Dr. Iain Stewart
Editor
Geoscience Communication

Dear Dr. Stewart,
Enclosed is the revised version of the article on "Built From the Crater Up – Chicxulub Science Museum, Geosciences Communication and Outreach" submitted for consideration in Geoscience Communication. We greatly appreciate the comments and suggestions from the journal referees, which have permitted to improve the presentation and discussion.

For the revision, we have modified the structure of the manuscript, focusing on the research, with the inclusion and separation of the sections and subsections in the discussion. The title was modified to better reflect the article contents. The Abstract has been modified and shortened. The Introduction has been shortened and the aims/goal of the paper included to examine the role of a museum in outreach, science communication and education. The museum aims to take advantage of the Chicxulub impact and the End-Cretaceous mass extinction, being located inside the multiring crater in Yucatan. This allows to introduce a wide range of themes on life evolution, geological processes, Earth´s systems, extinction and emergence of species, feedback mechanisms, which are interesting and challenging. The museum forms part of a research complex, which permits to expand activities to students and visitors, expanding the capabilities and its potential. The exhibits address present day concerns, for instance, climate change, sea level rise and effects of anthropogenic activity.

The discussion has been expanded to address the referee´s recommendations focusing on the museum exhibits and activities. Subsections are added on the education, outreach and science communication. The figures are improved and figures showing the museum exhibits added,

The specific comments/questions on the manuscript have been corrected and addressed. In the material for the revision, a pdf file with the modifications highlighted is included.

We thank for the comments and recommendations. We remain,
Sincerely yours,

J Urrutia Fucugauchi
L Perez-Cruz
A O. Urrutia

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Anonymous Referee #1

The manuscript addresses an important topic in science communication – science outreach via geoscience museums. The manuscript describes various activities of the museum and the research center in Yucatan, Mexico built at the place of the Chicxulub asteroid impact. The reading of the manuscript is enjoyable and easy. Meanwhile, the manuscript looks like a written piece of information about the museum and the center, and not as a research article. The paper should be revised to clarify the goal of the study/paper, research questions and methods/approaches, and results obtained.

General Comments 1. Abstract is rather descriptive and not focused on the goal of the study, main research questions, methods, and results of the study. If the research question was to understand how visitors appreciate science related to an asteroid impact and to other related topics such as extinction and emergence of species, climate change and natural hazards, then it should be mentioned in the abstract and clarified in the manuscript. 2. The paper should be more focused on the research done and results obtained rather than on the description of many details related to the museum and the research center. 3. There are a number of technical issues which should be fixed during the manuscript's revision (see below).

Specific Comments - Line 18: GeoParks are mentioned in the manuscript in a few places. Do you mean a national geoparks or UNESCO GeoParks? Pls clarify. - Line 44: Mujtaba et al., 2018 – missing reference - Line 66: Penfield and Camargo, 1981 – missing reference - Line 82: Fig. 2 appears at first after Figs. 3-7. The figure numbering should be revised. - Line 91: "coordinated by Enrique Ortiz Lanz". It should be clarify whether "Enrique Ortiz Lanz" is the name belonging to a person (then professional affiliation) or to company (then professional specialization). Otherwise, it is unclear why Enrique Ortiz Lanz is mentioned here.. - Line 135: it is mentioned that the Chicxulub asteroid impact structure is one of three large impact structures. Pls name two others. - Lines 182-183: "(Urrutia-Fucugauchi et al., 2004, 2008, 2011) (Figs. 8, 9)". It seems that the reference should be to Figs. 5 and 6. - Line 235-236: How the topics of climate change, sea level rise and space-related hazards are communicated to the public in the museum? Provide some examples or specific approached of the communication. This may help other museums in the development of science communication strategies and methods.

- Several publications are included in the Reference List but not referred in the manuscript, namely, Allen (2004), Allen and Gitwill (2004), Dahlstrom (2014), Melosh (1989), Panda and Mohanty (2010), Stevenson (1991), Urrutia-Ficigauchi and PeresCruz (2009).

Response - Thanks

Thanks very much for the review and comments on the manuscript. We agree with your recommendations on revising the manuscript to clarify the study goal, research questions, methods/approaches and results. The research aims of the center and museum are explained in additional detail. The questions addressed include how to introduce and present the science on the asteroid impact and End-Cretaceous mass extinction, how to take advantage of this geological site for attracting and engaging visitors and how visitors, including teachers and students appreciate these topics and those related to life evolution, geologic processes, climate change and hazards.

The revised manuscript has been reorganized, shortening the descriptive material to focus on the study and to incorporate the modifications and additions. The Abstract, Discussion and Conclusions are revised. The conclusions are shortened, focusing on the museum project and study, and adding comments and proposals.

We also address the specific comments, including the corrections on the Geoparks, figure numbering and checking the references in the text and reference list. We expand the discussion on the topics of climate change, sea-level rise and hazards, which are part of the exhibits in the museum.

Anonymous Referee #2

The manuscript addresses an interesting and important museum and research centre dedicated to the probably most famous known asteroid impact in the world. It also describes geological and research data, infrastructure aspects and outreach initiatives, as well as educational and tourism use. It also addresses the public support by local government. However, all this information is randomly distributed along the text, making it difficult to follow the various elements that compound the whole scenario regarding the establishment and the importance of the centre and, moreover, the importance of this kind of museum in the global context.

My suggestion is to reorganize completely the manuscript following an order that allows the reader to go through the different aspects starting from basic data regarding the place to the outreach facilities, proposals and comparisons with other places in the world. Specific comments Title – The whole paper is based on a specific place – the title should name it. Introduction – As proposed, the main aim of the paper is to use the example of that specific site museum and research centre to address the role of this kind of place in geoscience outreach. This general contextualization should come first, as well as the information about the relevance of the place. Items 2, 3 and 4 – Instead of describing these places separately, including facilities, research aspects, information on visitors, and so on, it would be better to describe them according to specific themes. So, the reader would have a complete idea of: 1) How the place is and what kind of facilities it has; 2) What kind of information it shows and its relevance; 3) What kind of public it has; 4) How is the interaction of this public. From this information, it would be easier to compare it with other exhibitions that are mentioned in the text and finally to discuss their relevance. No quantitative or, at least, semi-quantitative data are shown regarding the public interaction. It is important to address the discussion.

Discussion - The discussion is confused and the various subjects (relevance of the museum regarding mass extinction and K/Pg boundary, relevance of natural history museums, integration with other aspects such as flora and fauna, common misconceptions, among others) are all mixed with information on specific findings about impact craters and their global importance. I think the prime proposal of the paper (which is in the title) is mixed along the text and did not receive the proper attention.

Conclusions - The conclusions should not be a synthesis of the paper, but contain reflexions and proposals that come from it. Also, normally it does not contain references. For the figures: some of them are really technical (for example, fig 6 and 10) and should be a minor part of a paper addressing geoscience outreach aspects.

Technical corrections GeoPark – if this refers to an UNESCO Global Geopark, it should be written with no capital letter

Response- Thanks

Thanks very much for the review comments, which are very useful for revising the manuscript. The comments and recommendations are incorporated in the revision, including the title (“. . .-

Chicxulub Museum, Geosciences Communication and Outreach"), mentioning Chicxulub, and the abstract, introduction and the other sections.

The revision addresses how a Chicxulub science museum can offer interesting opportunities for presenting and attending outreach, education and geoscience communication. How this unique geological site can be attractive for engaging visitors and how from this, difficult topics on the nature of geologic time, life evolution, fossil record, climate change, etc., can be introduced and how visitors respond to the exhibits and related activities.

The specific comments are taken into consideration for revising the manuscript, reordering the way of presenting the museum and research facilities. We add a section providing the background and development of the project and then sections on the presentation on the facilities, exhibits, interactive activities and how visitors, including teachers, students are considered.

The reorganization allows to present a comparison with other natural history and geological museums and to discuss advantages and relevance of this museum that focuses on the last major mass extinction and the Cretaceous/Paleogene boundary. Based on your suggestions, the discussion has been restructured into three separate subsections to address the different topics, in this way, the text gives an orderly and easier reading. Thanks. This also facilitates to discuss how interesting yet difficult concepts are presented, how visitors respond and what strategies and alternatives could be considered. The information on visitors is semi-quantitative. The exhibition on the Chicxulub impact and extinction of dinosaurs" in the Grand Museum of Maya World attracted a larger number of visitors. The "Chicxulub Museum" in the Yucatan Science and Technology Park attended school groups, teachers and researchers, as well as visitors.

Results from related activities are also addressed in the revision. This includes information/results of the museum printed material/publications, interaction with teachers and schools, including two GIFT (Geosciences Information for Teachers) Workshops of the European Geosciences Union held in Merida in 2010 and 2016. The Panamerican GIFT Workshop, part of the new capacity-building program of EGU is scheduled for October 2020 to be held in the Chicxulub Museum in the Yucatan Science and Technology Park. Plans are affected by the worldwide pandemic of coronavirus (COVID-19), but the program is being reprogrammed. Other interesting activities included conferences, seminars and drawing contests for school children in primary schools. The GIFT Workshops have been organized in collaboration with the Secretaries of Education and Science, Innovation and High Education (SIIES) of the Yucatan government, Universities, Mexican Academy of Sciences and scientific societies. The Chicxulub Institute and Museum are part of the SIIES, which permits close interaction with the research and educational system.

The conclusion section has been shortened with conclusions rewritten and proposals to expand and optimize outreach, educational and science communication activities added. The Chicxulub impact and extinction of the dinosaurs and other species generate considerable interest on their own and being the museum in Yucatan - the impact site – opens interesting opportunities for outreach and geoscience communication.

Thanks for the comment on the figures. We agree and new figures are added on the museum exhibitions and facilities.

Referee #3

Review of "Built From the Crater Up-Site Museums in Geosciences Communication and Outreach" by Urrutia Fucugauchi et al.
Review by: C. Koeberl, University of Vienna, Austria

The manuscript describes a museum built in Yucatan to give information on the Chicxulub impact structure and event. As such, the text is mostly OK. However, the title of the manuscript promises something different, and more - a discussion of "site museums....". Only one site and only one museum is discussed, namely Chicxulub. Why is there not even any passing mention of, and description of, museums at various other impact sites, such as Meteor Crater (Barringer Crater) in Arizona, USA, the Ries Crater museum in Noerdlingen, Germany, the Tswaing crater museum in South Africa, the Steinheim crater museum in Germany, and several others? I think to do the topic justice, at least a short section on comparison with other international museums on similar topics should be included.

A few other short comments: I am missing any information on when the described museum opened, and where to find any visitor information. If it did not yet open (I think the opening was delayed several times, but hopefully it is open by now??) then this should be mentioned, and an opening date should be given, because otherwise, what is the reader to do with information about an inaccessible museum? (The sad story of the museum/visitor center at Vredefort in South Africa comes to mind). Chicxulub is often referred to as a "crater" but in the international impact community such large and already modified "craters" are usually called an "impact structure". Some references are in the list but not in the text and/or vice versa. Some more recent publications resulting from the ICDP-IODP drilling should be included.

Regarding the figures, I think to reproduce many old images (such as the gravity map, or photos and logos from the drilling) could be reduced somewhat, and more photos from the actual exhibitions at the museum be included.

Otherwise I think this is a useful contribution and would recommend acceptance after moderate revision.

Response - Thanks

Thanks very much for the review comments, which are very useful for revising the manuscript. The comments and recommendations are incorporated in the revision, including the title (“. . .-Chicxulub Museum, Geosciences Communication and Outreach”), mentioning Chicxulub, and the abstract, introduction and the other sections.

The revision addresses how a Chicxulub science museum offers interesting opportunities for presenting and attending outreach, education and geoscience communication. How this unique geological site can be attractive for engaging visitors and how from this, difficult topics on the nature of geologic time, life evolution, fossil record, climate change, etc., can be introduced and how visitors respond to the exhibits and related activities.

