Supplements

**Summary of the analytical methods used to obtain the data of this publication**

Whole-rock analyses:

Major element and trace elements were measured on whole-rocks by X-ray fluorescence analysis (XRF) at the “Geowissenschaftlichen Zentrum” of the University of Göttingen.

For XRF 700 mg of powdered sample were thoroughly mixed with 4200 mg Spectroflux 100 (Dilithiumtetraborate (Li2B4O7)) and melted to a glass disc by an automatic fusion device. Analytical errors for mayor elements are around 1% (except for Fe and Na, 2%) and for trace elements around 5%. For the calibration of major and trace element determination about 50 reference materials were used: a wide variety of international geochemical reference samples from the US Geological Survey, the International Working Group "Analytical standards of minerals, ores and rocks", the National Research Council of Canada, the Geological Survey of Japan, the South African Bureau of Standards, the National Institute of Standards and Technology.

EPMA measurements on natural mineral pairs for geothermobarometry

Quantitative analyses of mineral phases were determined by a JEOL JXA 8900RL electron microprobe on polished thin sections at the Geosciences Centre Göttingen using the wavelength dispersive method. The operating conditions for silicate minerals were 15 kV accelerating voltage, 15 nA beam current and 5-15 µm beam diameter, depending on the grain sizes. Oxide minerals were measured using 20 kV and 20 nA in focused spot beam due to the small grain sizes. Peak counting times were usually 15 s and 5 s for the background. For the trace elements in oxide minerals (Si, Al, Mg) 30 s for peak and 15 s for the background were applied. Matrix corrections for both measurement programs were performed automatically using the Phi-rho-Z procedure of Armstrong (1995). The analytical error is typically <1%.

EPMA measurements on experimental minerals and glasses

Analyses of the experimental products were performed with a Cameca SX100 electron microprobe at the Institute for Mineralogy, Leibniz University Hannover. Residual glasses were measured with a defocused beam of 5-10 µm, 4 nA beam current and counting times of 4 s for Na and K, 20 s for P and 8 s for the other elements. In samples with low melt fraction, the microprobe beam was defocused as much as possible. No significant alkali loss (within the uncertainty) was detected using these analytical conditions.

Minerals were analyzed with a focused beam at 15 kV, 15 nA beam current and counting times for major elements of 10 s. Na and K were analyzed first to minimize alkali loss. Phosphorous was analyzed at last with counting times of 20 s. Multiple measurements were made for each phase within a sample to minimize possible analytical errors and check for homogeneity.

The ‘by-difference’ method was applied to determine the H2O concentration in the quenched experimental glasses. To improve the quality of the ‘by-difference’ technique, hydrous standard basaltic and andesitic glasses with well-characterized water contents from 0.28 to 8.81 wt.% H2O (glasses characterized by Botcharnikov et al. (2006) and Shishkina et al. (2010)) were analyzed with the same EPMA setting. The results were used to establish a relation between the ‘by-difference’ value and the H2O concentrations of the standard glasses. As an example, a typical relationship obtained for an analytical session is H2OMeltcorrected = 0.9984 \* H2Oby-difference - 0.3024. The typical error using this approach is estimated to be ±0.5 wt.% H2O.

EPMA measurements on melt inclusions in natural samples.

Melt inclusions were analyzed with a Cameca SX-100 electron microprobe at the Institute for Mineralogy, Leibniz University Hannover. The analyses of the glasses were conducted using a 15 kV acceleration voltage, 4 nA beam current, and a 5-10μm defocused electron beam. Peak counting times for major elements were 5-10 s. Sulfur, chlorine, and fluorine were measured as the last elements with 30 nA beam current and the counting times for S, Cl, and F were 30, 30 and 60 s, respectively. BaSO4, ZnS, NaCl, and SrF2 were used as standard materials for S, Cl, and F analyzes.

EPMA measurements of pyroxene profiles

Pyroxene compositional profiles presented only in the supplements tables were taken with a JEOL JXA-iHP200F electron microprobe at the Institute for Mineralogy, Leibniz University Hannover. Single points were analyzed with a focused beam at 15 kV, 15 nA beam current and counting times for major elements of 10 s. Na and K were analyzed first to minimize alkali loss. In each sample, 3 pyroxene crystals, with clearly visible zoning in the backscatter image, were selected for the line scans. The lines were positioned so that they always run from rim to rim and through the core and hit as few glass inclusions and/or mineral inclusions as possible. Each line scan consists of approx. 20 to 80 individual measurements, depending on the size of the crystal grain. The distance between the points was kept constant at 7 µm.

