Received: 15 October 2024 | Revised: 21 November 2024 | Accepted: 11 March 2025

DOI: 10.1002/dep2.70011

COMMENTARY

The Depositional Record
A journal of the International Association of Sedimentologists
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Gomes et al. (2024) Early diagenetic evolution based on petrography and stable isotope analysis in the Barra Velha formation of the Brazilian Pre-Salt, *The Depositional Record*

André L. S. Pestilho[1] | **R. Agustin Mors**[1,2]

[1]Institute of Geosciences, University of São Paulo, São Paulo, SP, Brazil

[2]Centro de Investigaciones en Ciencias de la Tierra (CONICET—UNC), Córdoba, Argentina

Correspondence
André L. S. Pestilho, Institute of Geosciences, University of São Paulo, Rua do Lago 562, Butantã, São Paulo, SP 05508-080, Brazil.
Email: andrepestilho@usp.br

KEYWORDS
diagenesis, hydrothermal dolomite, Pre-Salt, Santos Basin

1 | INTRODUCTION

In their recent paper, Gomes et al. (2024) offer a detailed analysis of the mineralogical and diagenetic characteristics of the Aptian Pre-Salt in the Santos Basin. While their work enhances understanding of the Barra Velha formation (BVF), key aspects, especially the genesis and sequence of dolomite phases, require further discussion. This comment addresses their interpretations of dolomite formation, diagenetic timing and isotopic signatures, proposing alternative perspectives to improve comprehension of diagenetic processes.

2 | SADDLE DOLOMITE

All the dolomite described by Gomes et al. (2024) has been interpreted as an early diagenetic phase, formed prior to the deposition of the salt layer. This includes what the authors identify as 'saddle dolomite' (SD). In thin section, SD is typically characterised by its curved crystal faces, curved cleavage planes and undulose extinction (Warren, 2000). However, undulose extinction alone is not a definitive criterion for identifying SD, as it can also occur in other dolomite types, such as nonplanar replacive dolomite, which may exhibit curved boundaries without the presence of curved cleavage planes (Warren, 2000). In Gomes et al. (2024), figure 4D ('saddle dolomite cementation'; Figure 1A) and figure 4H ('saddle dolomite overgrowth'; Figure 1B) show examples of 'saddle dolomite' that lack curved cleavages and distinct curved boundaries. Instead, these examples display only faint curved outlines, especially in the reduced size images. These examples differ from the commonly reported SD in the literature (e.g. Figure 1C–F). Indeed, in the supplementary materials the authors have mentioned post-compactional SD, but they did not present any pictures. In their more detailed characterisation of pre-compactional 'saddle dolomite', they only mentioned a fibrous aspect, forming a 'fringe' around rhombohedral dolomite, although these characteristics are not distinctive of SD (Warren, 2000).

In brief, based on the images presented in Gomes et al. (2024), we suggest an alternative interpretation for authigenic phases: figure 4D displays poor resolution to certainly determine 'saddle dolomite' and the mentioned red square does not seem to match the same fabrics shown in figure 4E,F; figure 4H—the 'saddle dolomite' overgrowth—represents just a carbonate overgrowth, with no clear indication of its composition or any of the distinctive petrographic characteristics of SD.