The specific comments are taken into consideration for revising the manuscript, reordering the way of presenting the museum and research facilities. We add a section providing the background and development of the project and then sections on the presentation on the facilities, exhibits, interactive activities and how visitors, including teachers, students are considered. The reorganization allows to present a comparison with other natural history and geological museums and to discuss advantages and relevance of this museum that focuses on the last major mass extinction and the Cretaceous/Paleogene boundary. Based on your suggestions, the discussion has been restructured into three separate subsections to address the different topics, in this way, the text gives an orderly and easier reading. Thanks. This also facilitates to discuss how interesting yet difficult concepts are presented, how visitors respond and what strategies and alternatives could be considered. The information on visitors is semi-quantitative. The exhibition on the Chicxulub impact and extinction of dinosaurs" in the Grand Museum of Maya World attracted a larger number of visitors. The "Chicxulub Museum" in the Yucatan Science and Technology Park attended school groups, teachers and researchers, as well as visitors.

Results from related activities are also addressed in the revision. This includes information/results of the museum printed material/publications, interaction with teachers and schools, including two GIFT (Geosciences Information for Teachers) Workshops of the European Geosciences Union held in Merida in 2010 and 2016. The Panamerican GIFT Workshop, part of the new capacity-building program of EGU is scheduled for October 2020 to be held in the Chicxulub Museum in the Yucatan Science and Technology Park. Plans are affected by the worldwide pandemic of coronavirus (COVID-19), but the program is being reprogrammed. Other interesting activities included conferences, seminars and drawing contests for school children in primary schools. The GIFT Workshops have been organized in collaboration with the Secretaries of Education and Science, Innovation and High Education (SIIES) of the Yucatan government, Universities, Mexican Academy of Sciences and scientific societies.

The Chicxulub Institute and Museum are part of the SIIES, which permits close interaction with the research and educational system. The conclusion section has been shortened with conclusions rewritten and proposals to expand and optimize outreach, educational and science communication activities added. The Chicxulub impact and extinction of the dinosaurs and other species generate considerable interest on their own and being the museum in Yucatan - the impact site – opens interesting opportunities for outreach and geoscience communication.

Thanks for the comment on the figures. We agree and new figures are added on the museum exhibitions and facilities.

Built From the Crater Up – ~~Site Museums in~~Chicxulub Science Museum, Geosciences Communication and Outreach

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Abstract

~~What is the role of site museums and geological sites in geosciences communication, education and outreach?~~ Natural history and ~~site museums contribute to~~geological museums have a rich tradition with major contributions in learning, outreach and educational programs~~, with~~. Natural parks and geological sites ~~in National Parks, GeoParks and UNESCO heritage sites attracting~~attract large numbers of visitors, ~~as well as~~ scholars and students~~.~~, offering interesting experiences. Here~~,~~ we examine the role and potential of ~~a~~the Chicxulub science museum ~~and research center in Yucatan, Mexico built around studies of~~, in relation to the Chicxulub ~~asteroid~~ impact and the Cretaceous/Paleogene boundary mass extinction. The impact ranks among the major single events shaping Earth's history, triggering global climatic change and wiping out ~76% of species. ~~The crater~~Chicxulub, with a ~200 km rim diameter, is the best preserved of the three large terrestrial multi-ring impact structures, being a natural laboratory for investigating impact dynamics, crater formation and planetary evolution. The ~~crater~~structure and impact deposits are not exposed at the surface, being covered by carbonate sediments after its formation, which presents a challenge for outreach and ~~educational programs.~~education. The ~~Chicxulub~~ museum and ~~center~~research institute have a core mission to serve as a hub for multi-~~disciplinary~~ and interdisciplinary research on the impact, planetary sciences, climate change and life evolution, as well as educational, outreach and science communication programs~~. It fulfills~~, fulfilling a recognized task for dissemination and communication of geosciences. After decades of studies,

~~the~~ Chicxulub impact ~~and mass extinction remain~~remains under intense scrutiny and the new facilities built inside the crater, play a major role in expanding those efforts.

Keywords: Chicxulub Science Museum, Chicxulub impact, End-Cretaceous Mass Extinction, Geosciences Communication, Yucatan

Introduction

Here~~,~~ we address the potential of site museums with research capabilities, ~~referring to~~focusing on a museum and research center ~~in Yucatan, Mexico~~ dedicated to the Chicxulub asteroid impact and the Cretaceous/Paleogene (K/Pg) boundary mass extinction. The impact and mass extinction ~~of organisms~~, which includes the dinosaurs, ammonites, marine and flying reptiles among many other ~~species~~organisms, provide an interesting ~~attractive contexts~~setting for education, outreach and science communication.

The Chicxulub Science Museum is integrated to the Institute for Research and Advanced Studies (CIRAS) - an inter- and multidisciplinary center equipped with research laboratories and a core repository, located in the Yucatan Science and Technology Park (PCYTY), Mexico (Figs. 1 and 2). The museum is uniquely placed to engage school children, students and visitors to the Earth´s and planetary processes and life evolution in a broad context.

Natural history and geological museums have a ~~long~~ rich tradition, ~~housing important~~with collections of rocks, minerals, fossils and animals and plants. They play an important role in non-formal education, with high learning potential for ~~school~~ students, museum-school synergies, science engagement, and teachers' professional development (Stevenson, 1991; Allen, 2004; Panda and Mohanty, 2010; Dahlstrom, 2014; Mujtaba et al., 2018). Museums with research departments allow integrating up to date science advances, ~~expanding their capabilities. Modern museums take~~taking advantage of thematic exhibits, interactive displays and virtual reality experiences~~, opening new opportunities~~ (Collins and Lee, 2006; Panda and Mohanty, 2010; Louw and Crowley, 2013). ~~Site~~

Geological museums ~~and geological sites~~ play major roles in geosciences education and outreach. Field trips to geological sites are ~~part~~important components of the educational ~~curricula~~programs and in workshops, meetings and congresses. National parks, ~~GeoParks~~Geoparks and UNESCO heritage natural sites attract large numbers of scholars and students as well as visitors. Museums of natural history, geology and mineralogy present exhibits related to life evolution, fossil record, planetary exploration, plate tectonics and meteorite impacts (MacFadden et al., 2007; Koeberl et al., 2018). Some like the Smithsonian National Museum of Natural History, the British Museum, Geological Museum of China, Museum of Natural History of Paris, Natural History Museum in Vienna and Geological Museum of Barcelona, among many others, have rich fossil, meteorite and mineralogical collections (Komorowski, 2006; Koeberl et al., 2018). Geological site and impact crater museums are less numerous and include the Ries crater Museum in Nôrdlingen, the Meteor Crater Museum in Arizona, the Tswaing Crater Museum in South Africa, the Steinheim Crater Museum in Germany and the Meteorite Museum at Rochechouart (Pôsges, 2005).

~~The Chicxulub Center for Scientific Research and Advanced Studies (CCSRAS) is a multi-disciplinary center integrating research laboratories, a core repository and a science museum (Fig. 1). The CCSRAS is located inside the Chicxulub crater in a unique position to engage school children, students and visitors to Earth´s processes and life evolution in a broad context. Comprehensive, informative educational, outreach and science communication programs are needed to face pressing challenges (Stewart and Lewis, 2017).~~ Climate change, growth of the global population, ~~demographic changes,~~ increased ~~demands~~demand of energy and mineral resources, pollution, environmental deterioration and biodiversity ~~losses~~loss present major ~~urgent~~pressing challenges to governments and society, which emphasize need for comprehensive structured educational, outreach and science communication programs (Stewart and Lewis, 2017).

Understanding Earth`s origin and evolution, geologic time, tectonic processes, rock and fossil record, life evolution and extinction presents challenges which have been considered in designing exhibits and activities in relation to ongoing research on Chicxulub impact. The link to research is strengthened being integrated to ~~society.~~a research center, though facilities are yet limited compared to large natural history and geological museums. This connection facilitates participation of researchers and students with visitors through conferences, seminars and workshops, as well as allowing visits to the laboratories. How this translates in better appreciation

and understanding and impact on science communication has been a major part of the planning. The impact and extinction of the dinosaurs provide an interesting and attractive context for educational, outreach and geosciences communication.

1. Chicxulub Impact and Mass Extinction

The Chicxulub impact is among the most important single events shaping life on Earth (Alvarez et al., 1980; Schulte et al., 2010). The impact marks the end of the Mesozoic ~~era~~Era, with the mass extinction wiping out ~76% of species including dinosaurs, ammonites, marine and flying reptiles, and the start of the Cenozoic that saw important radiations of many groups including mammals and birds. Chicxulub ~~crater,~~structure formed by an asteroid impact on the Yucatan carbonate platform in southern Gulf of Mexico (Fig. ~~3),~~3a,b) and was first identified in oil exploration surveys and drilling programs by Petroleos Mexicanos (Pemex) (Penfield and Camargo, 1981). It has a ~200 km rim diameter and a peak-ring and multi-ring morphology (Fig. ~~4~~3c,d); the structure has been investigated by an array of geophysical/geological surveys and drilling programs (Figs. ~~5, 6).~~4 and 5) (Hildebrand et al., 1991, 1998; Sharpton et al., 1992; Urrutia-Fucugauchi et al., 2011).

The K/Pg boundary is marked globally by the impact ejecta layer, characterized by the iridium and platinum group elements derived from the impacting body (Fig. ~~7~~6; Schulte et al., 2010). The impact and its effects on Earth's climate and evolution of life have been intensively studied (Alvarez et al., 1980; Mukhopadhyay et al., 2001; Schulte et al., 2010; Urrutia-Fucugauchi et al., 2008, 2011; Lowery et al., 2018). Impact had massive ~~immediate, medium~~short- and ~~longer~~long-term global effects on the climate and environment, providing important lessons for understanding the ~~effects~~impact of ~~human~~man-made greenhouse emissions. Although the mechanisms for the extinction and subsequent species diversification remain under scrutiny, studies of this mass extinction uncover general principles governing species/clade resilience and evolvability in response to rapid climate and environmental changes. ~~CCSRAS research rests on multi-disciplinary and international cooperation to tackle these issues.~~

~~1.~~2. Background and Development of Chicxulub ~~Center~~Museum

The ~~CCSRAS is~~CIRAS research and museum facilities are housed over an area of ~19 square kilometers located in the central sector of the Yucatan Science ~~City ("Parque Científico~~

Tecnológico de Yucatán" - PCYTY) in the state of Yucatan, southern Mexico (Fig.and Technology Park (Figs. 1 and 2). CCSRASThe CIRAS is a joint project between the National University of Mexico, the National Council of Science and Technology and the Ministry of Science and Higher Education of Yucatanthe Yucatan government that has developed over the course of a decade.

The project developed over the course of a decade, first emergingemerged with the aim to establishingbuild a site museum dedicated to the Chicxulub impact, its and the effects on the planet and showcase the research past and present to better understand the world around us.life evolution. The first phase of the Chicxulub Science Museum was completed in 2011 withinwith the Yucatan Science City,Chicxulub Museum housed in the second and third floors of the PCYTY Central Library (Fig. 87). The second phase was the Chicxulub exhibition in the Meteorite Hall of the Grand Museum of the Maya World ("Gran Museo de Mundo Maya") in Merida City (Fig. 8), inaugurated in December 12, 2012.

The Grand Museum Chicxulub exhibition was coordinated by Enrique Ortiz Lanz andin the Grand Museum of the Maya World has attracted large number of visitors, including students and researchers (Fig. 9).. The exhibition providedChicxulub Impact and Extinction of Dinosaurs exhibition was planned at the time of the Mayan prophesy of the end of the world and included displays on historical accounts of catastrophic prophesies at various cultures. The exhibition presented and addressed beliefs on celestial phenomena such as comets and lunar and sun eclipses, which in some societies were associated with catastrophes, diseases, warfare and social unrest. The different contrasting views were presented in the framework of the Chicxulub impact, extinction of dinosaurs and other species and end of the Mesozoic Era.

