

## **PREDICTIVE COLOR ASSESSMENT OF PRE HEAT-TREATED GEUDA USING RAMAN SPECTROSCOPIC ANALYSIS**

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The gemstone industry faces significant challenges in predicting the final color outcome of heat-treated Geuda stones (low-grade corundum), leading to substantial financial risks due to subjective visual grading methods. This study presents a breakthrough solution using advanced machine learning techniques applied to pre-treatment spectroscopic data from 140 Geuda stones with varying internal characteristics. Our proprietary analytical framework successfully addresses the challenges of limited sample sizes and data complexity in gemological applications. The developed predictive model demonstrates exceptional performance, achieving 98.5% accuracy in predicting final colour grades using only pre-treatment spectroscopic signatures, with precision, recall, and F1 scores all exceeding 98%. Results were benchmarked against traditional GIA colour grading. Comparative analysis highlights that, while inexperienced graders and at times even experienced gemologists cannot consistently predict the correct heat-treatment outcomes, the proposed model provides reliable and objective predictions, directly addressing this long-standing industry challenge. Beyond prediction, this research provides new insights into spectroscopic signatures associated with colour development, identifying key features that correlate with successful blue sapphire formation. The practical implications are substantial: gemstone traders and processors can now make informed decisions about which Geuda stones to heat treat, significantly reducing financial risk and maximizing value recovery. This objective assessment tool eliminates guesswork in traditional evaluation, providing the industry with a scientific foundation for commercial decision-making whilst maintaining the precision required for high-value applications.

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