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Palynomorphs and foraminifera from Colombia housed in the systematic collections of Ecopetrol-ICP

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Resumen

Numerosos estudios palinológicos y micropaleontológicos (foraminíferos) realizados por ECOPETROL S.A. a través de investigaciones desarrolladas en diversas cuencas sedimentarias colombianas, han permitido entender la distribución vertical y horizontal de varios taxones incrementando tanto la resolución bioestratigráfica como la interpretación biofacial de las secuencias sedimentarias. Con el objetivo de estandarizar la taxonomía y preservar todo el conocimiento generado, el Instituto Colombiano del Petróleo (ICP) de ECOPETROL S.A creó las colecciones sistemáticas de palinomorfos y foraminíferos, las cuales contienen morfoespecies que abarcan desde el Cretácico hasta el Holoceno. Las colecciones están organizadas por morfoespecies y por asociaciones regionales. La colección de palinomorfos está constituida por 814 morfoespecies (83% polen y esporas, 13% dinoflagelados y 4% representados por elementos preservados en preparaciones palinológicas), de las cuales 368 han sido formalmente descritas y 345 son informales mientras que la colección de foraminíferos, comprende más de 600 morfoespecies entre formas planctónicas (35 %) y bentónicas (65%). Ambas colecciones –palinomorfos y foraminíferos– están indexadas en bases de datos por medio del software *FileMaker Pro,* migrando a MySQL con una interface de usuario cakephp la cual permite acceder a la herramienta por medio de la web. Estas bases de datos contienen descripciones y fotomicrografías del material depositado en ellas así como del material tipo original. Las colecciones son actualizadas permanentemente por los conservadores por medio de revisiones constantes, discusiones y mejoras en las técnicas de preservación. Este material es consultado de manera continua por los miembros del Grupo de Bioestratigrafía-ICP y por estudiantes así como por expertos internacionales, como en el caso de la colección de palinomorfos. Por estas razones, consideramos nuestras colecciones y sus bases de datos como herramientas eficaces para estandarizar la taxonomía y preservar el conocimiento bioestratigráfico del norte de Suramérica así como un repositorio potencial para nuevos holotipos que provengan de investigaciones futuras en Colombia y áreas adyacentes.

Palabras clave: Colecciones micropaleontológicas, Cretácico, Cenozoico, Colombia, dinoflagelados, esporas, polen, foraminíferos.

Abstract

Numerous palynological and foraminiferal studies made by ECOPETROL S.A. in several Colombian sedimentary basins have enabled us to understand the vertical and horizontal distribution of several taxa increasing both the biostratigraphic resolution and biofacial interpretation of these sequences. In order to standardise the taxonomy and preserve all the generated knowledge, the Colombian Pe-

troleum Institute (ICP) of ECOPETROL S.A built palynomorph and foraminiferal systematic collections comprising morphospecies from the Cretaceous to the Holocene. These collections are organised by taxa and by regional location, according to Colombian sedimentary basins. The palynomorph collection consists of 814 morphospecies (83% pollen and spores, 13% dinoflagellate cysts, and 4% elements preserved in palynological slides), 368 described and 345 informal morphospecies whilst the foraminiferal collection holds over 600 morphospecies of foraminifera among planktonic (35 %) and benthic forms (65%). Both collections - palynomorph and foraminiferal - are indexed in *FileMaker Pro* databases, and they are currently being migrated to MySQL employing a cakephp user interface which allows to access the tool through the web. These databases contain descriptions and photomicrographs of the material deposited in them as well as of the original types. These collections are updated regularly by the curators, by means of constant revisions, discussions and improvements of preservation techniques. This material is currently not only in constant use by members of the Biostratigraphy Team at ICP and students but also by international experts, as in the case of the palynomorph collection. For these reasons, we consider our collections and their databases as effective tools to standardise the taxonomy and preserve the biostratigraphical knowledge of northern South America as well as a potential repository of new holotypes derived from future research in Colombia and adjacent areas.

Key words: Micropalaeontological collections, Cretaceous, Cenozoic, Colombia, dinoflagellate cysts, pollen, spores, foraminifera.

