

Origin and palaeo-environmental significance of the Berrazales carbonate spring deposit, North of Gran Canaria Island, Spain.

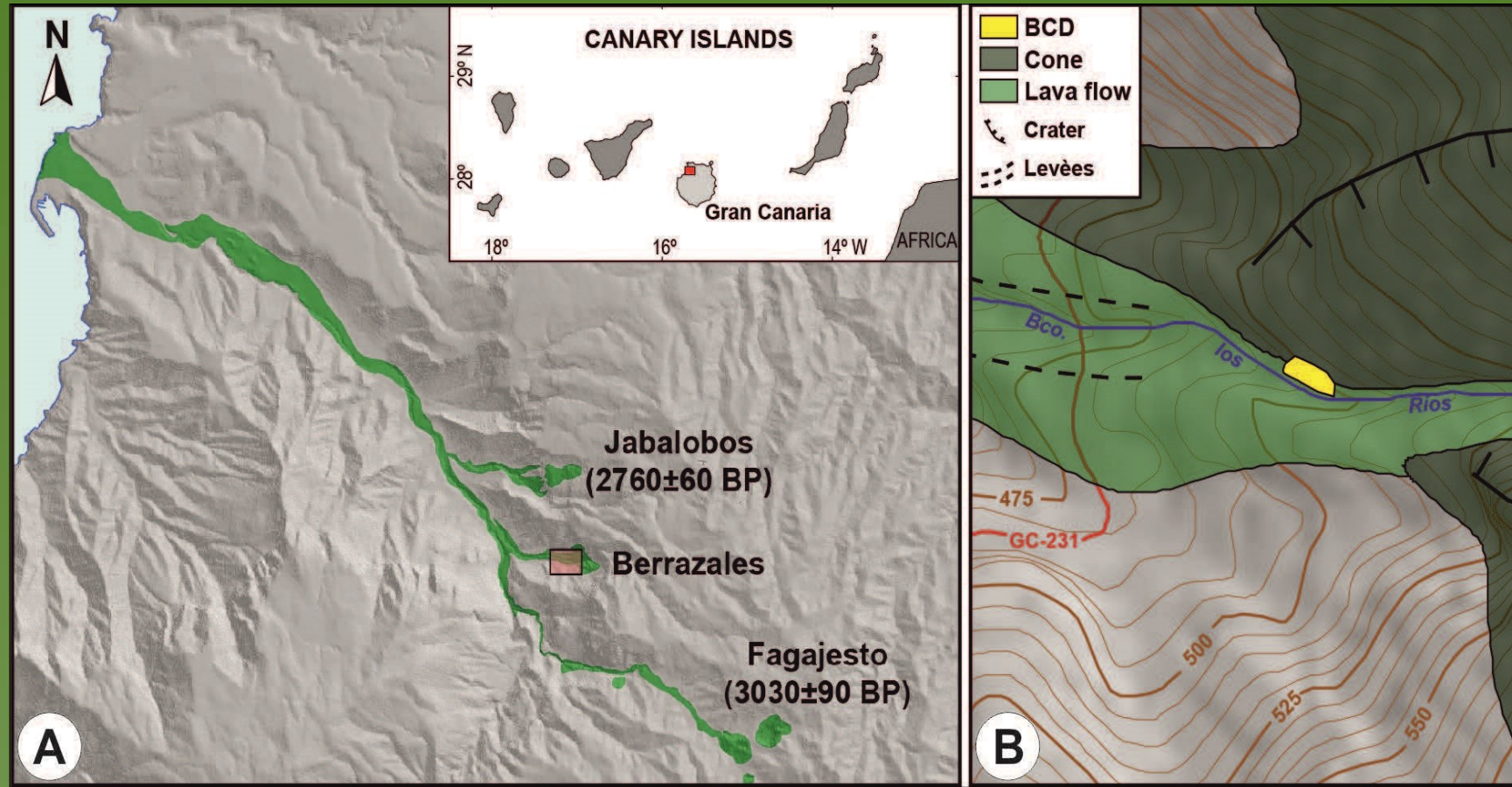
Jon Camuera^{1*}, Ana María Alonso-Zarza^{1,2}, Álvaro Rodríguez-Berriguete^{1,2}, Alejandro Rodríguez-González³

¹ Dpto. Petrología y Geoquímica, Facultad de Ciencias Geológicas, Universidad Complutense de Madrid, Spain.

