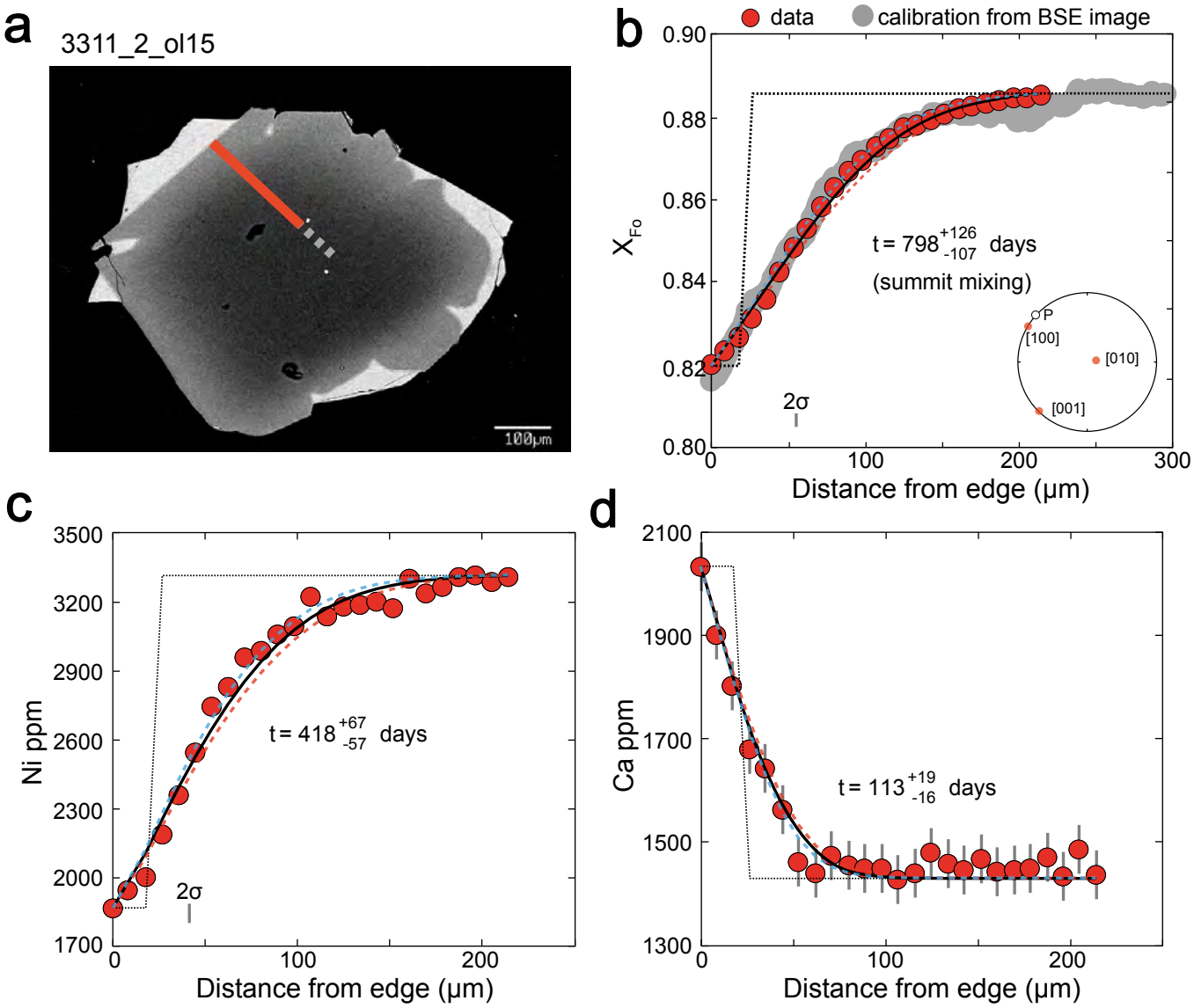
Supplementary Fig. 48: **Data, initial conditions and model fits for olivine crystal '3311_2_ol9'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



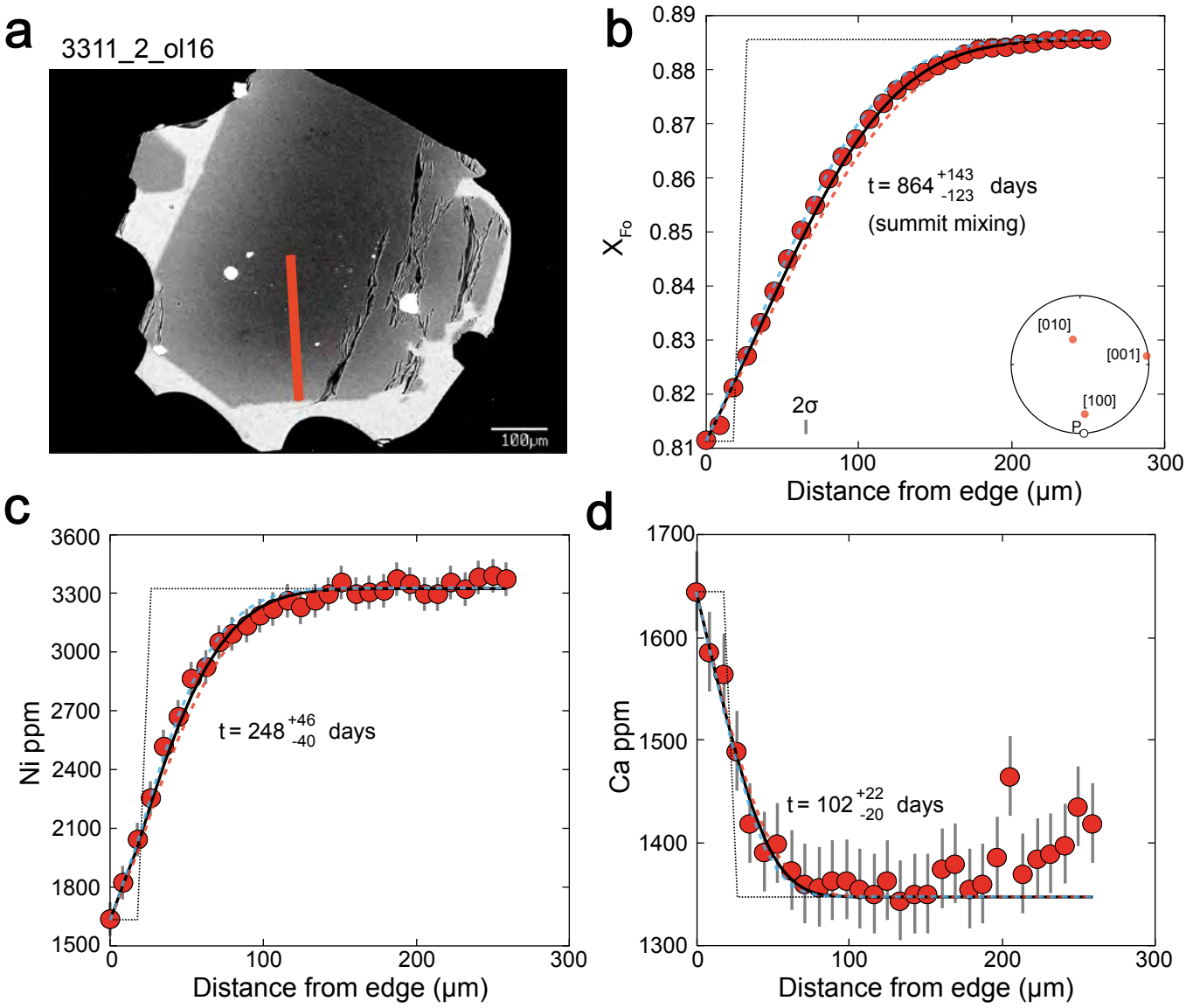
Supplementary Fig. 49: **Data, initial conditions and model fits for olivine crystal '3311_2_ol11'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



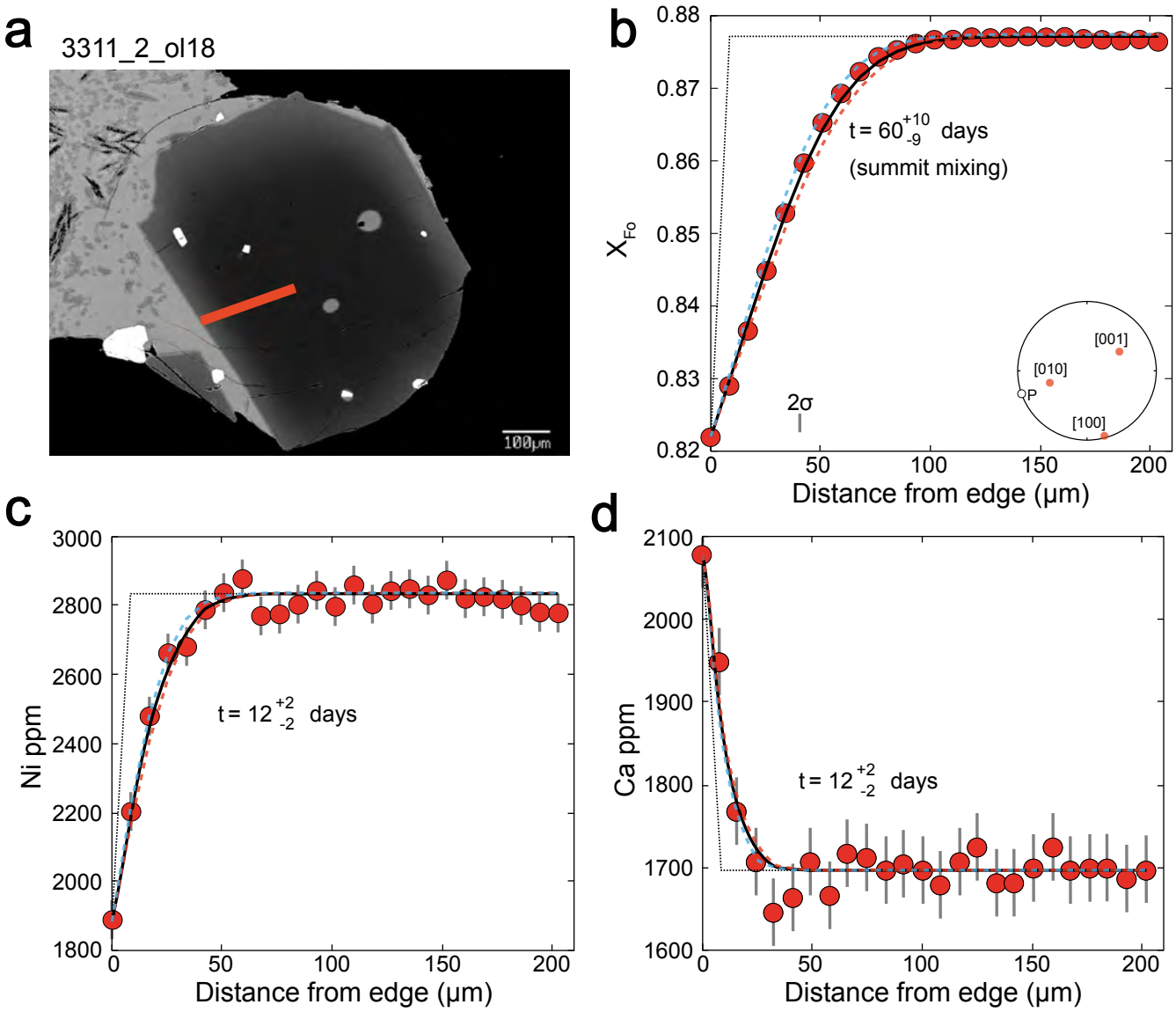
Supplementary Fig. 50: **Data, initial conditions and model fits for olivine crystal '3311_2_ol14'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



