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ex solo ad solem, वसुधैव कुटुम्बकम्
ex solo ad solem, Vasudhaiva Kutumbakam
from the earth to the sun, the world is one family

Microscale Controls on Reservoir Quality: Compaction, Cementation and Dissolution in Kwahu-Bombouaka Group, Volta Sedimentary Basin, Ghana.

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BACKGROUND

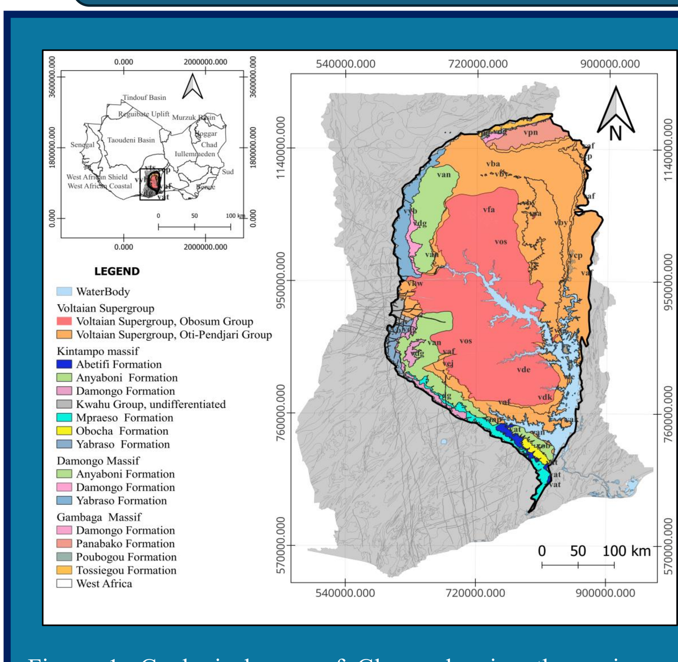

Figure 1. Geological map of Ghana showing the various formations within the Voltaian sedimentary basin (Highlighted in colour).

This study characterizes diagenetic features in the Kwahu-Bombouaka Group sandstones, evaluating how compaction, cementation, and dissolution jointly control reservoir quality to inform future petroleum exploration in the basin.

- **Reservoir quality (porosity/permeability) is controlled by post-depositional diagenesis**, with compaction, cementation, and dissolution recognized as the dominant processes shaping pore systems in siliciclastic reservoirs *(Bjørlykke, K., & Jahren, J. (2012)*.
- **The Voltaian Basin** is a large underexplored Neoproterozoic–Early Paleozoic intracratonic basin covering ~45% of Ghana and extending into neighbouring countries, hosting sedimentary successions deposited under tectonically stable conditions *(Affaton et al., 1990; Anani et al., 2017)*.
- Prior work has addressed its stratigraphy, sedimentology, and provenance within the Basin, but diagenesis especially, microscale diagenetic controls on reservoir quality remain poorly studied *(Zobah et al., 2022)*.
- **The Kwahu–Bombouaka Group** comprises texturally mature, quartz-rich sandstones with minor mudstones and conglomerates, deposited in fluvial-to-shallow-marine settings, and their high textural maturity and lateral continuity make them well suited for evaluating diagenetic evolution and reservoir quality *(Coueffe & Vecoli, 2011)*

