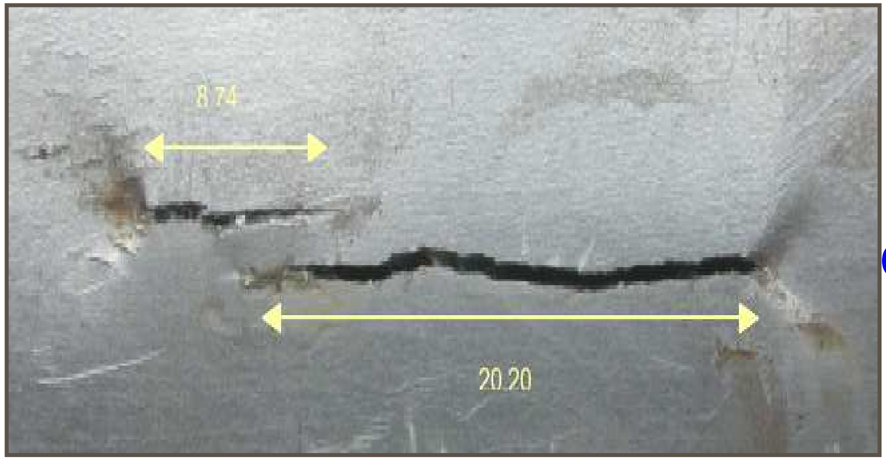
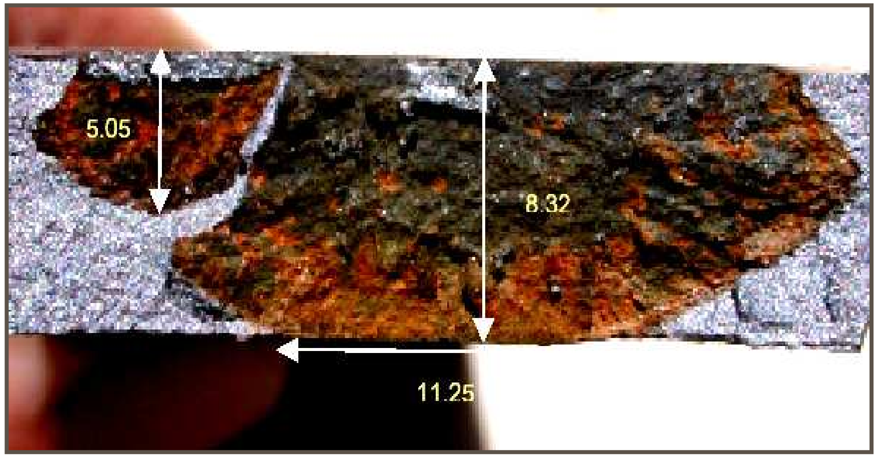
WGC2006 - Amsterdam
WOC 3 Committee Sessions



Study Group 3.2

Increased Service Life in the design, construction, operation and maintenance of Gas Pipelines



NETWORK LIFE TIME

Jorge Bonetto

Network life time

Objective of the SG3.2 group:

To evaluate what is necessary to do in the old pipeline, to extend the operation period and to get them up to their highest capacity.

The study group has decided to focus on the high pH SCC, due to the impact that this phenomenon has in the pipeline integrity and the insufficient methods for its detection nowadays.

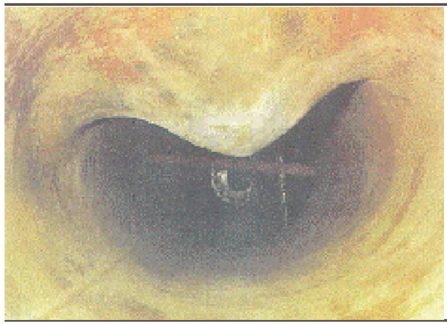
Classification of threats (according to ASME B31.8s)

a) Time Dependent

1) External Corrosion
2) Internal Corrosion
3) Stress Corrosion Cracking

b) Stable

4) Manufacturing Related Defect
5) welding / Fabrication related
6) Equipment



c) Time Independent

7) Third Party / Mechanical Damage
8) Incorrect Operations
9) Weather Related and Outside Force

SCC - Study Scope

How can a natural gas company face the possibility of having high pH SCC in its system, today?.

We would like to guide you along the topics we have just covered :

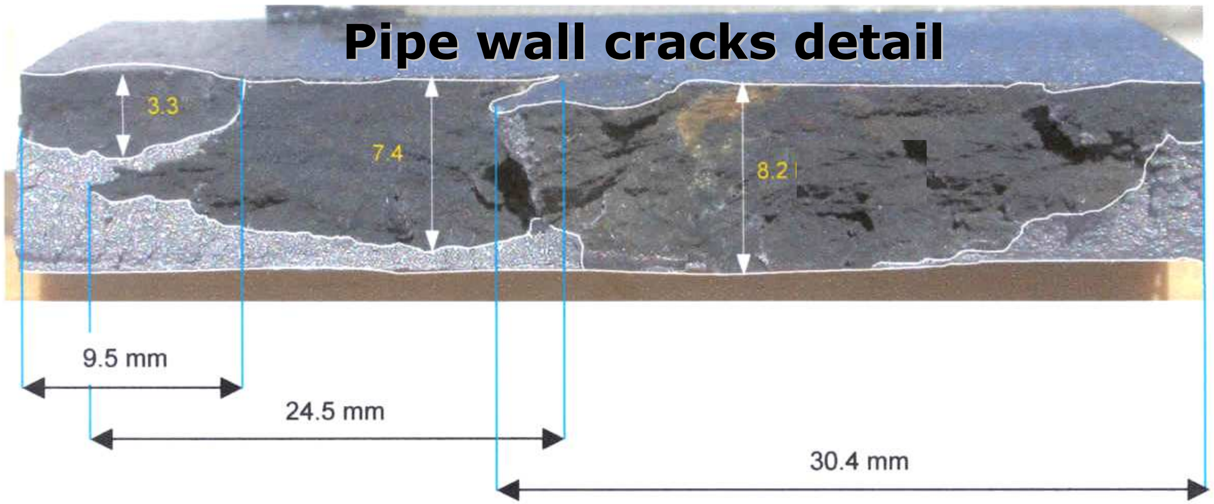
- What is SCC?, *(bibliographic information)*
- Causes and factors contributing to SCC initiation and growth *(study group investigation),*
- Methods for prevention, and detection of SCC on pipelines *(study group investigation):*
  - Hydrostatic test
  - ILI tools
  - Direct assessment methods

What is SCC?

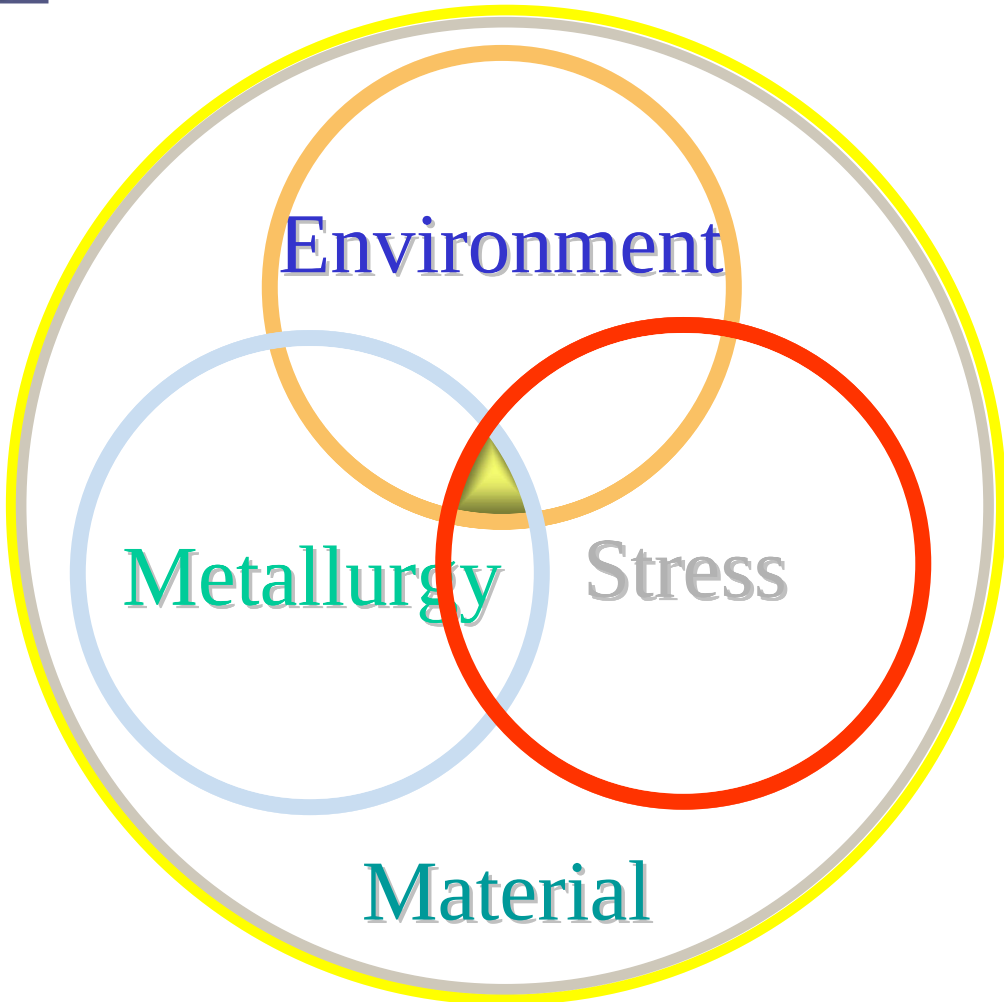
Stress Corrosion Cracking (SCC) appears as very thin, long and deep colonies of cracks, on the external surface of the underground pipelines.