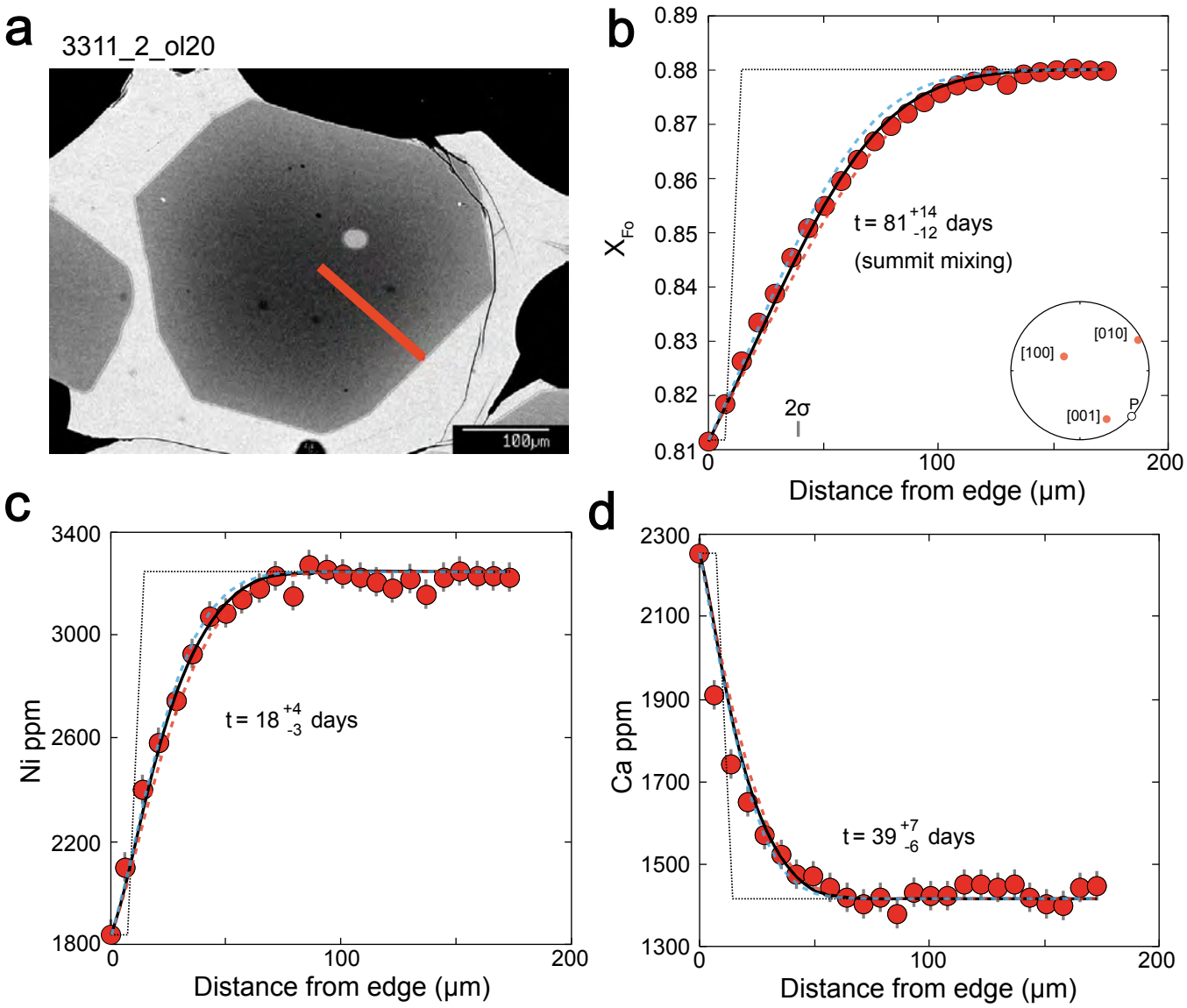
Supplementary Fig. 51: **Data, initial conditions and model fits for olivine crystal '3311_2_ol15'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



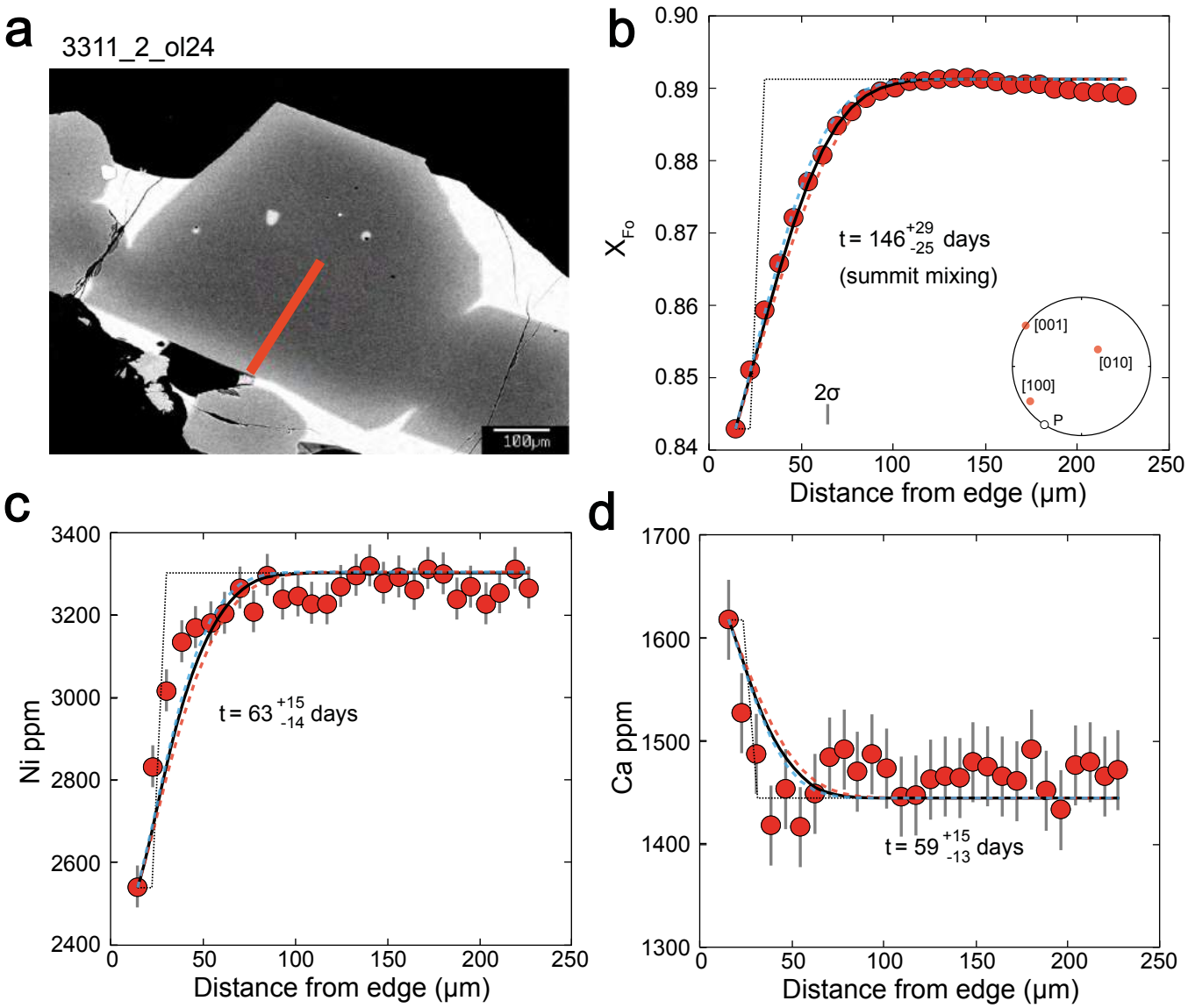
Supplementary Fig. 52: **Data, initial conditions and model fits for olivine crystal '3311_2_ol16'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



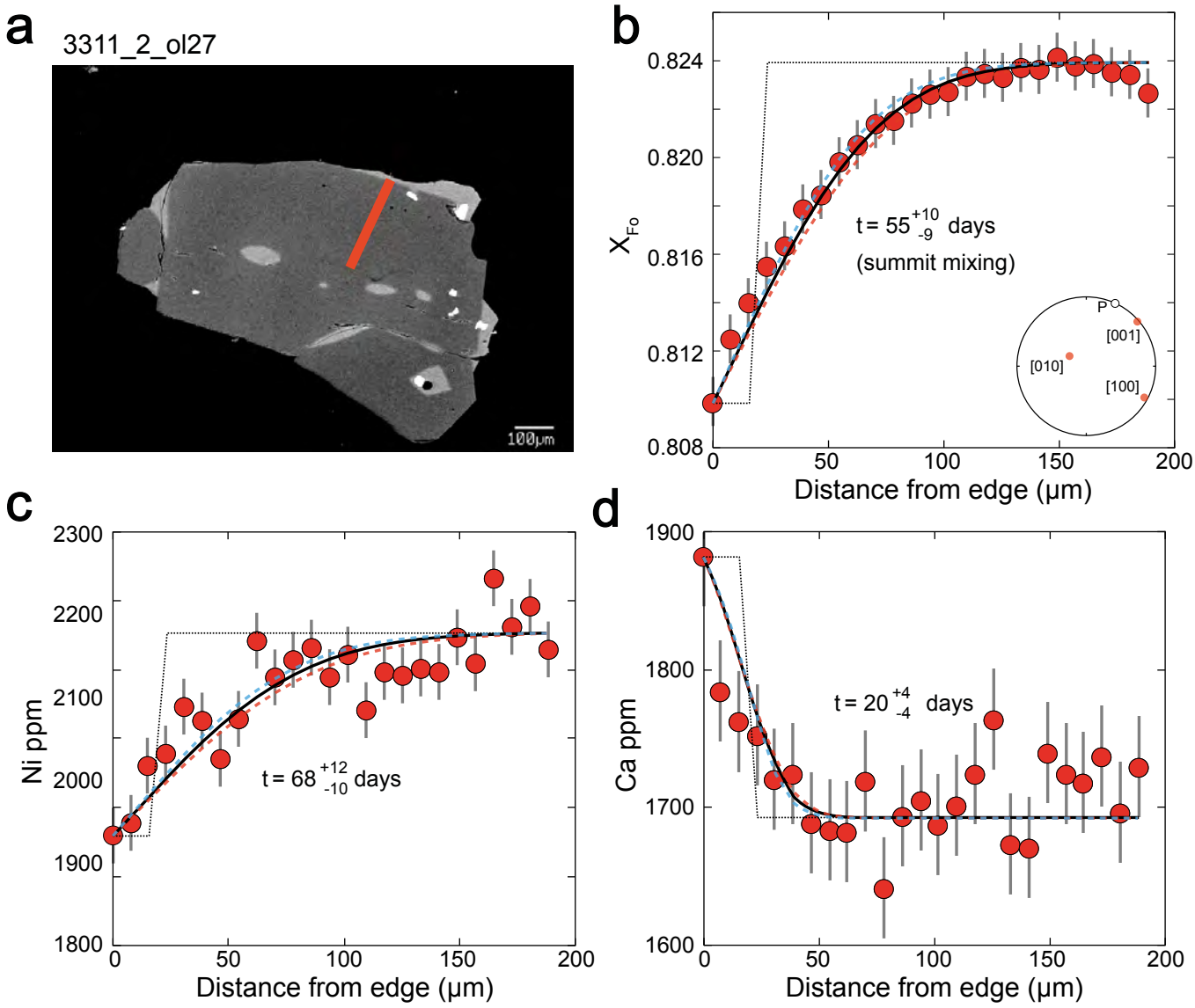
Supplementary Fig. 53: **Data, initial conditions and model fits for olivine crystal '3311_2_ol18'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



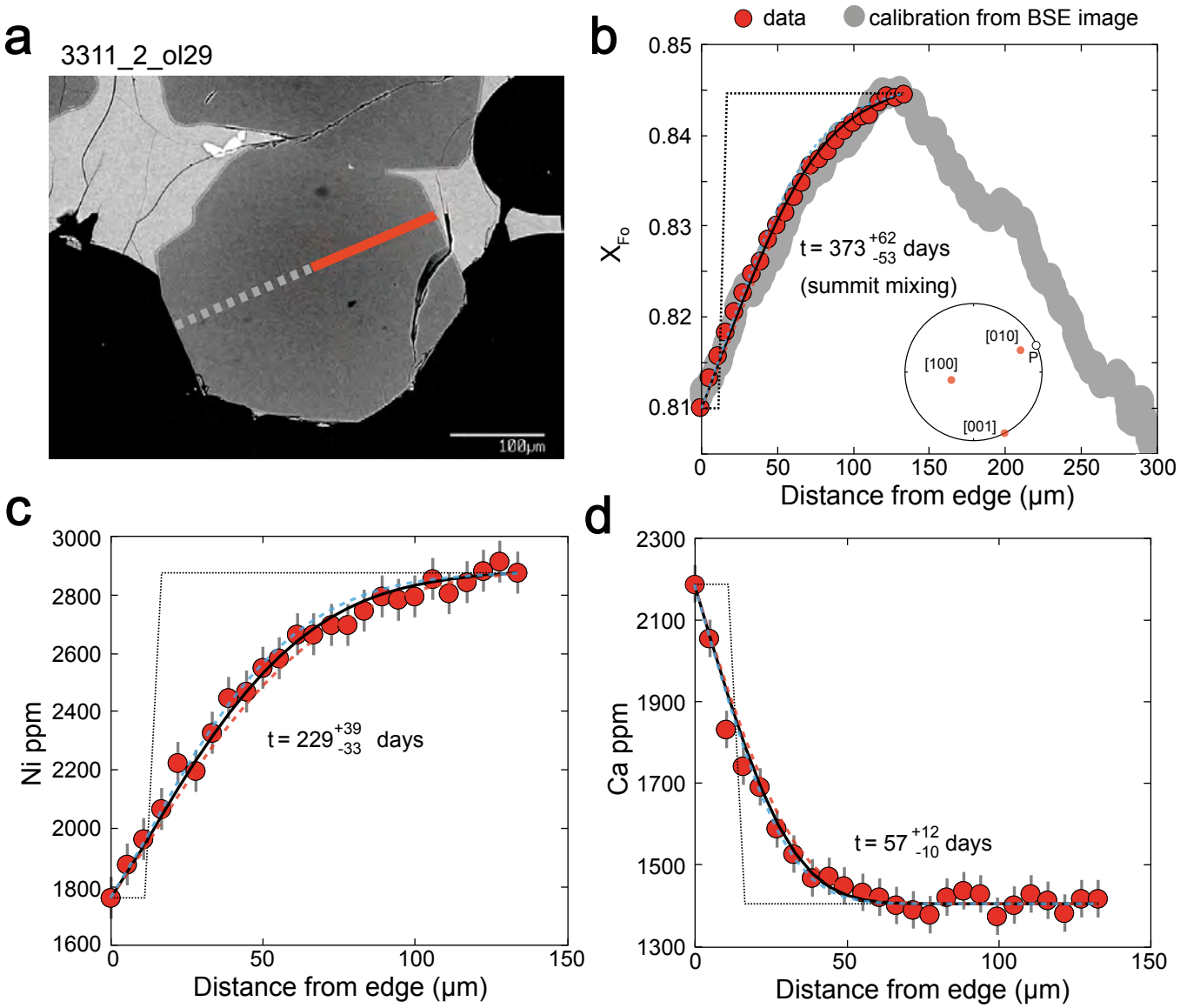
Supplementary Fig. 54: **Data, initial conditions and model fits for olivine crystal '3311_2_ol20'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