STUDY AREA

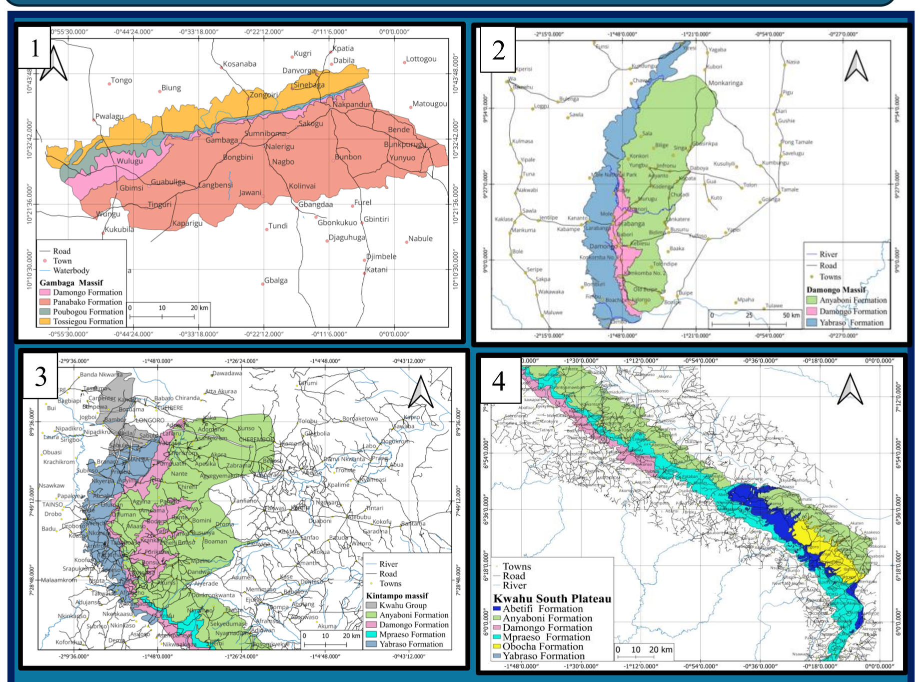

Figure 4. Map of the Voltaian sedimentary basin (GNPC, 2021) showing the maps of the four massifs where systematic field sampling was performed. Gambaga massif (top right-hand); Damongo massif (top left-hand); Kintampo Massif (lower left-hand) and Kwahu-South Plateau (lower right-hand).

STRATIGRAPHY

Table 1.Proposed lithostratigraphical scheme from Carney et. al., 2010 with inferred age and correlations.

	Carney et. Al., 2010		Inferred Age & Correlation		
MAJOR UNCONFORMITY					~700 MA
SOUTH & WEST	KWAHU GROUP			TONIAN	
	Anyaboni Sandstone Formation				
	Obocha Sandstone Formation	PANABAKO	EARLY NEOPROTEROZOIC		
	Abetifi Sandstone Formation				
	Mpraeso Sandstone Formation				
	Damongo Formation				
	Yabraso Sandstone Formation				
	Undivided Kwahu Group				
NORTH	BOMBOUAKA GROUP				
	Panabako Sandstone Formation		LATE MESOPROTEROZOIC?	STENIAN	
	Damongo Formation				
	Poubogou Formation				
	Tossiegou Sandstone Formation				~1100 MA
ABOVE STRATA UNCONFORMABLE UPON PALEOPROTEROZOIC BASEMENT					

CONTROLS ON RESERVOIR QUALITY

Compaction

Primary cause of reservoir quality degradation, reducing primary porosity and permeability through grain rearrangement, deformation and pressure solution.

Cementation

Decreases reservoir quality by filling pore spaces and blocking pore throats, although early cementation may locally preserve the grain framework against compaction.

Dissolution

Enhances reservoir quality by generating secondary porosity and enlarging pore networks, improving fluid storage and flow where pores are interconnected.

