Keeping old giants at the service of a local community: The Arroyo del Vizcaíno collection (Sauce, Uruguay)

by Mariana Di Giacomo[1], Martín Batallés[2,3*], Luciano Varela[2,3], P. Sebastián Tambusso[2,3], Lucía Clavijo[2,3] and Richard A. Fariña[2,3]

*[1]Yale Peabody Museum of Natural History, New Haven, CT, USA; [2]Departamento de Paleontología, Facultad de Ciencias, Universidad de la República, Iguá 4225, 11400 Montevideo, Uruguay; [3]Servicio Académico Universitario y Centro de Estudios Paleontológicos, Universidad de la República, Santa Isabel s/n, Sauce, Departamento de Canelones, Uruguay; *elcapitangarfio@gmail.com*
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The Arroyo del Vizcaíno collection began informally in 1997, when a group of high school students, teachers and other members of the community extracted around 300 bones from the Vizcaíno stream. Efforts were made by the students to prepare, catalogue and identify the remains, as well as to try to keep the remains in their hometown. The collection was housed at the local high school for many years until we obtained the permits to excavate the site and reunited the fossils collected in 1997 with those extracted in subsequent years. Since then the collection has grown substantially, with more than 1,800 fossils collected to date. The collection was moved several times, but in 2018 a new collaboration with the local high school meant the fossils could return there, but to new spaces, specially designed and built for them. These new spaces allow for better care of the remains and for the development of outreach activities with the community. The team of palaeontologists, students and designers involved in the project has developed didactic and educational resources both in physical and digital form, which have expanded the mission of the team to other localities within Uruguay. Today, the collection has been formally recognized as part of the Universidad de la República, a milestone that will translate into further collaborations with other institutions and members of the community. These past 10 years, the team has improved the conservation of the remains, generated academic publications and established relationships with local residents, hoping to help regain the sense of belonging and enthusiasm for fossils that the community felt in 1997.

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Introduction

The Vizcaíno stream ("arroyo" in Spanish) runs near the Uruguayan town of Sauce (ˈsau̯.se), not far from the country's capital, Montevideo. There, heavy winter rains cause flooding, but the stream flow usually comes to a standstill in the summer, leaving a string of little lagoons, similar to a beaded necklace, that local farmers use to irrigate their crops. One of these pools nearly completely dried during the severe 1997 summer drought. As a result of that, a wondrous surprise appeared on its bed: numerous remains of giant mammals such as ground sloths, toxodonts, glyptodonts and other members of the megafauna, which had been waiting to be discovered for about 30 millennia. Local *liceo* (high school) students, teachers and neighbours extracted more than 300 fossils before the rains returned and filled the bed again, covering the bones (Figure 1). The students took care of the remains until professional palaeontologists confirmed their importance as the most plentiful Pleistocene mammal site in the whole country (Fariña *et al*. 2014).

The initial collection work, care and use of the fossils by the Sauce community was the beginning of the Arroyo del Vizcaíno collection, which is now a centre of palaeontological research, education and outreach. In this work, we tell the story of the collection, how it began, how it evolved and what its future may be, but most importantly, how the community shaped its course and was kept involved throughout its history.

Figure 1. First excavation made by local residents, teachers and students, 1997 (author unknown).

The surroundings

The town of Sauce ("willow tree" in Spanish) has a population of around 13,000 people and is located 35 km from downtown Montevideo. Surrounded by farms and vineyards, Sauce is rich in its history. Uruguay's national hero, José Artigas, was supposedly born there, and many battles during the Independence War and civil wars of the 19th century were fought in the area. The fossil bone bed described in this paper outcrops about 4 km northeast from Sauce.

The Vizcaíno stream is a minor course whose headwaters are close to the palaeontological site. Despite intense human modification and impact due to agricultural activities, the area remains biodiverse. Because the site is covered by water, during the fieldwork season the stream needs to be dammed and diverted into a bypass, and the remaining water must be pumped out. The site is never fully dry due to continuous contribution of water from the aquifer below, so the pumping must be done more than once a day. No ecological analyses have been performed to assess the impact of our activities, but we have been striving to reduce our impact during our short field seasons, which last around two weeks.

In the neighbouring area, the soil lies on top of Cretaceous silicified sandstones of the Mercedes Formation. Quaternary sediments tend to deposit in lower areas, such as those in which the fossils are preserved.

