

Plagioclase-saturated melt hygrothermobarometry and plagioclase-melt equilibria using machine learning

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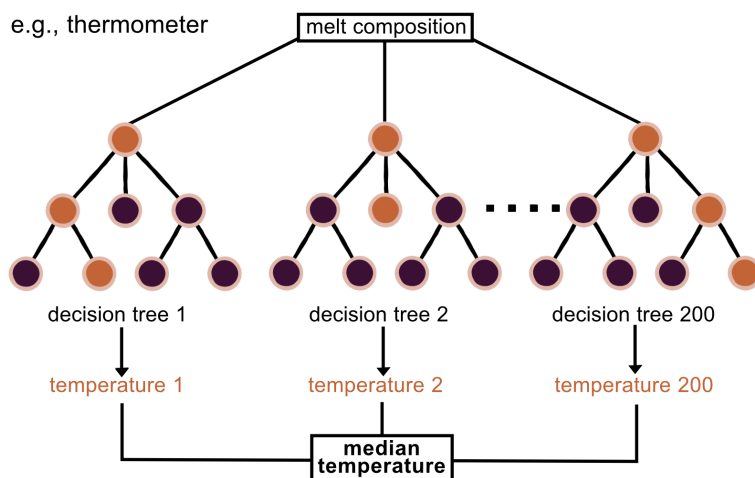
Introduction

This file contains supplementary text and figures omitted from the main manuscript. The supplementary text explains the error propagation used in the Mount St Helens application. The supplementary figures display the schematics of a random forest algorithm generating a prediction and 10-fold cross-validation, as well as significant geochemical relationships aiding algorithm prediction. Supplementary Table 2 provides a summary of RMSE and R^2 values of all models from cross-validation and test sets.

Text S1.

The ML H₂O-independent thermometer and T-dependent hygrometer provide an uncertainty value (standard deviation; SD) from the T or H₂O prediction of each individual glass compositional analysis. For n=50, a uniform distribution within the SD on every temperature or water content estimate predicted by the H₂O-independent thermometer and T-dependent hygrometer is sampled. For example, if the thermometer returns a value of 900 °C and an SD of ± 50 °C, 50 points are sampled between 850–950 °C according to a uniform distribution. All 50 temperature/water content estimates are then input into the T-dependent hygrometer or H₂O-dependent barometer for each glass analysis. The maximum absolute difference to the mean value is the maximum uncertainty associated with a given pre-eruptive water content/pressure estimate.

a) Forming a prediction with random forests



b) Cross-validation process (establishing model errors)

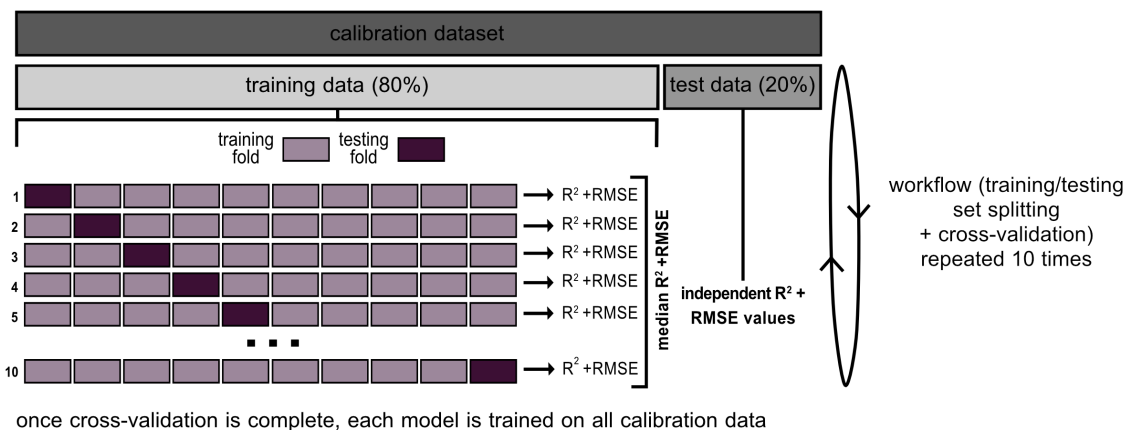


Figure S1. Summary diagrams of the random forest algorithm and the cross-validation process. **a)** Simplified diagram of a random forest thermometer displaying how a temperature prediction forms via averaging of multiple decision trees. **b)** Schematic of 10-fold cross-validation.

