IOCMS 2026 Conference
The 3rd International Online Conference on Mineral Science
10–12 March 2026 | Online
MDPI

Effect of Sintering Atmosphere on the Densification and Phase Transformation of Binary Lanao Red Clay-Black Cinder Ceramic Bodies

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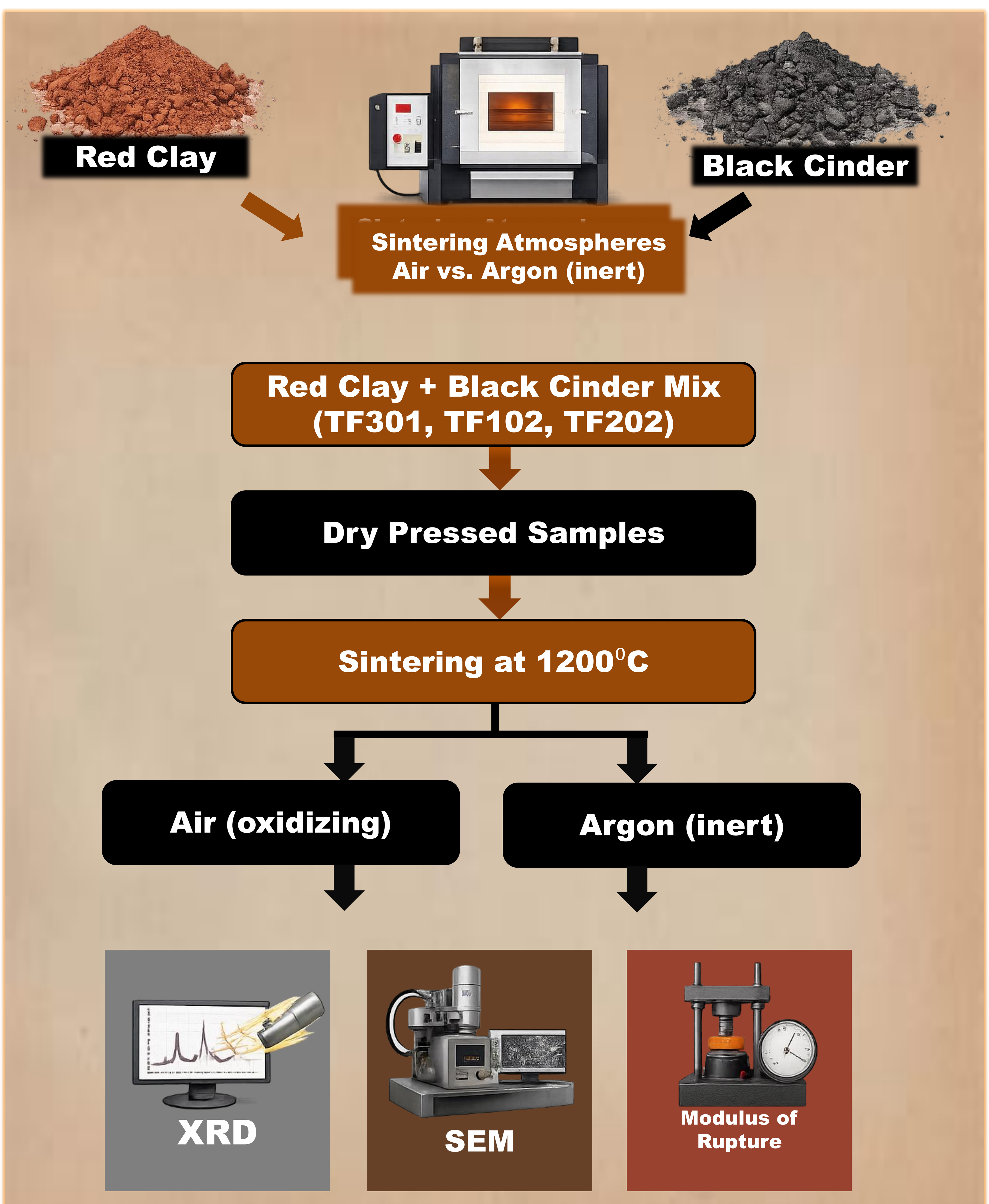
INTRODUCTION & AIM

Ceramic production involves several processing stages, among which sintering plays a critical role in determining the final properties of ceramic materials. The sintering atmosphere can significantly influence densification and phase transformations, which directly affect the microstructure and performance of the resulting ceramic body. Red clay and black cinder are iron-rich silicate resources abundant in Lanao del Norte, Philippines, and show potential as raw materials for ceramic production [1,2]. This study aims to investigates the effect of sintering atmosphere on the densification and phase transformation of binary red clay–black cinder ceramic compositions.

