SUPPLEMENTARY MATERIAL 3

Integrating olivine diffusion chronometry with monitoring data to decipher the magma dynamics at the Fani Maoré volcano

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Supplementary Material 3 has three parts looking at the impacts of uncertainties on pressure, eruption date, and diffusion coefficient on our diffusion times and intrusion dates. **Part 1:** shows the effect of pressure on the diffusion times and intrusion dates, **Part 2:** shows how the selection of the eruption date influences the intrusion dates (eruption date minus diffusion date), **Part 3:** shows how a faster $D_{Mg\text{-}Fe}$ by Shea et al. (2015) impacts the diffusion times and thereby, the intrusion dates and comparison with geophysical data.

Part 1

The uncertainty on the depth of the more evolved reservoir plays a minor role in impacting our results and interpretations, since the effect of pressure on diffusivity in olivine is low. Using a depth of ~17 km (i.e. pressure of 450 MPa) – the original location of the more evolved reservoir proposed by Berthod et al. 2021a – would lead to overall shorter timescales by a factor of ~0.15 (see Supplementary Tables). These diffusion times would be within uncertainty of those for a depth of ~30 km (pressure of 770 MPa). By replotting Fig. 9 and Fig. 10 of the main text as Fig. 1, the effect of this shallower depth on the correlation of diffusion timescales and intrusion dates, respectively, with the eruption date can be seen. The correlation between increasingly long diffusion dates with progressive eruption following the 1:1 line is clearer using a lower pressure for diffusion and intrusion dates largely remain unaffected, still resulting in the two main intrusions (March 2019, March 2020) as discussed in the main text. Thus, a correlation of the intrusion dates and geophysical data would persist.

