

# Unveiling the Chemistry of Scale Deposits: Insights from Microscopy Analysis

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## Summary

In the oil and gas industry, scale refers to the deposition of mineral deposits, such as calcium carbonate, barium sulfate, iron sulfide, or other amorphous compounds on the inner surfaces of pipelines or storage tanks. Scale can form when the produced fluids contain dissolved minerals that precipitate out as the fluid flows through the pipeline or settle within tanks. Scale deposition can lead to reduced flow rates, increased pressure drop, and ultimately, pipeline blockages.

The scale formation process can be divided into three stages: nucleation, crystal growth, and scale deposition. Nucleation occurs when the dissolved minerals reach a critical concentration and form solid particles. These particles then grow in size through crystal growth, which is influenced by factors such as temperature, pressure, and fluid chemistry. Finally, the solid particles can adhere to the pipeline surface and form a scale deposit.

To mitigate scale formation and its negative effects, the oil and gas industry employs various techniques:

1. **Chemical Inhibition:** Chemical inhibitors are added to the fluid to prevent scale formation. These inhibitors work by either reducing the nucleation rate or modifying the crystal growth kinetics. Common inhibitors include phosphonates, polyphosphates, and organic acids.
2. **Mechanical Cleaning:** Mechanical methods, such as pigging and scraping, are used to physically remove scale deposits from the inside of pipelines. Pigging involves inserting a device called a pig into the pipeline and using the fluid flow to push it along, scraping off scale deposits in the process.
3. **Chemical Cleaning:** Chemical cleaning involves the use of acids or other chemicals to dissolve scale deposits. This method is typically used for severe cases of scale buildup and requires careful handling to prevent damage to the pipeline.
4. **Scale Prediction and Monitoring:** Advanced modeling and monitoring techniques are used to predict scale formation and monitor its growth in real-time. This allows operators to take proactive measures to prevent scale deposition before it becomes a problem.

## Method

SEM elemental mapping, also known as scanning electron microscope elemental mapping, is a technique used to determine the spatial distribution of elements within a sample. It involves the use of a scanning electron microscope (SEM) combined with an energy-dispersive X-ray spectroscopy (EDS) system.

In SEM elemental mapping, an electron beam is focused onto the surface of the sample, causing the emission of various signals, including secondary electrons, backscattered electrons, and characteristic X-rays. The emitted X-rays contain information about the elemental composition of the sample.

The EDS system attached to the SEM detects and analyzes the characteristic X-rays emitted from the sample. By scanning the electron beam across the sample surface and collecting the X-ray signals at each point, a two-dimensional elemental map can be generated. This map shows the distribution of different elements in the sample, allowing for the identification of specific elements and the visualization of their spatial arrangement.

## Results

Elemental mapping of a cross-sectional view of a solid scale deposit identifies discrete compositional layering within scale which can reflect changes or events within complex chemical systems. The semi-quantitative elemental data collection from the EDS system is combined with the imaging capability of the SEM to provide textural and chemical representation of the scale deposit.

## Conclusions

Scale management is an important aspect of pipeline operations and tank monitoring in the oil and gas industry. By implementing effective scale control strategies, operators can ensure the smooth and efficient flow of hydrocarbons through their pipelines, minimizing downtime and maximizing production.

SEM elemental mapping has applications to industrial materials science and engineering. It provides valuable information about the elemental composition and distribution of a scale deposit, helping researchers and industry professionals understand the properties and behavior of materials at the microscale to better devise mitigation approaches and preventative practices.