Impacts in Carbonate Target Rocks: A Paleomagnetic Study of the Weaubleau-Osceola and Alamo Breccia Impact Structures. S. A. Dulin[1], R. D. Elmore[1], and K. G. Gardner[1], [1]University of Oklahoma, School of Geology and Geophysics, 100 E. Boyd Suite 810, Norman, OK 73019 smyers@ou.edu.

Introduction: There are many terrestrial craters that are associated with ancient bolide impacts in carbonate target rocks. These craters can be either well formed (Weaubleau-Osceola crater, Missouri [1]) or inferred from surrounding sedimentary deposits (Alamo Breccia, Nevada [2]). Often times it is difficult to accurately date the impact, because the deformed strata are not stratigraphically confined, or are bounded by an unconformity. Some of the sedimentalogical processes involved in bolide impacts are also complex. Paleomagnetic study of these craters can constrain the age of impact and can also provide insight on the sedimentary processes involved during deposition of bolide related beds. A paleomagnetic model of magnetization associated with carbonate impacts can be developed, and then applied to other carbonate impacts across the globe.

The Weaubleau-Osceola impact structure is a 19-km diameter circular feature that contains deformed Devonian Burlington-Keokuk limestones and a fall-back breccia. The age of the structure is stratigraphically constrained between deposition of the deformed Osagean limestones and the overlying undeformed Pennsylvanian (Desmoinesian) units. The deformed Burlington outcrops in a quarry located near the center of the impact. Outside the structure there are numerous outcrops of undeformed Burlington-Keokuk. WE sampled deformed rocks inside the crater and undeformed rocks outside the crater to test if a magnetization is localized in the crater. Geochemical and petrographic analysis was also undertaken to help discern the origin(s) of the magnetization, and link the impact to the remagnetized rocks.

The Alamo Breccia is a carbonate mega breccia located in southern Nevada that is commonly about 50m thick and covers an area of 10,000 km^2. Features such as shocked quartz and carbonate spherules have led to the conclusion that the Alamo Breccia was deposited during an impact event on the shallow carbonate platform during the Late Devonian [2]. The breccia consists of a graded bed that is interpreted as a tsunami deposit which formed after the impact. Sampling of the breccia will provide a test to determine if the unit contains a magnetization that coincides with the age of the deposit. If the results are positive, then the model can be applied to other tsunami deposits associated with impacts.

Methods: Eight sites (6-7 samples per site) in the undeformed Burlington-Keokuk Limestone were sampled along SH 13, approximately 3 miles north of Springfield, MO, west on SH 82, and south along SH 39. A reddish fine-grained Fall-Back Breccia was also sampled along SH 13, just south of the quarry inside the structure. Sites in the deformed Burlington-Keokuk were taken from the Ash Grove Aggregate Quarry which lies in the north-central section of the structure. A preliminary sample set was collected from the Alamo Breccia in the Pahranagat Range.

All samples were collected using a gasoline-powered portable drill and were oriented using an inclinometer and Brunton compass. Standard core samples were subjected to stepwise alternating field (AF) and thermal demagnetization using a 2G cryogenic magnetometer with DC squids.

Results: Stepwise thermal and alternating field demagnetization of tilted limestone samples in the Weaubleau-Osceola structure reveals a characteristic remanent magnetization (ChRM) with southeasterly declinations and shallow to moderate positive inclinations that has median destructive field of 20-30 mT, and maximum unblocking temperatures of 450°C. The ChRM resides in magnetite, is post folding, and the pole falls near the 309-365 Ma mean pole on the apparent polar wander path. The fall-back breccia samples are dominated by a Modern component residing in hematite. Most of the samples from outside the structure contain a Modern component residing in magnetite, although some contain a poorly defined component with southerly declinations.

The post-deformational ChRM is not a shock magnetization and is interpreted as either a chemical remanent magnetization (CRM) based on the maximum unblocking and burial temperatures, a post-depositional remanent magnetization (pDRM), or possibly a magnetization associated with acoustic fluidization. Preliminary analyses indicate that the rocks have slightly elevated $^{87}Sr/^{86}Sr$ values which might suggest a CRM related to alteration by hydrothermal fluids. Other geochemical data, however, indicate that the rocks in the quarry have the same signature as other carbonate rocks throughout Missouri. It is not clear that the alteration in the impact structure is distinctive. As a result, the evidence is not strong for a connection between the ChRM and impact-related hydrothermal activity. A pDRM is a possibility if the impact occurred in wet sediments with fluid filled pores which seem likely. Another possible explanation for the magnetization may be acoustic fluidization. As shock waves moved through the already deformed sediments, the magnetic grains may have realigned, creating the post-deformational magnetization. The paleomagnetic pole constrains the age of the impact to the Mississippian, refining the age compared to the stratigraphic constraints.

More sampling both within and outside the deformed beds of the Weaubleau-Osceola structure is needed to further constrain the age of impact, and to determine if the ChRM is localized in the structure. The large clasts in the fall back breccia also need to be sampled.

Preliminary results from the nearby Decaturville impact structure will also be presented. If the Decaturville structure is the same age as the Weaubleau-Osceola, then a serial impact, similar to Shoemaker Levy 9, on Jupiter, is a workable hypothesis.

The samples taken from the graded bed in the Pahranagat Range contain a remanent magnetization residing in magnetite whose direction lies close to the Late Devonian portion of the apparent polar wander path for North America. This magnetization is interpreted to be a detrital remanent magnetization (DRM) formed during deposition of the breccia or a pDRM formed after deposition. The pole is consistent with the age of the breccia based on the stratigraphic arguments.

More sampling is also needed of the Alamo Breccia. Its large aerial extent lends itself to numerous prospective sampling localities. With more analysis, further refinement of the pole position and of the model of magnetization associated with the impact can be developed.

Conclusion: Many ancient impacts are not well dated. Paleomagnetic analysis is one approach that can provide dates in some cases, particularly if a model is developed that relates a magnetization to the impact event. The preliminary study of the well dated Alamo Breccia suggests that we may be able to develop a model for a magnetization associated with an impact related tsunami unit that can be applied to other impact related deposits. The study of the Weaubleau-Osceola impact crater will be used to determine if the magnetization found in the preliminary study is related to the impact. If the Mississippian pole can be confirmed, it will further constrain the age of the magnetization, and therefore the impact, compared to the stratigraphic age range.

References. [1] Evans, K, C.W. Rovey II, K. Mickus, T. Plymate, and K. Thomson (2003) *Third International Conference on Large Meteorite Impacts*, *LPI*, 4111. [2] Leroux, H., Warme, J., and Doukhan, J., (1995) *Geology*, 23, 1003-1006.