Supplementary material for "Years of magma intrusion primed Kīlauea Volcano (Hawaii) for the 2018 eruption: evidence from olivine diffusion chronometry and monitoring data"

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1 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

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- Details on the temperature corrections for samples with <6.6 wt.% MgO that contain clinopyroxene and plagioclase
- Rainfall data, tilt and earthquake signals for all Kilauea eruptions from 1920 to 2018

2 Summary of changes in lava chemistry during the 2018 Kīlauea eruption

The 2018 Kīlauea lower East Rift Zone eruption involved a mixture of (1) older and colder stored magma (high-Ti basalt erupted during 'phase 1' with 3.6 - 4.6 wt.% MgO in the matrix glass), (2) a basaltic-andesite to andesite magma (fissure 17, 0.8 - 2.8 wt.% MgO) erupted between 13 to 25 May 2018, and (3) hotter magma (mafic magma, with 4.9 - 7.2 wt.% MgO 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).

3 The origin of the highly magnesian olivine (Fo_{89}) erupted in 2018

In this section, we examine in further detail various hypotheses and scenarios for the formation of the Fo_{89} olivine erupted with the 2018 LERZ lavas at Kīlauea and explain why those crystals can only have arrived in the summit systems carried by primitive melts (MgO $\sim$ 14.5 wt.%) shortly before the diffusion clocks we leverage for this study started. Importantly, we outline why the moment at which they formed (the timing between Fo_{89} olivine nucleation/growth and arrival into the reservoir) has no impact on our interpretations, which are based on their final mixing with more evolved magma residing within the summit reservoirs.

3.1 Option 1: Fo_{89} olivine is old cumulate material below the summit (e.g., disaggregated dunite)

Main point: Fo_{89} would no longer be Fo_{89} if these crystals stayed in the summit region for years. As discussed in previous studies (Shea et al. 2015; Ferrando et al. 2020; Gordeychik et al. 2020), re-equilibration of Fe-Mg in phenocryst-sized olivine with a more evolved surrounding melt so that the original compositional plateau is lost (in our case Fo_{89}) takes a few weeks to a few years depending on the surrounding magma temperature. As a result, high-Fo olivine in Fo_{80-82} melts would lose their core if these crystals grew several

years or centuries before 2018 and none of the crystals erupted in 2018 would be Fo_{89}. These highcould show a high, Fo_{89} core only if primitive melts intruded the system before 2018 or if their crystals were formed in 2018. Importantly, all the Fo_{89} olivine erupted in 2018 has well faceted, polyhedral habits (indicating faces grew surrounded by liquid, unimpeded by other crystals) and almost no kink bands (Gansecki et al. 2019), confirming that these are not old cumulates but recently grown crystals.

3.2 Option 2: Could the Fo_{89} olivine be lower Fo olivine (e.g., Fo_{80-82}) that has re-equilibrated with primitive melt?

Main point: This scenario is very unlikely based on zoning observed, would still indicate arrival of primitive magma. In the case that pre-existing summit Fo_{80-82} olivine were intruded by primitive melts, it would take a few months to years to homogenize their core to a Fo_{89}. So, this scenario is not impossible purely based on Fe-Mg zoning. Even if that were the case, the result would be the same: primitive melt would have to have dominated the surroundings of those lower Fo crystals up until the time at which those high MgO melts and their Fo_{89} cargo intruded the summit reservoirs. Our point thus still remains valid: the prior history of the high Fo_{89} matters little, it's the intrusion of their carrier primitive melt that is important and based on the current evidence, undeniable. These Fo_{89} were carried by primitive melts into the summit between 2014 and 2018. We note that there is other evidence from olivine trace element compositions not presented in this study (presented in Mourey et al. 2022) that the Fo_{89} crystals are not formerly Fo_{82} crystals. Very slow diffusing elements like Al would have preserved this history (in the form of high Al cores corresponding to low Fo) and they instead yield evidence for primitive, low Al cores and a birth of those crystals in high Mg, lower Al primitive magma.

3.3 Option 3: Fo_{89} is mush residing in the summit reservoirs with wide range in ages.

Main point: Any prior interactions between Fo_{89} and other lower Fo magmas would have modified the Fo_{89} olivine. Even without losing their Fo_{89} cores, these crystals would be at least partially re-equilibrated if they had seen months or years of other magmas prior to arriving at the summit. The ubiquitous normal zoning (no zoning 'shoulders' or 'reversals') and the relatively simple diffusion story recorded in those crystals strongly contradicts a scenario where these crystals would have had a complex protracted residence (decades) as

a mush within the shallow summit reservoirs without being significantly modified. We do note that there are olivine crystals with lower Fo (e.g., Fo_{87} or lower) that may well have undergone prolonged residence in those summit reservoirs, lost their cores etc... But not Fo_{89} crystals, those are as primitive as Kīlauea olivine get (Lynn and Swanson 2022).

3.4 Option 4: The Fo_{89} olivine cargo arrived with primitive melts shortly prior to mixing with more evolved summit magmas

The high-Fo olivine preserves a detailed and fairly straightforward Fe-Mg zoning record, where nearly all crystals are normally zoned. The most likely scenario is that a primitive magma carrying this cargo (wherever it formed in the crust within this primitive magma) intruded in and mixed with more evolved magma. The lack of reverse zoning implies that the primitive components were never volumetrically abundant enough to shift the composition of the resident evolved magma and its olivine cargo and cause Fe-Mg reversals. While the primitive magmas were chemically diluted, the increase in their supply rate and with the geophysical data, all point towards an increase in the supply of primitive melts to the summit in the years prior to 2018. This is the most likely interpretation; it is fully consistent with seismicity (both in the cumulative number and the upward migration of EQs) and deformation (inflation patterns in the four years prior accelerating in the months before) and the one we ultimately considered throughout this paper. There is no evidence for possibilities 1 and 3, and while we favor possibility 4 based on the evidence listed above, both 2 and 4 result in the same outcome: primitive magma undoubtedly intruded Kīlauea's reservoirs in the weeks to 4 years preceding the eruption, a phenomenon that accelerated in the months prior to May 2018.

Summary of the different hypothesis for the origin of the Fo_{89} olivine cargo

Hypothesis	Supporting evidence	Contradicting evidence	Interpretation
Fo_{89} olivine is old cumulate material below the summit (e.g., disaggregate dunite)	It is possible for old cumulates/dunites to be of high Fo compositions.	Overall absence of kink bands or triple grain junctions, olivine is perfectly faceted, sometimes with skeletal branches and/or budding	Inconsistent with Fo_{89} cargo erupted in 2018, hypothesis abandoned early on.
Fo_{89} is old Fo_{80-82} that re-equilibrated with incoming primitive melt	Both Fo_{80-82} and Fo_{89} olivine was erupted in the LERZ 2018 lavas.	No reverse zoning in all the cargo erupted. Slow diffusing elements (Al) would preserve that history and profiles and mapping of Fo_{89} (Mourey et al. 2022) argue the crystal cores were never low Fo, high Al olivine.	Unlikely scenario. There is no evidence in olivine zoning for such a complex sequence. Even in the event where somehow all Fo_{89} olivine were formed by re-equilibration of low Fo crystals with high Mg, primitive melts, this wouldn't change the interpretation of this paper which is that primitive melt had to arrive at the summit to form them, and that this high Fo olivine mixed with a more evolved summit magma shortly after.
Fo_{89} is mush residing in the summit reservoirs with wide range in ages (example Kīlauea Iki 1959)	Cr diffusion in olivine from Kīlauea Iki 1959 with timescales between 10 days to 43 yrs (Bradshaw et al. 2018). Gansecki et al. (2019) suggest that crystals from the phase 1 (not phase 3) are older cargo from eruptions (potentially 1955) Different trace elements in melt inclusions from high Fo olivine (Wieser et al. 2019)	For Kīlauea Iki, longer Cr diffusion timescales are obtained with profiles showing NO Cr zoning (best fit have no meaning), profiles with clear Cr zoning have timescales between <2 to 82 days. The textures of the olivine from the phase 3 are completely different from the ones from the phase 1. Olivine from the 1969-74 (Wieser et al. 2019) have clear deformation features NOT observed in the 2018 crystals. Olivine are all normally zoned without any evidence of long storage in more evolved magma prior to the final zoning history.	Inconsistent with the absence of kink bands in the olivine from the phase 3 in 2018. Hypothesis is inconsistent with the preservation of high Fo without mixing with more evolved magma. Any prolonged residence in summit reservoirs would cause partial to total re-equilibration.
Fo_{89} olivine arrived with primitive melts shortly prior to mixing with more evolved summit magmas (*our preferred interpretation*)	Fe-Mg diffusion in high Fo with timescales between <10 days to 4.5 yrs correlating with an increase in the number of earthquakes below the South Caldera reservoir All high Fo are normally zoned, with euhedral shape, no kink bands. No evidence for prior mixing with evolved magma.	Evidence of older olivine mush piles at other eruptions at Kīlauea (e.g. 1959 and 1969-1974) that could have also erupted in 2018.	The high Fo olivine phenocrysts, along with the detailed and fairly straightforward Fe-Mg zoning record it preserves, and with the geophysical data, all point towards an increase in the supply of primitive melts to the summit in the years prior to 2018.

4 Uncertainty in temperature estimates for the diffusion models

As discussed in the methods, the uncertainty for the temperature is calculated by adding olivine back in until they reach Kd equilibrium at 0.33 (±0.02; Putirka 2016). For our models, we chose the Montierth et al. (1995) thermometer, which generally gives temperature estimates slightly higher than Helz and Thornber (1987) thermometer but lower than the Matzen et al. (2011) thermometer. This choice of thermometer is also consistent with recent experimental results. The small differences in composition between the Mauna Loa and Kīlauea compositions (Montierth et al. 1995; Helz and Thornber 1987; Matzen et al. 2011) at a given MgO (mainly SiO_2 differs by ∼1 wt.%, TiO_2 by ∼0.7 wt.% and FeO by ∼1.5%) have little to no effect on MgO thermometry. The uncertainty related to the choice of the MgO thermometer (±10°C; Montierth et al. 1995) and the choice of K_D have now been incorporated into the diffusion model according to the propagated error:

$$Err_{total} = \sqrt{(uncertainy\ for\ the\ K_D)^2 + (thermometer\ uncertainty)^2} \qquad (1)$$

5 Temperature corrections for plagioclase-clinopyroxene saturated samples

Some of our samples (KE62-3267F, KE62-3276F and KE62-3290F) with <6.6 wt.% MgO glass compositions have crystallized clinopyroxene and plagioclase, leading to anomalously high FeO contents compared to the true liquid line of descent (FeO>11-12 wt.%) if olivine only is added back in until reaching an equilibrium K_D of 0.33. We corrected the temperature of our diffusion models for these samples that had <6.6 wt.% MgO by re-adding clinopyroxene and plagioclase that could have formed. This MgO cutoff for clinopyroxene and plagioclase appearance is consistent with Helz and Thornber (1987) and MELTS models. We estimated the proportion of clinopyroxene and plagioclase that crystallized in each sample with MgO<6.6 wt.% using MELTS models, and recalculated the glass composition before clinopyroxene and plagioclase crystallization. The timescales 't_1' for these 3 samples (representing 27 olivine from the 71 profiles) changed by a factor 1.5x.

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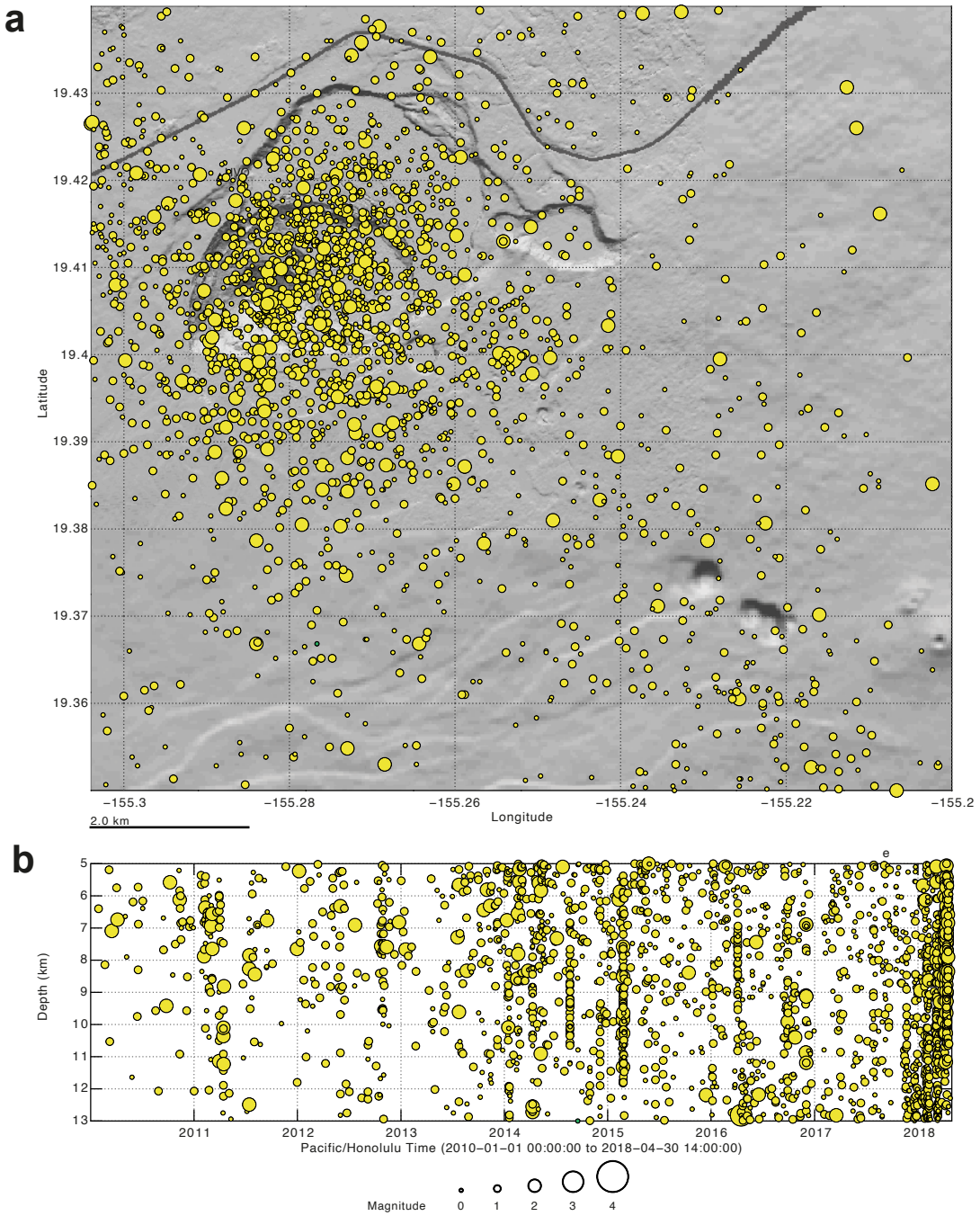
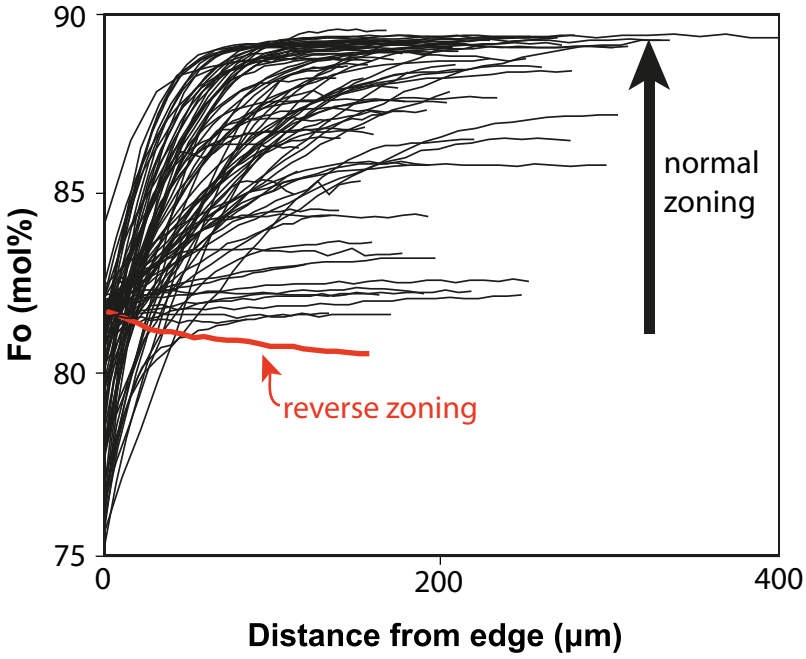
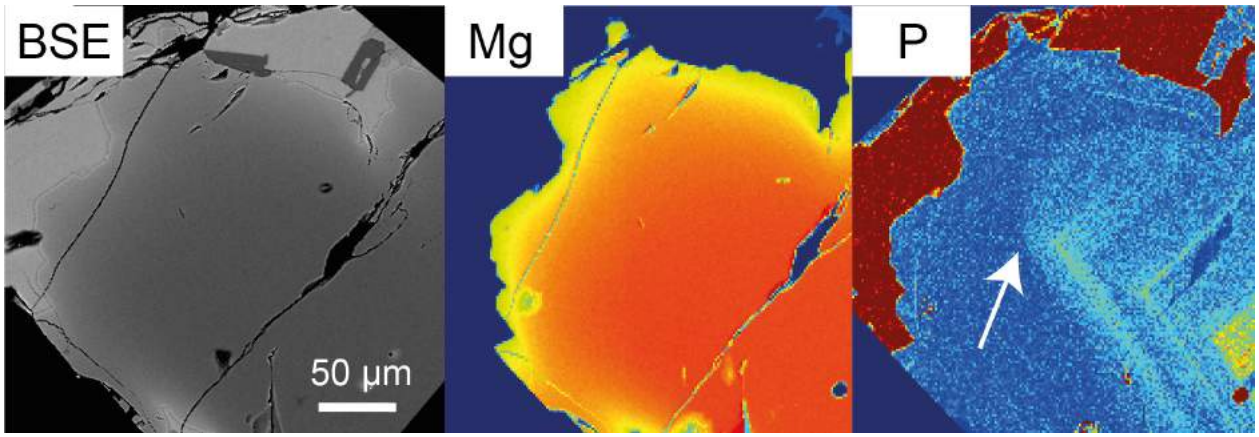


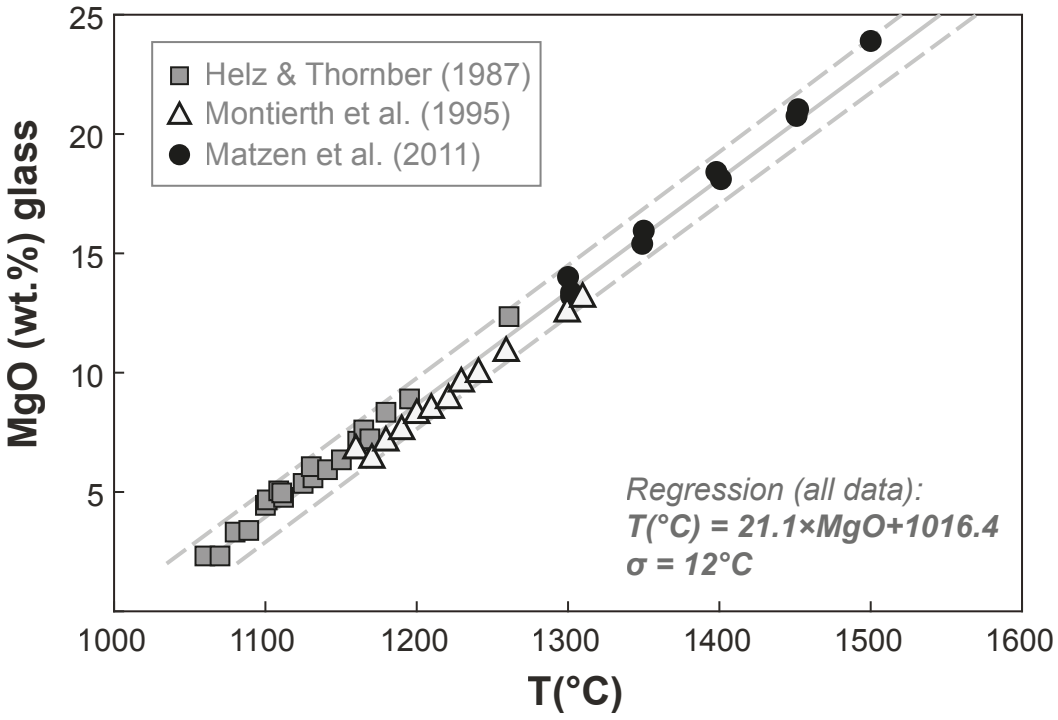
Supplementary Fig. 1: Seismicity (5-13 km depth) at the Kīlauea summit between January 2010 and April 27, 2018. a, Map of the Kīlauea summit with the East rift connector showing the location and magnitude of the earthquakes. **b,** Depth and magnitude of the earthquakes between January 2010 and April 27, 2018. Earthquakes between 5 and 13 km correspond to the seismicity below the South Caldera reservoir (see Fig. 4d for cumulative earthquake plot).



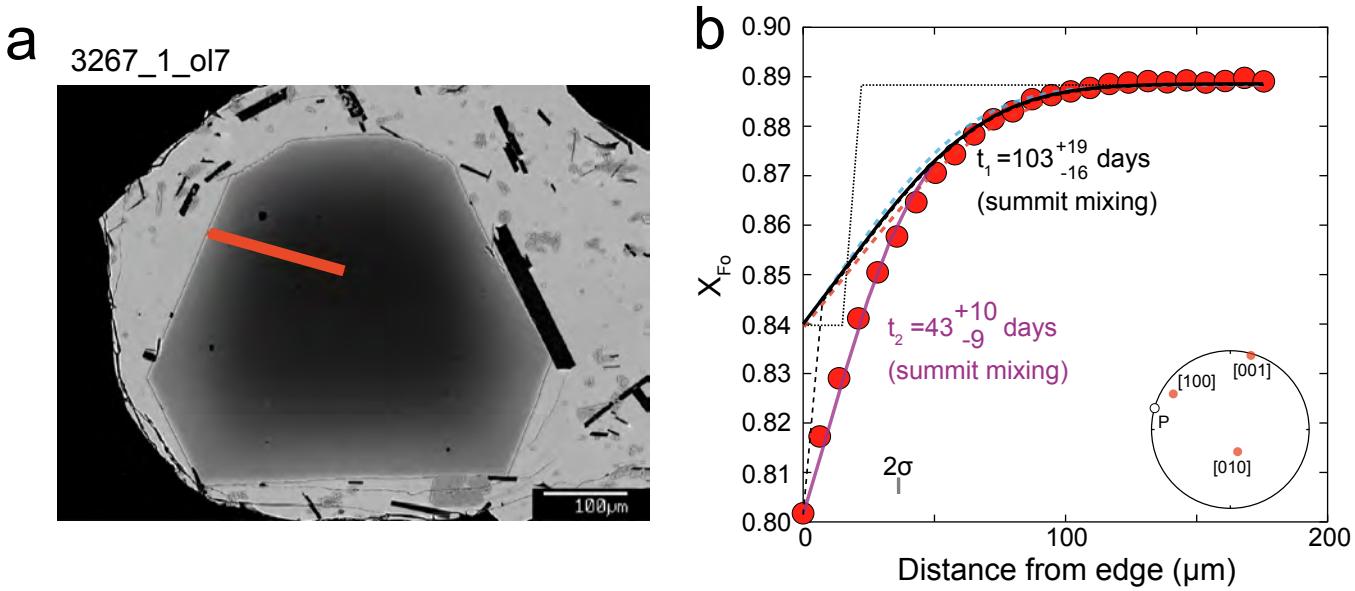
Supplementary Fig. 2: Olivine forsterite profiles grouped to highlight similar normal zoning patterns (except for one crystal with slight inverse zoning) found in samples investigated.



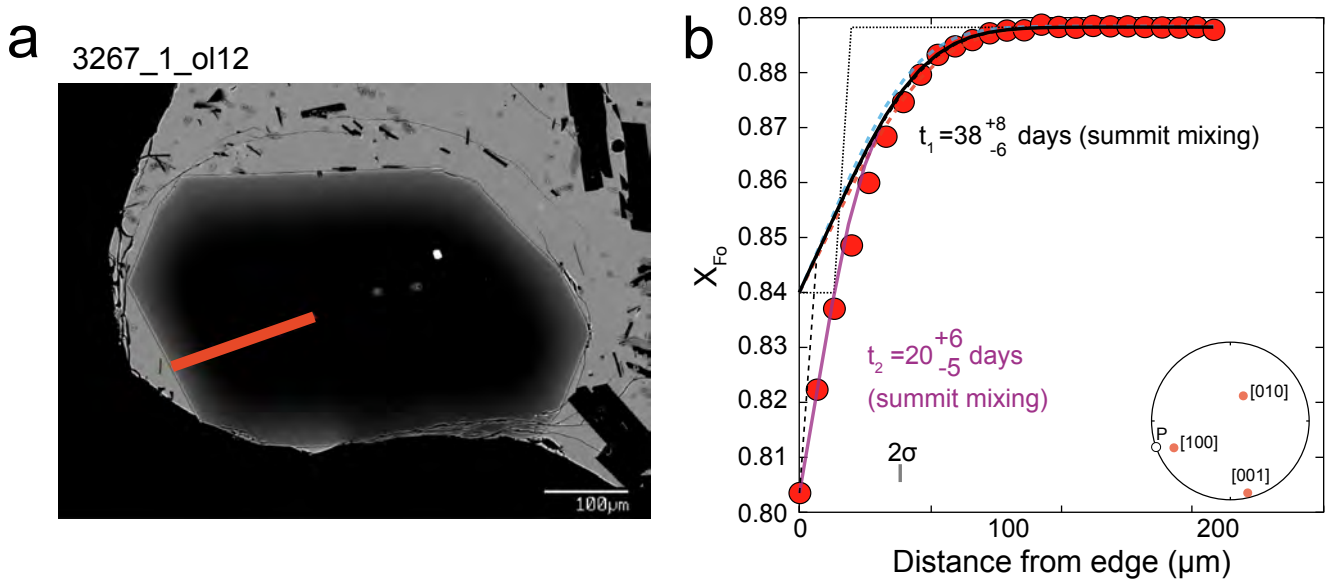
Supplementary Fig. 3: BSE image, magnesium map and phosphorus map of a Fo_{89} olivine from the 2018 LERZ. The white arrow in the P maps shows a dissolution in the high Fo olivine prior to rim growth. P diffuses slowly and is sharp, Mg diffuses rapidly and has already produced a concentration gradient. 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.



