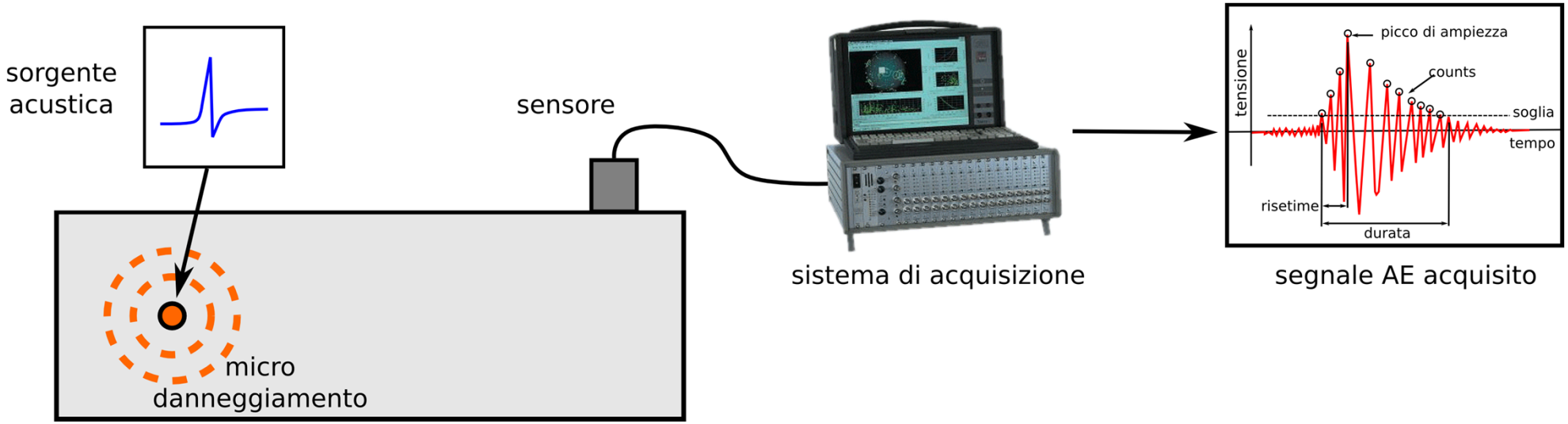
La tecnologia dell'emissione acustica nello studio dei fenomeni corrosivi

E. Proverbio · Università di Messina

Riduzione del rischio negli impianti e nelle strutture

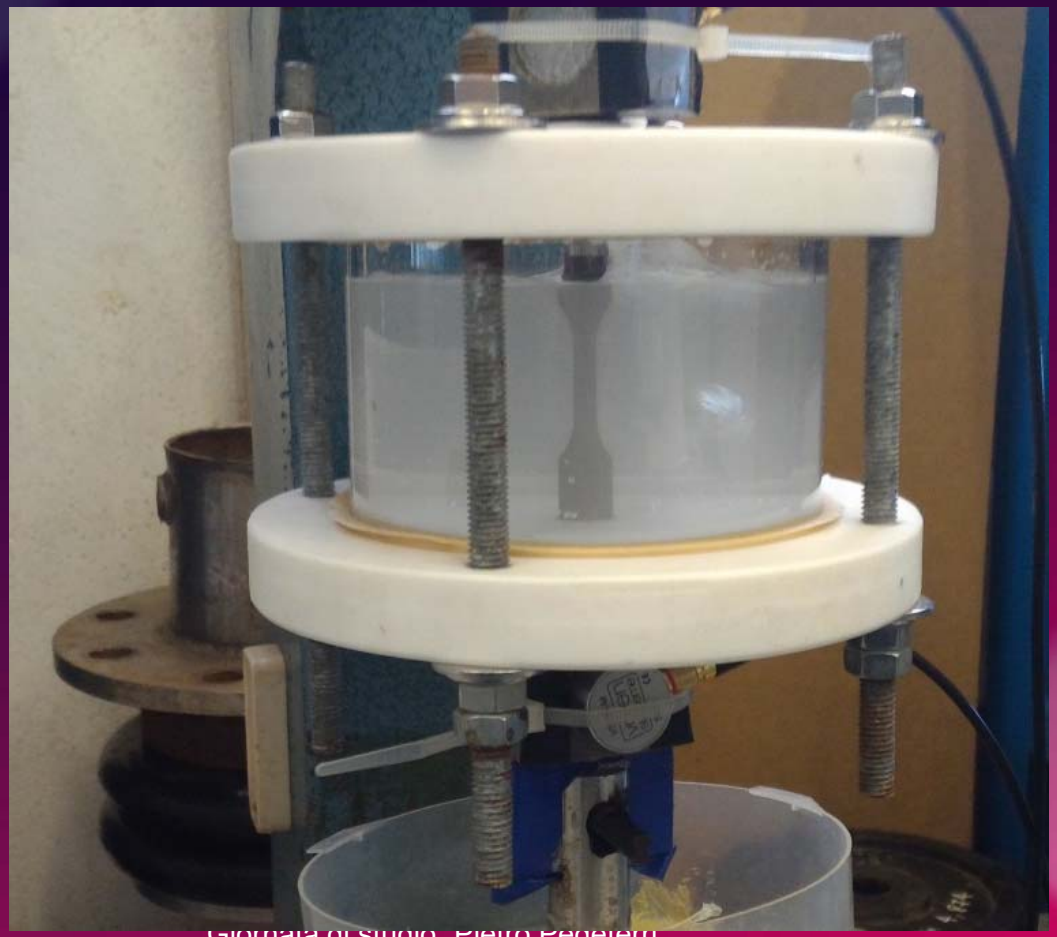
- Sistemi di monitoraggio avanzati
  - Metodologie di analisi multivariata
    - Informazioni multispettrali sui fenomeni corrosivi in atto

Emissione Acustica



Tecnologia di Emissione Acustica

Dal provino in laboratorio….



