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SPOTLIGHT

MANIFESTO OF THE SOUTH AMERICAN SCHOOL OF (ACTUALISTIC) TAPHONOMY

MATIAS DO NASCIMENTO RITTER,[1] CLAUDIO G. DE FRANCESCO,[2] FERNANDO ERTHAL,[3] GABRIELA S. HASSAN,[2] ELEONOR TIETZE,[2] AND SERGIO A. MARTÍNEZ[4]

[1]*Programa de Pós-graduação em Geociências, Instituto de Geociências, Universidade Federal do Rio Grande do Sul, CEP 91.501-970, C.P. 15001, Porto Alegre, Rio Grande do Sul, Brazil*

[2]*Grupo de Ecología y Paleoecología de Ambientes Acuáticos Continentales, Instituto de Investigaciones Marinas y Costeras, CONICET-Universidad Nacional de Mar del Plata, Juan B. Justo 2550 1° Piso, 7600, Mar del Plata, Argentina*

[3]*Departamento de Paleontologia e Estratigrafia, Instituto de Geociências, Universidade Federal do Rio Grande do Sul, CEP 91.501-970, C.P. 15001, Porto Alegre, Rio Grande do Sul, Brazil*

[4]*Departamento de Evolución de Cuencas, Instituto de Ciencias Geológicas, Facultad de Ciencias, Universidad de la República, Iguá 4225, 11400, Montevideo, Uruguay*

When the young Charles Darwin explored the Atlantic coast of southern South America, he was impressed by its fossils—as he wrote in the first paragraph of the Origin of Species (1859)—and the magnitude of its "wide and desolate" plains (Darwin 1839, p. 124). Although his adventures on the Patagonian plains became more famous, Darwin's first observations were on the Pampas, a flat area that covers parts of Argentina, Brazil and Uruguay, where the gaucho was lord and master. Since that time, these flat lowlands have been the object of much geological and paleontological research, but there is still much more to discover, especially in the field of taphonomy.

South America is particularly suited to test taphonomic ideas thanks to the recent geological evolution of the area, associated with sea level oscillations since the Pleistocene, which left numerous lagoons and estuaries along the coast. In fact, the Patos Lagoon (Brazil) and Río de La Plata (Uruguay and Argentina) are the largest lagoon and one of the largest estuaries in the world, respectively, providing vast areas of diverse shallow coastal environments. In the terrestrial realm, southern Argentina is characterized by fluvial systems originating in the high Andes Cordillera as well as numerous permanent and temporary lakes due to the gentle slope of the plain. In addition to a diverse array of marine and terrestrial environments, exposures of fossiliferous accumulations from continental shelf, coastal plain, and freshwater basin settings provide exceptional opportunities for comparing modern death assemblages with fossil counterparts.

Thanks in part to this profusion of "natural taphonomy laboratories", actualistic taphonomy in South America is experiencing a period of exciting growth and advancement. Studies on the southern Brazilian continental shelf have focused on the comparative taphonomy of bivalved mollusks and brachiopods (Kowalewski et al. 2002; Carrol et al. 2003; Rodland et al. 2004, 2006, 2014; Simões et al. 2004, 2007, 2009; Barbour Wood et al. 2006; Rodrigues et al. 2008; Rodrigues and Simões 2010; Krause et al. 2010; Dexter et al. 2014). These studies have constrained the magnitude of time averaging in brachiopod assemblages, providing important insights on the paleoecology and preservation of Paleozoic assemblages in which mollusks are rare. These pioneering contributions drew the attention of the international scientific community due to the high quality and visibility of the resulting publications as well as the exciting discoveries reported in them.

Much of this work was led, in collaboration with foreign researchers, by the Brazilian pioneer of South American taphonomy, Marcello G. Simões. More recently, a new generation of scientists in Argentina, Uruguay, and southern Brazil have undertaken taphonomic projects in their home countries and begun training students with a focus in actualistic taphonomy, resulting in numerous recent articles from Brazilian (Erthal et al. 2011, 2014, 2015; Ritter et al. 2013, 2014), Argentinean (Hassan et al. 2008; Cristini and De Francesco 2012; Tietze and De Francesco 2012, 2014; Hassan 2015) and Uruguayan (Rojas et al. 2014) scientists (Figs. 1, 2). Clearly, there is much taphonomic research to be done in South America and the region is exceptional for doing so.

Some of the most distinctive work has emerged from the profusion of sedimentary environments of the South American plains. These range from oligo- to hypersaline conditions in less than 500 km resulting in strong conductivity and alkalinity gradients (Hassan et al. 2011) with subsequent implications for the preservational dynamics of siliceous diatom and carbonate molluscan remains. Taphonomic studies on alkaline lakes are particularly scarce worldwide, so the role of pH on preservation has been addressed mainly under acidic or nearly neutral pH conditions in previous work (e.g., Cummins 1994; Kotzian and Simões 2006). For example, work by De Francesco et al. (2013) and Hassan et al. (2014), has revealed that under contrasting conditions of conductivity and probably alkalinity, diatoms and mollusks of Pampean shallow lakes show opposite patterns of preservation, leading to new insights on the comparative taphonomy of siliceous and carbonate remains and, outstandingly, highlighting the perils of ignoring taphonomic signals in paleoenvironmental studies. The plains of South American provide the opportunity to carry out such comparative studies of preservation under a wide variety of conditions, complementing or perhaps changing many of the assumed "truths" of taphonomy in continental settings.