1. INTRODUCTION

The systematic collections at ICP began as an effort to preserve and consolidate the biostratigraphical information which had been acquired during several years of oil exploration by ECOPETROL S.A-ICP. As a result, the collection of palynomorphs (pollen, spores and dinoflagellate cysts) was created in 2004 by the palynologist Carlos Jaramillo. The preservation of the slides revealed the necessity to standardise the taxonomy of tropical palynomorphs and an electronic database using *FileMaker Pro* (Jaramillo *et al.,* 2004) was then created. The main purpose was to have a quick reference to the tropical morphospecies described for northern South America, especially the ones present in Colombian continental sedimentary sequences. All this knowledge was then successfully used in exploratory oil wells (on-site) as applied biostratigraphy (Jaramillo *et al.*, 2004; Rueda *et al.*, 2005; Pulido *et al.*, 2006; Vargas *et al.*, 2007, 2008; Torres *et al.*, 2008). The same process was subsequently employed for the construction of the foraminiferal collection by micropalaeontologists at ICP with the permanent advice and revision of the stratigrapher and micropalaeontologist Hermann Duque-Caro, with material from marine sedimentary sequences of northern Colombia (Jaramillo *et al.*, 2004; Rueda *et al.*, 2005; Pulido *et al.*, 2006; Espitia & Arenas, 2006; Espitia, 2007, 2008; Espitia *et al.*, 2008).

2. METHODS

Hundreds of rock samples not only from wells (wet and dry ditch cutting samples) but also from outcrop sections and stratigraphic wells from several Colombian sedimentary basins were analysed on the basis of their microfossil content over a period of about five years as a result of multiple projects related to oil exploration research at ECOPETROL SA.-ICP. From these analyses, several key marker palynomorph and foraminifera morphospecies were selected taking into account the concept of an index fossil: a taxon with easily recognizable morphological characteristics, with a widespread geographical distribution and with a short geologic time range. In some cases though, several morphospecies which do not have a short stratigraphic range, as in the case of benthic foraminifera, were selected because they were significant biostratigraphic events of a given stratigraphic level in a regional scale by means of their first and/or and last occurrences. Once selected, each morphospecies was taxonomically revised –based on classic literature- and validated by experts of each fossil group before entering into the collections formally.

After that, a unique code was generated for each slide and in the case of palynomorphs the position of the specimen on the slide was defined using the England Finder System. For foraminiferal slides, where the specimens can be picked

and mounted on a single cardboard-slide commonly 3 of a single morphospecies the slides were properly labelled including not only a unique code but also key information such as morphospecies´ name, author, locality, age, depth and collector's name, among a few others. Next, optical and/or SEM photomicrographs were taken and loaded into the database where descriptions and biostratigraphic information relating to the taxa were also entered.

3. RESULTS

The palynomorph and foraminiferal systematic collections at ECOPETROL S.A-ICP constitute the organised arrangement of taxa which are consulted permanently by palynologists and micropalaeontologists. Based on their morphological characteristics and biostratigraphical value they represent reference material for proper and accurate identification of organic, calcareous and agglutinated microfossils.

These collections constituted reference collections holding more than 1400 morphospecies among foraminifera and palynomorphs. Currently, the palynomorph collection consists of 814 morphospecies. The material is mainly composed of pollen (68%), spores (15%) and dinoflagellate cysts (13%) with 549, 125 and 107 morphospecies respectively. The additional 4% are constituted of algae, acritarchs, fungal remains and foraminiferal inner linings. The foraminiferal collection is constituted of 640 foraminiferal morphospecies, including both planktonic (226) and benthic (414) forms. The latter group encompasses 310 calcareous, 1 pseudochitinous, and 103 agglutinated specimens.

3.1 Status of the material

The foraminiferal collection is predominantly composed of secondary type specimens, i.e., 686 homeotypes, 20 topotypes, and 118 morphotypes. From the former group 37 morphospecies of planktonic foraminifera are illustrated in Rincón *et al.* (2007). Recently, the first holotype entered the collection. It is an agglutinated benthic foraminifera from the Colombian Caribbean Sea (continental slope). Along with the holotype, 10 paratypes are also deposited in this collection. It is worth mentioning that another paratype of this morphospecies is deposited in the collection of foraminifera at the Smithsonian National Museum of Natural History in Washington. The complete taxonomic information of this form is addressed in Fiorini (2009). On the other hand, the palynomorph collection is made up of 29 holotypes (Yepes, 2001; Jaramillo *et al.*, 2007; Jaramillo *et al.*, in press), 29 paratypes, 38 homeotypes, the last one selected from workshops on the bases of publications (Jaramillo & Yepes, 1994; Jaramillo & Dilcher, 2001; Jaramillo *et al.*, 2007; Silva-Caminha *et al.*, 2010), 101 morphotypes and 345 "informal" morphospecies, that is, morphospecies which have not been formally proposed.

