Questioning the Evidence for the Hadean Dynamo

C. S. BORLINA[1*], B. P. WEISS[1], E. A. LIMA[1], F. TANG[2], R. TAYLOR[2], J. F. EINSLE[2], R. J. HARRISON[2], R. R. FU[3], E. A. BELL[4], E. W. ALEXANDER[4], H. M. KIRKPATRICK[4], M. M. WIELICKI[5], T. M. HARRISON[4], J. RAMEZANI[1], A. C. MALOOF[6]

[1]Massachusetts Institute of Technology, Cambridge, MA, USA (*correspondence: caue@mit.edu)
[2]University of Cambridge, Cambridge, UK
[3]Harvard University, Cambridge, MA, USA
[4]University of California, Los Angeles, USA
[5]University of Alabama, Tuscaloosa, AL, USA
[6]Princeton University, Princeton, NJ, USA

Determining the long-term evolution of Earth's magnetic field would constrain the thermal evolution of the planet's interior and the mechanisms that powered the geodynamo [1]. Previous paleomagnetic studies indicate that an active dynamo existed at least as early as 3.5 billion years (Ga) ago [2]. Ancient records of the early geomagnetic field could be carried by 3.0-4.4 Ga detrital zircon crystals from the Jack Hills and other locations in the Yilgarn craton of Western Australia. Recently, it was suggested that Jack Hills zircon crystals contain records of the dynamo dating back to 4.2 Ga [1]. Here we assess this possibility by presenting new magnetic, geochemical and mineralogical data.

We non-magnetically extracted 4,000 zircon crystals from their host rocks. We then selected grains that could have retained robust paleomagnetic records based on the following criteria: (a) concordant (>90%) U-Pb dates; (b) the presence of <10 μm internal Li-rich domains correlated with growth zonation (suggesting they were not thermally remagnetized since formation); and (c) minimization of secondary ferromagnetic minerals (by washing with hydrochloric acid and avoiding grains that contain secondary deposits, large cracks, or that are metamict [3]).

We conducted paleomagnetic experiments on 75 grains, which comprised all grains older than 3.5 Ga that passed the above criteria and a set of grains that failed one of the criteria. We found that Jack Hills zircon crystals are poor recorders of the early geomagnetic history and their magnetic carriers are mostly secondary in origin. Therefore, there is currently no compelling evidence for the existence of the dynamo during the Hadean eon and Eoarchean era.

[1] Tarduno, J.A. et al. (2015) *Science* 349, 521; [2] Tarduno, J.A. et al. 327, 1238 (2010) *Science*; [3] Weiss, B.P. et al. (2018) *Geology*;