² Instituto de Geociencias, CSIC. Madrid, Spain.

³ Dpto. Física GEOVOL, Campus de Tafira, Universidad de Las Palmas de Gran Canaria, Spain.

E-mails: (*) jcamuera@gmail.com; alonsoza@ucm.es



Berrazales Carbonate Deposit (BCD), located in the north-west of Gran Canaria Island (Fig.1A, B) over volcanic lavas with around 2700-3100 years old, is a 6-7m long outcrop constituted mainly by cascade-like geometries (Fig.2).



Fig.1: (A) Location of Berrazales area in the north-west of Gran Canaria Island. (B) Situation of Berrazales Carbonate Deposit (BCD) in the Barranco Los Ríos.

Fig.2: Main part of the outcrop of the Berrazales carbonate spring deposit

This continental spring deposit is made of **four main facies**:

1) Fibrous dense macrocrystalline facies are formed by large fibrous calcite crystals which nucleate and grow on sub-horizontal surfaces or plant moulds, generating branching feather or dendrite morphologies (Fig.3). Terminations of fibrous crystals are perforated by microbes, micritizing them (Fig.4). This facies is the product of rapid physicochemical precipitation from supersaturated water because of rapid CO₂ degassing under high-flow conditions.

2) Framestone facies consist in subparallel coated plant moulds (Fig.5) which provide a nuclei for calcite precipitation with crystalline-fan morphologies (Fig.6). This type of facies is formed under slow water-flow, favouring the presence and preservation of biological supports.

3) Banded micrite-coarse crystalline facies is composed of palisade crystals which include thin micritic and translucent sheets (Fig.7). The alternating bands are result of cyclic changes in physicochemical conditions and/or biological processes due to variation in microbial activity or presence of small contents of organic matter.

4) Micrite/microsparitic facies are primary micritic-microsparitic masses which include calcified cyanobacterial filaments, small crystalline-fans, dark micritic layers and not mineralized Exopolymeric Substances (EPS) (Fig.8 and 9). Organic filaments are favourable microenvironment for calcite nucleation and subsequent crystalline growth during purely physicochemical processes (Fig.10). Thus, these samples are linked to EPS. The degradation of EPS by heterotrophic bacteria liberates Ca⁺² and Mg⁺², increasing cation concentration in solution and allowing micritic (Mg)CaCO₃ precipitation.