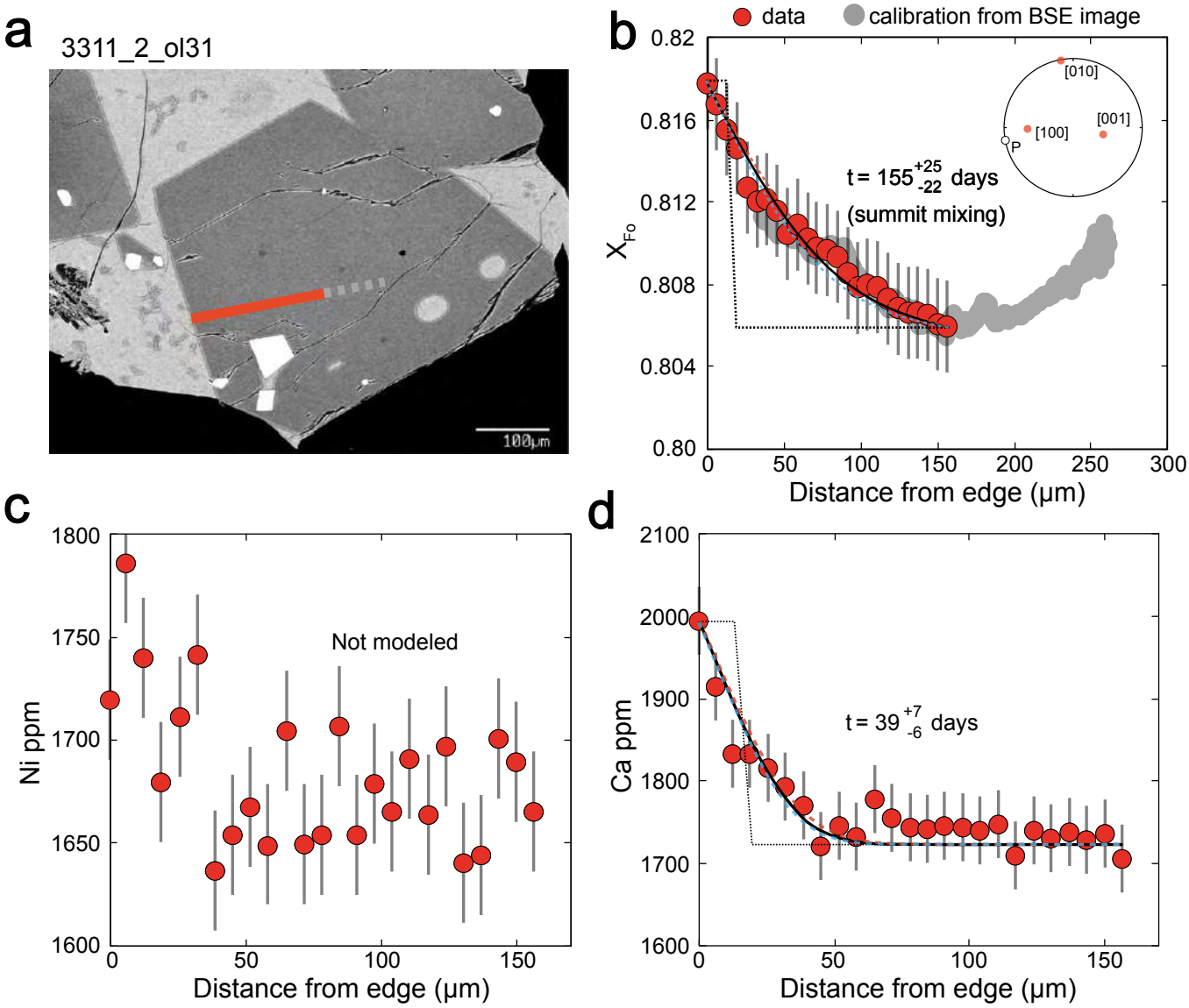
Supplementary Fig. 55: **Data, initial conditions and model fits for olivine crystal '3311_2_ol24'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



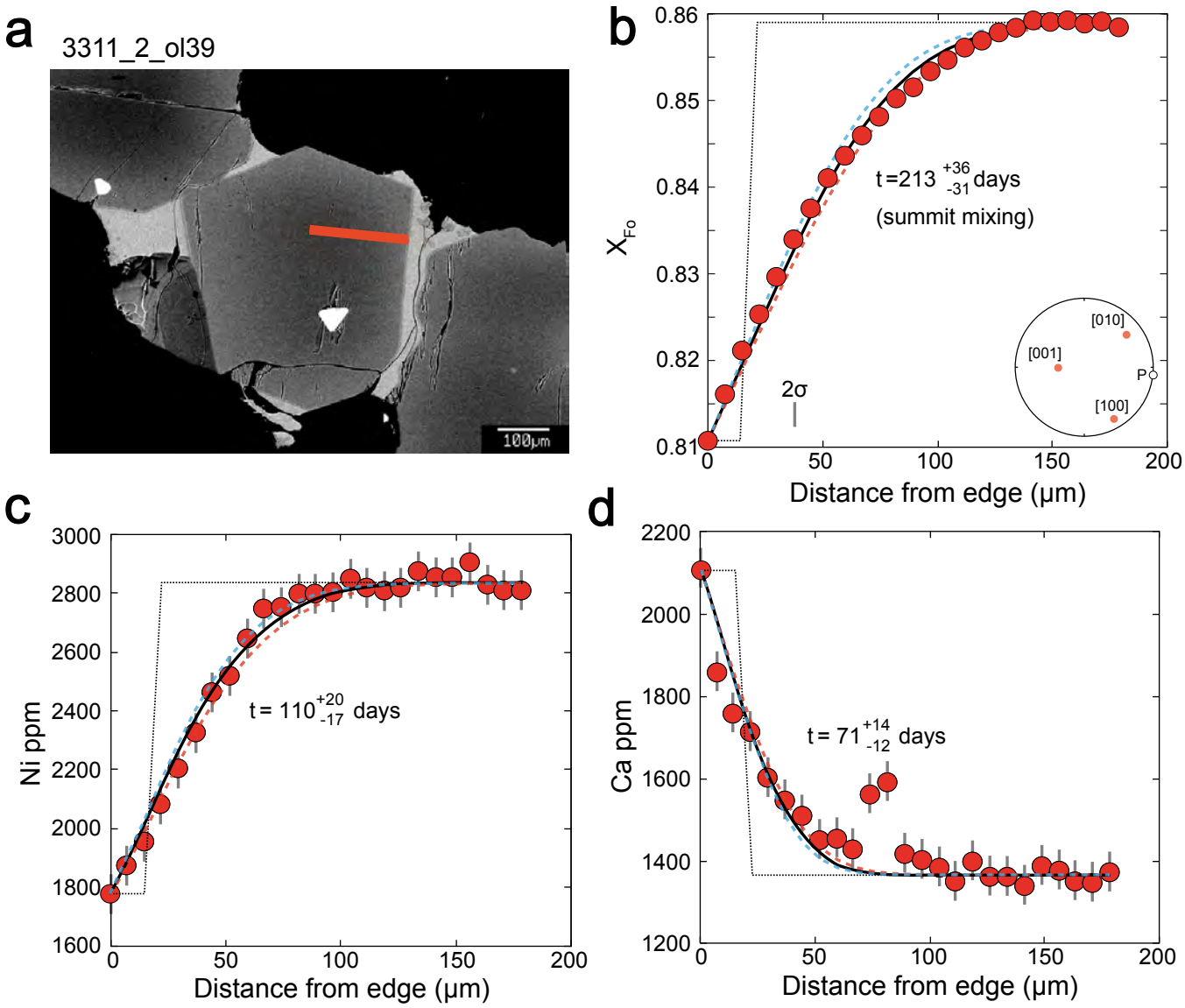
Supplementary Fig. 56: **Data, initial conditions and model fits for olivine crystal '3311_2_ol27'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



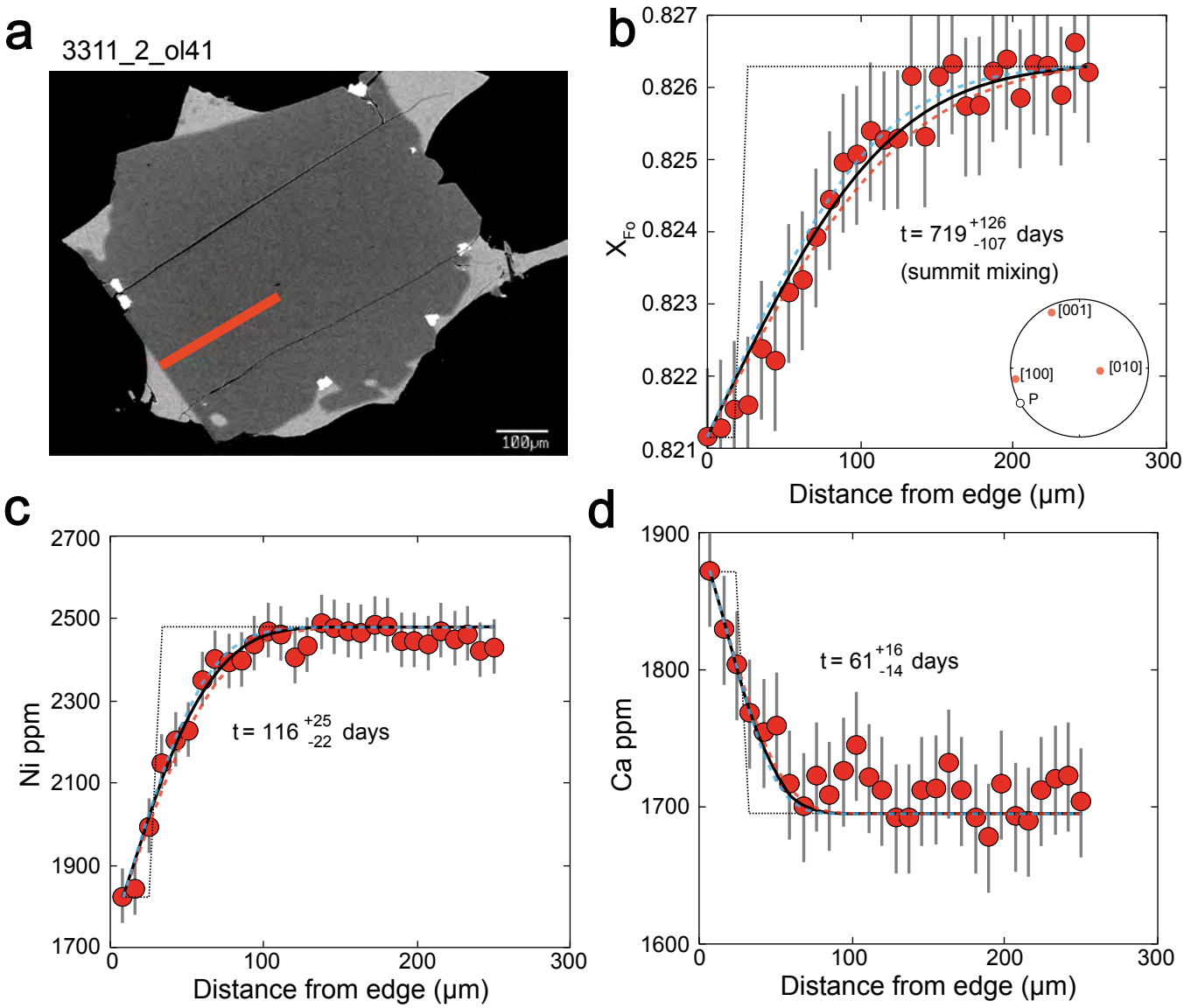
Supplementary Fig. 57: **Data, initial conditions and model fits for olivine crystal '3311_2_ol29'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