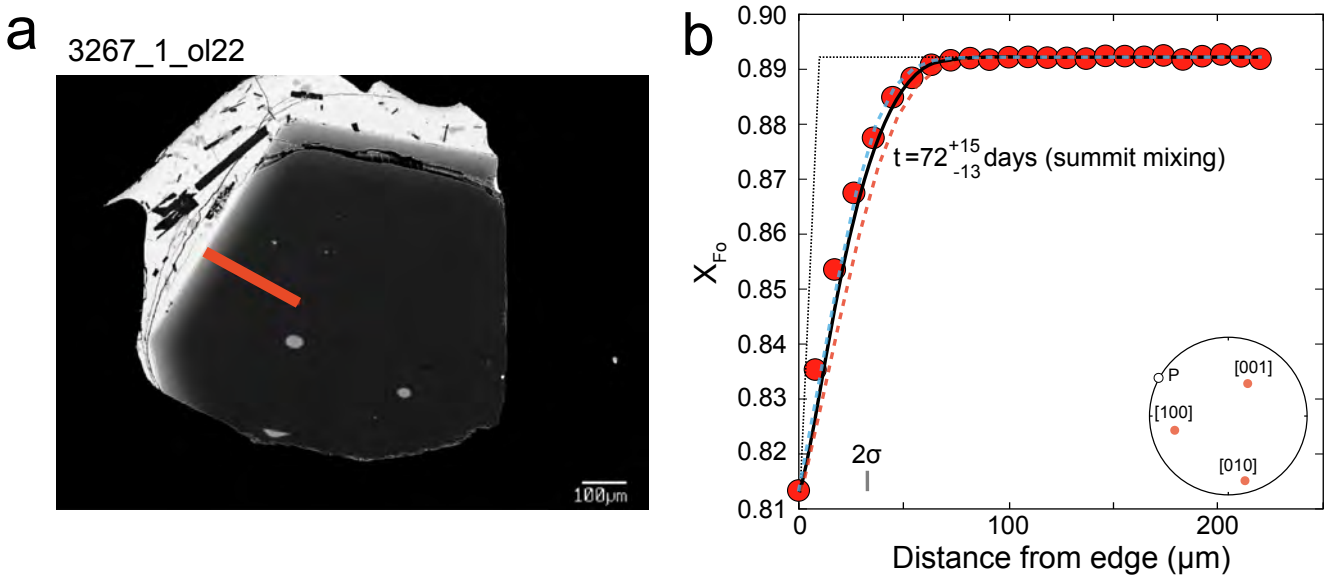
Supplementary Fig. 4: MgO content in experimental glasses from studies of Hawai'i basalt versus experiment temperature. A regression through the entire dataset gives a global glass thermometer valid within the temperature range 1060-1500°C, applicable to Hawaiian tholeiites and most water-poor OIB magmas.



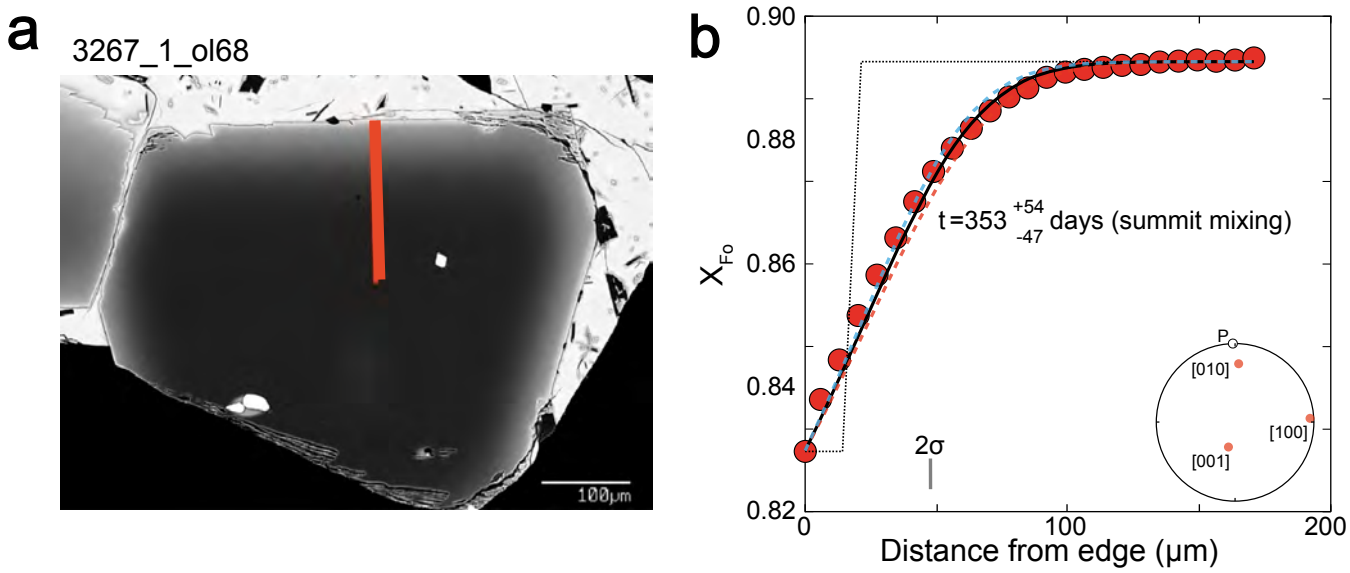
Supplementary Fig. 5: **Data, initial conditions and model fits for olivine crystal '3267_1_ol7'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset 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. 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.



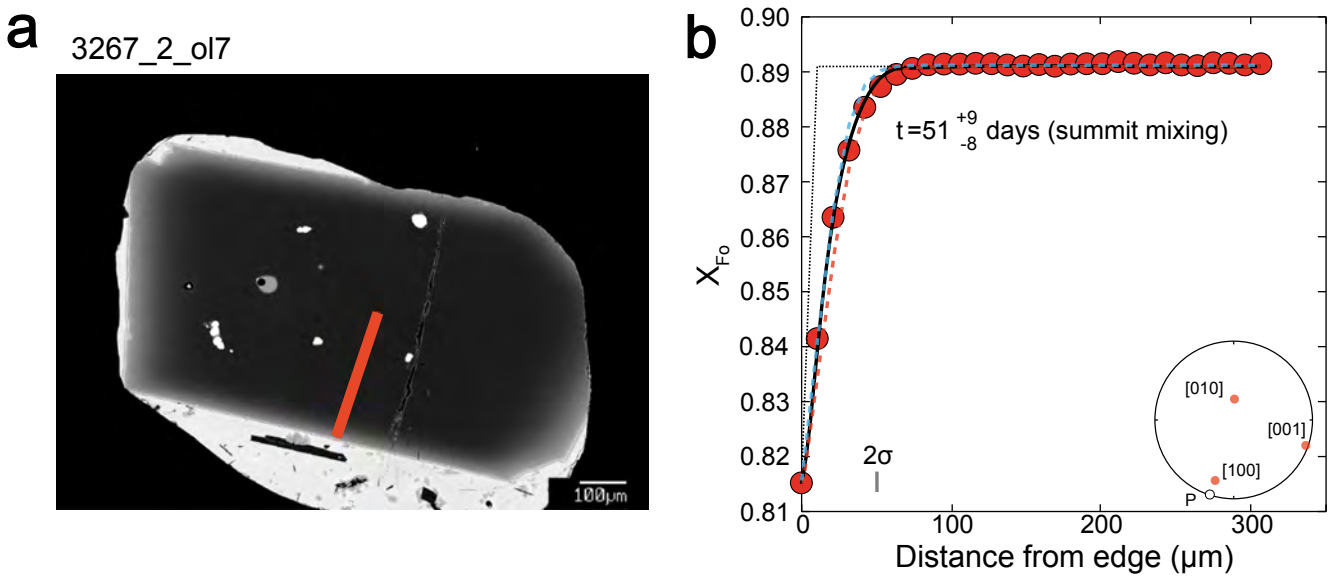
Supplementary Fig. 6: **Data, initial conditions and model fits for olivine crystal '3267_1_ol12'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset 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. 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.



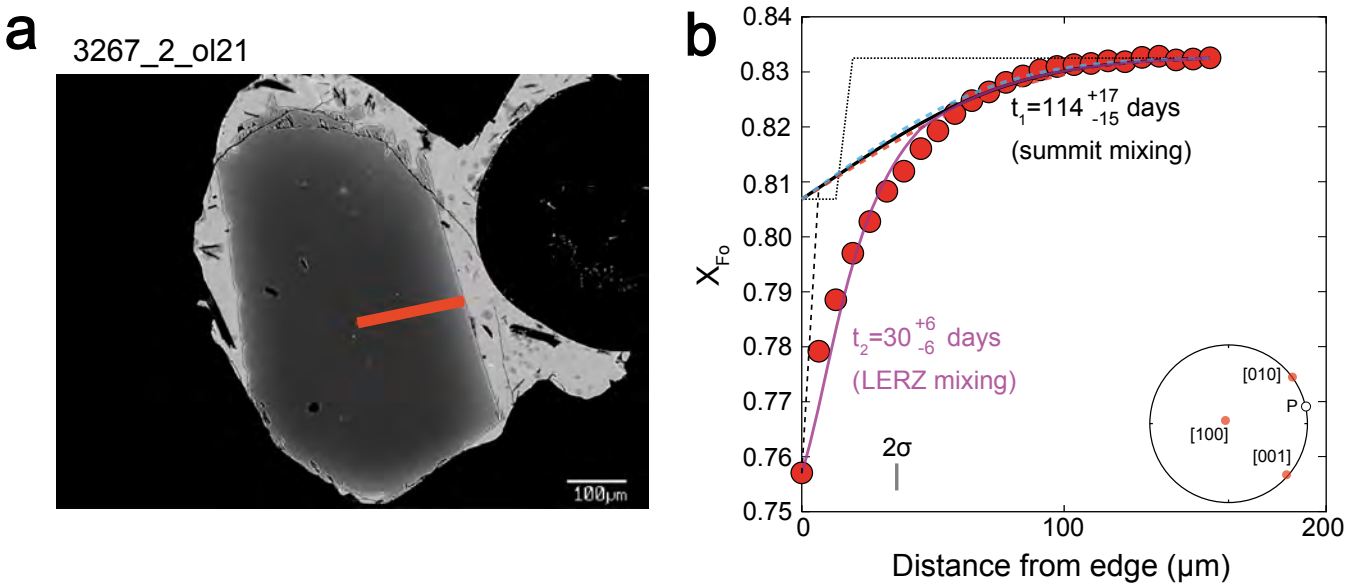
Supplementary Fig. 7: **Data, initial conditions and model fits for olivine crystal '3267_1_ol22'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



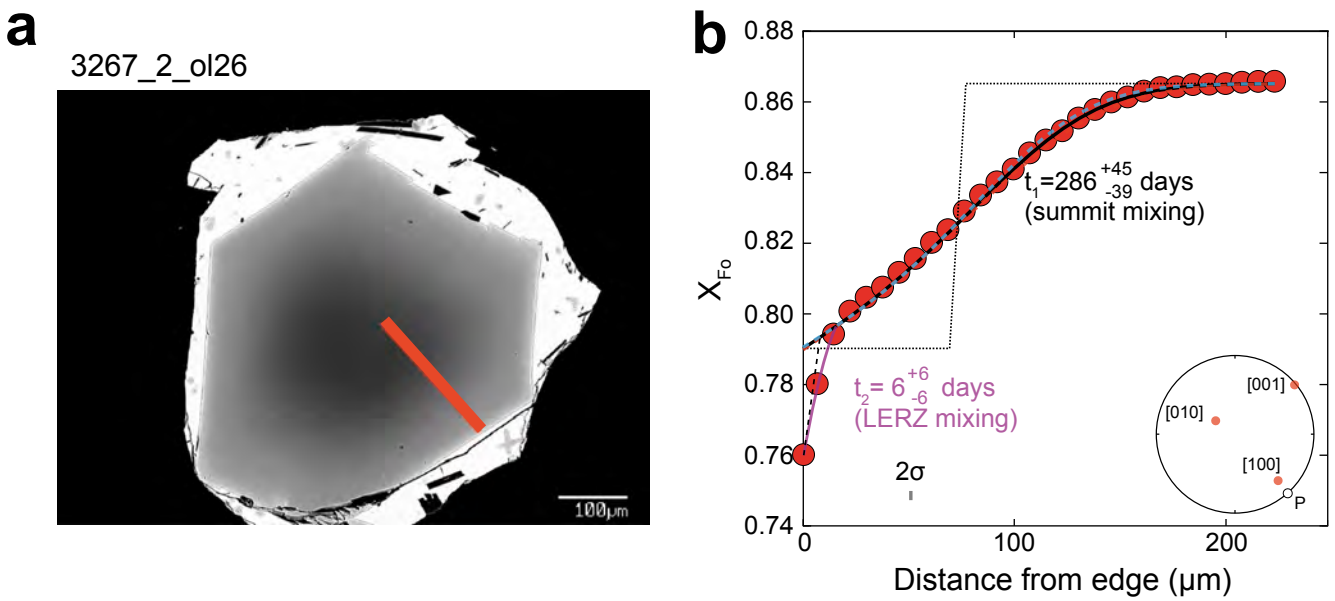
Supplementary Fig. 8: **Data, initial conditions and model fits for olivine crystal '3267_1_ol68'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



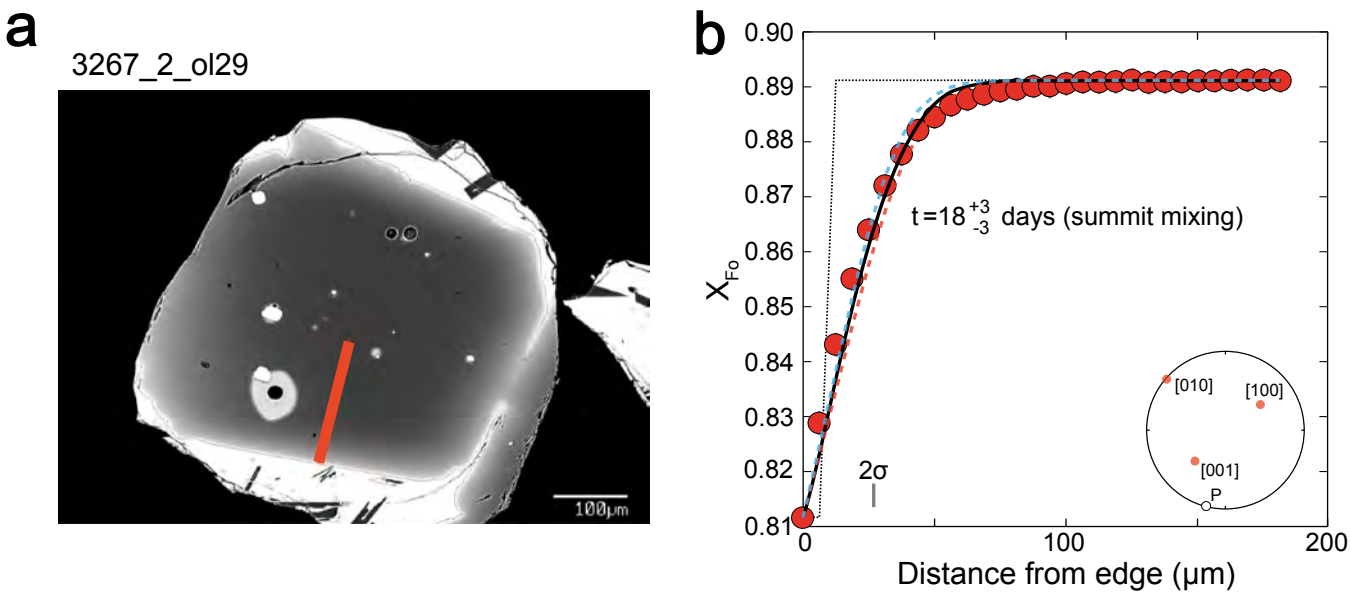
Supplementary Fig. 9: **Data, initial conditions and model fits for olivine crystal '3267_2_ol7'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



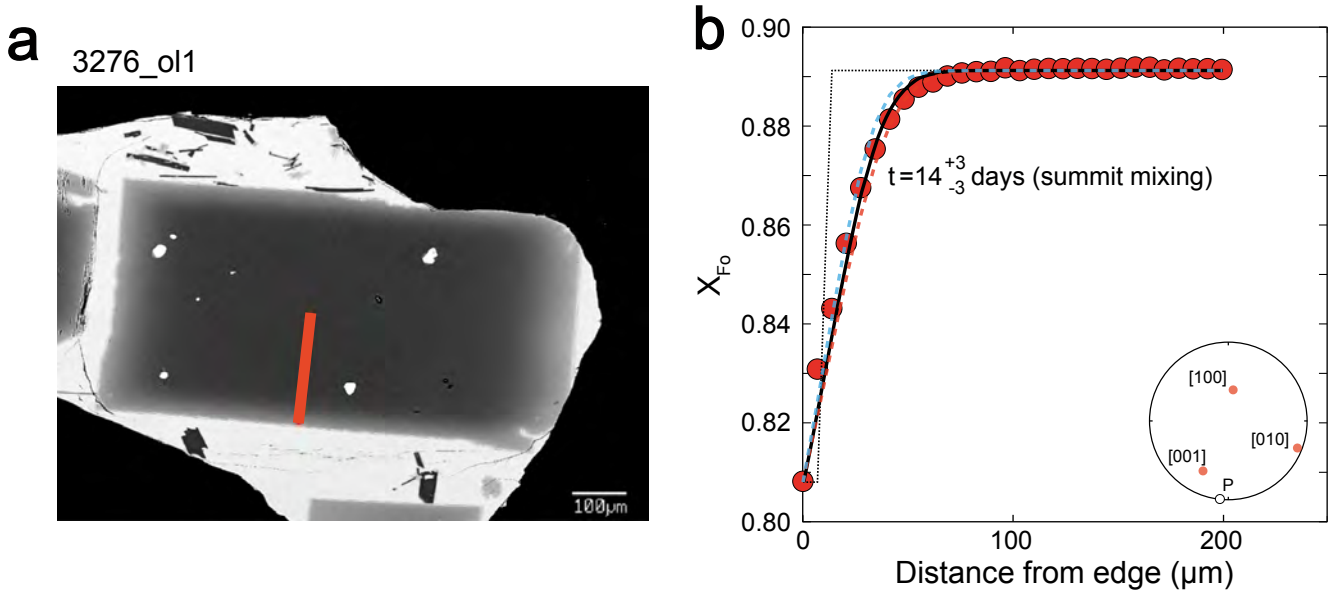
Supplementary Fig. 10: **Data, initial conditions and model fits for olivine crystal '3267_2_ol21'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. 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.



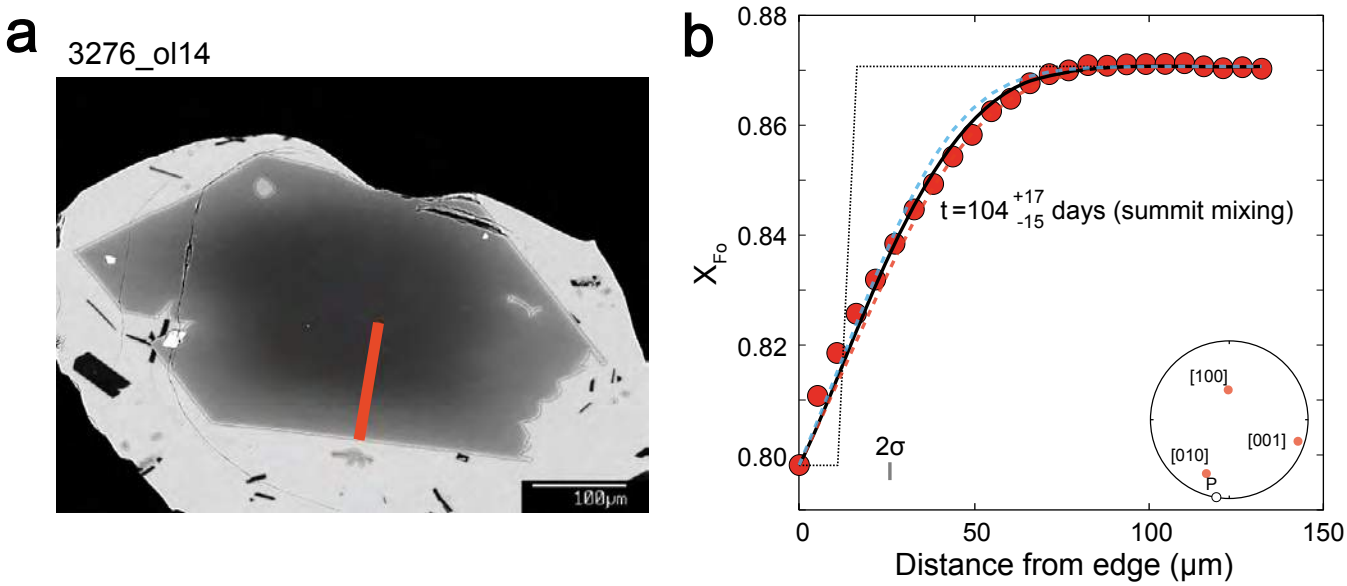
Supplementary Fig. 11: **Data, initial conditions and model fits for olivine crystal '3267_2_ol26'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. 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.



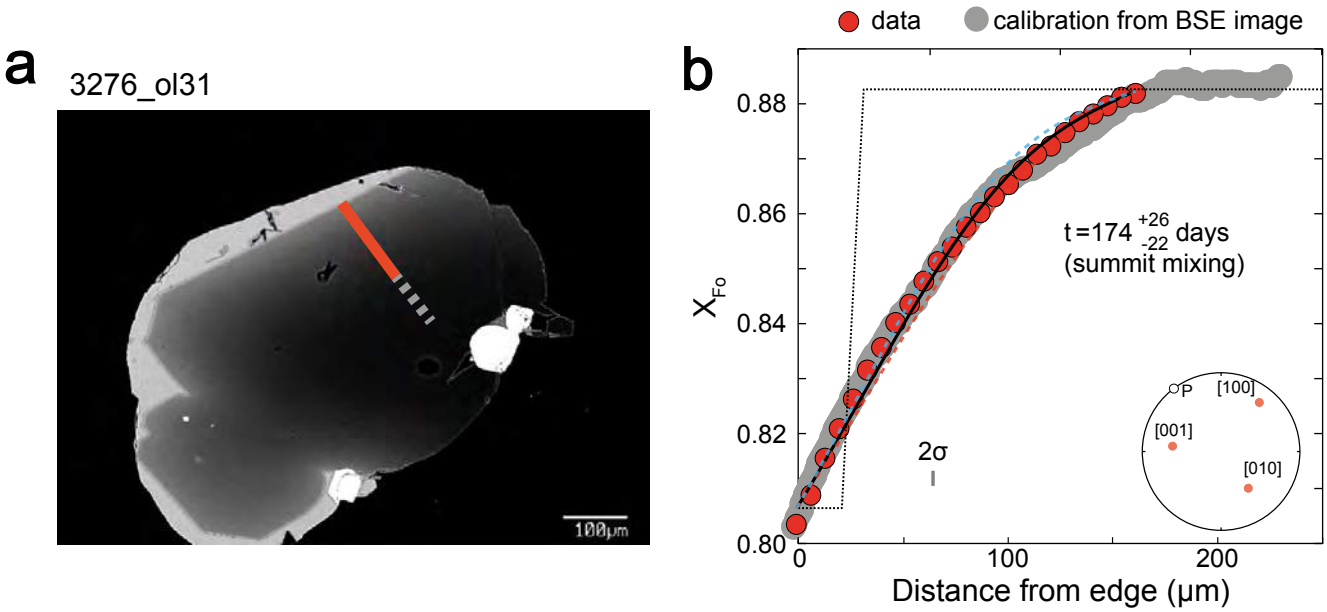
Supplementary Fig. 12: **Data, initial conditions and model fits for olivine crystal '3267_2_ol29'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



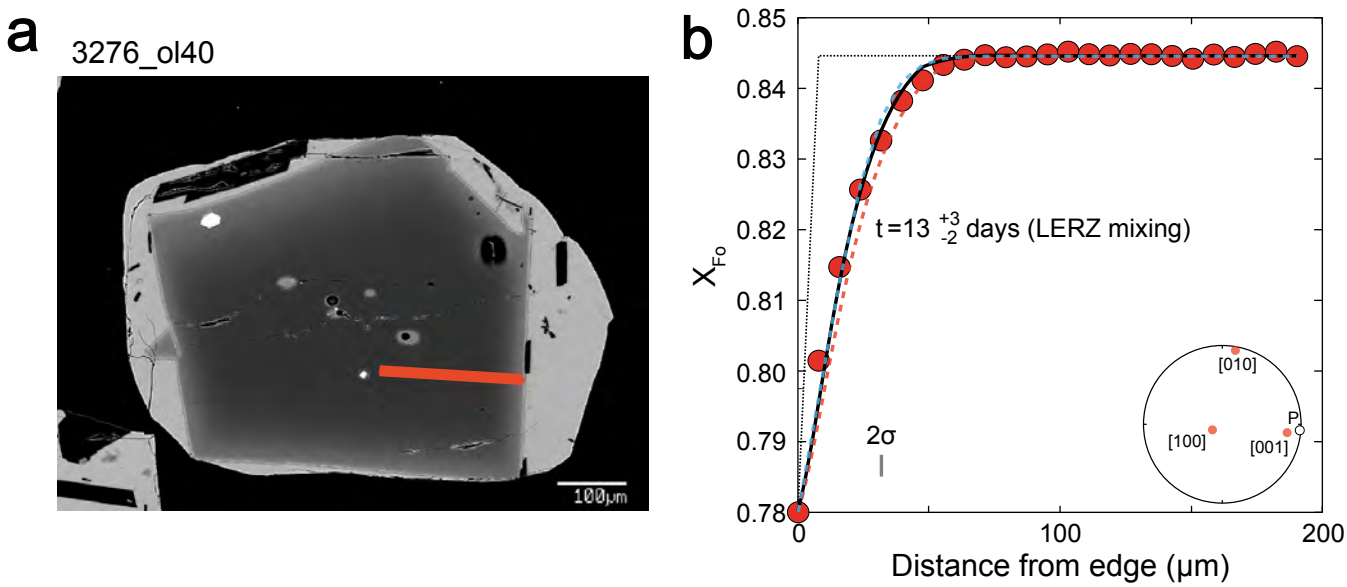
Supplementary Fig. 13: **Data, initial conditions and model fits for olivine crystal '3276_ol1'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