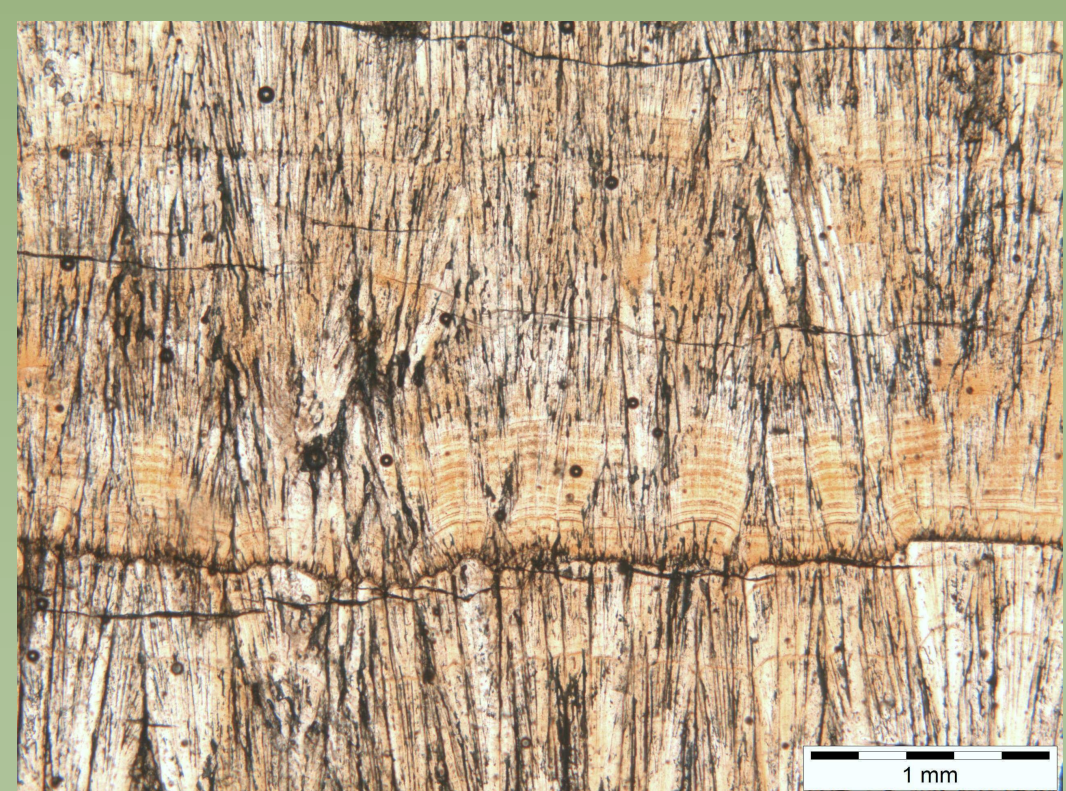


Fig.3: Fibrous dense macrocrystalline facies growing on a micritic lamina

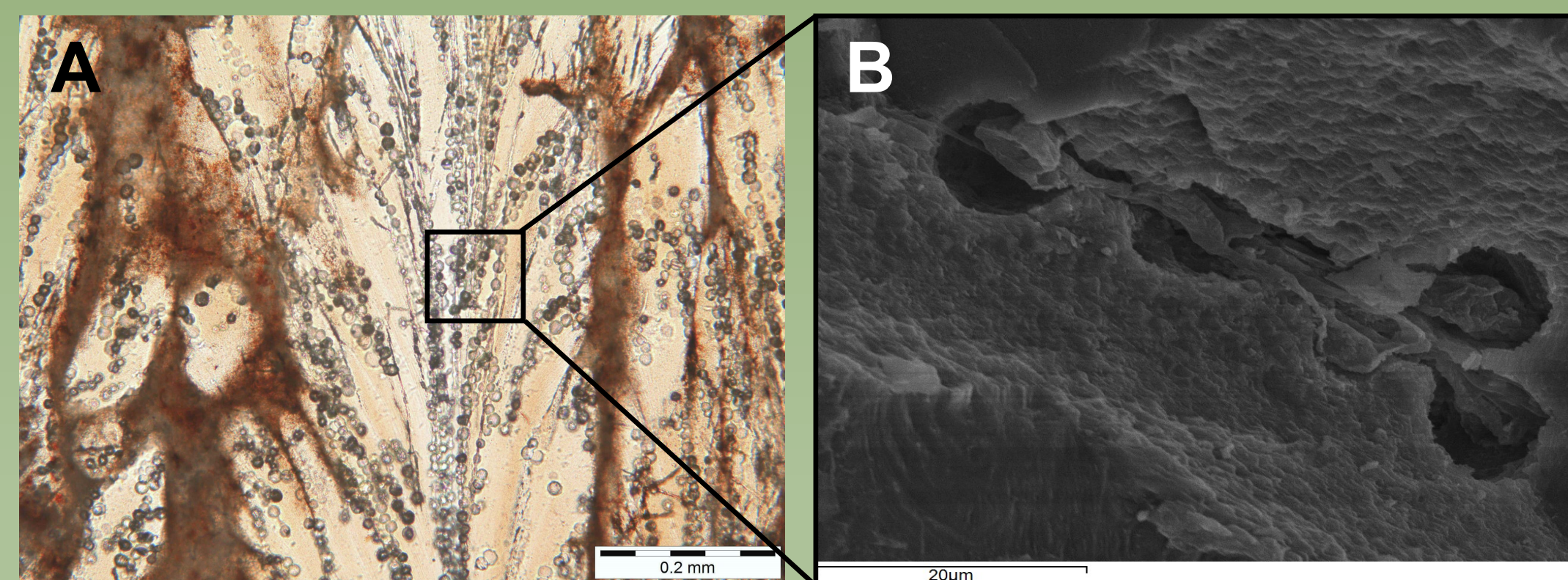


Fig.4: Microbial filaments penetrating fibrous calcite crystals. Image taken with: (A) Petrographic microscope. (B) SEM