History of the collection

The 1997 archives

Some records remain about the events that occurred in the summer of 1997 (Figures 1 and 2). These include a VHS tape with footage of the initial collection of the remains and the consequent cleaning, identifying and cataloguing over the following months; an assortment of photographic prints, newspaper clippings, and other documents. Among them is a remarkable notebook (both a catalogue and a fieldwork book) kept by Reinaldo Castilla, one of the students that extracted the first fossils from the site (Figure 3). The first part of the notebook is a catalogue of the bones extracted that summer with a first attempt at anatomical and taxonomic identification. On the first pages, it is mentioned that some bones appear to belong to glyptodonts or the giant ground sloth *Lestodon*. The second part of the notebook is a diary that covers the period January–September 1997. The excavation days, participants and extracted bones are noted there, as well as the preparation and identification activities, the teachers that advised and the visits of the public, academics, politicians and the press. In addition, the diary contains meetings, organisation plans and museum projects, donations received, appearances in radio shows, promises from the authorities and even the arrival of a fossil dealer who offered money to take the pieces to the United States.

This notebook is a key document to understand the origins of the collection, the expectations that

Figure 2. Frames from a home VHS recording of the first excavation (A and B), the process of fossil preparation and cleaning (C and D), made by local residents, teachers and students, 1997 (author[s] unknown).

this finding generated in the town, the roles of the government, academia and civil society and the decisive role that the community had in protecting this heritage. We summarize short passages of the notebook below (names have been removed as sensitive information):

Friday 1/31/97
Afternoon: (EXTRACTION) we removed the water with a pump and made dams in the slopes, then we extracted bones. CLEANING OF THE BONES: ONLY WITH TOOTHBRUSHES AND WATER (NOT WITH A JET LIKE FROM THE TAP)

Wednesday 2/19/97
A person came to extract bones with us, he left phone number and name (…) he had palaeontological tools, he appears to be a private collector.
Wednesday night we found out that [the collector] offered thousands of dollars (…) to take the bones to the USA, and, before that, take them out himself.

Tuesday 2/25/97
[Authorities] come. One of them talks about leaving 3 or 4 bones and taking the rest.
MEETING: 19:00hs
The Commercial Centre of Sauce gives us a store location for us to use and donates U$500, they gave us the idea to form a PRO-MUSEUM OF SAUCE commission.
AFTERNOON: councilman [of Canelones] came and said he wants the museum to remain in Sauce (the bones) …
NIGHT: after the meeting until 4:30 am [we] glued bones, cleaned [bones] and put joints together.

Tuesday 3/4/97
The governor's wife came and said that they (the bones) are staying in Sauce…
AFTERNOON: [we] received the public, glued bones and went to see a [railroad] warehouse to place the museum.

Monday 3/10/97
At school the teachers made each student write a letter so that the bones could remain in Sauce (a letter to the intendente [i.e., the governor of the administrative unit or departamento of Canelones])

Tuesday 4/8/97
FARIÑA and VIZCAÍNO (the palaeontologists that gave the talk) are going to teach a course of introduction to palaeontology, POSTERS WERE MADE (…), the course is from 4/14 to 4/18." (note from the authors: the diary states that the course had to be moved from its original location on April 15th because 75 people signed up and there was no room)

Monday 8/18/97

We are told that together with R. Fariña will come a Canadian palaeontologist (he speaks English), Fariña translates, and they will give a talk on 8/21 in the Commercial Centre.

THURSDAY 8/21/97
At 16:30 came Fariña, with the Canadian palaeontologist Jerry D. IULIIS and his wife, at 20:00 the talk begins (70 people more or less) and it was awesome, then Jerry was shown the lines on the bones - "we think that this was make for humans" - "I don't know, it probably" he answered*
Then we had a meeting to start the pro-museum commission. We wrote up the minutes, and all (or almost all) the institutions of the city were represented, it was decided that the teenagers would call people to be part of the group, and that those people vote the members of the pro-museum commission, and that all the institutions of the city would support them morally and effectively
TAKE THAT!

Transcribed notebook. *Note they mean Dr. Gerry De Iuliis. The dialogue was transcribed literally, as the teenager wrote it in English on the notebook.