Identified Cracks

Pipe wall cracks detail



SCC - Conditions for SCC



Three conditions must be met concurrently for SCC; there must be a tensile stress, a cracking environment, and a material that is susceptible to cracking in that environment. If any of these three conditions is not met, cracking either does not start, or it slows down, or it stops.

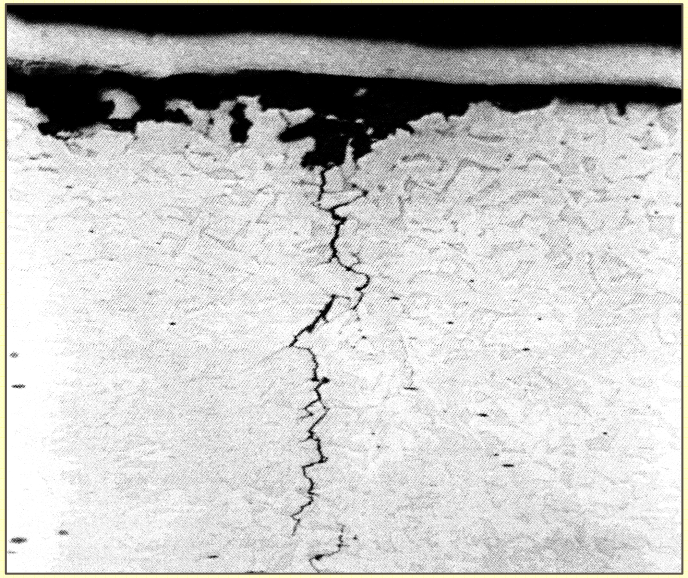
- **SCC requires time to be developed**

(average 20-25 years)

Metallography of SCC

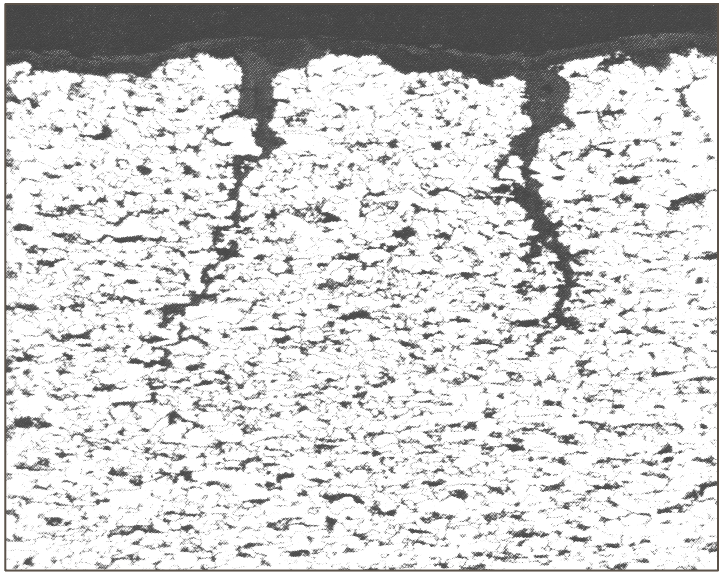
Concerning the pipeline industry
there are 2 types of SCC.

High-pH SCC
(electrolite pH between 8.5 and 11)
Intergranular



(Magnified 250 times)

Low-pH SCC
(electrolite pH between 6.0 and 8.5)
Transgranular



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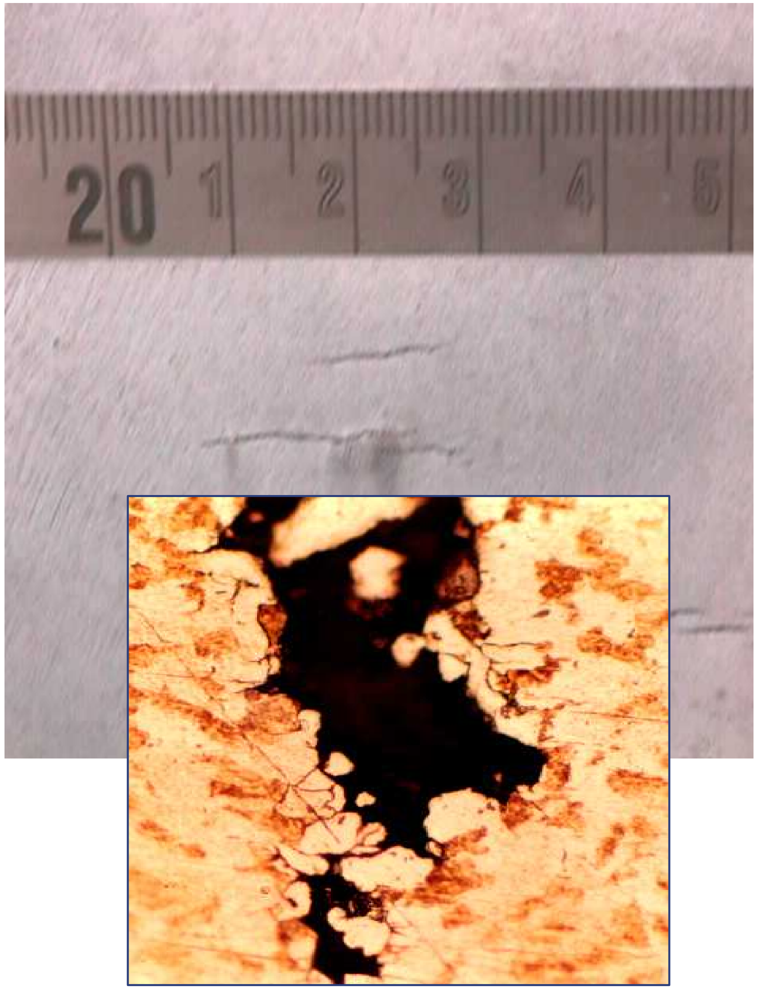
The study group has studied High pH SCC

SCC Cracks Development Conditions



- Mainly in Pipelines covered with deteriorated asphalt coating.
- Requires the formation of $FeCO_3$ on the steel surface.
- Formation of Fe CO_3 only takes place at a narrow potential interval where it coexists with Fe_3O_4

  (660-750 mV)