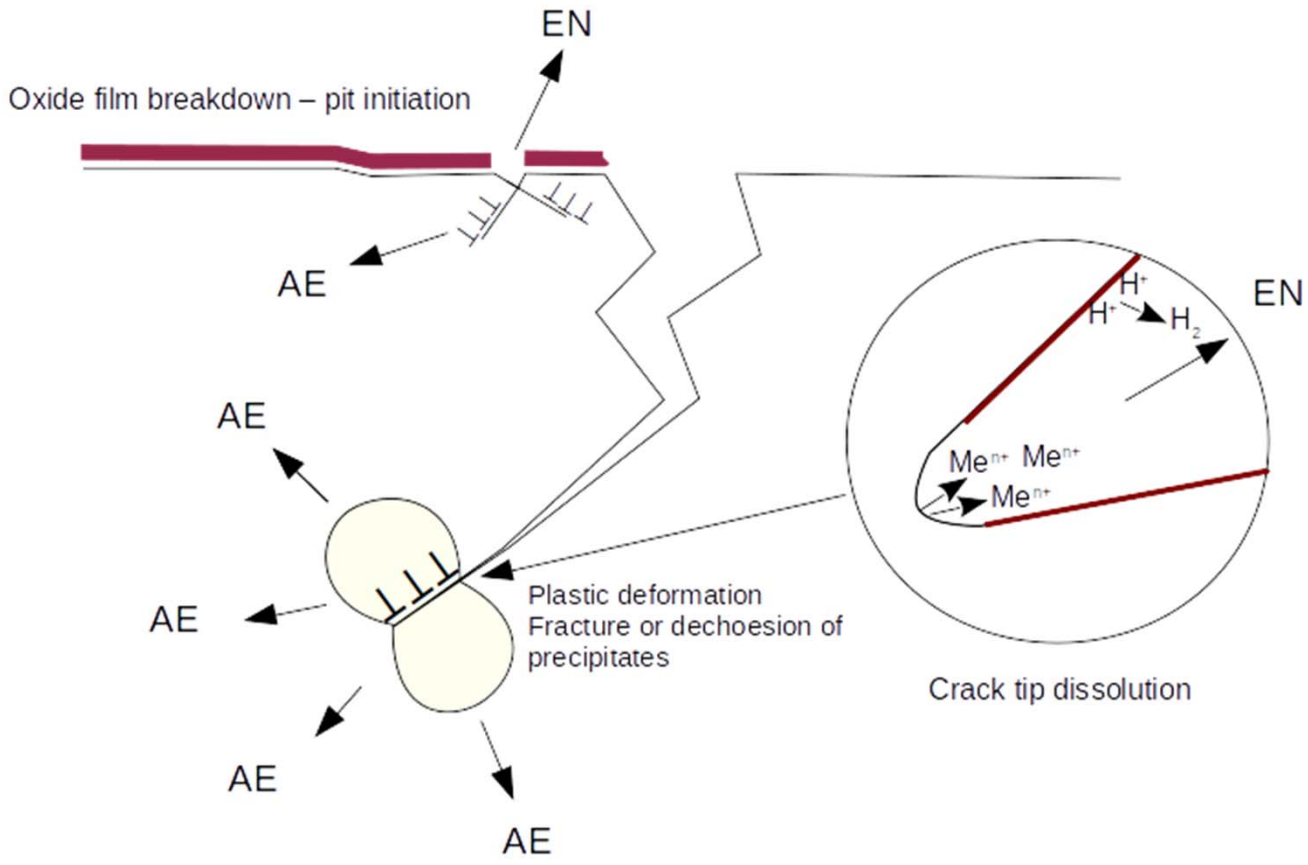
Tecnologia di Emissione Acustica

al sistema in scala ridotta….

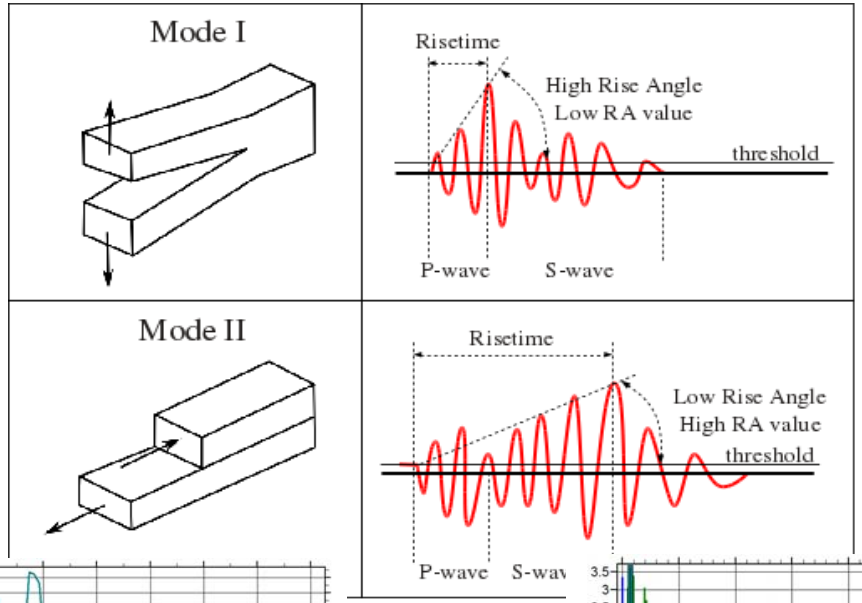
Tecnologia di Emissione Acustica

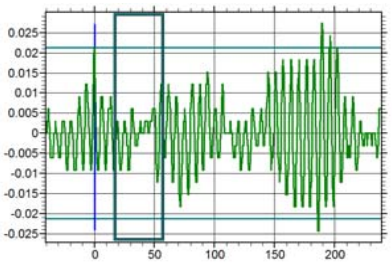
….sino alla scala reale

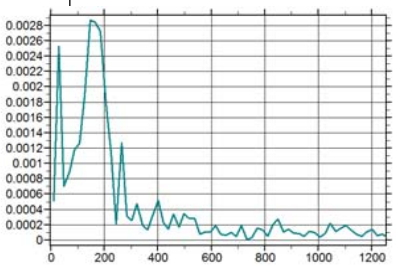
Corrosione e sorgenti di emissione acustica

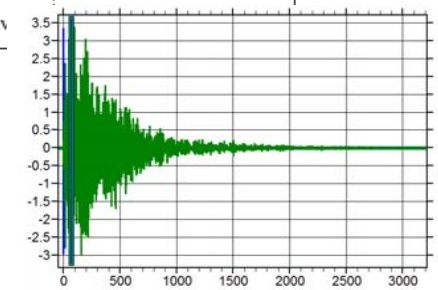


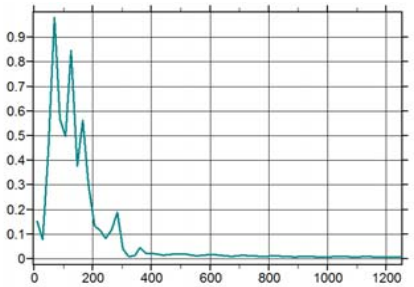
La forma d’onda dell’impulso acustico è legata alla tipo di sorgente



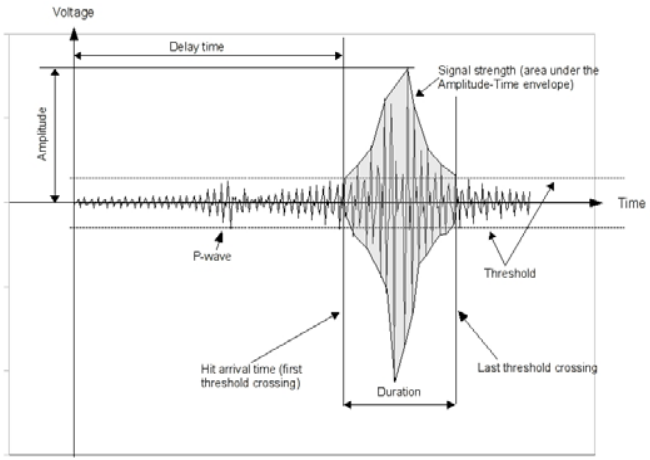








Dalla forma d’onda è possibile individuare degli insiemi di parametri che caratterizzano in maniera univoca la tipologia di sorgente



Ampiezza

Duration

Rise-time

Counts

Energy

.....