METHOD



RESULTS & DISCUSSION

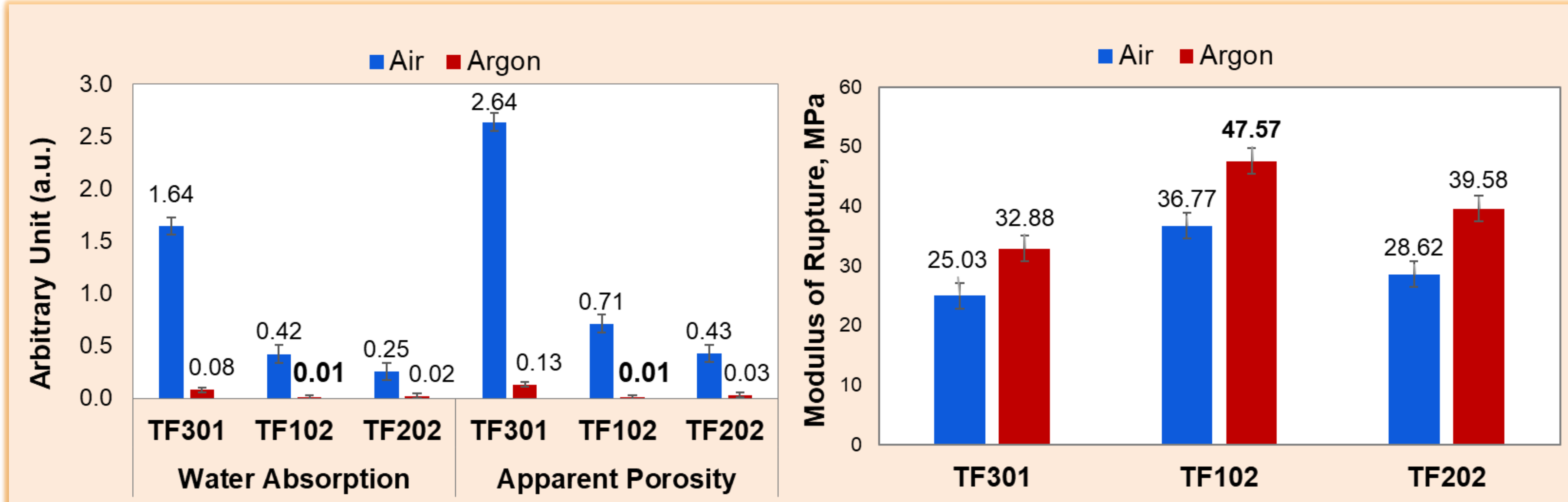


Figure 1. Water absorption, apparent porosity and modulus of rupture (MOR) of red clay-black cinder bodies sintered under air or argon atmosphere.

In Figure 1, argon-sintered samples exhibited significantly lower water absorption and apparent porosity compared with air-sintered samples, indicating improved densification under an inert atmosphere. Among the formulations, **TF102** showed the lowest water absorption and porosity (0.01 ± 0.22) and the highest modulus of rupture, demonstrating superior mechanical performance. These results suggest that the argon atmosphere promotes enhanced densification and strength in red clay–black cinder ceramic bodies.

The XRD analysis of air-sintered samples revealed tridymite, mullite, hematite, cristobalite, and labradorite, indicating the formation of silica polymorphs and aluminosilicate phases at 1200 °C. SEM images show an uneven surface with visible pores, suggesting incomplete densification. These microstructural features are consistent with the higher water absorption and porosity observed in air-sintered samples [3,4].

