Materials and Methods

Zircons were selected for xenon analysis following ion microprobe U-Th-Pb age measurements. As >4.1 Ga zircons make up less than 1% of the detrital population, we devised a method to rapidly survey $^{207}\text{Pb} / ^{206}\text{Pb}$ ages (~10 sec/zircon) using both the UCLA Cameca 1270 and ANU SHRIMP II ion microprobes in multi-collector mode. Zircons older than 4.1 Ga were then characterized by the traditional U-Th-Pb ion microprobe method and selected for this study on the basis of age and degree of U-Pb concordance (Table 1). In Manchester the selected zircons were placed in machined depressions in a previously outgassed molybdenum disk which was then mounted under a quartz window in the RELAX vacuum system. Samples were heated by a focussed CW Nd-YAG laser beam for 1 minute in three or four stages until fused (recognized by the absence of further xenon release). Prior to admission to the mass spectrometer the released gases were gettered for 1 minute.
Figure S1 – Typical RELAX raw data mass spectrum of fissiogenic xenon from ancient zircon. Visible peaks are at masses 129, 131, 132, 134 and 136. Note the absence of a detectable peak (on this scale) at mass 130, indicating the near absence of atmospheric xenon.
Figure S2 - Xenon release patterns during stepped heating of Jack Hills zircons.

The amounts are measured in numbers of atoms. The major releases are detailed in Table 1.
Figure S3 – Mixing diagram of $^{\text{130}}\text{Xe}/^{\text{136}}\text{Xe}$ vs. $^{\text{131}}\text{Xe}/^{\text{136}}\text{Xe}$ for all data. The points with the largest error bars contain a few hundred atoms of $^{\text{130}}\text{Xe}$ and have typical uncertainties of ± 150 atoms. The analyses on which the Pu/U ratios are based are plotted in figure S4 and have $^{\text{130}}\text{Xe}/^{\text{136}}\text{Xe}$ ratios less than 0.015. Open circles are zircon data, filled squares $^{238}\text{U}$, $^{244}\text{Pu}$ fission and Earth’s atmosphere.
Figure S4 – Mixing diagram of $^{130}\text{Xe}/^{136}\text{Xe}$ vs. $^{131}\text{Xe}/^{136}\text{Xe}$ for major xenon release steps (Fig. S2). Based on the near zero values of the $^{130}\text{Xe}/^{136}\text{Xe}$ ratio the contribution of atmospheric $^{136}\text{Xe}$ in these analyses was less than 1 part in 300. The fission compositions were effectively calculated by projecting the points in the above figure away from the AIR point (i.e. parallel to the arrowed lines) onto the ‘fission line’, $^{130}\text{Xe}/^{136}\text{Xe} = 0$. Note that the $^{130}\text{Xe}/^{136}\text{Xe}$ scale is two orders of magnitude less than in Fig. S3. Open circles are zircon data, filled squares $^{238}\text{U}$ and $^{244}\text{Pu}$ fission compositions.