Karl Fischer-Titration (KFT)

To further constrain the accurate determination of H2O contents in the experimental glasses, samples above the liquidus were measured by Karl-Fischer titration (KFT, Behrens et al., 1996). The samples (composed of one or several glass pieces with a total weight of about 10–20 mg) were placed into an open platinum crucible and heated up with a high-frequency generator (Linn electronic HTG 1000/1,3) from room temperature to 1300 °C. Extracted water was transported by an Ar-stream to the titration cell with an electrolytic solution. The amount of extracted H2O was measured by a moisture meter (Mitsubishi CA-100) after quantitative reaction between H2O and coulometrically generated I2. The uncertainty in the water determination was estimated on the basis of the uncertainty of the titration rate which is 0.2 μg/s (Behrens et al., 1996)

**Supplement Figures**

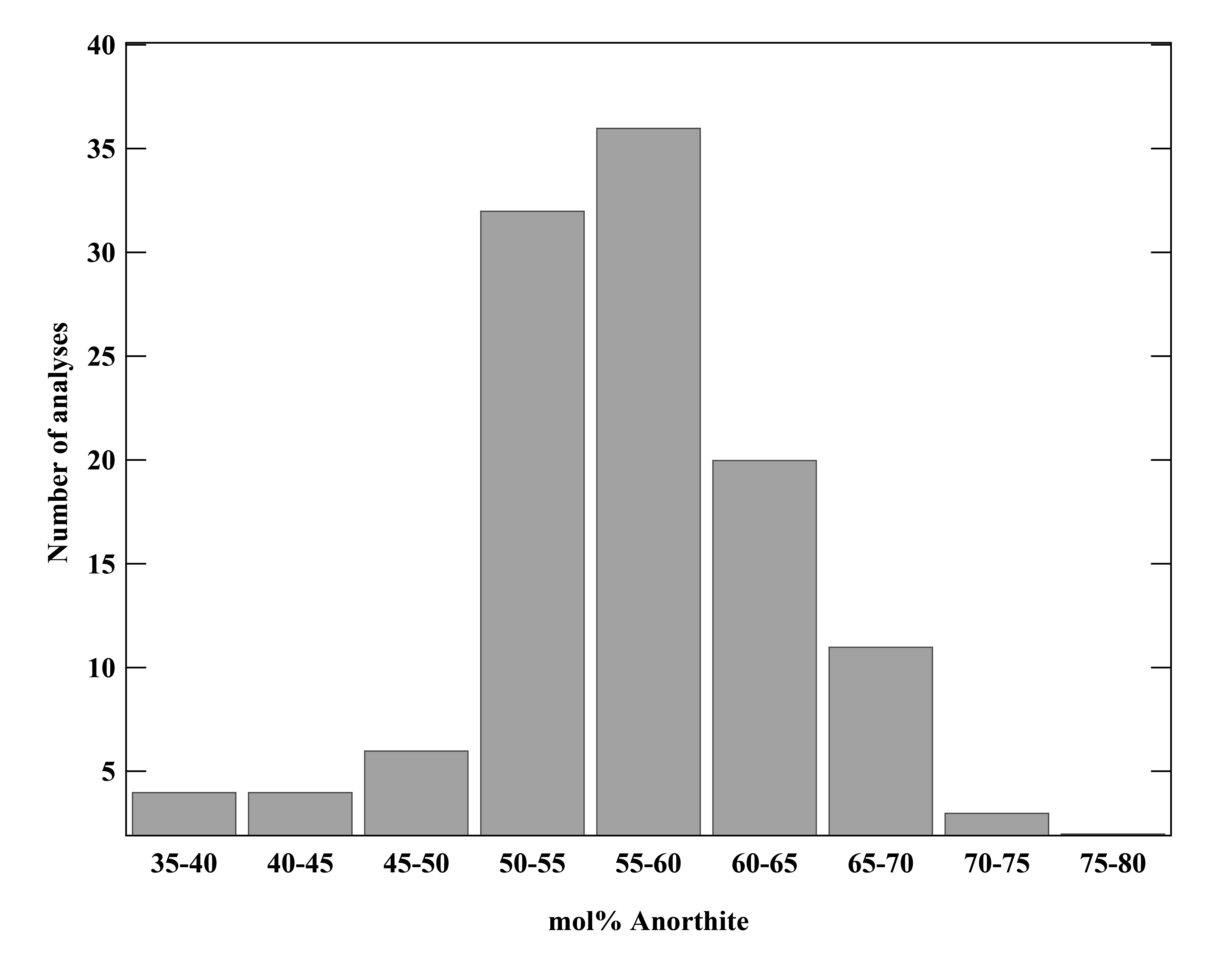


Figure S1: Histogram of anorthite contents in natural Stage IV plagioclases.