METHODOLOGY

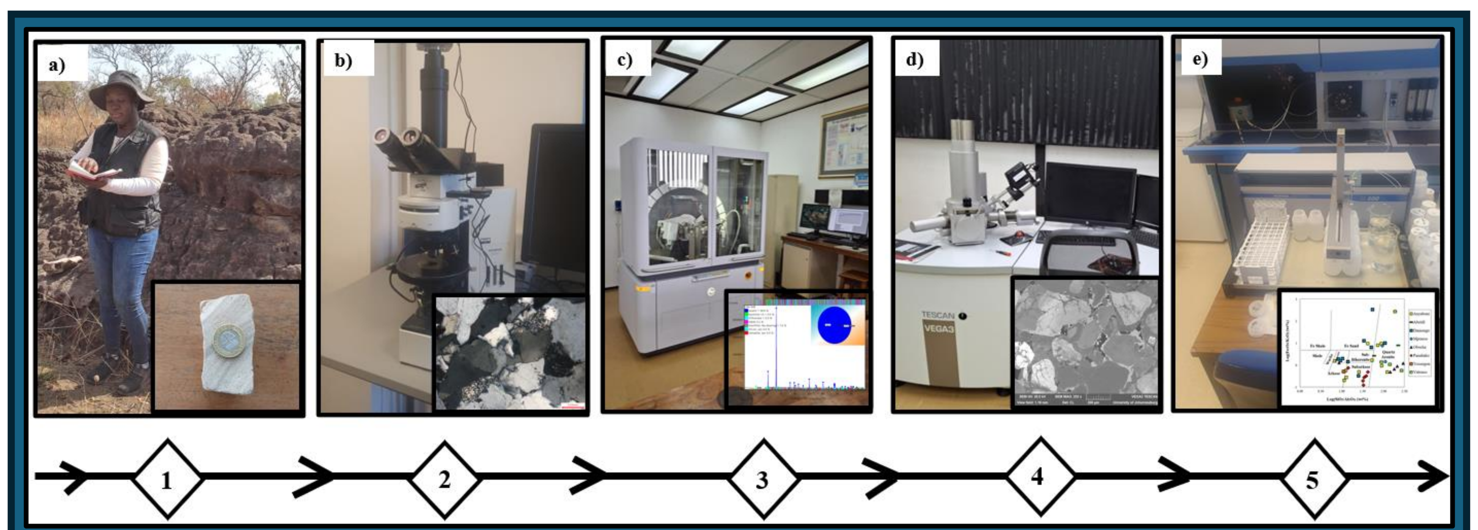

Figure 2. Photographic summary of the methodology adopted in this study, illustrating the sequential stages of the workflow. Field sampling across selected areas (1) and sample preparation including cutting, mounting thin section preparation; petrographic analysis under transmitted light microscopy (2) and X-Ray diffraction analysis (3) for mineralogical, modal and textural characterization; (4) microtextural analysis using Scanning Electron Microscopy equipped with Cathodoluminescence imaging; (5) Geochemical analyses conducted to determine major and trace element composition.

