Continuation/Research Progression Projects Form (7)

Required for projects that are a continuation/progression in the same field of study as a previous project.
This form must be accompanied by the previous year's abstract and Research Plan/Project Summary.

Student's Name(s) Ethan Sontarp

To be completed by Student Researcher: List all components of the current project that make it new and different from previous research. The information must be on the form; use an additional form for previous year and earlier projects.

Components	Current Research Project	Previous Research Project: Year: 2019
1. Title	Modeling Uranium Uptake in Fossilized Teeth and Bones: Insight into Potential for Long-Term Uranium Waste Storage in Phosphates	U-Pb Geochronology of Fluid Flow Events in the Barstow Formation, California
2. Change in goal/ purpose/objective	Model the uptake of uranium in a porous biomaterial for application in containing nuclear waste	Date fluid flow events using fossils
3. Changes in methodology	Laser Ablation mapping of various sections of fossil samples Create mathematical model and code in Matlab to calculate possible scenarios of uranium uptake and produced ages	Laser Ablation spots of specific points to collect U, Pb, and rare Earth element ratios for plotting on a Tera-Wasserburg age diagram
4. Variable studied	Uranium uptake rate Initial amount of uranium uptaken Predicted age Predicted U and Pb content	Fluid flow event age
5. Additional changes		

Attached are:

☑ Abstract and Research Plan/Project Summary, Year 2019

I hereby certify that the above information is correct and that the current year Abstract & Certification and project display board properly reflect work done only in the current year.

Ethan Sontarp	Ethan Sontarp	9/26/19
Student's Printed Name(s)	Signature	Date of Signature (mm/dd/yy)

ABSTRACT

U-Pb Geochronology of Fluid Flow Events in the Barstow Formation, California

Diagenesis is the compositional change in geologic samples such as fossils, which are often used to date significant geological events in their vicinity. Fossilized dentin from teeth can undergo diagenesis during a geologic fluid flow event due to its high porosity. By contrast, tooth enamel cannot sequester Uranium during a fluid flow event because of its low porosity, which is required in order to date a fluid flow event in a sample. The purpose of this experiment was to investigate components of fossils, namely dentin, enamel, and foot bones, for their viabilities as models for determining the age of geological events, using U-Pb geochronological dating methods. Tooth and bone samples from California's Barstow Formation were prepared, then analyzed using LA-ICPMS (Laser Ablation- Inductively Coupled Plasma Mass Spectroscopy) to determine the concentration of certain isotopes of U, Pb, and rare-earth elements (REE). Iolite software was used to process the isotope data from several locations in fossils. A preserved sample was dated at ~10 Ma for both enamel and dentin locations. An eroded sample showed results with differing ages for the enamel sections and the dentin sections, with the dentin at 10 Ma and the enamel at 4.5 Ma. The bone sample varied in its local dates of diagenesis because of an ancient fracture, with an average age of 4.5 Ma that was consistent with the enamel ages. The samples yielding 4.5 Ma and 10 Ma differed in their REE content, distinguishing between two known fluid flow events in the Barstow Formation. Going forward, these results suggest that a dentin sample may be a stronger candidate than an enamel sample for U-Pb dating of older geological events, whereas enamel locations would be more viable for dating the most recent fluid flow event.

Ethan Sontarp

U-Pb Geochronology of Fluid Flow Events from the Barstow Formation, California

Addendum:

The Research Plan was placed in ABCD Format.

The Research Plan was modified to accommodate new developments in the experiment.