Fig.5: Framestone facies composed of plant moulds

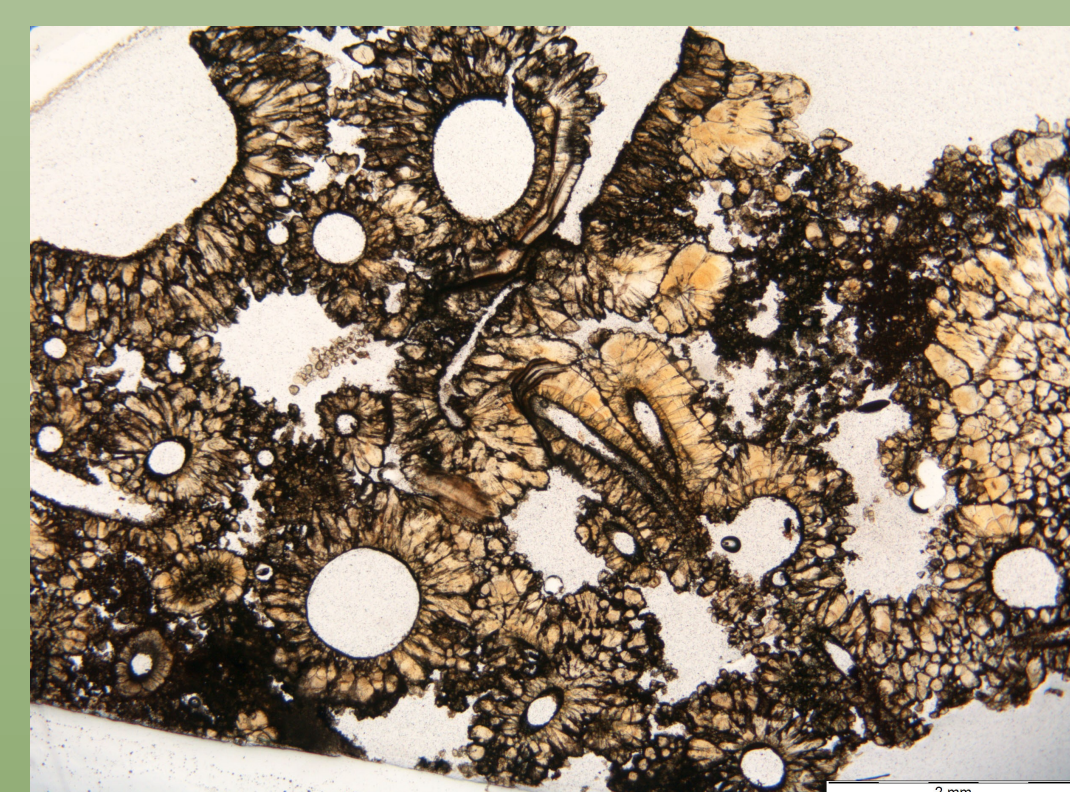


Fig.6: Crystalline-fan morphologies precipitated on plant moulds

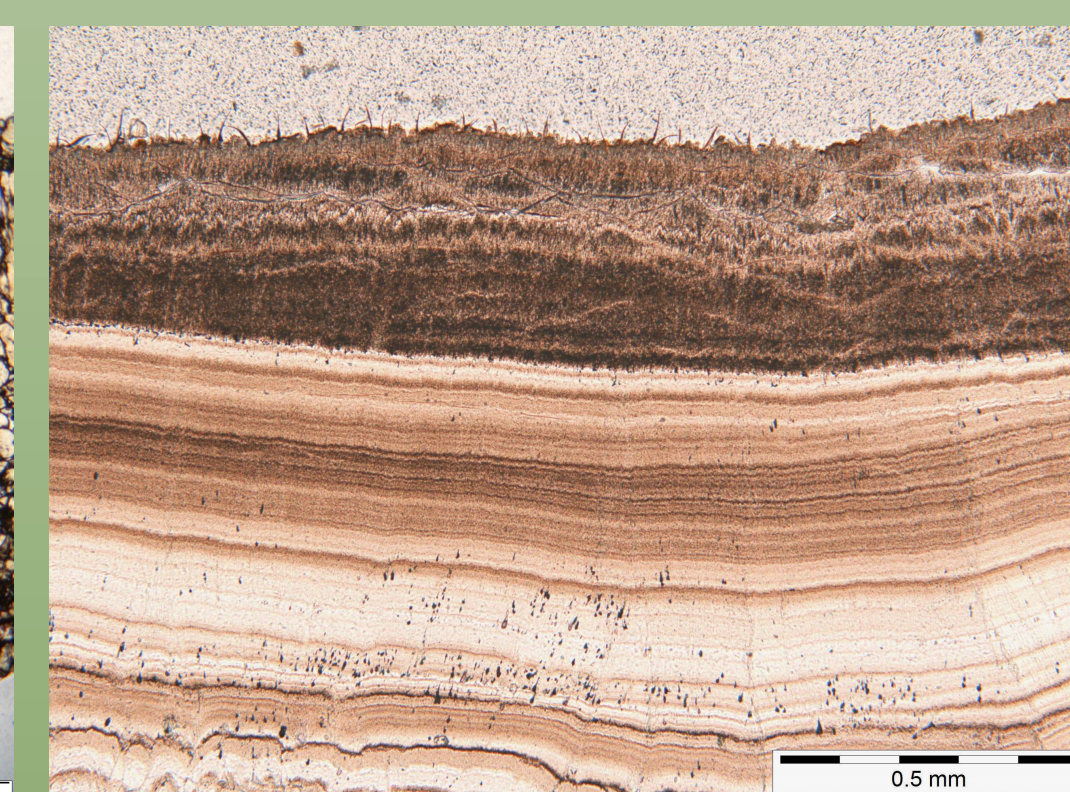


Fig.7: Banded micrite-coarse crystalline facies formed by alternating lamination

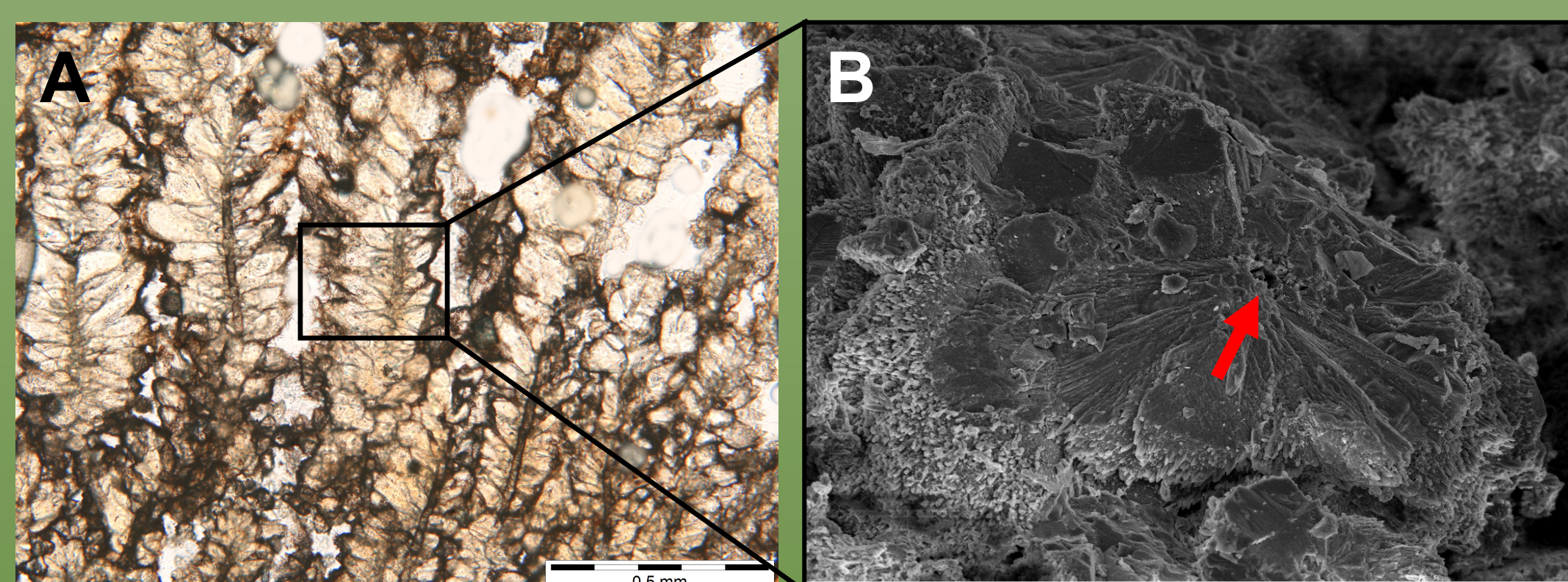


Fig.8: Micrite/microsparitic facies with organic filaments surrounded by calcite crystals. Arrow in Figure B indicates the central hole left by dissolved filament. Image taken with: (A) Petrographic microscope. (B) SEM



Fig.9: EPS (arrow) coating micrite/microsparitic facies

Micritic/microsparitic facies show higher $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ values in comparison with other facies. The small size of the deposit suggest that isotopic variations due to changes in evaporation, water temperature or degassing were probably not significant. Thus, CO₂ removal and subsequent variations mainly in $\delta^{13}\text{C}$ could have occurred due to biological processes (respiration, microbial photosynthesis...) which consume preferably the lighter carbon isotope (¹²C), enriching water and precipitated calcite in the heaviest one (¹³C).

Biogenic and abiogenic processes are intercalated during crystalline calcite growth:

1st stage: Microbial filaments provide a favourable site for calcite nucleation. Slow growth allowed filament not to be completely entombed (Fig.10A, B).

2nd stage: Physicochemical precipitation prevails over biogenic growth due to the increase of the crystallization rate (Fig.10C).

3rd stage: Biogenic micritization occur when microbial filaments perforated crystals, dissolving and micritizing them (Fig.10D).

