ZIRCON U–Pb GEOCHRONOLOGY & TRACE ELEMENTS OF THE CHIXCULUB IMPACT STRUCTURE BASEMENT C. H. Ross[1,2], D. F. Stockli[1], C. Rasmussen[2], S.P.S. Gulick[1,2], S. J. de Graaff[3,4], Ph. Claeys[3], J. Zhao[5], L. Xiao[5,6], A. E. Pickersgill[7,8], M. Schmieder[9], D. A. Kring[9], A. Wittmann[10], J. V. Morgan[11] and the IODP 364 Science Party [1]Department of Geological Sciences, University of Texas at Austin, Austin, TX Contact: catherine.ross@utexas.edu, [2]Institute for Geophysics, University of Texas at Austin, Austin, TX [3]Analytical, Environmental and Geo-Chemistry, Vrije Universiteit Brussel, Belgium, [4]Laboratoire G-Time, Université Libre de Bruxelles, Brussels, Belgium, [5]State Key Laboratory of Geological Processes and Mineral Resources, Planetary Science Institute, School of Earth Sciences, China University of Geosciences, Wuhan, China [6]State Key Laboratory of Space Science Institute, Lunar and Planetary Science, Macau University of Science and Technology, Taipa, Macau, China [7]School of Geographical & Earth Sciences, University of Glasgow, Glasgow, U.K. [8]NERC Argon Isotope Facility, Scottish Universities Environmental Research Centre (SUERC), Glasgow, UK [9]Center for Lunar Science and Exploration, Lunar and Planetary Institute -USRA, Houston, TX [10]Eyring Materials Center, Arizona State University Tempe, AZ [11]Department of Earth Science and Engineering, Imperial College London, UK

Introduction: The most recent of Earth's five largest mass extinction events occurred 66 Ma as a ~12 km asteroid catastrophically crashed into the Yucatán Peninsula, México, producing the ~200 km-wide Chicxulub impact structure. Geochronological characterization of the Chicxulub target rock is an important step towards advancing the understanding of the ejecta signatures, duration, and temperatures of the impact-induced hydrothermal system. Atmospheric dispersion of ejecta and climate models rely on groundtruth data that are currently limited to the ejecta thickness and Ir anomalies [e.g., 1]. By constraining the ages of the Yucatán basement preserved within the Chicxulub crater, we can better understand how ejecta mixes and disperses globally as well as calculate relative volumes of Yucatán basement units of varying age that were ejected and deposited in distal K-Pg sites.

Age dating the basement is also useful for tectonic reconstructions of the Gulf of México. The paleogeographic position of pre-Mesozoic crustal blocks in México, Central America, and the Caribbean region is challenging to reconstruct because Southern México and Central America have complex tectonic histories which makes ascertaining their relationship to one another uncertain. The Yucatán block is an attractive locale to study the pre-Mesozoic paleogeography because it is suggested to lie between Gondwana and Laurentia during Pangea formation and is not notably disturbed by subsequent deformation (as is the case in Northern México). Few studies have determined basement ages in the Yucatán [2-8], but uplift of mid-crustal granitoid blocks through cratering processes that were sampled during IODP-ICDP Expedition 364 provides a unique opportunity to quantify the pre-impact tectonic evolution of the Yucatán block.

Methods: We have collected a total of 890 zircon U-Pb ages from 22 samples from the granitoid peak ring collected during Exp. 364. Before analysis, we imaged each zircon crystal to identify shock metamorphic microstructures using a JEOL6490LV SEM at University of Texas at Austin Electron Microbeam Laboratories. We performed U–Pb zircon using the UTChron Laser Ablation Inductively Coupled Plasma Mass Spectrometer (LA-ICP-MS) which allows for unpolished grains to be mounted and depth-profiled for better age domain resolution, particularly between rims and cores of crystals. Due to the zircon crystal sizes, a 25-30 μm spot size was used. Each grain was analyzed continuously to a depth of ~15-20 μm with an ablation rate ~0.5 μm/s. We completed simultaneous trace element analyses on a subset of the zircon crystals. Using the depth profiling technique during the data reduction, we split 30-second ablation analysis into one-second increments, which allows us to plot how the age changes through a single crystal. Weighted mean $^{206}Pb/^{238}U$ ages for the youngest mode (excluding inherited age components) were calculated using the TuffZirc module in Isoplot.

Results: Degree of discordance relates to the amount of shock features with shock-induced crystallographic structural changes [9]. Because the zircon grains are only fractured and do not display planar deformation features, we interpret that our ages do not reflect partial recrystallization due to shock. Concordant ages seem to reflect pre-Mesozoic tectonic processes.

Throughout the basement, the zircon grains record concordant ages from ~300 to ~350 Ma with inheritance ages of ~500–550 Ma and ~1100 Ma congruent with the hypothesis that Carboniferous arc-related magmatism intruded into Pan-African crust as the Rheic Ocean closed between Gondwana and Laurentia (Fig. 1).

