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Scaling of CaCO3 crystals on DLC-coated and metal alloys – SPE-231785-MS

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Lecture... *11 slides. (SPE – 231786-MS)*

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Vitória Silva Lourenço
Scaling of $CaCO_3$ Crystals on DLC-coated and Metal Alloys
SPE-231785-MS

Experimental setup

Study the carbonatic scaling phenomena closer to operational conditions.

$CaCl_2 + NaHCO_3 \leftarrow\rightarrow CaCO_3 + H_20 + NaCl + CO_2$

- High pressure
- High temperature
- Crude oil
- Chemical species
- Gas injection (CH_4, CO_2)

(Patent BR10202101340)

Experimental setup

Pressure: 100 bar (CO_2+ CH_4 50 bar each)

Temperature: 100 ^oC

Rotating cage (ASTM G184, G202): 125 RPM

Crude oil (BSW 91%)

Chemical species: Ca^{2+}, HCO_3^-, Na^+, Cl^-, Mg^{2+}, Sr^{2+}, Ba^{2+}, K^+, Br^-, and SO_4^{2-}

Optical microscope (for *in situ* crystals analysis)

pH probe

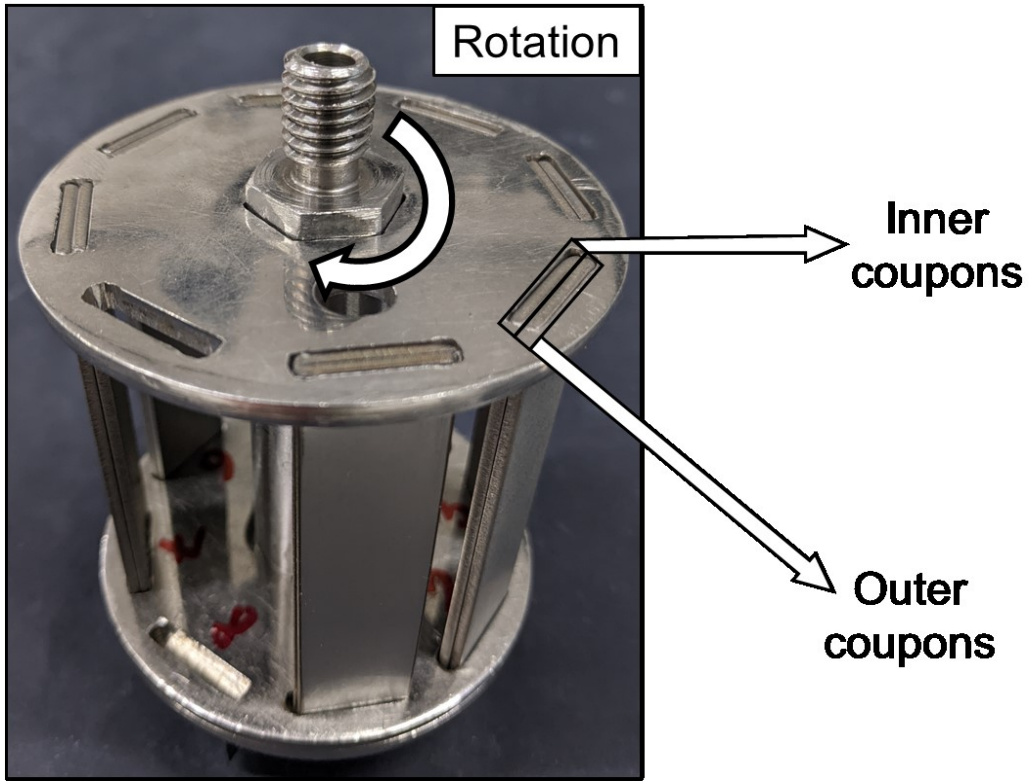
Methodology

Evaluate $CaCO_3$ scaling on coupons:

- Stainless steel 316L
- Inconel 718
- Super Duplex 2507
- PVD DLC-coated Super Duplex 2507

Up to 8 coupons (pairs) under same conditions

Analysis: gravimetry and microscopy



	SOLUTION A	MIXTURE		
Reagents	mg/l	mg/l	Ions	mg/l
$NaHCO_3$	1514	1387	Na^+	51343
NaCl	140906	129164	HCO_3^-	1008
NaBr	7726	644	Cl-	98528
Na_2SO_4	710	59	Ca^{2+}	6728
	SOLUTION B		Mg^{2+}	821
$CaCl_2$	223574	18631	Sr^{2+}	3097
$CaCl_2.2H_2O$	296156	24680	Ba^+	27
$MgCl_2$	38594	3216	K^+	3700
$MgCl_2.6H_2O$	82408	6867	Br^-	500
$SrCl_2$	67239	5603	SO_4^-	40
$SrCl_2.6H_2O$	113085	9424		
$BaCl_2$	491	41		
$BaCl_2.2H_2O$	576	48		
KCl	7696	7055		