3.2 Repository

The collections are located in the biostratigraphy section of the ICP. The palynomorph collection currently contains 1214 "references slides" and 27000 slides of the regional collection. The foraminiferal collection is composed of more than 6000 micropalaeontological slides (see Fig. 1). The slides of this latter collection are arranged either by morphospecies name for quick reference to a single morphospecies or according to the basin where the microfossil assemblage comes from, namely morphospecies and regional collections (see Fig. 2). Each slide of the regional collection contains the picked and/or sorted microfauna of the analysed stratigraphic level (see Figs 2 and 3). Apart from foraminifera, these slides contain, where available, ostracods, microbivalves, microgastropods, diatoms, radiolaria and remains of echinoderms and fish (teeth, denticles and otoliths).

3.3 Geological interval

The foraminifera from these collections cover the range from the Cretaceous (Cenomanian) to the Quaternary (Holocene). The Cenozoic specimens comprise 89% of the collection whilst the Cretaceous microfauna comprise about 11 %. In the case of palynomorph taxa, the oldest forms correspond to the Maastrichtian (Cretaceous) and the younger ones to Pleistocene, with a proportion of 76% of palynomorphs covering the Cenozoic and 24% the Cretaceous.

Figure 1. Repository of the systematic collections at ICP. 1. Palynomorph collection a. Morphospecies collection, b. Regional collection; 2. Foraminiferal collection a. Morphospecies collection, b. Regional collection.

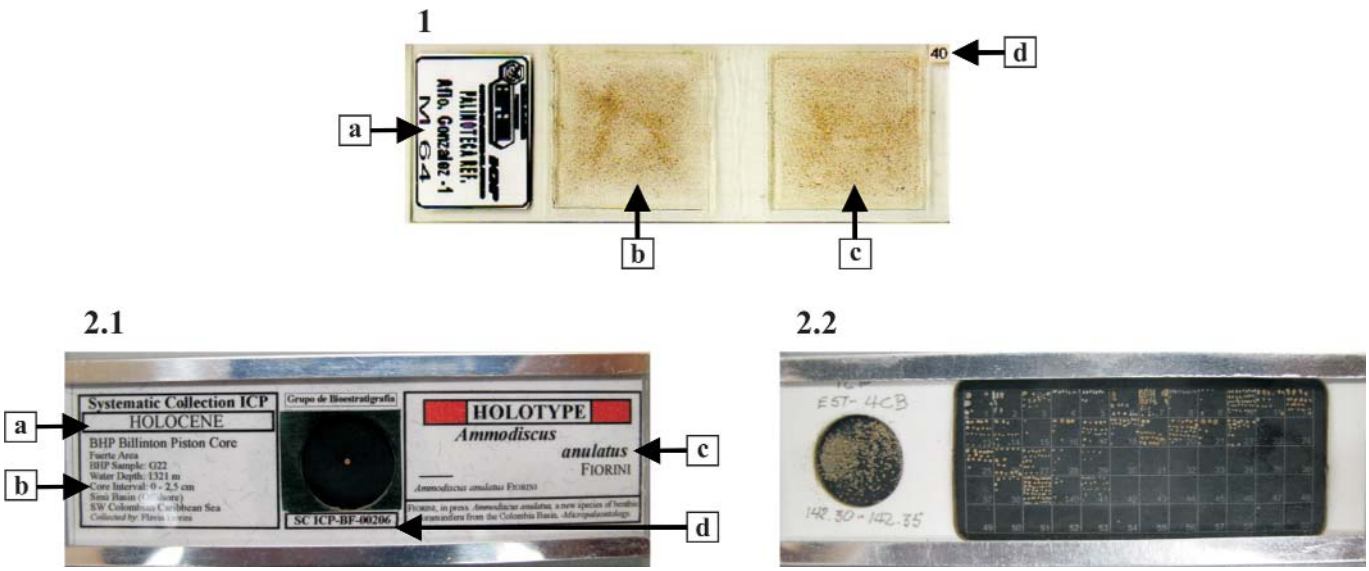

Figure 2. Slides. 1. Palynological slide. a. General information, b and c. Assemblages. The slide has two preparations, with (c) and without (b) oxidation methods, in order to compare the recovery of palynomorphs, d. Slide code. 2. Foraminiferal slides. 2.1. Morphospecies collection a. Age, b. General information, c. Species name, d. Slide code; 2.2 Regional collection. Note the complete assemblage of foraminifera within the slide.