RESULTS : CEMENTATION

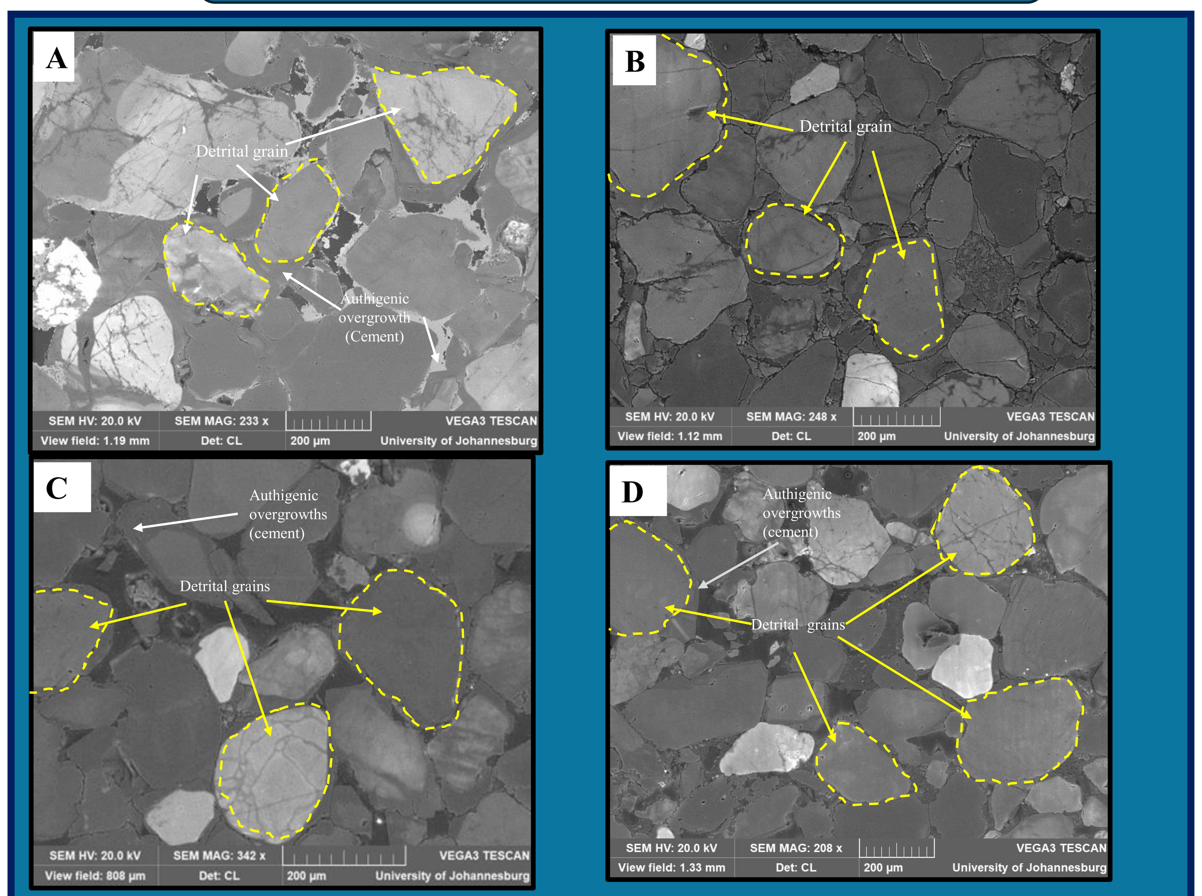

Figure 5. SEM (CL) images of A. KM-31A from the Damongo formation in the Kintampo-North Massif; B. KM-81 from the Abetifi formation of the Kwahu-South plateau; C. DM-04B from the Yabraso formation of Damongo Massif; and E. DM-09 from the Anyaboni formation of the Damongo Massif. These images show silica cementation existing as quartz overgrowths and pore-filling cements. These cementing materials occlude intergranular pores and narrow pore throats, reducing porosity and permeability. Cementation enhances framework stability but is a major microscale control responsible for progressive deterioration of reservoir quality.

RESULTS: CLASSIFICATION

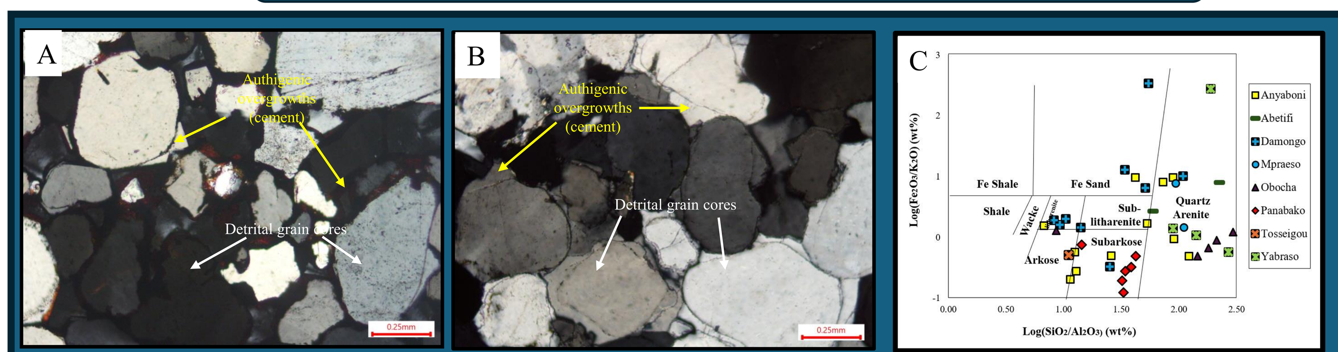

Figure 3. Photomicrographs of (A) Fe-sandstone (KM-57) from the Yabraso formation, Kintampo-North Massif, and (B) quartz arenite showing signs of silica and ferrous oxide cementation as microscale controls on the reservoir quality of these sandstones. C. Geochemical classification based on log (Fe_2O_3 / K_2O) vs log ((SiO_2 / Al_2O_3) diagram of Herron, 1988. Coloured symbols represent the various samples.