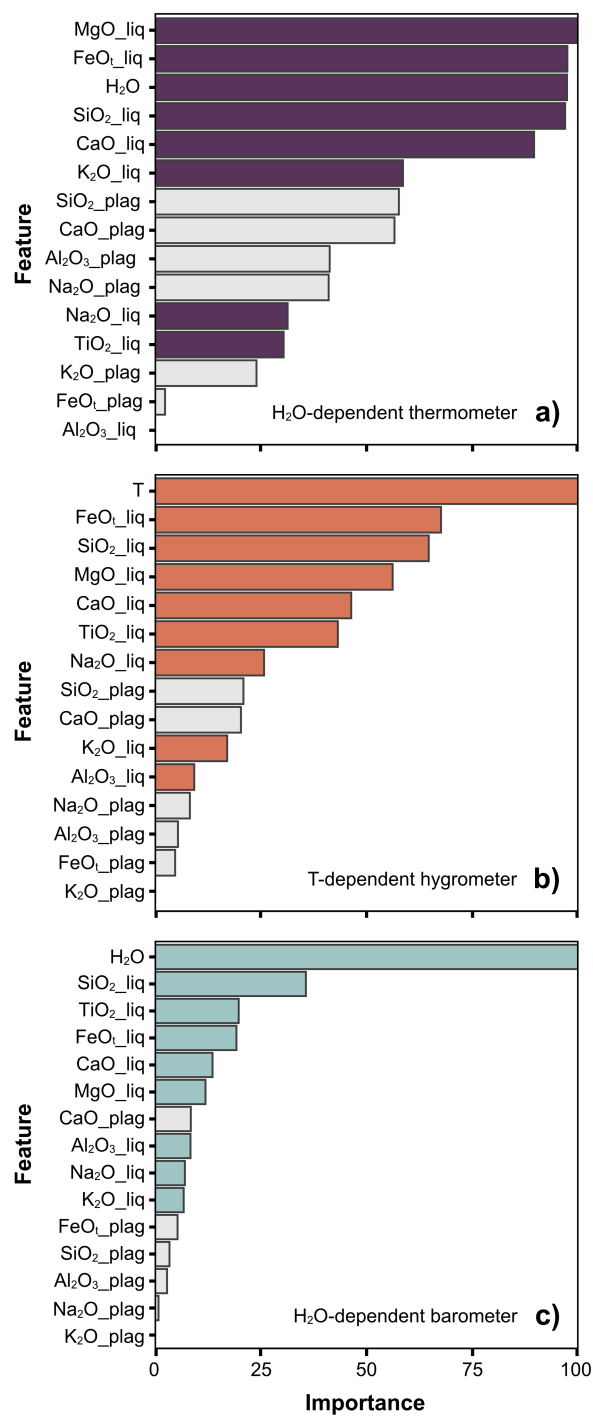


Figure S2. Plots of variable importance vs. input parameter for the H₂O-dependent thermometer (a), T-dependent hygrometer (b), and H₂O-dependent barometer (c), highlighting the most important variables used by the algorithm to make predictions. Light grey bars represent plagioclase compositional inputs and coloured bars represent melt oxide inputs along with additional parameters such as T or H₂O.