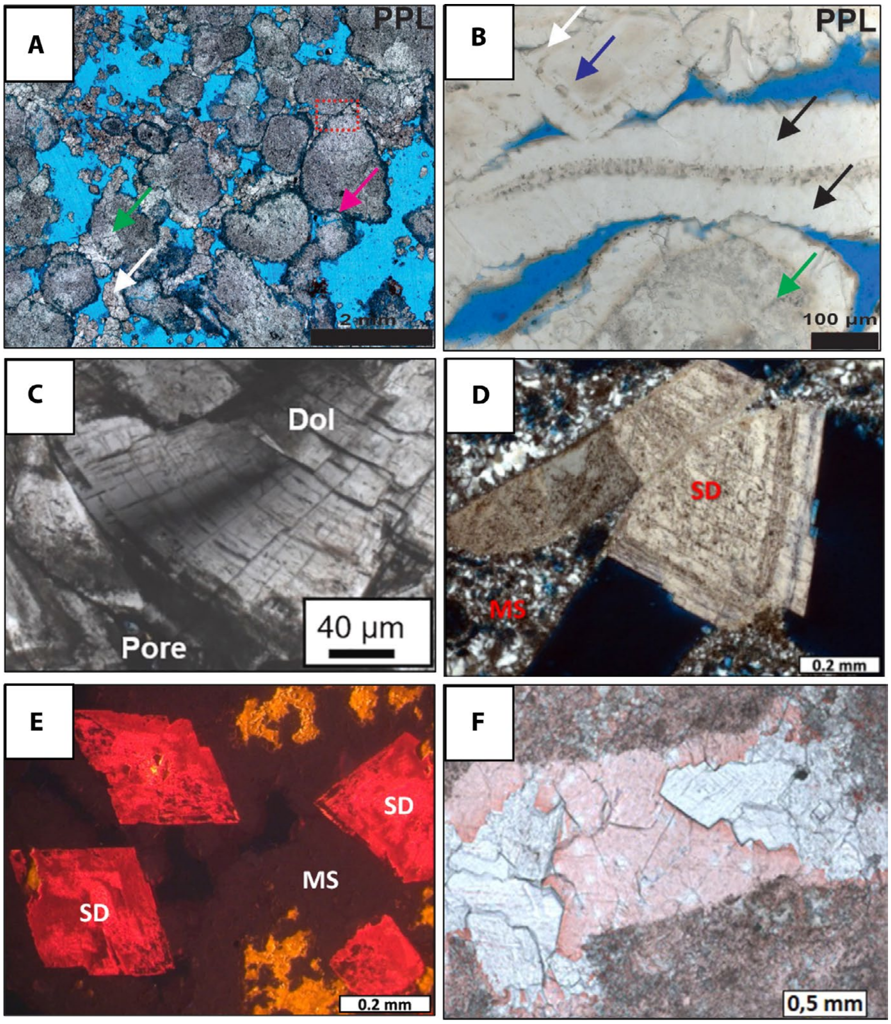

FIGURE 1 (A) 'Intraclastic grainstone with saddle dolomite (SD; white arrow) formed before mechanical compaction (pink arrow)' (figure 4D, Gomes et al., 2024) (PP); (B) 'Detail of Spherulitic shrubstone with rhombohedral (blue arrow), lamellar (black arrow) and replacive (green arrow) dolomites formed before mechanical compaction (pink arrow)' (figure 4H, Gomes et al., 2024) (PP). (C–F) Other examples of SD: (C) Vein from Ponta do Mel Formation, Potiguar Basin (figure 3Q, Pestilho et al., 2021) (PX); (D in PP) and (E in CL): Aptian Pre-Salt in Campos Basin (figure 9F and 11C, Lima & De Ros, 2019); (F) SD and mosaic calcite (red-stained) in the BVF, Santos Basin (figure 8F, Carvalho et al., 2022) (PP). CL, cathodoluminescence; PP, transmitted light/parallel polarisers; PX, transmitted light/crossed polarisers.

3 | TIMING OF DIAGENETIC EVENTS

Gomes et al. (2024) focus exclusively on the early diagenetic history, omitting any discussion of the late diagenetic record of the Santos Basin. Previous studies have described both the early and late diagenetic histories of the Aptian section in the Pre-Salt layers of the Santos (Carvalho et al., 2022) and Campos basins (Lima et al., 2020; Lima & De Ros, 2019; Strugale et al., 2025). Despite being a review paper, Gomes et al. (2024) do not reference a previous work, which outlines the diagenetic evolution of the Aptian interval in the Santos Basin (Carvalho et al., 2022) nor do they contrast their findings and interpretations with previous results on similar diagenetic phases (Lima et al., 2020; Lima & De Ros, 2019). Carvalho et al. (2022) provide an extensive description of late-stage burial dolomitisation and the occurrence of SD, indicating late hydrothermal activity.