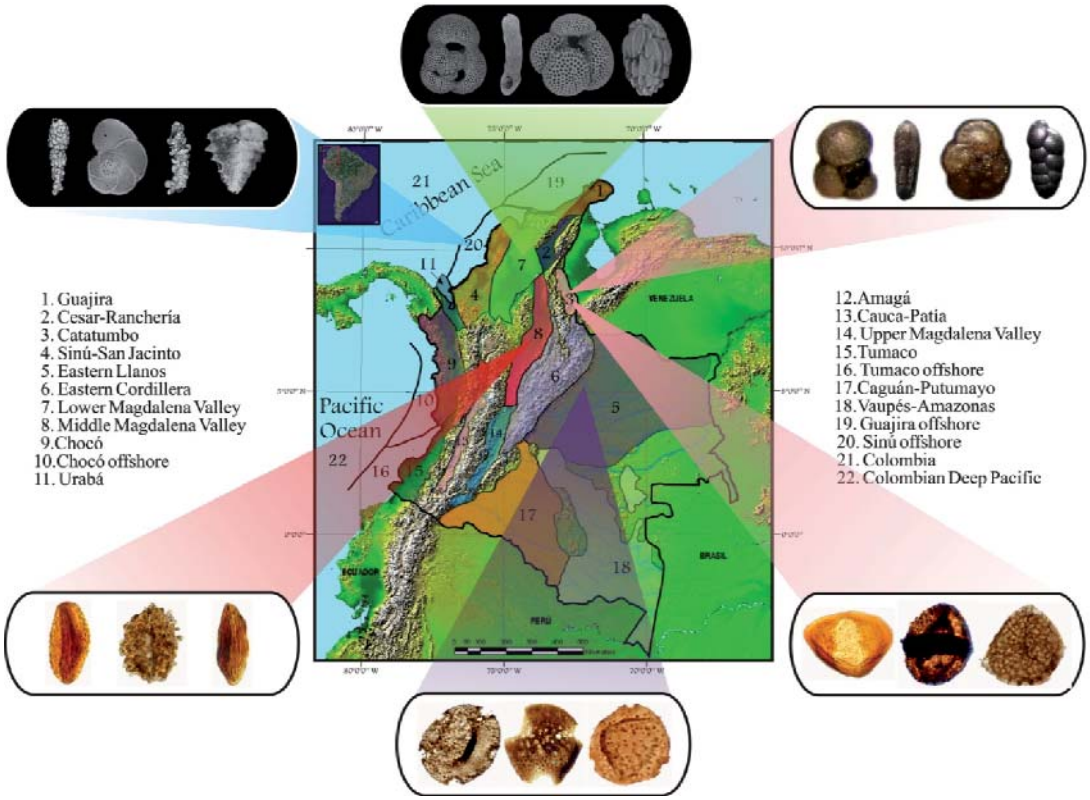

Figure 3. Colombian sedimentary basins. Modified from ANH (2007). Note the palynological (below) and foraminiferal (above) assemblages of five basins.

4. DATABASE

The physical collections are linked to databases built in *File Maker Pro 8* software, and they are currently being migrated to MySQL employing a cakephp user interface which allows to access the tool through the web (http://biogeodb.stri.si.edu/jaramillo/palynomorph/pollen). In this manner they constantly feed the electronic record which is consulted by palynologists and micropalaeontologists not only at the Colombian Petroleum Institute (ICP) but also those working on biostratigraphic control on-site at exploratory wells where the response of the biostratigrapher must be fast and effective. Certainly these databases have proven to be quite useful tools to achieve this goal.

The structure of the databases consists of multiple panels which are connected to each other through several easy-to-use links which help the user to find a given morphospecies with a simple search. The information contained in the databases includes morphological description of each morphospecies, remarks and comparison with related forms, biostratigraphic range and distribution, optical and/or SEM photomicrographs, bibliographic references and also information on the location within the physical collection in order to have quick access to any slide for direct consultation using the microscope or stereomicroscope (Figs 4 and 5). In those cases where there are no homeotypes or topotypes for physical reference of certain morphospecies, the original description of the holotypes and/or paratypes as well as their photomicrographs are included for reference. That is why the biostratigraphers and mainly the curators are continually in search of these morphospecies and related assemblages within the material from Colombian basins through numerous taxonomic revisions, discussions and final validation with the aim of having more complete reference collections which constitute the basis of a better understanding of the regional distribution of these microfossils in time and space and its relation to the geologic, stratigraphic, and tectonic evolution of northern South America.