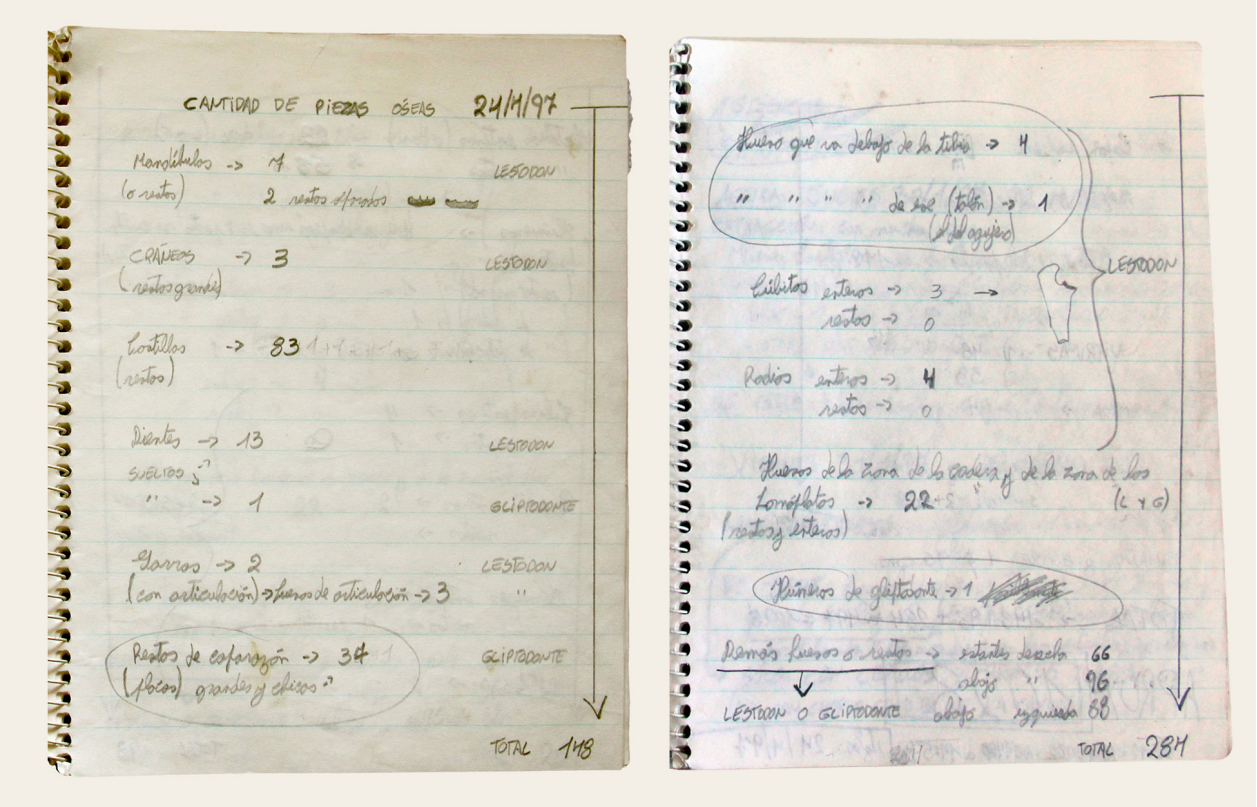

Figure 3. Pages from the first catalogue and field diary, made by students of the local high school.

Testimonials

Aside from the physical archives, oral testimonies from those involved in the finding and first excavation of the remains are key to interpreting the meaning of the collection for the community, the context in which the findings were made, and even to understand the state of preservation of some of the remains we work with. To this day, the authors and rest of the team involved continue to hear stories from that time that bring new perspectives and slowly complete the jigsaw puzzle of the history of this site and collection. Here we present a few of those testimonials from neighbours and teachers, taken from the book *Historia reciente del poblamiento remoto* ("Recent History of the Distant Past," Courtoisie and Fariña 2015; approximate translation that falls short of the local vernacular).

