Science and Technology Group
Annual Report FY2015

Chirienco Mirona
Science and Technology Associate

1 Introduction

During FY2015 I continued research on paleoclimate (meaning, climate of the past) using cave stalagmites from the Midwestern USA. I focused on the time period from ca. 60,000 to 29,000 years BP (before present, meaning before A.D. 1950), known as the Marine Isotope Stage 3 (MIS3). The MIS3 holds particular significance in paleoclimate studies due to the abrupt changes and extreme oscillations in climate conditions and due to the fact that the mechanisms that triggered these events are poorly understood. One crucial factor that limits our understanding is the paucity of paleoclimate data that can be used to reconstruct the spatial distribution of large-scale atmospheric circulation patterns. In particular, very little data is available from the Midwestern USA. To provide such data, I analyzed two stalagmites from Donnehue's cave (Midwestern USA). By comparing the oxygen and carbon stable isotope data ($\delta^{18}O$ and $\delta^{13}C$, respectively) from the two stalagmites, I verified that the climate signal recorded in these stalagmites is replicable and reliable. The two isotope signals provide different information. The variation in the $\delta^{18}O$ data provides information about the variation in the rainfall in the region, which in turn is linked to the changes in the atmospheric circulation pattern. The variation in the $\delta^{13}C$ data provides information about the variation in the regional vegetation and soil productivity, which can be used to infer the effect of climate change on the local ecosystems.

During FY2015 I finished a project on using cave deposits as a tool to infer past earthquakes. A research paper based on the results was published in the Bulletin of the Seismological Society of America (published online on September 2016).

In addition to the work on caves, I conducted research on Okinawa and Ishigaki ceramic artifacts (from 17^{th}-18^{th} century).

2 Activities and Findings

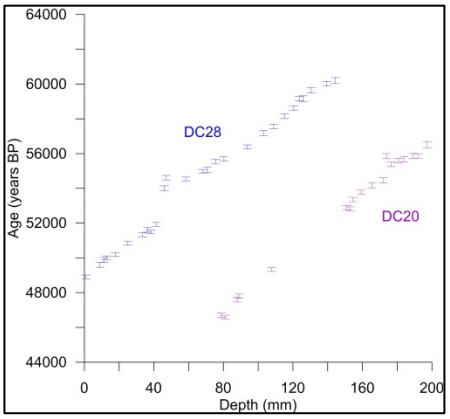
1) I analyzed two stalagmites, DC20 and DC28, from different parts of Donnehue's cave, Midwestern USA. Figure 1 shows the cross-section of cut and polished DC20. In order to accurately compare the signal recorded in the two stalagmites, I first established a detailed age model for each stalagmite. (An age model shows the ages of the different bands in a stalagmite; see Figure 2.). To obtain the ages, I sampled from different regions of the stalagmites and conducted Uranium-Thorium (U-Th) analyses on these samples. (I performed the U-Th analysis at the Xi'an Jiaotong University, China). Building on the work from the previous fiscal year, I obtained finer resolution data for DC28; the ages were in good accord with my earlier results. I also obtained ages for DC20. Additionally, I obtained high-resolution data of oxygen and carbon stable isotopes ($\delta^{18}O$ and $\delta^{13}C$) for DC20 and DC28. (I performed the stable isotope analysis at University of Innsbruck, Austria). The preliminary results are encouraging and show consistent climate signals from the two stalagmites. Also, I found that DC20 continued to grow over a time period where DC28 was in hiatus, thereby filling in missing data for this hiatus period. Further work on these stalagmites could help constrain the variation in rainfall in Midwestern USA and help elucidate the mechanisms responsible for the abrupt changes and extreme oscillations in climate conditions.

Science and Technology Group
Annual Report FY2015

Chirienco Mirona
Science and Technology Associate

Figure 1. Stalagmite DC20 after sampling for stable isotopes and U-Th (length: 21 cm)

Figure 2. Age versus depth models for DC20 and DC28.



2) In the project on studying past earthquakes using cave deposits, we analyzed sediments and four stalagmites from Donnehue's Cave (Midwestern USA). Three of the stalagmites displayed abrupt shifts in their growth axes and all four displayed episodes of hiatus in growth. In two of the stalagmites, there was a re-initiation in growth after two long hiatuses (ca. 94,000 years BP and ca. 160,000 years BP). From a detailed analysis of the scientific literature on local paleoclimate events and from the analysis of the cave sediments, we concluded that these stalagmites recorded evidence of earthquakes from Wabash Valley and from New Madrid seismic zones (Midwestern USA) over the past 300,000 years BP.

3) I continued the study of thin sections of ceramic artifacts from additional kiln sites on Okinawa main island (Tsuboya and Wakuta kilns) and on Ishigaki island (Fushina and Akobana kilns). Using a petrographic microscope, I analyzed the components from the thin sections. The overall aim of this project is to determine their composition, provenance, and manufacturing techniques.

3 Collaborations

Prof. Hai Cheng, Xi'an Jiaotong University, China.
Mr. Samuel Panno, Illinois State Geological Survey, USA.
Prof. Christoph Spötl, University of Innsbruck, Austria.

4 Publications and other output

Panno S.V., Chirienco M.I., Bauer R.A., Lundstrom C.C.L., Zhang Z., Hackley K.C.: *Possible earthquakes recorded in stalagmites from a cave in south-central Indiana*. Bulletin of the Seismological Society of America, Vol. 106, No.5, (2016)

Chirienco M.I., Li X., Spötl C., Cheng H., Panno S.V., Lundstrom C.C.L.: *Preliminary stable isotope results and interpretations of a MIS3 stalagmite from Midwestern USA*. Poster presentation, Summer School on Speleothem Science, Oxford, U.K. (2015)