Museum visits start with a video on the Chicxulub impact and the mass extinction, followed by an introduction to comets, asteroids and meteorites, the early observations, myths and interpretations of meteorite falls and cometary showers, which that later evolved as part of the studies of the planetary system. It includedincludes exhibits of the fossil record, particularly during the Mesozoic and evolution of the dinosaurs, marine microorganisms, ammonites and flying and marine reptiles, which went extinct withat the K/Pg boundary. The Chicxulub impact. The crater studies are presented within the context of the oil exploration in southern Mexico and the geological characteristics of the Yucatan peninsula. The (Urrutia-Fucugauchi et al., 2013). Exhibits display surface geological processes, including the groundwater flow and fracturing are influenced by the

buried crater, which can be traced by the ring of cenotes and semicircular topographic depression over the crater rim. The Chicxulub exhibition was awarded the 2013 Miguel Covarrubias Prize from the National Institute of Anthropology and History. Related programs at the museum ~~have included~~include conferences, seminars and symposia, ~~with~~including the progress reports of ~~studies~~the research and drilling projects.

The PCYTY Chicxulub Museum has attracted large number of visitors. Entrance is free and records are only for the guided tours and appointed visits of school children. In a four-year period, number of visitors is around seventeen thousand, including six thousand school students and one thousand pre-school children. Number of visitors to the Chicxulub Exhibition at the Grand Museum has been much larger, due to its association to the archaeological exhibits and easy access in Merida City. The comments and reactions to the PCYTY museum exhibits and outreach activities discussed below mainly come from the student groups and teachers, with additions from groups during conferences and seminars. The PCYTY guided tours for school groups offered the advantage of engaging with the teachers, which provided valuable interactions and feedback. In connection with the museum exhibits, conference series and workshops were held with participation of students and researchers. Among them, the workshops of the drilling and marine geophysics projects and on geosciences education.

Around the initial ~~aim,~~ plan ~~for a larger facility in addition to the museum exhibits was born in 2015, which rapidly~~, research facilities expanded to ~~have~~include laboratories~~, offices~~ and the core repository ~~of material from successive drilling programs. The PCYTY~~ built in the Yucatan Science Park, which houses academic and research institutions ~~and~~, start-ups and research-oriented firms, including ~~the~~ Yucatan State University, ~~National University~~UNAM, National Council of Science and Technology research centers~~, CINVESTAV Center for Research and High Education,~~ and technology-oriented firms. CIRAS construction project took several years and the center was formally established on February 2th 2018, with the inauguration of the laboratories and core repository (Fig. 9). It has access to the National Hydrocarbon Core Repository, analytical laboratories and the apartment blocks ~~for~~to host visiting ~~scholars and students.~~ academics and students. The third phase started in 2016 with construction of the larger museum facility that started operating in the early 2019. The new museum aims to provide up to date information on the geophysical studies and drilling projects (Figs. 3, 4 and 5).

3. Chicxulub Institute and Science Museum

4.1 Science Museum

Studies on large meteorite impacts, dinosaurs, mass extinctions and life evolution attract the interest of wide audiences, opening interesting possibilities for science communication. The ~~museum~~ exhibits are organized around the studies of the Solar System, impact cratering, evolution of planetary surfaces, Chicxulub impact, crater formation, impact effects on climate and life-support systems, extinction of organisms, biotic turnover and life evolution. Exhibits aim to present, inform, engage and entertain visitors ~~on the Earth and planetary sciences~~ through studies on the Chicxulub impact, life evolution, K/Pg turnover and related inter- and multidisciplinary research~~.~~ (Figs. 10-12).

Exhibits on the Universe hall ~~introduce~~present an introduction to the origin and evolution of the Universe, formation of stars and galaxies, the Milky Way galaxy~~, planetary system formation~~ and the Solar System. The formation of planetary systems involves dynamic processes with collisions at different scales, with formation of first solids, planetesimals and large bodies. The origin and evolution of planetary systems are marked by collisions of bodies, which are the main process in the formation of planets, satellites, dwarf planets, asteroids and comets. Impact craters characterize the surfaces of solid planetary bodies and constitute the geological record of the dynamic evolution through time and space. Large-scale collisions resulted in construction and fragmentation of ~~proto-~~ planetary bodies.

The ~~impact cratering~~ hall on the Solar System and Impact Cratering presents an engaging introduction on the characteristics and evolution of planetary surfaces, impact dynamics, crater formation, impacts on time and space, comets, near-Earth asteroids and impact hazards. Hypervelocity impacts deliver high amounts of energy in short time scales; resulting in deep excavation cavities, material transport and deformation. Planetary surfaces preserve a record of impacts, with the magnitude and frequency of impacts higher in the early stages. Impact cratering is a major process in the evolution of planetary surfaces and the deep interiors. The terrestrial crater record has been erased and modified, with limited number of craters preserved in contrast to other bodies like the Moon, Mars, Venus and Mercury.

~~Exhibits~~The exhibits on Chicxulub structure introduce the crater ~~give an introduction to the ,~~ impact and impact effects. ~~Chicxulub~~It is the best preserved of the three large impact structures in the terrestrial record, being a natural laboratory for investigating impact dynamics, crater formation and planetary surface evolution in the Solar System~~. The crater is presently~~ (Urrutia-Fucugauchi and Perez-Cruz, 2009). The structure is located half on land and half offshore, with geometric center at Chicxulub Puerto on the coastline; it has a peak-ring and multi-ring morphology, which characterizes complex craters on the Moon and other Solar System bodies~~.~~ (Melosh, 1989).

~~Hall~~The hall on the End-Cretaceous extinction and life evolution ~~introduces to~~presents the effects of the meteorite impact ~~end effects~~ on the life-support systems, linking the impact processes with the mass extinction. Exhibits introduce the fossil record, geological processes, the geological time scales and concepts of deep time and life evolution. The mass extinction marks a major boundary from the Mesozoic to the Cenozoic. In the geological record the boundary is marked by the Chicxulub ejecta layer. Interactive exhibits are used to introduce species communities and diversification after the impact and macro-evolutionary trends.

~~Exhibits present~~The exhibits include challenging themes ~~such as extinction of species~~on life evolution including extinctions, emergence of species, macroevolution and global climate change (Sepkoski, 1998; Jablonski, 2006, 2008). Experiences in ~~Science Museums~~science museums and ~~Museums~~museums of ~~Natural History emphasise~~natural history emphasize roles of teachers and museum staff in interacting with visitors, particularly with school groups and students. ~~In this regard,~~The exhibits on the end Cretaceous mass extinction and the asteroid impact effects on the life support systems permit to address present day extinctions and global warming.

The ~~exhibition in the Grand~~ Museum ~~of Maya World was planned at the time of the Mayan prophesy of the end of the world and included displays on historical accounts of catastrophic prophesies at various cultures. They included beliefs on what celestial phenomena such as comets and lunar and sun eclipses were associated with catastrophes, diseases, warfare and social unrest. How they were presented in the framework of the end of the Mesozoic era and mass extinction was subject of discussion.~~

has a projection facility room, which is used to present videos and animations of the Chicxulub ~~Museum takes advantage of the research programs, laboratories and core repository, providing up~~

~~to date information on studies and drilling projects. Plan is to~~ impact; plus, an auditorium, two meeting rooms and a child playing room. Independently managed souvenir shops complement the facilities. It has also space to host temporary exhibits on ~~studies of~~the Yucatan peninsula, Gulf of Mexico-Caribbean Sea, mineral and energy resources, global climate change and biodiversity. This is also part of the collaboration programs with other institutions. The space around the museum has outdoor exhibits (dinosaurs and marine and flying reptiles) that take advantage of the vegetation with endemic plants and large-size fossiliferous carbonate rock boulders (Fig. 12). Additionally, the PCYTY Botanical Garden is next to the museum facilities, which opens join activities.

~~4 CCSRAS Research~~

~~CCSRAS has a~~

4.2 Chicxulub Institute

The CIRAS Institute core repository and six laboratories have facilities for core ~~analyses,~~ description and sample preparation, core analysis, petrography, micropaleontology, geochemistry and physical properties. Laboratories are equipped with an array of analytical instruments, including core scanners, X-ray fluorescence system, gamma-ray core logging system, magnetic susceptibility meters, electrical resistivity meter, petrographic microscopes, laser particle analyser and an electronic scanning microscope (e.g., Fig. ~~10~~9). The core repository has storage space for core samples and for conducting experiments, including low-speed ~~impacts.~~impact experimental simulations. It has facilities for slim-core logging sensors and geophysical field ~~equipment~~instruments, including ~~electrical resistivity,~~ gravity and magnetic field meters.

~~Projects~~Ongoing projects focus on studies of crater structure, dimensions, morphology, ~~ejecta~~breccia deposits, melt sheet, ~~target~~ deformation of target rocks, impact-induced hydrothermal system, pre-impact structures and post-impact processes. ~~The crater~~Chicxulub has been investigated with a wide array of geophysical methods, including gravity, magnetics, electromagnetics and seismic reflection (Hildebrand et al., 1998, Sharpton et al., 1993; Collins et al., 2008; Urrutia-Fucugauchi et al., 2011; Morgan et al., 2016).

The ~~crater~~structure and ejecta ~~deposits~~ are not exposed at the surface, making drilling an indispensable tool to sample the impact lithologies and pre- and post-impact sedimentary rocks~~.~~

(Fig. 3). Initial drilling was carried out by Pemex oil company, with intermittent core recovery providing samples of the carbonates, impact breccias and melt ~~that~~, which were key for confirming the age of the impact ~~age~~structure, corresponding to the K/Pg boundary (Hildebrand et al., 1991; Sharpton et al., 1992). Subsequent drilling programs incorporated continuous core recovery and geophysical logging (Urrutia-Fucugauchi et al., 2004, 2008~~, 2011~~) (Figs. ~~8, 9~~4, 5), with tens of thousands of core samples distributed to groups in different countries, which has allowed to expand the research on the crater and K/Pg boundary.

Impact resulted in global ~~effects on~~affectation of the climate and life support systems triggering a mass extinction in the marine and continental environments (Alvarez et al., 1980; Schulte et al., 2010; Urrutia-Fucugauchi and Perez-Cruz, 2016; Lowery et al., 2018~~).~~), Recent studies are shedding light on factors determining the likelihood of taxa becoming extinct as in the case of arboreal birds after forests disappeared (Field et al. 2018). Mass extinction coinciding with the impact ~~was~~were followed by radiations in numerous taxa including mammals (Dos Reis et al. 2012), worm lizards (Longrich et al. 2015) and birds (Field et al., 2018). Further ~~investigations~~understanding of the factors driving species extinction and radiations ~~are~~is crucial to ~~understand~~make predictions on the effects of ~~human-induced changes~~man-made climate change.

~~The CCSRAS conducts~~CIRAS carries research relevant to the communities ~~at the~~of Yucatan peninsula, which is characterized by karstic terrains~~,~~ with low ~~elevations~~elevation and smooth relief (Fig. ~~2~~3). The city of Merida, located ~30 km away from the coastline, is just a few meters above sea level. The platform is an extensive low-inclination shallow ramp, which records the sea-level fluctuations during the Late Pleistocene glaciation and the Holocene. The ~~region~~peninsula is in the trajectory of hurricanes and tropical storms, with a thin soil cover and no surface waters~~,~~ ~~being~~. It is vulnerable to coastal erosion, marine intrusion, aquifer contamination and to global warming with changes of precipitation, sea level, cloud coverage and evaporation.

The northern Yucatan peninsula is marked with sinkholes and dissolution structures and the buried ~~crater~~ structure exerts a strong influence in surface geological processes including ~~groundwater flow,~~ subsidence, fracturing, groundwater flow, coastal and karst processes. The density and distribution of karstic structures ~~are related~~relate to dissolution and in turn to fracturing, topography, rainfall and groundwater flow. The sinkhole distribution correlates with the buried ~~crater~~structure, notably with the cenote ring located over the crater rim. Surface fracturing is

related to the stress/strain state, with the regional tectonics ~~and~~, differential subsidence of the crater fractured breccias and carbonates~~, inside and~~ surrounding the crater and rheological properties of the surface formations. Coastline morphology and processes are related to the buried structure, marked by the correlation at the intersections with the ~~crater~~ gravity anomaly rings. The ~~crater is marked~~thick carbonate cover has protected the structure and ejecta deposits from erosion, adding challenges for the studies. The structure, characterized on the surface by ~~a~~ gravity and magnetic semi-circular concentric ~~pattern~~patterns (Fig. ~~4),~~3), is characterized by a gravity high and high-amplitude magnetic anomalies associated with the basement uplift, peak-ring and impactite deposits. The crater rim and terrace zone are marked on the surface by the cenote ring, fracturing and semi-circular topographic depression.