> "The bone thing was in a drought in 1997. We saw the lagoon come down. One day I tell Marta [his wife] that we are going to take the fish out of the lagoon. The water into the lagoon was cut off. There were very few fish, but those bones appeared. I called the neighbour. Look what fish we have here. We were amazed at all that. Night fell. We left everything as it was." (p. 30)

> "He was the one who found them. In the afternoon. He said to me: I found some bones. They were huge. Then the children came. All muddy. It was nice to see those children, they looked like ovenbirds." (p. 31)

> "The truth is that the first to find a bone and remove it was me. But I pulled it out thinking it was an ox that had died in the stream. We had an ox die there and I thought that maybe the water brought him back. I had just asked the neighbour to come so I washed the carrots. I was in the water and I found that bone I was stepping on and threw it away. I kept passing the bins. I found that bone but the one who realised it was the other [neighbour, Alberto Valetto]. After a while he told me that with that bone the animal should be this tall. He realised that it was not an ox. I did not pay any attention because at first I thought it was the house ox. I think he took the bone home and that's when everything started to wake up." (p. 36)

> "What I will always ask myself is what happened. Why so many animals there. It is a strange thing, so many different animals. All together there! And there must be much

more. Under a wicker the other day it seems that more bones had been hooked." (p. 37)

"… Someone asked for permission to dig. A guy said to me 'I can assure you that you can ask for a lot of money'. Here some Brazilian guys came 8 or 10 years ago. They were after this meteorite thing. They heard about the bones and they dived here. 'If we take out X piece, we pay you X amount.' I told them that that was of no use to me. That can't be touched down there." (p. 31)

"Bones were removed in two instances. Naldo Castilla's grandmother who had a shop in front of a shoe shop was the first destination of the bones. A group of young people gathered there to work on preservation tasks. Then the bones went to the Liceo de Sauce [the local high school]. Talks were given, the motivation was very great." (p. 32)

The birth of the collection

The finding generated excitement in the community. In addition to the excavation, conservation and preparation, some students and teachers began to organise themselves to publicise the discovery and find a permanent place to house the new collection. Professionals from the public university were contacted, meetings were generated with local and provincial authorities and the press was convened. Public talks on palaeontology were held with national and international academics who visited Sauce to learn about the findings and analyse the fossils. It was evident that this was an important discovery, and the expectations of creating a palaeontological museum in the town grew significantly, as can be attested in newspaper articles from 1997 (Anonymous 1997a-c).

For different reasons, typical of the ups and downs of the public administration and the academic world (see Courtoisie and Fariña 2016, chapters 5 and 6, and "Haunted Bones" 1997), not all of these expectations were met, in particular the creation of the museum. As a consequence, the fossils were finally stored (and almost forgotten) in the Sauce high school awaiting a destination more suited to their importance, and excavations could not be resumed until many years later.

After the hiatus: 2010–2020

Excavations and research

Fourteen years after the original discovery, and after overcoming several difficulties (Courtoisie & Fariña 2016, chapters 5 and 6) and obtaining the necessary permits, it was possible to begin with the systematic extraction of the material. In March 2011, the weather conditions were favourable. The small team of the *Laboratorio de Paleobiología, Facultad de Ciencias, Universidad de la República* [Palaeobiology Laboratory, Faculty of Sciences, University of the Republic] (referred to from now on as 'the team') finally undertook the first excavation campaign (Fariña and Di Giacomo 2014). The stream was dammed with dirt bags and the water was pumped out. The sight of the fossil-lined stream floor was the reward for so much waiting (Figure 4). Since that year, every summer (weather permitting) excavation campaigns have been carried out in which palaeontologists, geologists, archaeologists, photographers, students and volunteers participate, both from Uruguay and

Figure 4. View of the fossils* in situ *(with field grid for reference) and of the collaborative nature of the excavations, 2016 (left) and 2012 (right). Photos by Martín Batallés, left, and Gabriela Costoya, right.

abroad. Numerous new fossils have emerged from these excavations, which added to those extracted in 1997 to form the current Arroyo del Vizcaíno collection.

The collection, which still remains in the town of Sauce, houses more than 1,800 pieces and contains representatives of many of the great mammals of the South American Pleistocene. Although some species of sloths, glyptodonts and other mammals were found, over 90 percent of the fossils belong to the same species of ground sloth: *Lestodon armatus*. Together with the absence of small organisms and adding the massive accumulation of bones in that specific place, many questions have arisen about the formation of the site and the ecological relationships between these species.