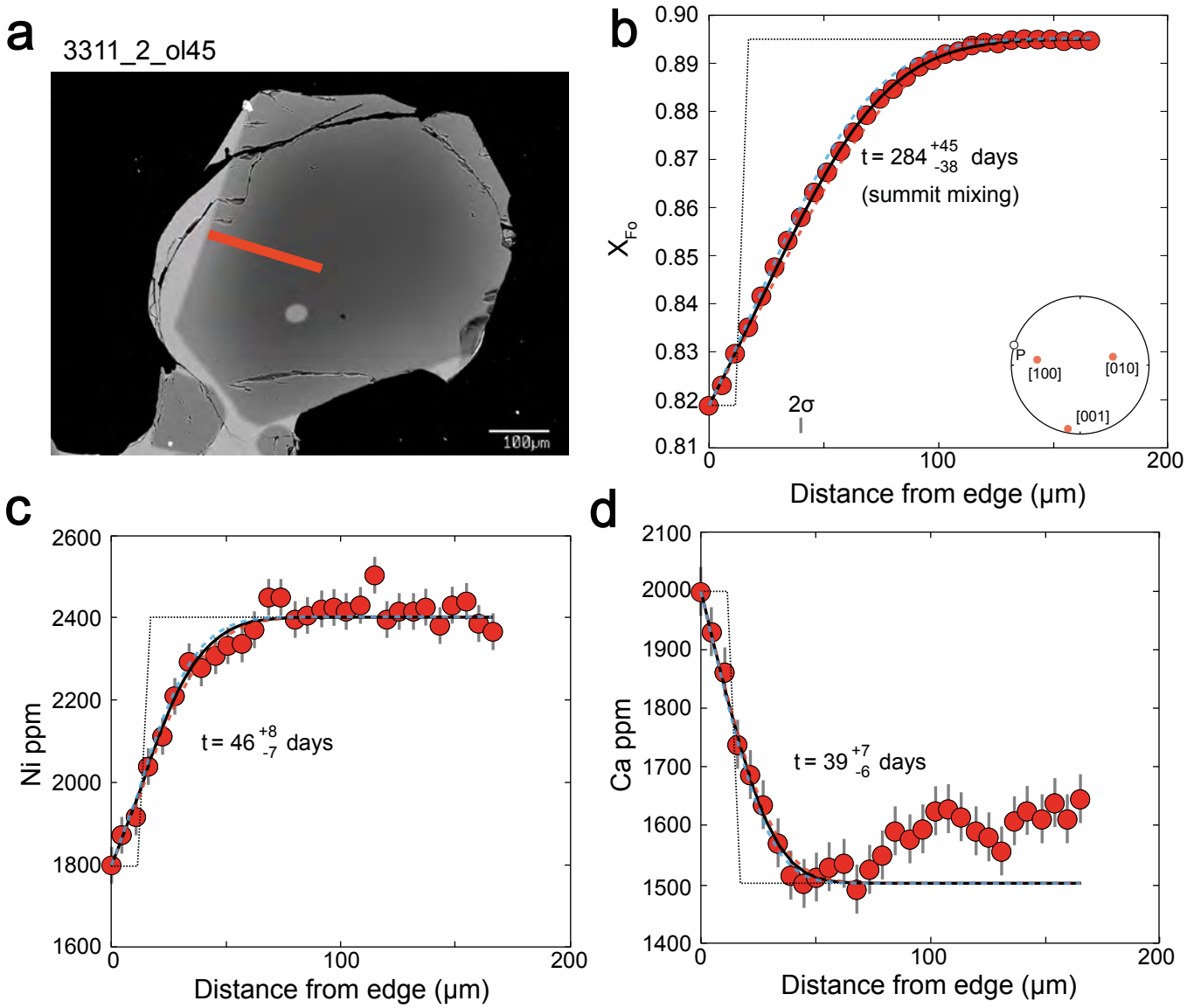
Supplementary Fig. 58: **Data, initial conditions and model fits for olivine crystal '3311_2_ol31'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit. LERZ = lower East Rift Zone.



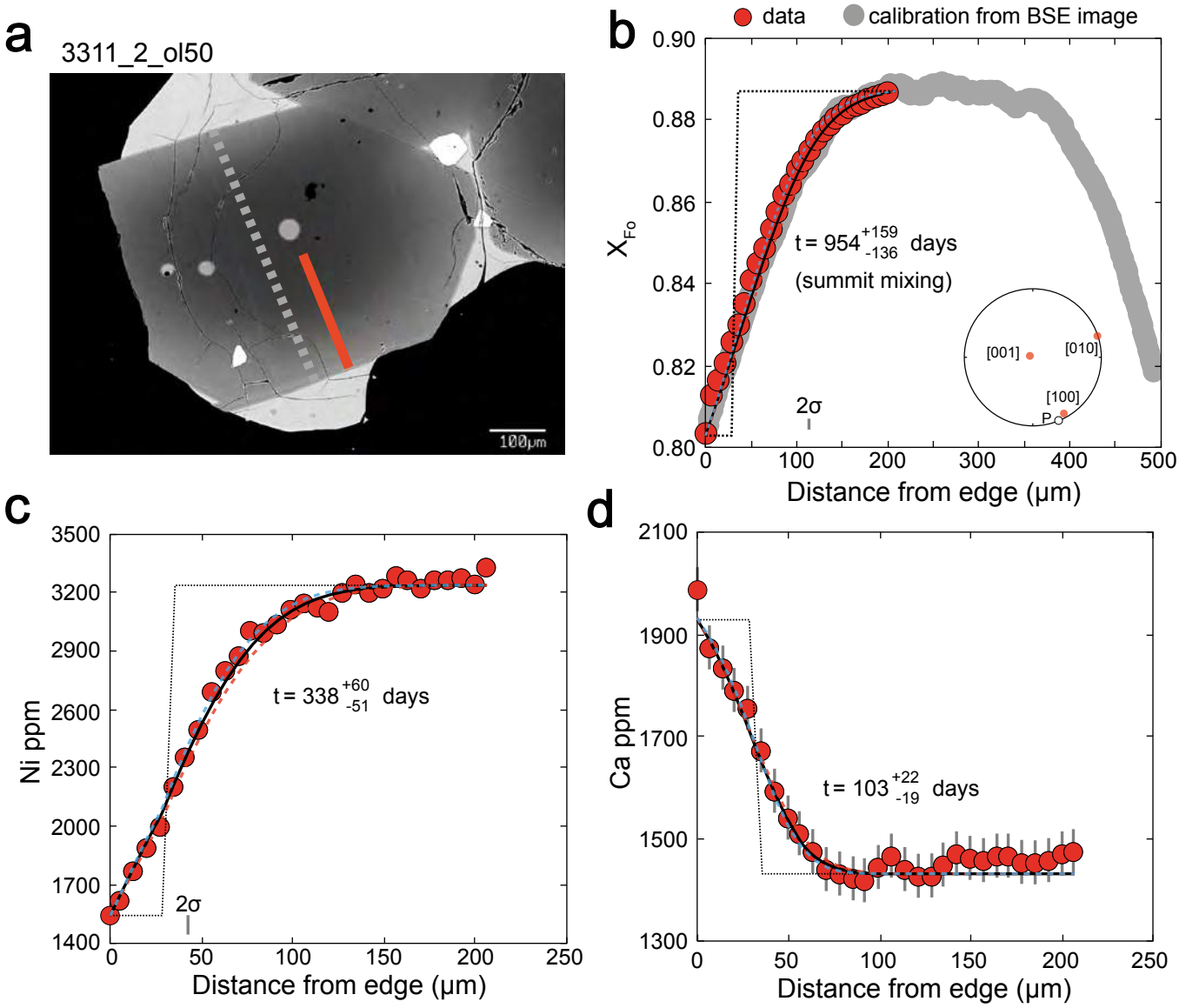
Supplementary Fig. 59: **Data, initial conditions and model fits for olivine crystal '3311_2_ol39'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit. LERZ = lower East Rift Zone.



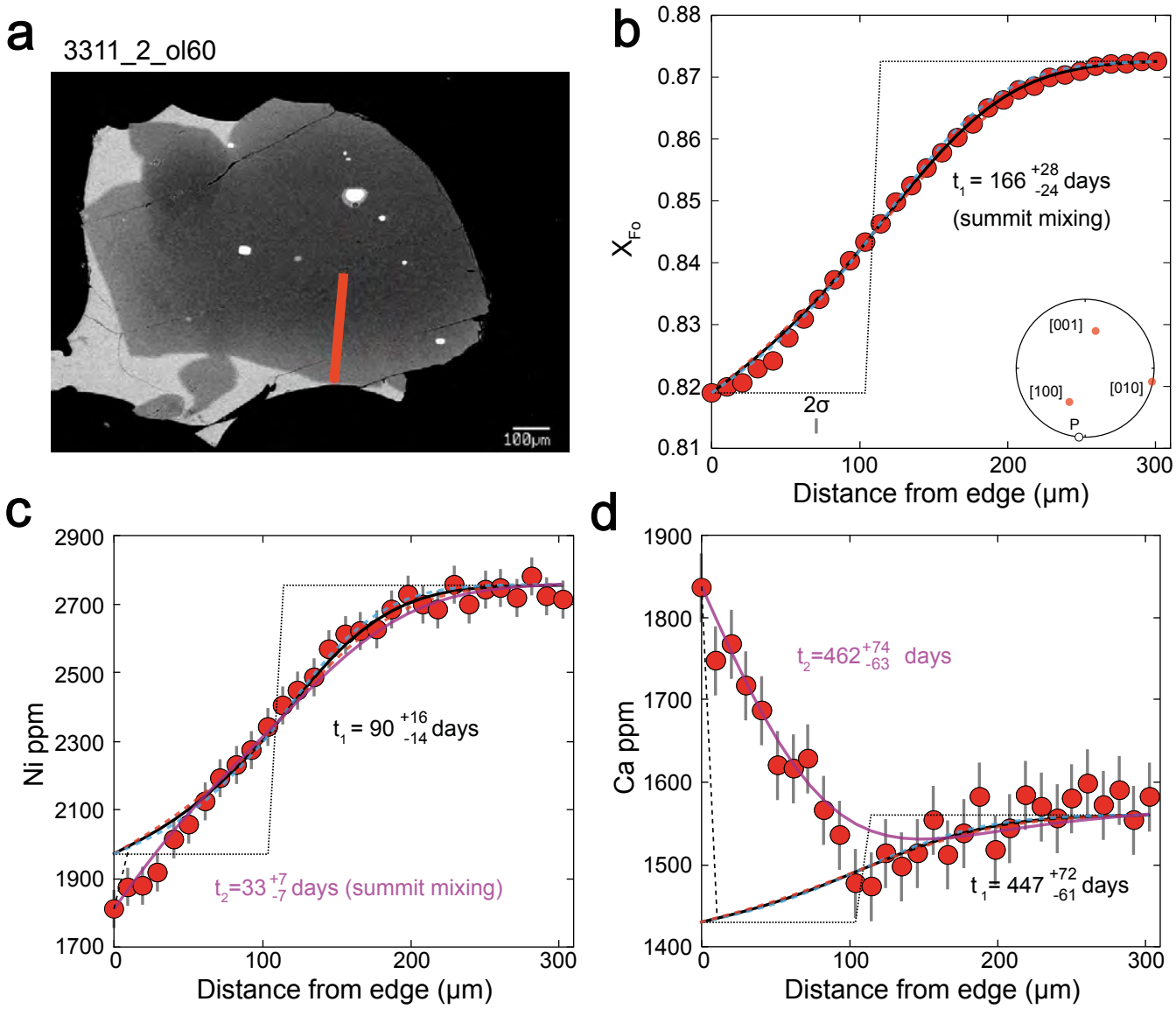
Supplementary Fig. 60: **Data, initial conditions and model fits for olivine crystal '3311_2_ol41'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