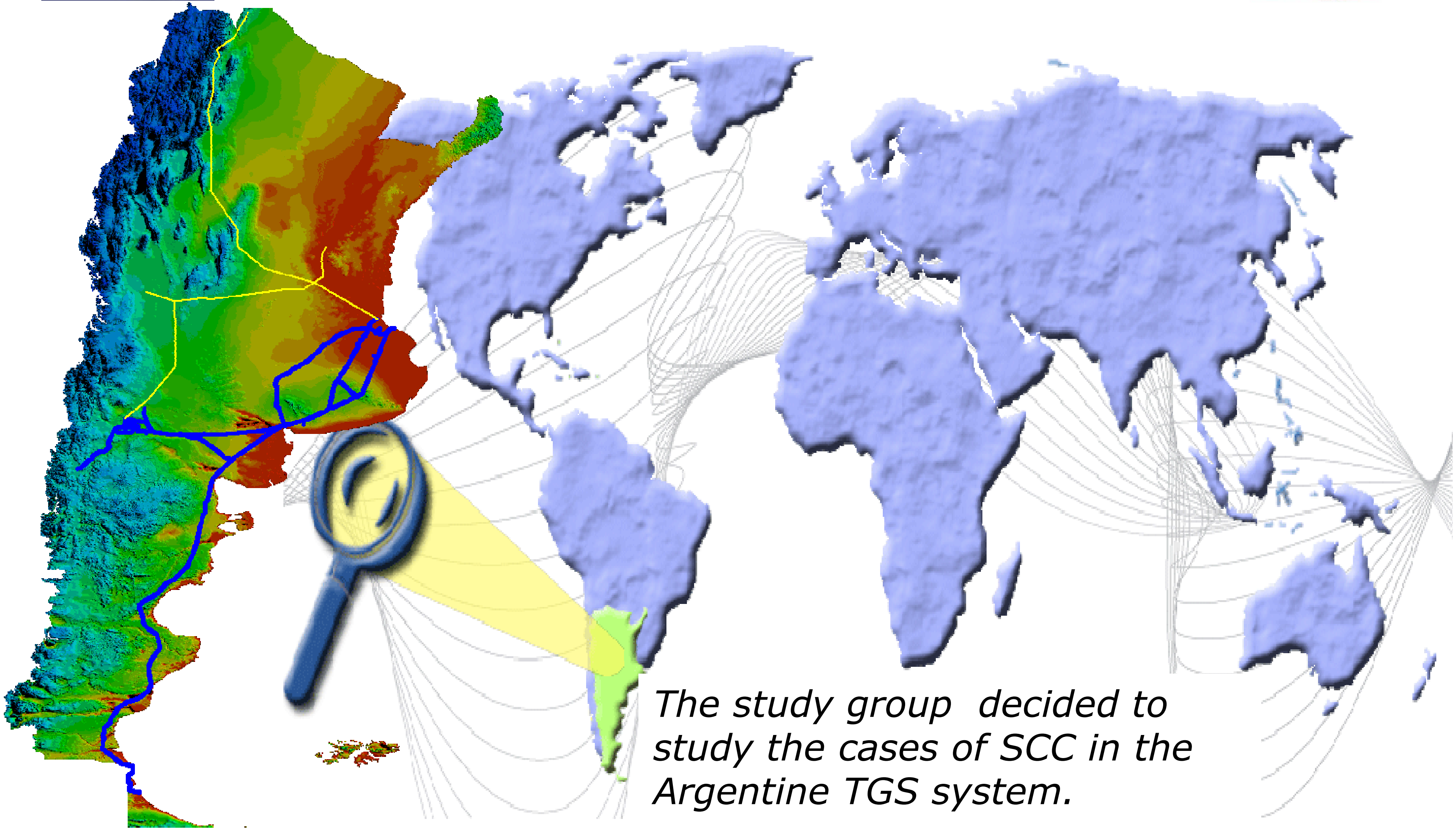
Variables that contribute to SCC development

- Susceptible Soil.
- High level of temperature in pipeline.
- Cycles of pipeline stress.
- Susceptibility level of cathodic protection.
- Coating type (eg. asphalt).
- Pipeline/Coating Age (more than 20 years).

Study group

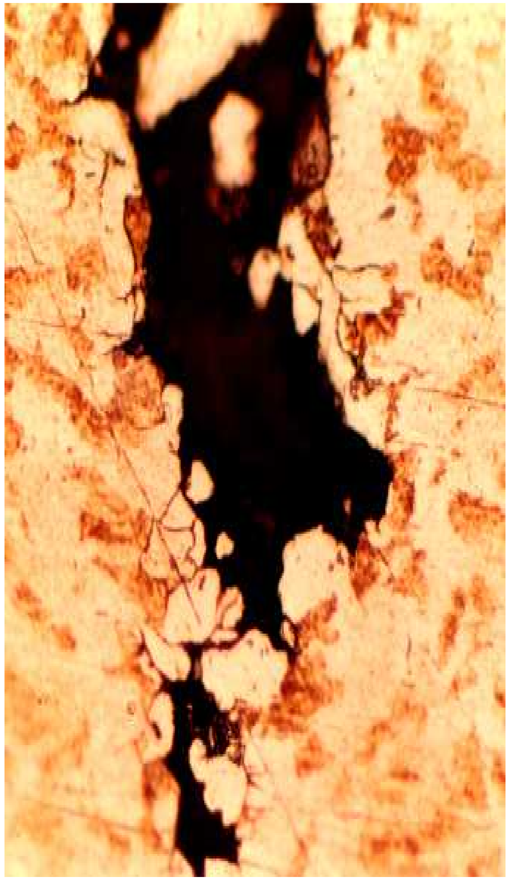
Investigations

Causes and factors contributing to SCC initiation and growth. Studied Cases



The study group decided to study the cases of SCC in the Argentine TGS system.

Studied Cases



Enlargement: X600

- Summary of the TGS SCC cases

2 ruptures in service
3 ruptures by hydrostatic test
7 colonies were detected by a Canadian predictive model
1 colony was detected during recoating tasks.
1 colony was detected by the TGS model

- A detailed soil study was carried out

- A detailed characterization (morphological, physical, and chemical) of soils was done at the areas where SCC was detected.
- Common patterns among the various areas under study were recognized.

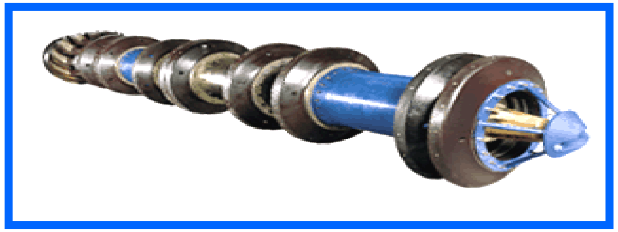
Detection techniques

Detection techniques

There are three main techniques:

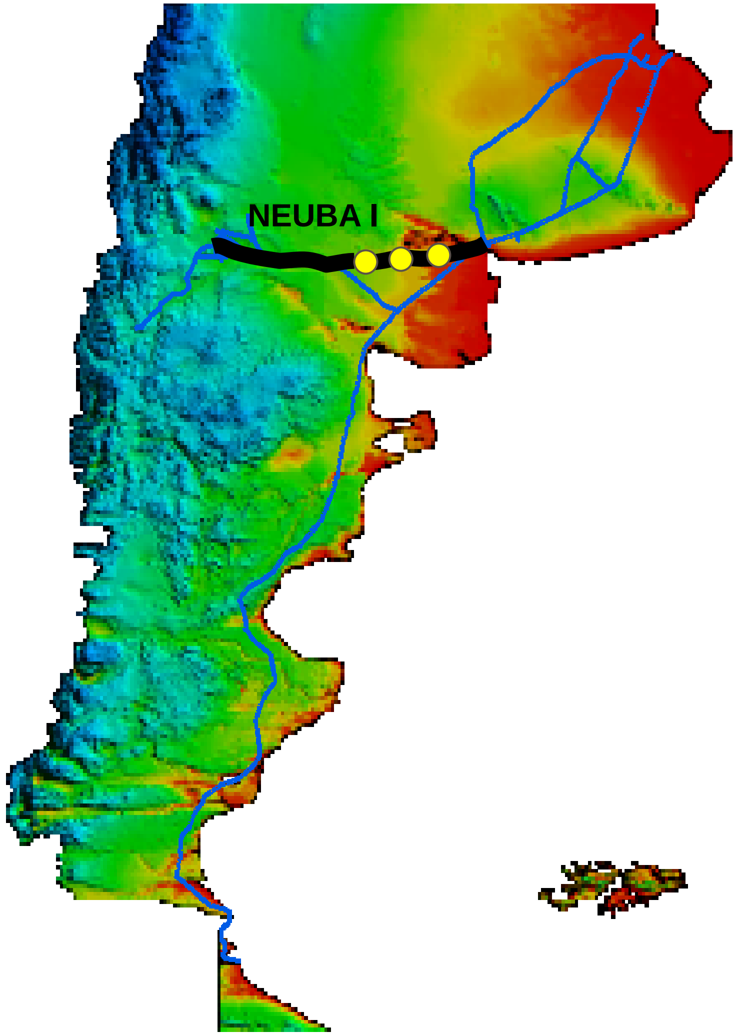
- Hydrostatic test

- In line inspection



- Direct Assessment program (predictive Modeling + Investigative excavations)

Hydrostatic test
Argentina Neuba I pipeline



Diameter:	24”
Pipe wall thickness:	7,14 mm
Material:	ASTM X52
Year of installation:	1973
Coating type:	Asphalt
Hydrostatic test pressure :	110% SMYS

3 three failures due to Hiydrostatic test were found.