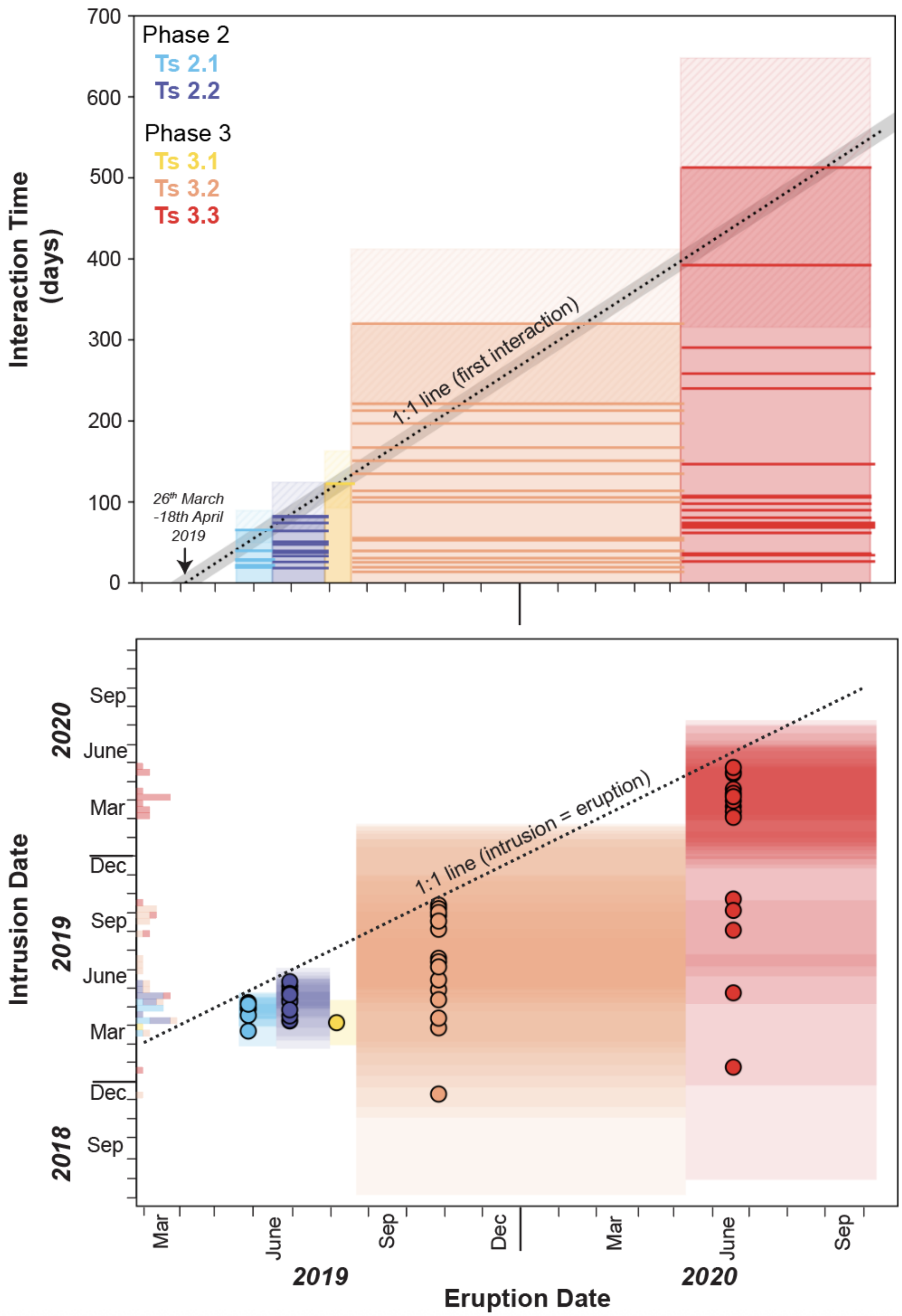

Fig. 1. Fig. 9 from main text replotted using a lower pressure of 450 MPa (~17 km depth) to calculate the diffusion times. Diffusion times calculated using a lower pressure leads to little change compared to the results shown in the main text: The correlation between diffusion times and eruption dates (top) is slightly better and intrusion dates remain overall similar.

Part 2

The uncertainty on the eruption date (due to the long durations between cruises) has a significantly larger uncertainty than the diffusion times. Thus, the selection of the eruption date will shift the intrusion dates and impact our interpretation of when intrusions occurred and whether these are comparable to geophysical signals. While these uncertainties are shown in Fig. 9B and Fig. 10 of the main text, we have replotted these two figures in Fig. 2 and Fig. 3, respectively, to demonstrate how intrusion dates would change if the maximum and the minimum eruption date where chosen. Choosing maximum eruption dates results in later intrusion dates and less well-defined intrusions that do not correlate well with changes in geophysical signals. Choosing minimum eruption dates results in intrusions occurring earlier, however, the times are still somewhat similar to those in the main text. Thus, less obvious, there would still be an overlap with real-time monitoring data.