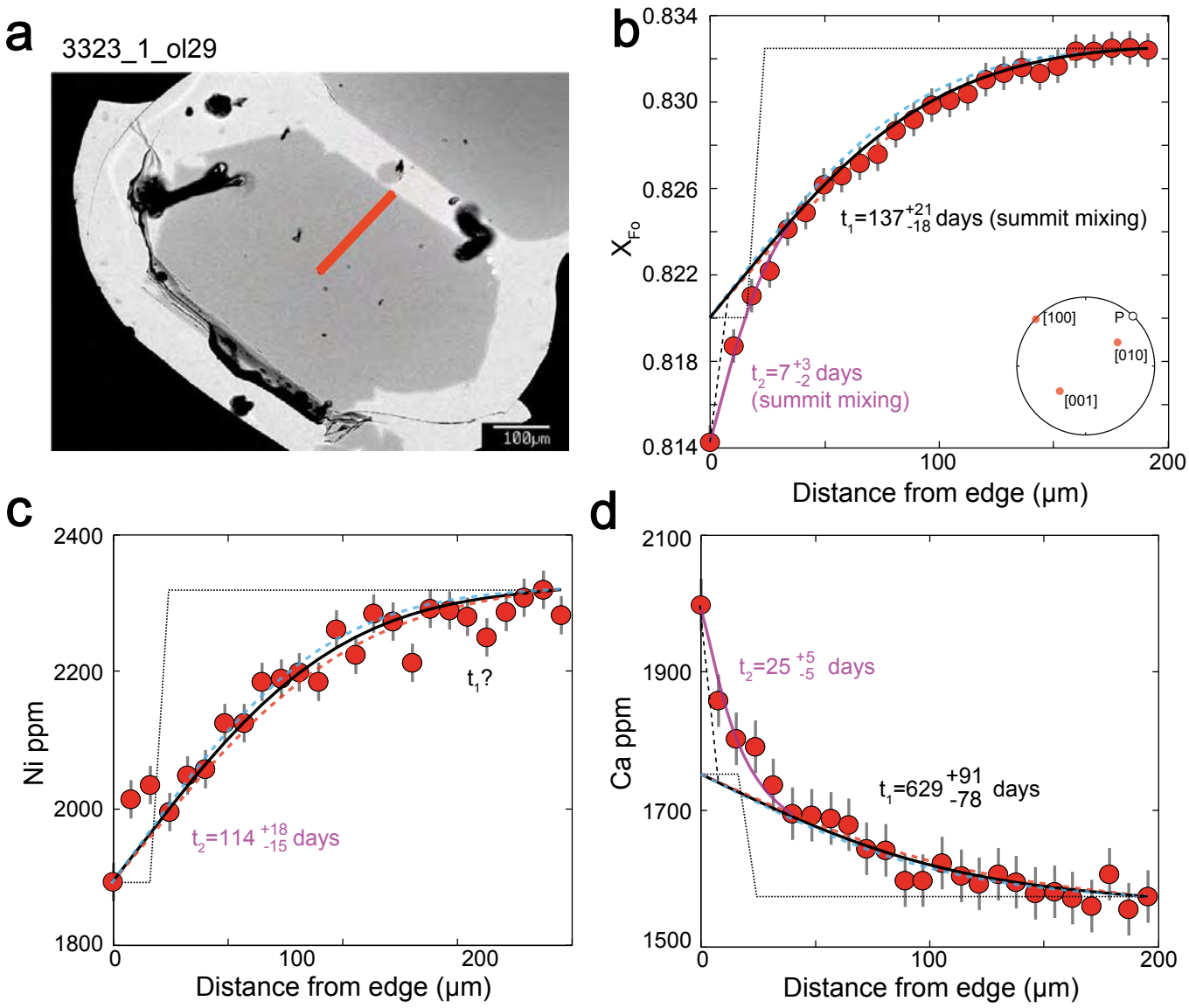
Supplementary Fig. 61: **Data, initial conditions and model fits for olivine crystal '3311_2_ol45'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



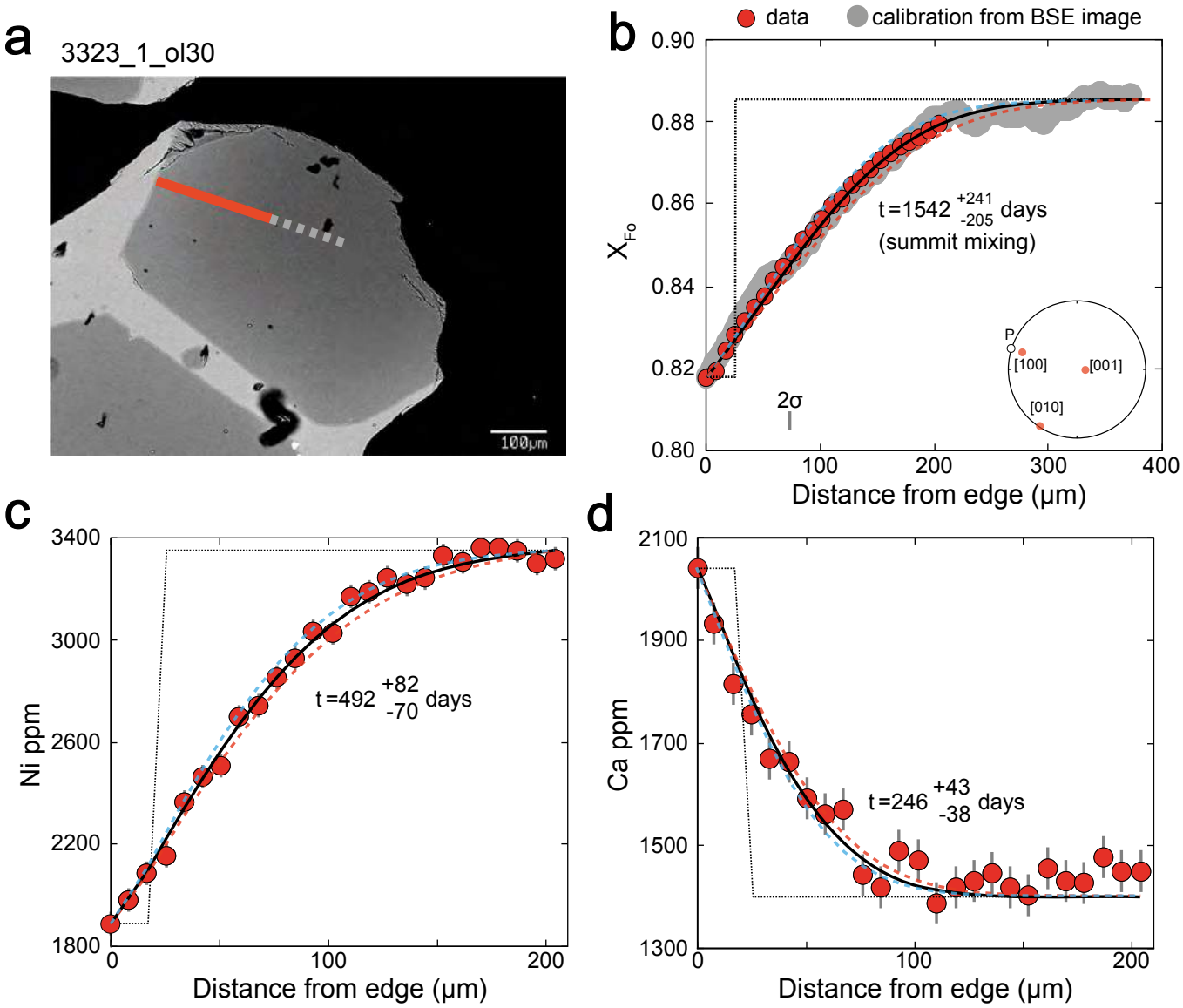
Supplementary Fig. 62: **Data, initial conditions and model fits for olivine crystal '3311_2_ol50'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



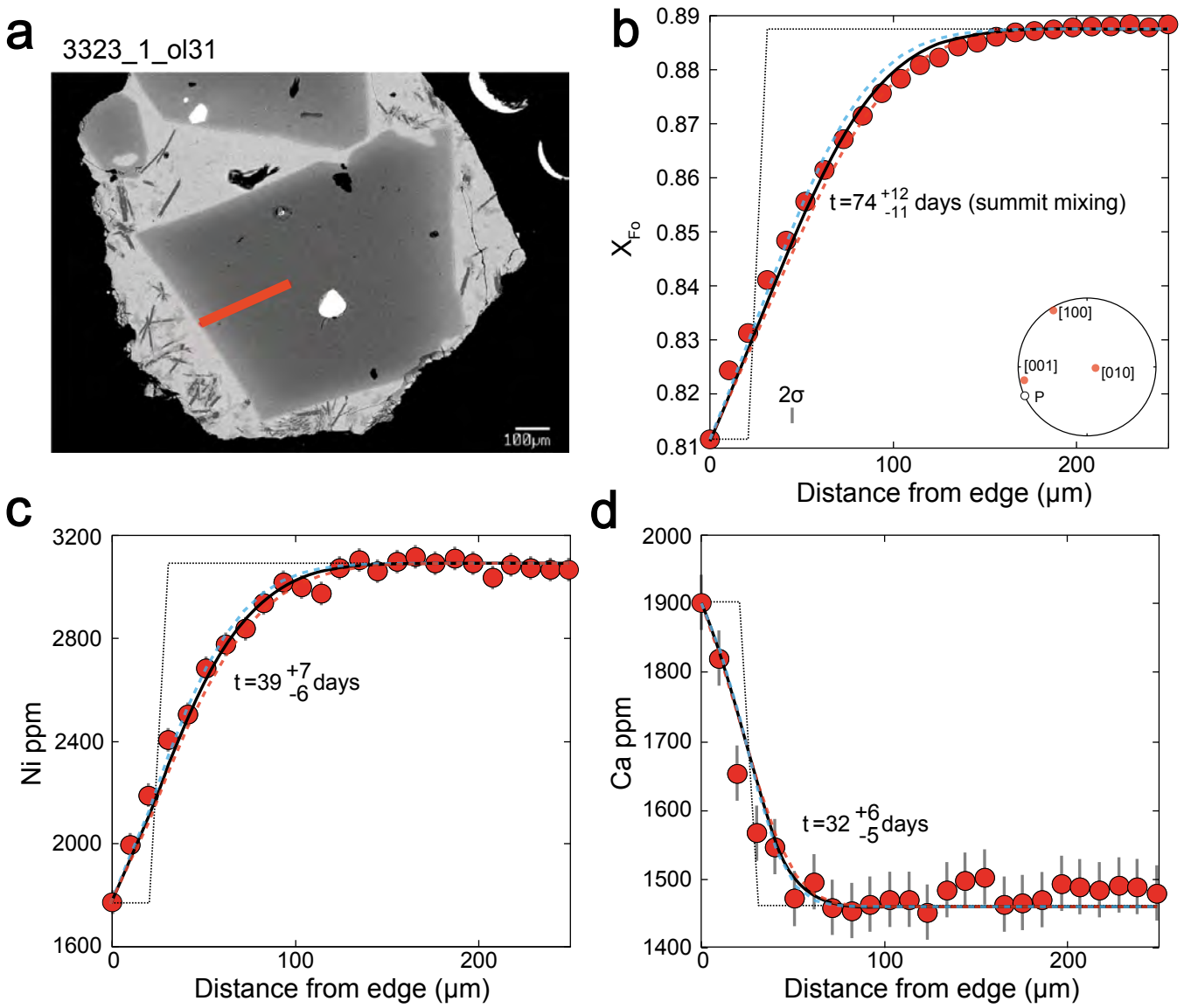
Supplementary Fig. 63: **Data, initial conditions and model fits for olivine crystal '3311_2_ol60'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit.



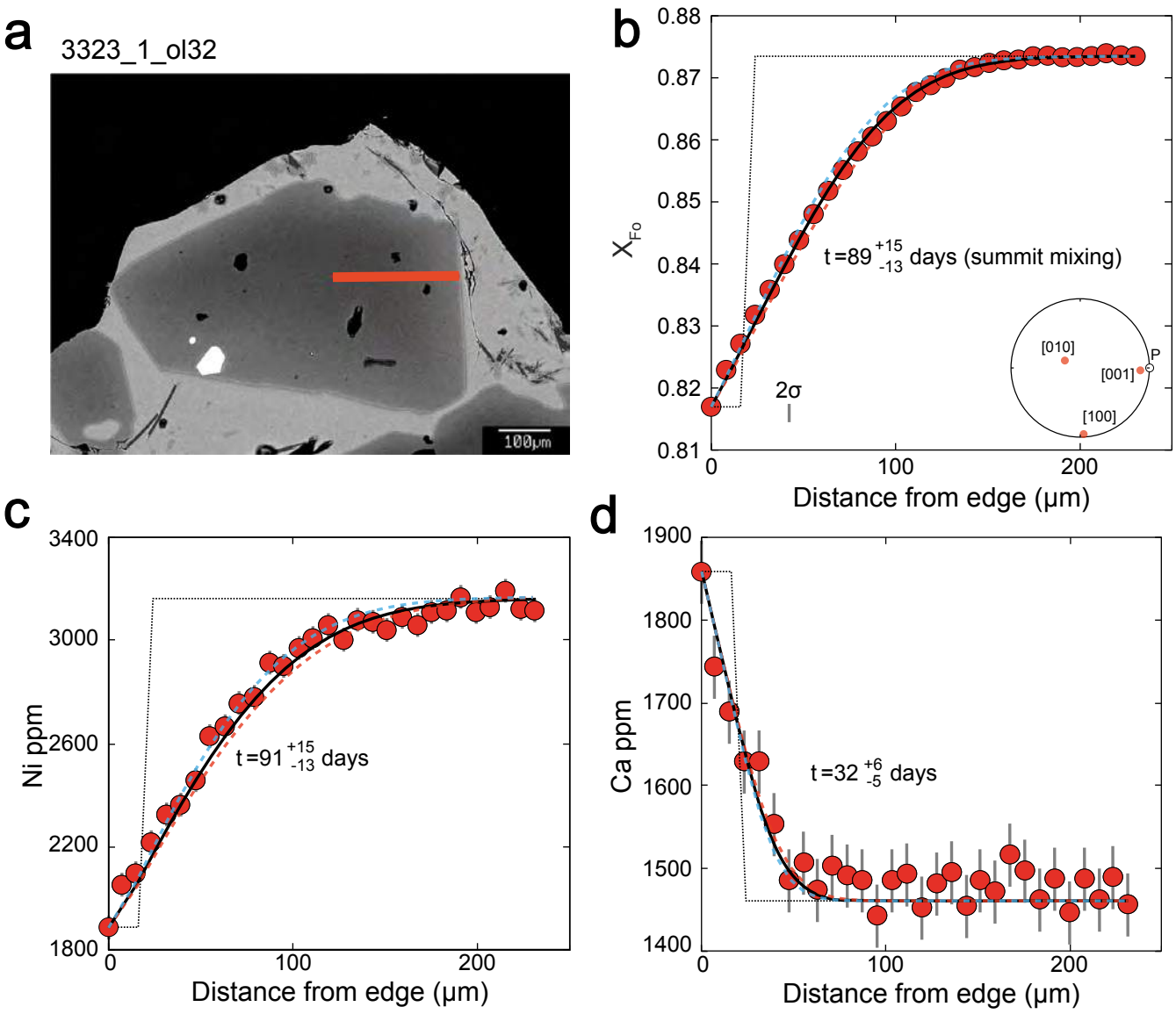
Supplementary Fig. 64: **Data, initial conditions and model fits for olivine crystal '3323_1_ol29'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit.