Frattura ossido

Decoesione inclusioni

Avanzamento cricca

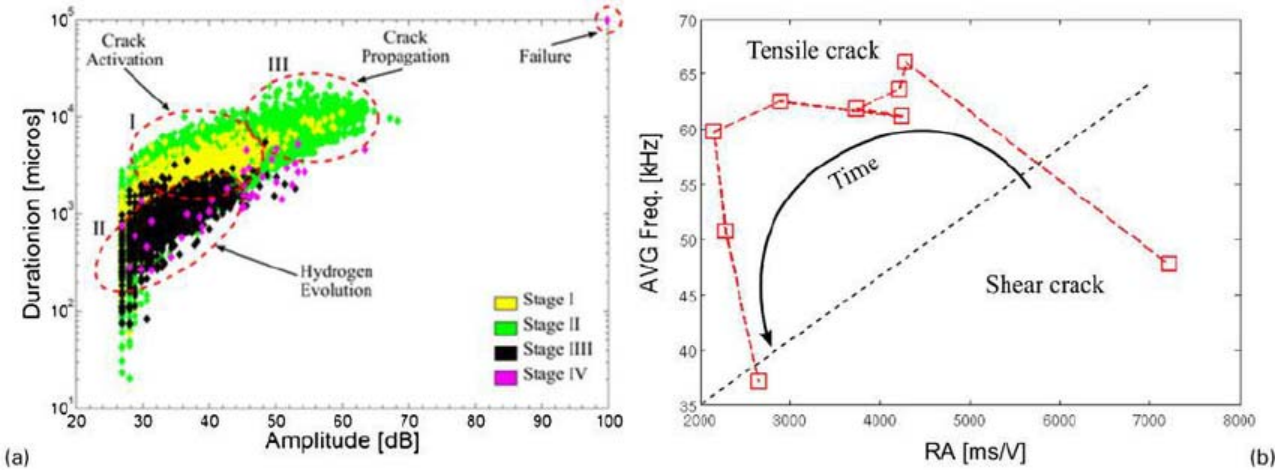
Hydrogen bubbling

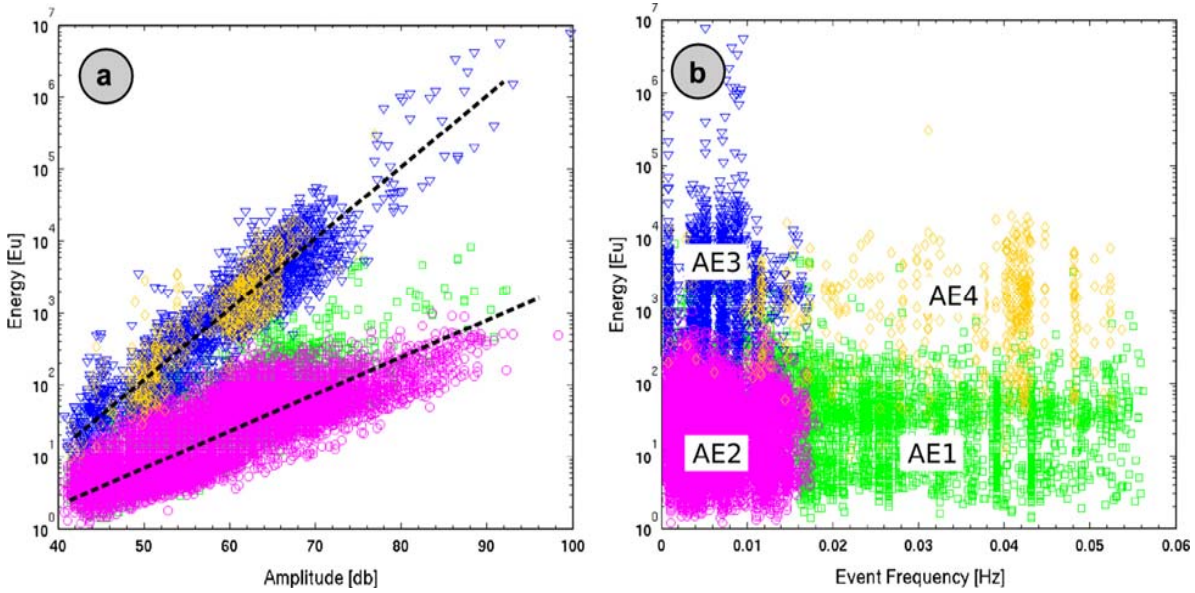
Bearing

Frattura adesiva

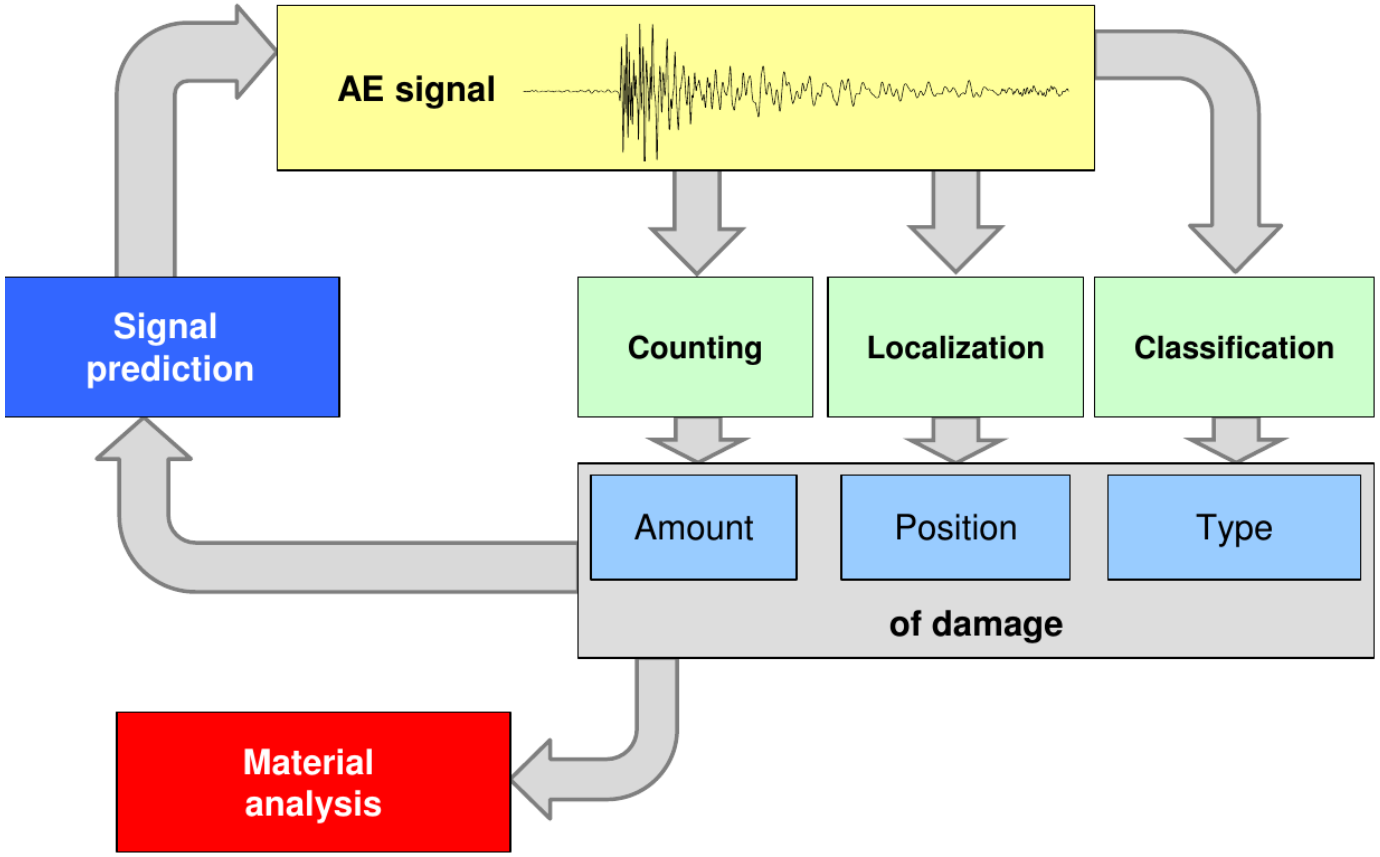
.....