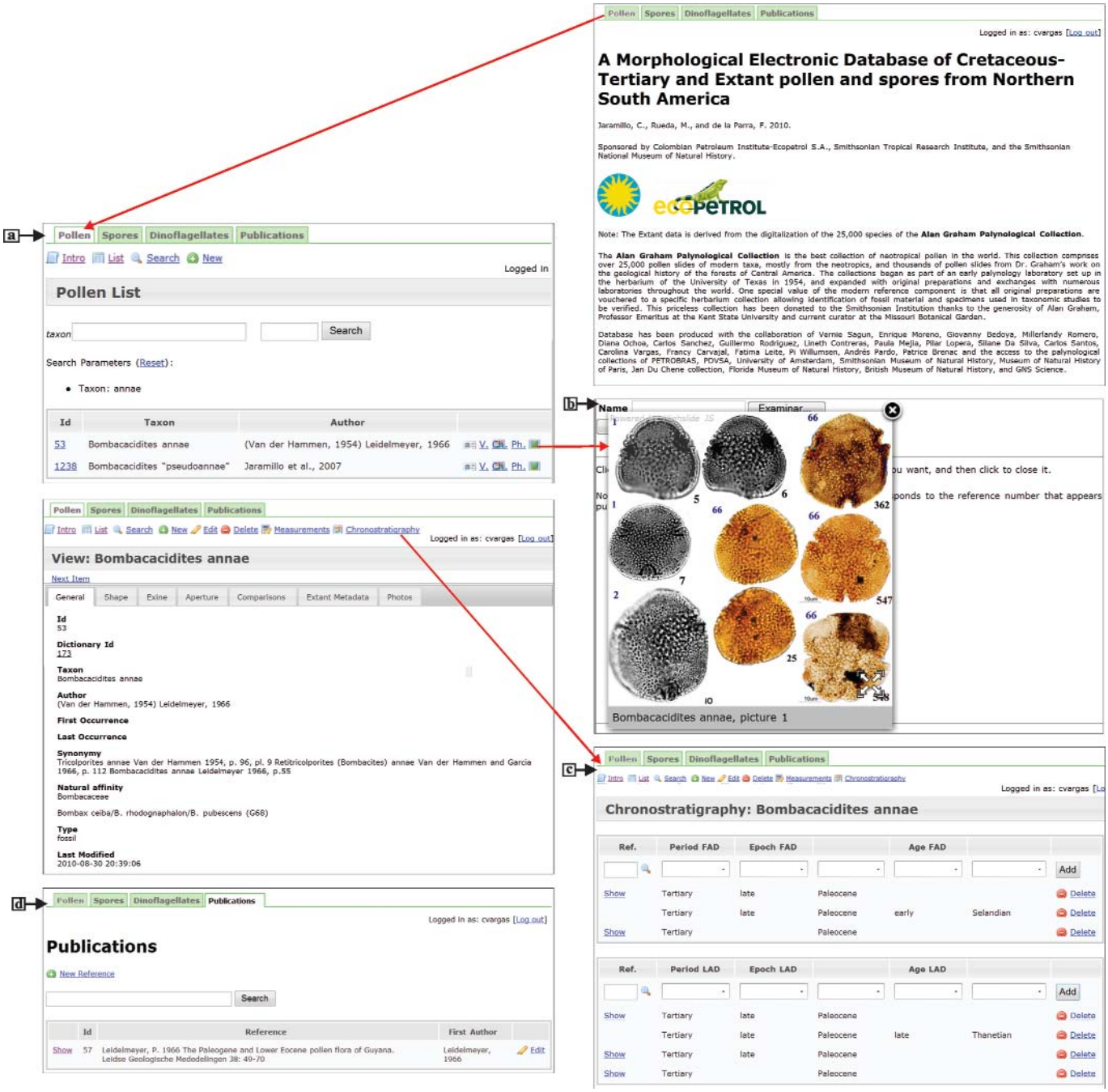

Figure 4. Slide shots of the palynomorph MSQL database. a. Morphological information, b. Photomicrographs, c. Biostratigraphic information, d. References cited.

These collections are accessible to micropalaeontologists and palynologists who are interested in the field of Biostratigraphy, Micropalaeontology, Palaeobotany, Palaeoecology and also to international scientists.