A distinctive feature of the site is the high density of bones. With approximately 20 m^2 excavated, at about 100 elements per m^2, the majority of the fossils were found in very good condition. Most of them do not show signs of major transport or erosion and, although many are fragmentary, others are complete or with minimal weathering. Preservation, in many cases, is remarkable. Several fossils contain relatively high amounts of proteins, like collagen, that allow to conduct several studies, including ^{14}C dating, ^{13}C and ^{15}N isotopes analyses, and phylogenetic studies based on proteomics (Buckley *et al.* 2015). This exceptional preservation is also exemplified in relation to the presence of microfossils like pollen grains, silicophytoliths and diatoms, which, in conjunction with the macrofossils, provide a unique opportunity to study a large part of an ecosystem in a crucial moment of the Earth's history during the onset of the Last Glacial Maximum. The study of the site and the collection has enabled studies covering diverse lines of research, including morphology and biomechanics (Tambusso and Fariña 2019), ecology (Czerwonogora *et al.* 2011) and biogeography (Varela and Fariña 2016).

Many of the fossils collected show marks that could be explained due to the trampling of other animals while the fossils were near or on the surface before being buried. However, we observe other marks that, due to their characteristics, could be attributed to human-made tools. When the remains found in the site in 1997 were still in the local high school, the Spanish palaeontologist Alfonso Arribas observed that a *Lestodon* clavicle showed marks that could be interpreted as being made by human tools (Arribas *et al.* 2001). The morphological features of these marks, their association with muscle insertion areas and their orientation were analysed. However, Alfonso's trained eye had not been the first to find such interesting evidence; as early as 1997, the enthusiastic teenager collectors had identified some of those surprising marks.

After these initial findings, a rib with marks belonging to the ground sloth *Lestodon* from this deposit and the marked clavicle itself were dated using radiocarbon. The ages were much older than expected: between 28,000 and 29,000 years before present. To address the contradiction with the received knowledge that humans arrived in the Americas not before half that age, the research continued. The marks were studied in greater detail using 3D reconstructions from photomicrographs to define whether they were due to trampling or if they were the consequence of human agency. Five other dates obtained from fossils from the site, four of them on bone and one on wood, corroborate the dates previously obtained and transform the Arroyo del Vizcaíno into a site with interesting evidence of ancient human presence on the continent (Fariña *et al.* 2014). The publication of these investigations generated a debate in the local and international academic community (Courtoisie and Fariña 2016, chapter 7).

Management and preservation of the remains

The fossil remains were first stored in a room of Reinaldo Castilla's grandmother's house (Figure 5). After that they were moved to the local high school where they had several homes, from cabinets and shelves in storage rooms to filing cabinets in an

Figure 5. First collection storage room, at one of the student's grandmother's house, 1997 (author unknown).

Figure 6. Preparation (A), labelling (B) and storage (C and D) of the fossils in the second location at the Casa de la Cultura, 2012. Photos by Martín Batallés.

outbuilding. The bones were assessed a few times in those spaces by some of the palaeontologists to begin a formal catalogue, and numbers were painted on them. A few of the bones were housed in a glass vitrine in a central location of the high school, where students and teachers could see them on a daily basis.

Not long before the excavations began in 2011, the bones were moved by the team to a small room at the Casa de la Cultura, a cultural centre in the town of Sauce. This small room could fit only two palaeontologists working together on identification and cataloguing at a time, which made the initial assessment of the collection rather slow. Since this room was so small, after the first excavation the recently excavated bones were stored in the mayor's office building, until a new, larger room in the Casa de la Cultura was allocated a few months later (Figure 6). After that, the new room housed both the 1997 collection and those extracted in the subsequent excavations. This new location marked a new chapter in the collection, as the space served as laboratory, where preparation, cataloguing, digitalization and storage could be performed simultaneously by several members of the team.

In 2016, the collection was moved once again to a rented location in Sauce due to the Casa de la Cultura moving to a different building and the local authorities not being able to provide an alternative, multipurpose location as was needed for normal activities to continue. This new space had separation between the collection and laboratory spaces, making the work easier. During this time, conversations began to build a new lab and collection space in the high school lot, bringing back the collaborations between secondary and tertiary education institutions.

In 2018, the collection was moved one last time to the high school lot, to its specially built spaces (Figure 7). The new collection space has room for the collection to grow, while the lab space has the capability to serve as outreach, education and exhibit space. Increased separation between the lab and collection allows for better preservation of the remains, as dust from preparation activities does not get into the collection area, maintaining a better environment where the fossils are stored. In addition, the fossils are kept in a more stable environ-

Figure 7. Views of the new collection space, during installation of specimens, 2018. Photos by Martín Batallés (top) and Luciano Varela (bottom).

ment and the team has been working on rehousing and digitising the remains.