La clusterizzazione dei dati

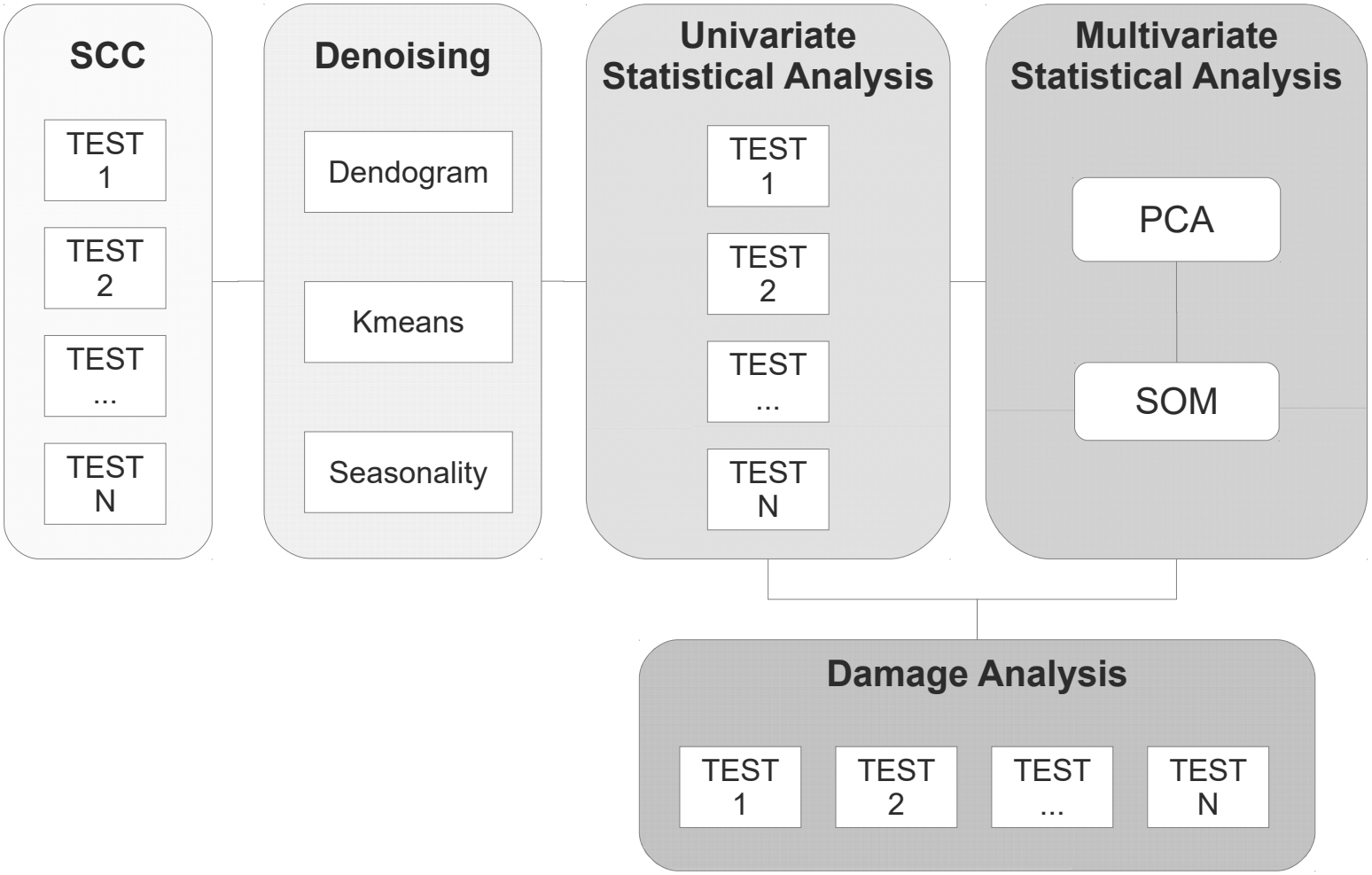




Il processo di acquisizione ed elaborazione dei segnali di emissione acustica

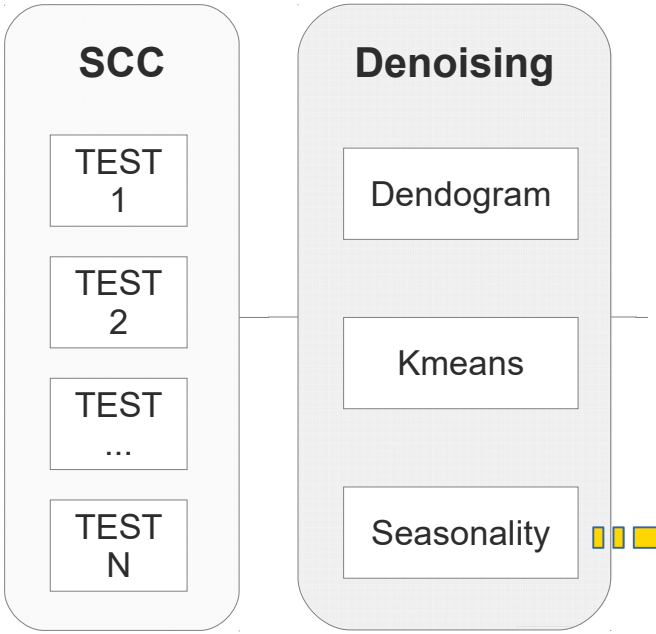


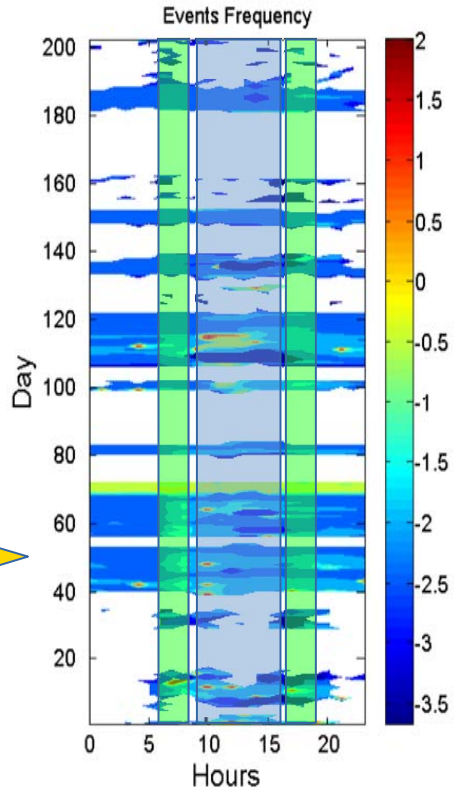
Algoritmi di analisi



Un problema aggiuntivo: il rumore

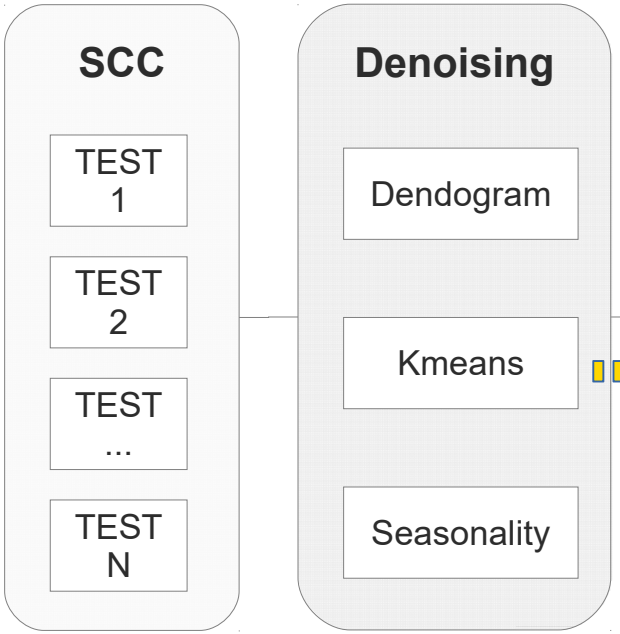