ILI Tools

So far, there are three main technologies available:

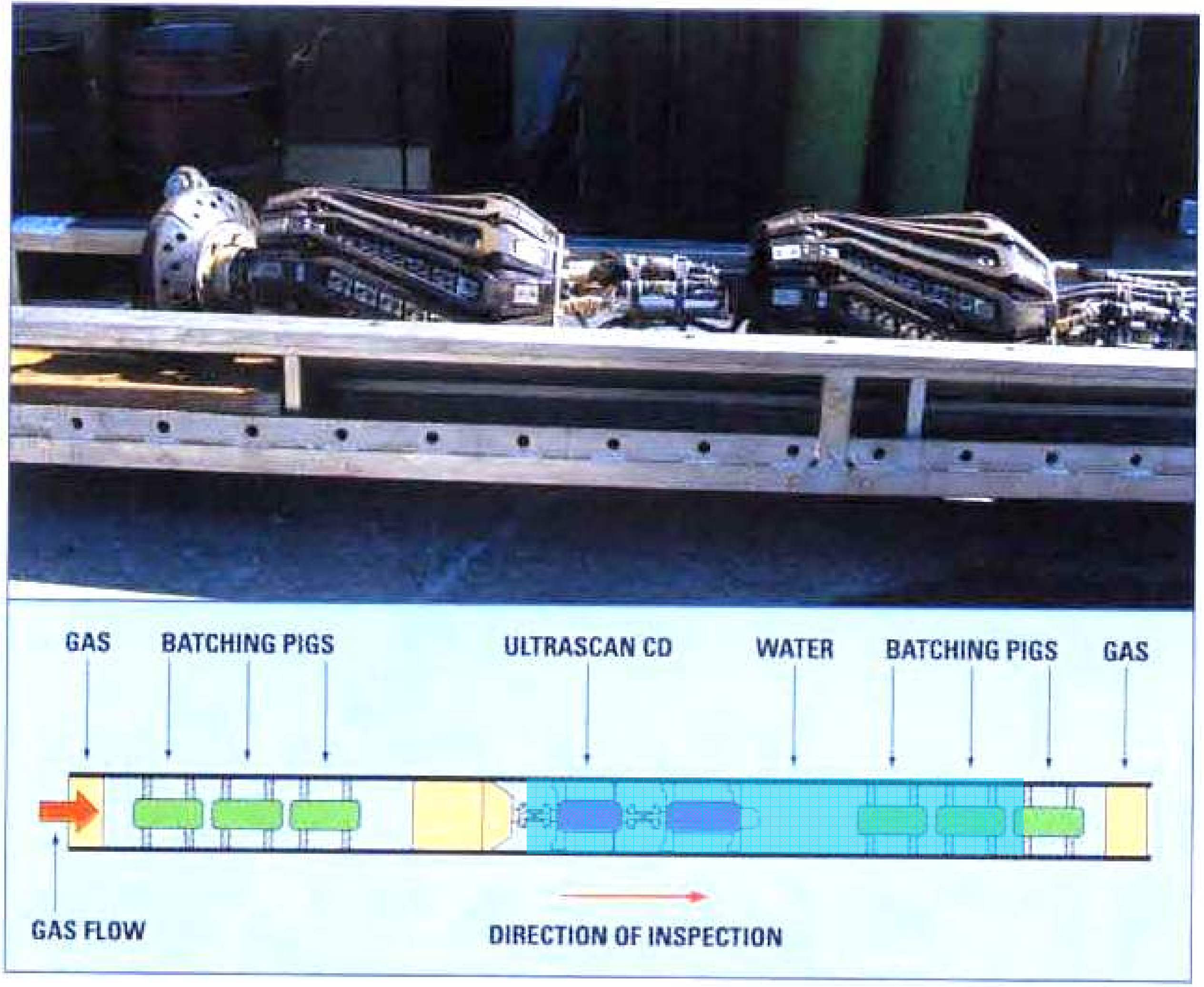
- Ultrasound Tool

- Magnetic Tools (MFL + TFI)

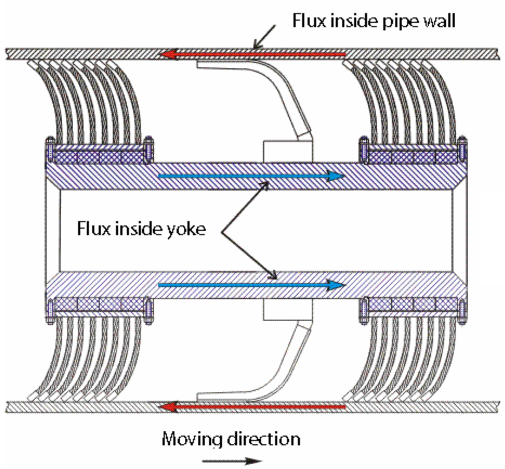
- EMAT Tool

Ultrasound Tool

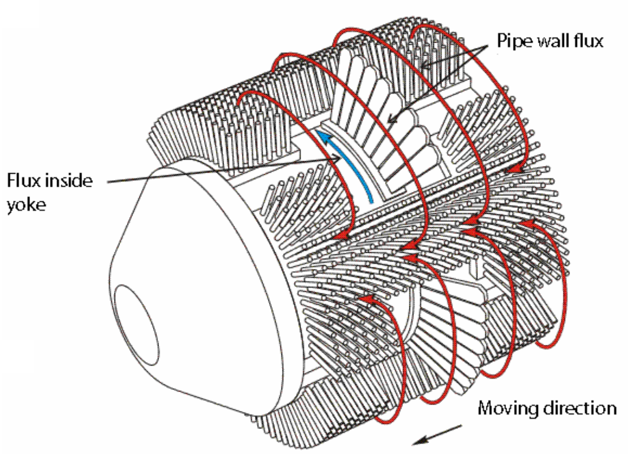
Main disadvantage: liquid batch required.



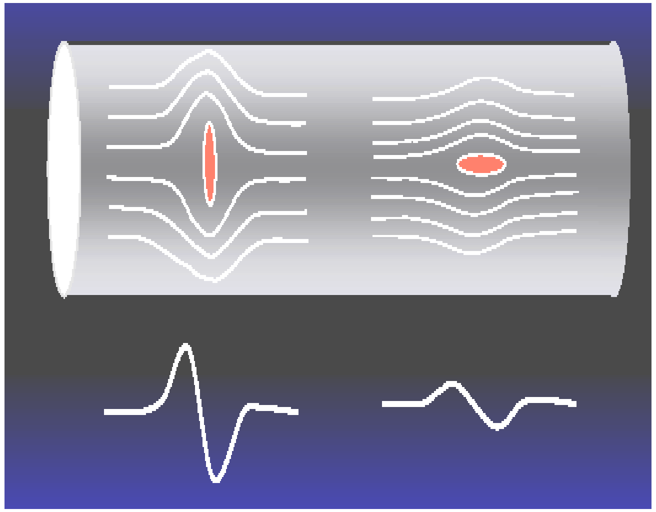
Magnetic Tools (MFL + TFI)
Operation principle