From the beginning, it was important for the fossils to remain in Sauce and to be part of the public sphere. The Arroyo del Vizcaíno collection has not only achieved this, but has also gone full circle, returning to the high school where it lived in its beginnings.

Outreach and community engagement

The new space as a vector for outreach

Aiming at keeping the collection's original spirit, the work currently being done maintains a strong vocation for the dissemination, communication and social appropriation of knowledge. In this sense, since the resumption of excavations and conservation work, the collection space has also attempted to be a space open to the community. Even in its most precarious locations, the collection has been (and still is) the site of talks, workshops, guided tours and periodic visits to high schools and other schools in the area and in other regions of the country (Figures 8A, C and D). In the new lab/exhibit space we sometimes work, weather and activities permitting, with the door open, allowing occasional visitors to pass by and ask questions or even sit and colour pictures of animals from the megafauna. This spirit of community involvement brings people of all ages to the space, some curious about the fossils, others fascinated by the colourful prints of reconstructions of these animals.

The Arroyo del Vizcaíno collection is conceived as a flexible and itinerant environment. Flexible, because, in addition to its being a research and conservation centre (and despite its small dimensions), it has managed to become a classroom, a conference auditorium, a projection room, a space for games and art activities and an exhibition room. Itinerant, because its pieces have travelled to be part of temporary exhibitions in other museums and at science fairs, and also because the team moves frequently to give talks and workshops in colloquia, schools, high schools, teacher training centres and palaeontological collections from different parts of the country.

One example of outreach outside our walls happened in 2017 when, together with the *Centro de Fotografía de Montevideo* (CDF, Photographic Centre of Montevideo), we set up an extensive photo exhibition about the history of the findings of the Arroyo del Vizcaíno. This project encompassed images from the archive of the discovery in 1997 to recent photographs of the excavations, conservation and preparation work (Figure 8B). In addition, the exhibit included palaeoartistic reconstructions of the animals and specially-designed infographics about evolution, human settlement in the Americas and the different stages of our scientific research (Figure 9). The exhibit, which was free and open to all, was held for several weeks in an outdoor photo gallery space in Montevideo and later displayed in Sauce's high school lot, where it remained for several months.

The team and collaborators have found other means to tell stories about the findings and work done: books have been published (Courtoisie and Fariña 2016), short films have been broadcast, articles have been published in magazines, blogs and popular portals and some television specials have been filmed. The summer excavations have also been an open space to receive visits from residents of the area, students, journalists and curious people in general. Our physical spaces have been the roots that allowed these and many other projects to grow, which in turn allow us to achieve our main goals: research, education and outreach.

Digital Outreach Initiatives

Aside from the workshops, talks and other in-person activities, much of the collection's outreach happens on the internet. The www.arroyodelvizcaino.org site

Figure 8: Outreach activities: A) School visit to the collection, 2016 (Photo by Martín Batallés); B) Photo exhibition of excavations and lab work, Montevideo, 2017 (Photo by Gabriela Costoya); C) School students and teachers gathered at the school to hear a talk by the team, 2017 (Photo by Martín Batallés); D) Children's activity based on augmented reality, Sauce, 2018 (Photo by Martín Batallés).

houses images and videos of the excavations and fossils, shows the history of the findings and research and offers general information on South American megafauna (Figure 10). Information on the progress of the research and excavations is kept up to date on its associated social media platforms, where outreach activities are announced and exchanges with followers are generated. These tools make it possible to give the collection great visibility, maintain active contact with the community and reach audiences beyond the immediate geographical area.

Our audiences not only interact with us by liking or commenting on our posts, they engage more actively with us via our direct messages by showing us their own findings and alerting us of possible new palaeontological sites. The Arroyo del Vizcaíno collection is slowly becoming a repository of fossils from other Uruguayan sites, some of which were found by our followers. This has shown us the power of community science as a tool for the accumulation of knowledge and appreciation of our palaeontological heritage.

