Monitoring the Corrosion Deterioration Rate and Evaluating the Conservation Effectiveness of an Iron Stirrup Excavated in Liaoning Province, China: Application of MA-XRF, Oxygen Consumption Measurement, and In-situ EIS

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Abstract In recent years, the techniques for evaluating the stability and conservation effectiveness of iron artifacts have progressively evolved from non-in situ, localized, destructive, and qualitative methods to in-situ, comprehensive, non-destructive, and quantitative approaches. This study utilized Macro X-ray Fluorescence (MA-XRF) scanning imaging, oxygen consumption measurement, and in-situ electrochemical impedance spectroscopy (EIS) techniques to monitor the corrosion deterioration rate and assess the conservation effectiveness of an iron stirrup excavated in Liaoning Province, China at various stages before and after conservation treatment.

MA-XRF scanning imaging provided insights into the distribution of elements on the artifact's surface, which is crucial for determining the necessity of desalination and for guiding targeted sampling analyses; it also reflected the effectiveness of desalination treatment. The oxygen consumption measurement method monitored the overall corrosion rate of the artifacts under certain environmental conditions, with changes in the corrosion rate across different conservation stages indicative of the treatment's effectiveness. The in-situ EIS characterized the corrosion behavior of the artifact's surface in real-time, allowing for the evaluation of the mechanisms and effectiveness of corrosion inhibitors and coatings.

The combined analytical results indicated that the iron stirrup was severely corroded, with rust layers rich in chlorides, exhibiting typical active corrosion such as "weeping" and the presence of akaganeite. Following conservation treatments including rust removal, desalination, inhibition, and coating, the corrosion rate of the iron stirrup gradually decreased, their stability significantly improved, and the effectiveness of the conservation treatments was markedly demonstrated.

Keywords iron artifacts conservation, corrosion rate, conservation effectiveness, MA-XRF, oxygen consumption, in-situ EIS

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