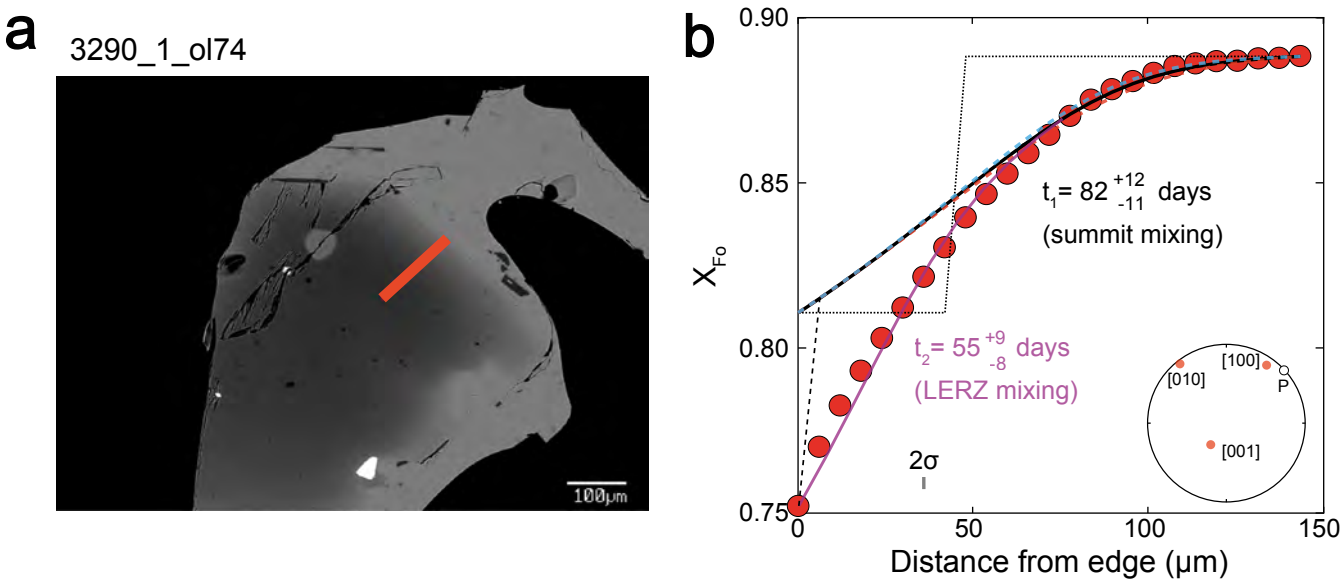
Supplementary Fig. 14: **Data, initial conditions and model fits for olivine crystal '3276_ol14'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



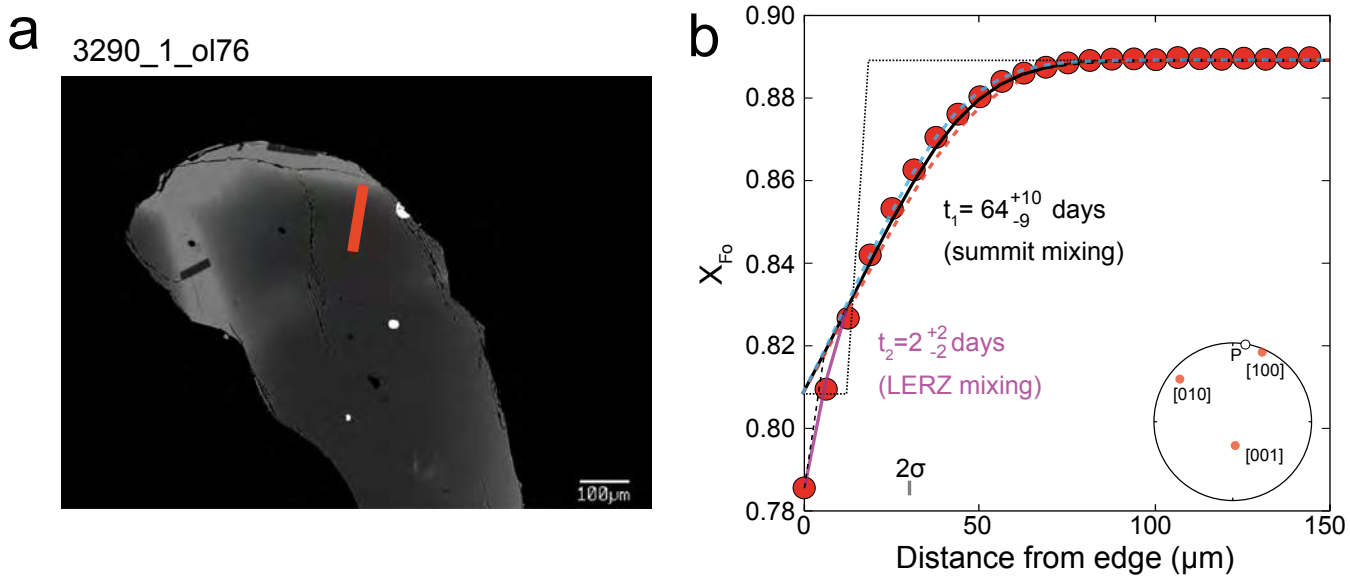
Supplementary Fig. 15: **Data, initial conditions and model fits for olivine crystal '3276_ol31'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



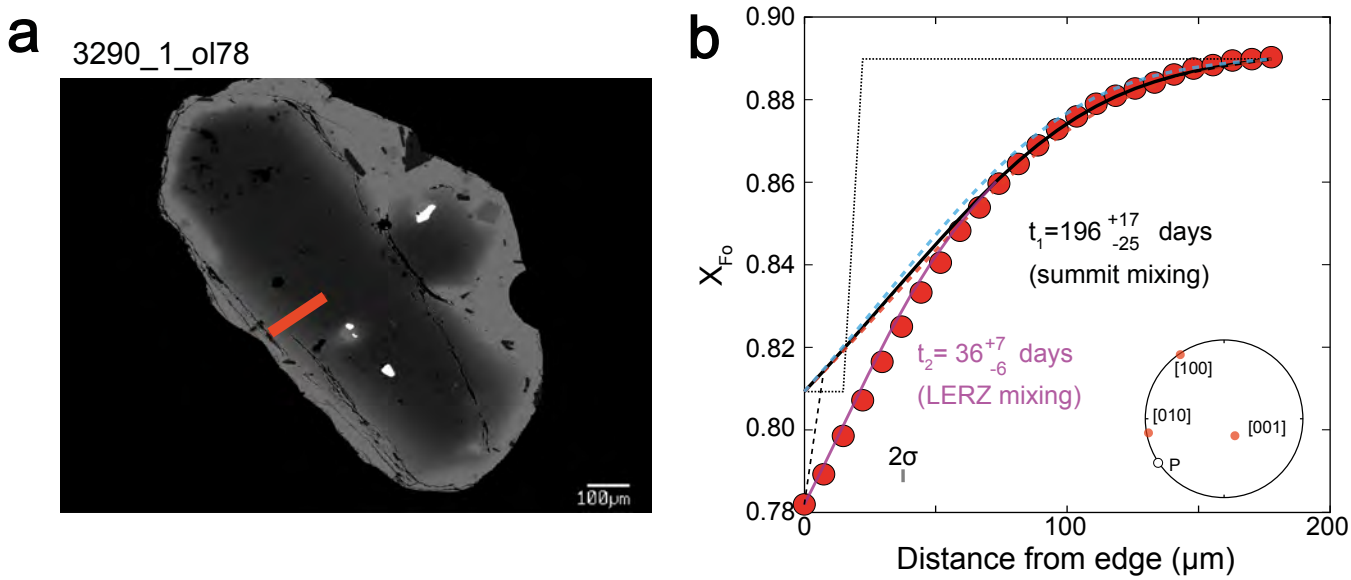
Supplementary Fig. 16: **Data, initial conditions and model fits for olivine crystal '3276_ol40'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset 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. The black dashed lines correspond to constant (homogeneous) initial conditions. LERZ = lower East Rift Zone.



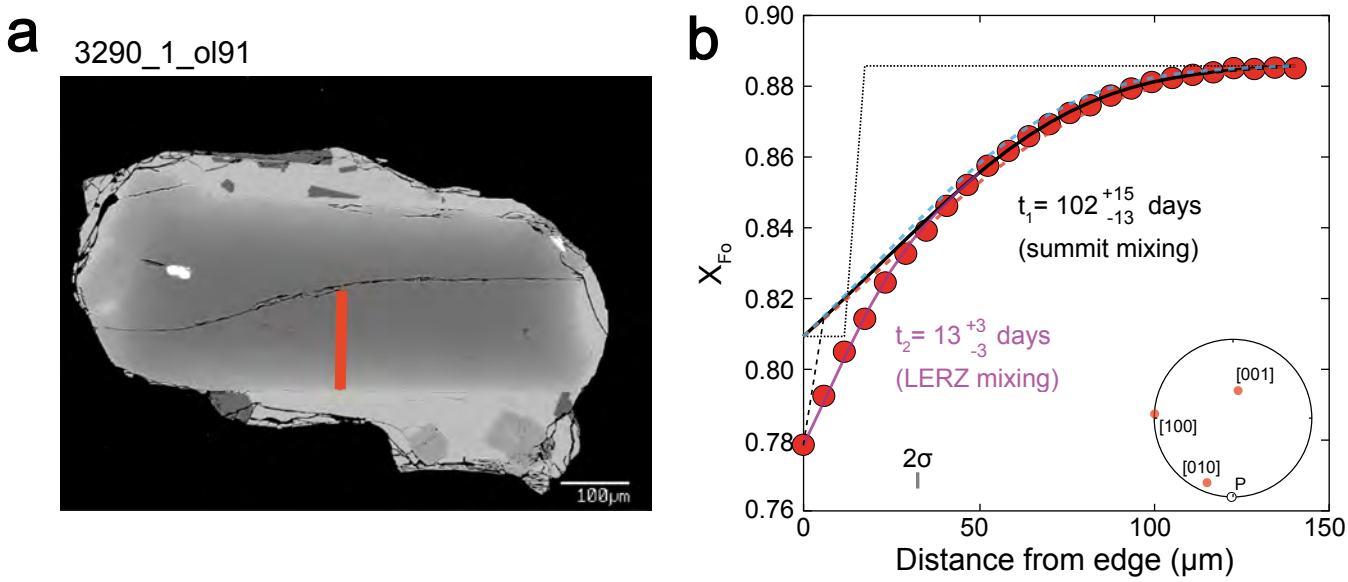
Supplementary Fig. 17: **Data, initial conditions and model fits for olivine crystal '3290_1_ol74'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. 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.



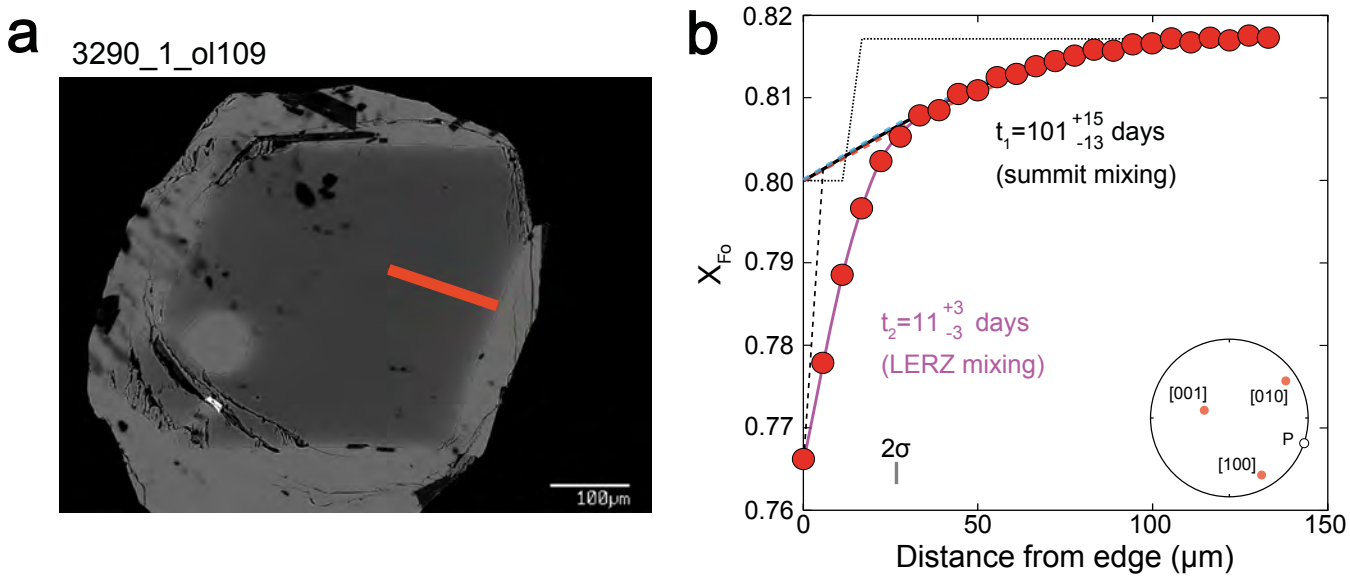
Supplementary Fig. 18: **Data, initial conditions and model fits for olivine crystal '3290_1_ol76'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. 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.



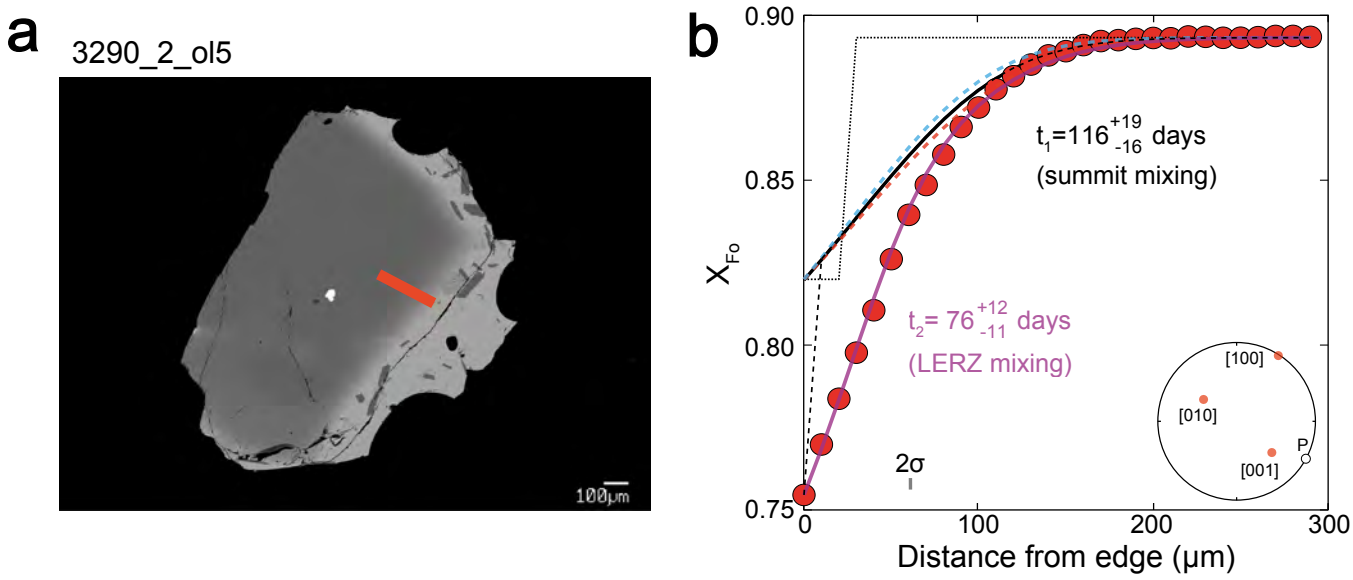
Supplementary Fig. 19: **Data, initial conditions and model fits for olivine crystal '3290_1_ol78'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. 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.



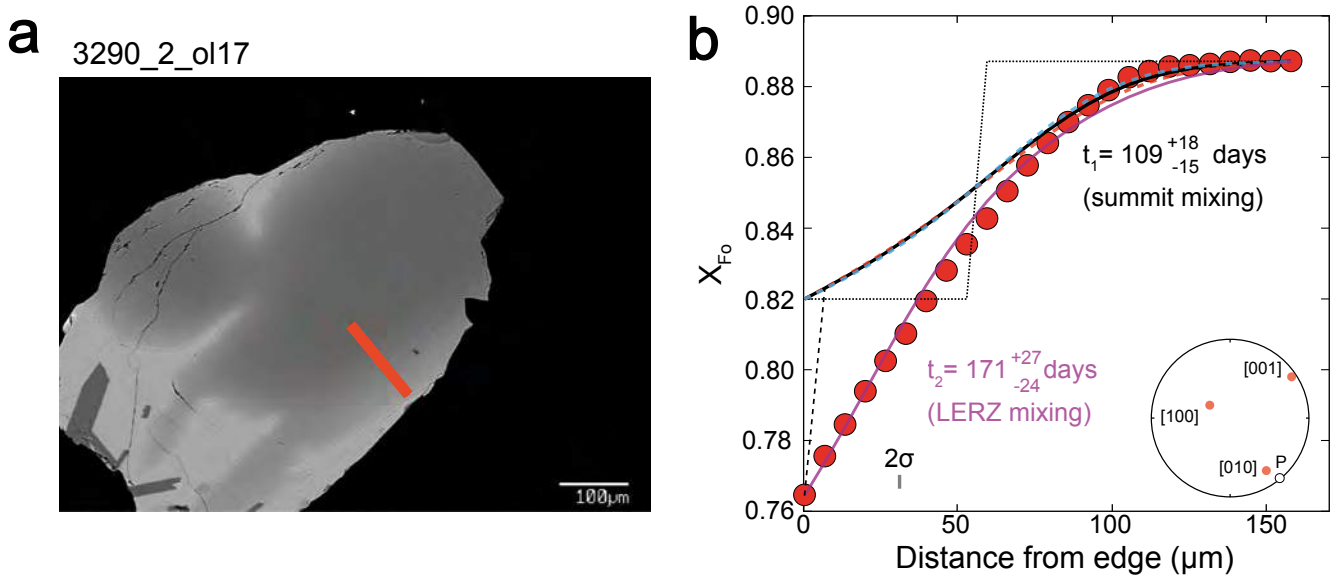
Supplementary Fig. 20: **Data, initial conditions and model fits for olivine crystal '3290_1_ol91'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. 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.



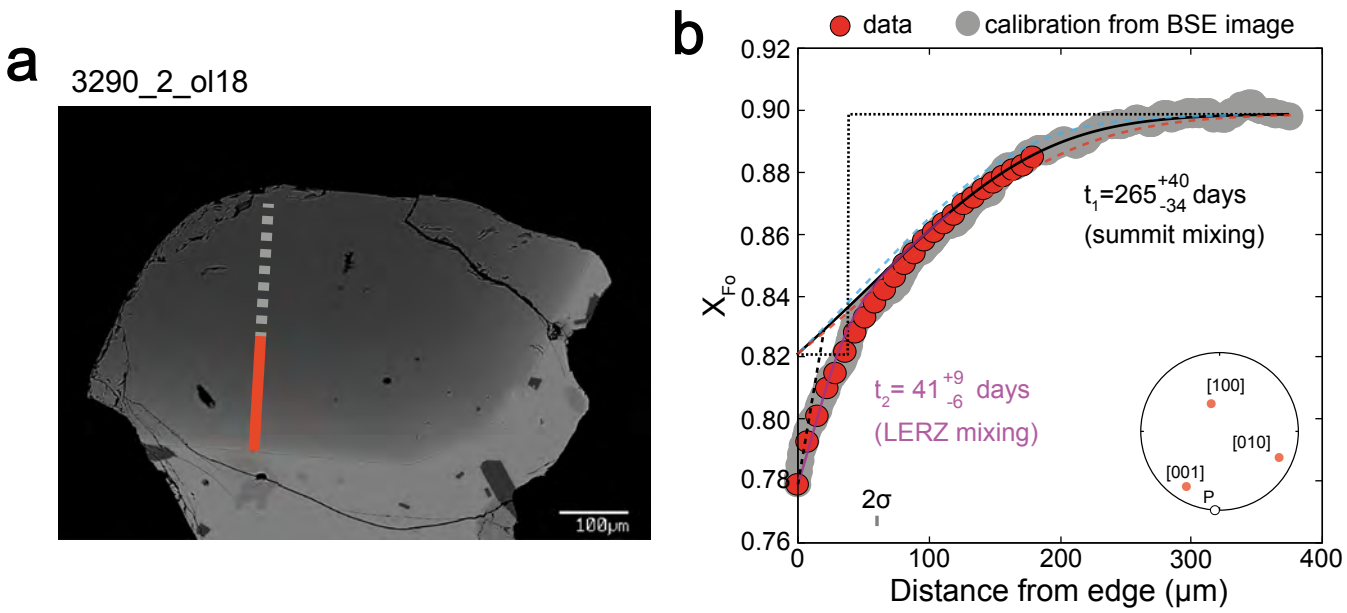
Supplementary Fig. 21: **Data, initial conditions and model fits for olivine crystal '3290_1_ol109'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. 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.



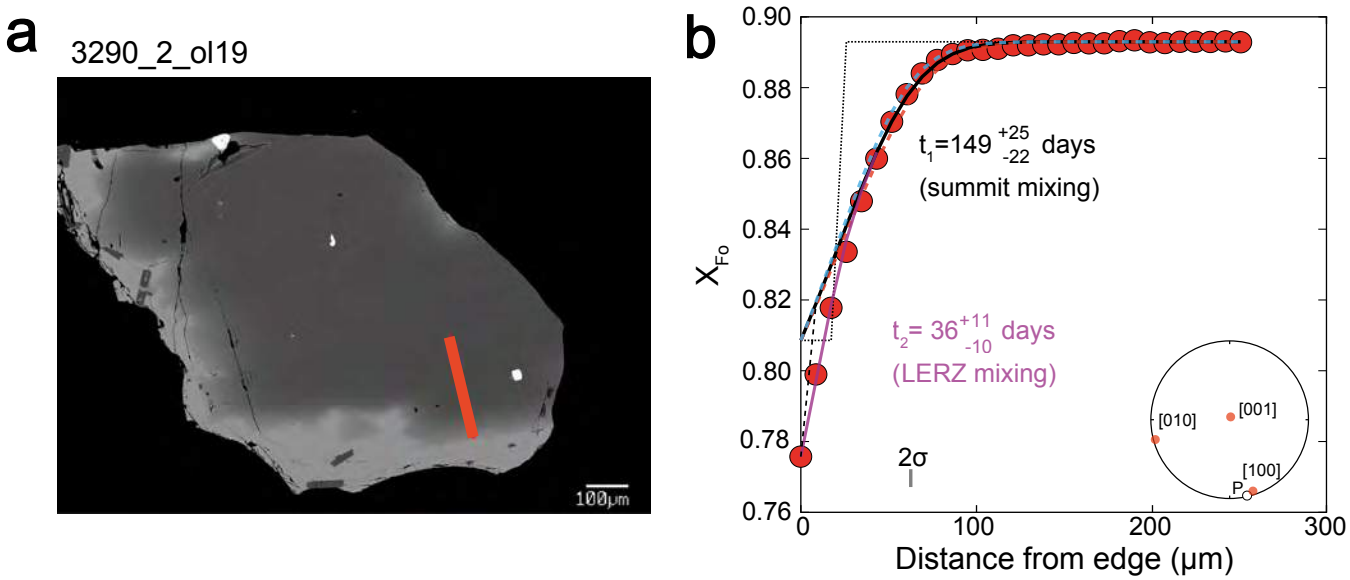
Supplementary Fig. 22: **Data, initial conditions and model fits for olivine crystal '3290_2_ol5'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset 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. 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.



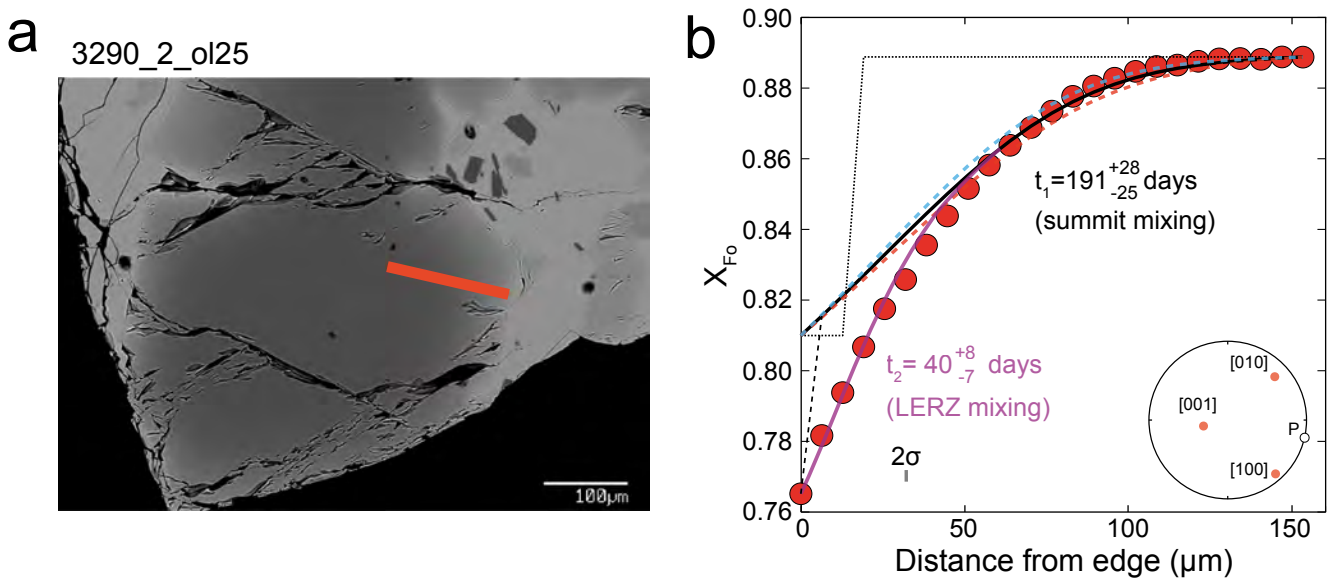
Supplementary Fig. 23: **Data, initial conditions and model fits for olivine crystal '3290_2_ol17'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. 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.