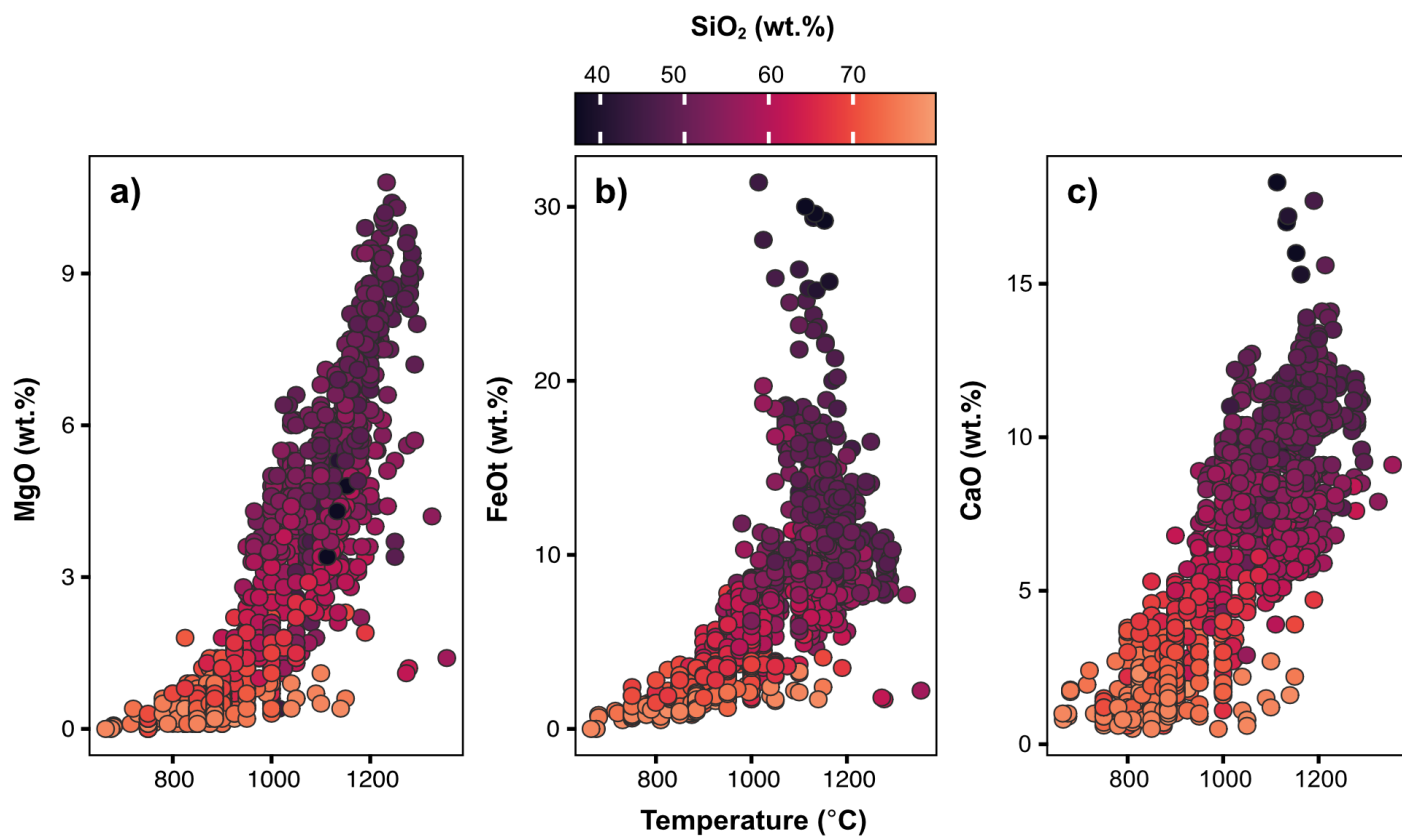


Figure S3. Plots illustrating the strong non-linearity between temperature and (a) MgO (wt.%), (b) FeO (wt.%), and (c) CaO (wt.%) in the liquid. Colour coding reflects the SiO₂ (wt.%) of the liquid.

