4-16-2012

Stratigraphy, Geochronology and Detrital Zircon Provenance of Two Silicic Ash Layers at Hagerman Fossil Beds National Monument, Idaho

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Questions

1. Can a more precise age be determined for the Hagerman Horse (*Equus simplicidens*) fossils at Hagerman Fossil Beds National Monument (HAFO) in south - central Idaho by dating the marker ash bed above the fossils?
2. What depositional environments were present when the Peters Gulch and Horse Quarry marker ash beds were deposited?
3. Will the marker ash beds contain detrital zircons and if so, can the sources of these zircons be determined?

Site Significance

HAFO is one of the most important sources of middle Pliocene paleontological data. The Hagerman Horse Quarry (HHQ), located at the northern end of HAFO, has yielded the largest concentration of Hagerman Horse fossils to date. A previous study arrived at an inferred age of 3.2 Ma for the HHQ based on an eruption age younger than 3.66 +/- 0.67 Ma for the ash layer on the upper wall of the HHQ (Hart and Brueseke, 1999). HAFO is comprised of the Glenns Ferry Formation, a sequence of fluvial/flood plain sediments interbedded with basaltic lava flows and silicic ash layers. Two silicic ash marker beds were sampled for this study.

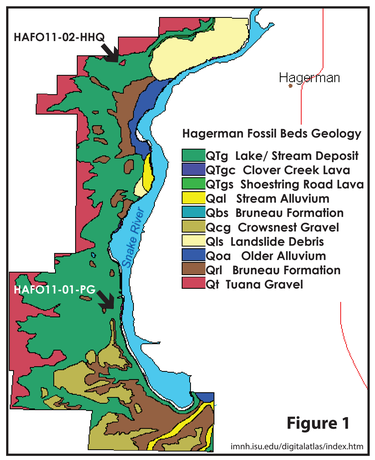


Figure 1

Hypotheses

1. Based on the fluvial/floodplain environment in which the ash from the two marker beds was deposited (Figure 1), the derived zircons will be detrital and the maximum apparent ages will be determined.
2. Accuracy in dating the marker ash beds will be enhanced by determining the date and geochemistry of individual zircon crystals.
3. Sources of detrital zircons will be derived by correlating zircon dates to past major igneous events in the region.

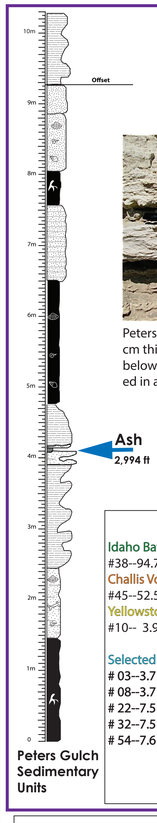
Hagerman Horse (Equus simplicidens), the ancestor of all modern horses, roamed the Hagerman area approximately 3.5 million years ago.

Glenns Ferry Formation deposits along the Snake River at Hagerman Fossil Beds National Monument. As evidenced in the descriptions of sedimentary units, HAFO is composed of lacustrine, fluvial and floodplain facies.

Methods

1. Stratigraphic sequences were measured, described and interpreted at the two marker ash bed sample sites.
2. Samples from ash marker beds were extracted: HAFO11-01-PG (Peters Gulch) and HAFO11-02-HHQ (Horse Quarry).
3. Zircon were separated from sediments and sharply faceted crystals were mounted for imaging.
4. Zircon underwent $^{238}U/^{206}Pb$ dating using LA-ICPMS. CA-TIMS dating was then applied to the youngest zircon grains in the end sample. (n=6)
5. Sources of detrital zircons were determined based on probability graphs of zircon ages, correlating peaks with past regional igneous events.

Peter's Gulch Ash Sample HAFO11-01-PG



Peters Gluch marker ash is rougly 6 cm thick. Ripple marks above and below indicate the ash was deposited in a fluvial environment

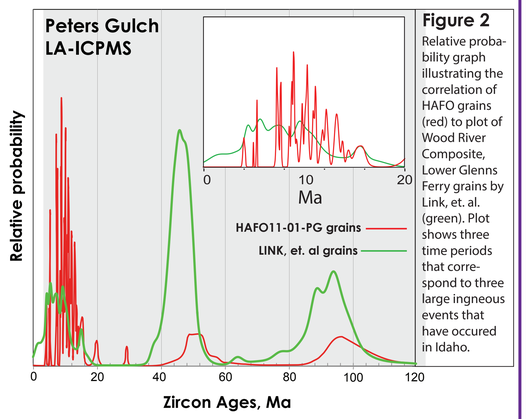
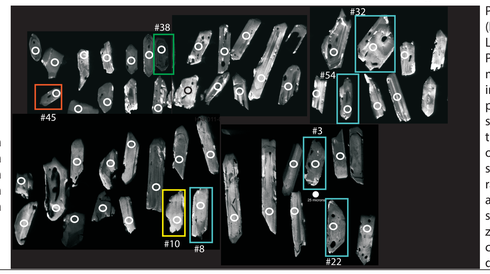