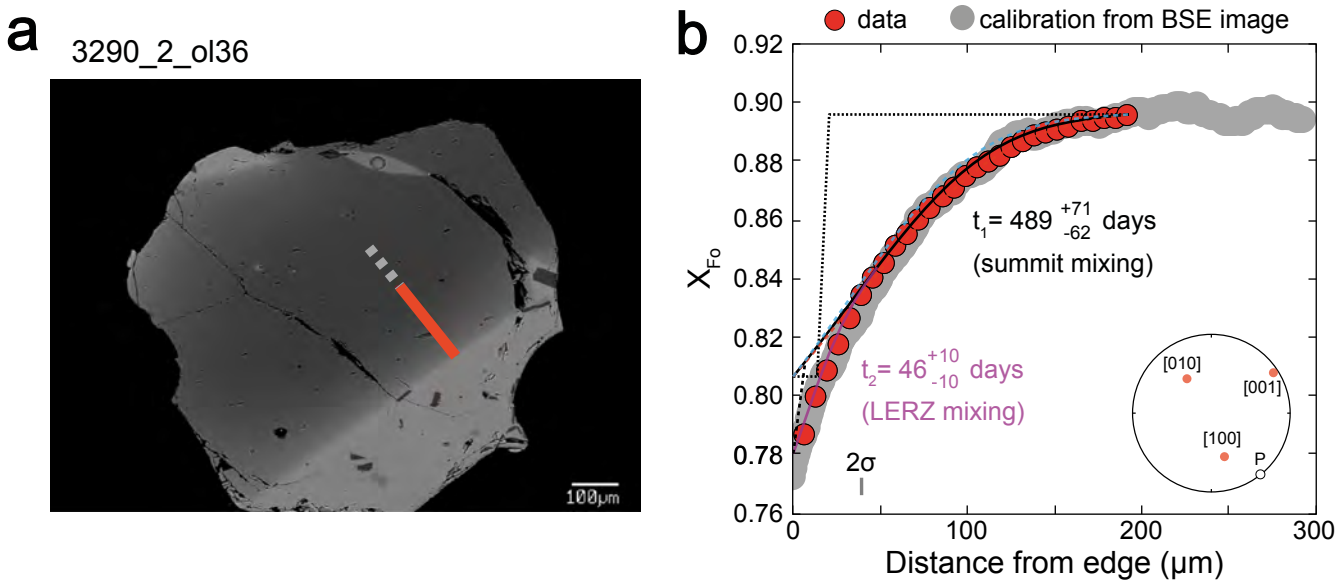
Supplementary Fig. 24: **Data, initial conditions and model fits for olivine crystal '3290_2_ol18'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. 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.



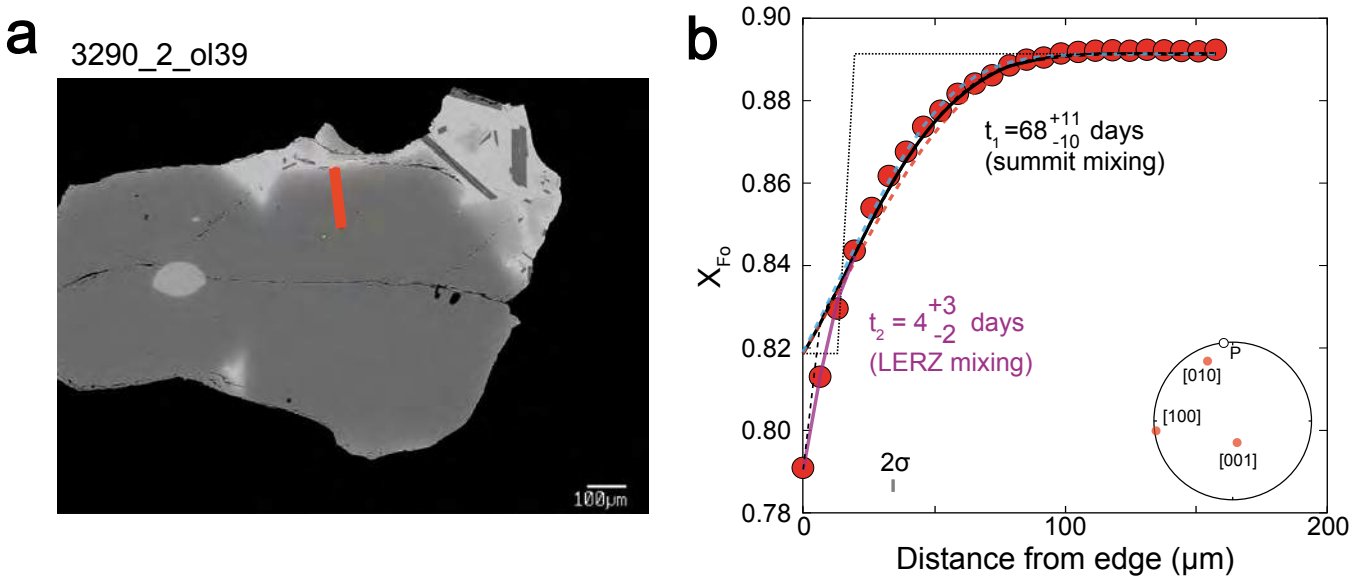
Supplementary Fig. 25: **Data, initial conditions and model fits for olivine crystal '3290_2_ol19'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. 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.



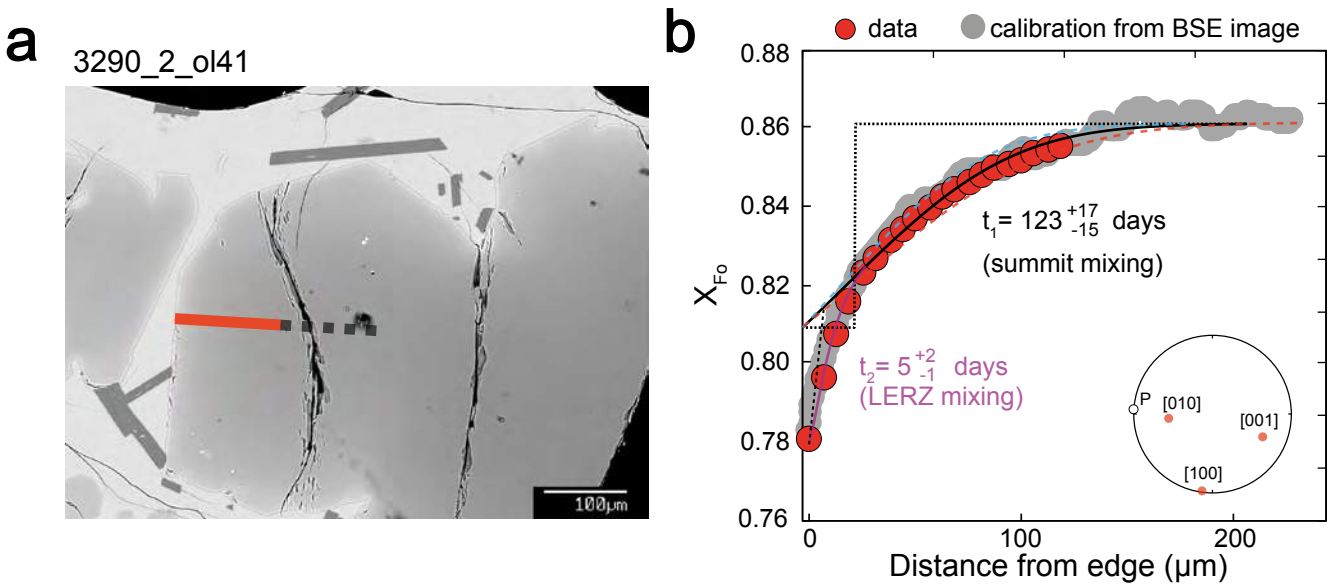
Supplementary Fig. 26: **Data, initial conditions and model fits for olivine crystal '3290_2_ol25'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. 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.



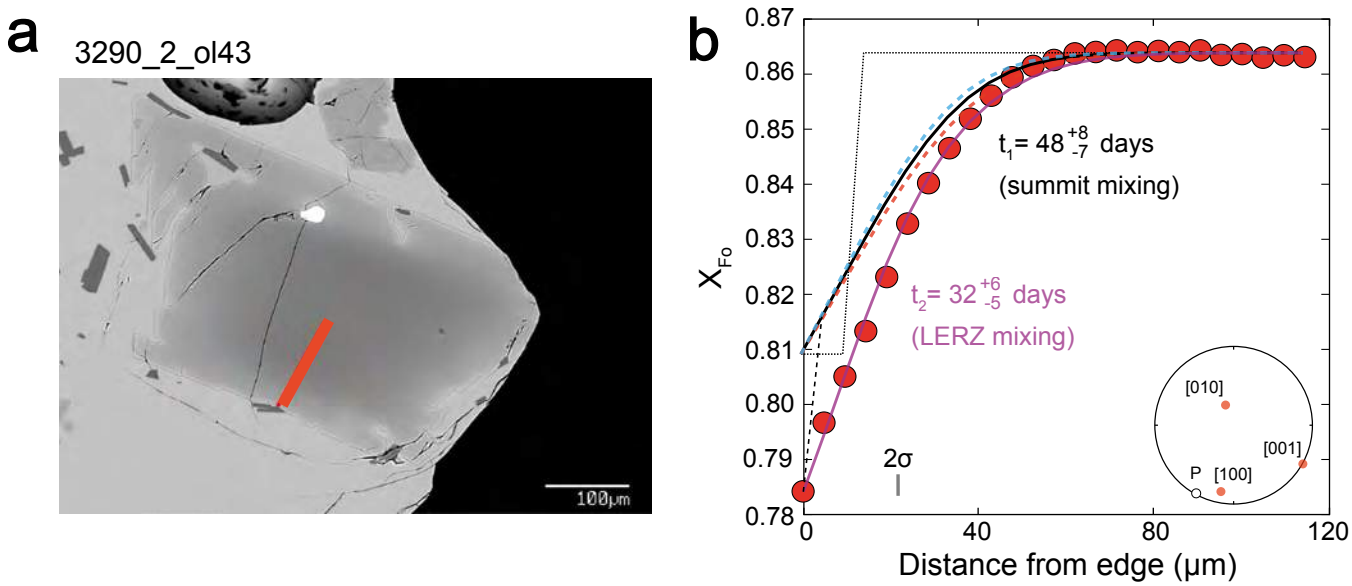
Supplementary Fig. 27: **Data, initial conditions and model fits for olivine crystal '3290_2_ol36'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. 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.



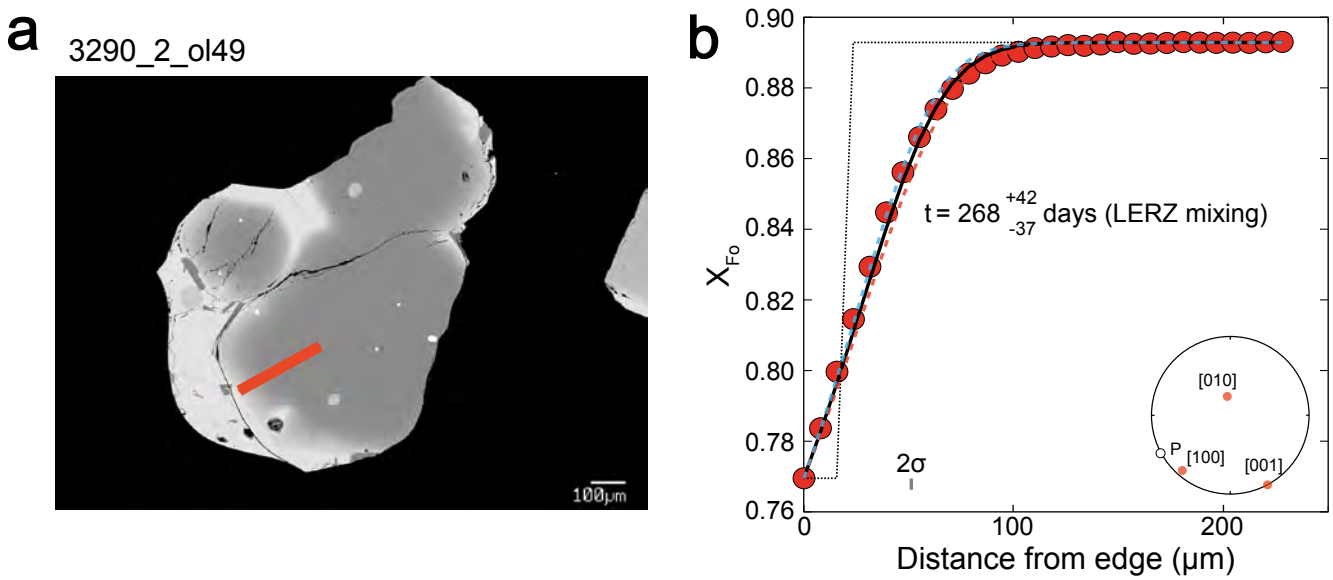
Supplementary Fig. 28: **Data, initial conditions and model fits for olivine crystal '3290_2_ol39'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. 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.



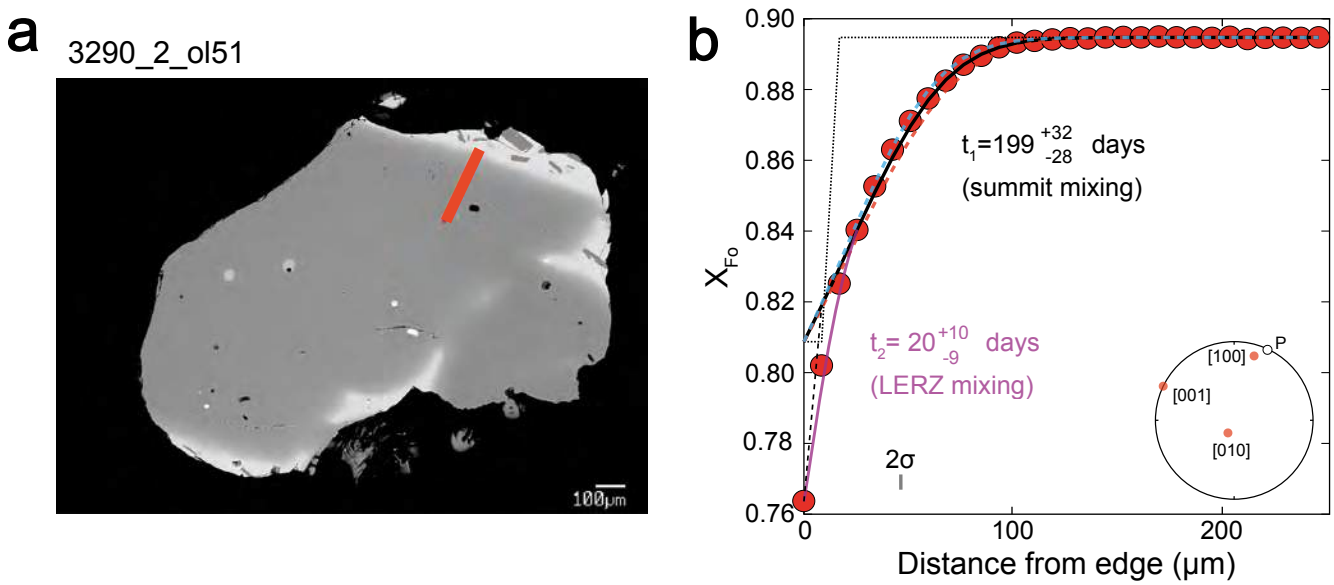
Supplementary Fig. 29: **Data, initial conditions and model fits for olivine crystal '3290_2_ol41'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. 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.



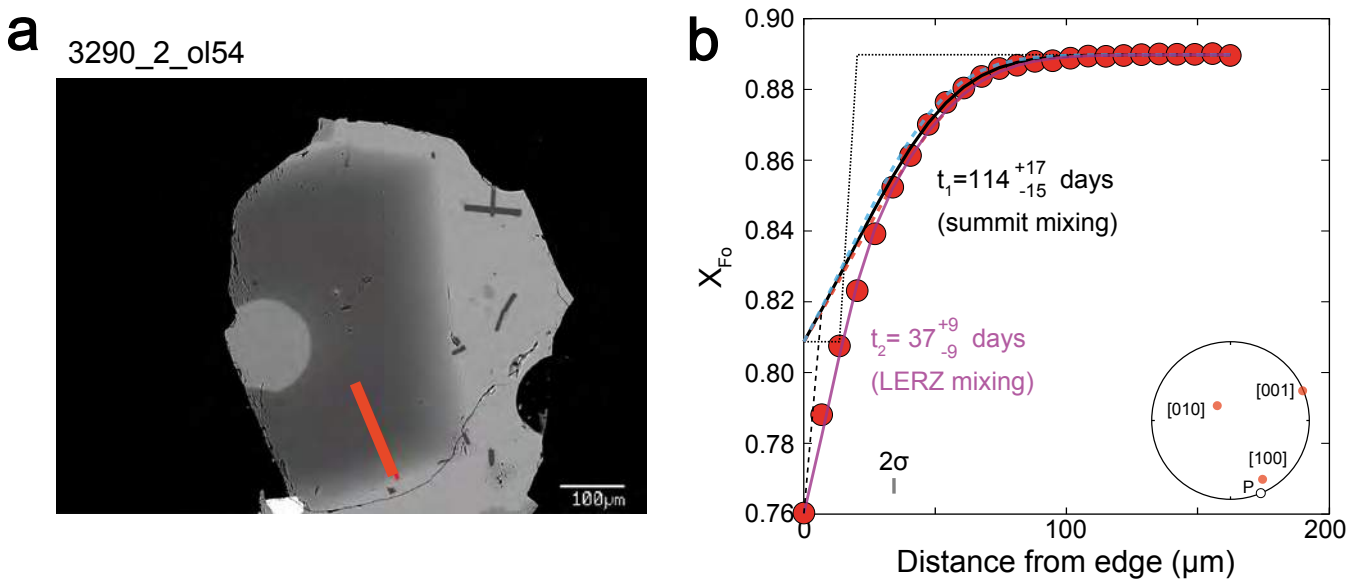
Supplementary Fig. 30: **Data, initial conditions and model fits for olivine crystal '3290_2_ol43'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. 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.



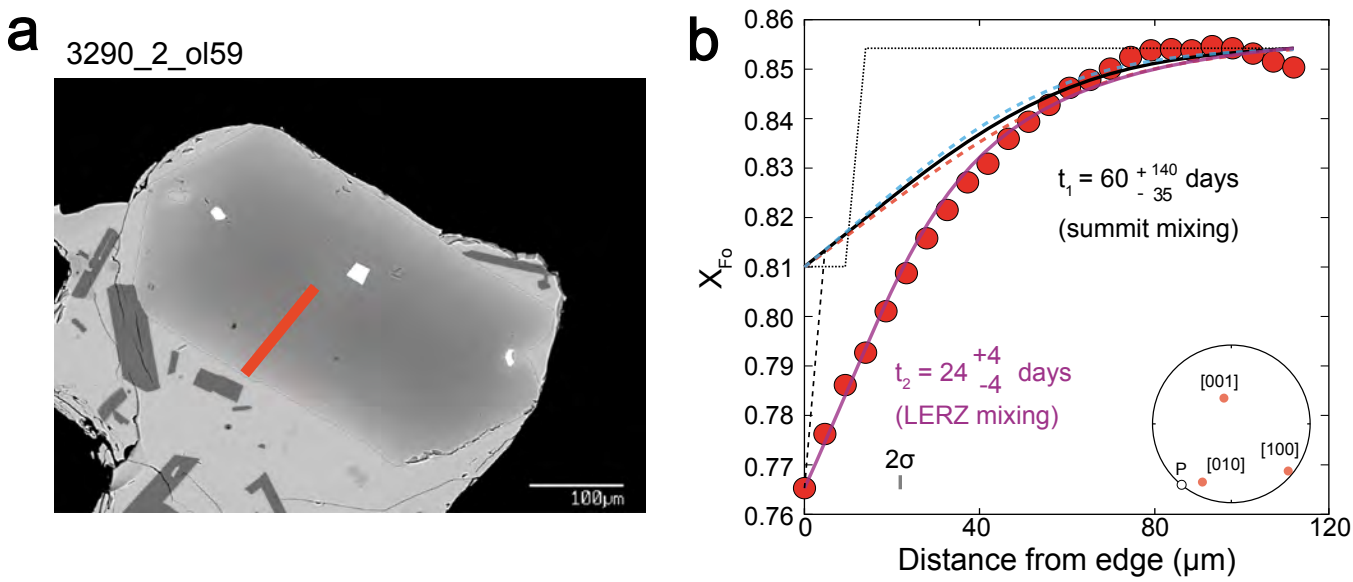
Supplementary Fig. 31: **Data, initial conditions and model fits for olivine crystal '3290_2_ol49'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. The black dashed lines correspond to constant (homogeneous) initial conditions. LERZ = lower East Rift Zone.



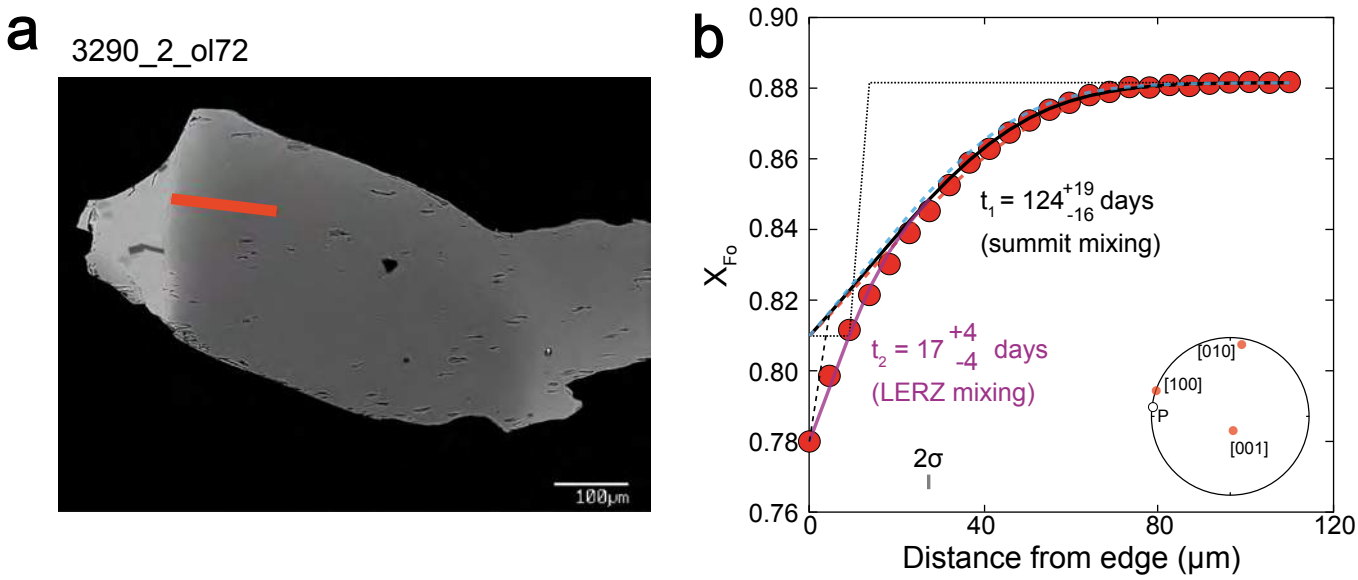
Supplementary Fig. 32: **Data, initial conditions and model fits for olivine crystal '3290_2_ol51'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. 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.



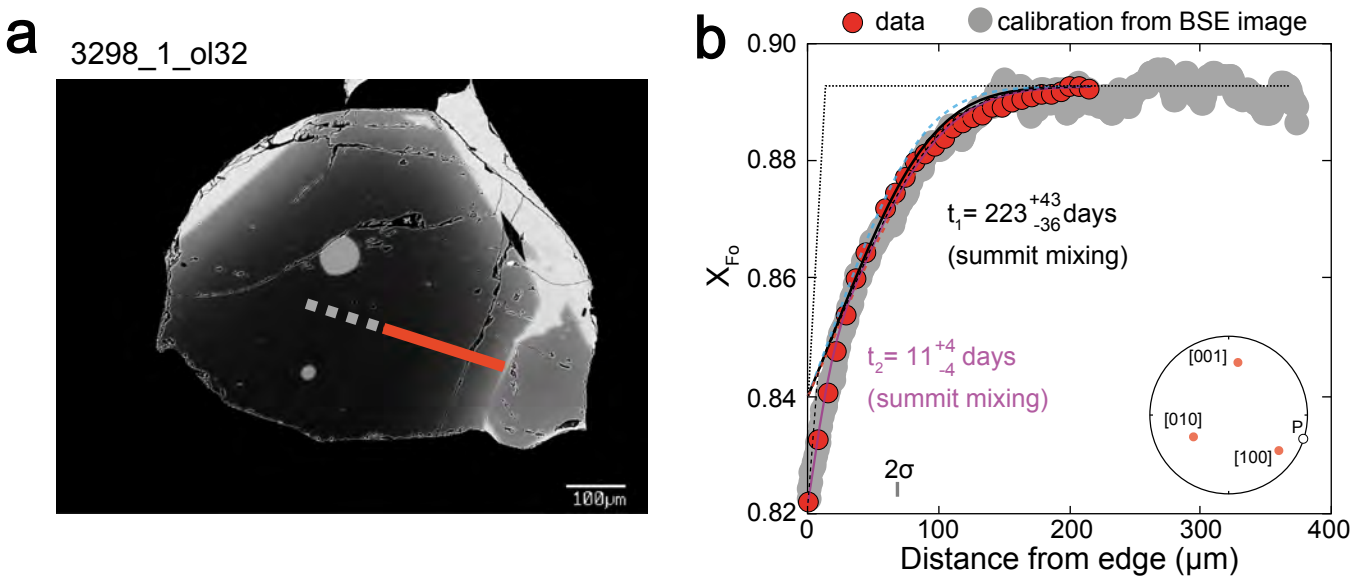
Supplementary Fig. 33: **Data, initial conditions and model fits for olivine crystal '3290_2_ol54'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. 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.



