

From Local Resource to Advanced Material: Philippine Talakag Clay as an Emerging Additive for Ceramic Manufacturing

Grandeur V. Paglinawan II¹, Lori-Ann I. Cabalo², Eduardo Magdaluyo Jr.³, Julie Bourret⁴, Raymond V. Rivera-Virtudazo¹

¹Advanced Porous Ceramic Particles (APCerP) Lab., Ceramic Research for Engineering Advanced Technology & Environment (CREATE) Lab, Research Center for Advanced Ceramics (RCAC), Research Institute for Engineering and Innovative Technology (RIEIT), Mindanao State University – Iligan Institute of Technology, Iligan City 9200, Philippines

²Department of Materials and Resources Engineering and Technology, College of Engineering and Technology, Mindanao State University – Iligan Institute of Technology, Iligan City 9200, Philippines

³Department of Mining, Metallurgical and Materials Engineering, College of Engineering, University of the Philippines Diliman, Quezon City 1101, Philippines

⁴Institut de Recherche sur les Céramiques (IRCER), UMR 7315 CNRS, Centre Européen de la Céramique, Université de Limoges, Limoges 87068, France

INTRODUCTION

Ceramic additive manufacturing (AM), particularly extrusion-based 3D printing, is gaining increasing attention for its ability to fabricate complex and customized ceramic structures. However, most current systems rely on commercially prepared and pre-formulated ceramic pastes, which are costly and often optimized for industrial settings rather than local resource utilization [1].

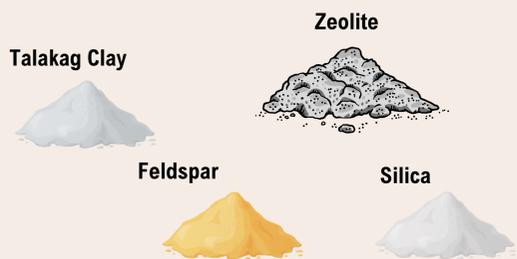


Production Cost

Sustainability

However, the development of printable ceramic formulations remains challenging due to strict requirements in rheological behavior, particle packing, and thermal stability [2]. Many studies rely on commercially refined powders, which increase production cost and limit sustainability.

The Philippines possesses abundant natural mineral resources such as Talakag clay from Bukidnon, yet their potential for advanced ceramic additive manufacturing remains largely unexplored.



This study investigates the feasibility of utilizing locally sourced Talakag clay, blended with zeolite, silica, and feldspar, as a sustainable and cost-effective material system for extrusion-based 3D printing of ceramic structures.

METHOD



RESULT AND DISCUSSION

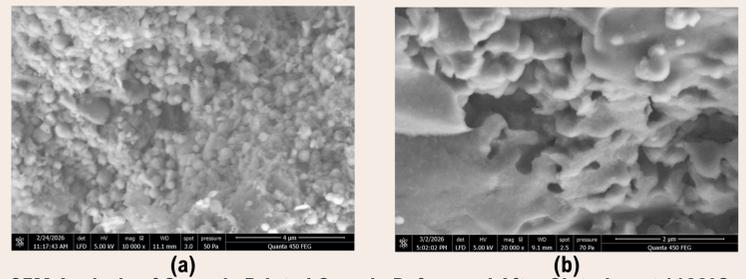


Figure 1. SEM Analysis of Ceramic Printed Sample Before and After Sintering at 1100°C x10,000 Magnification (a) Before (b) After

Before sintering, the printed sample shows loosely packed particles with high porosity and limited neck formation. After sintering at 1100 °C, enhanced particle bonding, neck growth, and reduced pore size are observed, resulting in a denser and more homogeneous microstructure. These changes confirm effective solid-state densification and improved structural integrity of the 3D-printed ceramic.

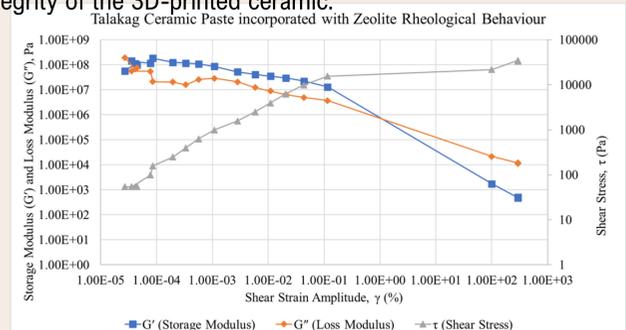


Figure 2. Rheological Behaviour of Ceramic Paste incorporated with Zeolite

The Talakag clay–zeolite ceramic paste exhibited dominant elastic behavior at low shear strain ($G' > G''$), indicating a stable and well-structured internal network suitable for shape retention after extrusion. As shear strain increased, both G' and G'' decreased, demonstrating shear-thinning behavior essential for smooth extrusion during printing. The crossover point at higher strain amplitude marks the transition from solid-like to flowable behavior, confirming good printability and structural recovery. Overall, the rheological response validates the paste formulation for extrusion-based 3D printing applications.

CONCLUSION

The Talakag clay–zeolite composite demonstrated suitable rheological behavior characterized by elastic dominance and shear-thinning response, enabling smooth extrusion and stable layer deposition at 3–3.5 bar. The optimized 71% solid-loaded paste exhibited good plasticity, dimensional accuracy, and structural stability after printing.

SEM analysis further revealed significant microstructural evolution after sintering at 1100 °C, showing enhanced particle necking, reduced porosity, and improved densification, resulting in a more compact and homogeneous ceramic matrix.

Overall, these results confirm the feasibility of utilizing locally sourced Talakag clay as a sustainable and cost-effective material for extrusion-based 3D ceramic additive manufacturing.

FUTURE WORKS / REFERENCES

[1] Duan, L., Bai, M., Xiao, N., Zhang, L., Wang, H., Wu, Y., ... & Ming, W. (2026). A review of recent advances in ceramic 3D printing technologies. *Journal of Manufacturing Processes*, 157, 1091-1122.

[2] Jiří Rozbroj, David Žurovec, Jakub Hlosta, Michaela Topinková, Hana Ovčáčíková, Jan Diviš, Kamila Pokorná, Jan Nečas, Jiří Zegzulka, Rheological characterization of clay–refractory waste composites for direct ink writing of ceramic structures, *Open Ceramics*, Volume 24, 2025, 100850, ISSN 2666-5395, <https://doi.org/10.1016/j.oceram.2025.100850>.