~~2.~~4.~~5~~ Discussion

The Chicxulub museum ~~has been~~is designed in a broad context~~, focusing~~ based on the Chicxulub impact and ~~crater, and also including~~relation to life evolution, impact dynamics and cratering on planetary scales. ~~As a site~~The museum~~, it joins other museums located in impact craters (e.g., Pösges, 2005).~~ opens interesting opportunities and challenges. How can the Museum develop opportunities for outreach, education and geoscience communication? How attractive is this unique geological site for engaging visitors? How, from this, difficult topics on the nature of geologic time, life evolution, fossil record, climate change can be introduced? How visitors respond to the exhibits and related activities?

The mass extinction and K/Pg boundary provide ~~interesting~~an engaging start point and the context for addressing Earth´s evolution and how life evolves linked to geological processes, climate and environment. ~~Exhibits~~The exhibits allow introducing fundamental concepts on geological time, processes, life evolution, Earth System ~~connections, feedback Earth component mechanisms~~components and interconnections and role of sudden ~~global~~ changes~~.~~ (Urrutia-Fucugauchi and Perez-Cruz, 2016).

5.1 Outreach and Education

Mujtaba et al. (2018) reviewed the learning potential of natural history museums, focusing on school students, interactions museum-~~school~~schools, science engagement~~, opportunities~~ and

teachers' professional development. Natural history museums have a rich tradition, with exhibits, interactive displays and collections of rocks, minerals, fossils and animals and plants. ~~Site museums~~Museums play also important roles in conservation and preservation of fossils, minerals and geological sites (Lipps and Granier, 2009; Boonchai et al., 2009). Natural history exhibits and interactive displays on life evolution permit presenting and understanding difficult concepts in the life and geological sciences (Baum et al., 2005; Diamond and Scotchmoor, 2006; Spiegel et al., 2012; MacDonald and Wiley, 2012). They include the theory of evolution, natural selection, speciation, extinction, concepts of deep time, intense sudden high-amplitude events versus gradual incremental changes, global versus local processes~~, extinctions, speciation~~ and macroevolution. Visitors to natural history museums are in general more familiar with evolutionary concepts~~.~~ than those who do not have the experiences. Studies on how visitors view, approach and accept/reject/ignore evolution show that museum visitors accept and are more familiar with evolution than general public (Mujtaba et al., 2018). However, large sectors of the public ~~have~~face difficulties comprehending those concepts, including students and teachers, which is also the ~~situation~~case with other topics such as climate change, sea level rise and cause of global warming.

~~Museums that take~~Related activities include conferences, seminars, drawing contests for school children in primary schools, material/publications, interaction with teachers and schools and two GIFT (Geosciences Information for Teachers) Workshops of the European Geosciences Union (EGU) held in Merida in 2010 and 2016. The GIFT Workshops have been organized in collaboration with the Secretaries of Education and SIIES, Universities, Mexican Academy of Sciences and scientific societies. The Panamerican GIFT Workshop of the EGU capacity-building program scheduled for October 2020 in the Chicxulub Museum and PCYTY has been postponed for 2021. Other activities include the publication of the Chicxulub Newsletter with four issues per year starting in 2018 and the online outreach material.

Field experiences taking advantage of ~~attractive locations, expand~~ museum location are used to enhance learning ~~experience with~~ experiences, from field observations of ~~geological outcrops~~rocks, fossils and local flora and fauna. ~~Chicxulub is located next to the~~ The close-by PCYTY Botanical Garden ~~and fossiliferous~~with marine fossil-rich outcrops ~~which are open as part of~~permits to expand the ~~museum~~ visit experience. Additional activities can include microscopic observations for petrographic and microfossil analyses~~. With the advent of~~, complementing

activities in the classrooms and museum visit. Novel avenues are being developed, using the internet, digital tools, apps and new spaces particularly for the natural and physical sciences ~~are developing~~ (e.g. Braund and Reiss, 2004, 2006). ~~Plans include field~~Field trips to K/Pg boundary sites ~~(e.g.,~~ open opportunities to appreciate the impact effects and geological record (Fig. ~~7), with nearest~~6). Nearest K/Pg boundary sites are in Campeche, Quintana Roo and ~~Belize. Exhibits of boundary sites are~~ Belice are displayed in exhibits, maps, videos and images, which are complemented ~~in videos and computer simulations, which illustrate~~by animations illustrating how ejecta was emplaced proximal to impact site and at distant locations.

5.2 Challenges and Approaches

The ~~crater~~structure and proximal ejecta deposits are not exposed at the surface, which is a challenge in comprehending the huge ~~dimensions~~size and characteristics of the structure. We found that visitors have difficulties understanding how and why dinosaurs went extinct, dynamics of asteroid impacts and crater formation, sequence of events, other species affected, what happened with the mammals, why and how some mammal species did not go extinct, how some species went extinct while others do not. The ~~crater~~Chicxulub size and relation of buried structure ~~and~~to the ring of cenotes ~~generate questions, with difficulties following~~are difficult to appreciate because of the large dimensions. Following the sequence of events~~.~~ and crater formation in a short time and with large energy release also generates questions. For instance, many visitors consider that impact formed the cenotes~~,~~ (particularly the cenote ring), though they acknowledge the crater lies deep beneath, covered by ~~young~~post-impact rocks and that the cenotes are ~~much younger~~recent surface features. The origin of ~~the crater~~Chicxulub structure also generates confusion, though there are exhibits on the impacts, craters on the Moon and other bodies, asteroids, etc., some visitors have difficulty understanding volcanic craters and volcanoes as different geological processes.

Presenting ~~and understanding~~in an engaging way concepts on geological time, evolution ~~and~~, fossil record ~~are not~~and geological processes is no easy ~~tasks~~task. Museums have developed and tested a wide range of approaches (Braund and Reiss, 2004, 2006; Allen and Gutwill, 2004; MacFadden et al., 2007; Mujtada et al., 2018). Results show mixed responses and the complex interactions, which have been discussed and evaluated in different contexts. Exhibits on dinosaurs attract more interest than displays on other groups. Widespread interest in dinosaurs comes from their large sizes and diversity, including predators like the T Rex and raptors as well as the feathered

dinosaurs. The dinosaurs were a highly successful group during the Mesozoic, occupying the ecosystems in the continental land masses including the polar regions (Sereno, 1999; Barret et al., 2009).

Mammals are also attractive, particularly those on the Late Pleistocene megafauna from the Last Glacial age or the large land and marine mammals like whales and dolphins. Exhibits on human evolution and primates are more popular than similarly well-structured exhibits on other species. Chicxulub exhibits focus on relations and evolution of the various groups particularly the dinosaurs and mammals. Dinosaurs and mammals coexisted for a long time, with the different spatial distributions, habitats, body masses and ~~life styles~~lifestyles. What happened after dinosaurs, marine and flying reptiles, ammonites and many other groups went extinct helps to appreciate macro-evolutionary traits, species interdependency, how species evolve and interact, how ecosystems develop and function and how species relate and react to environmental and climatic conditions (Jablonski, 2005, 2008; Bambach, 2006; Barrett et al., 2009).

The End-Cretaceous mass extinction is the fifth and last large extinction event recognized in the geologic record (~~Alvarez et al., 1980;~~ Emiliani et al., 1981; Bambach, 2006). Exhibits on the other major extinction events and the extinction rates for genera, families and species during the Phanerozoic in the marine and land realms allow to present macroevolution and changes through time (Sepkoski, 1998; Jablonski, 2005, 2008). Paleogeographic reconstructions document the evolving distribution of continents and oceans, with assemblage of the Pangea supercontinent and its breakup and drift apart. The changing ocean-continent distribution, ocean circulation, climate and landscapes form the backdrop for life evolution.

Impact affected the climate and environment at global scales, with a sharp sudden period of darkness and cooling caused by the fine dust ejecta in the stratosphere~~. This impact winter~~, which was followed by a global warming caused by the massive injection of carbon dioxide and other greenhouse gases (Alvarez et al., 1980; Alvarez, 1997; Schulte et al., 2010). The deposition of the fine ejecta resulted in severe changes in the sea surface water chemistry, affecting the marine organisms. The warm climates of the Cretaceous were followed by a cooling trend during the Cenozoic, with the formation of the ice polar caps and the Late Pleistocene glaciation (Zachos et al., 2008). Evolution of the different genera, families and species correlates with the long-~~-~~term climate evolution and changing paleogeographic and climate evolution during the Cenozoic.

Geo- and biological sciences scholars and students often have problems grasping details of evolutionary processes (MacFadden et al., 2007; Mujtada et al., 2018). This illustrates the challenges particularly for non-formal curricula and learning outside the classroom. ~~Highlighting~~Also highlighting importance of formal and informal comprehensive education and outreach programs, science museums and supplementary activities directed to inform and engage the public on what science is and what represents~~.~~ (Stevenson, 1991; Allen, 2004; Allen and Gutwill, 2004). What is the scientific method and what makes it unique in understanding the natural world? In recent years with the development of molecular biology, with genetics, molecular clocks and metagenomics, evolutionary studies entered ~~into~~ a new field (Chen et al., 2014). Introducing new developments and findings present opportunities and challenges. Recent discoveries provide unprecedented detail into the events before, during and after the impact and mass extinction, which allow for a narrative of events, integrating evidence in a multidisciplinary approach.

~~CCSRAS has a~~ **5.3 Outreach and Science Communication**

Museum programs integrate research ~~approach~~components, displaying ~~new results~~up to date developments and challenges, ~~with~~ reflected in the exhibits, interactive displays and virtual reality experiences (Louw and Crowley, 2013). ~~It provides an attractive forum, although its potential still needs to be further developed. In particular, we require to implement an evaluation of the programs, visitor experiences and ways to engage with teachers and students. Museums that house research and educational departments permit to keep up to date advances. Needed is a closer and better structured relationship with other actors in the science park and state education system. We require a strategic plan for science communication, with a wider scope and well defined priorities (Stewart and Nield, 2013: Stewart and Lewis, 2017).~~

~~Key aspects for science communication include global changes and effects on biodiversity and threats presented by the global warming and environmental affectations, which present severe effects on the biodiversity, with the loss of species at global scales. Displays showing examples on how studies connect to fundamental questions of life evolution can be used with reference to familiar groups of organisms. For instance, studies by Field et al. (2018) examined the extinction of birds, showing that the birds spared from extinction were land dwelling groups. This in contrast with what one will expect considering the abundance of arboreal stem birds before the impact~~

~~during the Mesozoic and that flying capacity could offer survival advantages. The study, based on examination of the fossil record and molecular phylogenies, analyzes the extinction event and the post-impact radiation of crown birds. An explanation for the selective extinction of birds relates the widespread affectation of forests as a result of the impact. Studies show the intricate interconnections and complex responses during major biotic transitions and the post-mass extinction processes.~~

~~3.1.6~~ Exhibits cover a large multidisciplinary ~~Conclusions~~

~~The CCSRAS is the first museum and research center built around the Chicxulub impact and the End-Cretaceous mass extinction, being part of a multi-disciplinary project integrating research laboratories and museum exhibits that conducts research, outreach and educational programs. The wide~~ range of ~~projects opens new inquiry lines as well as applied studies on environment and biotic conservation. The museum provides a space for learning, exploring and experimenting aimed to engage the interest of children, youngsters and adults. Science museums are important for science communication and important components of the natural sciences research enterprise; part of the discovery process and integrating and housing research laboratories enhances the capacities, making them more attractive to learn, wonder and experiment.~~

~~Science research and technological development are the driving forces for transformation of the societies. The museums of science are linked to development of modern societies and key components, fulfilling a recognized task for "effective dissemination and communication of the (geo)sciences to decision-makers and society" (Arattano et al.,~~ topics, moving from the physics of ~~2018; Stewart and Lewis, 2017; Illingworth et al., 2018).~~

~~Knowledge among the general public of the Earth System characteristics and processes, principles of species evolution and extinctions and the power of human activities to transform our planet and impact on other species is critical to address the geo-environmental hazards (Stewart and Lewis, 2017; Illingworth et al., 2018). The CCSRAS combines features of natural history museums and research facilities, with exhibits that cover from~~ hypervelocity impacts, high pressure/temperature processes and rheological properties to the delicate balance of geological processes and life evolution. The museum provides a forum for outreach, educational and science communication; although its potential needs to be further developed. In addition, it needs to address topics and matters relevant for policy making and the society. Needed is a closer and better structured

relationship with other components of the science park. Programs for visiting researchers and postgraduate students are needed to expand the lecture and seminar program focusing on science communication. In this context, a strategic program for science communication with wider scope and well-defined priorities is required (Stewart and Nield, 2013: Stewart and Lewis, 2017).