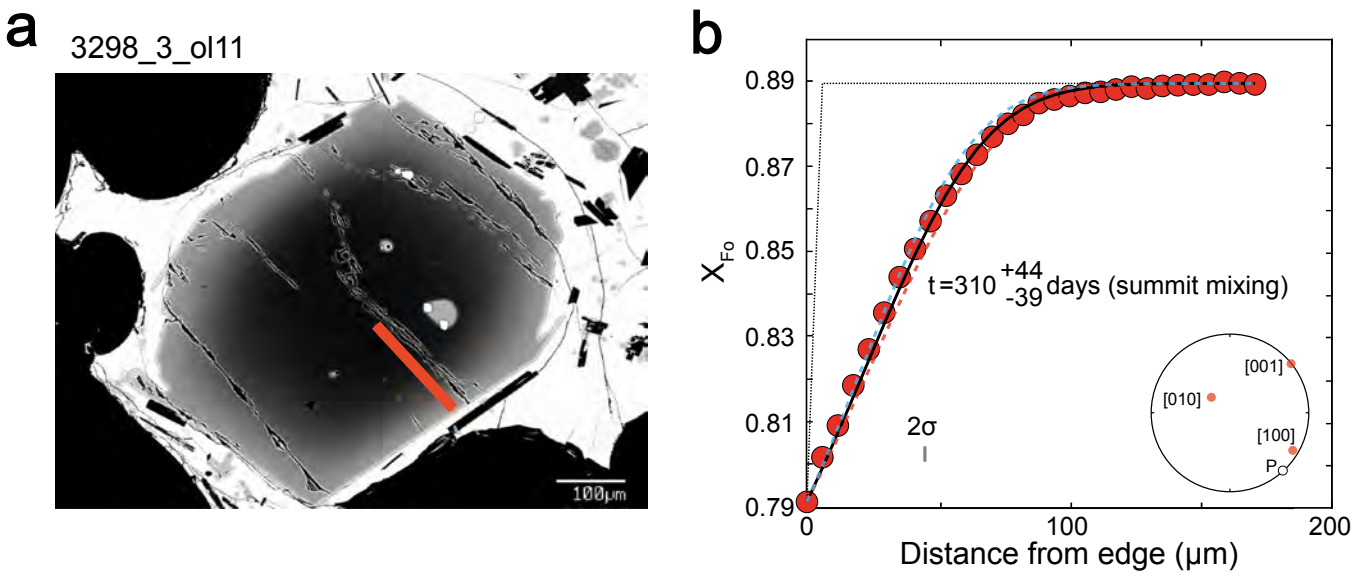
Supplementary Fig. 34: **Data, initial conditions and model fits for olivine crystal '3290_2_ol59'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. 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.



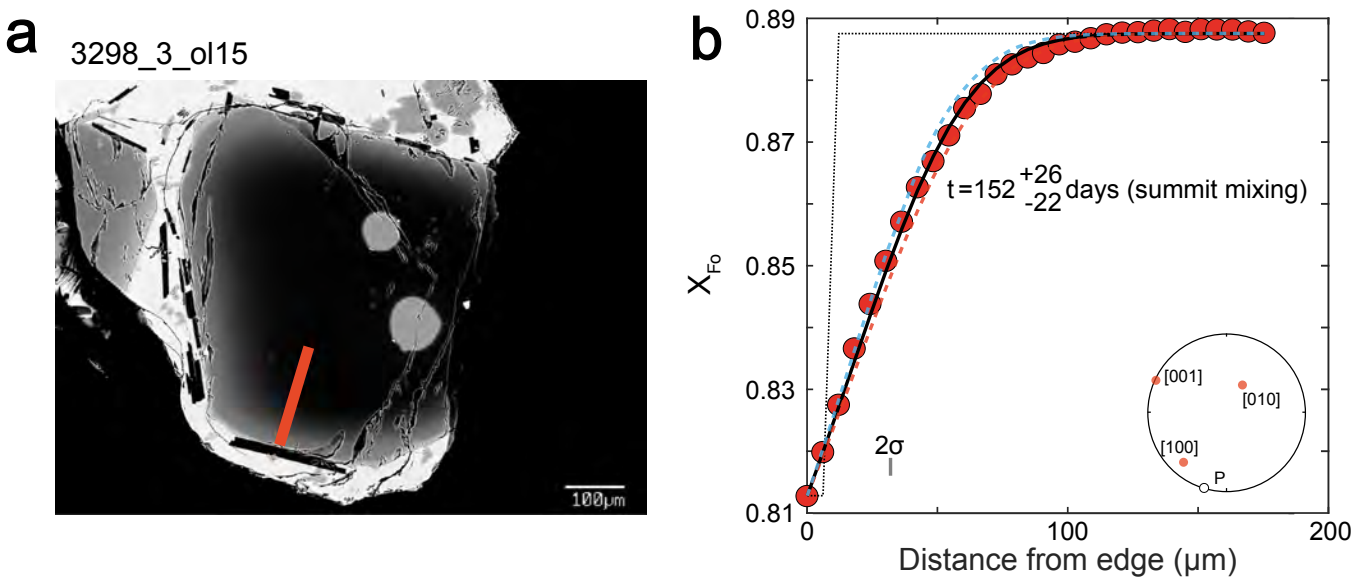
Supplementary Fig. 35: **Data, initial conditions and model fits for olivine crystal '3290_2_ol72'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. 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.



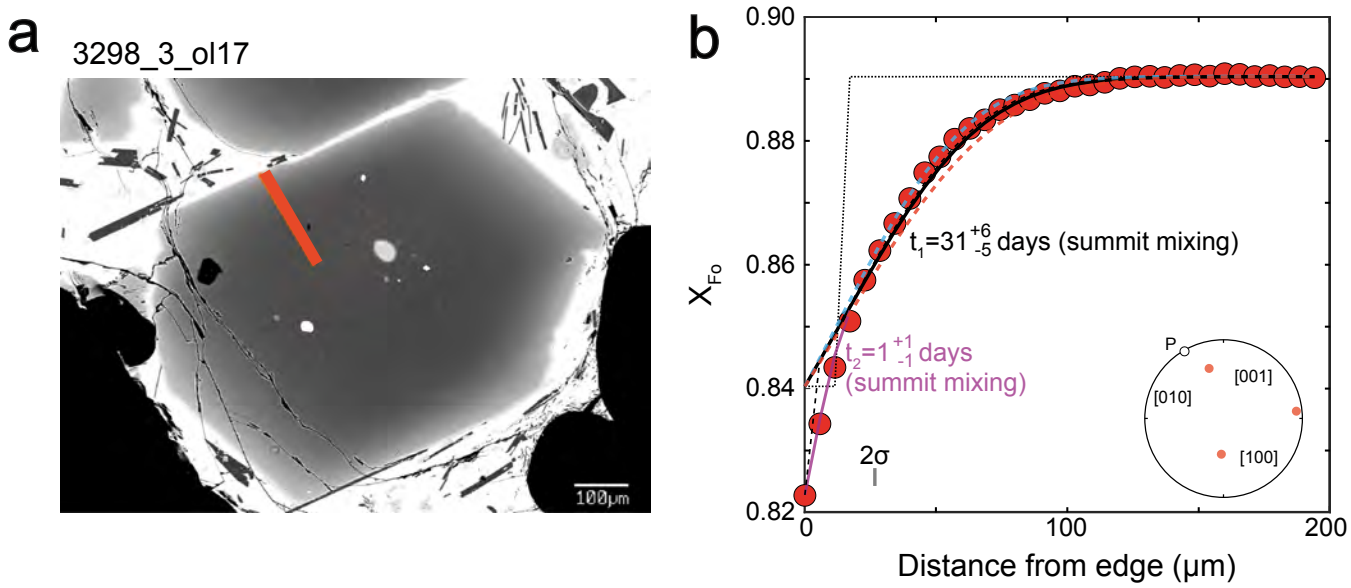
Supplementary Fig. 36: **Data, initial conditions and model fits for olivine crystal '3298_1_ol32'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. 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.



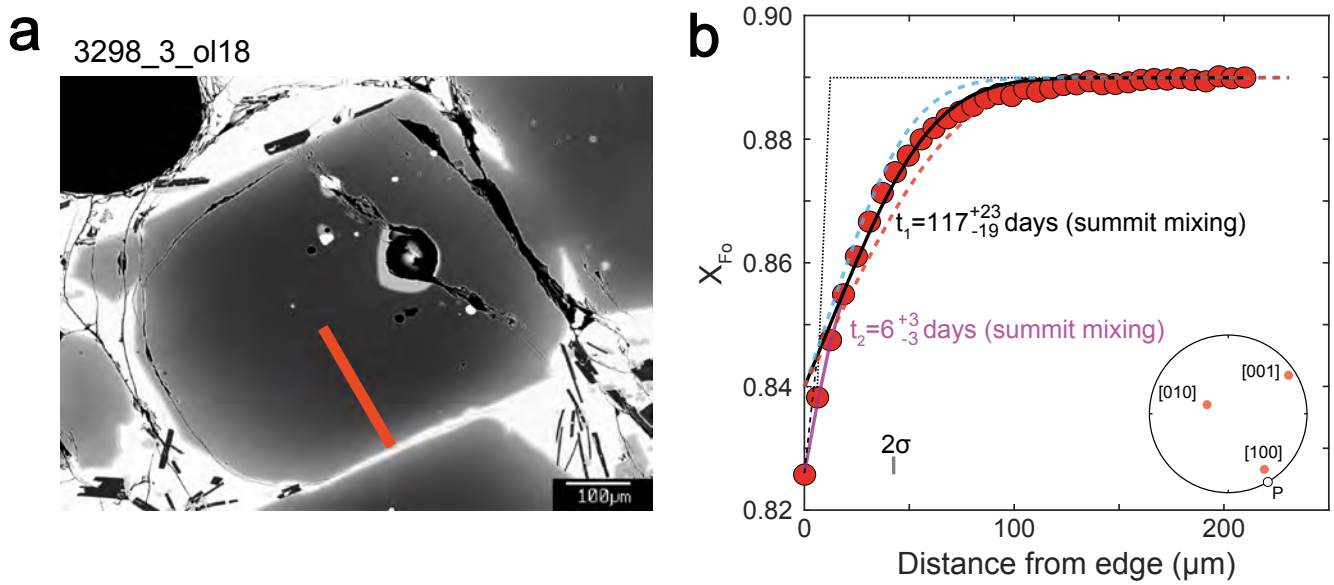
Supplementary Fig. 37: **Data, initial conditions and model fits for olivine crystal '3298_3_ol11'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



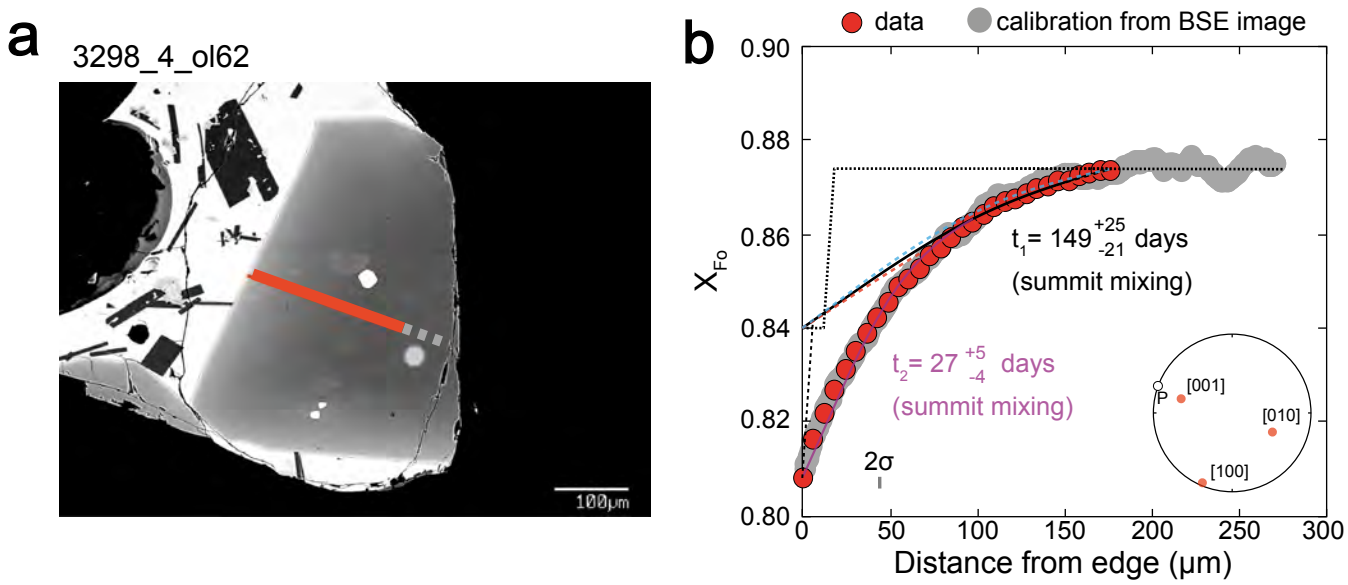
Supplementary Fig. 38: **Data, initial conditions and model fits for olivine crystal '3298_3_ol15'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



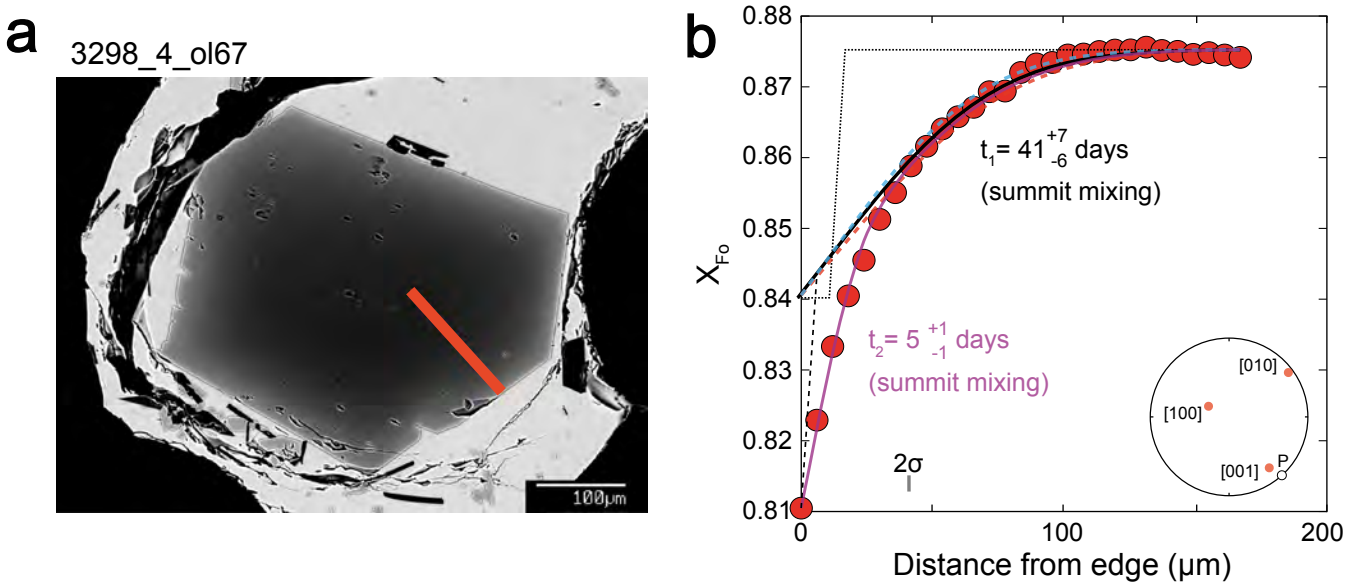
Supplementary Fig. 39: **Data, initial conditions and model fits for olivine crystal '3298_3_ol17'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. 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.



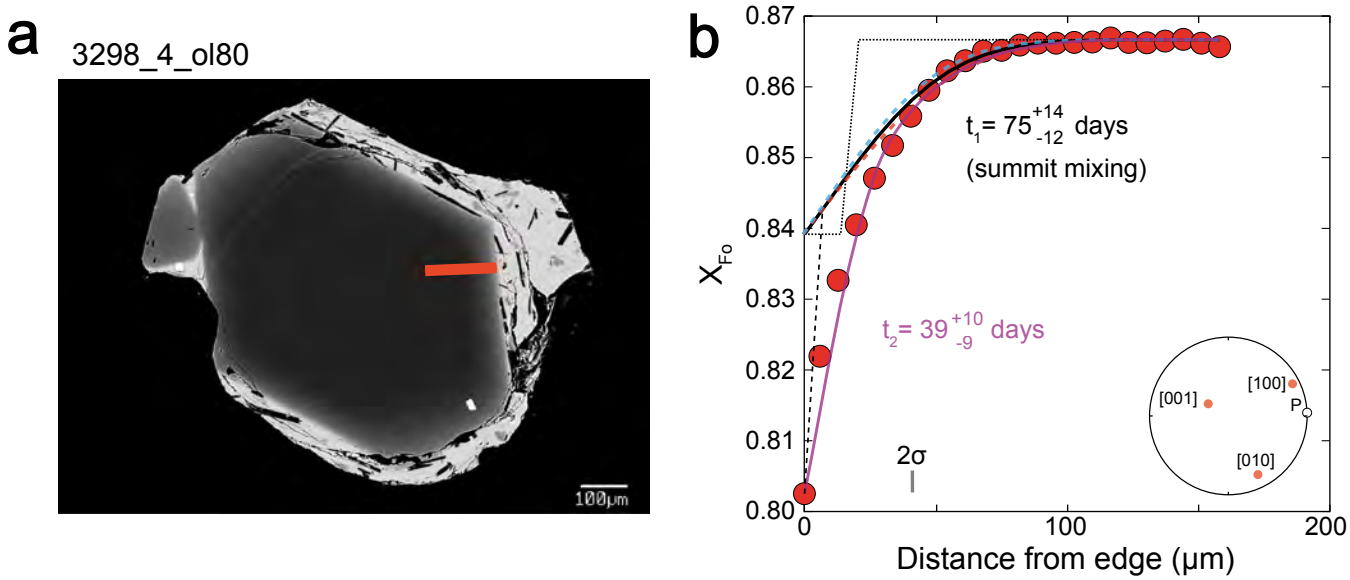
Supplementary Fig. 40: **Data, initial conditions and model fits for olivine crystal '3298_3_ol18'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. 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.



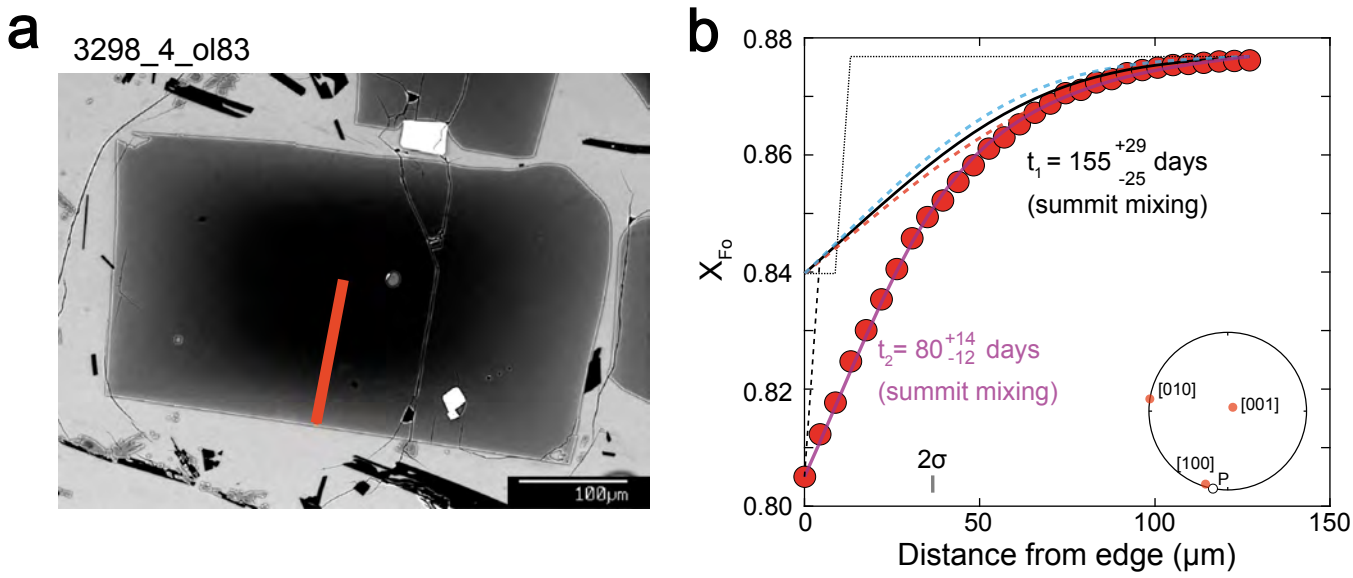
Supplementary Fig. 41: **Data, initial conditions and model fits for olivine crystal '3298_4_ol62'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. 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.



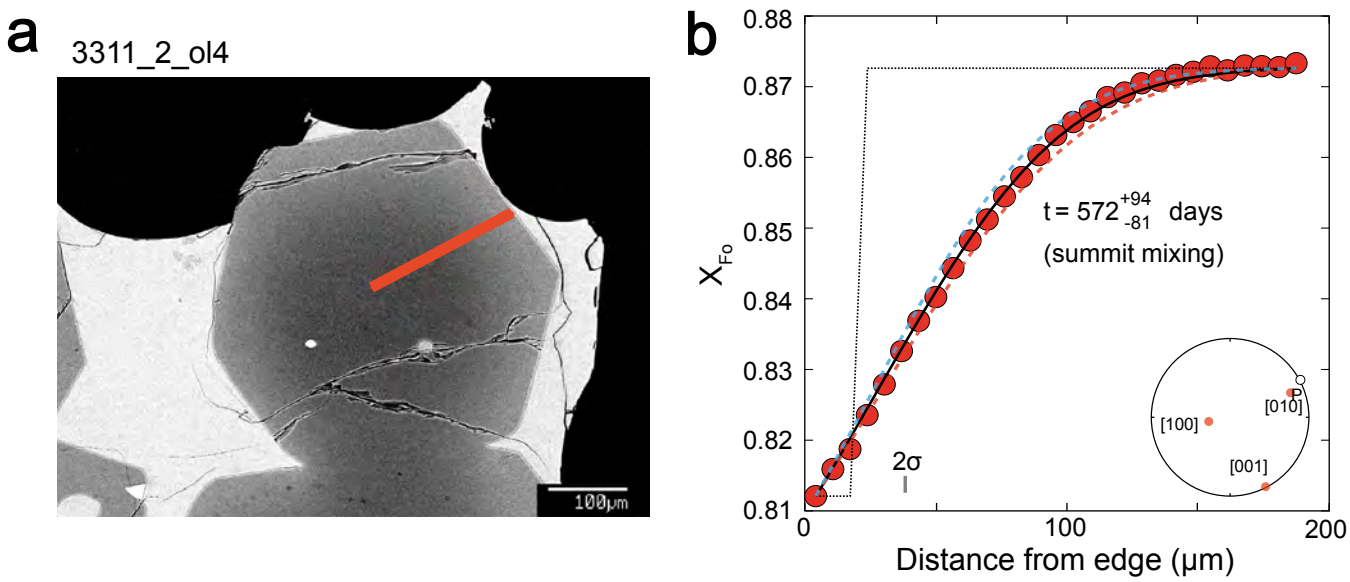
Supplementary Fig. 42: **Data, initial conditions and model fits for olivine crystal '3298_4_ol67'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. 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.



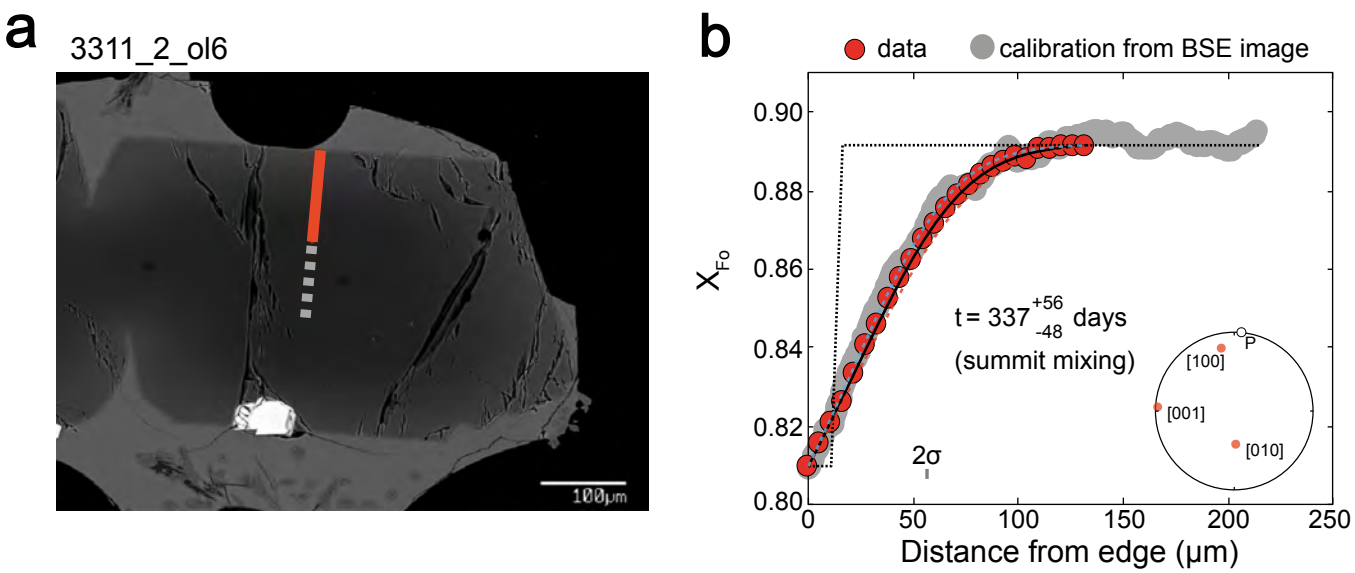
Supplementary Fig. 43: **Data, initial conditions and model fits for olivine crystal '3298_4_ol80'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. 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.



