MATTERS ARISING
https://doi.org/10.1038/s41561-019-0304-z

nature geoscience

No evidence for equatorial Pacific dust fertilization

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ARISING FROM Matthew R. Loveley et al. *Nature Geoscience* https://www.nature.com/articles/ngeo3024 (2017)

Loveley and co-authors[1] present ^{232}Th and biogenic barium (Ba_{xs}) fluxes from eastern equatorial Pacific (EEP) site MV1014-02-17JC (17JC). They argue that millennial increases in dust flux enhanced productivity via Fe fertilization and increased efficiency of the biological pump. Here, we show that this conclusion is unwarranted, and present an alternative explanation that is consistent with data from nearby Ocean Drilling Program (ODP) Site 1240. Our understanding of the carbon cycle further suggests that Fe fertilization in the EEP cannot influence p_{CO_2} (ref. [2]), necessitating a careful examination of claims to the contrary.

At the centre of the conclusion reached by Loveley et al.[1] is their suggestion of a correlation between the flux of ^{232}Th, a dust proxy[3–5], and the flux of Ba_{xs}, an export productivity proxy[5,6]. However, the coefficient of multiple correlation (R^2) between these two parameters is 0.0007, with correlations of 0.006 for stadial events and 0.0005 for the residual record (Fig. 1a) (with corrresponding P values of 0.59, 0.43 and 0.70). No function, nonlinear or otherwise, can provide a statistically significant relationship between these variables, rendering any variations in the production or preservation of Ba_{xs} immaterial. Furthermore, several productivity pulses precede dust flux increases, and millennial increases in dust and productivity occur independently of one another or of any stadial event. Thus, there is no relationship between the flux of ^{232}Th and Ba_{xs} at 17JC, and we conclude that there is no dust fertilization of the EEP on millennial or orbital timescales. This result matches previous reconstructions from 11 equatorial Pacific sites (including two from the EEP) that show no correlation between dust flux and productivity[3,5] or nutrient utilization[7].

New data from nearby ODP Site 1240 show a weak correlation between records of ^{232}Th and Fe flux (Fig. 1b), suggesting that dust did not enhance productivity because it is not the primary control on Fe availability in the EEP. This is consistent with evidence[3,8,9] that upwelling of the Equatorial Undercurrent delivers an order of magnitude more dissolved Fe than aeolian dust. Indeed, the flux of Ba_{xs} is more strongly correlated with Fe flux than it is with ^{232}Th (Fig. 1c), suggesting that upwelling may be related to both the Fe flux and productivity. Upwelling, in turn, probably responds to changes in wind strength, a potential common influence on the fluxes of both total Fe and aeolian ^{232}Th. Thus, Fig. 1 suggests that increases in EEP productivity are related to the upwelling of nutrient and Fe-rich subsurface waters, not aeolian dust.

Although export production in the EEP does vary with climate, these changes do not alter the net efficiency of the biological pump. At present, the EEP is a net source of CO_2 to the atmosphere due to

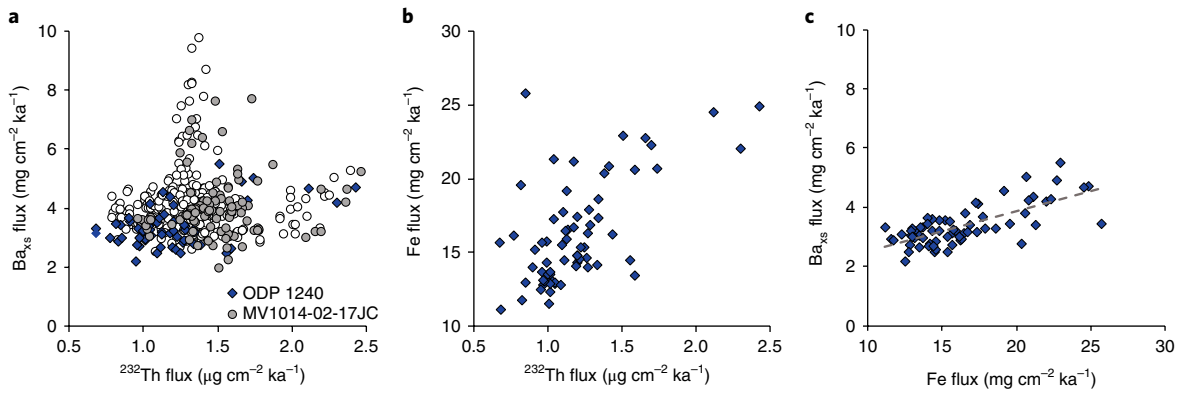

Fig. 1 | Statistical assessment of factors influencing productivity. a, Correlation between ^{232}Th and Ba_{xs} fluxes at site 17JC (0.18° S, 85.87° W; 2.8 km depth) ($R^2 = 0.0007$, $P = 0.59$) (circles), during Heinrich events 0–8 ($R^2 = 0.006$, $P = 0.43$) (grey circles), non-stadial periods ($R^2 = 0.0005$, $P = 0.70$) (white circles), and at ODP Site 1240 (0.02° N, 86.46° W; 2.9 km depth) ($R^2 = 0.24$, $P < 0.01$) (blue diamonds). **b**, Correlation between ^{232}Th and Fe fluxes at ODP Site 1240 ($R^2 = 0.38$, $P < 0.01$) (blue diamonds). **c**, Correlation between Fe and Ba_{xs} fluxes at ODP Site 1240 ($R^2 = 0.51$, $P < 0.01$) (blue diamonds).

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a reduction in gas solubility when upwelled seawater is warmed[2,10]. As equatorial waters diverge polewards, nutrients not immediately utilized are fully consumed off-axis[2]. Consequently, although the addition of Fe may stimulate productivity locally, it does so at the expense of nutrient consumption downstream. Thus, the biological carbon pump in the EEP operates at full efficiency when integrated regionally[2]. Data from 17JC provide neither evidence of aeolian Fe fertilization, nor of enhanced CO_2 drawdown in the EEP during times of greater dust supply.

Data availability

Data supporting the results of this contribution are available through PANGAEA at https://doi.pangaea.de/10.1594/PANGAEA.897587.

Received: 2 August 2018; Accepted: 7 January 2019;
Published online: 27 February 2019

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Author contributions

R.F.A., G.W. and A.W.J. designed the research, A.W.J. performed the analyses and all authors were involved in writing and revising the manuscript.

Competing interests

The authors declare no competing interests.

Additional information

Supplementary information is available for this paper at https://doi.org/10.1038/s41561-019-0304-z.

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