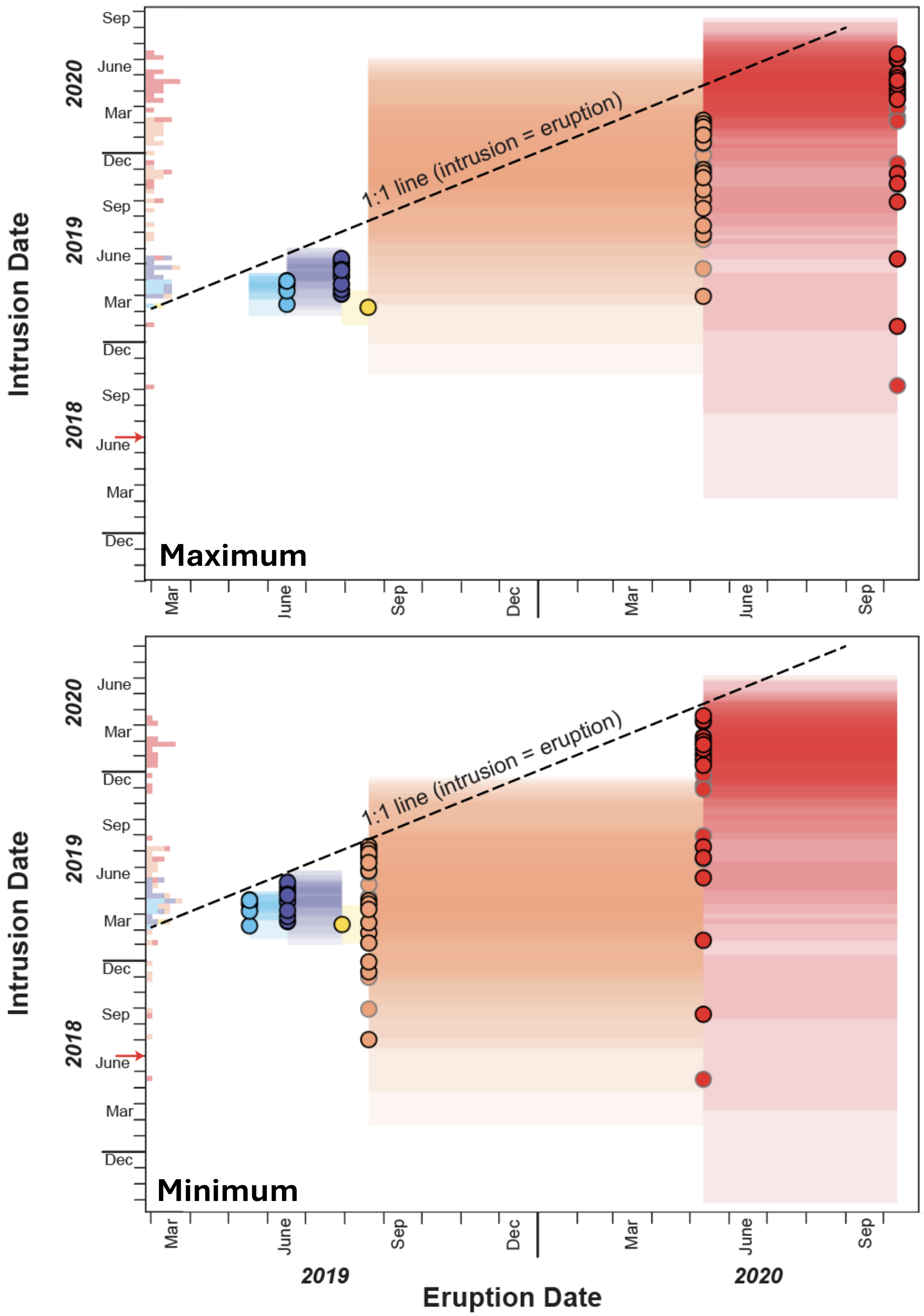

Fig. 2. Fig. 9 from main text replotted using the maximum (top) and minimum (bottom) eruption dates to calculate intrusion dates. Maximum intrusion dates would be later and are less well defined, with intrusions in: March-June 2019, a long-lasting intrusion from September 2019-March 2020, one from April-June 2020. Minimum intrusion dates would be slightly earlier, with three intrusions being: March-May 2019, possibly a subsequent second one in June-August 2019, and the last one in December 2019-March 2020.

