Geochemistry, Geophysics, Geosystems

Supporting Information for

What can we learn from X-ray fluorescence core scanning data? A paleo-monsoon case study

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Contents of this file

Introduction

This supporting information file provides relevant information how the age model for core U1448 is reconstructed and additional information on XRF data calibration (Text S1-S2 and Figures S1-S4).

Text S1. Core stratigraphy

The age model of Site 17 is based on correlation of benthic *C. wuellerstorfi* $\delta^{18}O$ to the LR04 global benthic $\delta^{18}O$ stack [*Lisiecki* and *Raymo*, 2005] resulting in an average linear sedimentation rate of ~5 cm/kyr and is described in detail elsewhere [*Gebregiorgis* et al., 2018]. For the uppermost section of the core, the age model was further constrained by five ^{14}C dates converted to conventional ages following *Southon* et al., [2002] and identification of the youngest Toba ash layer [*Ali* et al., 2015]. The age model for Site U1448 was constructed by cross correlating the Ti/Ca data of Site 17 and U1448 using Analyseries [*Paillard* et al., 1996]. Ti/Ca data of both cores consistently maintain high signal-noise ratios, which allow a well-constrained cross-site correlation (Figure S1). Ages between XRF-based tie points are linearly interpolated and each continuous core section was reduced to a frequency of 1/kyrs using a cubic spline model prior to tuning. The primary aim was to provide a continuous high-resolution time series representing the Andaman Sea by filling the few gaps identified in the Site 17 core, which exist due to the fact that only a single hole was cored during the NGHP expedition and onboard sampling of sediment material. The accuracy of the Ti/Ca based age model for U1448, however, is only verified on statistical grounds by calculating phasing offsets and coherence between the Ti/Ca records of both cores at the main orbital frequencies, for which the Ti/Ca records are significantly coherent (> 95%) in all main orbital frequencies. The age model offsets between the two records for the three major orbital frequencies is <2 Kyrs and we specifically focus on peak variance analysis at major orbital frequencies. We also compared the Ti/Ca exported age model with the unpublished U1448 benthic $\delta^{18}O$ based age model and the two age models are consistent with each other (Figure S2).

Text S2. XRF core scanning data calibration

Initially raw XRF data were calibrated against quantitative analyses of 80 discrete samples spanning the topmost 15 m of the core. Given the porosity/water content effect on lighter elemental (e.g. Si, Al) count intensities, we have excluded samples from high porosity/water content sections (i.e. upper 6 m) for the lighter elements (i.e. Si, Al). However, this does not impact the relatively heavier elements (i.e. Ti, Fe, Ca and K) and the XRF data for these elements (Figure S3). To convert the raw XRF core scan data (given in cps) to elemental concentrations, a robust regression model from the Statistics toolbox in MATLAB (R2014b) was applied using the equations shown in Figure 2. *Weltje* et al., [2015] however, recommend using multivariate log-ratio calibration (MLC) equations for calibration purposes, which applies log-ratios of element counts and concentrations instead of counts of single elements. Results of both procedures agree well (Figure S4) and a robust regression model is preferred here as we are particularly interested in patterns of changes in both individual elements and ratios.