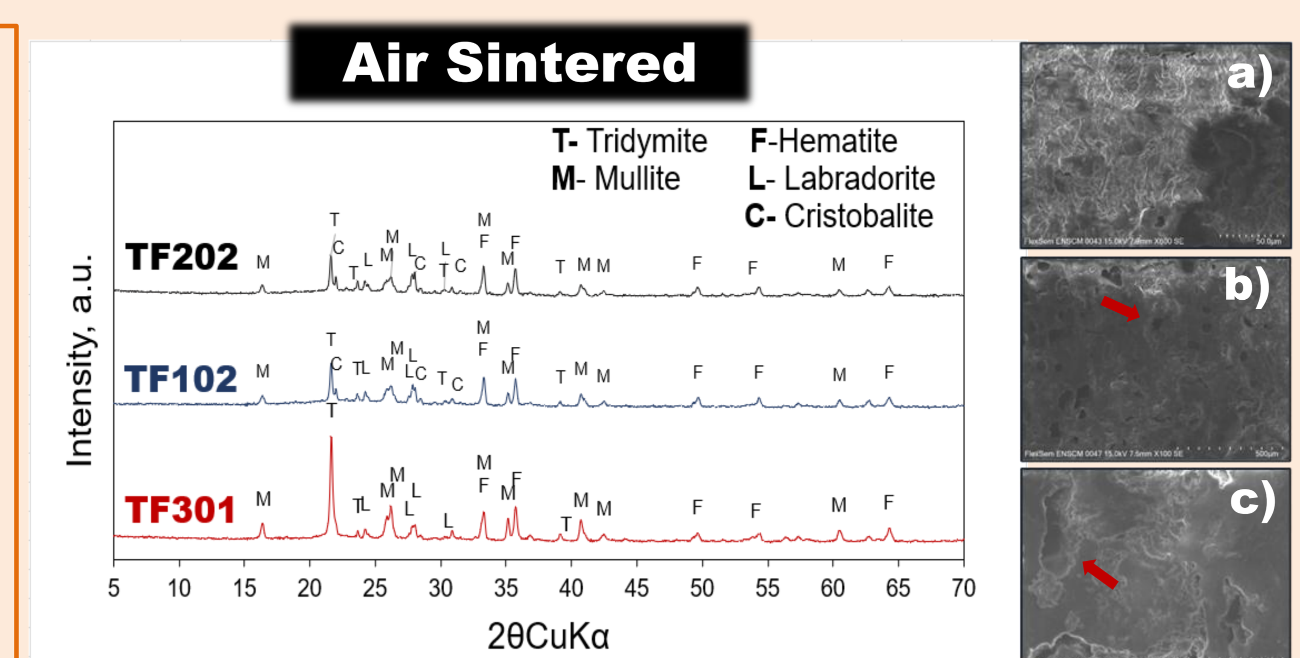


Figure 2. XRD patterns and corresponding SEM micrographs of red clay–black cinder ceramic bodies: (a) TF301, (b) TF102, and (c) TF202, sintered at 1200 °C under an air atmosphere.

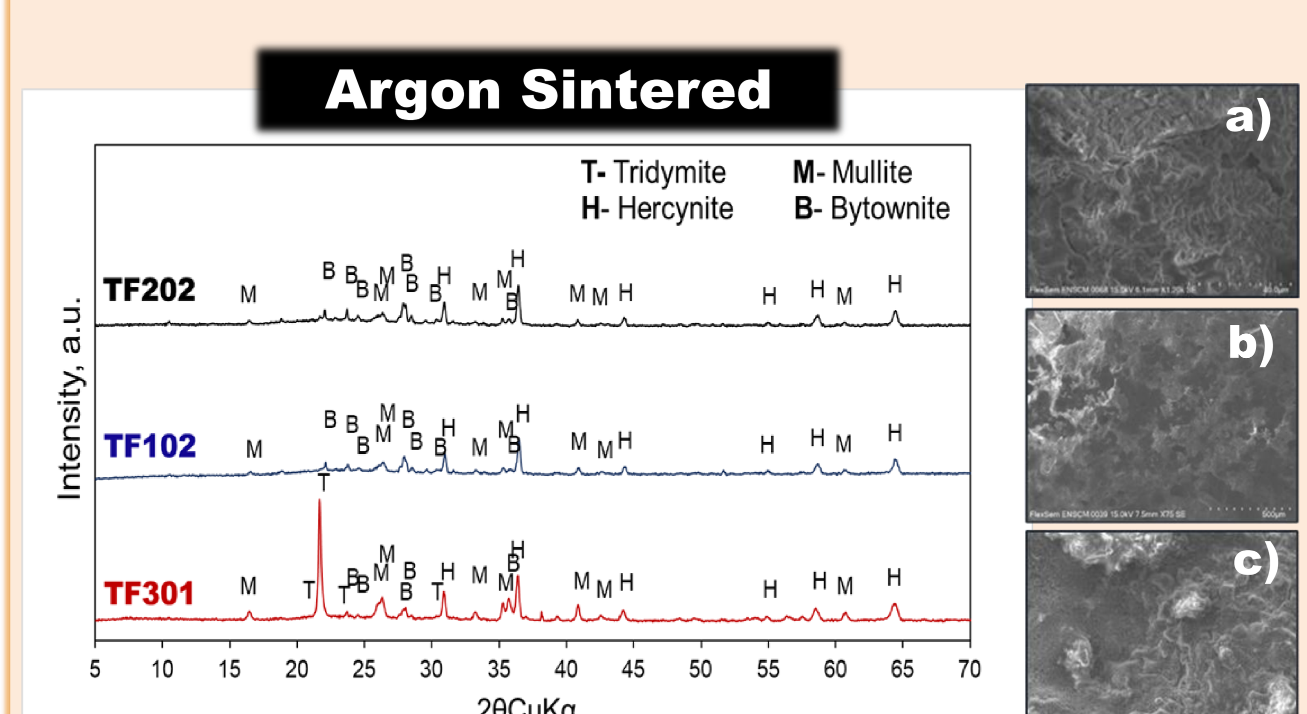


Figure 2. XRD patterns and corresponding SEM micrographs of red clay–black cinder ceramic bodies: (a) TF301, (b) TF102, and (c) TF202, sintered at 1200 °C under an argon atmosphere.

Argon-sintered samples showed the formation of tridymite, mullite, hercynite, and bytownite phases. The presence of hercynite ($FeAl_2O_4$) indicates reduction reactions involving iron-bearing phases under an inert atmosphere. SEM observations reveal a denser microstructure with reduced porosity, which explains the improved densification and higher mechanical strength of argon-sintered samples [3,5].

CONCLUSION

The sintering atmosphere significantly influences the densification, phase formation, and mechanical properties of red clay–black cinder ceramic bodies. Argon sintering promoted the formation of hercynite and produced a denser microstructure, resulting in lower water absorption and porosity and higher modulus of rupture. Among the formulations, TF102 exhibited the best overall performance, indicating strong potential for high-strength ceramic applications.

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