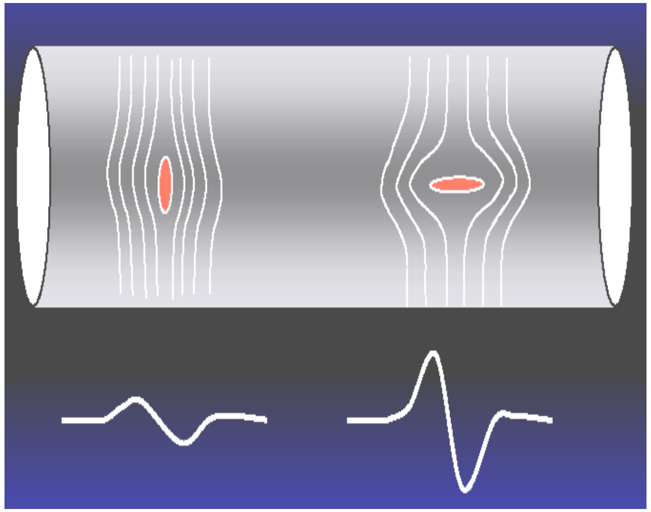


a) MFL tool



b) TFI tool



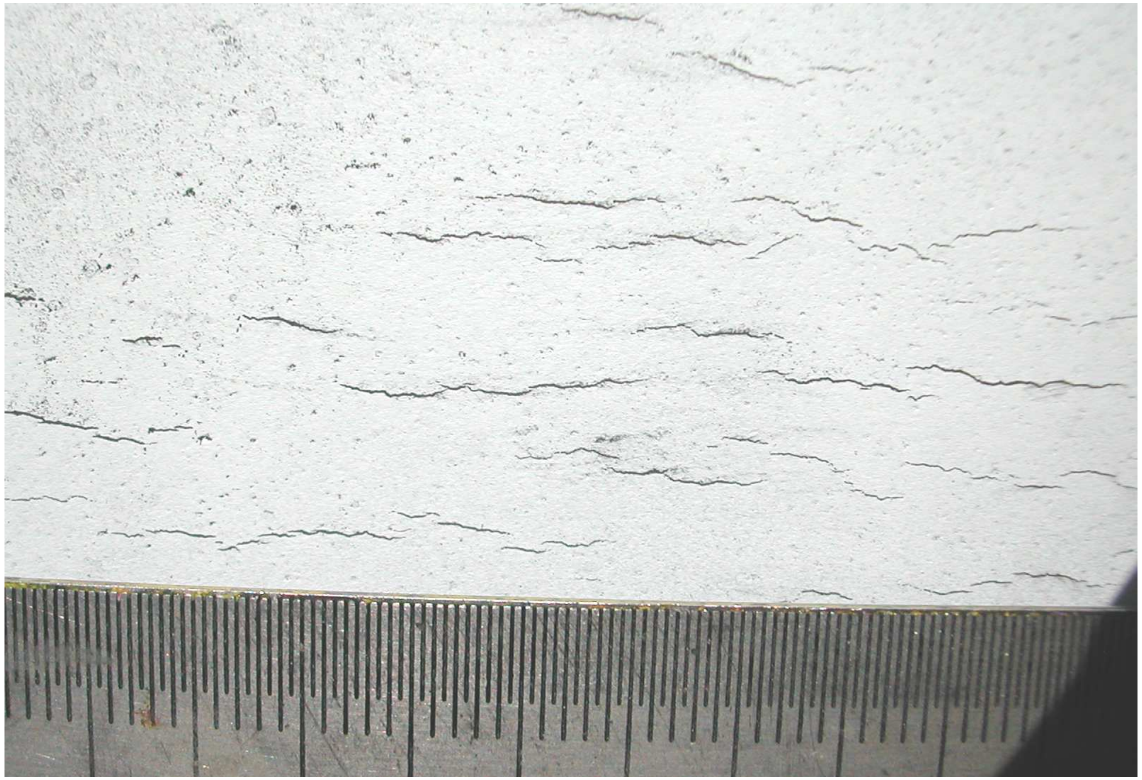


Experience MFL + TFI in Russia

Gazprom (Russian national gas company) has been using the magnetic tools technology for finding SCC with great success. They have already run ILI inspection over more than 100.000 km detecting more than 30.000 SCC colonies (**low pH SCC**).

Taking advantage of this experience, the Argentine company TGS decided to run those tools in their system in order to detect SCC.

MFL + TFI tools - Argentine conclusion
<u>Not enough discrimination</u> .



Due to the fact that high pH SCC cracks are not open <u>(intergranular and not transgranular),</u> the disturbances in the magnetic field are almost impossible to detect.

EMAT Tools

Cracks

- EMAT waves are reflected at cracks
- Echo wave appears

Coating Disbondment

- EMAT waves are attenuated by coatings
- Coating disbondment decreases signal attenuation

No commercial runs have been done up to the making of this presentation.

Conclusion of the ILI tools

There is not satisfactory commercially available tool for finding high pH SCC in gas pipelines yet

- **Liquid – coupled UT** too cumbersome and expensive
- **MFL + TFI** has not adequate discrimination
- **EMAT**´s possibilities still need to be demonstrated in field operation

SCC Direct Assesment

SCC - DA Program

SCC direct assessment (SCCDA) is a structured process that contributes to improve safety by reducing the impact of SCC on pipeline integrity

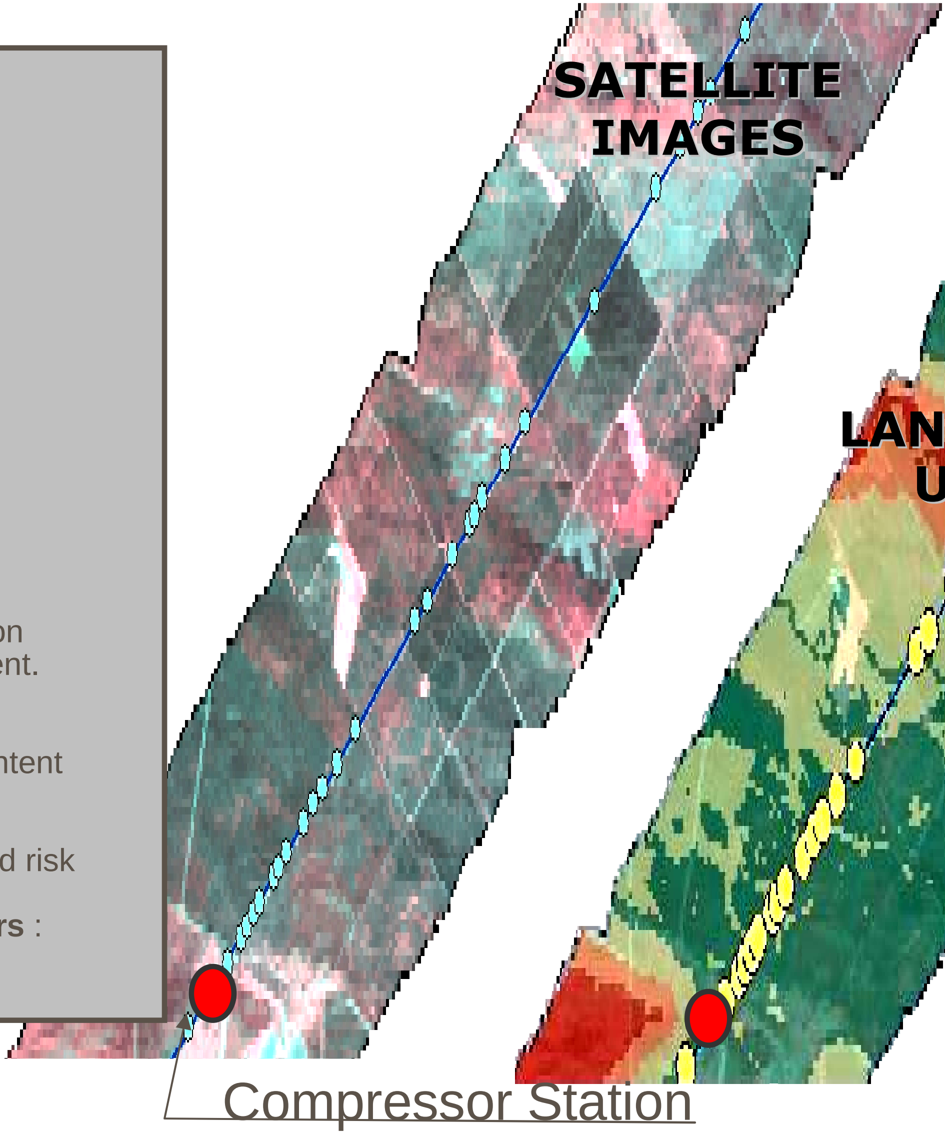
- Step 1: Pre – Assessment
- Step 2: Indirect Inspections
- Step 3: Direct examinations
- Step 4: Post Assessment