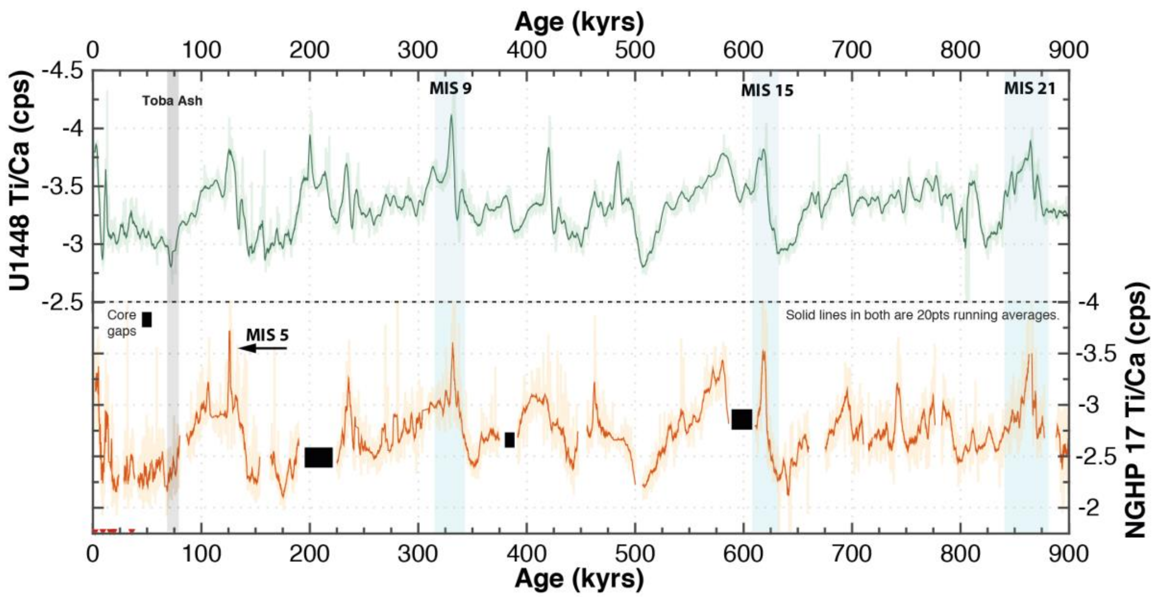

Figure S1. Cross-site comparison of XRF Ti/Ca records of the two Andaman Sea Sites (NGHP Site 17 and U1448). The age model for the U1448 site record was derived by splicing the Ti/Ca records for both cores and transferring the benthic $\delta^{18}O$ record of NGHP17 onto the new composite depth. Inverted triangles in red show radiocarbon dates. Inverted triangles in red show 5 radiocarbon dates used to constrain the age model for the younger sections of the core.

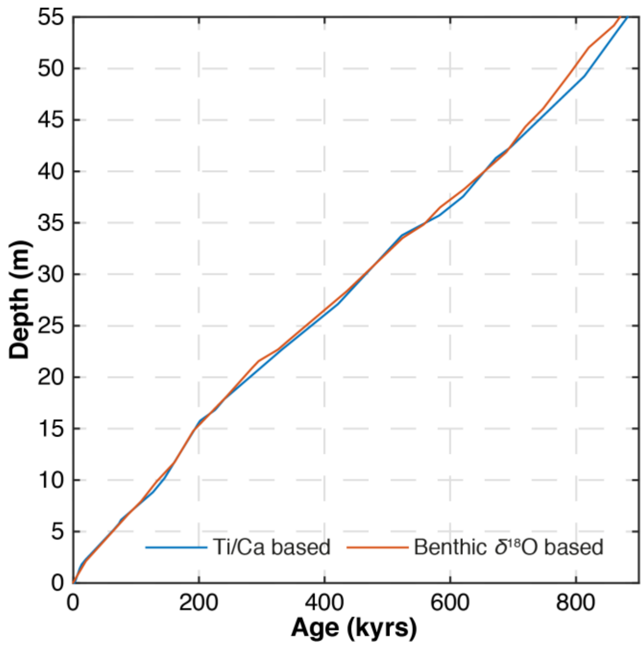

Figure S2. Comparison of the Ti/Ca exported age model with the unpublished U1448 benthic δ^{18}O based age model.