Algoritmi di denoising

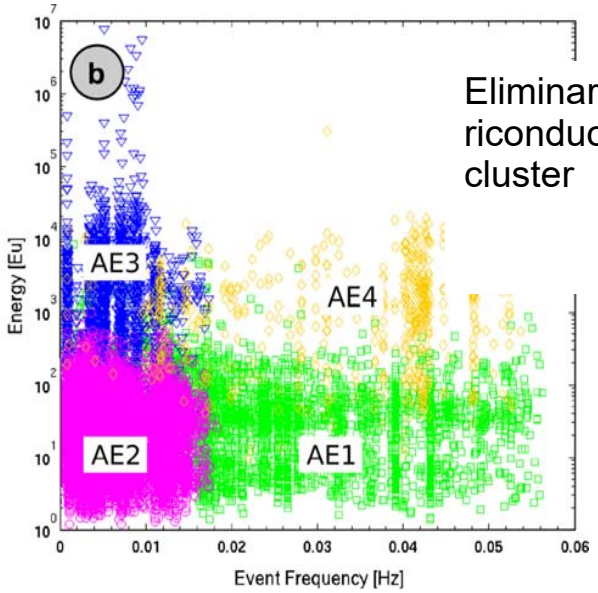




Eliminare eventi correlati ad elevate frequenze in specifiche finestre temporali

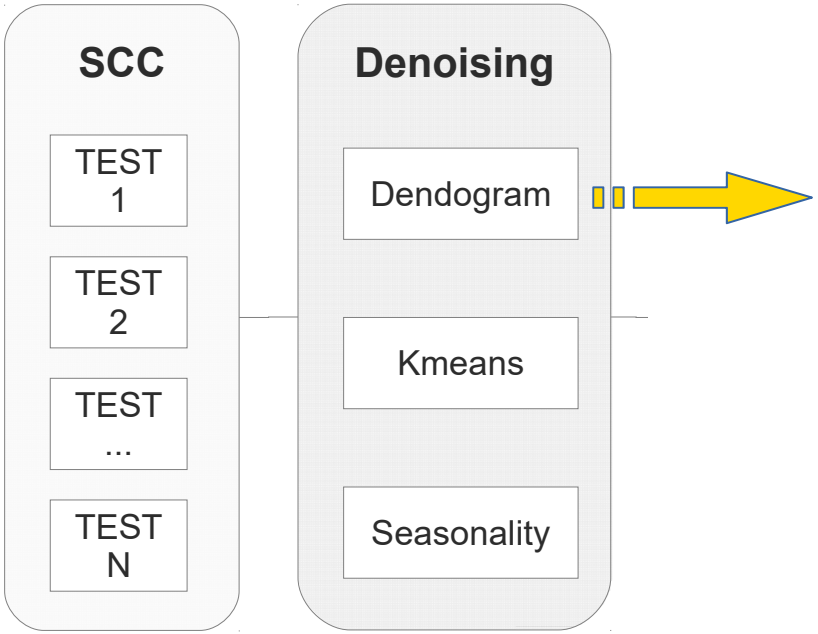
Algoritmi di denoising

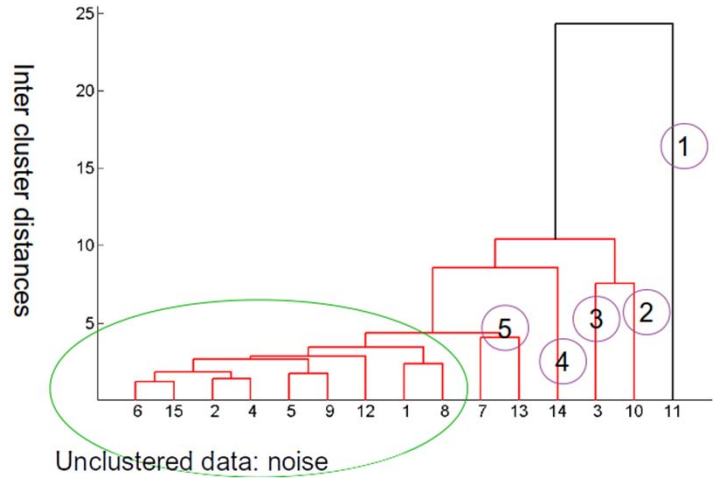




Eliminare eventi non riconducibili a specifici cluster