What began as an idea to digitise the Arroyo del Vizcaíno collection became a new standalone project as we added fossils from other collections in Uruguay. The Megafauna 3D project was created and has since gone far beyond its initial conception, becoming an autonomous platform for outreach and education. It is a project that seeks to gather fossils from different collections to disseminate and bring value to the palaeontological heritage of Uruguay and South America through new digitisation and 3D-printing technologies. Apart from an initiative to digitise fossils of the South American megafauna of the Pleistocene, it is also an online educational platform, a repository of 3D models, a series of educational resources and didactic and interactive activities on palaeontology, a physical didactic suitcase and a tour of talks and workshops visiting schools and museums in different locations of Uruguay (Figure 11). Megafauna 3D lives mainly on its website (www.megafauna3d.org) and social media platforms (Figure 10), but also expands to in-person activities that not only engage audiences differently, but act as a first step for the public to interact with the physical didactic resourc-

Figure 9: Educational graphic showing teeth from the collection and which animals they belonged to. Photo by Martín Batallés and Gabriela Costoya.

es and then continue on their own with the digital ones.

The main goal of the project is to preserve the richness of the palaeontological heritage of the region, with an emphasis on the giant mammals of the Pleistocene, making it accessible to the general public. It also seeks to promote the communication of scientific knowledge by the community, on issues such as biodiversity and extinction processes, using new technologies to generate exchanges between different social actors.

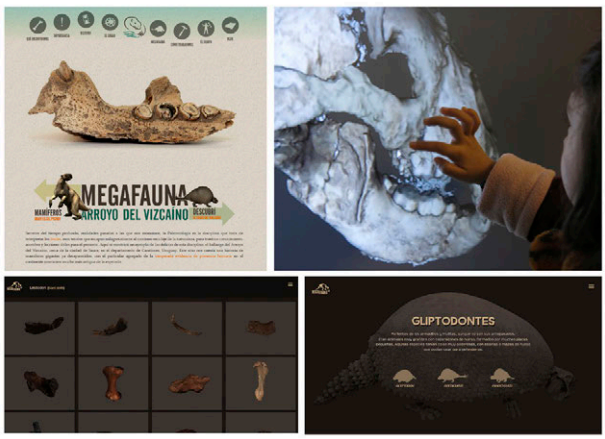

Figure 10: Screenshots and images from www.megafauna3d.org and www.arroyodelvizcaino.org websites.

The future of the collection

The Arroyo del Vizcaíno collection began as a quick recovery of fossils from a stream bed after a drought. High school students were involved not only in the recovery but also in identifying the remains and requesting they stay in their town. Two decades later, the fossil remains are once again tied to the high school, both due to their physical location and the collaborations that have occurred since the team of palaeontologists and collaborators became involved. Our goal is to continue to strengthen these ties and to expand them even further.

Since 2019, the collection is officially affiliated with the Universidad de la República, after the creation of SAUCE-P (*Servicio Académico Universitario y Centro de Estudios Paleontológicos*, University Academic Service and Palaeontological Studies Centre), a formal institution that serves as education and research facility for palaeontological studies. With the support of the university, we hope to continue to educate undergraduate and graduate students and to incorporate high school students and teachers in our

Figure 11: Megafauna 3D educational suitcase, containing plastic fossil replicas, 3D glasses, a teacher's guide and other didactic resources.

education efforts. Teachers have already shown interest in incorporating palaeontology into their curricula as part of both science and humanities classes. When we began our work, we paid attention to the requests of the high school students and other members of the community to keep the remains in Sauce; we hope that with the creation of SAUCE-P and the collaborations we established with the authorities in charge of public education, we will be able to fulfil the community's wish.

The work done in the collection is a continuation of what the community started. The archives from 1997 and testimonials tell the story of the collection and beginnings of the research on the material. This shows the importance of keeping this information as part of the collection, as it is informative about the collection's state at different points throughout its history. The archives and other documentation we have kept throughout the years allow us to understand issues with cataloguing, the coloration of the fossils and the history of the fossils' preparation. This is information we have been keeping and will continue to keep in the coming years as it will inform future researchers about where it all began and how things evolved.

Finally, outreach activities will continue to be developed and new projects will be created. Our experience working with our audience has taught us the interest in this collection goes beyond the limits of Sauce. For this reason, we will continue to expand our digital platforms, think of new ways to create educational and didactic content and collaborate with other institutions. Our doors will continue to be open (both literally and figuratively) for anyone wanting to learn.

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Statement

All authors declare no competing interests.

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