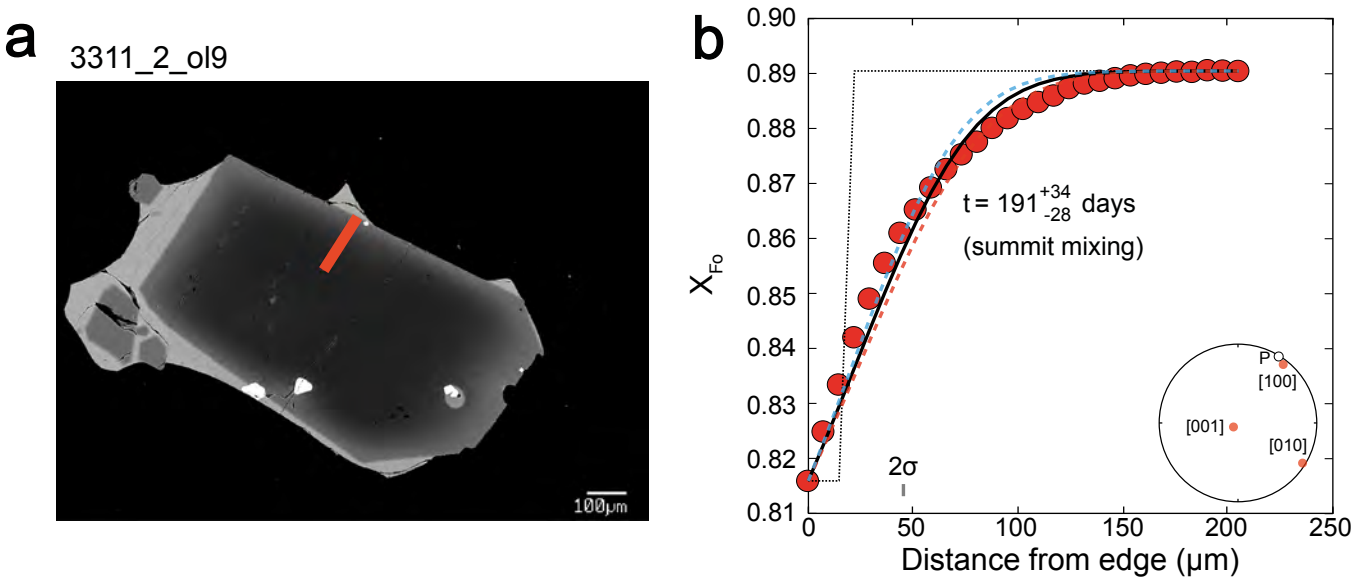
Supplementary Fig. 44: **Data, initial conditions and model fits for olivine crystal '3298_4_ol83'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. 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.



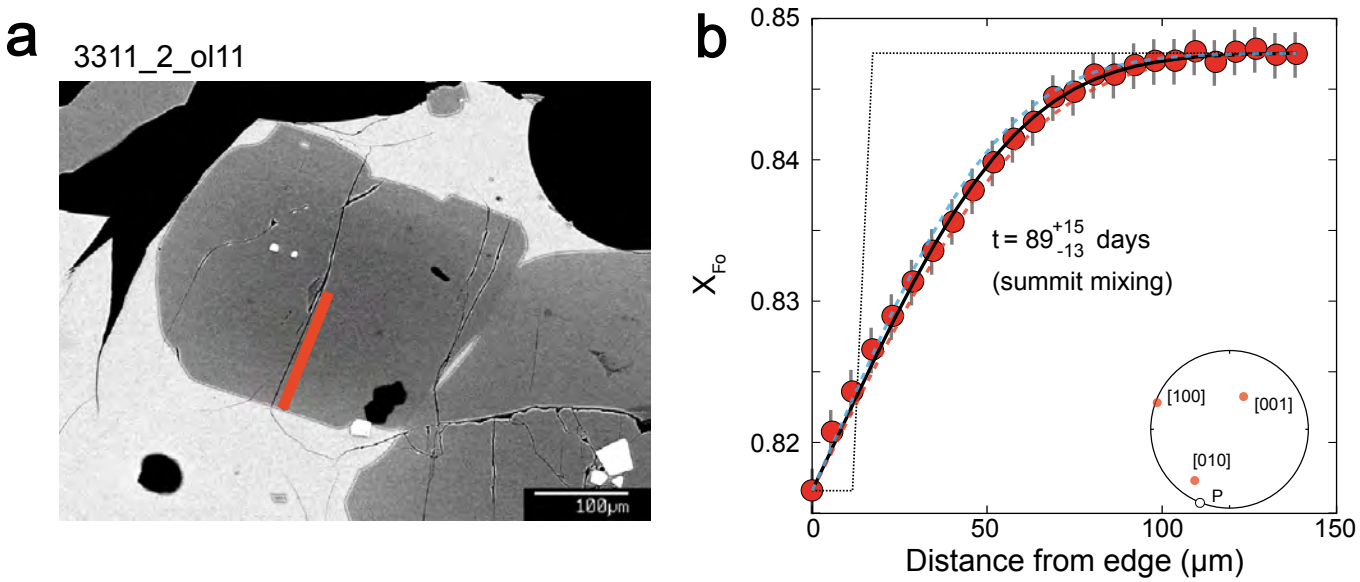
Supplementary Fig. 45: **Data, initial conditions and model fits for olivine crystal '3311_2_ol4'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



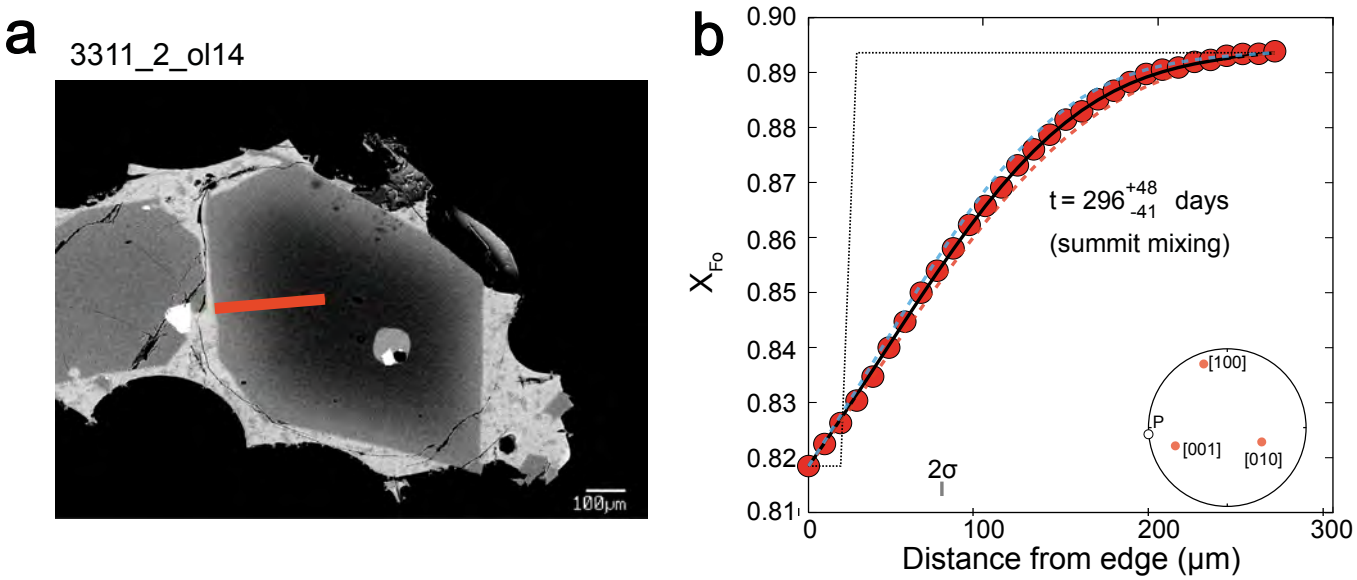
Supplementary Fig. 46: **Data, initial conditions and model fits for olivine crystal '3311_2_ol6'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



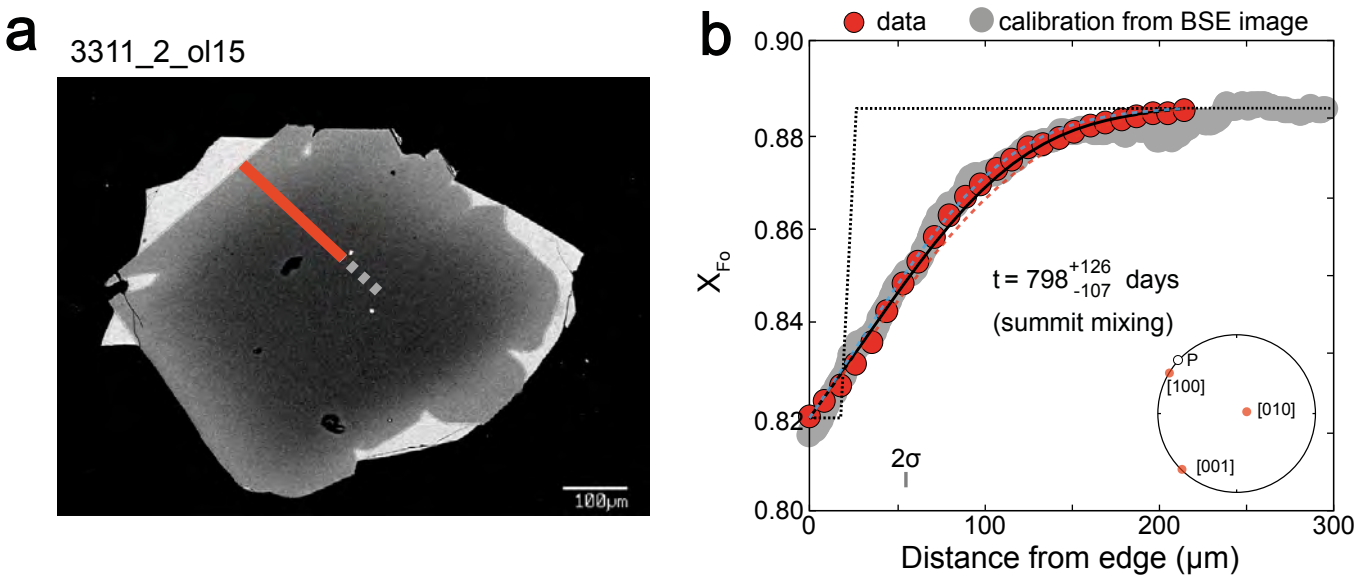
Supplementary Fig. 47: **Data, initial conditions and model fits for olivine crystal '3311_2_ol9'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. Inset 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



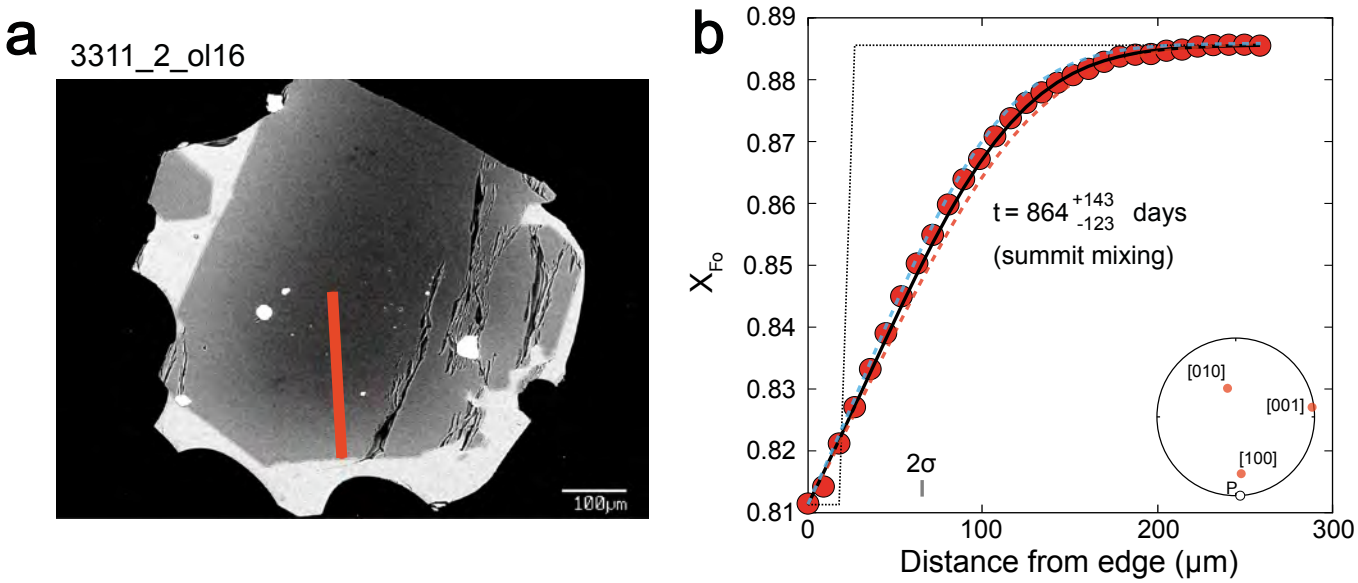
Supplementary Fig. 48: **Data, initial conditions and model fits for olivine crystal '3311_2_ol11'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



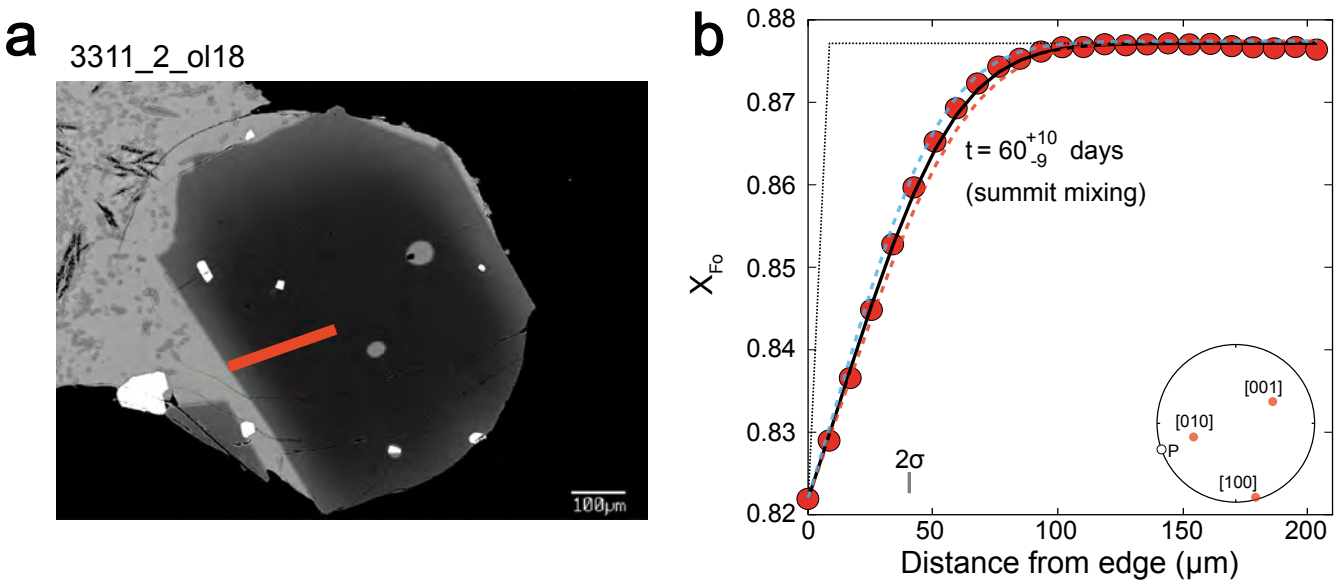
Supplementary Fig. 49: **Data, initial conditions and model fits for olivine crystal '3311_2_ol14'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



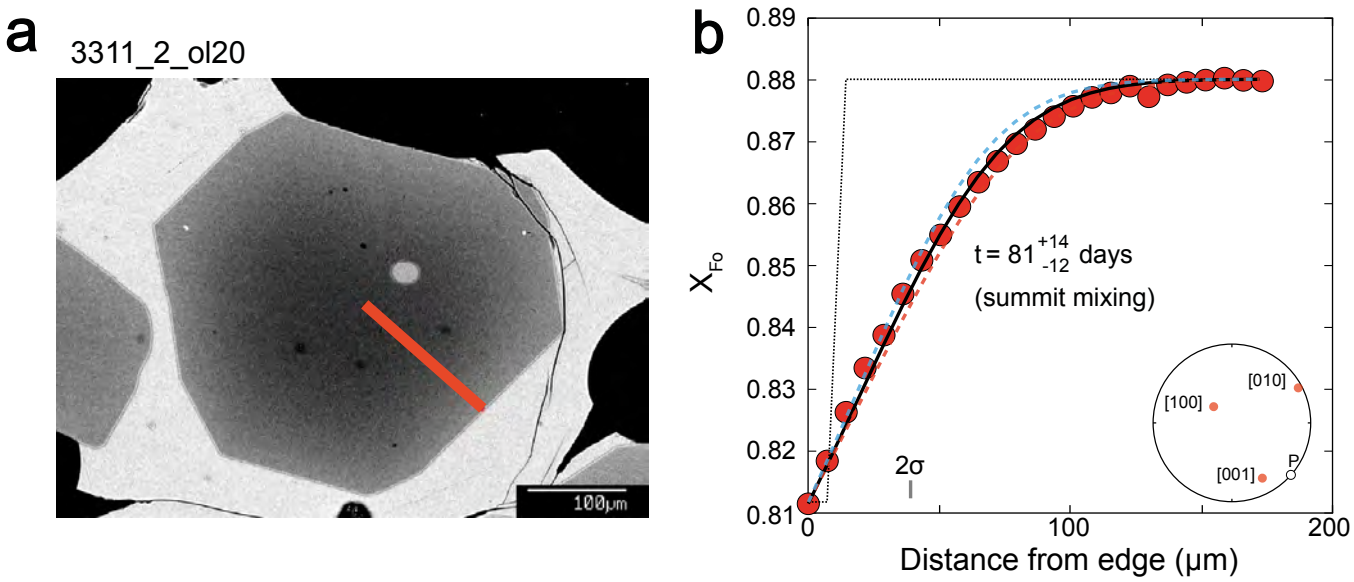
Supplementary Fig. 50: **Data, initial conditions and model fits for olivine crystal '3311_2_ol15'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



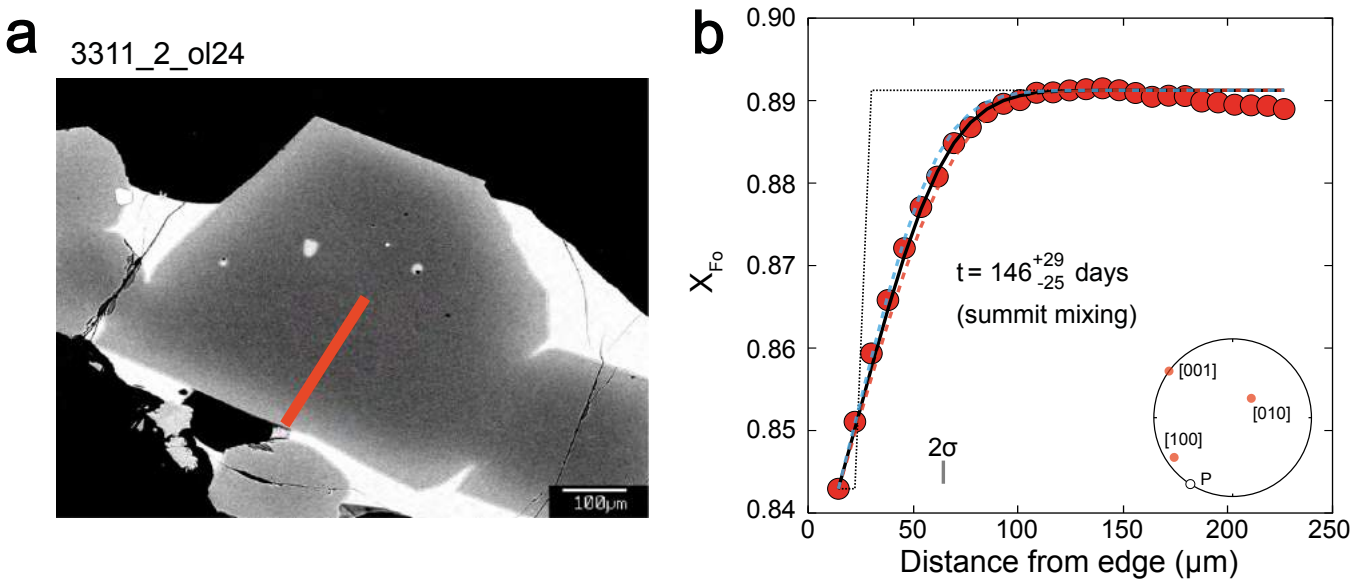
Supplementary Fig. 51: **Data, initial conditions and model fits for olivine crystal '3311_2_ol16'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



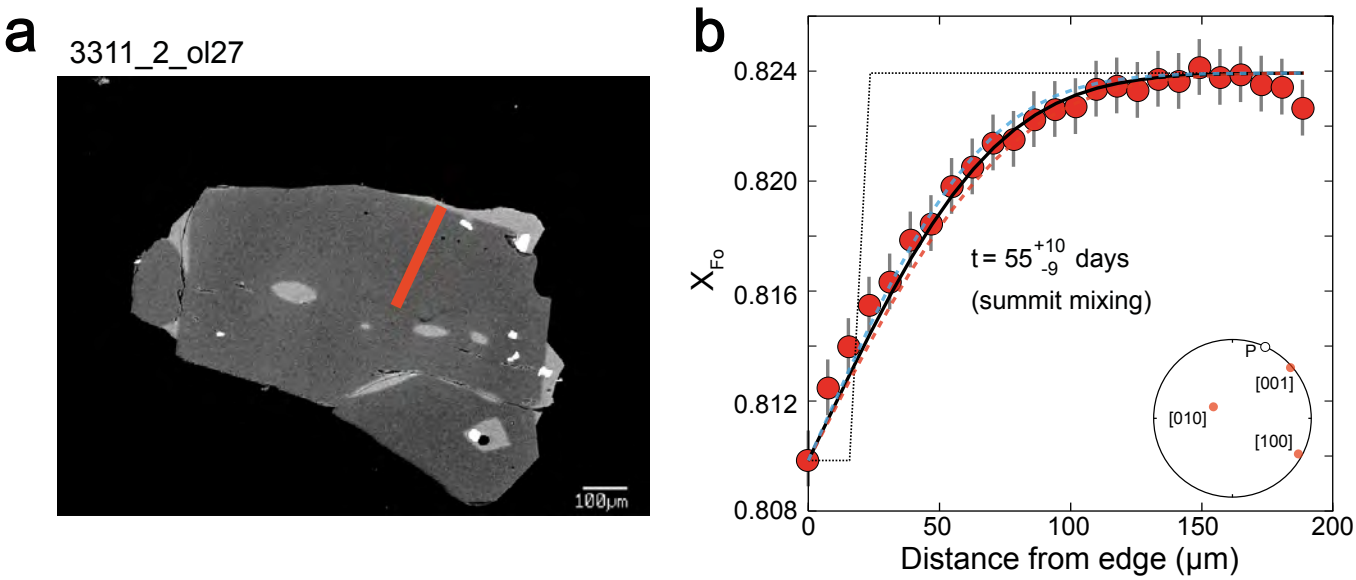
Supplementary Fig. 52: **Data, initial conditions and model fits for olivine crystal '3311_2_ol18'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



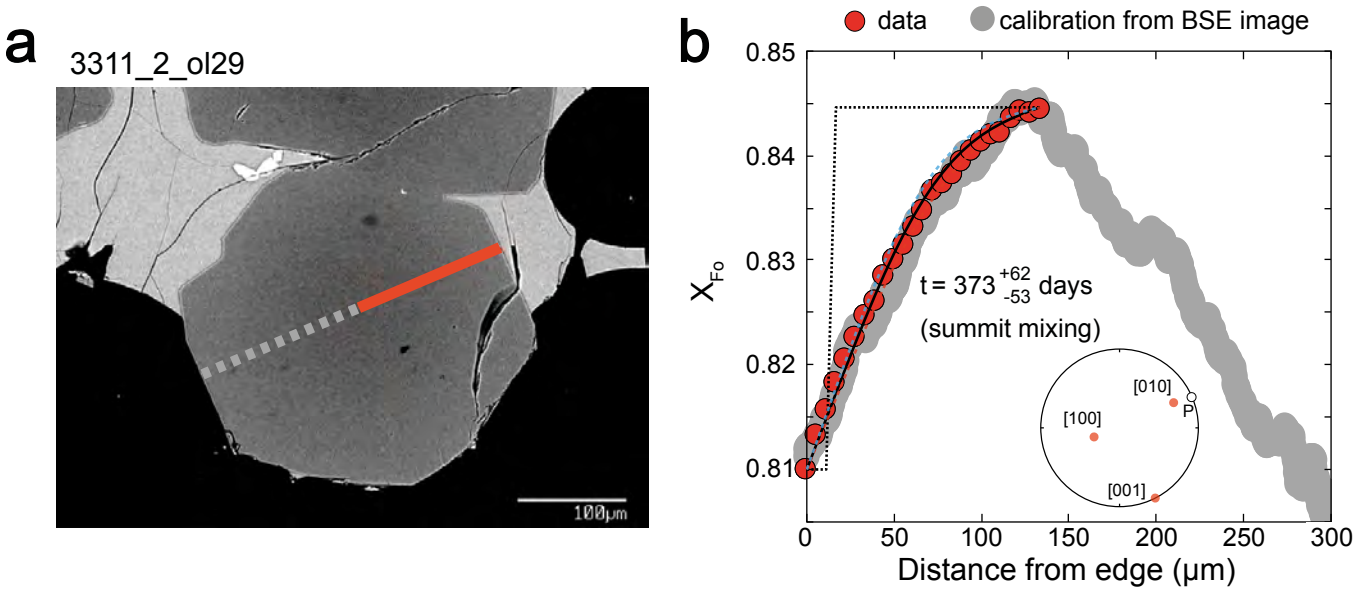
Supplementary Fig. 53: **Data, initial conditions and model fits for olivine crystal '3311_2_ol20'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