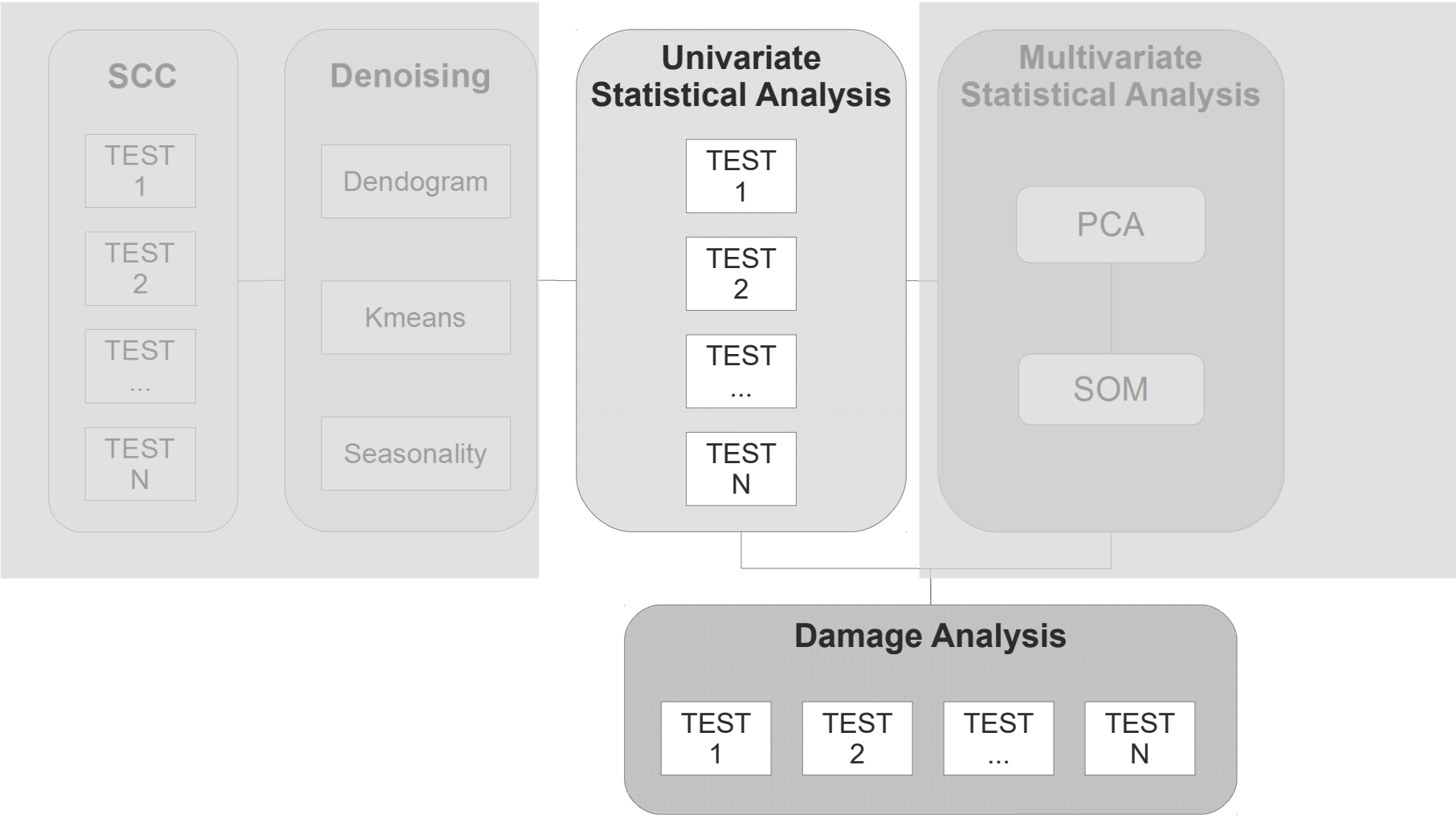
Algoritmi di denoising





Eliminare eventi non classificabili

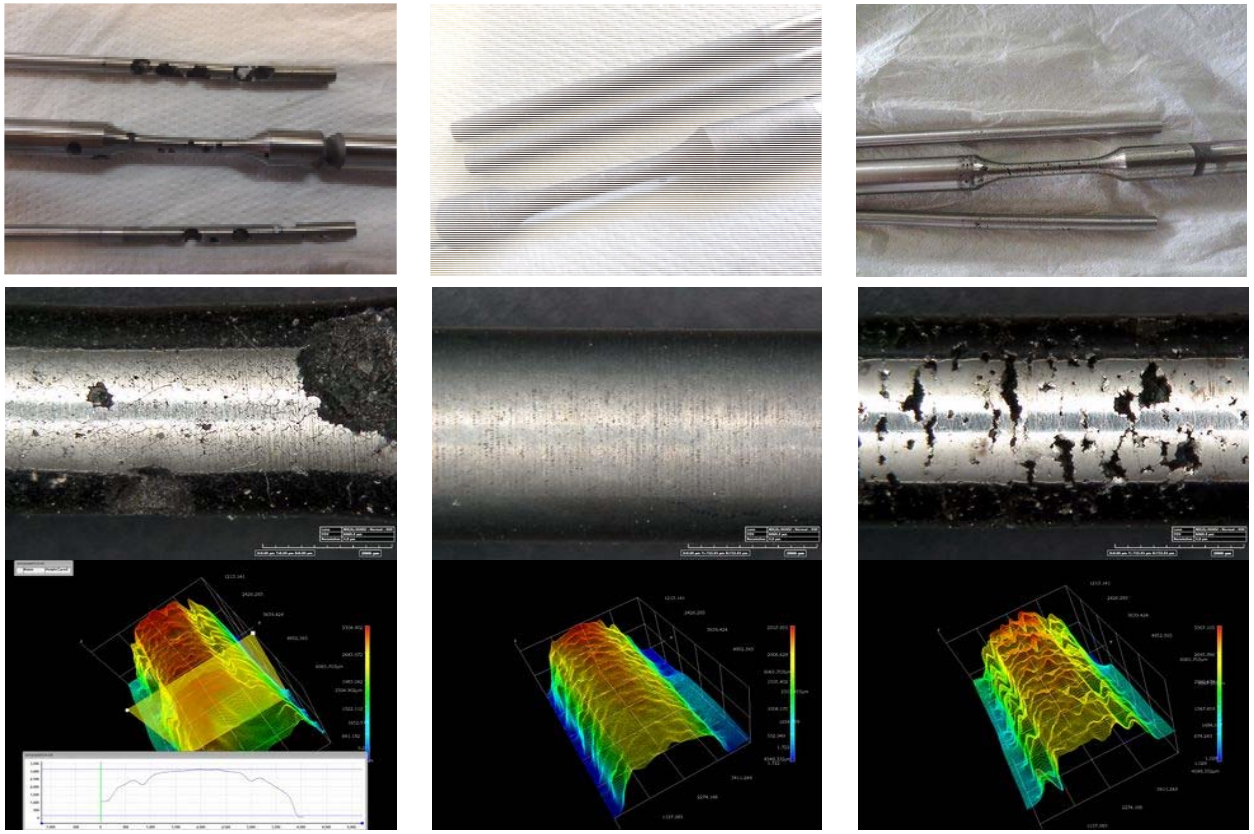
L’analisi univariata e bivariata



Analisi uni/bi-variata

Esempio: acciai inossidabili martensitici in $MgCl_2$

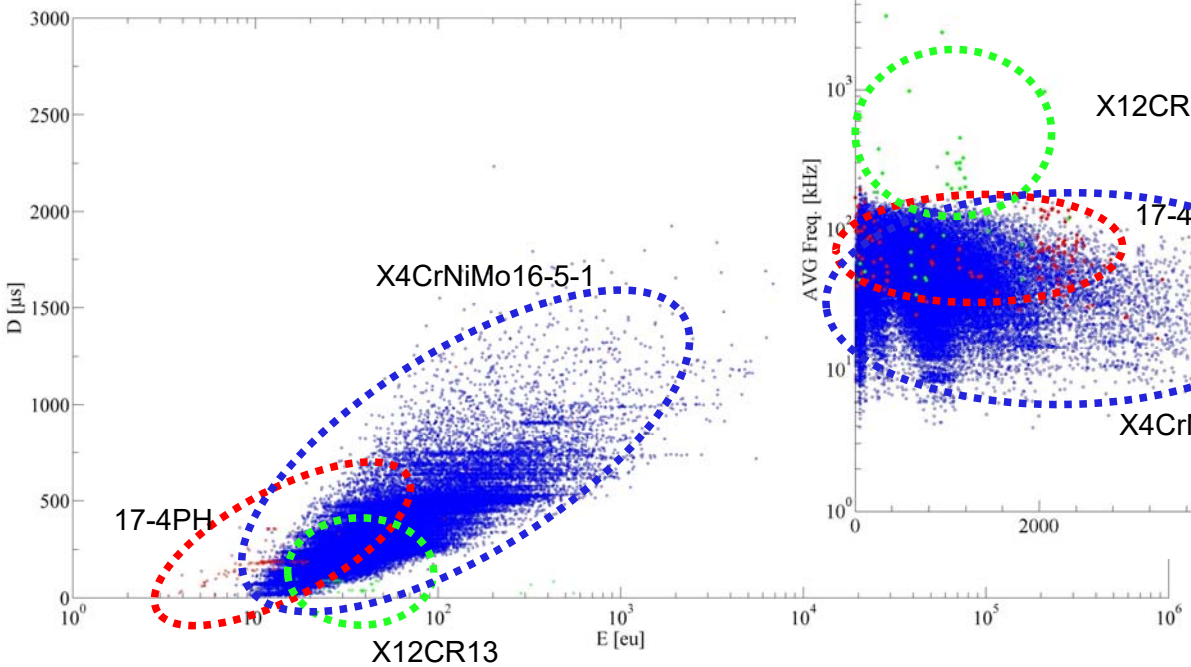