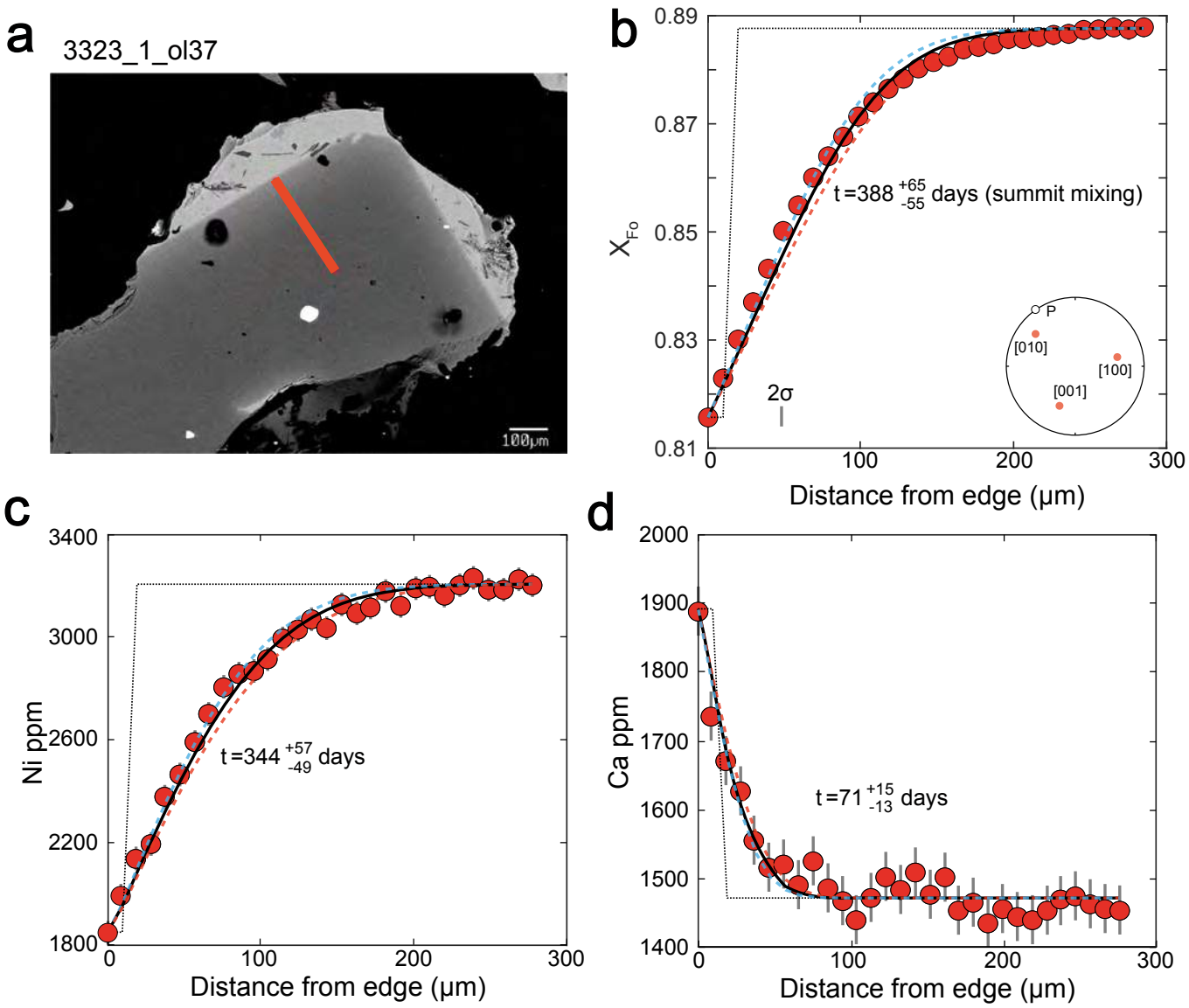
Supplementary Fig. 65: **Data, initial conditions and model fits for olivine crystal '3323_1_ol30'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



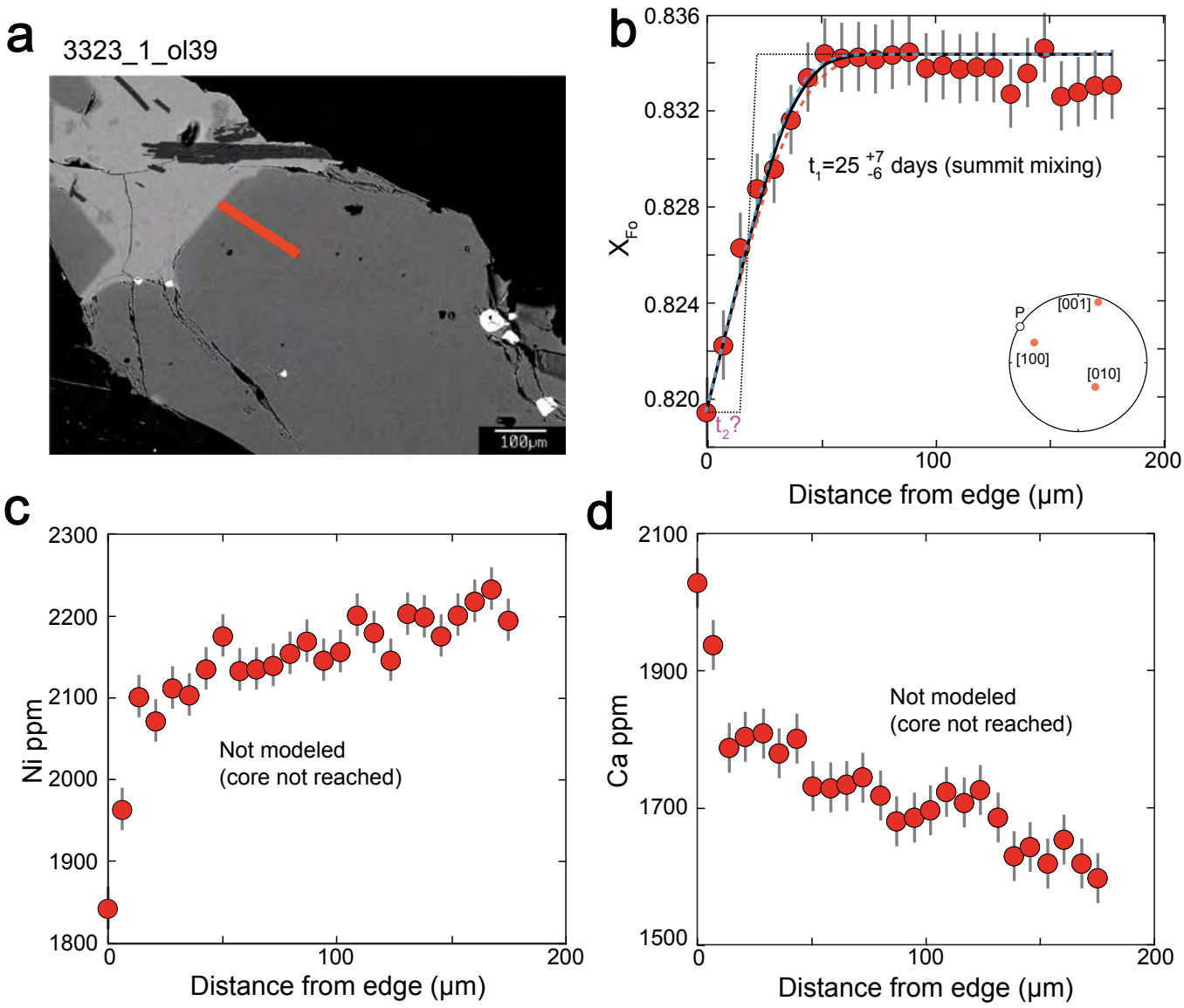
Supplementary Fig. 66: **Data, initial conditions and model fits for olivine crystal '3323_1_ol31'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



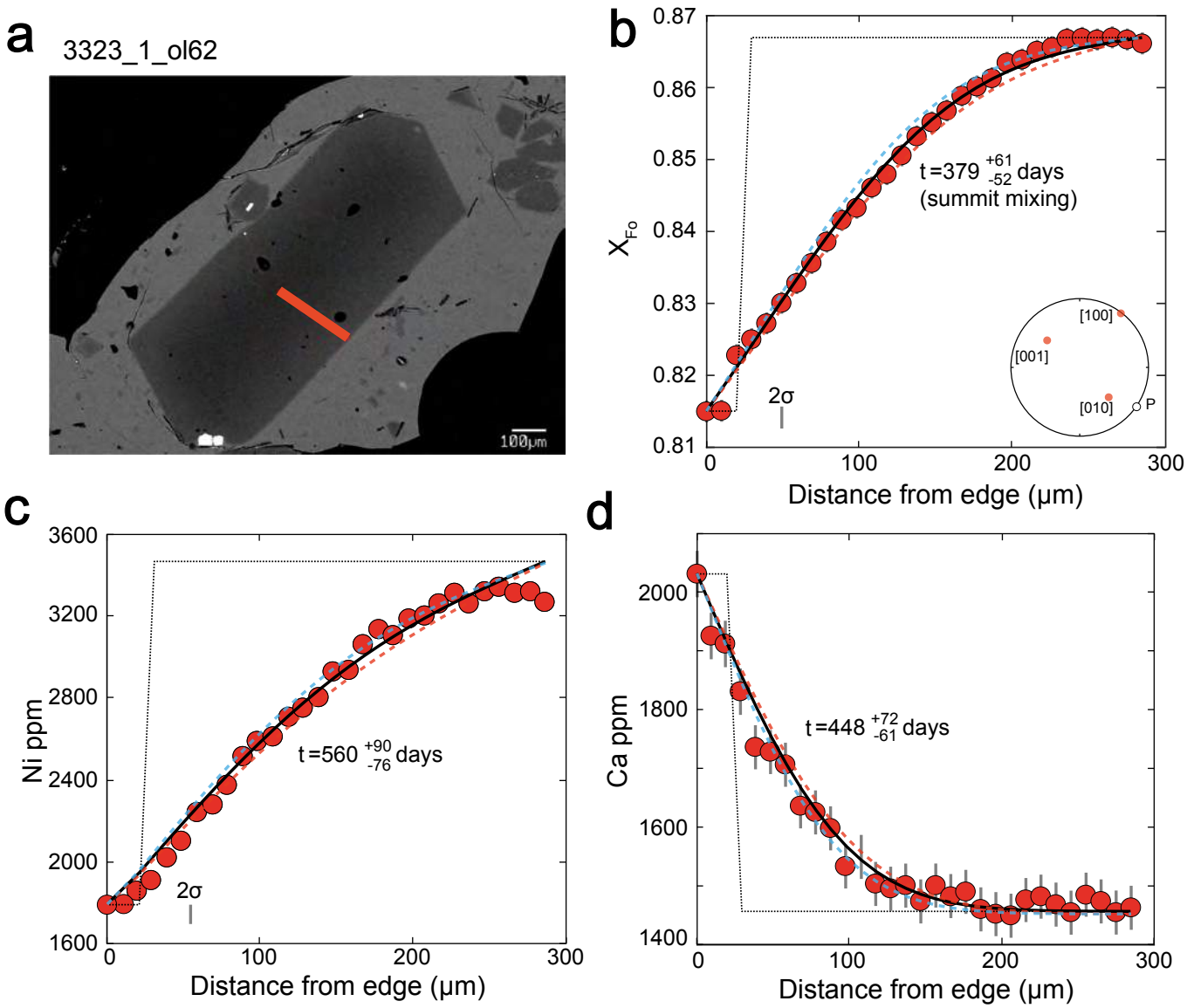
Supplementary Fig. 67: **Data, initial conditions and model fits for olivine crystal '3323_1_ol32'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