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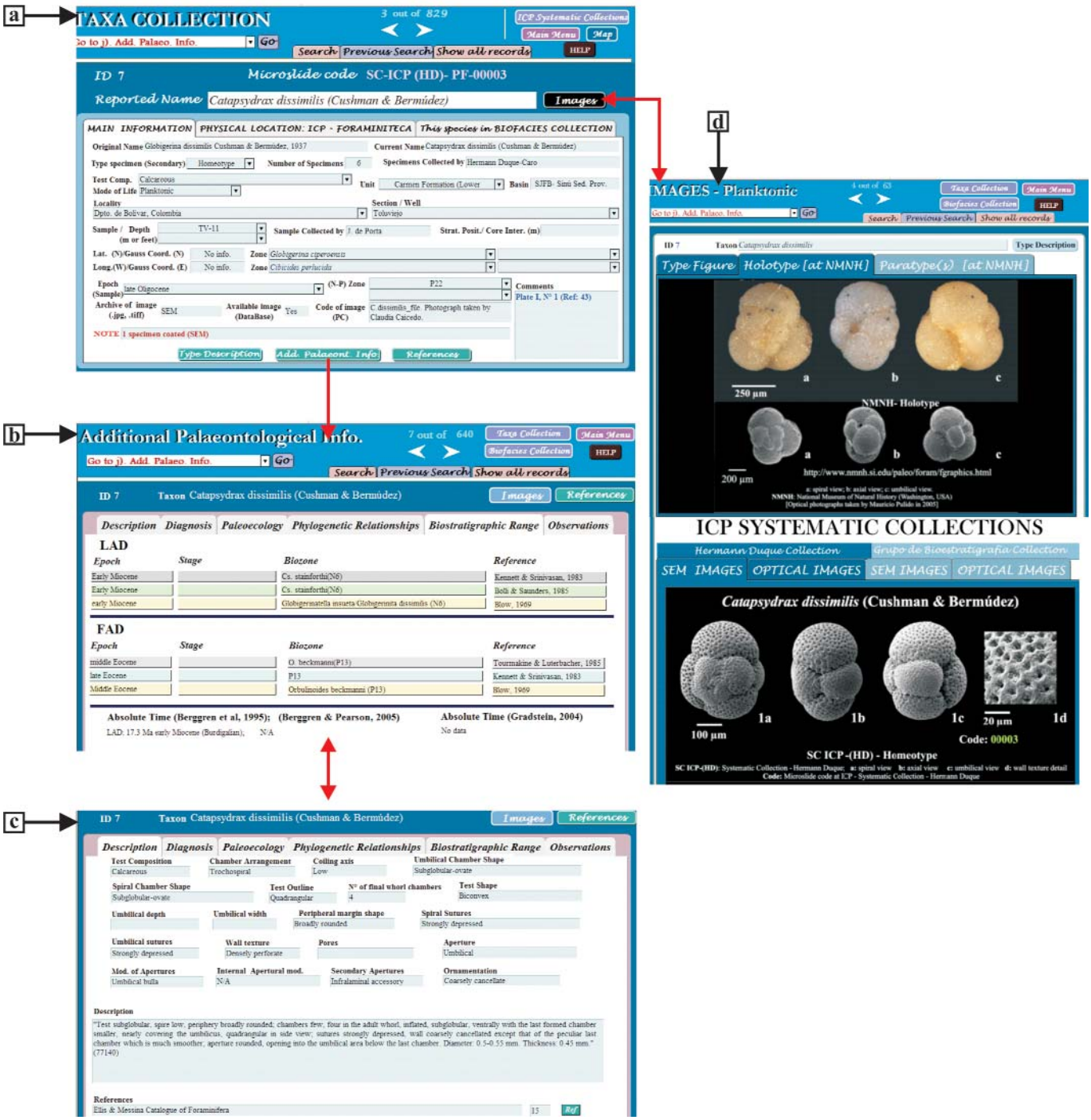

Figure 5. Slide shots of the foraminiferal Filemaker Pro-8 database. a. General information and physical location, b. Biostratigraphic information, c. Morphological characteristics, d. Optical and SEM photomicrographs.

ini for choosing our foraminiferal collection as repository of her new morphospecies and also for her discussions about agglutinated benthic taxa. We are grateful to Olga Lucia Celis Guzmán for constant assistance with *FileMaker Pro* software. The authors also thank the reviewers, Dr. Gary Rosemberg and an anonymous reviewer for their helpful comments and suggestions which improved the manuscript. This research was supported by the Colombian Petroleum Institute (ICP) of ECOPETROL S.A. Partial funding toward this research was given by the Smithsonian Institute of Tropical Research (Panama).

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