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# Mapping Surface Corrosion Damages of C1018 Carbon Steel When Exposed to High Temperature Environment

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Metal coupons are commonly used in oil and gas wells to assess the downhole corrosion environment impacting the tubing health. Coupons of target metallurgies, placed on a corrosion coupon holder, are tested for a pre-defined period where they are exposed to fluids, gases at high temperature undergoing corrosion, scale, and erosion damages. Composition of the fluids, presence of dissolved gases ($H_2S$ and $CO_2$), tubing material composition, pressure, temperature, and fluid flow velocity dictate the severity of the damages from micro to macro scales impacting the overall mechanical integrity of the tubing.

This work describes the corrosion study of C1018 coupon exposed to a high temperature (80 °C) environment. We observed that the coupon suffered severe corrosion damages showing corrosion triggered surface metal loss including corrosion cracking followed by the formation of complex scaling minerals, as evident in the optical image in Fig 1 (left) and the strong contrast in height topography in Fig 1 (right). Formation of iron sulfide, iron chlorides, calcium sulfate, calcium/iron carbonates, iron oxide/hydroxide, magnesium hydroxide and trace of barium sulfate were detected using a combination of XRF and EDX techniques.

Fig 2 shows the XRF mapping of dominating role of sulfur and chloride components on the deposited scale layers on the C1018 surface. The coupon lost 8.7% of its original weight which means the corrosion triggered metal loss was more dominant over the scale formation leading to a net metal loss. Fig 3 (left) shows the microstructure of pristine C1018 substrate, while Fig 3 (right) exhibits corrosion damages in three layers - (1) a top layer of formed scale on the left side of the image, (2) surface embrittlement and mild cracking on the base substrate with manufacturing cold rolling marks visible, (3) bottom layer of severe metal loss followed by deep cracking.

Experimental:
A 3” x 0.5” x 0.02” pristine metal strip of carbon steel (C1018) was placed on a corrosion coupon holder assembly (6.5” long, 1.25” diameter). Pristine C1018 coupon has the following chemical composition- Mn (0.79%), C (0.18%), Cu (0.03%), Cr (0.02%), Ni (0.02%), S (0.021%), Si (0.2%), P (0.014%), Fe (balance). It was deployed in an environment with high temperature (80 °C), pH of ~6.5 and an average of 25,000 mg/L total dissolved solid (TDS). The coupon was retrieved after it was exposed to the corrosive aqueous medium for three months and later analyzed for change in weight, optical imaging, 3D surface profilometry, scanning electron microscopy and X-ray fluorescence. [4]

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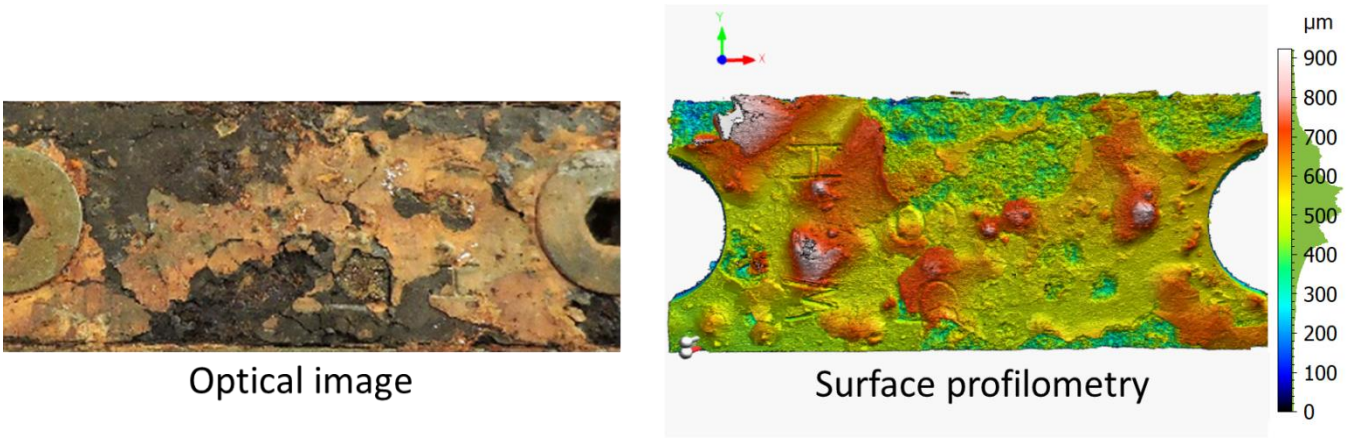


**Fig. 1.** Optical images of retrieved C1018 coupon (left). corresponding surface profilometry showing high (red) and low (green) elevations, indicating scale deposition and surface corrosion, respectively.