In addition to comparative studies of different taxa from the same settings, South American researchers have made significant contributions to understanding the preservation of a single group in different settings. In particular, a series of studies have found that although mollusk death assemblages show consistently high agreement with living communities in environments ranging from shallow lakes (Pampean lakes of Argentina; Tietze and De Francesco 2012) to rivers (Martello et al. 2006; Erthal et al. 2011) to coastal lagoons

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FIG. 1.—Southern School of Taphonomy. (All left to right). Top: Matias N. Ritter and Claudio G. De Francesco. Middle: Fernando Erthal and Gabriela Hassan. Bottom: Eleonor Tietze and Sergio Martínez. Matias Ritter is a Marine Biologist who has been working on taphonomy since 2010. He received his Master's degree from the Federal University of Rio Grande do Sul in 2014 with a thesis about molluscan taphonomy in lagoonal environments. He wishes to become a famous scientist after finishing his Ph.D. Therefore, he is a dreamer since his childhood. Claudio De Francesco is a very strange biologist because he enjoys studying dead rather than live animals. His research interests include taphonomy and Quaternary paleoecology of freshwater mollusks, and he is currently carrying out an actualistic taphonomy project in shallow lakes of the Pampas of Argentina together with Gabriela Hassan and Eleonor Tietze. He is euphoric about working collaboratively with this South American team but has also made it clear that Messi is the best soccer player of all time. Fernando Erthal never dreamt of becoming a paleontologist, even less a taphonomist, but since his shift from studying biochemistry as an undergraduate to Quaternary fluvial mollusks, advised by Carla Kotzian, he realized that quantifying the biases in the formation of the fossil record, especially in the continental realm, is challenging and exciting. He is now developing a long-term relationship with the R software and many children of this union are on the way. Gabriela S. Hassan is a diatomist, who has been working on diatom-based paleoenvironmental reconstructions for the last ten years. As she became increasingly interested in the biases of the diatom fossil record, she started dealing with questions about diatom preservation both in estuaries and shallow lakes. As a child, Sergio Martínez dreamed of being a professional cyclist, but his thirst for knowledge was more powerful; then he hesitated between studying history or biology and found the perfect synthesis in paleontology. Eleonor Tietze is a young researcher working on actualistic taphonomy and paleoenvironments since 2008. Her aspiration is to continue answering questions of how the fossil record forms and how Pampean environments evolved.

(Ritter and Erthal 2013), the degree of similarity between live and dead depends on the physical and chemical properties of the environments as well as the spatial scale of comparison. For example, even though dissolution introduces a pervasive taphonomic bias in lagoonal and estuarine environments (Ritter et al. 2013), the living assemblage is fully captured in the fossil assemblage when a broad spatial scale is considered (Ritter and Erthal 2013). Also, in a pioneering study on the compositional and environmental fidelity of diatoms in both estuarine (Hassan et al. 2008) and freshwater environments, Hassan (2015) demonstrated that poor live-dead fidelity of diatom species composition does not hamper the preservation of environmental gradients in death assemblages (environmental fidelity).

Another research theme emerging in South American studies of taphonomy focuses on how taphonomic signal varies among different environments (marine, estuarine, freshwater) at a regional scale. Kotzian and Simões (2006), Tietze and De Francesco (2014), Pisano et al. (2015) and Erthal et al. (2015) have analyzed lake and fluvial environments, De Francesco and Hassan (2008) and Ritter et al. (2013) have focused on estuarine environments, and Erthal et al. (2014) and Rojas et al. (2014) have studied marine environments of the southern and northeastern Brazilian Shelf. Erthal et al. (2014) found that up to 60% of the taphonomic variation can be explained by environmental variation, but this pattern remains to be explored in different settings such as rivers, lakes, and estuarine lagoons.

In addition to comparative studies of taxa and environments, South Americans have initiated work on experimental taphonomy. In a recent study, Cristini and De Francesco (2012) identified dissolution as a primary taphonomic agent acting in freshwater lakes, with its main influence occurring at the sediment-water interface and extending to the first 10–25 cm below it. In another example, Ritter et al. (2013) and Ritter and Erthal (2013) analyzed the taphonomically active zone in estuarine environments and also concluded that dissolution appears to be the factor of greatest influence there. Furthermore, a taphonomic experiment conducted in artificial marine settings revealed that encrustation on mollusk shells is associated with reinforcement structure, probably due to larger niches availability to larvae. Nevertheless, infaunal species experienced lower encrustation rates, possibly due to intrinsic shell features, such as more moderate morphological heterogeneity (Ritter et al. 2014).