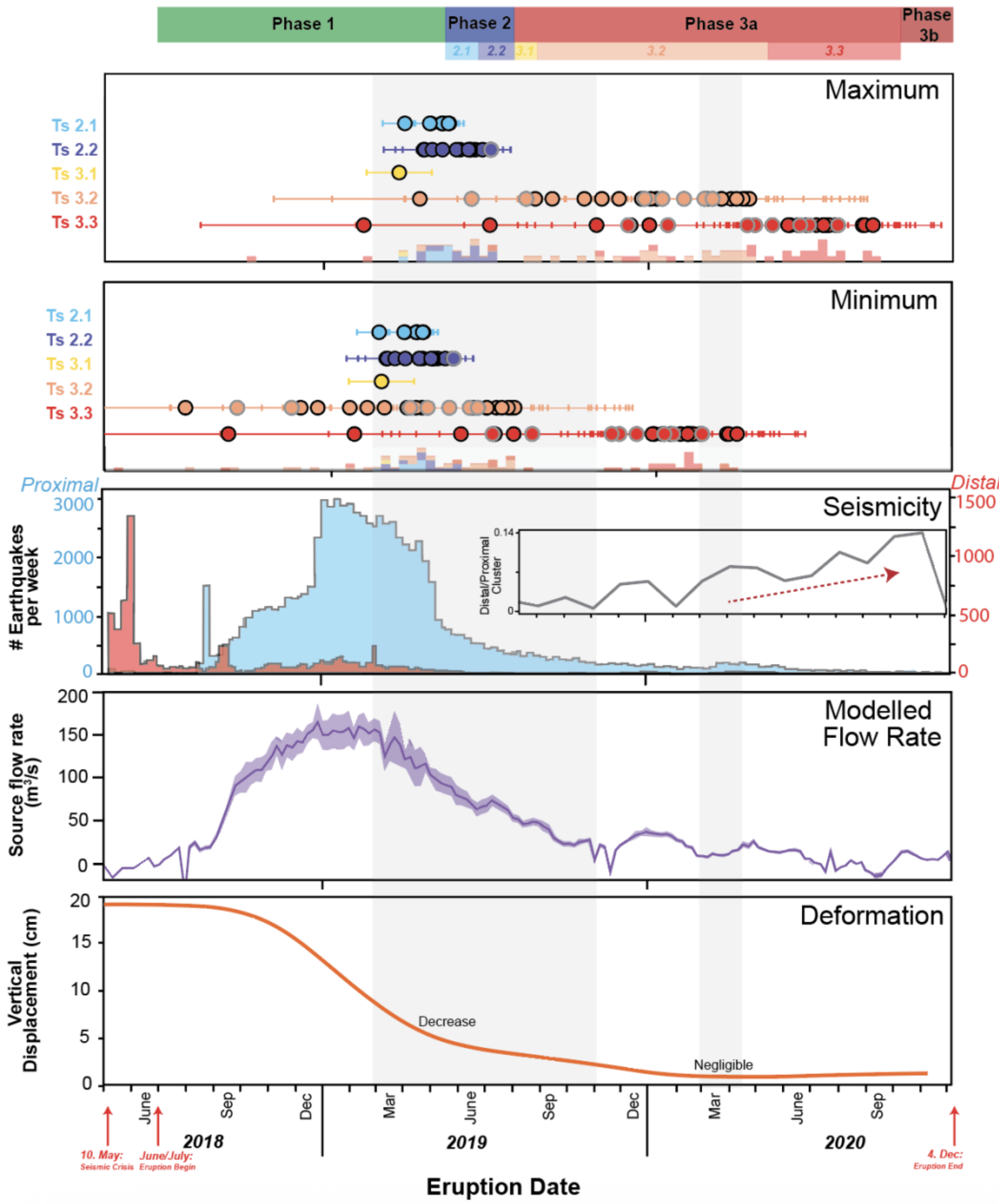

Fig. 3. Fig. 10 from main text replotted using the maximum (top) and minimum (bottom) eruption dates to calculate intrusion dates and compared to geophysical data. When using the maximum eruption date, the first overlap in March 2019 is still seen as intrusions in Timespans 2.1 and 2.2. Intrusions continue to occur in Timespan 3.2 even after the decrease in seismic signals up until the second intrusion in March 2020. This intrusion is less well defined by diffusion chronometry with intrusion dates correlating with this time found in Timespan 3.2. The last intrusion identified in Timespan 3.3 is later, around June 2020, where no changes in geophysical signals occur. Therefore, many intrusion dates from maximum eruption times do not overlap with geophysical data. Minimum intrusion dates would show more overlap similar to those discussed in the main text. The first overlap in March 2019 would have started earlier than the decline in geophysical signals according to some intrusion dates from Timespan 3.2. The second intrusion from Timespan 3.3 slightly pre-dating the geophysical changes in March 2020.

Part 3

We test how the faster $D_{Mg\text{-}Fe}$ by Shea et al. (2015) would impact our diffusion data, by replotting Fig. 9 and Fig. 10 in the following Fig. 4 and Fig. 5, respectively, assuming 10x shorter diffusion times. Using this approach, the diffusion times do not become longer with progressive eruption, suggesting that there was no stalling of basanitic magma below the shallower reservoir. Furthermore, each eruption of a flow would be caused by a separate intrusion. Hence, there would be five different short-lived injections. Lastly, while there is still an overlap of the injection dates with the real-time monitoring data, the interpretation would change. The changes in real-time monitoring signals in March 2020 would still be caused by an injection associated with Timespan 3.3. However, the overlap with geophysical signals in March 2019 is less clear. Four successive intrusions would correlate with part of the time during which geophysical signal decrease. There would be no other changes in geophysical signals that would indicate four successive intrusions. Lastly, there would be no indication of intrusion and passage of basanitic magma through the more evolved reservoir in an isolated pathway during the early stages of eruption (prior to March 2019).