The rare earth element (REE) patterns are congruent with subduction zone magmatism (Fig. 2). The spread in the light REE (LREE) may be due to impact-induced fracturing and correlate with degree of discordance [10]. The average Ce/Ce* anomaly is 8.6 and

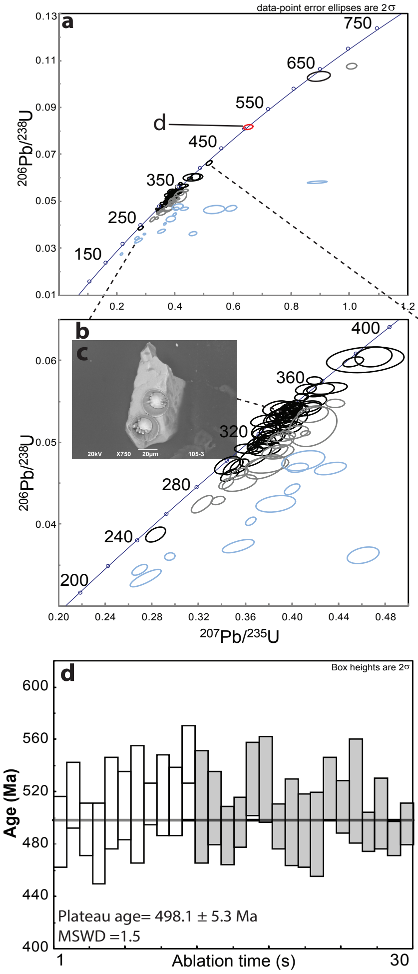

Figure 1. a. Wetherill Concordia diagram for sample at ~772 m depth. Black ellipses are <5% discordant, grey ellipses are 5–10% discordant, and light blue ellipses are >10% discordant. Red ellipse is also shown as a depth profile through grain in c. b. Wetherhill Concordia diagram showing only the Carboniferous zircon grains. c. Fractured Carboniferous zircon grain with 2 depth profile pits, one for U-Pb ages and other for trace element analysis. d. Depth profile of an inherited grain with a concordant age of 498.1± 5.3 Ma using the grey portion of the depth profile only.

Eu/Eu* is 0.8, which suggests that these grains were formed under oxidizing conditions. The three grains with elevated REE concentrations are from a sample that is <1 m away from a melt-bearing dyke with pervasive epidote mineralization suggesting that REE enrichment might correlate with the post-impact hydrothermal system (Fig. 2). The bold lines indicate inherited Pan-African grains with a significantly negative Eu/Eu* anomaly of 0.04 and no Ce anomaly, highlighting the geochemical differences between the inherited Pan-African and Carboniferous grains (Fig. 2).

Discussion: Carboniferous ages were previously observed in basement clasts within suevite from Yaxcopoil-1 and Y6 [4-6, 8], basement from IODP 364 [10], and ejecta from various North American localities and Spain [2-5, 7]. However, these ages only make up a small percentage of analyzed grains and were often attributed to Pb-loss due to shock metamorphic overprint [5]. An interesting implication of these new ages and trace element results is to re-examine K-Pg sites with the new insight that these Carboniferous ages are of tectonic origin and not due to impact-induced Pb loss.

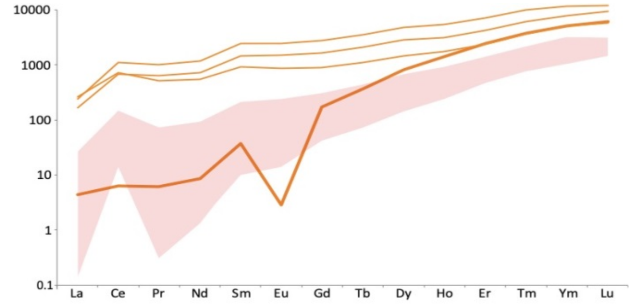

Figure 2. Chondrite normalized trace element analyses of a subset of 84 zircon crystals from 3 samples. Shaded area indicates area where 80 analyses all have similar patterns. Bold line indicates a grain with an inherited Pan-African age of 507.4 ± 5.8 Ma. Three lines elevated in all REE are from a sample 272R1 (~1237 msbf).

We suggest that the Carboniferous granitoids are related to arc magmatism that accompanied the closure of the Rheic Ocean, which eventually led to the collision of Laurentia and Gondwana. Our well-constrained zircon U–Pb ages and trace element analyses paired with SEM images of the surficial grain topology do not fully explain the discordance within the grains. Grains with <5% discordance still range from 300 to 360 Ma perhaps indicating multiple intrusion events (Fig. 1). The inherited ages suggest Gondwanan affinity in agreement with most previous work. However, few studies suggest the presence of a pre-collisional magmatic arc in the Yucatán/ Maya Block [5-6]. Our evidence of arc magmatism on the southern side of the subduction zone is influential because some reconstructions have the opposite subduction polarity [11]. There is some evidence of Carboniferous-Permian arc magmatism in Eastern México [e.g., 12], but this is the first direct evidence of Carboniferous arc magmatism within the Maya Block itself, which allows us to further constrain distal K-Pg ejecta.

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