Figure 2 Relative probability graph illustrating the correlation of HAFO grains (red) to plot of Wood River Composite, Lower Glenns Ferry grains by Link, et. al. (green). Plot shows three time periods that correspond to three large ingneous events that have occured in Idaho.

Zircon mounts and spots for LA-ICPMS dating

Idaho Batholith
#38--94.7 Ma +/- 4.5 Ma
Challis Volcanics
#45--52.5 Ma +/- 2.6 Ma
Yellowstone Hotspot
#10-- 3.9 Ma +/- 2.4 Ma

Selected for TIMS
03--3.7 Ma +/- .008 Ma
08--3.7 Ma +/- .035 Ma
22--7.5 Ma +/- .082 Ma
32--7.5 Ma +/- .036 Ma
54--7.6 Ma +/- .065 Ma



Peter's Gulch grains (left) used for initial LA-ICPMS dating. Peters Gulch grains are more sharply faceted in comparison to HHQ probably due to a smaller amount of tranport. Grains listed on Ithe far eft represent examples of date ranges in the sample and the three possible source areas of the zircons, include zircons selected for TIMS dating.

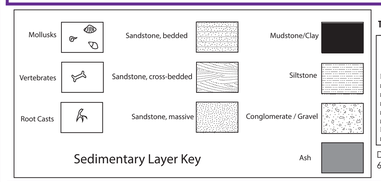
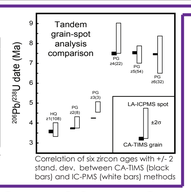


Table 1. U/Pb Data Table for TIMS results

Sample	CA-TIMS $^{206}Pb/^{238}U$	(±)	LA-ICPMS $^{206}Pb/^{238}U$	(±)	% err	MSWD
Peter's Gulch Ash						
PG-z2(8)	3.730	0.035	4.029	0.288	7.2	*8.8*
PG-z5(3)	4.243	0.008	4.803	0.266	5.5	*13.2*
PG-z6(22)	7.511	0.082	8.283	0.768	9.3	*16.1*
PG-z5(54)	7.551	0.065	7.458	0.439	5.9	*1.2*
PG-z6(32)	7.471	0.036	7.449	0.941	12.6	*6.1*
Horse Quarry Ash						
HQ-z1(108)	3.567	0.078	3.663	0.349	9.5	*2.7*

Determined CA-TIMS vs. LA-ICPMS ages for 6 of the youngest zircons



Correlation of six zircon ages with +/- 2 stand. dev. between CA-TIMS (black bars) and IC-PMS (white bars) methods

Hagerman Horse Quarry Ash Sample HAFO11-02-HHQ

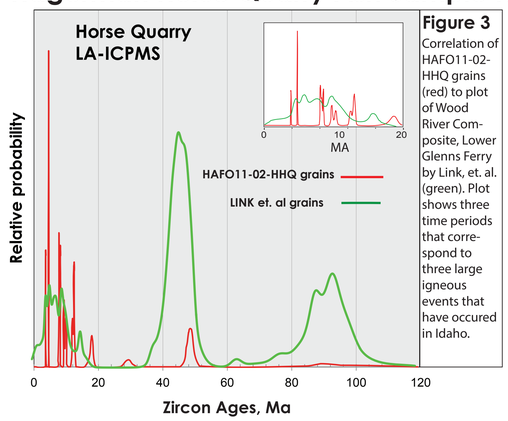
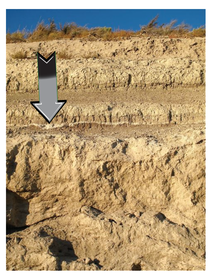
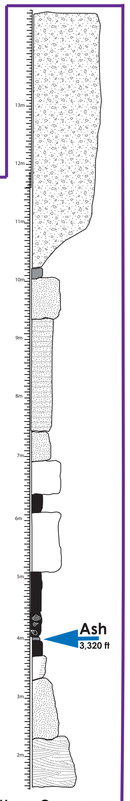


Figure 3 Correlation of HAFO11-02-HHQ grains (red) to plot of Wood River Composite, Lower Glenns Ferry by Link, et. al. (green). Plot shows three time periods that correspond to three large igneous events that have occured in Idaho.