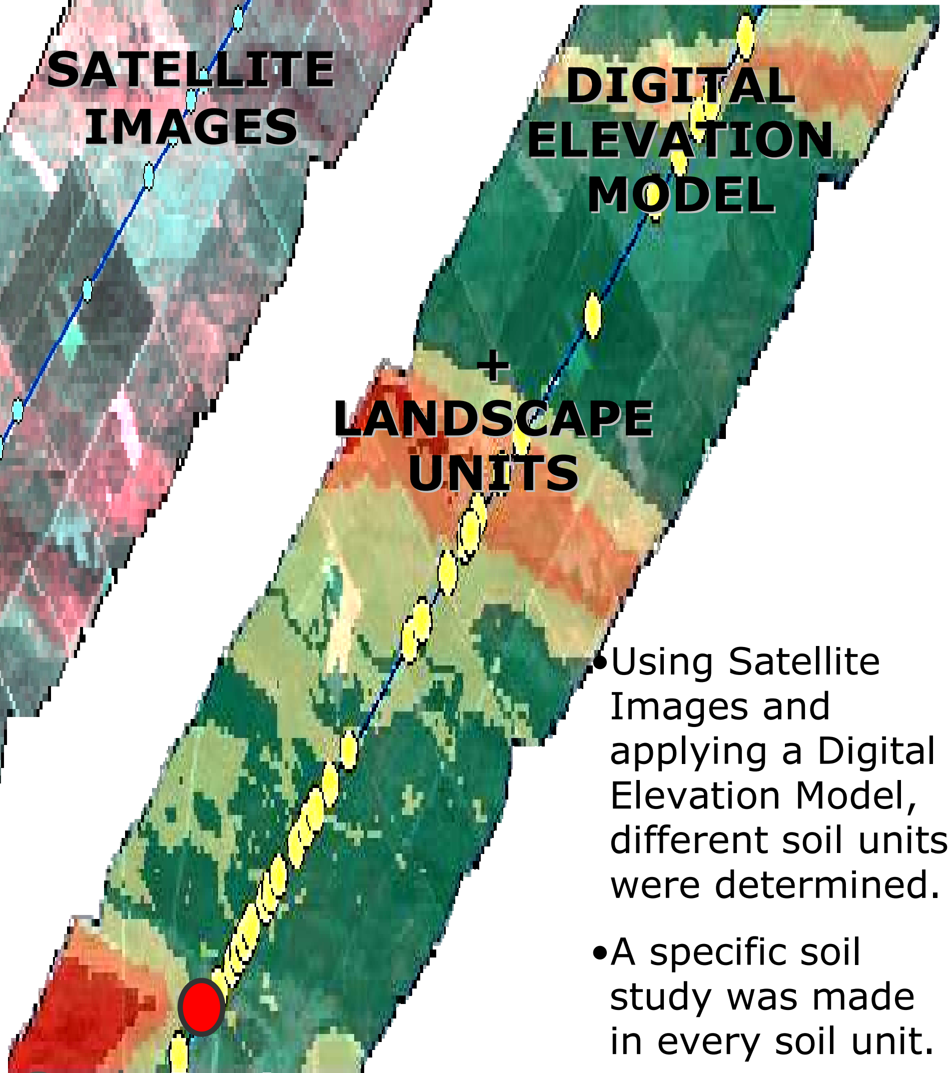
Step 1 (Different types of soils must be identified)

Physical characteristics:
- Relief and micro-relief
- Natural drainage
- Superficial drainage
- Flooding
- Surface flora
- Surface lithology
- Human influence

The edaphic profile
- Horizon description
- Texture
- Structure
- Permeability
- Porosity
- Stoniness
- Rock outcrop proportion
- Organic material content.
- Color
- Soil-pH reaction
- Calcium carbonate content
- Internal drainage
- Consistency
- Soil instability and flood risk

Physical-chemical parameters :
- pH
- Specific conductivity

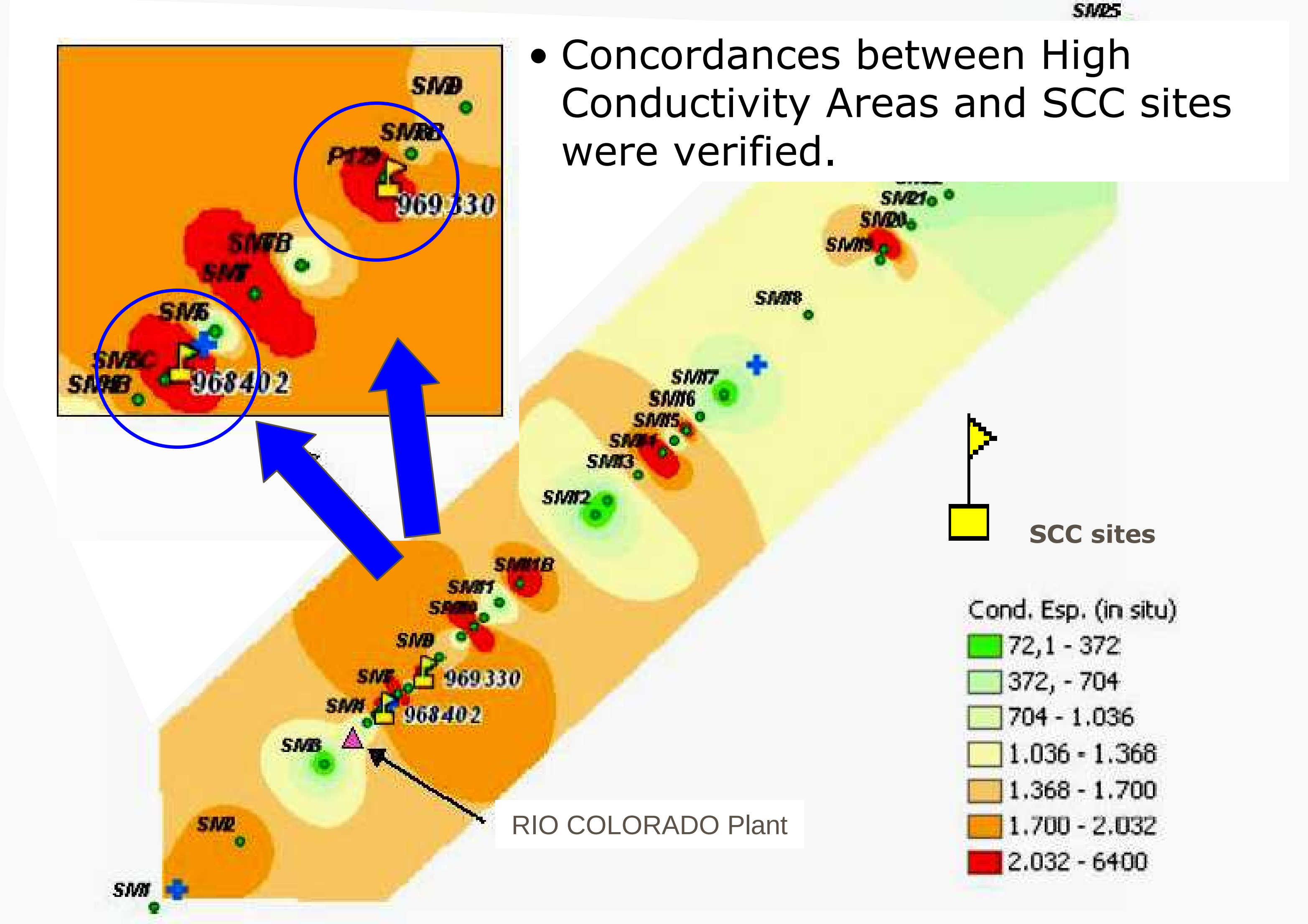




- Using Satellite Images and applying a Digital Elevation Model, different soil units were determined.
- A specific soil study was made in every soil unit.

