SUPPLEMENTARY INFORMATION

This document provides detailed information on the sources of the data for the atmospheric O_2 and CO_2 time series of Berner (2006, 2009), and the clay abundance time series of Ronov et al. (1990), and the statistical procedure that was used to examine their correlations.

A. Russian Platform clay abundance time series

The relative abundances of the kaolinite group, chlorite group, smectite group (reported as "montmorillonite"), and illite group minerals were taken from Table 1 in Ronov et al. (1990). The times assigned to the values were adjusted to GTS 2004 (Gradstein et al. 2004), using Russian zonation-to-standard chronostratigraphy information and geochronologic updates in *TS Creator* (2010). Specific ages were assigned by taking the average of the beginning and end of each series or stage. This procedure provides four clay abundance time series sampled at 25 time points throughout the Phanerozoic at a mean spacing of 23 Ma. Data are reported in Tables S1 and S3 below and plotted in Figs. 3-6 of the main manuscript.

B. Model O_2 and CO_2 time series

Values and times for the GEOCARBSULF-modeled atmospheric O_2 and CO_2 time series were obtained by digitizing the data points in Berner (2009) and (2006), respectively, as reported in Table S2 of this document. These values were smoothed and interpolated graphically to give values at the same ages represented by the mineral abundance data in order to carry out the statistical tests referred to below. The data are given in Table S3 below.

C. Statistical correlation

The sample Pearson product-moment correlation coefficient (PMCC) is a standard statistical measure of linear correlation between two variables X_1 and Y_1 (Snedecor and Cochran 1989):

$$r = \frac{\sum_{i=1}^{n}\left(X_i - \overline{X}\right)\left(Y_i - \overline{Y}\right)}{\sqrt{\sum_{i=1}^{n}\left(X_i - \overline{X}\right)^2}\sqrt{\sum_{i=1}^{n}\left(Y_i - \overline{Y}\right)^2}}$$

In this case, X corresponds to the set of n clay abundances and Y to the set of n modeled O_2 (or CO_2) values, that are paired with respect to time, with n=25, and $\overline{X}$ and $\overline{Y}$ correspond to sample means of X and Y.

The value of r falls in the range of ±1, where r = –1 signifies a perfect negative correlation, r = +1 a perfect positive correlation, and 0 no correlation between the variables. If X and Y are uncorrelated and normally distributed, the distribution of r follows Student's t distribution with n – 2 degrees of freedom, centered on r = 0. Hypothesis testing can be carried out with Student t critical values. An alternative approach, known as Fisher transformation, transforms r into a variable that is effectively normally distributed with a standard error s_z=1/(n-3)$^{-0.5}$:

$$z = 0.5\,[\ln(1+r)-\ln(1-r)]$$

for which the 95% confidence limits are the usual $z \pm 95\% = \pm 1.96 s_z$. Inverse transformation gives $r \pm 95\% = \pm \exp[2(1.96 s_z)-1] / \exp[2(1.96 s_z)+1]$.

As an example, PMCC computation for the kaolinite versus modeled O_2 time series gives the following: $r = -0.5105$, $s_z = 0.2132$, and $r \pm 95\% = \pm 0.3951$. The null hypothesis that the two time series are not correlated (actual $r = 0$) requires that calculated r occur within the $r \pm 95\%$ confidence limits. It does not; consequently, the two time series are significantly negatively correlated. The $r \pm 95\%$ confidence limits of ±0.3951 are assumed for all of the correlations discussed in this study.

Values of PMCC were determined for all possible pairs of clay minerals and the atmospheric variables O_2 and CO_2 and are listed in Table S4.

Supplemental References

Berner, R.A. (2006) GEOCARBSULF: a combined model for Phanerozoic O_2 and CO_2. Geochimica et Cosmochimica Acta, 70, 5653–5664.

Berner, R.A. (2009) Phanerozoic atmospheric oxygen: New results using the GEOCARBSULF model. American Journal of Science, 309, 603-606.

Gradstein, F., Ogg, J.G., and Smith, D.G. (2004) A Geologic Time Scale 2004. Cambridge, UK: Cambridge University Press.

Ronov, A.B., Migdisov, A.A., and Hahne, K. (1990) Abundance and composition of clays in the Russian-Platform sedimentary cover. Geokhimiya, No. 4, 467-482.

Snedecor, G.W. and Cochran, W.G. (1989) Statistical Methods, Eighth Edition. Ames, Iowa: Blackwell Publishing.

TSCreator visualization of enhanced Geologic Time Scale 2004 database (Version 4.2.1; 2010) James Ogg (database coordinator) and Adam Lugowski (software developer) http://www.tscreator.org