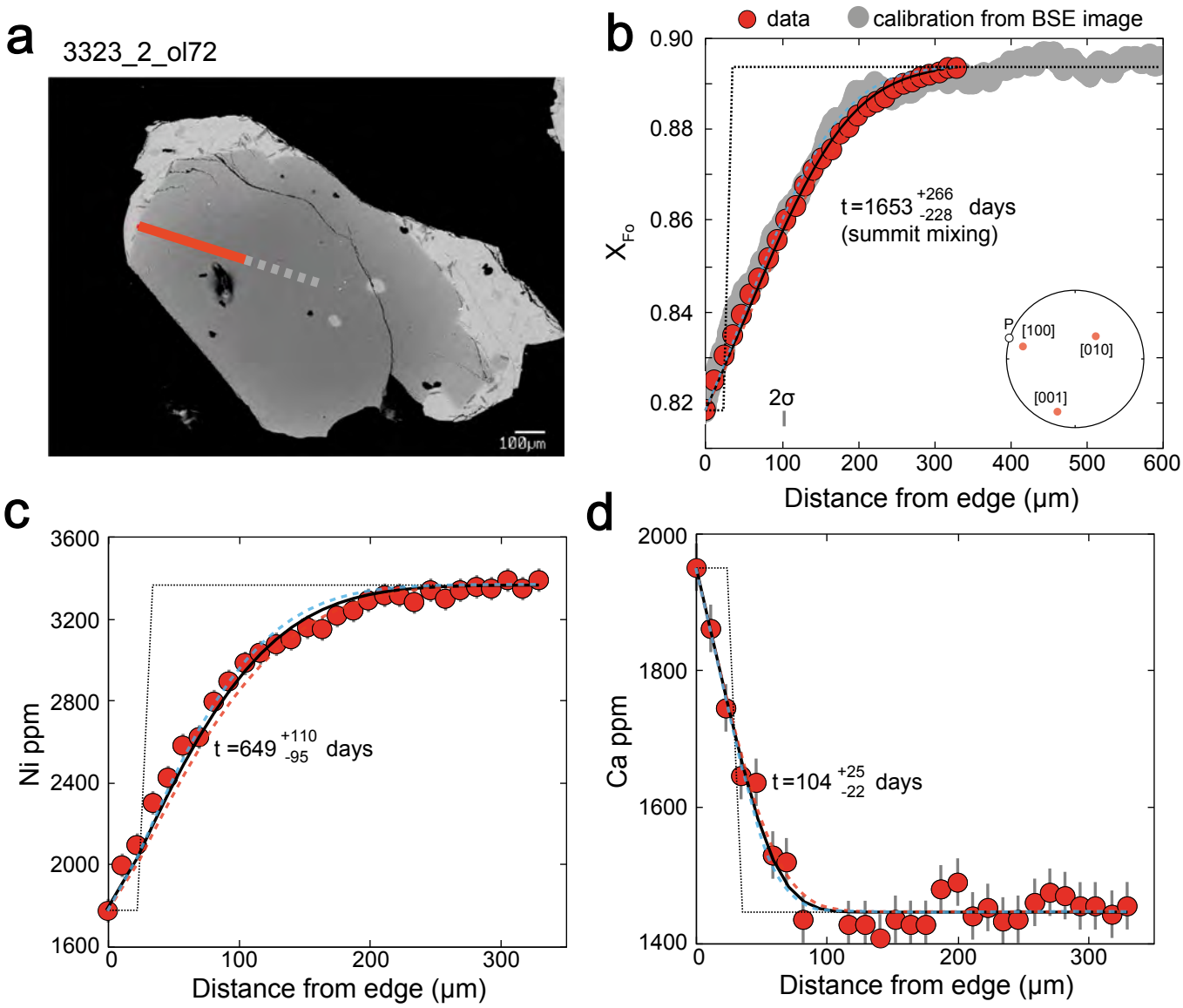
Supplementary Fig. 68: **Data, initial conditions and model fits for olivine crystal '3323_1_ol37'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



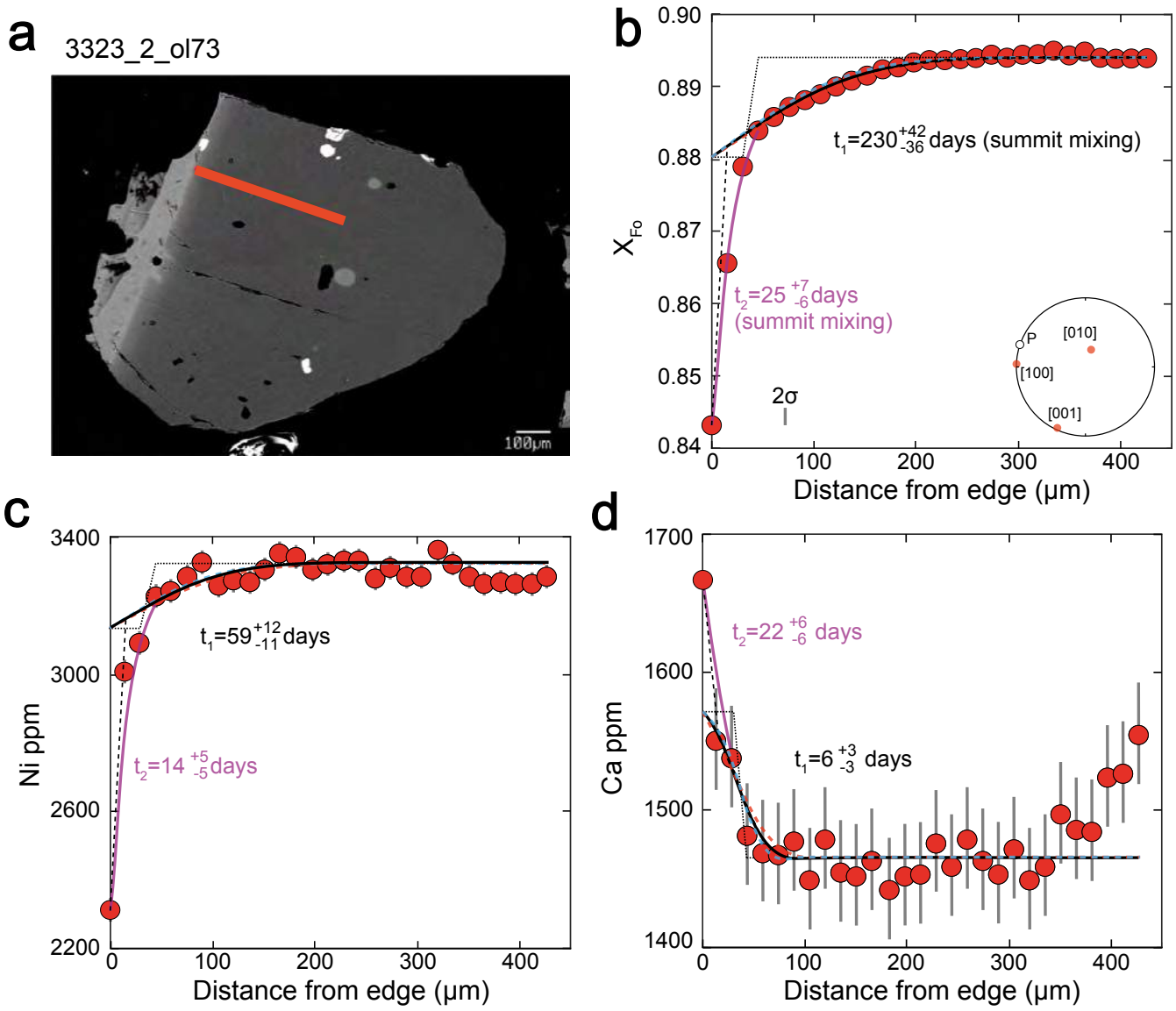
Supplementary Fig. 69: **Data, initial conditions and model fits for olivine crystal '3323_1_ol39'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit.



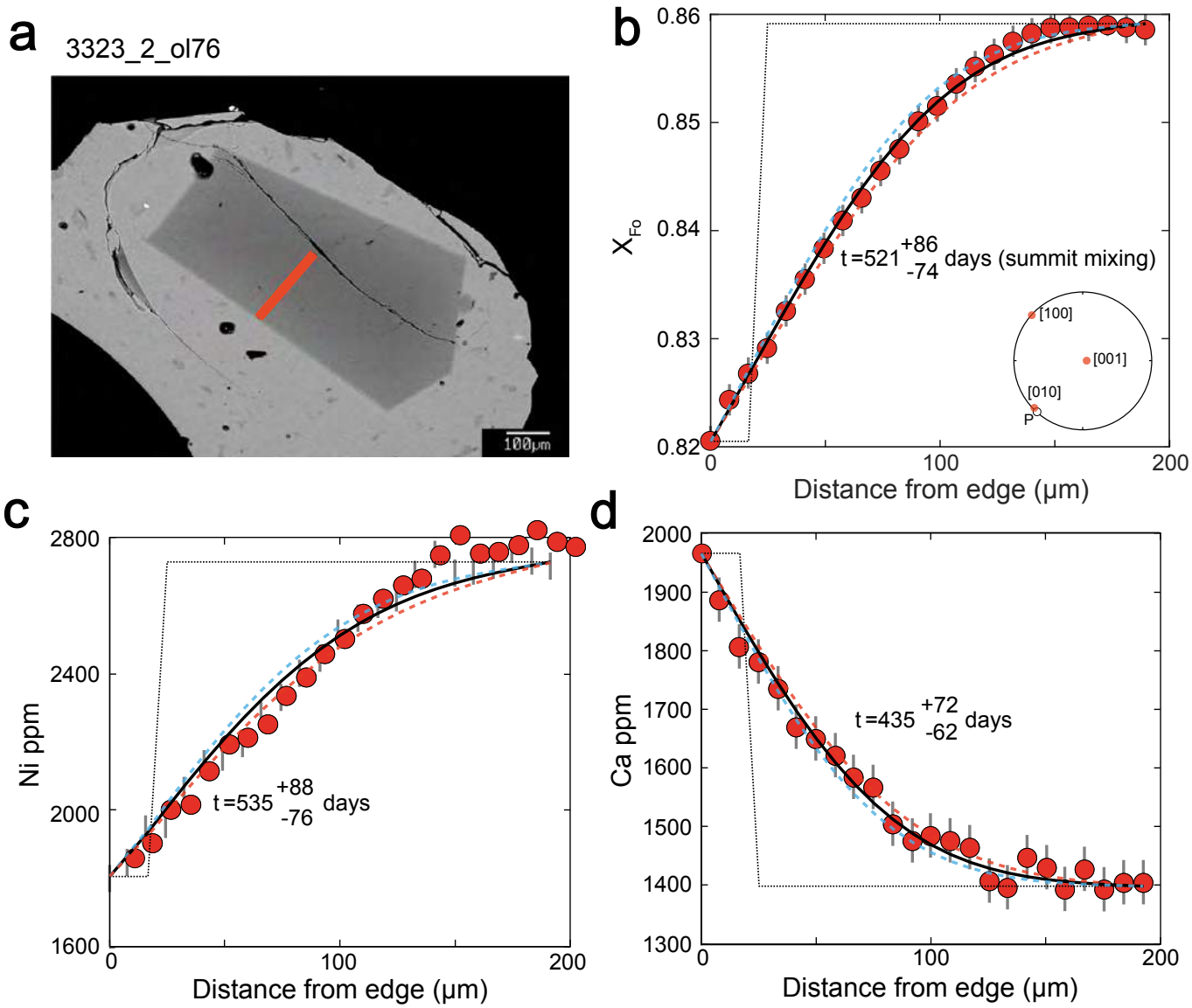
Supplementary Fig. 70: **Data, initial conditions and model fits for olivine crystal '3323_1_ol62'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