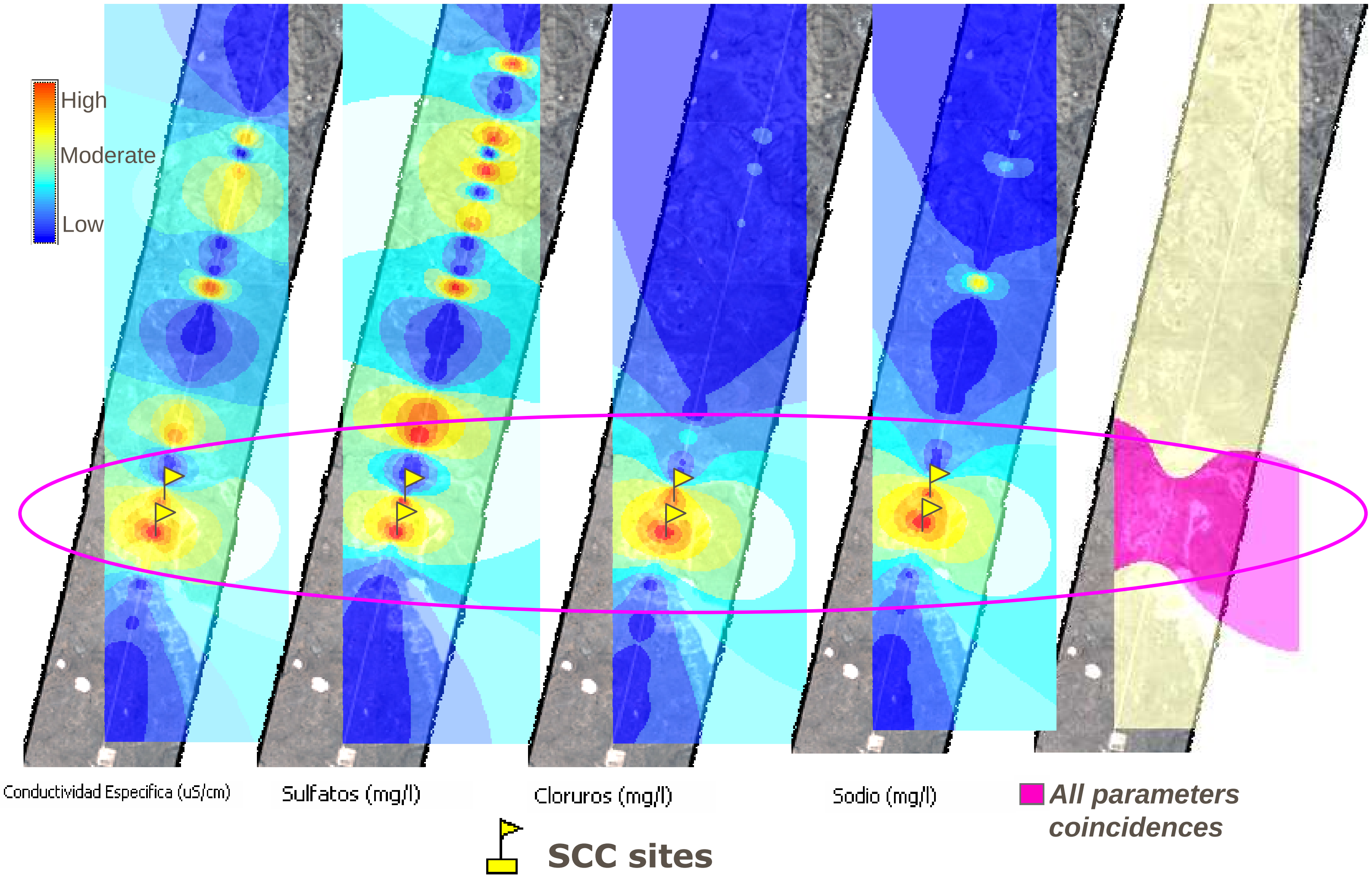
Step 1 (Specific conductivity (μs/cm))

- Concordances between High Conductivity Areas and SCC sites were verified.



Step 2
(Common characteristics found at all studied sites)

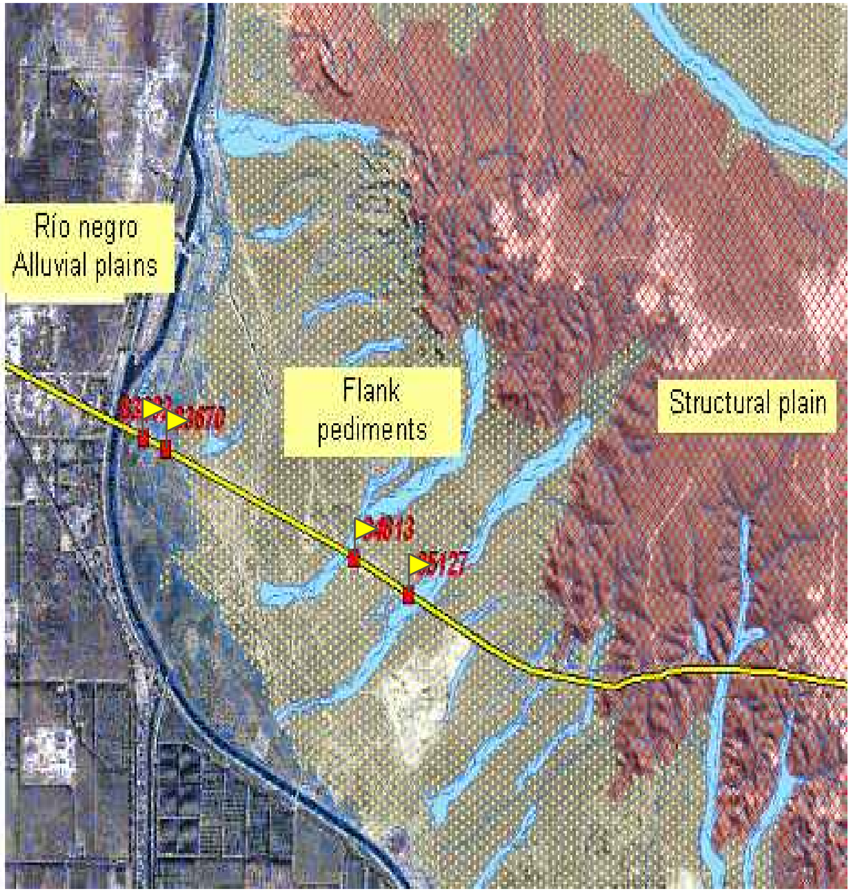
- The charts show the coincidences among SCC sites and high values of Sulfate, Chloride and Sodium.



Step 2

(Common characteristics found at all studied sites)

- Close to riverbed areas.
- Abundance of carbonates.
- Inefficient drainage.
- Short distance to rectifier equipment.

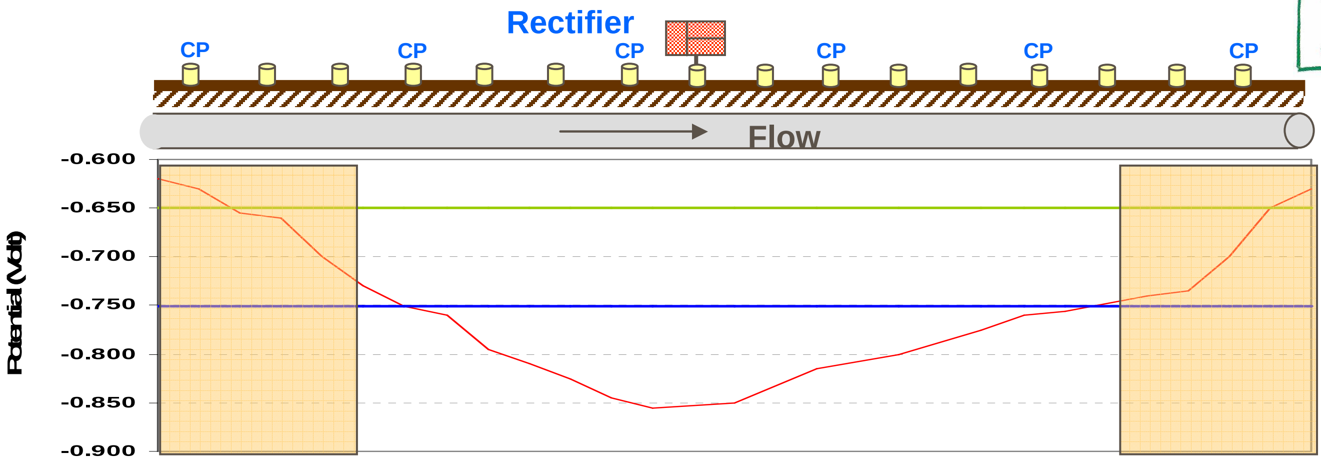


SCC sites

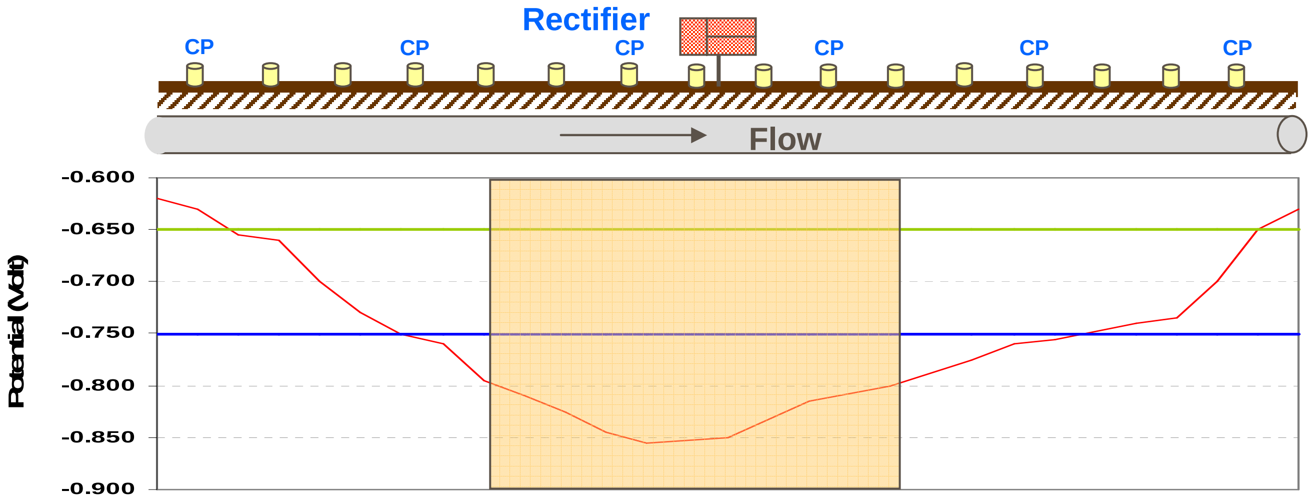
Comparison of characteristics. Literature Vs. Studied Sites