Key aspects for science communication include climate change and effects on biodiversity and global warming and environmental affectation caused by human activity. A recognized task in science communication is "effective dissemination and communication of the geosciences to decision makers and society" (Arattano et al., 2018; Stewart and Lewis, 2017; Illingworth et al., 2018). The global changes present severe effects on the biodiversity, with the loss of species that are being interpreted as the sixth mass extinction. Displays showing examples of how studies connect to life evolution can be used with reference to familiar groups of organisms, connecting the K/Pg extinction, evolution of species and present situation (e.g., Field et al., 2018). Recent developments, relating studies on the fossil record and molecular phylogenies are also displayed that show the intricate interconnections and complex responses during biotic transitions and pre- and post-extinction processes.

5. Conclusions

~~. The Yucatan peninsula, known as the cradle of the Maya civilization that reached high levels of development, offers additional advantages for the project. The CCSRAS aims to become a multi-disciplinary hub for academics and students, expanding the capabilities for research, outreach and science communication programs of the PCYTY.~~The museums of science and technology are linked to the development of modern societies, with science and technology being the driving forces for the transformation of societies. The Chicxulub complex is part of a multidisciplinary project integrating research laboratories and museum exhibits. The museum provides an attractive space for learning, exploring and experimenting aimed to engage the interest of children, youngsters and adults. Museums are key elements for science communication and engaging on the discovery process. In this context, integrating and housing research laboratories enhances the capacities, making them more inviting to learn, wonder and experiment.

With the 40th anniversary of the impact theory and discovery of Chicxulub structure, research on the impact and mass extinction has intensified. Anthropogenic activities are a major force for climate and environmental change and species extinction. Enhanced understanding of the Earth

System, processes, life evolution and extinctions and impact of human activities is critical to address the geo-environmental hazards. The CIRAS aims to provide scientific and technical information and advice to society and decision-makers and to construct a wide collaboration network.

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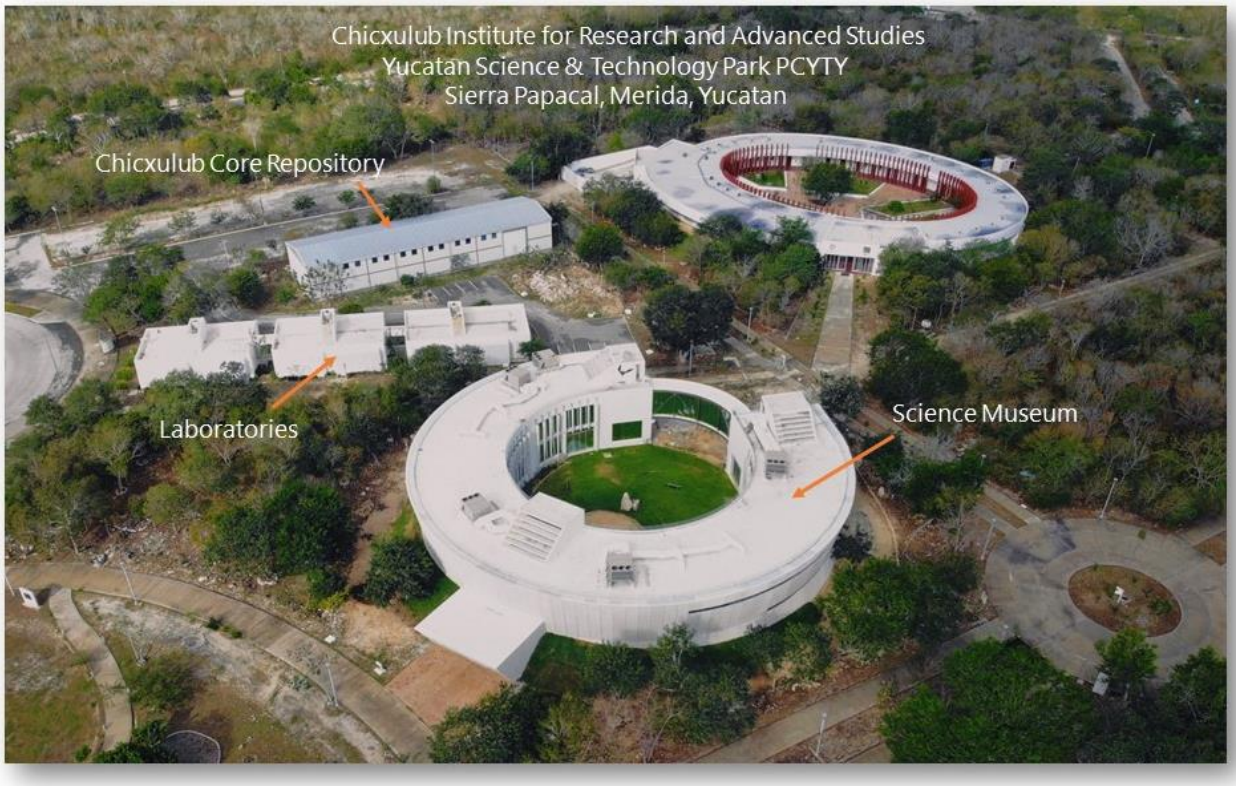
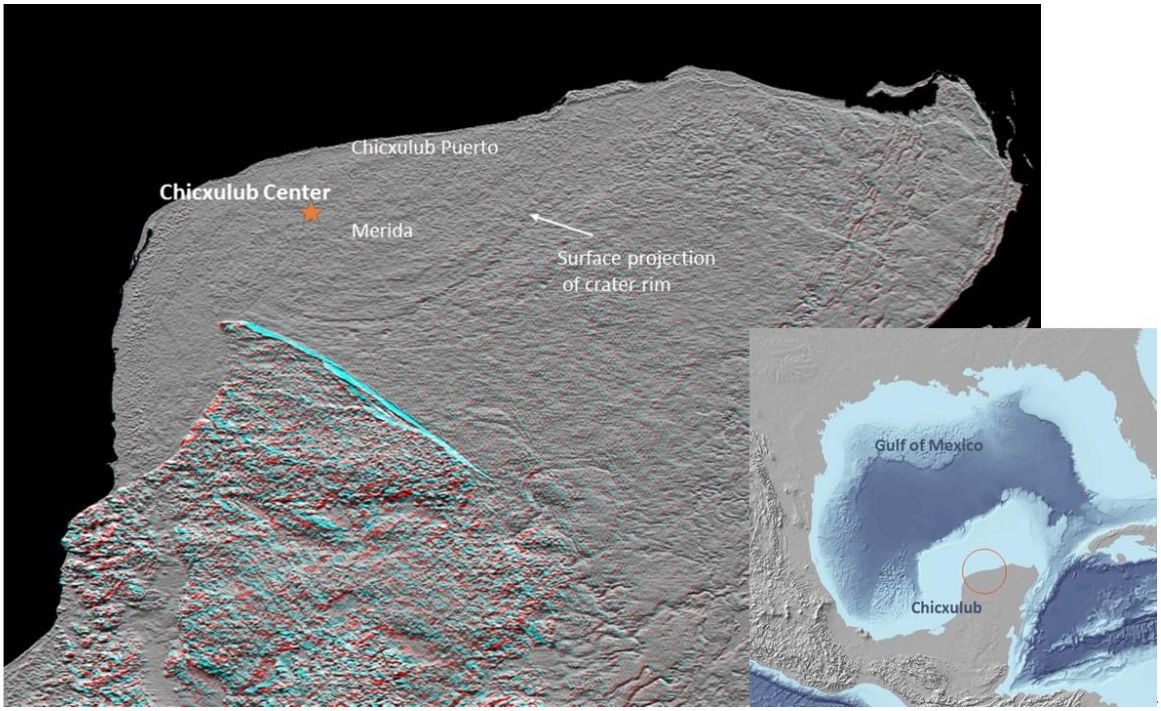

Chicxulub Institute for Research and Advanced Studies
Yucatan Science & Technology Park PCYTY
Sierra Papacal, Merida, Yucatan
Chicxulub Core Repository
Laboratories
Science Museum

Fig. 1


Parque Científico y Tecnologico de Yucatan
Sierra Papacal, Merida, Yucatan


Yucatan Science & Technology Park (PCYTY)
Sierra Papacal, Merida, Yucatan

Fig. 2


Chicxulub Puerto
Chicxulub Center
Merida
Surface projection
of crater rim
Gulf of Mexico
Chicxulub

