The search for viruses through the fossil record

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The research presented here summarizes experiments to test the hypothesis that viruses can undergo fossilization (e.g. silicification) by using techniques developed during bacterial fossilization experiments[1]. The well-characterized wild type filamentous phage M13 was chosen as a model to investigate the effect of simulated silicification and/or high pressure on nucleic acid integrity and coat protein structure. In addition, the viability of the M13 to disrupt host growth (Escherichia coli) after exposure to high Si^{4+} and excesses of pressure is discussed. Interesting results include the recovery and amplification of a 0.2kb target fragment of M13 VIII gene (major coat protein) despite exposure to high Si^{4+} concentrations for prolonged timescales. These results coupled with field emission gun scanning electron microscopy (FEG-SEM) and transmission electron microscopy (TEM) monitoring demonstrate the environmental limits of structural integrity of this well constrained model and therefore provide an insight into the limits of nucleic acid or protein-based detection methods for detection of viruses through the fossil record.

References

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Time-scales of planetary accretion

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To convert Hf-W chronometry to an absolute time-scale requires knowledge of the initial W isotopic composition of the bulk solar system ($\varepsilon^{182}W_{BSSI}$). Using this and the present value [1] constrains the initial Hf isotopic composition or $(^{182}Hf/^{180}Hf)_{BSSI}$. Unradiogenic W in iron meteorites [2,3] indicates $(^{182}Hf/^{180}Hf)_{BSSI} \geq (2.1\pm0.7)\times10^{-4}$, but this has been questioned [4] in support of the view that $(^{182}Hf/^{180}Hf)_{BSSI} \sim 1.0\times10^{-4}$ [1,5]. We have measured $\varepsilon^{182}W$ for several iron meteorites using N-TIMS and MC-ICPMS. The spread is consistent with parent body accretion and differentiation over millions of years and extends to $\varepsilon^{182}W \sim -4.0$ for Tlacotopec and Arispe. The implied $(^{182}Hf/^{180}Hf)_{BSSI}$ is $\geq (1.4\pm0.2)\times10^{-4}$. This estimate is easier to reconcile with W isotope data for the Earth [1,5,6], Moon [7], Mars [8] and Vesta [9].

It is a common misconception that the W isotope composition of the silicate Earth defines an age of terrestrial core formation. This is only likely for rapidly formed objects but even then the duration is unconstrained. In objects like Earth the protracted time-scales of accretion limit W isotopic effects [10,11]. The same holds for U-Pb [10]. With $\varepsilon^{182}W_{BSSI} = -4.0$ the mean life of accretion assuming exponentially decreasing rates is 13 Myrs. The W isotopic data for the Earth and Moon are consistent with an age for the Giant Impact of ~40 to 45 Myrs, longer than recently proposed [1,5]. Most estimates of the Pb isotopic composition of the silicate Earth yield >15 Myrs for the accretionary mean life and > 45 Myrs for the Giant Impact. The discrepancy might reflect relative rates of refractory W versus volatile Pb isotopic equilibration during accretion. The spread in published W isotope data for martian meteorites also is more readily explained if the $(^{182}Hf/^{180}Hf)_{BSSI}$ is $\geq (1.4\pm0.2)\times10^{-4}$ given the low Hf/W of the martian mantle. The time-scales for accretion and differentiation still have to be rapid ($<10^7$ years). The W isotope data for eucrites indicate that the time-scales for the accretion and differentiation of Vesta are $\sim10^7$ years, consistent with some other isotopic data.

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