RESULTS: COMPACTION

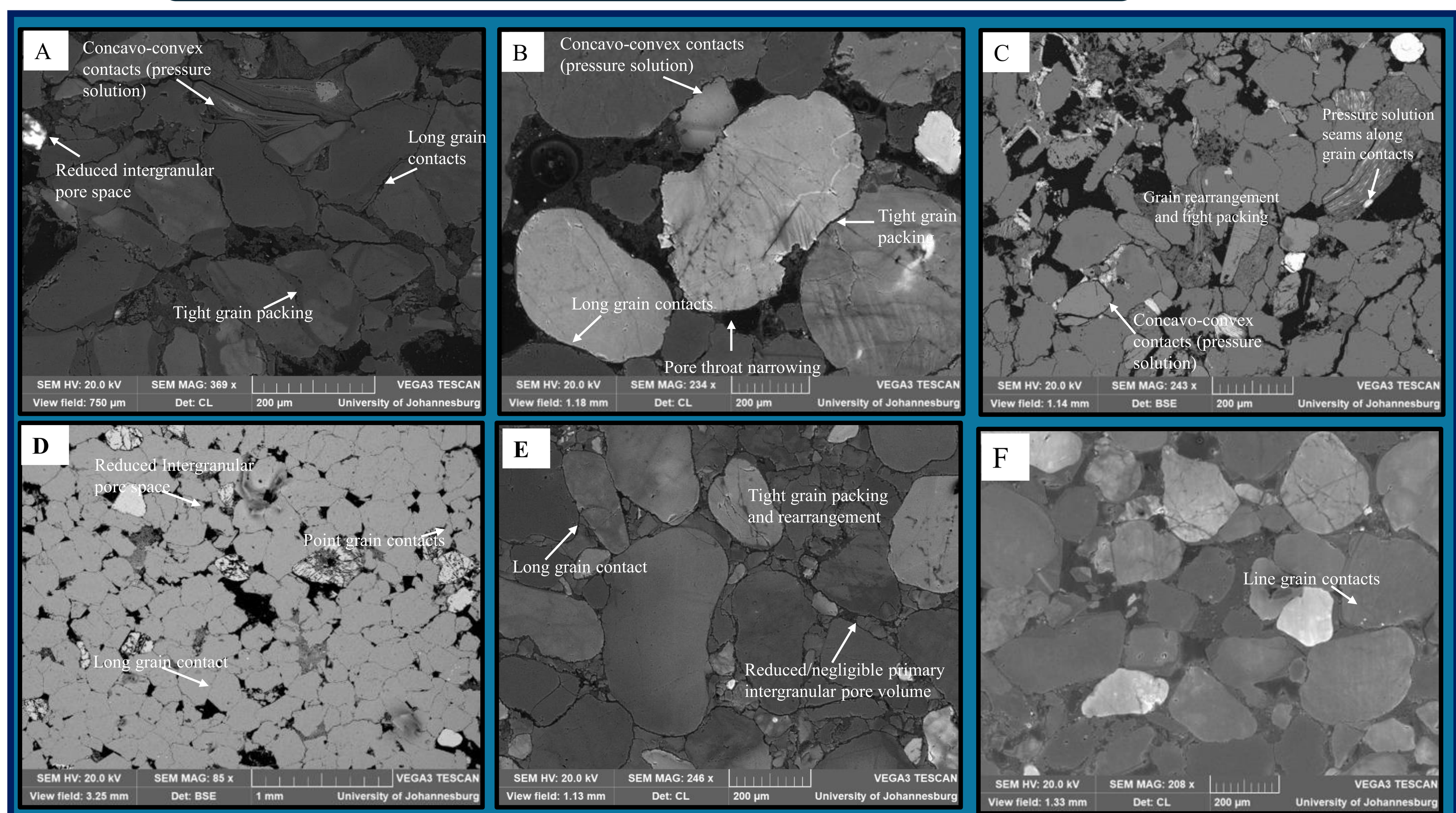

Figure 3. A. SEM(CL) image of a quartz–rich sandstone (VO-4) from the Panabako formation showing significant mechanical compaction followed by chemical compaction (pressure solution). B. SEM (BSE) image showing textural evidence of chemical compaction (pressure solution) and narrow pore throats showing pore reduction in a quartz-rich sandstone (KM-64) from the Mpraeso Formation. C. SEM (BSE) image of a quartz-rich sandstone (KM-30) from Damongo formation showing both mechanical and chemical compaction. D. SEM (BSE) image of VO-18 from the Panabako formation . E. SEM(CL) image of KM-81 from the Abetifi Formation. F. SEM (CL) image of a quartz-rich sandstone (DM-09) from the Anyaboni formation showing lower degrees of mechanical and chemical compaction with little to no tight grain packing and varying detrital grain shapes.