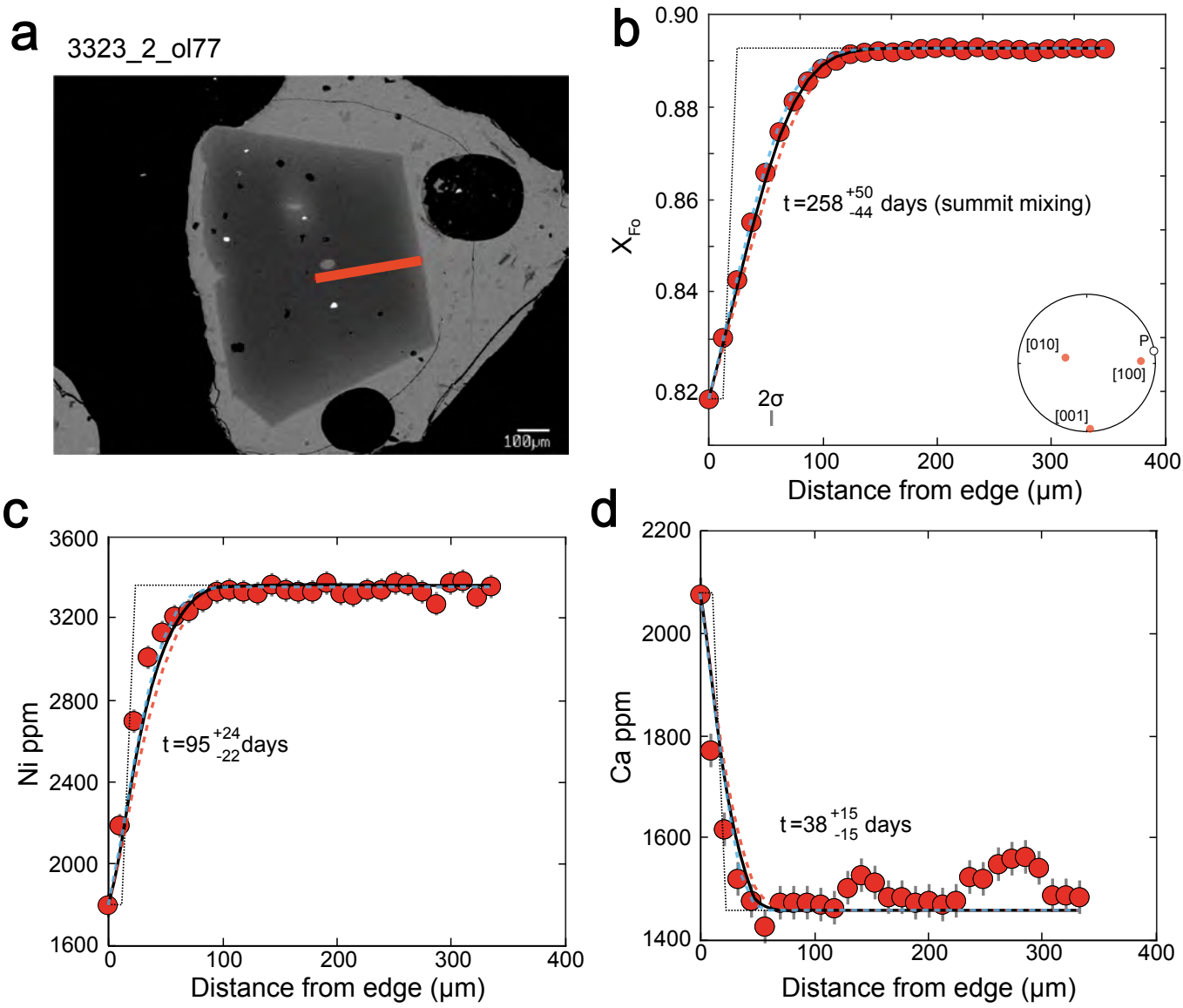
Supplementary Fig. 71: **Data, initial conditions and model fits for olivine crystal '3323_2_ol72'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



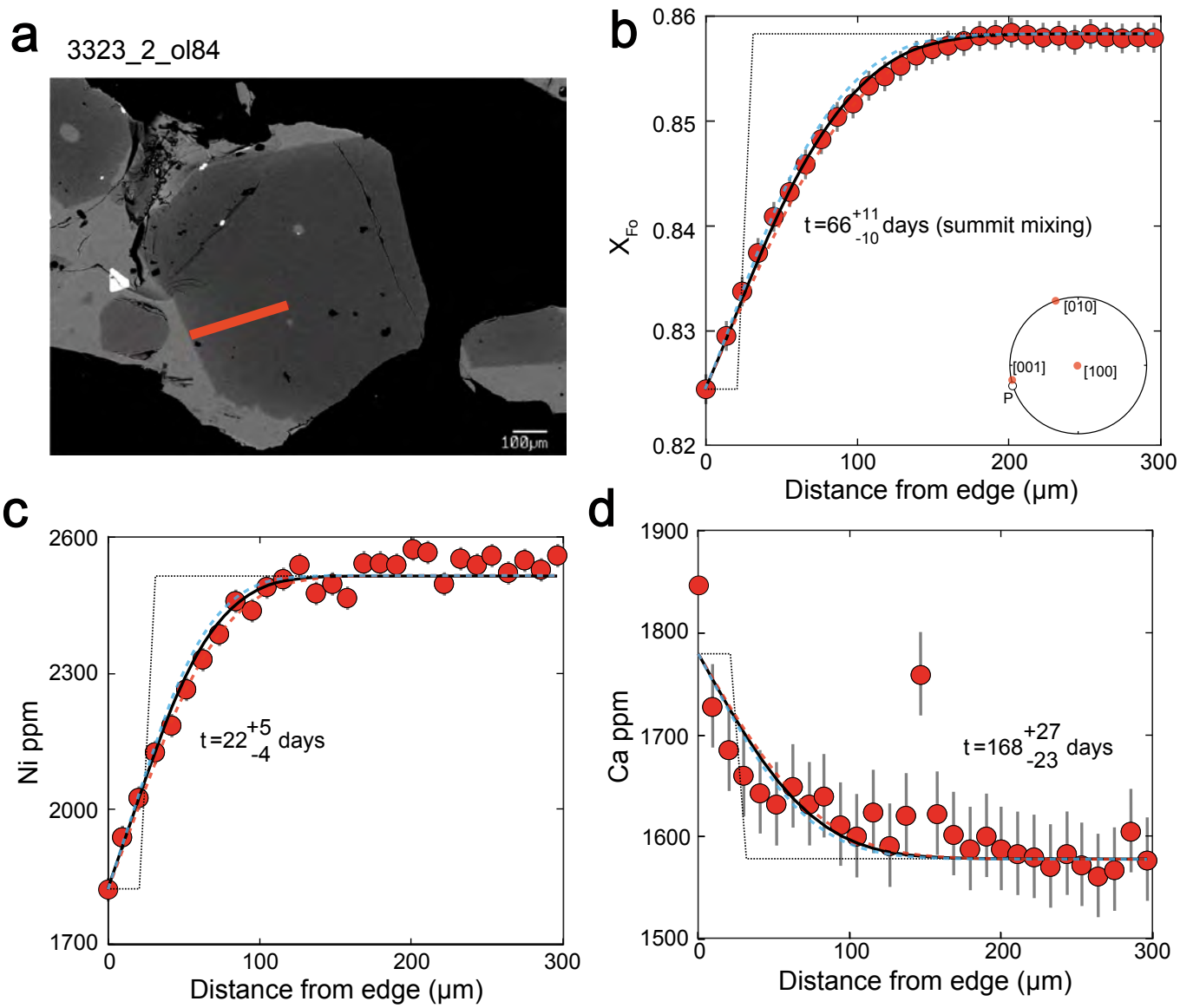
Supplementary Fig. 72: **Data, initial conditions and model fits for olivine crystal '3323_2_ol73'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions. An additional diffusion step t_2 is necessary to fit this profile and is consistent with the different olivine populations identified in the general core-rim data. Mixing-to-eruption timescales t_1 and t_2 correspond here to mixing prior to the eruption at the summit.



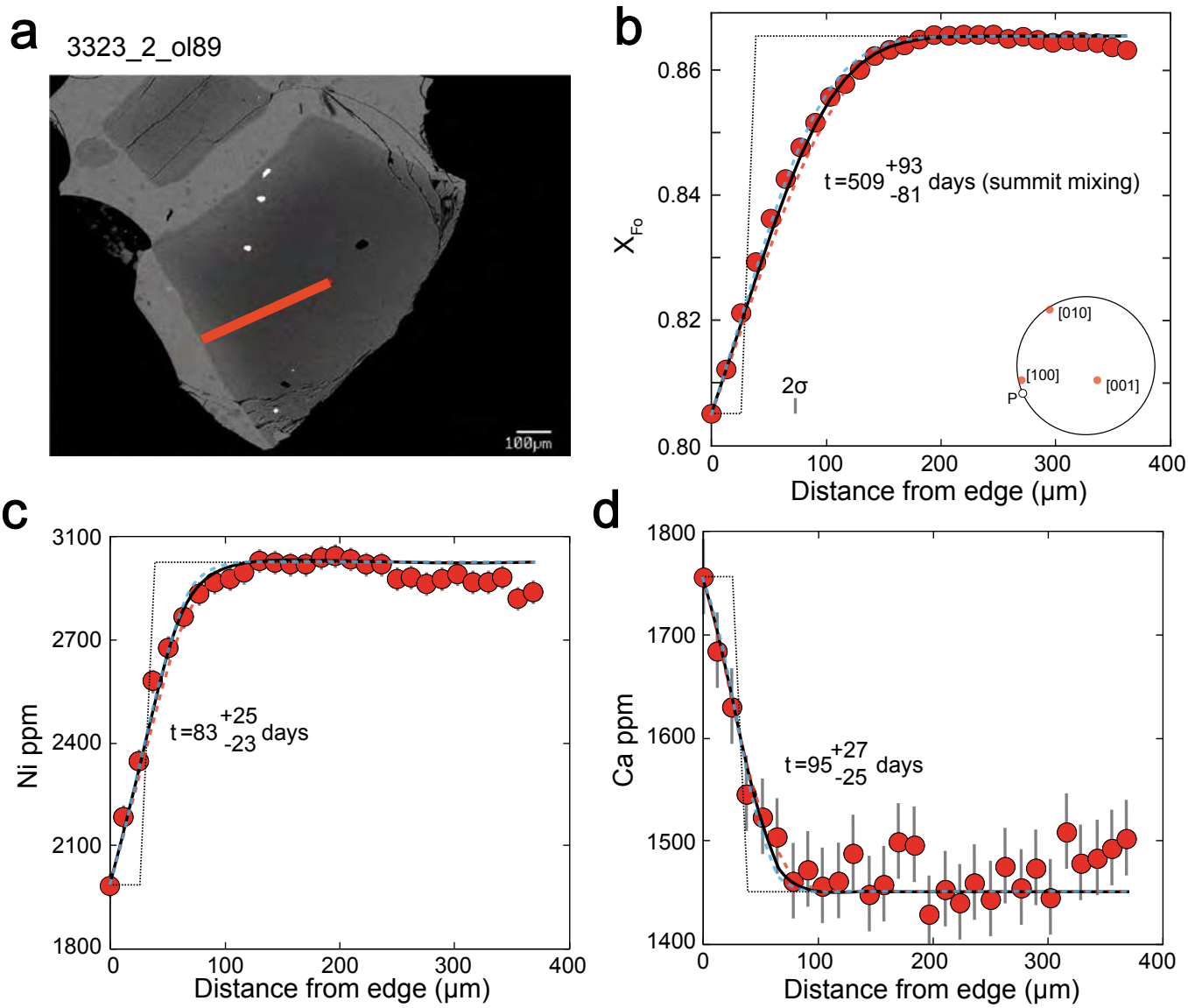
Supplementary Fig. 73: **Data, initial conditions and model fits for olivine crystal '3323_2_ol76'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



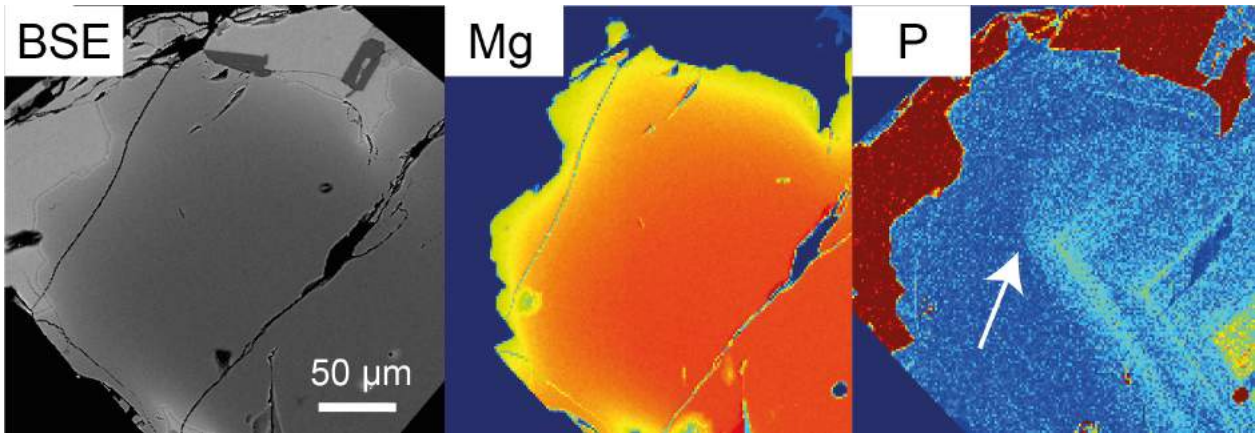
Supplementary Fig. 74: **Data, initial conditions and model fits for olivine crystal '3323_2_ol77'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



Supplementary Fig. 75: **Data, initial conditions and model fits for olivine crystal '3323_2_ol84'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



Supplementary Fig. 76: **Data, initial conditions and model fits for olivine crystal '3323_2_ol89'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset is an equal area pole figure of the crystal showing the orientation of the main crystallographic axes (red points) relative to the profile (white point marked 'P'). Modeled timescales have minimum (dashed blue line), best fit (solid black line), and maximum (dashed red line) values. **c,** EPMA profile of Ni shown in red. **d,** EPMA profile of Ca shown in red. The black dashed lines correspond to constant (homogeneous) initial conditions.



Supplementary Fig. 77: BSE image, magnesium map and phosphorus map of a Fo_{89} olivine from the 2018 LERZ. The white arrow in the P maps shows a dissolution in the high Fo olivine prior to rim growth. P diffuses slowly and is sharp, Mg diffuses rapidly and has already produced a concentration gradient. The P map therefore implies rim growth was rapid enough and during a period where the melt composition did not change significantly. The gradient in Mg is therefore due to diffusion process.