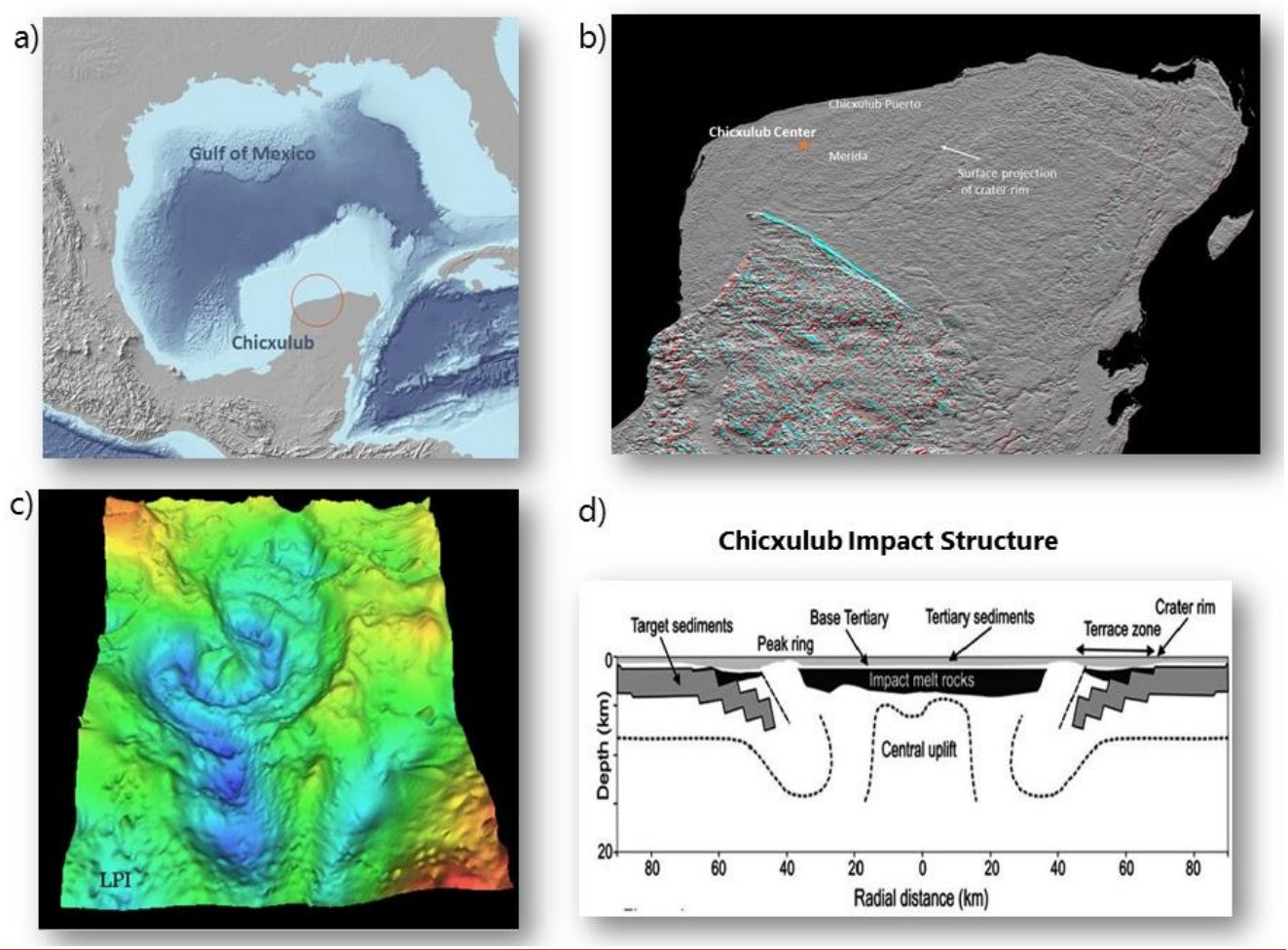
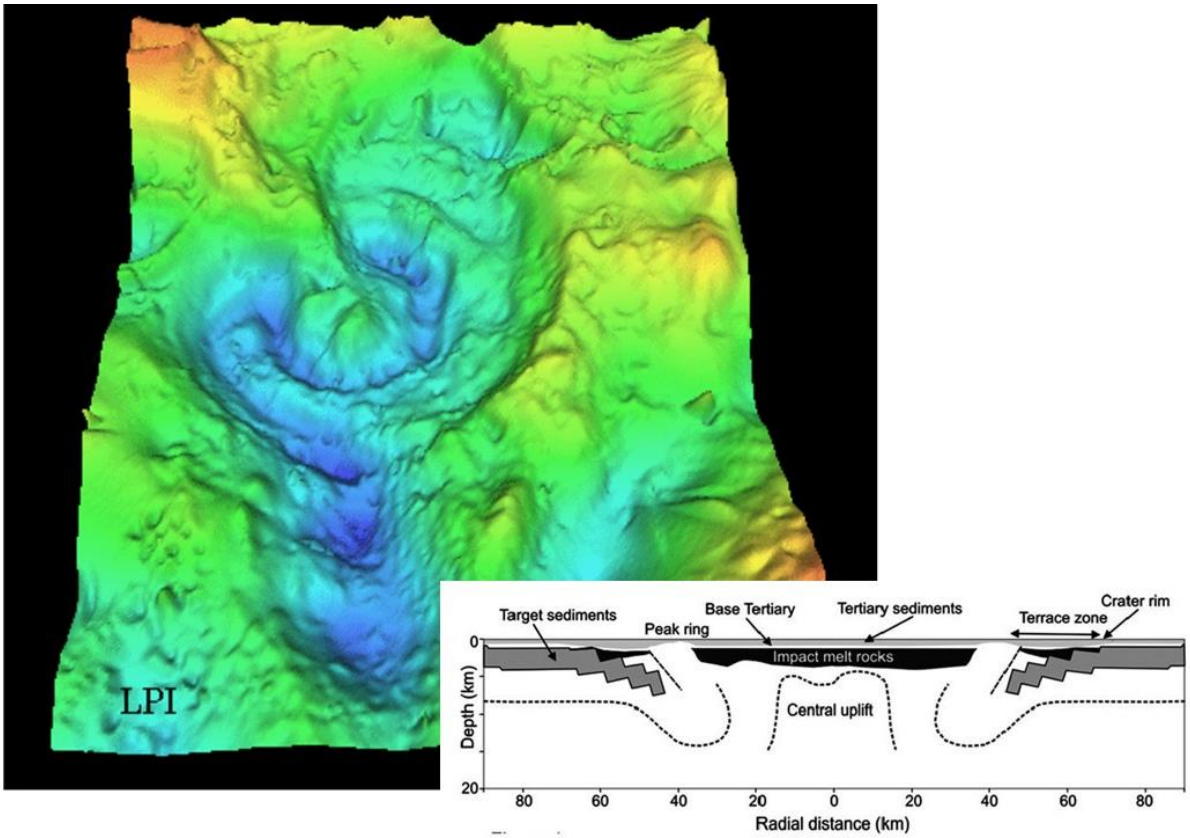

a)
Gulf of Mexico
Chicxulub
b)
Chicxulub Puerto
Chicxulub Center
Merida
Surface projection of crater rim
c)
LPI
d)
Chicxulub Impact Structure
Target sediments
Peak ring
Base Tertiary
Tertiary sediments
Terrace zone
Crater rim
Impact melt rocks
Central uplift
Depth (km)
0
20
80
60
40
20
0
20
40
60
80
Radial distance (km)

Fig. 3


LPI
Target sediments
Peak ring
Base Tertiary
Tertiary sediments
Terrace zone
Crater rim
Impact melt rocks
Central uplift
Depth (km)
0
20
80
60
40
20
0
20
40
60
80
Radial distance (km)

985

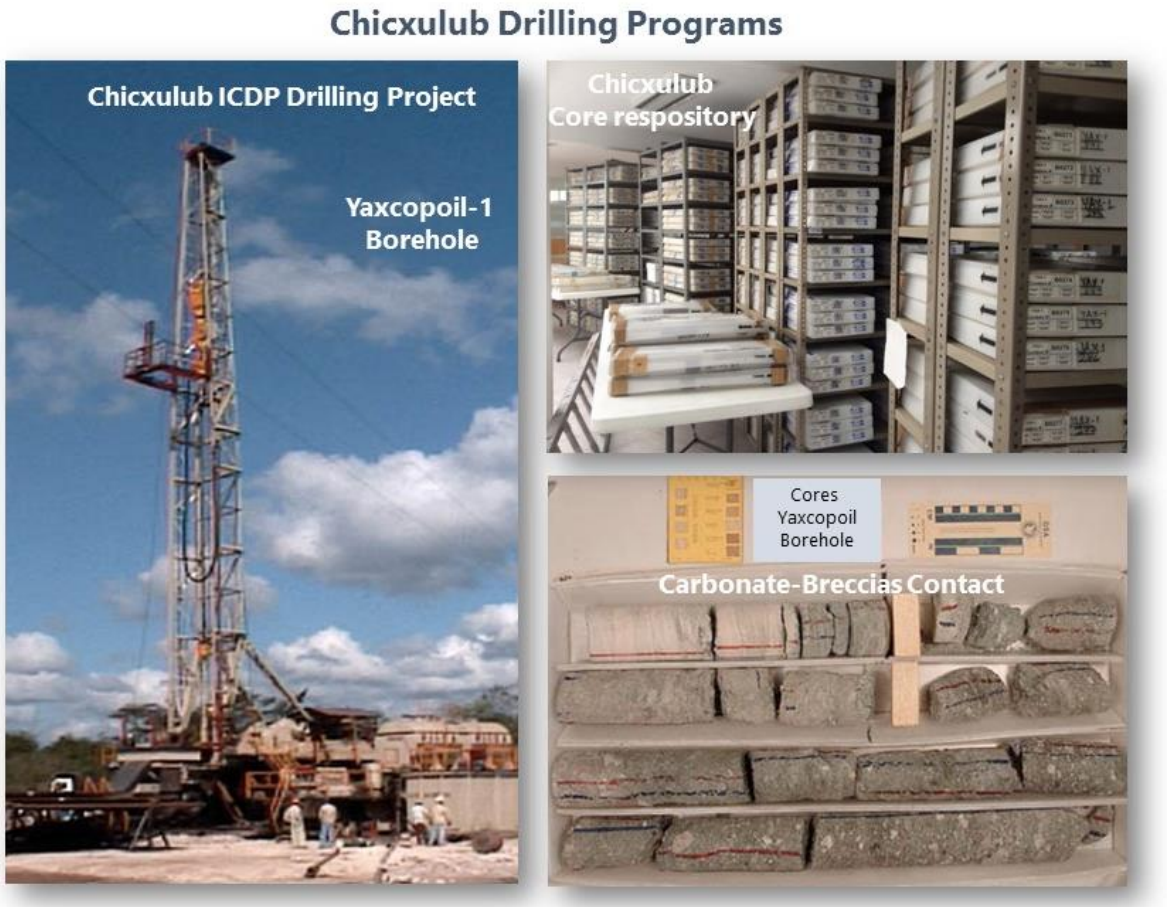

Chicxulub Drilling Programs
Chicxulub ICDP Drilling Project
Yaxcopoil-1
Borehole
Chicxulub
Core respository
Cores
Yaxcopoil
Borehole
Carbonate-Breccias Contact

Fig. 4


Chicxulub drilling programs
YAX-1
BOX 178
794.82 - 796.82
Chicxulub Marine Geophysics and Drilling Programs
IODP ICDP Chicxulub Drilling Expedition 364
R/V "Justo Sierra"
UNAM