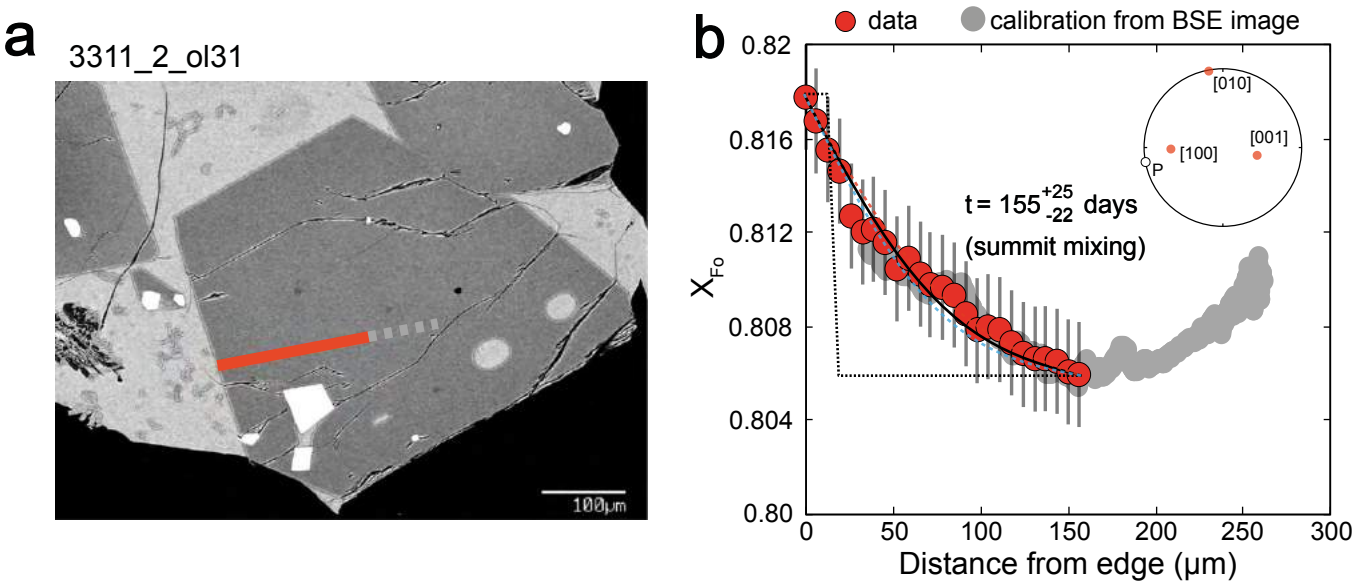
Supplementary Fig. 54: **Data, initial conditions and model fits for olivine crystal '3311_2_ol24'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



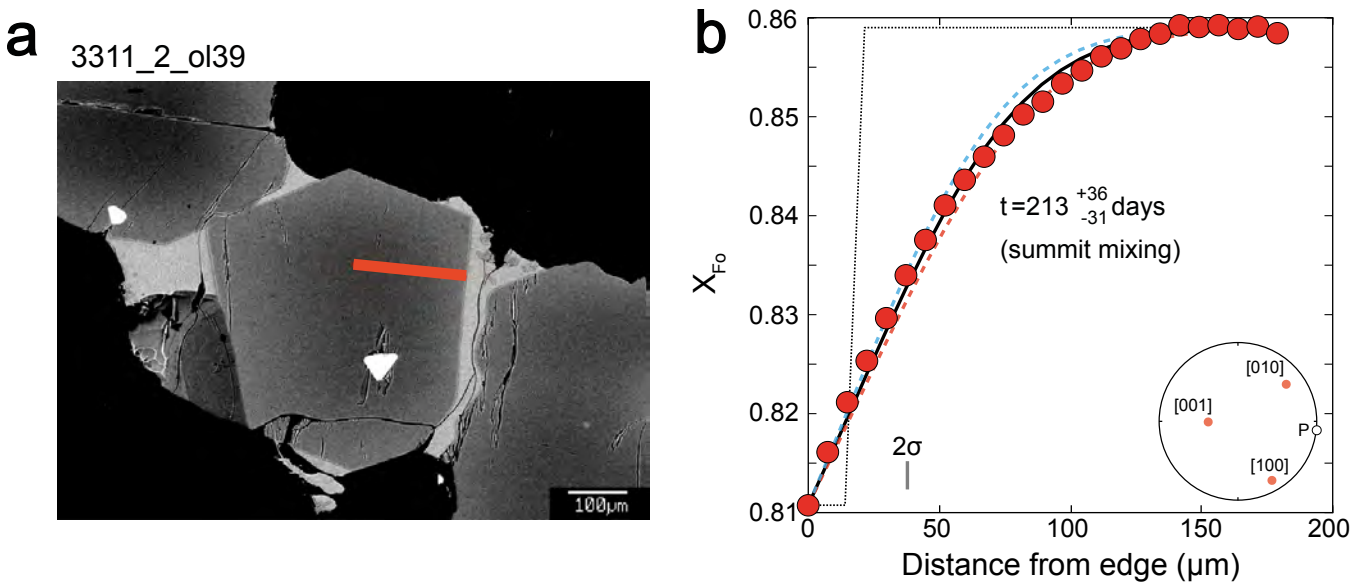
Supplementary Fig. 55: **Data, initial conditions and model fits for olivine crystal '3311_2_ol27'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



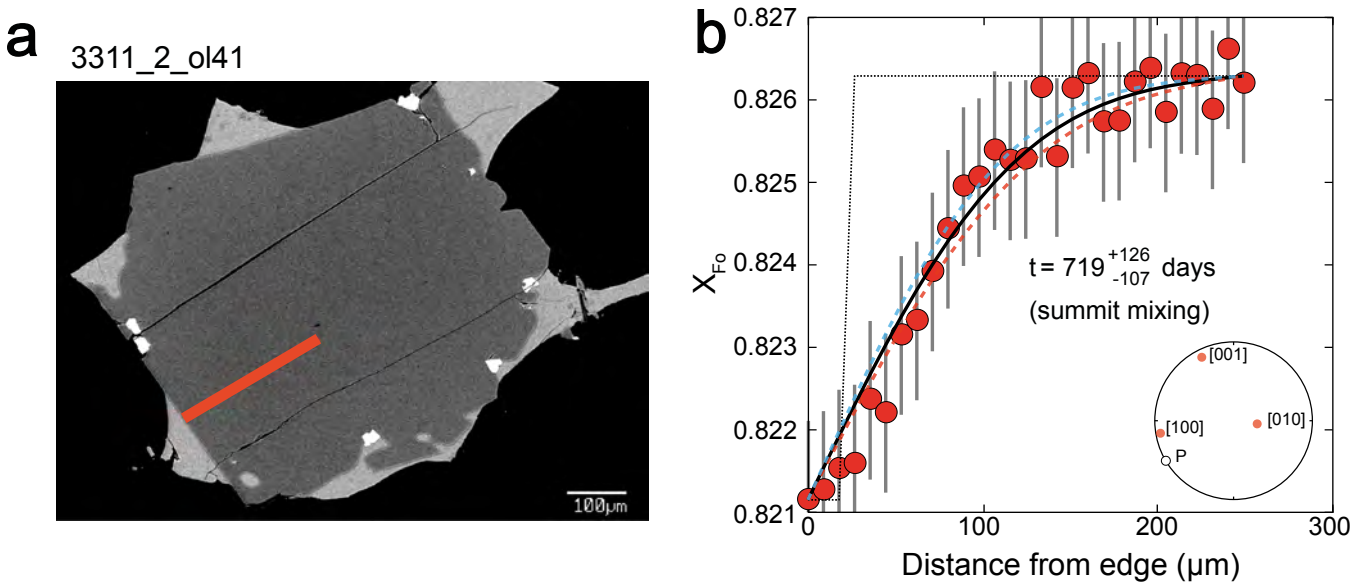
Supplementary Fig. 56: **Data, initial conditions and model fits for olivine crystal '3311_2_ol29'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



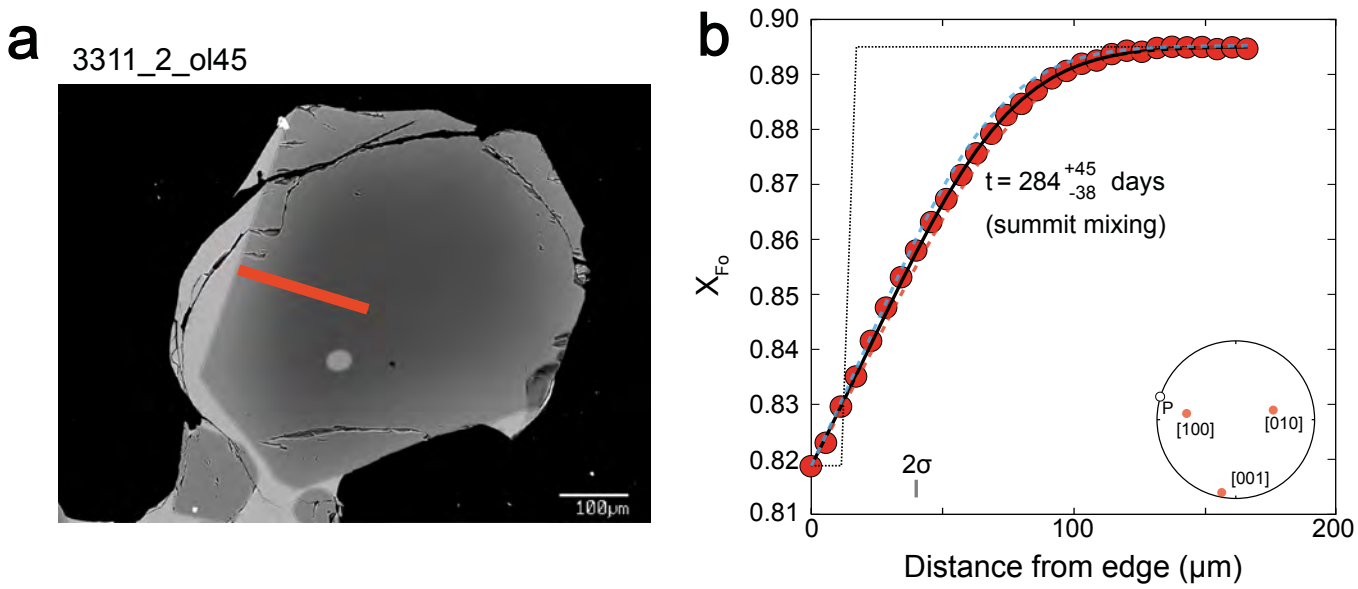
Supplementary Fig. 57: **Data, initial conditions and model fits for olivine crystal '3311_2_ol31'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



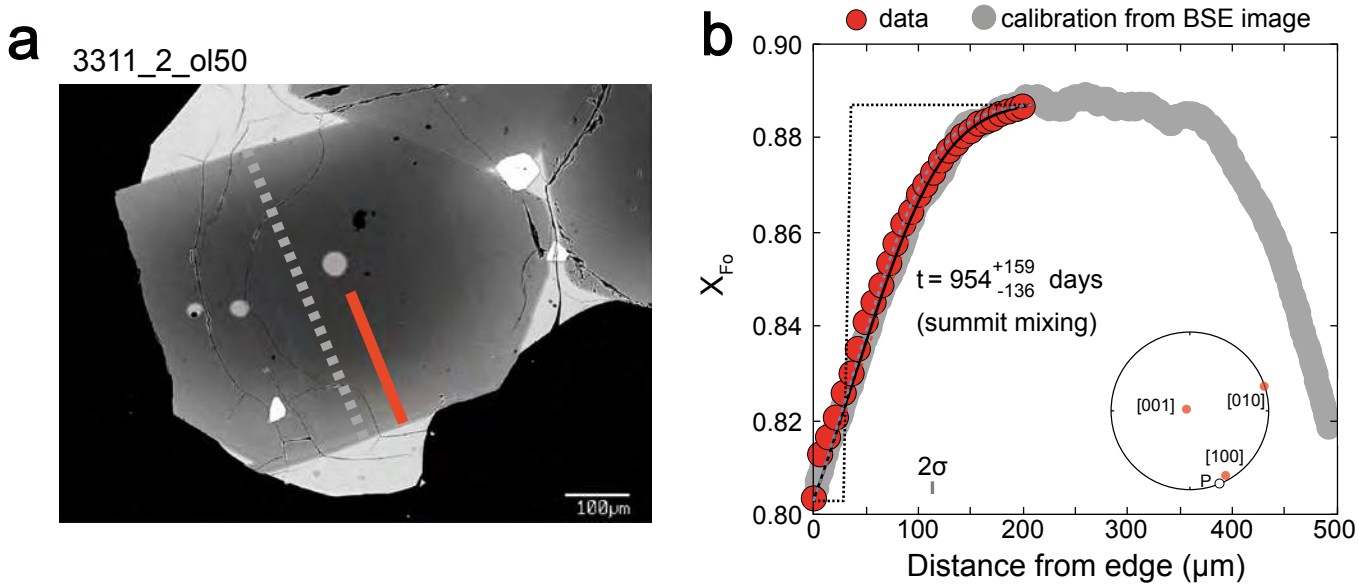
Supplementary Fig. 58: **Data, initial conditions and model fits for olivine crystal '3311_2_ol39'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



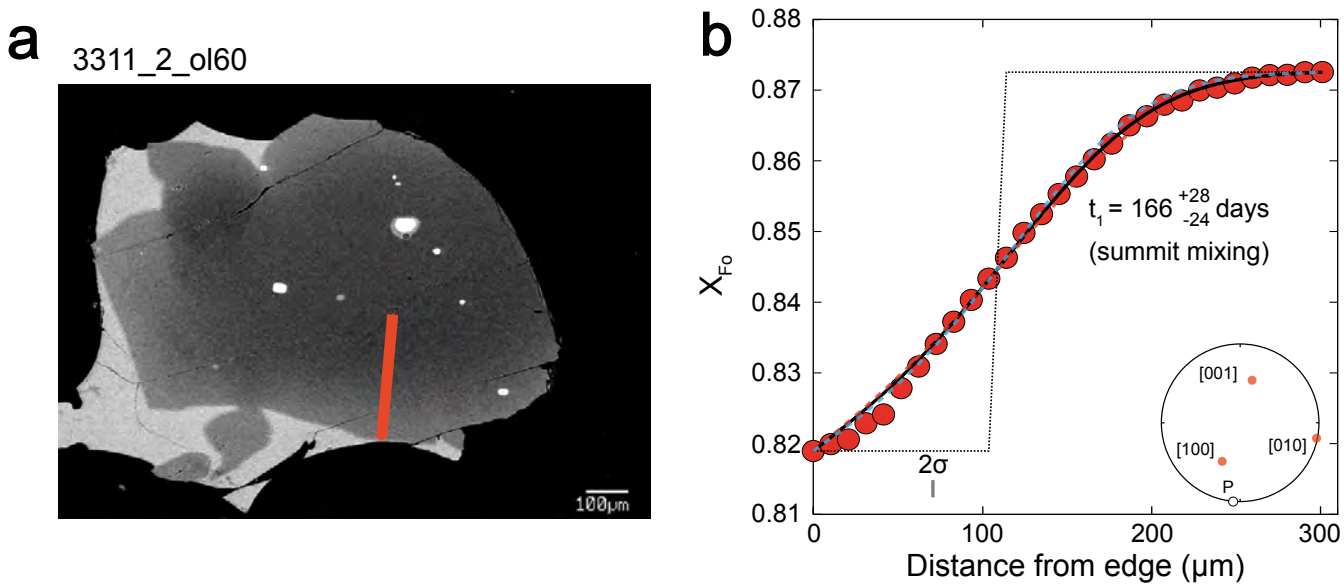
Supplementary Fig. 59: **Data, initial conditions and model fits for olivine crystal '3311_2_ol41'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



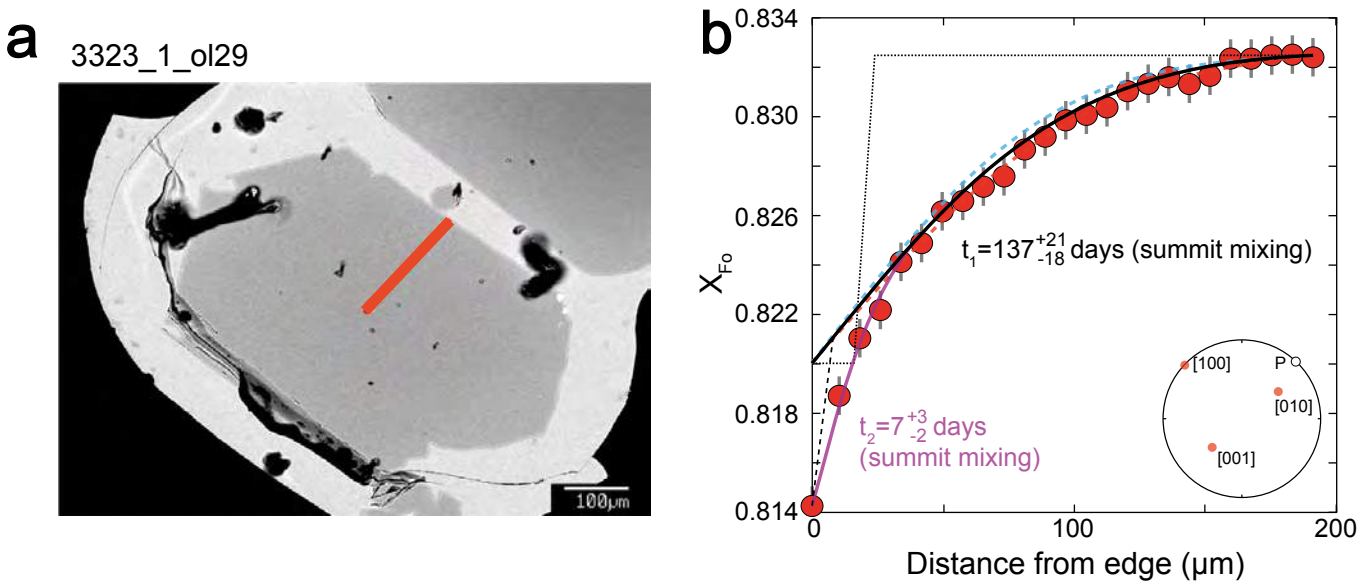
Supplementary Fig. 60: **Data, initial conditions and model fits for olivine crystal '3311_2_ol45'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



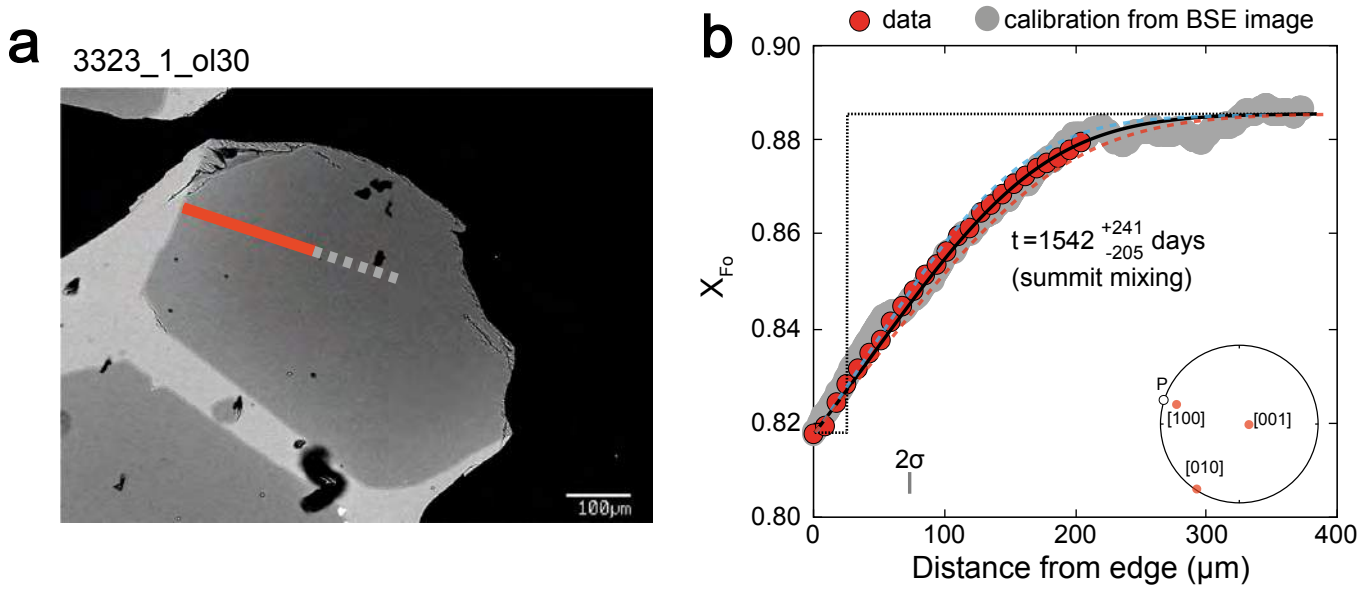
Supplementary Fig. 61: **Data, initial conditions and model fits for olivine crystal '3311_2_ol50'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



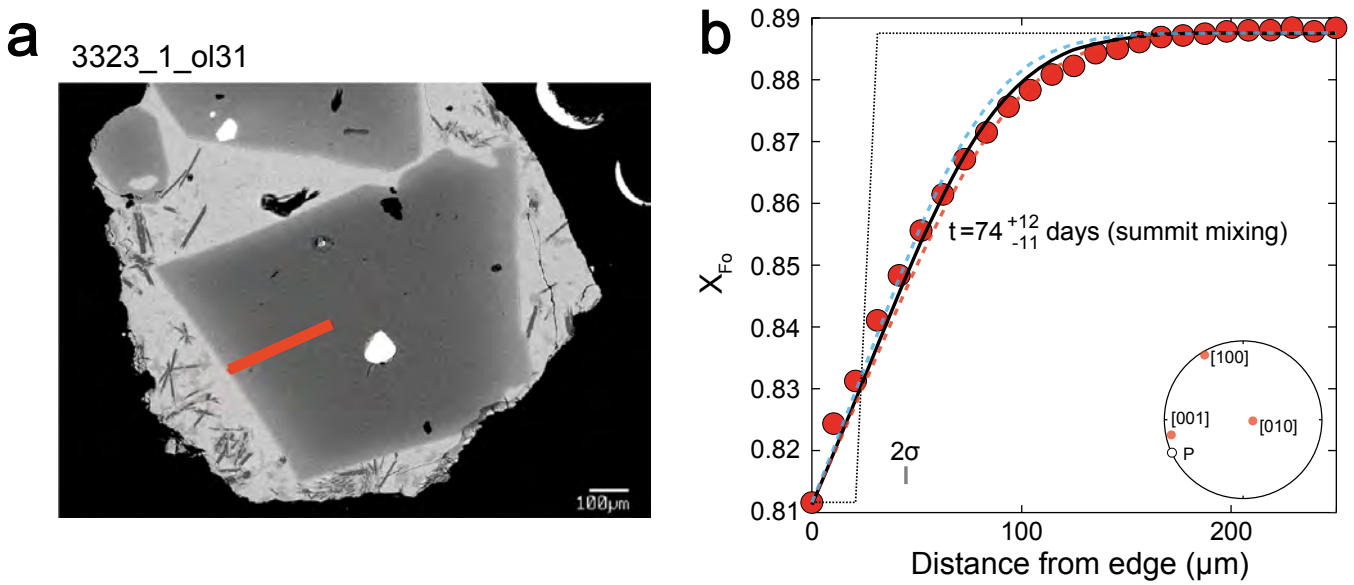
Supplementary Fig. 62: **Data, initial conditions and model fits for olivine crystal '3311_2_ol60'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. 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.