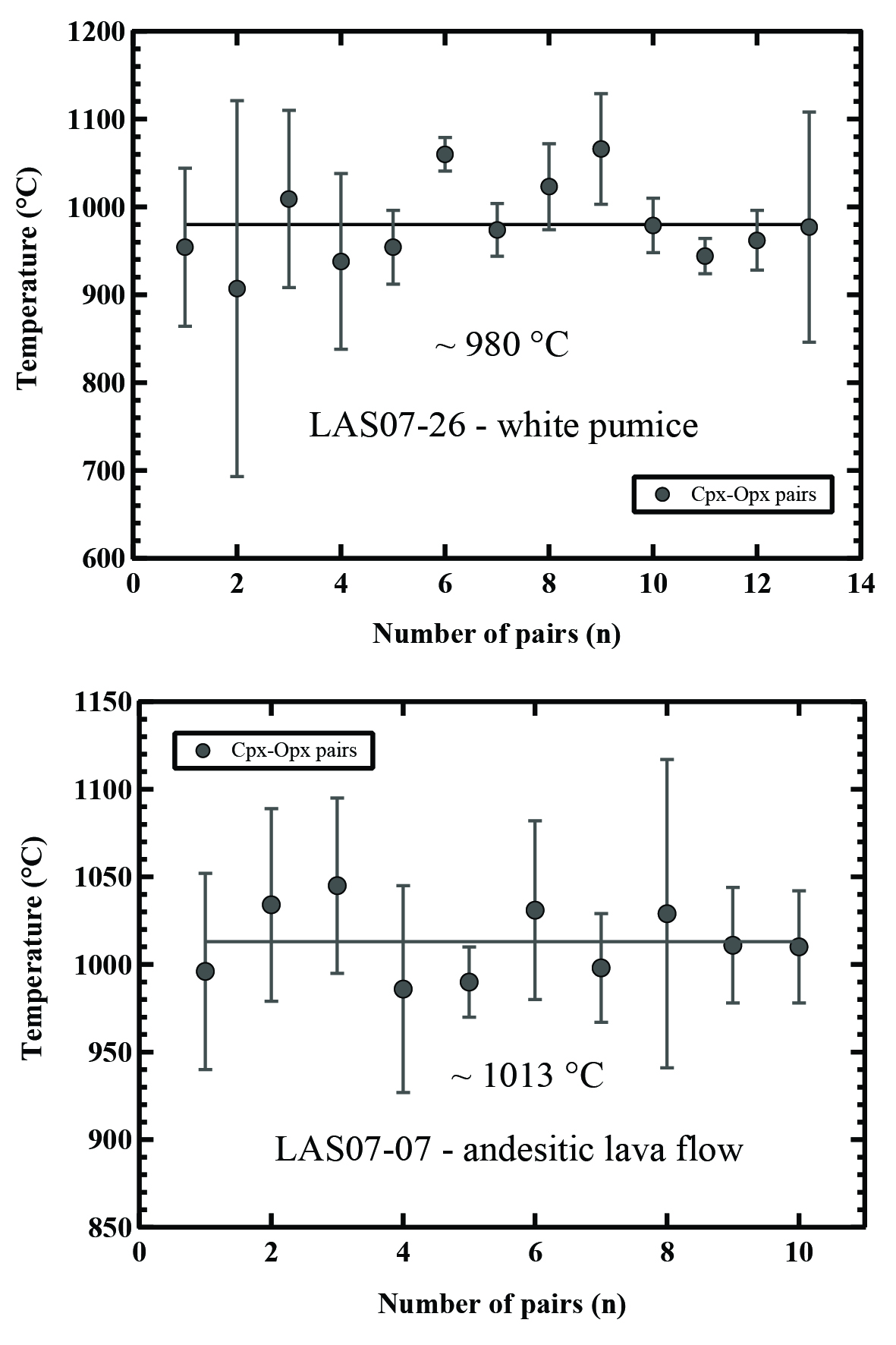


Figure S2: Temperature estimates for representative Stage IV eruptives using the Opx-Cpx geothermobarometer

from Andersen et al. (1993).