Characteristics	Literature	SG3.2 findings
• Distance from Compressor Plant • Distance from rectifier	80% within 20 km Not described	38% within 20 Km. 100% within 60 Km. Near:< 3 km from a rectifier
• Terrain conditions • Slope	Good drainage Flat or slight slope	Poor or imperfect drainage Flat or slight slope
• Failure in CP Levels	Low Conductivity of the soil, cause CP shielding.	High conductivity of the soil. CP shielding is caused by hydrogen production and formation of deposits.
• Carbonates	Yes	Yes
• Soil pH	Alkaline	Alkaline
• Temperature	> 40 C	> 40 C

Failure in C.P. Levels (CP shielding)



Traditional Model: Far from rectifiers-Low conductivity Soil

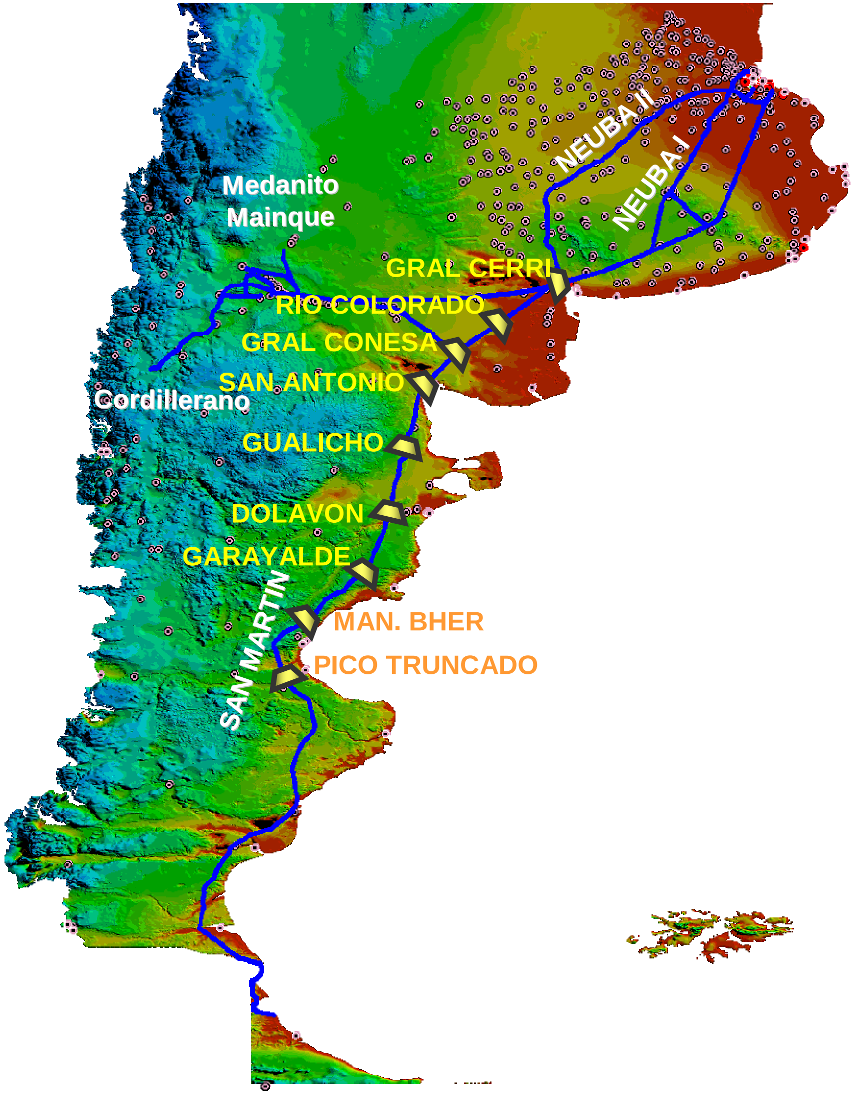


Susceptible Area

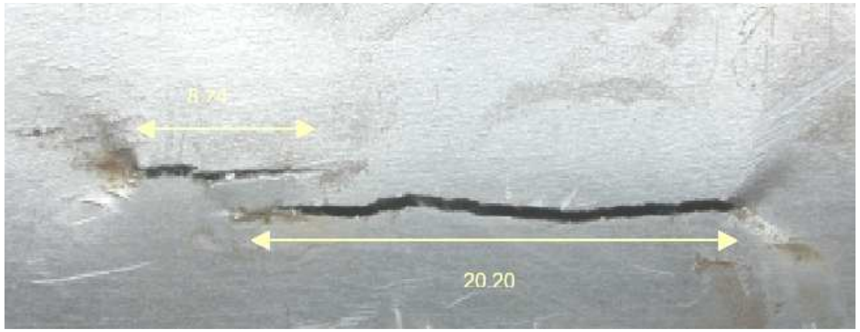
In Argentina Near to Rectifier- High conductivity Soil

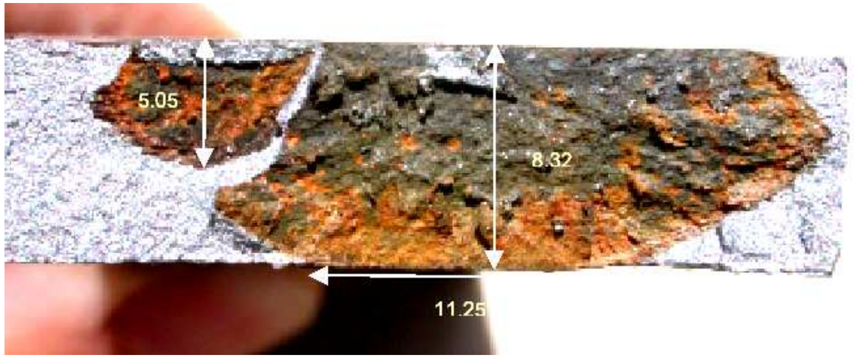
Step 3 + Step 4: Field Work

Completed Task



By applying this DA SCC 80 digs were done and one colony was found.





Conclusion of Evaluation Methods

Methodology	Advantages	Disadvantages
Hydrostatic Test	Critical cracks fail. Slow down propagation velocity.	High affectation to Gas Transport. Non critical cracks lengthened.
ILI by Ultrasound tool	Accurate Information about critical and subcritical cracks	High affectation to Gas Transport due to liquid batch.
ILI by MFL + TFI tool	Low affectation to Gas Transportation. It is not necessary to cut service to run the inspection.	It has inadequate discimination in the detection of high pH SCC cracks
ILI by EMAT tool	Low affectation to Gas Transportation. The tool does not require the use of liquid batch .	Its possibilities still need to be demonstrated in field operation
Direct Assessment program	Low affectation to Gas Transport	Low effectiveness

THE IDEAL METHODOLOGY TO FIND HIGH pH SCC IN PIPELINES SHOULD STILL BE DEVELOPED.

Which variables could be controled ?
(for minimizing the risk of SCC)

Susceptibile Soil.

Cycles of pipeline stress.

Susceptibility level of cathodic protection.

Coating type (eg., asphalt).

Coating Age (more than 20 years).

High level of temperature in pipeline

It is accepted that "DECREASING THE TEMPERATURE OF THE PIPELINE BY 10°C THE CRACKS GROWTH VELOCITY WILL DECREASE AT LEAST 10 % "

Summary

▪ We have analyzed environmental and operational factors that determine the microenvironment present in the failure areas where high pH SCC has been found.

Much has been learned and there is still much more to learn

▪New variables have been identified to be able to locate a site of high pH SCC.

Thank you very much !!!