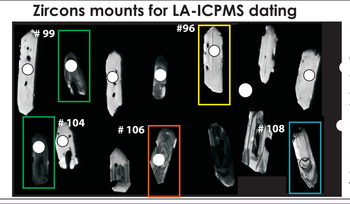
Horse Quarry marker ash bed is roughly 0-7 cm thick.



Zircons mounts for LA-ICPMS dating

Idaho Batholith
#104 -- 89.5 Ma +/- 2.8 Ma
99 -- 96.6 Ma +/- 4.4 Ma
Challis Volcanics
#106 -- 49.1 Ma +/- 2.4 Ma
Yellowstone Hotspot
96 -- 9.9 Ma +/- 1.6 Ma

Selected for TIMS
108 -- 3.6 Ma +/- .078 Ma

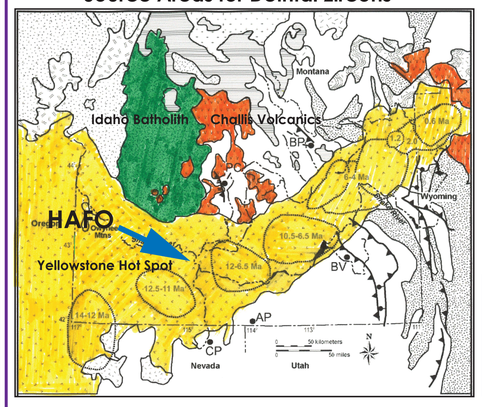


Horse Quarry grains (left) used for initial LA-ICPMS dating . Horse Quarry grains are more rounded in comparison to Peters Gulch, probably due to a greater amount of transport. Grains listed on the far left represent examples of date ranges in the sample and the three possible source areas of the zircons, including zircons selected for TIMS dating.

We would like to thank Phil Gensler, Vicki Meyers, Bob Lorkowski, Jim Crowley Debbie Pierce, and Paul Olin for their help during various stages of this study.

Figure 4 illustrates three detrital zircon source areas for dated zircon grains from both ash samples. These igneous events correlate to the zircon probability graphs (Figures 2 and 3) that show zircons grouping into three distinct time periods. The graphs of both samples show a relatively large prevalence of detrital zircons dated ~ 4 to 17 Ma, the period of the Yellowstone Hot Spot.

Source Areas for Detrital Zircons



The Challis Volcanics that occured north of HAFO at ~ 55 to 42 Ma contributed another prevalence of zircon grains. The Idaho Batholith contributed most of the older detrital zircons (80-110 Ma)

Figure 4, Link et. al., 2005

- Miocene to Holocene (17 to 0 Ma) Yellowstone-Snake River Plain rhyolite and basalt
- Eocene (60 to 42 Ma) Challis Volcanic Group
- Cretaceous (110 to 70 Ma) Atlanta Lobe of the Idaho Batholith

Results & Conclusions

1. STratigraphic and sedimentological observations illustrate that the two ash layers studied (HHQ and Peters Gulch) were deposited onto fluvial and floodplain overbank deposits, where reworking introduced signifcant quantities of holoclastic detritus.

2. The depositional age of the two marker ash beds remains elusive because of detrital zircon contamination of the volcanic crystal population during post-depositional reworking in the fluvial, floodplain environment.

3. Based upon a CA-TIMS date of the youngest zircon in the sample, the maximum depositional age for the Peters Gulch volcanic ash marker bed is ≤ 3.730 ± 0.035 Ma. This estimate is consistent with an earlier fission track age of 3.75 ± 0.36 Ma (Izett, 1981), but conflicts with a 3.79 ± 0.02 Ma $^{40}Ar/^{39}Ar$ age for a basaltic tephra 100 feet above the Peters Gulch ash (Hart and Bruesecke, 1999), perhaps due to excess Ar in the basaltic glass.

4. The CA-TIMS date of the youngest zircon in the sample constrains the maximum depositional age for the upper Horse Quarry volcanic ash marker bed at ≤ 3.567 ± 0.078 Ma, which is consistent with earlier estimates on the basis of underlying silicic tuffs and basalt flows (Evernden et al., 1964; Hart and Bruesecke, 1999).

5. Sources of detrital grains in the two samples include the Atlanta Lobe of the Idaho Batholith, the Challis Volcanics, and Yellowstone Hot Spot volcanic centers.

References

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