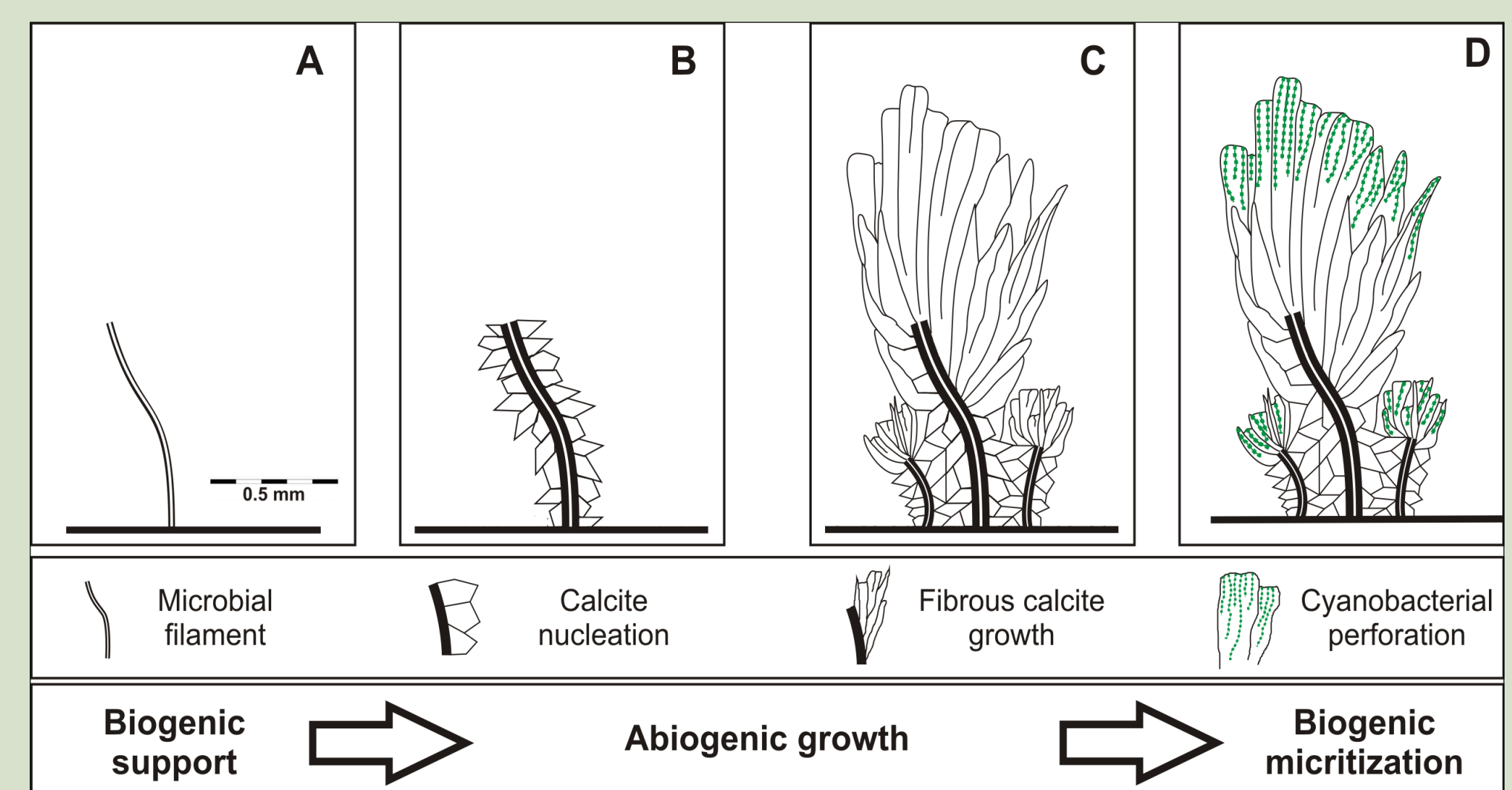
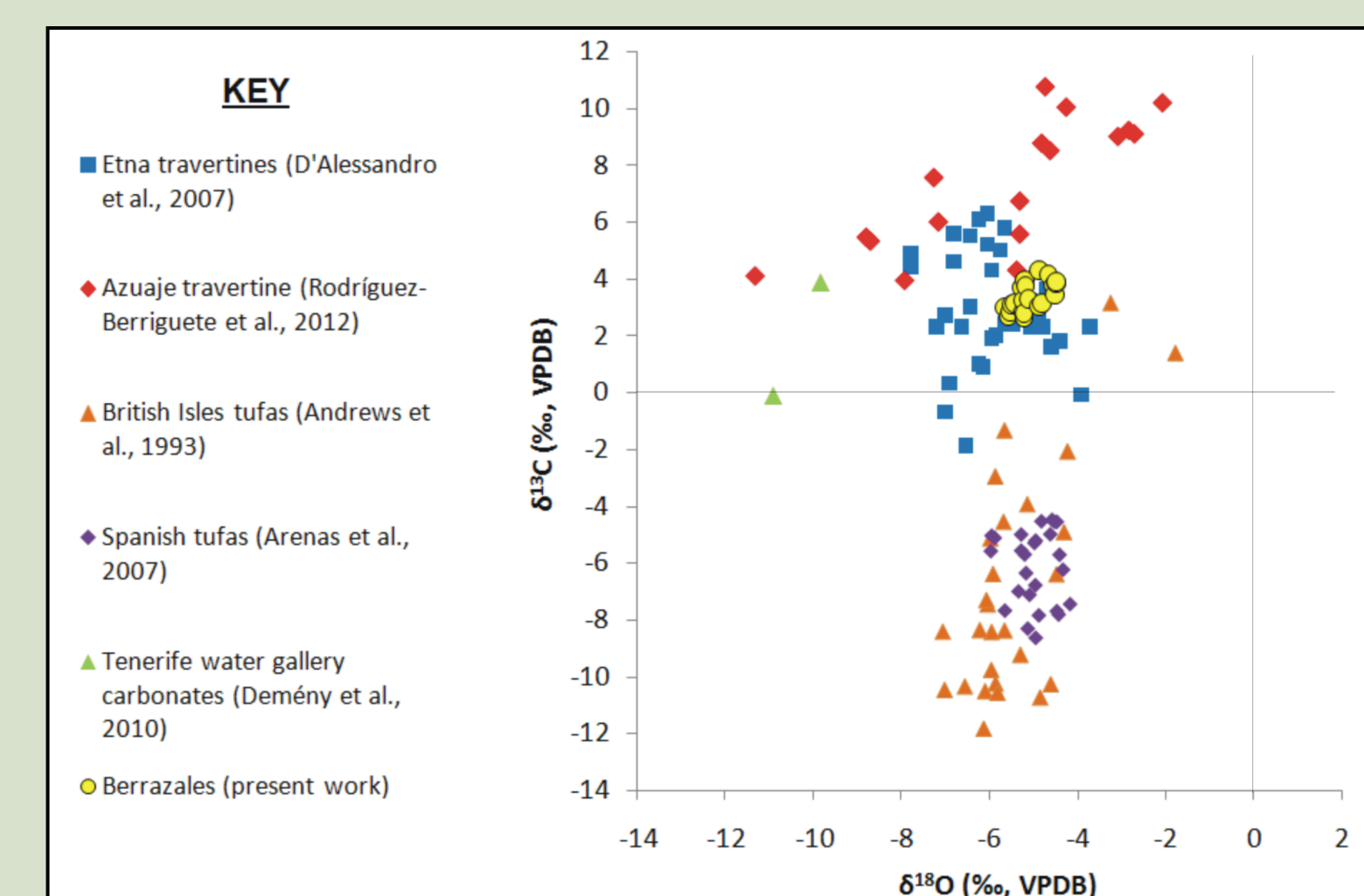


Fig.10: Growth phases of fibrous branching feather or dendrite morphologies. (A) Microbial filament. (B) Sparite nucleating on biogenic support. (C) Abiogenic growth of fibrous calcite crystals. (D) Perforation and micritization of fibrous calcite by microbes

Berrazales carbonate spring deposit is classified as travertine from geochemical point of view and as tufa from textural point of view. Geochemically, positive $\delta^{13}\text{C}$ values (from +2.63 to +4.29‰ VPDB) indicate thermogene-travertine formed from "deep-sourced" fluids. However, from the textural point of view, we can find a lot of plant molds and microbes, characteristic of tufa deposits and precipitated from cold to warm waters (calculated temperature = 20°C to 35°C).



FINAL REMARKS

The study of Berrazales carbonate spring deposit provide a valuable information about thermal water temperature; volcanic CO₂ contribution to thermal water springs; the role of biogenic vs abiogenic processes during and after crystalline growth; and micritization, dissolution and cementation processes. The presence of these type of deposits in Canary Islands is very scarce due to their low preservation potential, so their study can be an aid to understanding the main processes and controls involved in the formation of travertines in volcanic settings, and their palaeo-environmental and palaeo-hydrological significance.