Fig. 5


IODP
icdp
IODP EXPEDITION 364
CHICXULUB K-Pg IMPACT CRATER
JUSTO SIERRA
TUXPAN

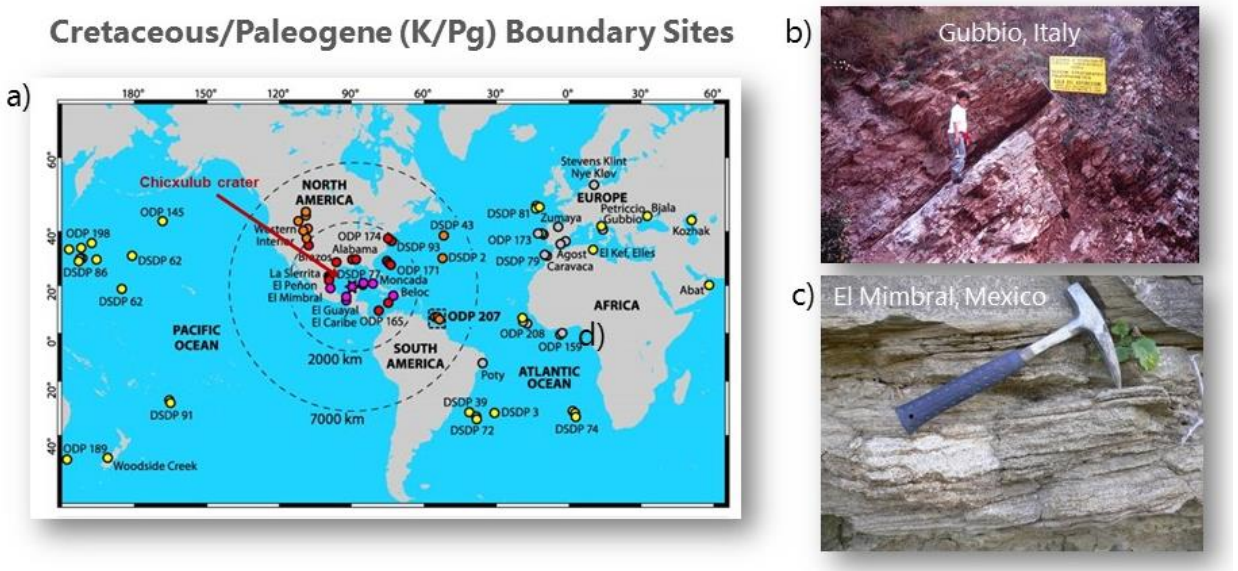
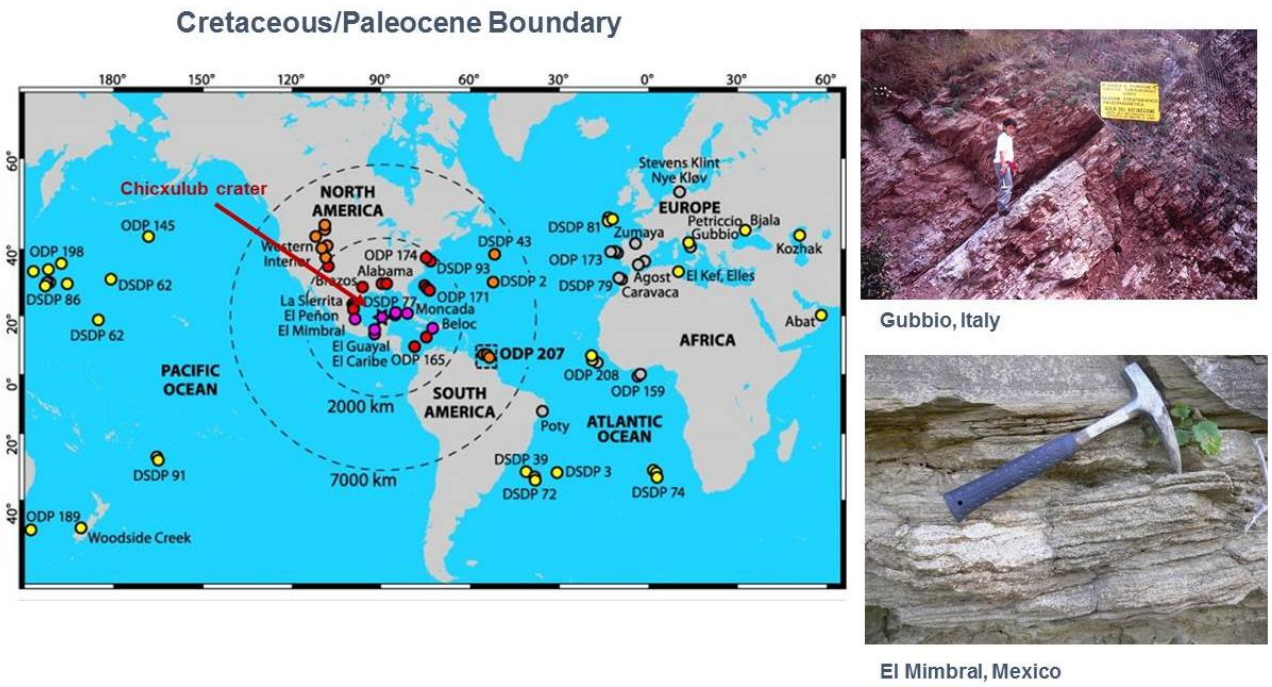
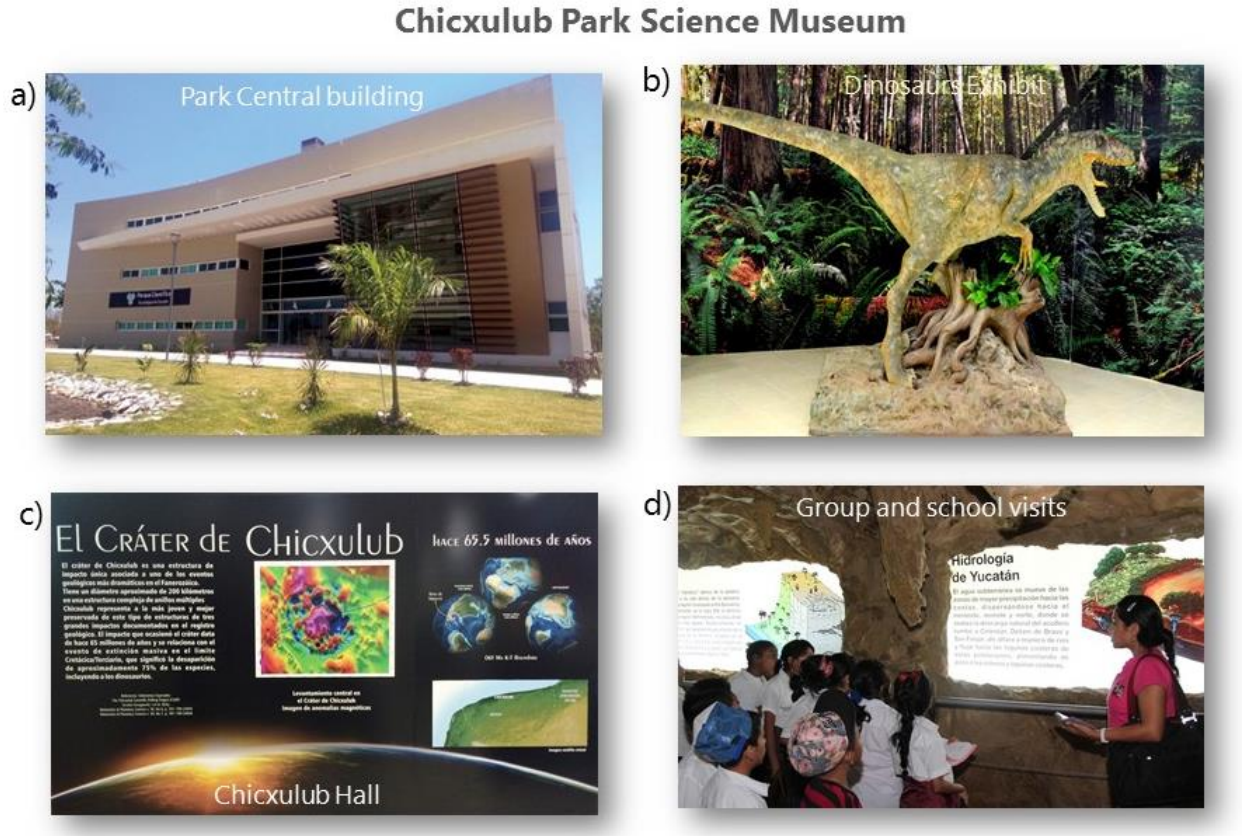

Cretaceous/Paleogene (K/Pg) Boundary Sites
a)
b)
c)
d)
Gubbio, Italy
El Mimbral, Mexico
Chicxulub crater
NORTH AMERICA
EUROPE
AFRICA
SOUTH AMERICA
PACIFIC OCEAN
ATLANTIC OCEAN
2000 km
7000 km
ODP 145
ODP 198
DSDP 62
DSDP 86
DSDP 91
ODP 189
Woodside Creek
Western Interior
Alabama
Brazos
La Sierrita
El Peñon
El Mimbral
El Guayal
El Caribe
ODP 165
ODP 174
DSDP 93
DSDP 77
ODP 171
Moncada
Beloc
DSDP 43
DSDP 2
ODP 207
ODP 208
ODP 159
Poty
DSDP 39
DSDP 72
DSDP 3
DSDP 74
DSDP 81
ODP 173
DSDP 79
Stevens Klint
Nye Klov
Zumaya
Petriccio
Bjala
Gubbio
Kozhak
Agost
Caravaca
El Kef, Elles
Abat

Fig. 6



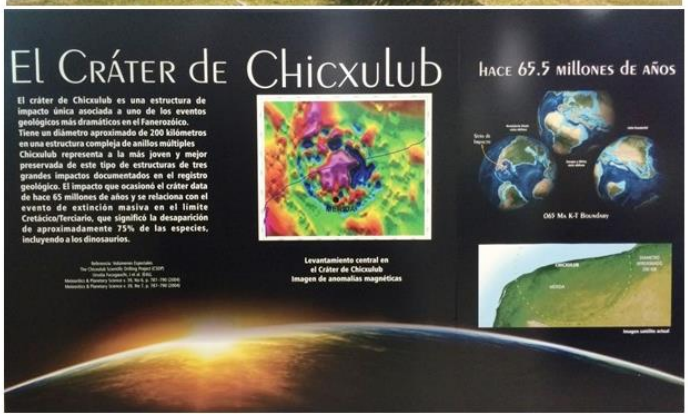
995



996

997 Fig. 7


Chicxulub Science Museum


El Cráter de Chicxulub
El cráter de Chicxulub es una estructura de impacto única asociada a uno de los eventos geológicos más dramáticos en el Fanerozoico. Tiene un diámetro aproximado de 200 kilómetros en una estructura compleja de anillos múltiples Chicxulub representa a la más joven y mejor preservada de este tipo de estructuras de tres grandes impactos documentados en el registro geológico. El impacto que ocasionó el cráter data de hace 65 millones de años y se relaciona con el evento de extinción masiva en el límite Cretácico/Terciario, que significó la desaparición de aproximadamente 75% de las especies, incluyendo a los dinosaurios.
Hace 65.5 millones de años
065 Ma. K-T Boundary
Levantamiento central en el Cráter de Chicxulub
Imagen de anomalías magnéticas


Hidrología de Yucatán

998
999


Chicxulub and the Extinction of Dinosaurs
Grand Museum of Maya World

Fig. 8


Chicxulub and the Extinction of Dinosaurs
Gran Museo de Mundo Maya

1003

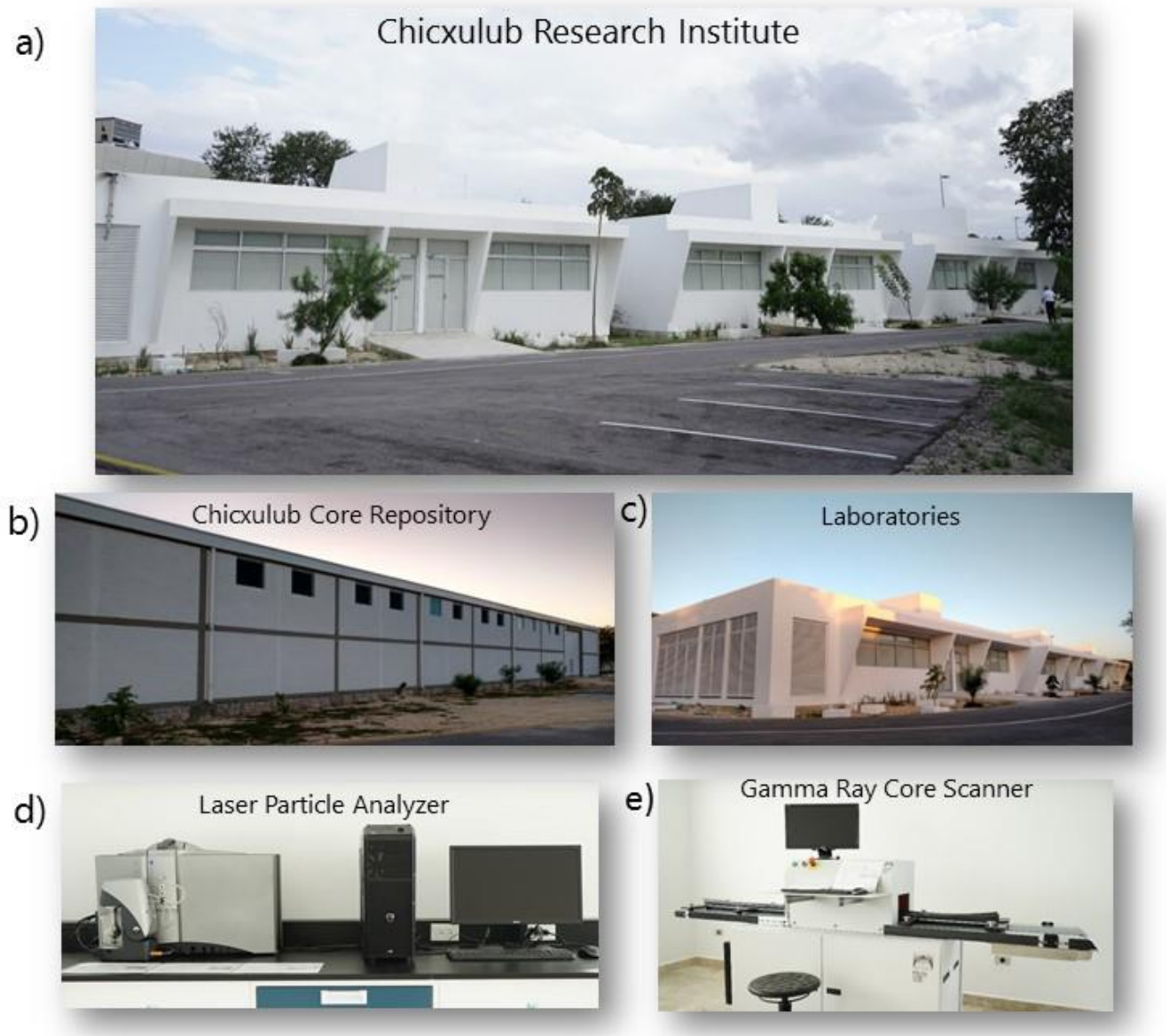

a)
Chicxulub Research Institute
b)
Chicxulub Core Repository
c)
Laboratories
d)
Laser Particle Analyzer
e)
Gamma Ray Core Scanner