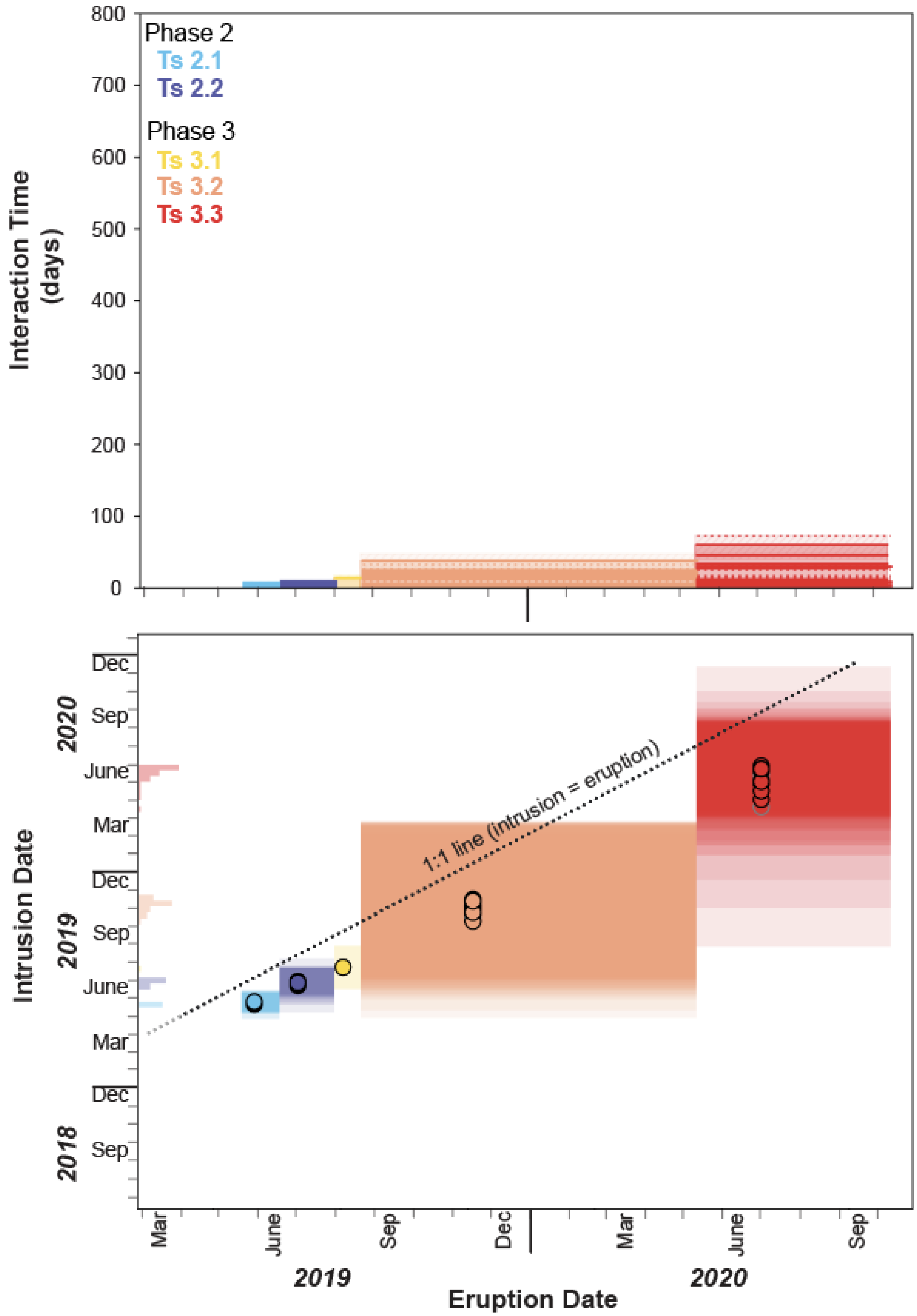

Fig. 4. Fig. 9 from main text replotted assuming 10x shorter diffusion times. This leads to extremely short interaction times for all Timespans (range: 1.4-51 days) and therefore, no correlation between interaction time and eruption date. Thus, there would be no stalling of the basanitic magma below the shallower reservoir. Instead, each flow for a given Timespan would be caused by an intrusion.