Methodology

Reactor → 2,75L solution A + 0,3L Crude Oil + CO_2

Pressurized pipette → 0,25L solution B + CO_2

$CaCl_2 + NaHCO_3 \leftarrow\rightarrow CaCO_3 + H_20 + NaCl + CO_2$

The mixture has a total salinity of 164,000 mg/L

No crystals precipitation at 100 ^oC and 100 bar

CO_2 flash → supersaturation → precipitation → scaling

Scaling induced by CO_2 depressurization

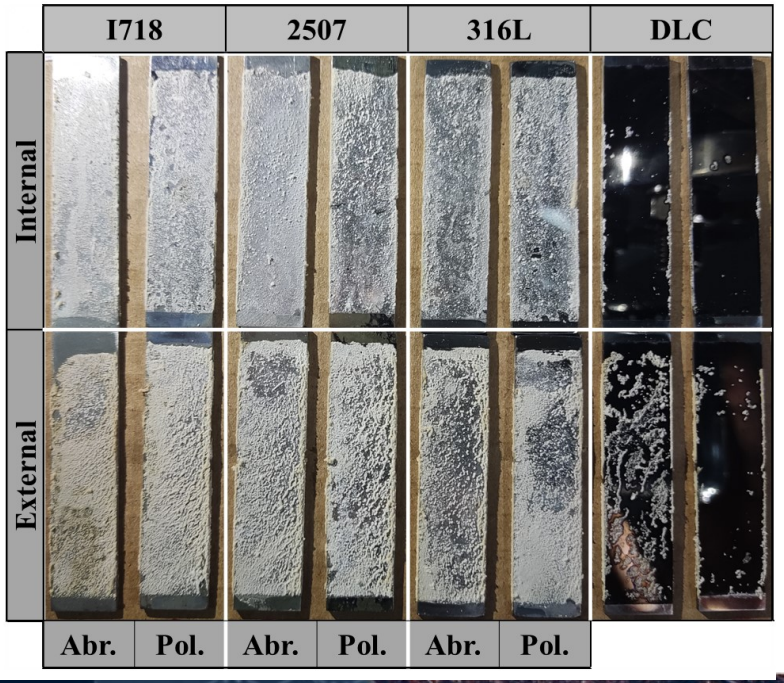
Results

Coupons characterization

Surface roughness of the samples:

Ground samples has Ra values six times higher than those of the polished samples

Materials	Surface condition	Ra (µm)	Cut-off (µm)
Super Duplex 2507	Ground	0.06 ± 0.02	0.25
	Ground and polished	0.01 ± 0.00	0.08
	DLC	0.01 ± 0.00	0.08
Inconel 718	Ground	0.07 ± 0.02	0.25
	Ground and polished	0.01 ± 0.00	0.08
316L	Ground	0.06 ± 0.01	0.25
	Ground and polished	0.01 ± 0.00	0.08



Results

Visual assessment of scale deposition

Coupons were cleaned with chloroform to remove residual oil;

Lower scaling observed on the DLC-coated coupons;

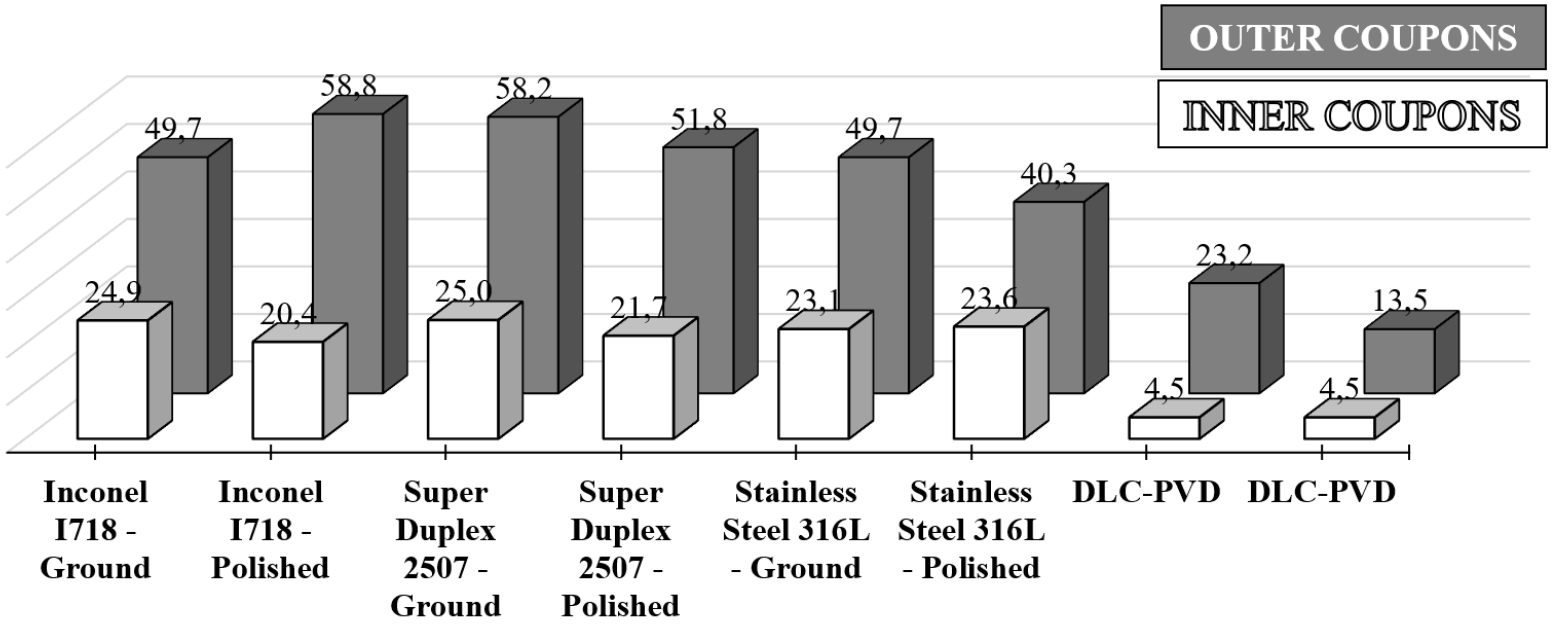
External coupons has a visibly higher amount of $CaCO_3$ compared to the internal coupon.