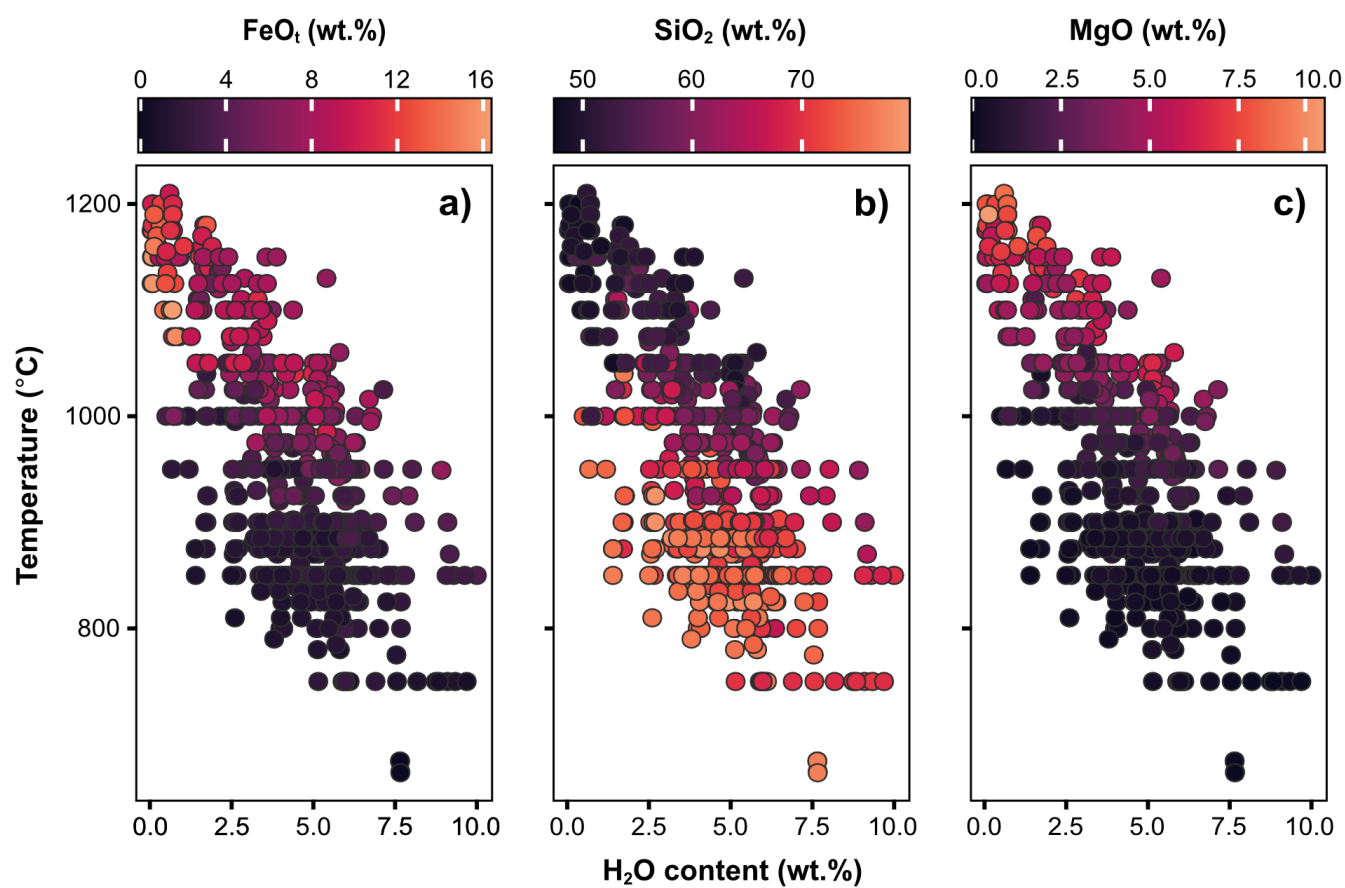


Figure S4. Temperature vs. H₂O (wt.%) of experimental glass compositions with colour coding showing the (a) FeO_t (wt.%), (b) SiO₂ (wt.%), and (c) MgO (wt.%) contents in the liquid.