A) Rationale: The Barstow Formation, located in the central Mojave Desert of Southern California, contains an abundance of well-preserved fossils. Its layers and fossils have been studied continuously to define a distinct Land Mammal Age and precise calibration points for other formations in North America. One group of fossils found in the Barstow Formation belong to the ancient horse genus *Scaphohippus*. Several teeth from this ancient horse genus were found surrounding the Robbins Quarry, which is dated at 13.6 m.y.a. ± 0.65 million years. While this provides an accurate relative age, horse tooth dentin may be useful in the geochronologic field as a model for dating geological events. Two fluid flow events have penetrated the Barstow Formation since its creation, one about 10 m.y.a. after the creation of a water basin, and one about 5 m.y.a. after the uplifting of the Sierra Nevada Mountains. Dating enamel is a proven method for dating the age of diagenesis, or when the uranium levels in the tooth were last replaced. However, because of its low porosity, often not enough uranium can be absorbed into the enamel for analysis. Dentin is composed of the same calcium phosphate mineral as enamel, yet during a mammal's life there are microtubules that run through the dentin filled with organic matter. When fossilized, this organic matter is broken down, leaving the dentin susceptible to immediate diagenesis. It was theorized based on the high uranium levels present in diagenetic dentin that it will be a useful tool for dating the fluid flow events which have occurred.

B) Research Question/Hypothesis:

Can tooth dentin be used as a model to date geological events?

If dentin is porous and resistant to uranium homogenesis, a process in which all of the original uranium in a sample is replaced, then it can be used as a reliable source for dating

geological events. Dentin could be used in areas where rocks are less viable for dating due to later homogenization and fluid flow events. The dentin will provide an age of about 10 million years old, as this is the age of the fluid flow event which first affected the teeth.

C) Procedure/Risk and Safety Analysis/Data Analysis:

U and Pb are naturally occurring in the dentin present in the tooth samples. As per 8/6/18 communication with Henry Disston, ISEF SRC Member, this project does not require any additional forms (email attached with forms).

Tooth samples will first be placed in a standard, over –the-counter epoxy with a 4:1 ratio of resin to hardener.

All samples will then be sliced into 5 mm thick sections using a Beuhler IsoMet Low Speed precision cutter, which uses a gravity-fed sample without any human intervention during the cutting. Gloves and protective eyewear will be used when mounting the sample for cutting, yet there will be no contact whatsoever with the saw as it cuts.

One side of each of the thick sections will be hand-polished using a sequence of 120, 320, 400, and 600 aluminum oxide and silicon carbide grits.

Each of the thick sections will be scanned and imaged on an Epson scanner. These images will be used to determine the structure of the layers in the teeth and bones.

Next, 160-micron diameter spots will be ablated using an Agilent 7700 Series' laser ablation and mass spectrometer system. When using this instrument, the laser is fully contained within a stainless-steel barrier and poses no risk of exposure.

The NIST-612 glass and Walnut Canyon carbonate standards will be ablated alongside the samples to provide a comparative measurement used for providing baseline elemental counts.

The data from the Agilent will be imported into the Iolite software of the Igor Pro program. Baseline measurements of geochronologically useful elemental ppm and rare earth elemental ppm counts, and the samples' elemental composition will be selected and then reduced on Geochron-4 Data Reduction Scheme (DRS).

The data points for individual samples or sections of samples will then be graphed with a U/Pb ratio on the x-axis and the ratio of the two lead daughter products on the y-axis, with a geological standard isochron curve. This standardized curve is called the Tera-Wasserburg Diagram, is used by geochronolgists to find precise ages. Where the line of best fit intersects the curve is the age of the data set. The different samples will be compared to each other for their age, and the fit of the line will determine how accurate those ages are. The sample or area of the teeth with dates which lie closest to 13.6 Ma would be the most effective for dating.

The trace element data will be reduced on the Trace Elements DRS, and the elemental counts will be normalized to calcium, multiplied by 1 x 10^6, then the individual elements will be compared to try to determine the fluid flow history of the samples.

All of the processes described in the procedure will be performed under supervision of a trained professional. The isotopes that will be handled during the experiment are naturally-occurring and therefore do not require forms, as approved by Henry Disston, an ISEF SRC Member. The laser ablation instrument is fully contained in an enclosure and there is no possible exposure to radiation, and the slow speed precision cutter is gravity-fed, not requiring any human manipulation while cutting.

D) Bibliography:

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