X4CrNiMo16-5-1 X12Cr13 17-4 PH



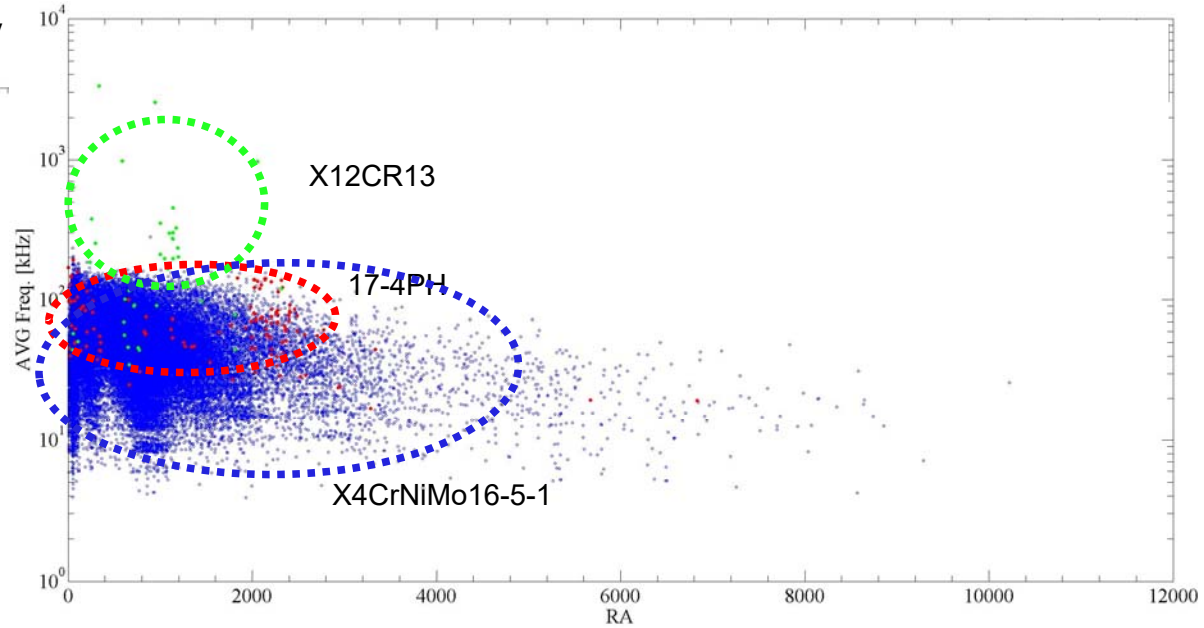
Analisi uni/bi-variata

Esempio: acciai inossidabili martensitici in $MgCl_2$

Duration vs Energy

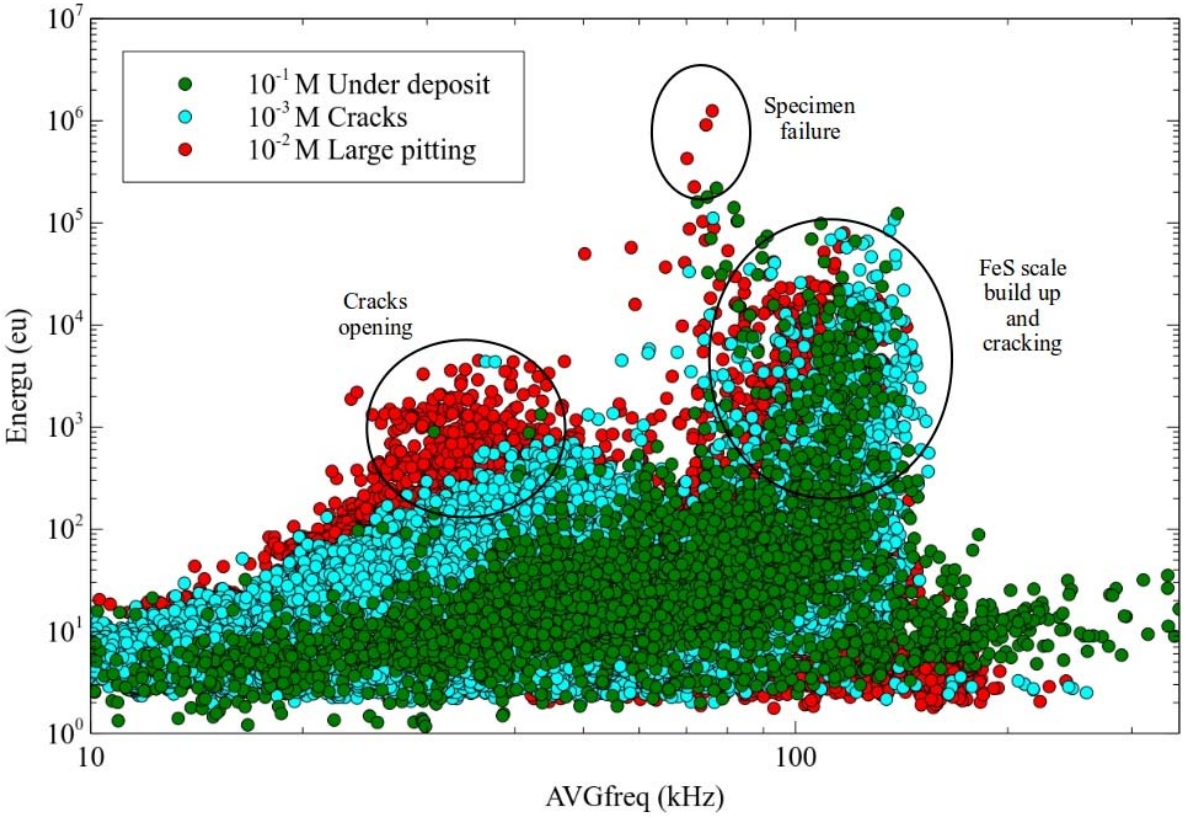


AVG freq vs RA



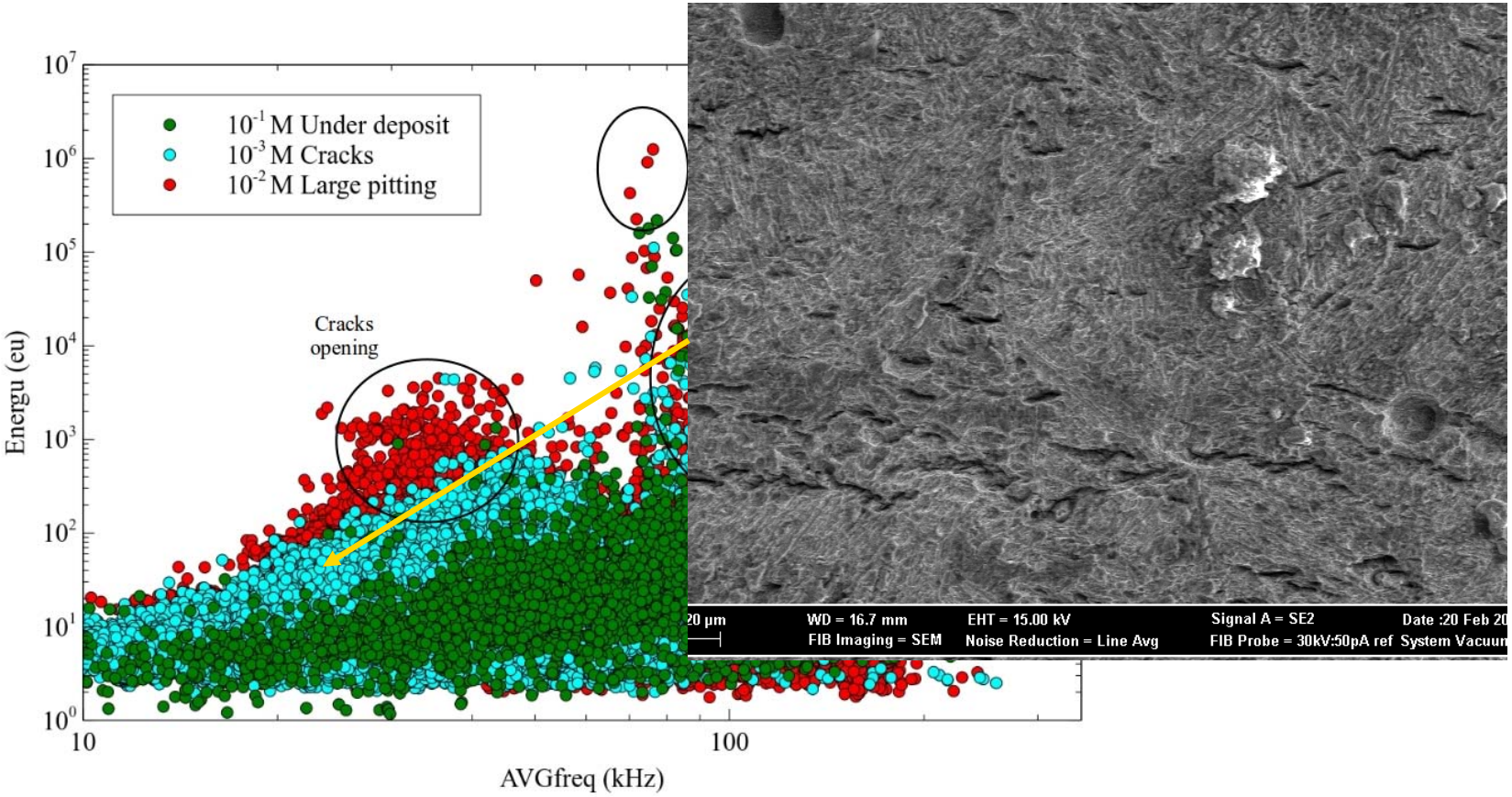
Analisi uni/bi-variata