Results

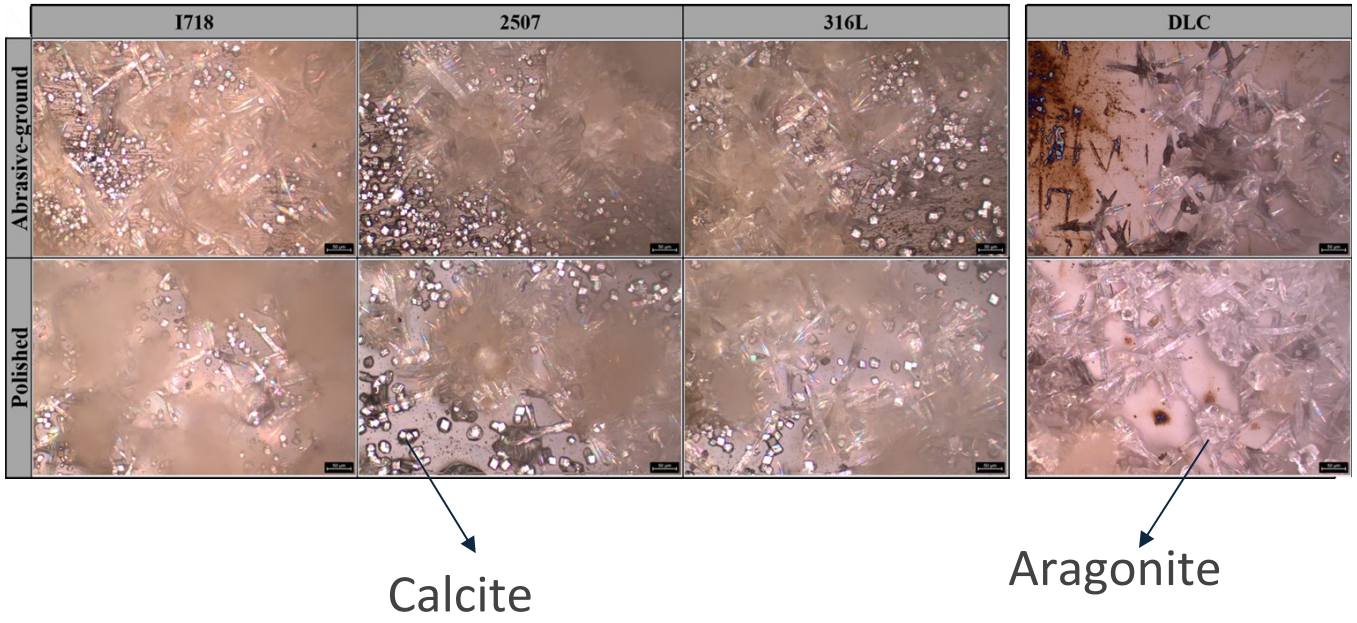
Measurement of scale

DLC → less CaCO3 adhered;

More $CaCO_3$ adhered at the external coupons.



Results



Photomicrographs of external coupons

Predominant: Aragonite
Underlayer: Calcite
Layering structure (aragonite over calcite)

DLC:
No layering → less calcite that anchor the aragonite crystals

Conclusion

The carbonatic scale showed a “layering” structure;

Material type and evaluated range of Ra → No influence the total adhered mass;

Hydrodynamics + chemistry → dominant factors;

DLC reduces adhesion significantly limiting calcite scaling;

Method reproduces realistic oilfield conditions;

The results demonstrate the potential of DLC coatings.

SPE Scale Symposium

20-21 May 2026 Aberdeen, UK

For more details please contact
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Thank you