Moreover, while early hydrothermal activity during the deposition of the BVF is possible, as demonstrated by the reported travertine facies in other areas of the Santos Basin (Fontaneta et al., 2024), the dolomite cementation presented by Gomes et al. (2024) bears no clear features indicating it formed in shallow depths, and thus could be interpreted as formed later in diagenetic history. Nevertheless, Gomes et al. (2024) suggest that the near-surface hydrothermal activity and dolomitisation happened concomitant to 'meteoric diagenesis' (figure 11; Gomes et al., 2024). We notice that the influx of hydrothermal fluids in such a scenario could have led to boiling and heterogeneous trapping of fluid inclusions (Roedder & Bodnar, 1980); However, no constraints from fluid inclusions were provided. For instance, Lima et al. (2020) have noticed that all fluid inclusions homogenised to a single liquid phase indicating homogeneous trapping, suggesting confining pressure (Roedder & Bodnar, 1980). Furthermore, the fluid inclusions that Gomes et al. (2024) do mention to have found in SD in table S3 of their article could provide an additional temperature and pressure constraint.

Lastly, U–Pb ages reported by Brito et al. (2024) indicate that SDs (97 ± 4 Ma) were formed late in the diagenetic history of the Santos Basin. Although this work was published after Gomes et al. (2024), the work of U–Pb ages is consistent with the earlier article of Carvalho et al. (2022).

4 | INTERPRETATION OF TRENDS IN $\delta^{13}C$ AND $\delta^{18}O$

Trends in $\delta^{13}C$ and $\delta^{18}O$ values were interpreted assuming that all relevant compositions are associated with the depositional environment (Gomes et al., 2024). While it is true that carbon isotope composition is mostly conservative, trends in $\delta^{18}O$ values in cements might have recorded the influence of mesodiagenesis (Lima et al., 2020). As discussed earlier, some minerals indicate an alternative late diagenesis origin; therefore, some negative $\delta^{18}O$ values of dolomite may relate to deep-burial hydrothermal alteration.

Other uncertainty comes from sampling methods. Some of the C and O isotopic data of Gomes et al. (2024) displaying little to no difference between micro-drilling and whole-rock sampling for isotope analysis might indicate mixing of isotope sources. There is no reference in their work as to what drilling method they used and the size of the drilling device. For instance, more than one dolomite/calcite phase is recognised in the 100 μm size range in figures 3 (3J–L; 3N–O) and 4 (4A–C; 4G–I) (Gomes et al., 2024). Other high-resolution methods such as SIMS have shown variability in $\delta^{18}O$ values by comparing them with the bulk analysis of carbonate minerals (De Boever et al., 2022). In addition, calcite recrystallisation might also bring up some changes in $\delta^{18}O$ values (Killingley, 1983). Recrystallisation of spherulites and shrubs has been consistently reported in the Pre-Salt of the Santos Basin (Altenhofen et al., 2024; Rochelle-Bates et al., 2022; Rossoni et al., 2024; Schrank et al., 2024; Tamoto et al., 2024). However, no recrystallisation of calcite has been described in Gomes et al. (2024). In fact, the authors have omitted any description of recrystallisation (Scholle & Ulmer-Scholle, 2003) features of shrubs and spherulites, which are often reported for the Pre-Salt diagenesis. Pictures (e.g. figure 3J–L) from Gomes et al. (2024) suggest that some carbonate recrystallisation took place prior to dolomitisation.

5 | CONCLUSION

Recent studies on the Pre-Salt rocks of the Santos and Campos basins have revealed a complex and diverse diagenetic history. While the article by Gomes et al. (2024) provides valuable new data and insights into the early diagenetic evolution of the BVF, a thorough evaluation and comparison with previous research and the full diagenetic history should be addressed in a review paper to validate the interpretations presented in their study.

ACKNOWLEDGEMENTS

We thank Ricardo Astini for his insights. R.A.M. thanks Lena V.S. Monteiro and Caetano Juliani for the opportunity to delve into these topics through a postdoctoral fellowship.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

ORCID

André L. S. Pestilho https://orcid.org/0000-0002-5497-4236
R. Agustin Mors https://orcid.org/0000-0001-6261-5965

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How to cite this article: Pestilho, A.L.S. & Mors, R.A. (2025) Gomes et al. (2024) Early diagenetic evolution based on petrography and stable isotope analysis in the Barra Velha formation of the Brazilian Pre-Salt, *The Depositional Record*. *The Depositional Record*, 00, 1–4. Available from: https://doi.org/10.1002/dep2.70011