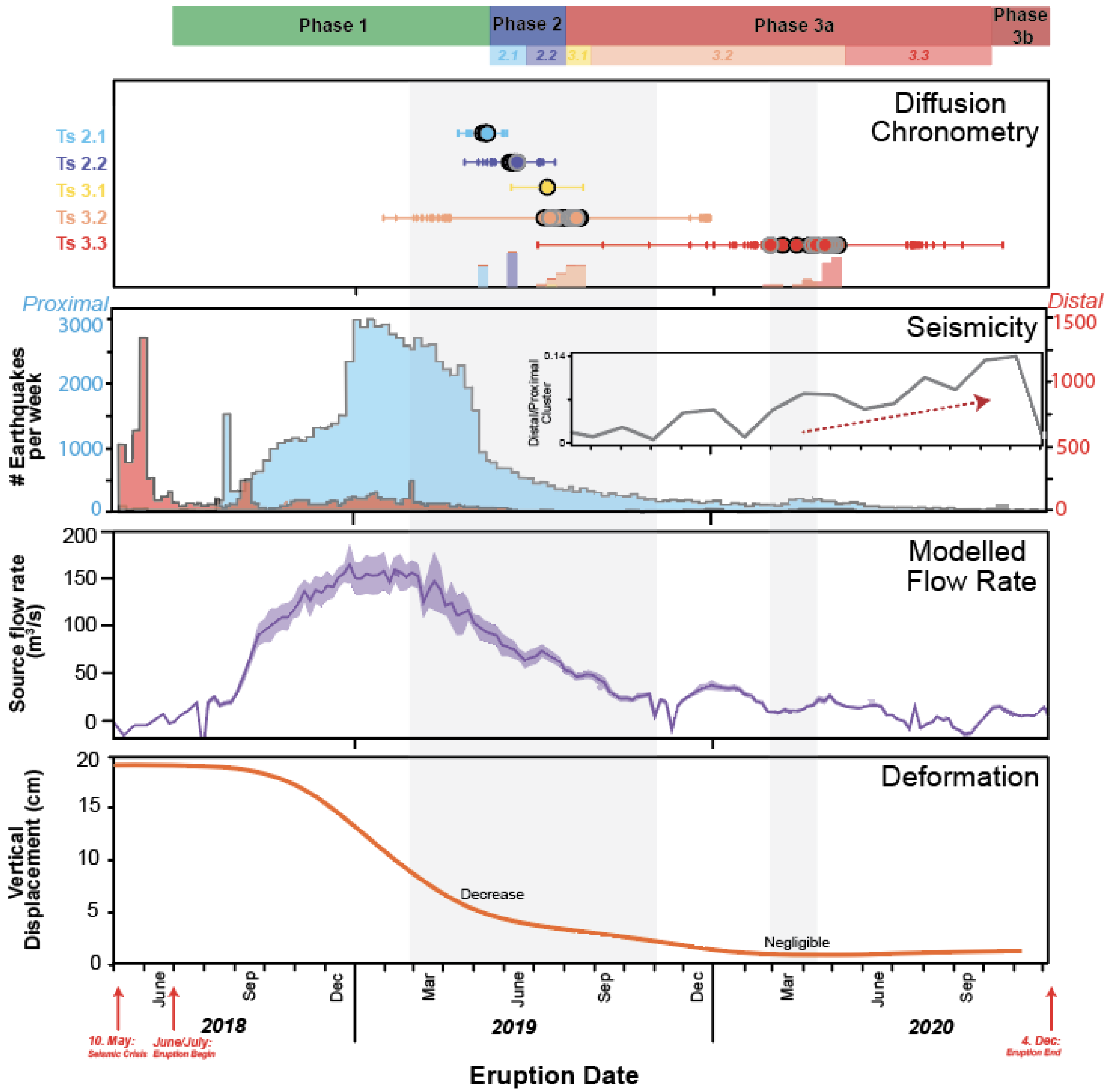

Fig. 5. Fig. 10 from main text replotted assuming 10x shorter diffusion times for calculating best estimate intrusion times. While the overlap with real-time monitoring data remains, the interpretation changes. For the overlap in March 2020, the intrusion associated with Timespan 3.3 could still cause the change observed in seismic and deformation data. However, in 2019 the gradual decline in seismicity, flow rate and deformation would correlate with a time period of four successive intrusions associated with Timespans 2.1-3.2 starting in early May 2019.