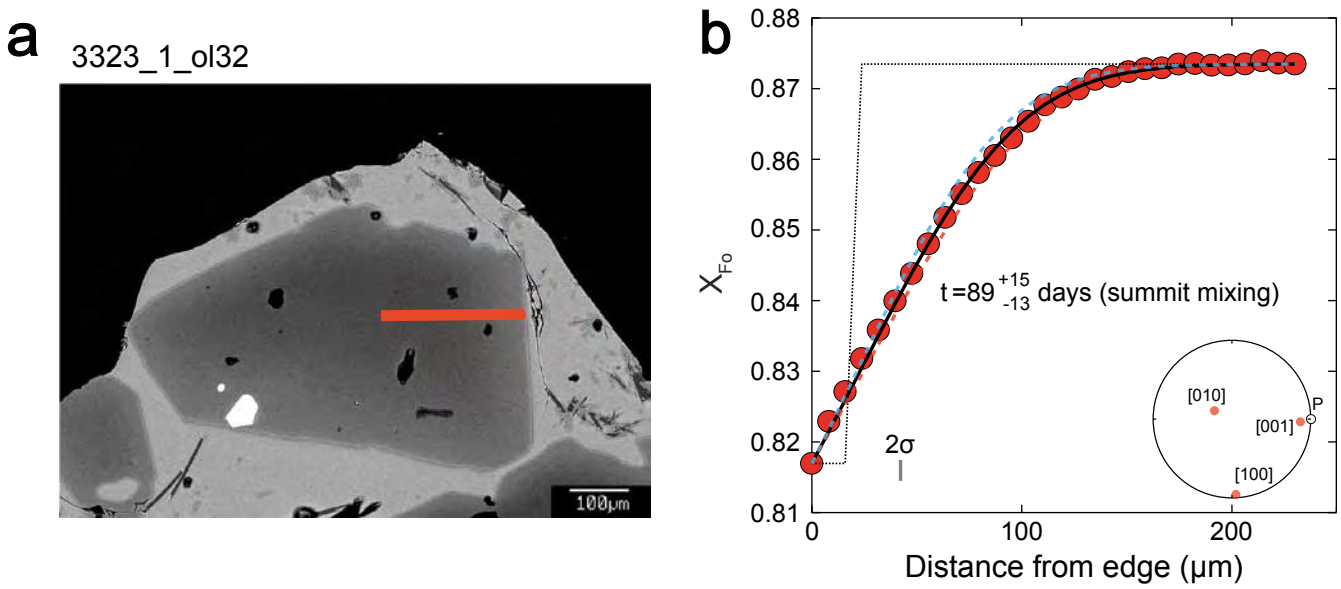
Supplementary Fig. 63: **Data, initial conditions and model fits for olivine crystal '3323_1_ol29'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. 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.



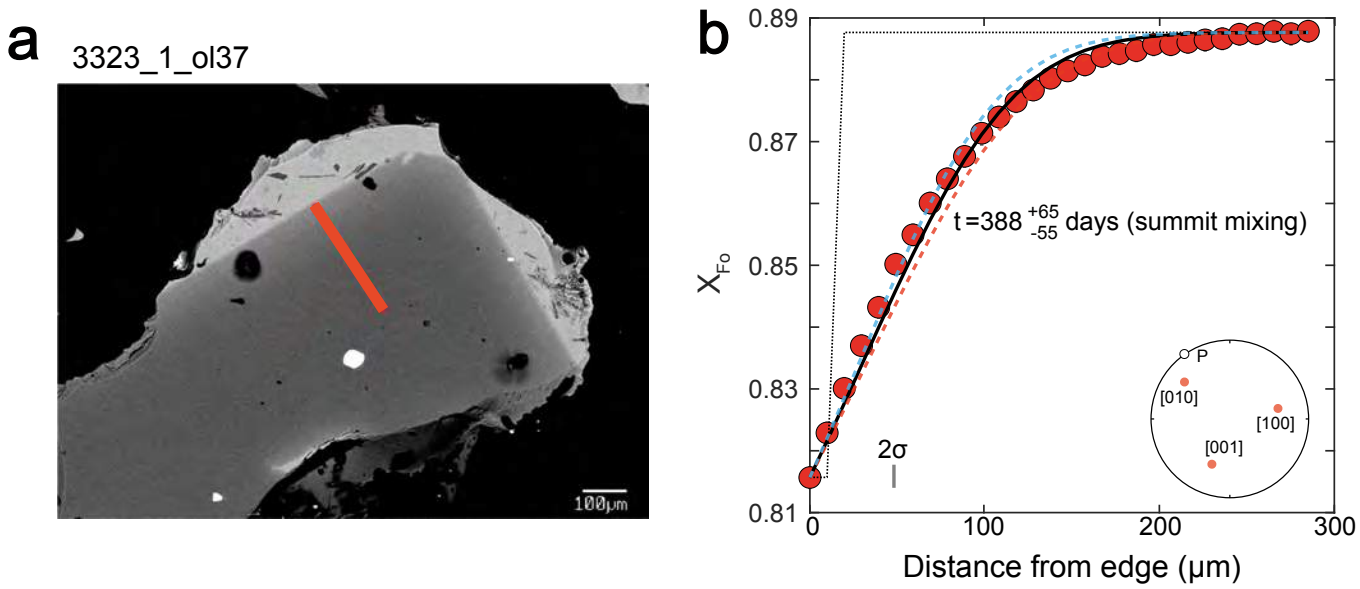
Supplementary Fig. 64: **Data, initial conditions and model fits for olivine crystal '3323_1_ol30'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



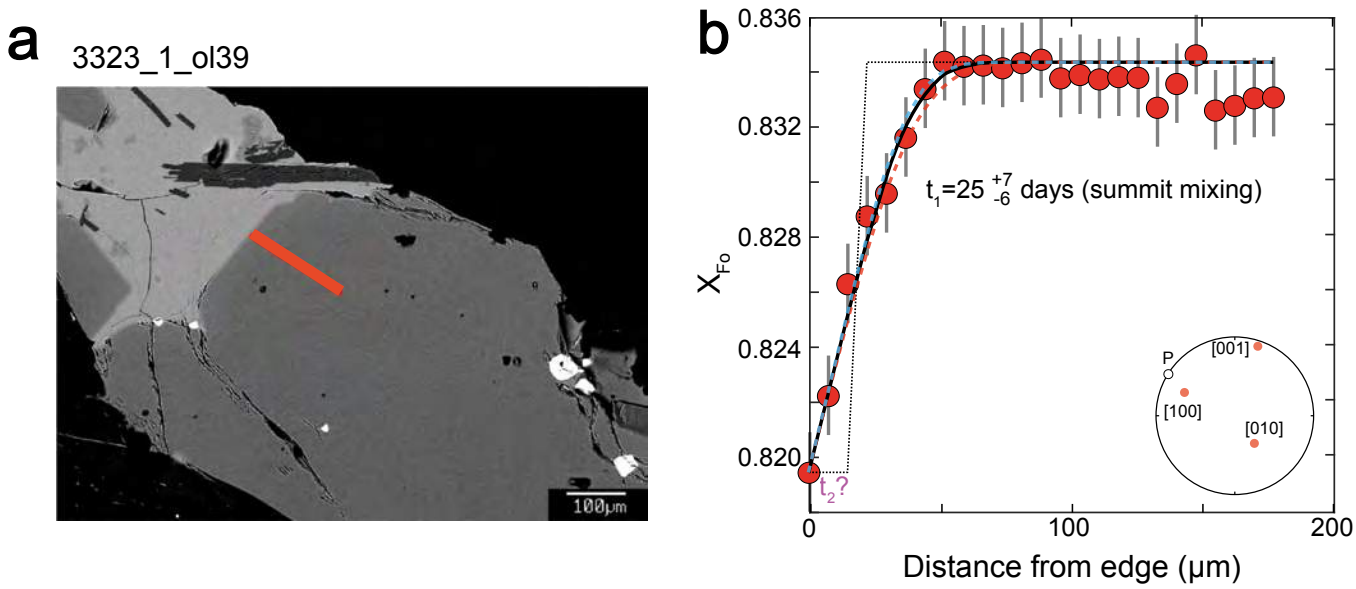
Supplementary Fig. 65: **Data, initial conditions and model fits for olivine crystal '3323_1_ol31'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



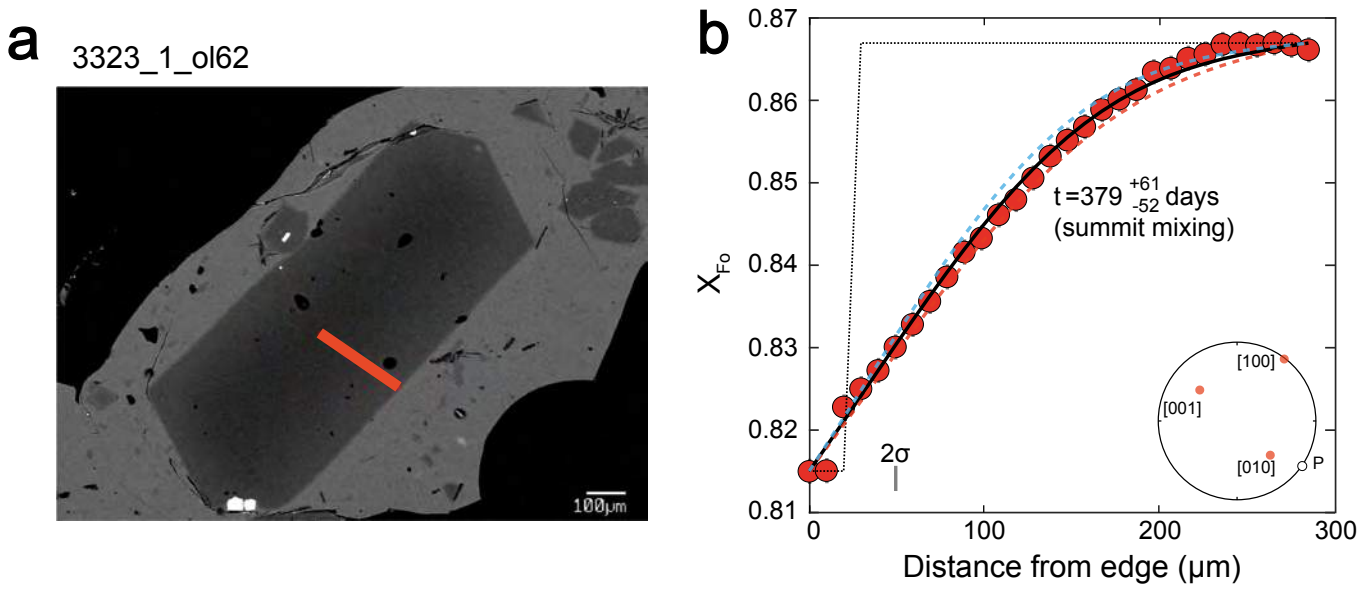
Supplementary Fig. 66: **Data, initial conditions and model fits for olivine crystal '3323_1_ol32'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



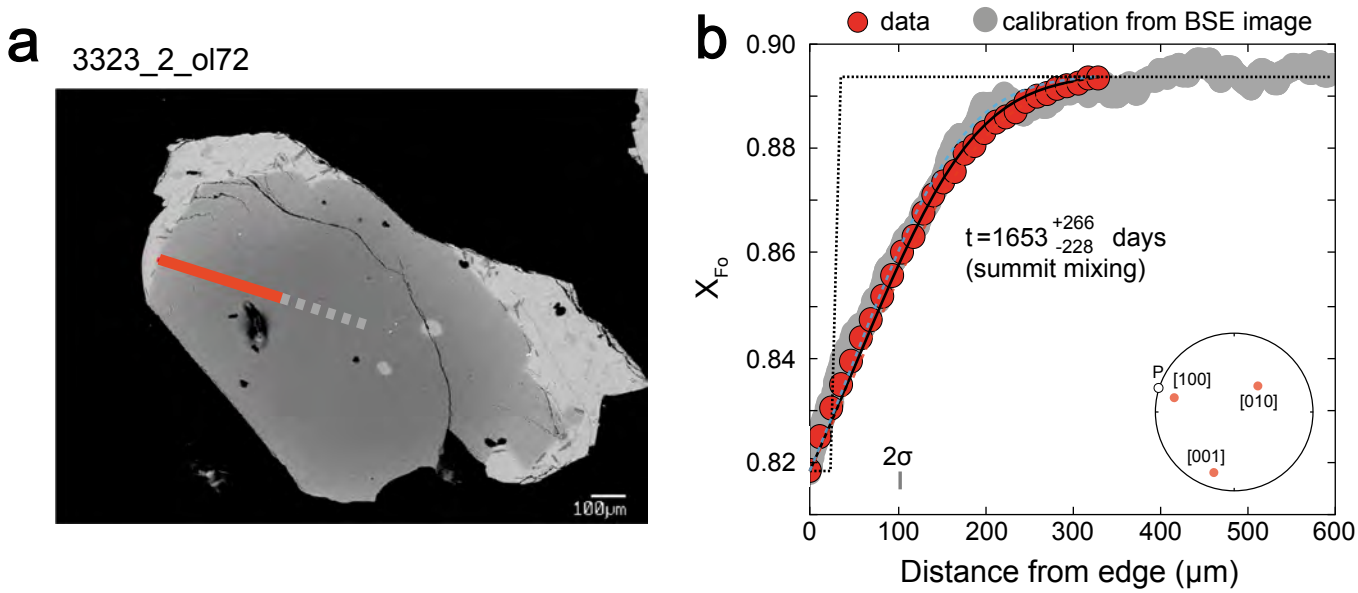
Supplementary Fig. 67: **Data, initial conditions and model fits for olivine crystal '3323_1_ol37'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



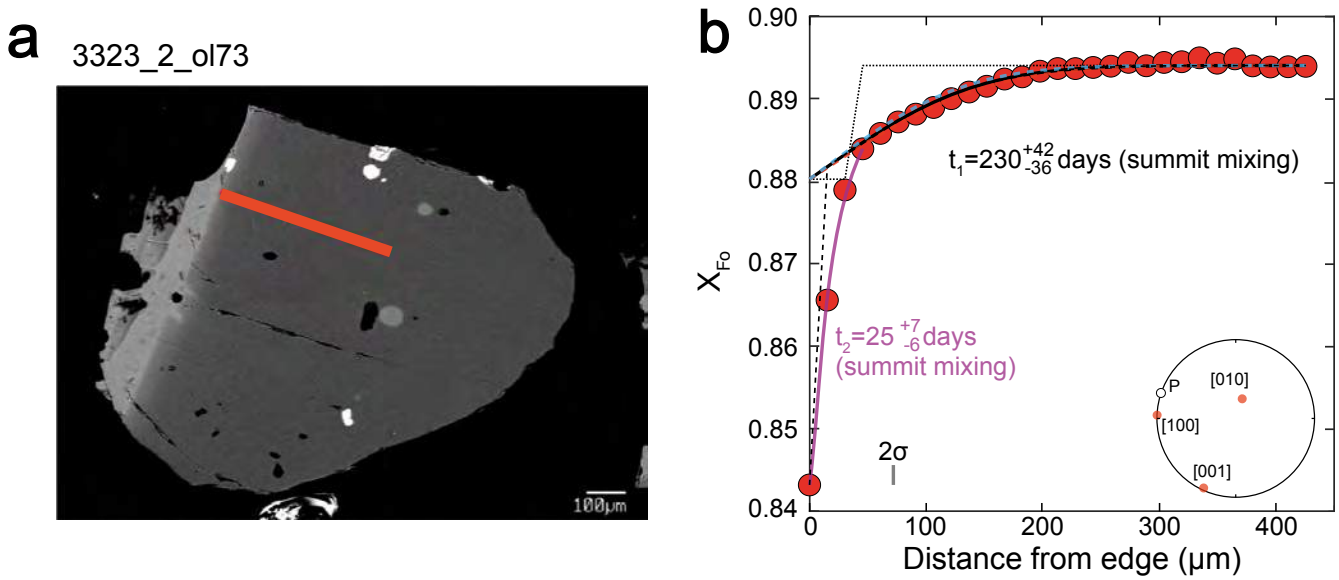
Supplementary Fig. 68: **Data, initial conditions and model fits for olivine crystal '3323_1_ol39'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



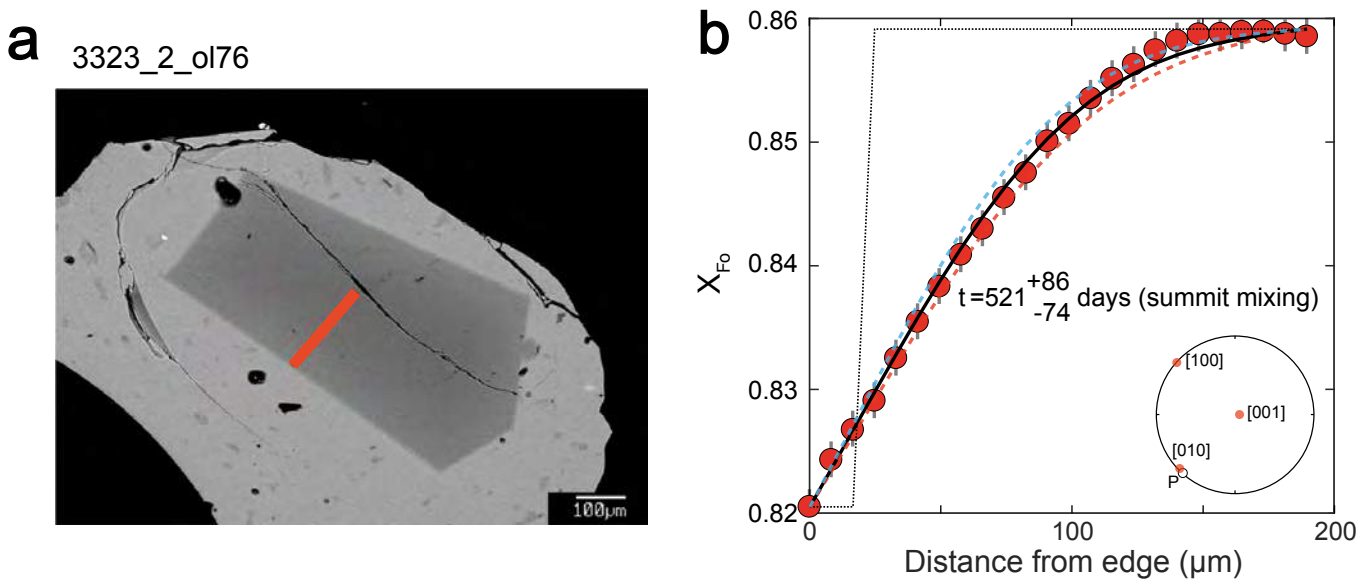
Supplementary Fig. 69: **Data, initial conditions and model fits for olivine crystal '3323_1_ol62'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



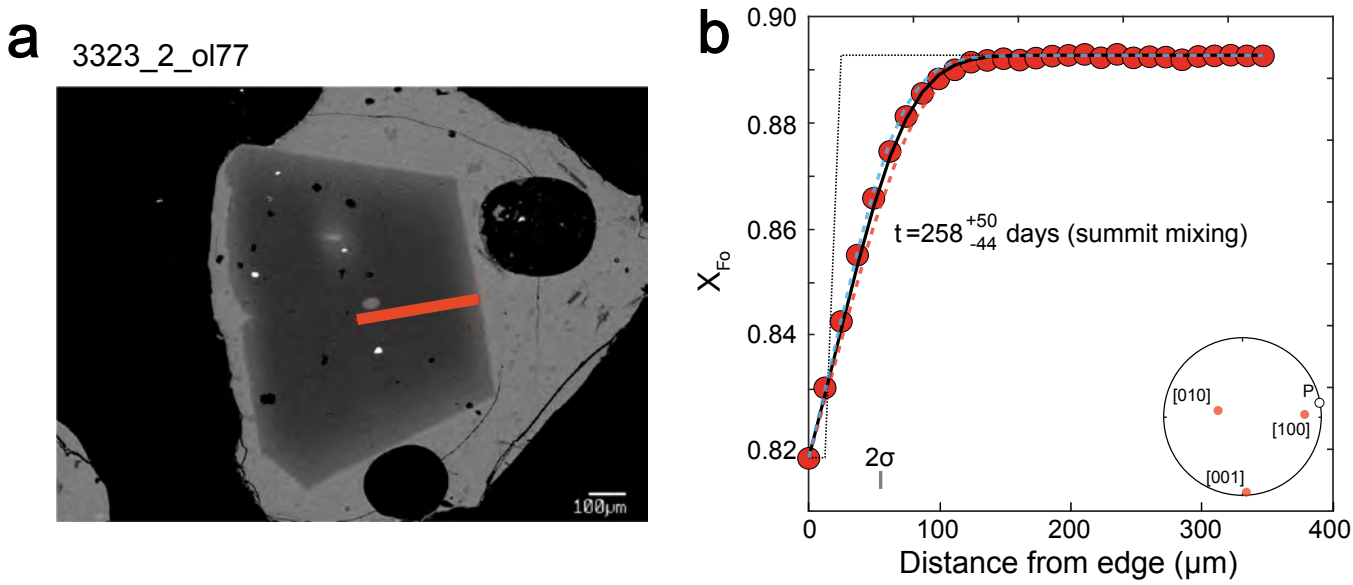
Supplementary Fig. 70: **Data, initial conditions and model fits for olivine crystal '3323_2_ol72'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



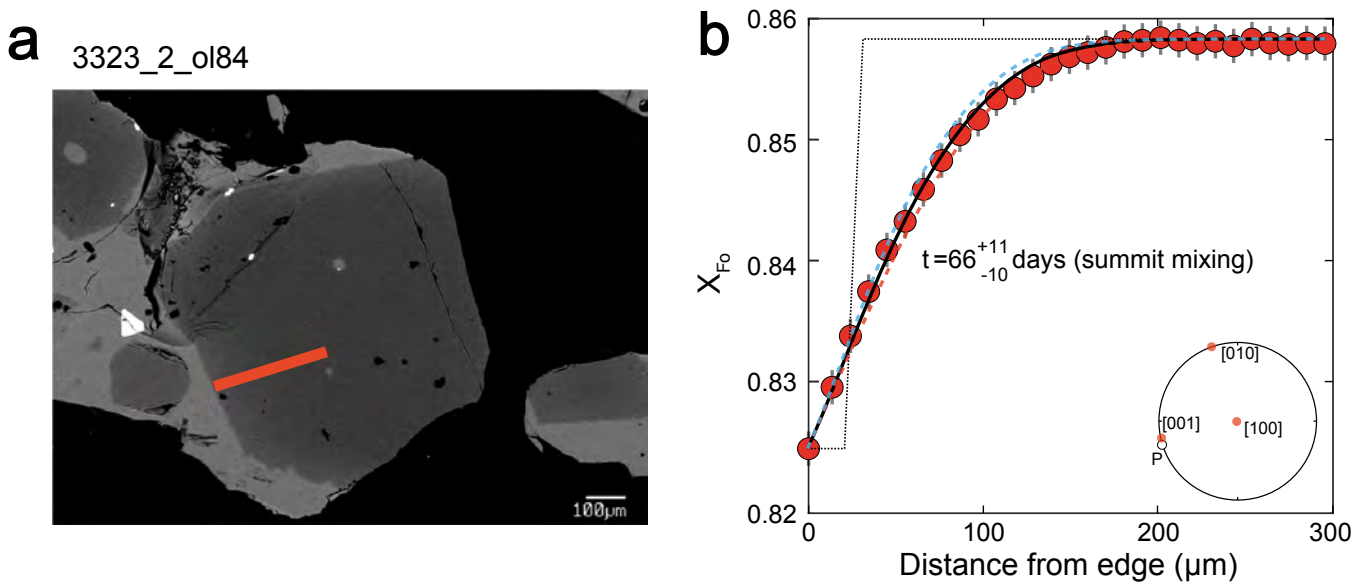
Supplementary Fig. 71: **Data, initial conditions and model fits for olivine crystal '3323_2_ol73'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. 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.



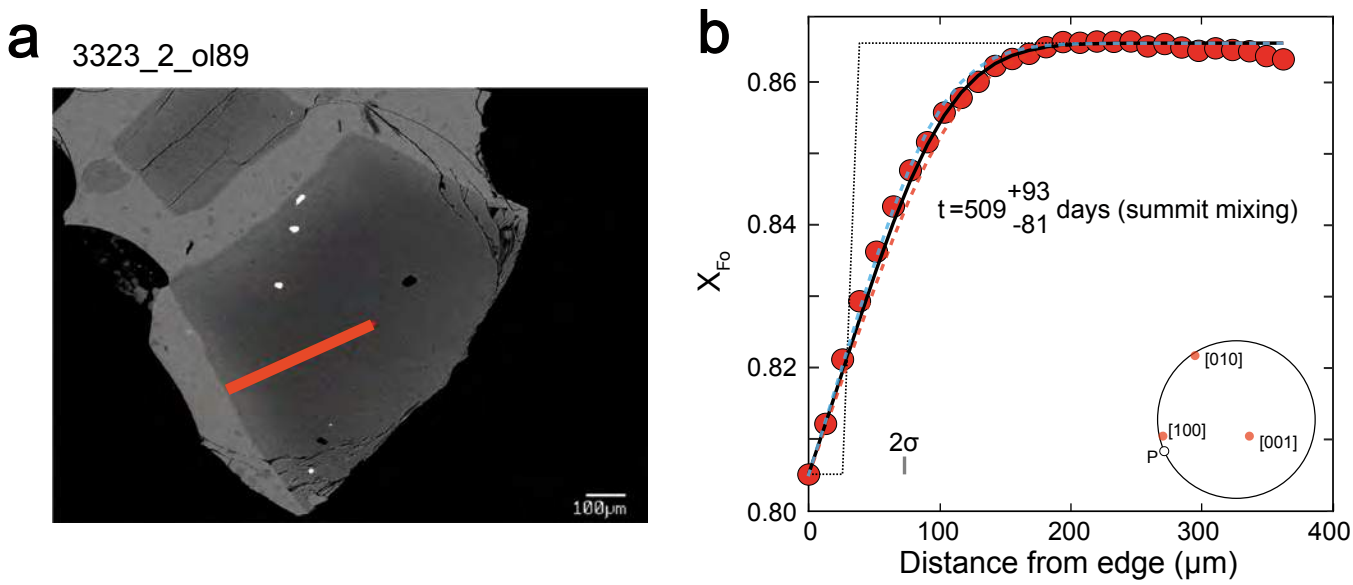
Supplementary Fig. 72: **Data, initial conditions and model fits for olivine crystal '3323_2_ol76'. a,** Backscattered electron (BSE) image of the analysed olivine crystal with the location of the EPMA profile (red line). **b,** EPMA profile of mole fraction forsterite content (X_{Fo}) shown in red. 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. The black dashed lines correspond to constant (homogeneous) initial conditions.



Supplementary Fig. 73: **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. The black dashed lines correspond to constant (homogeneous) initial conditions.



Supplementary Fig. 74: **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. The black dashed lines correspond to constant (homogeneous) initial conditions.



Supplementary Fig. 75: **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. The black dashed lines correspond to constant (homogeneous) initial conditions.