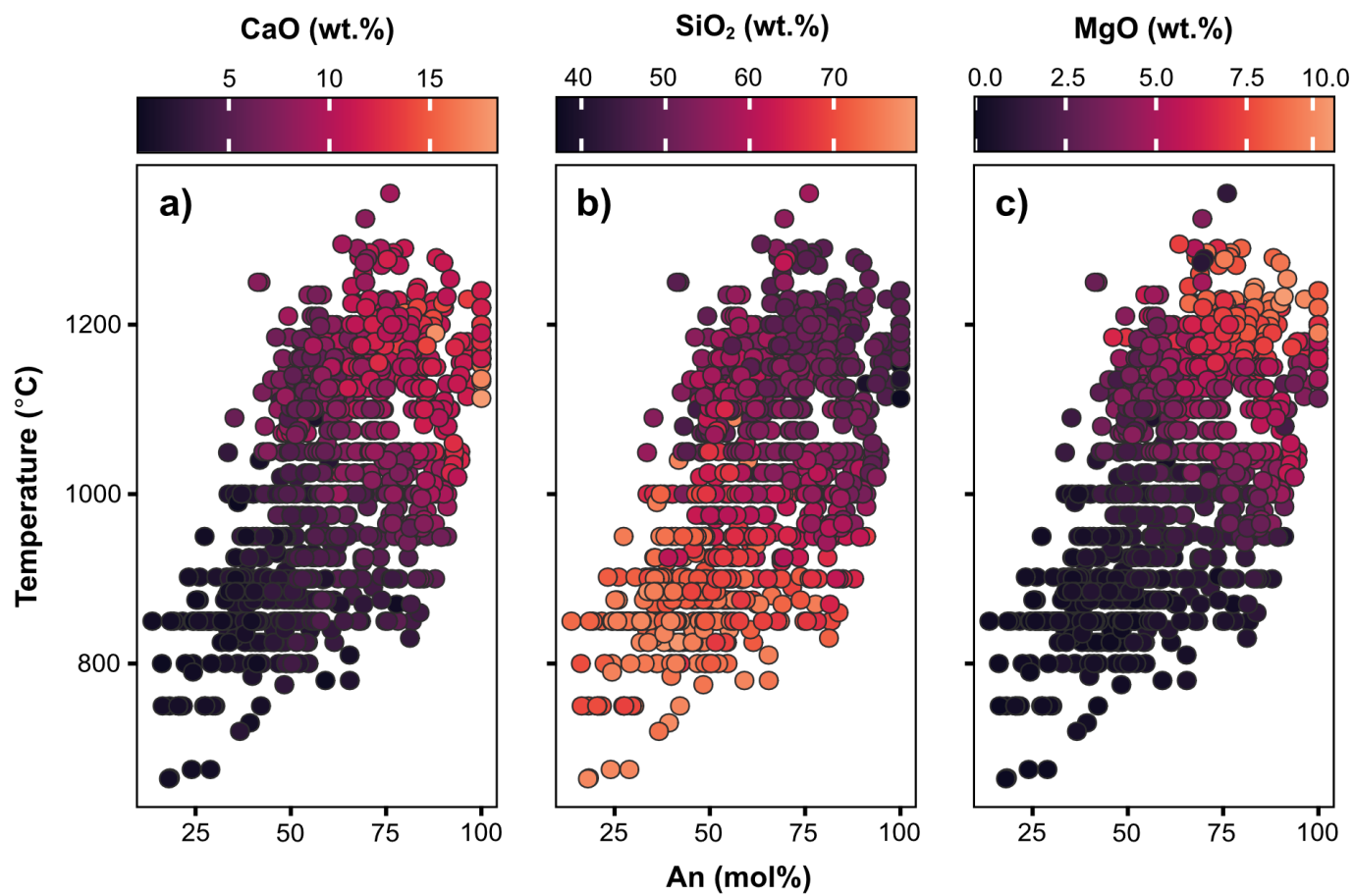


Figure S5. Temperature of experimental glass compositions vs. An content (mol%) of experimental plagioclase with colour coding showing the (a) CaO (wt.%), (b) SiO₂ (wt.%), and (c) MgO (wt.%) contents in the liquid.