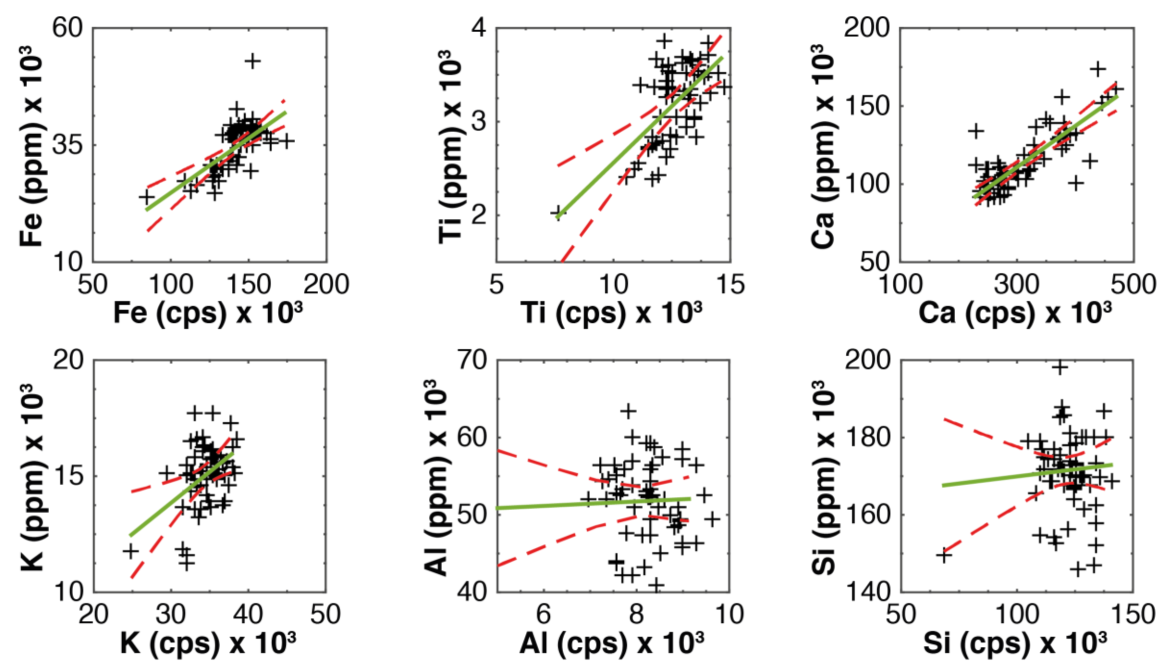

Figure S3. Calibration of U1448 XRF elemental concentrations measured by pXRF and applied to XRF core scanning data using a robust regression model after excluding samples from high porosity/water content sections (i.e. upper 6 m). Note that porosity/water content does not affect relatively heavier elements (i.e. Ti, Fe, Ca and K) and robust regression models shown in Figure 2 and here are virtually identical.

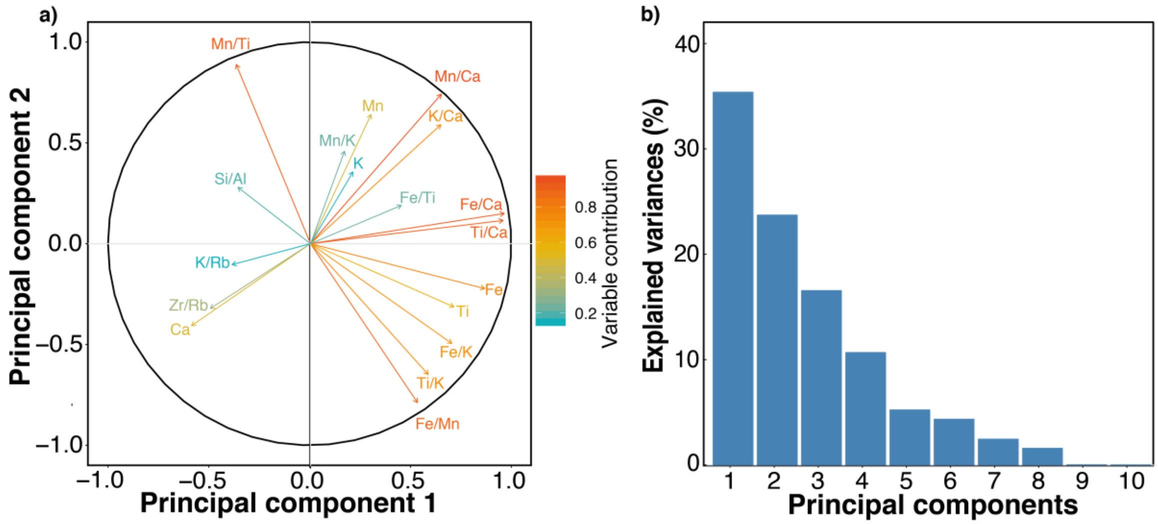

Figure S4. Principal component analysis applied to the XRF data matrix applying log-ratios of element counts and concentrations agree well with results obtained based on a robust regression model. In both cases, the first two principal components (PC1 and PC2) explain 65% of the total variance and variable input contributions to PC1 and PC2 are nearly identical as shown in (a) and (b).

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