Fig. 9


Chicxulub Laboratories


Gamma Ray Core Scanner


Laser Particle Analyzer

1006
1007

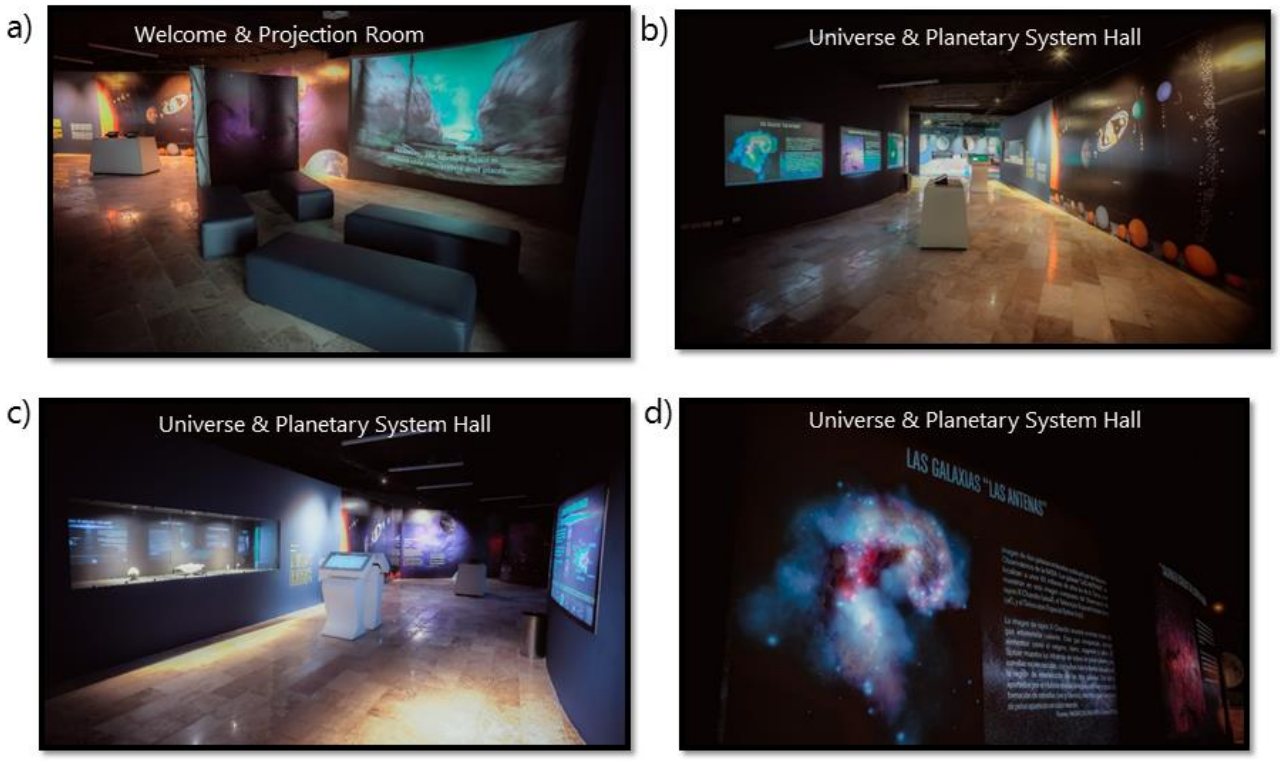

a)
Welcome & Projection Room
b)
Universe & Planetary System Hall
c)
Universe & Planetary System Hall
d)
Universe & Planetary System Hall
LAS GALAXIAS "LAS ANTENAS"

Fig. 10

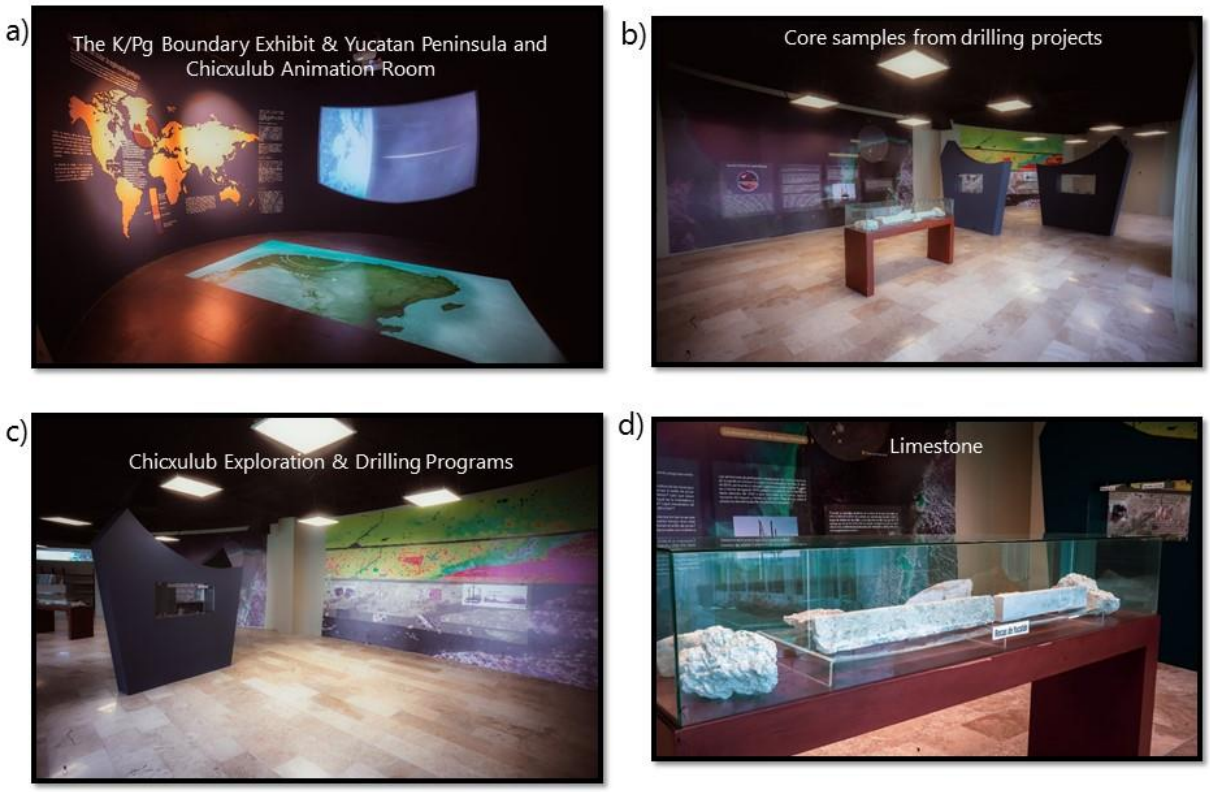

a)
The K/Pg Boundary Exhibit & Yucatan Peninsula and Chicxulub Animation Room
b)
Core samples from drilling projects
c)
Chicxulub Exploration & Drilling Programs
d)
Limestone

Fig. 11

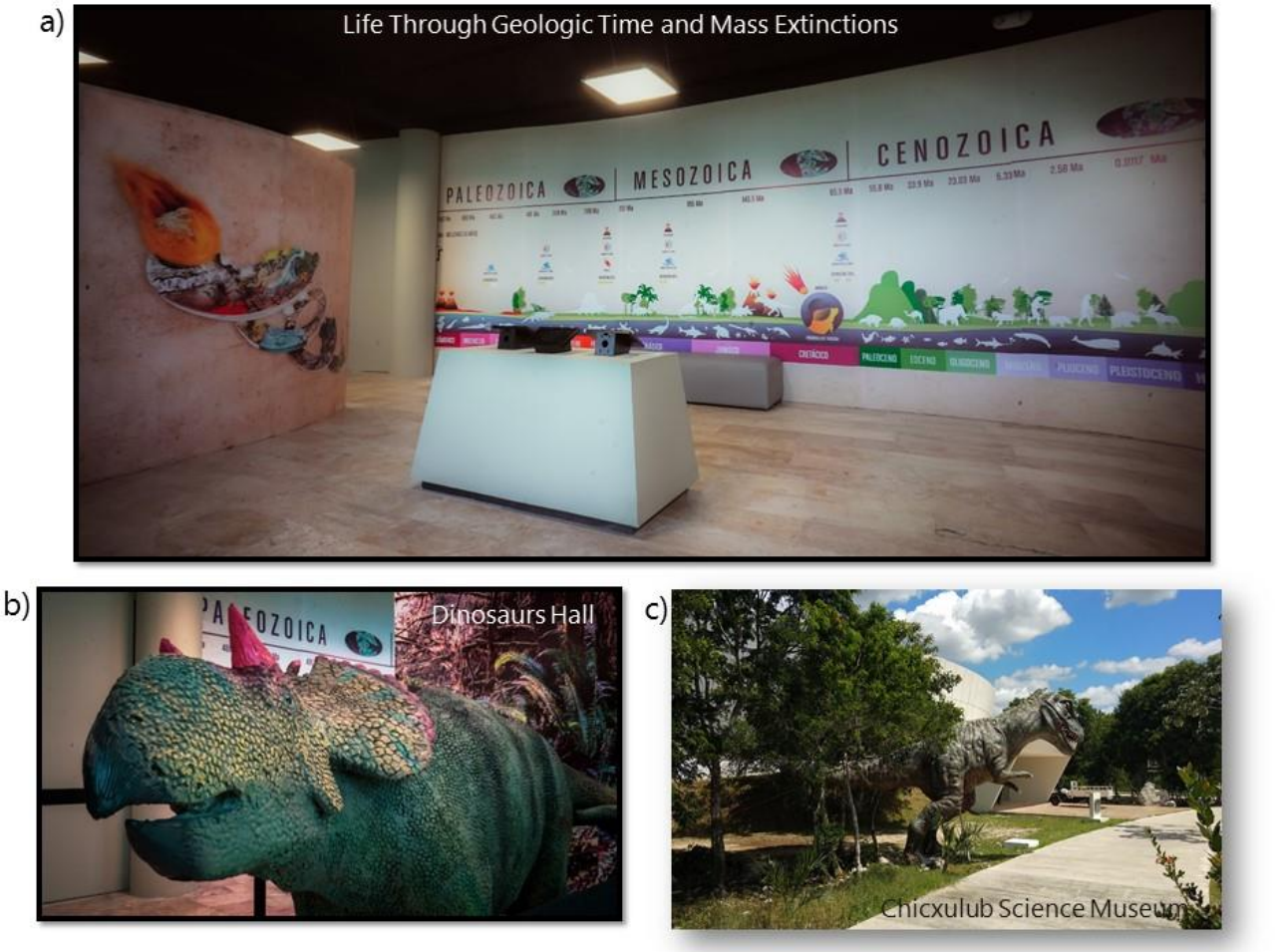

a)
Life Through Geologic Time and Mass Extinctions
PALEOZOICA
MESOZOICA
CENOZOICA
b)
Dinosaurs Hall
c)
Chicxulub Science Museum

Fig. 12