RESULTS: DISSOLUTION

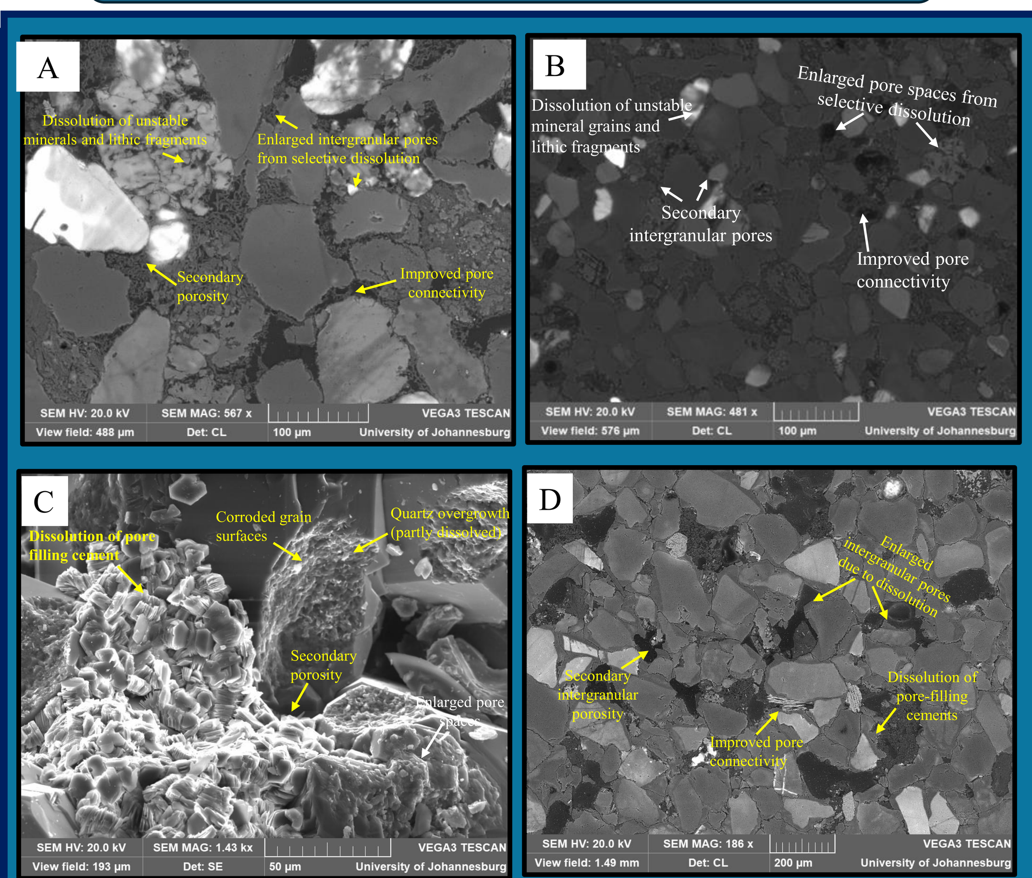

Figure 6. SEM(CL) images of (A) KM-40 from Anyaboni formation of the Kintampo-North Massif, (B) and (D) DM-27 from the Damongo formation of the Damongo Massif showing selective intragranular dissolution of feldspars. C. SEM(SE) image of DM-04B from the Yabraso formation within the Damongo massif showing dissolution features of pore-filling cement and unstable minerals has produced secondary porosity, enlarged pore spaces and corroded grain surfaces. Dissolution of unstable mineral grains, lithic fragments and pore-filling cements has generated secondary intergranular porosity.

CONCLUSIONS

- Mechanical compaction is the dominant diagenetic process controlling reservoir quality within the sandstones of this study area, causing substantial reduction in primary porosity and permeability.
- Localized dissolution is the principal porosity-enhancing diagenetic process on microscale, creating secondary pore networks that can significantly improve reservoir quality, provided these pores are not subsequently occluded by cementation.
- In the Kwahu-Bombouaka Group, quartz (i.e. overgrowths) and clay cementation is the principal control on porosity reduction by pore occlusion and restriction of pore-throat connectivity, although its effect may be offset locally by dissolution that creates secondary porosity.
- The interplay between compaction, cementation and dissolution governs the heterogeneity and overall reservoir quality of the Kwahu-Bombouaka Group sandstones.

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Structural Geology in a Changing World: Tectonics, Resources and Sustainable Transitions