South American taphonomists have also been making contributions to conservation paleobiology (Erthal et al. 2011; De Francesco et al. 2013; Martínez et al. 2013). Erthal et al. (2011) found that the low compositional correspondence between fossil, death, and living assemblages in fluvial settings was a consequence of the recent introduction of exotic species in the area (among other factors such as differential preservation). As another example, Martínez et al. (2013) showed how artificial modifications in an estuarine lagoonal system modified mollusk assemblages in less than 200 years. Last but not least, actualistic taphonomy is being used as a tool to differentiate between natural and anthropogenic accumulations of shells with the same taxonomic composition, a key issue for archeologists (Beovide 2011; Beovide et al. 2014a, 2014b).

The number of scientific publications on actualistic taphonomy authored by South American scientists has risen sharply during the last decade, reflecting an increased interest in this subject by local researchers. This is also evidenced by the rise in the number of master's and doctoral theses. For example, Eleonor Tietze's doctoral thesis (Tietze 2013) dealt with the understanding of the taphonomic processes that affect mollusk preservation in shallow lakes and streams of the Pampas Plain (Argentina). In the same environments, Paula Cristini is conducting a doctoral project on the taphonomic processes that affect mollusk preservation below the sediment-water interface. The project includes the observation of taphonomic patterns recorded in the field, as well as the analysis of processes using experimental approaches. Regarding experimental taphonomy, Marisel Diaz is initiating her doctoral research on the effects of salinity on diatom dissolution in those environments, which will be assessed through laboratory experiments. These actualistic studies are framed within a major project on comparative taphonomy recently initiated and led by Claudio De Francesco and Gabriela Hassan. The aim is to compare the preservation of diatoms and mollusks in freshwater environments of different conductivities. Both field and lab experiments on fragmentation and dissolution will be performed. Eleonor Tietze is conducting another project in the Pampean Region that evaluates the effect of environmental and biological variables (as pH, conductivity, and carbonate saturation and bioturbator abundance among others) on the preservation potential of mollusk shells. Fernando Erthal concluded his doctoral dissertation (Erthal 2012) on taphonomic analysis of mollusks at broad spatial scales in marine environments of the South Brazilian Shelf (Erthal et al. 2014). In the same region, Matias Ritter is conducting a pilot study on time averaging of mollusk assemblages, with samples collected as deep as 242 m. The aim is to understand how depth influences time averaging and will serve as a benchmark for understanding fossil assemblages along a broad bathymetric gradient in subtropical environments.

The broad and geographically diverse areas covered in the studies of South American taphonomists give us the opportunity to address some key topics in actualistic taphonomy, such as the role of climatically and geographically driven environmental gradients on preservation and the role of spatial scales. The physiognomy and environmental diversity of South America allow us to explore (1) the effect of using different spatial scales (fine and broad) on preservation and fidelity bias in both continental and marine environments; (2) patterns of preservation of organic remains under continental gradients of alkalinity and conductivity; and (3) patterns of preservation of groups other than mollusks, such as diatoms and ostracods.

Although this "southern taphonomy" explosion is rooted in the opportunities afforded by South American landscapes, a second (but no less important) trigger is the human dimension fostered by social and scientific interactions. As a collaborative research effort, we are pursuing the ambitious objective of proposing and developing critical questions and ideas in the

FIG. 2.—Part of the South American School of Taphonomy, in Brazil, when Claudio was teaching a postgraduate course about taphonomy (obviously). During this marvelous Sunday, while Matias made the best *churrasco* ever (according to Claudio), we began to formulate our manifesto, presented in this spotlight. Left to right: Claudio G. de Francesco, Matias Ritter, and Fernando Erthal.

field of taphonomy from a South American point of view. The idea was born during the last International Paleontological Congress (2014) held in Mendoza, Argentina. As a consequence of a session on "Actualistic Taphonomy" led by Michał Kowalewski and Claudio De Francesco, we met as a group for the first time and discussed our future with the aid of Argentina's fine Malbec wines. Soon after, we formalized our intention of conducting collaborative research during a post-graduate course in Porto Alegre, Brazil (this time with the aid of *caipirinha* and traditional *churrasco)*. During these meetings, we began sharing our views on each other's projects and founded a regional project that we call the South American School of Taphonomy (SST) (Fig. 2).

The SST project intends to combine and coordinate the results of our respective studies in order to develop a comprehensive taphonomic model that includes multiple depositional settings, bioindicators, and spatial scales. As a first step towards its foundation, we are currently working to integrate the information from the variety of environments we study. Our future ambition is to develop a theoretical framework and to expand the discipline through postgraduate courses and Ph.D. theses.

We are going towards the unknown, and every new result raises new questions in a continuous, intense process. Our recent exchange of ideas, conversations, and wine tastings has led to the production of taphonomic knowledge with an international reach. We hope readers will find us all together soon in PALAIOS!

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