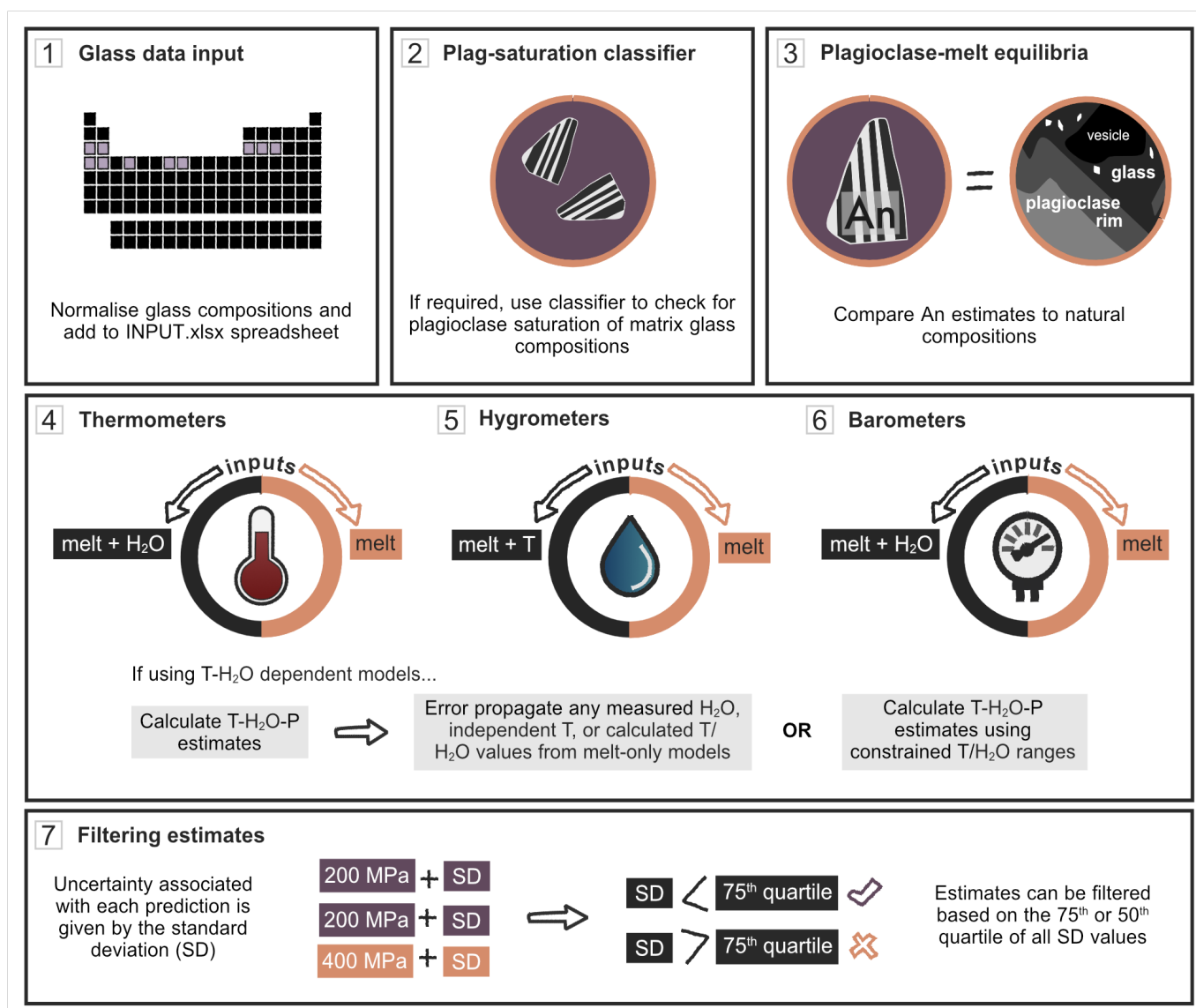


Figure S6. Schematic of recommended workflow to use the plagioclase-saturated melt models.

Model	T (°C)		H ₂ O (wt.%)		P (MPa)		An (mol.%)
	Melt + H ₂ O	Melt-only	Melt + T	Melt-only	Melt + H ₂ O	Melt-only	Melt-only
CV RMSE	24.5	35.3	0.68	0.97	76.3	91.5	5.8
CV R ²	0.97	0.93	0.94	0.88	0.60	0.41	0.91
Test set RMSE	25.9	37.5	0.69	0.95	76.2	91.3	5.8
Test set R ²	0.96	0.93	0.93	0.88	0.60	0.42	0.90

Table S2. Summary of cross-validation (CV) and test set RMSE and R² values for all models.