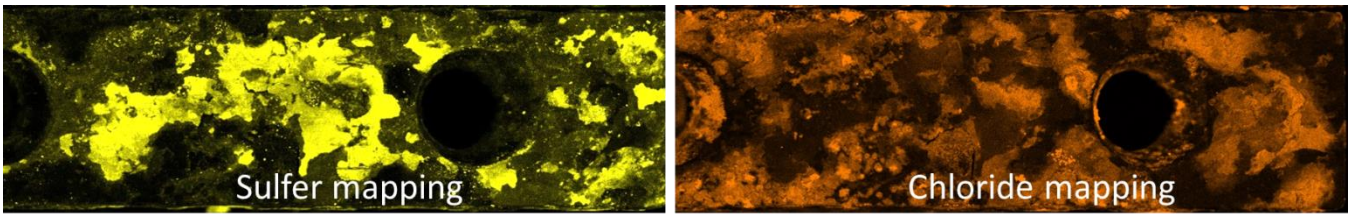


**Fig. 2.** X-ray Florescence (XRF) mapping for elemental compositions on retrieved C1018 coupon. Mapping shows presence of sulfur (left, bright yellow) and chloride (right, brownish) on scale layers.

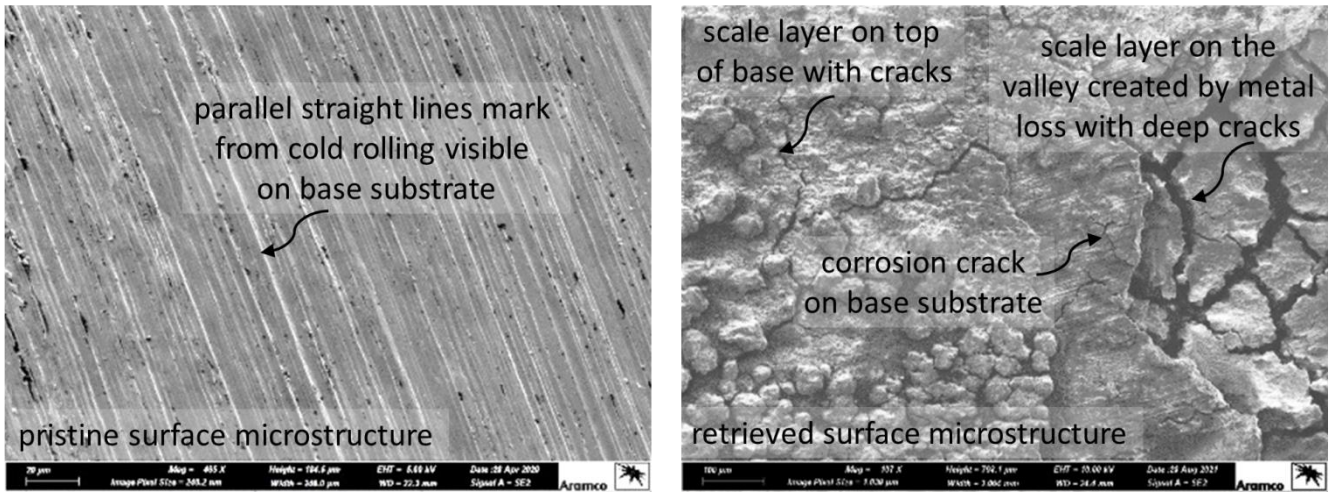


**Fig. 3.** SEM images of pristine (left) and retrieved (right) carbon steel C1018 coupon.

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