Esempio: acciai inossidabili martensitici in Tiosolfato + NaCl



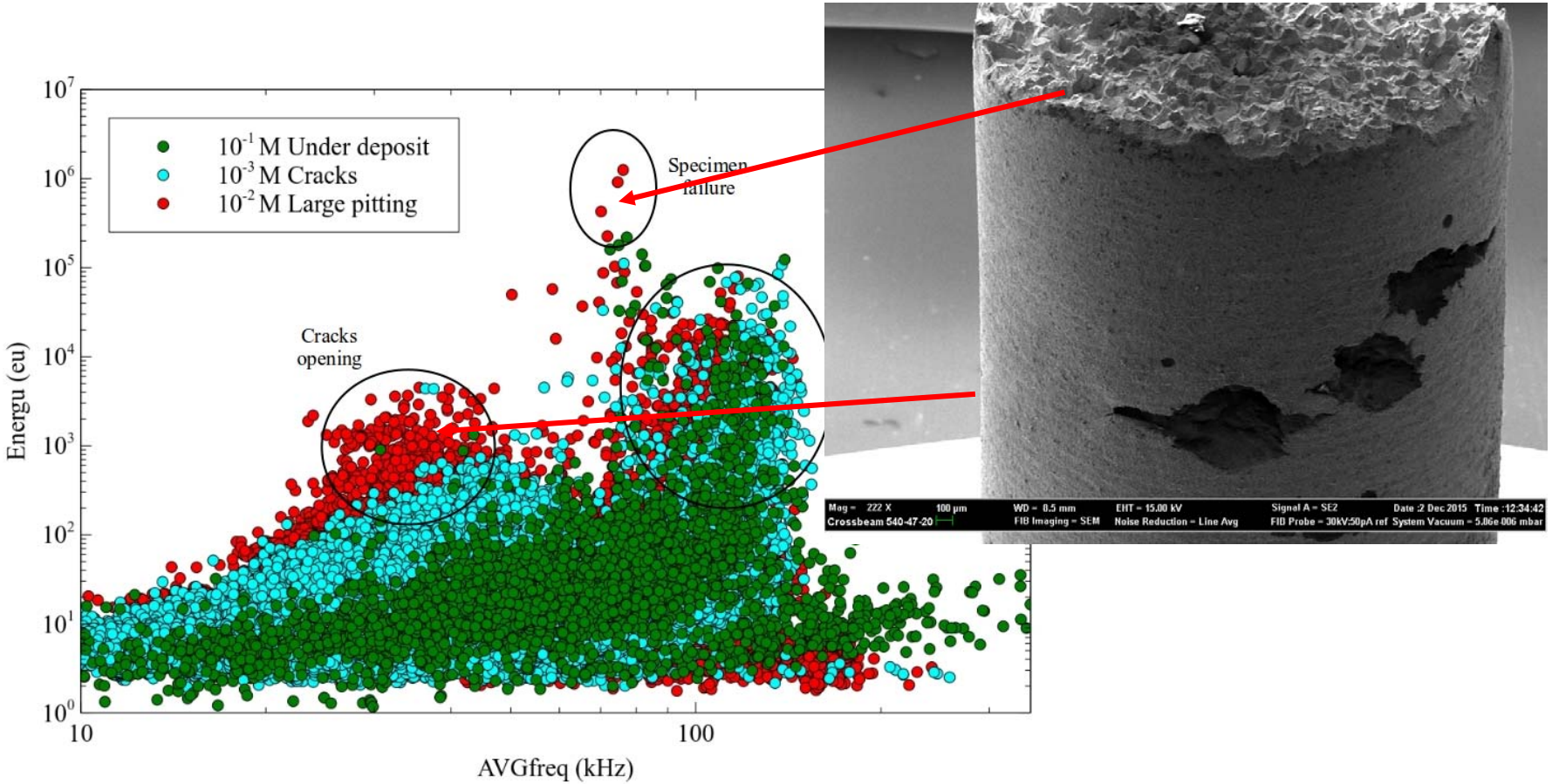
Analisi uni/bi-variata

Esempio: acciai inossidabili martensitici in Tiosolfato + NaCl



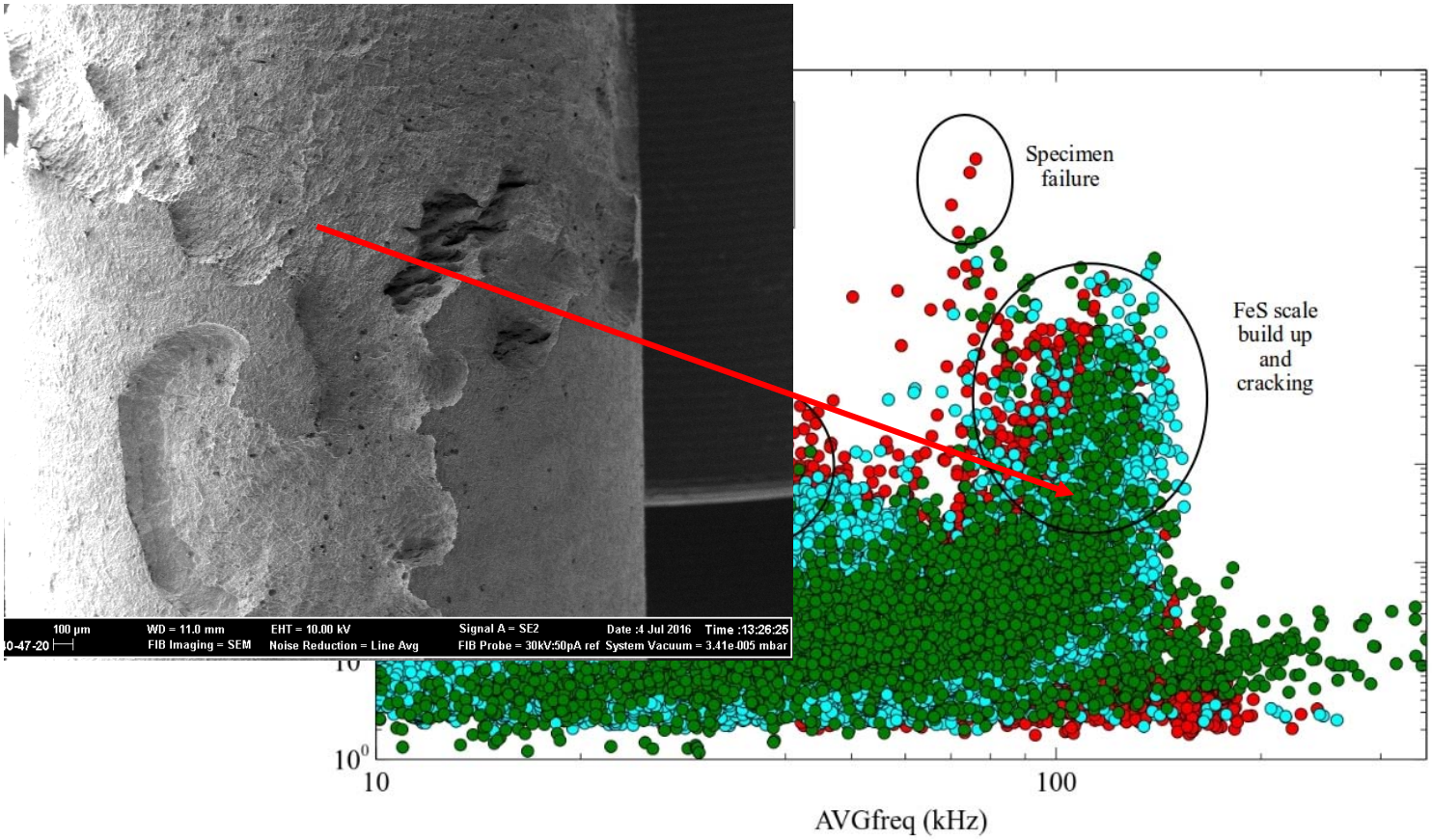
Analisi uni/bi-variata

Esempio: acciai inossidabili martensitici in Tiosolfato + NaCl



Analisi uni/bi-variata

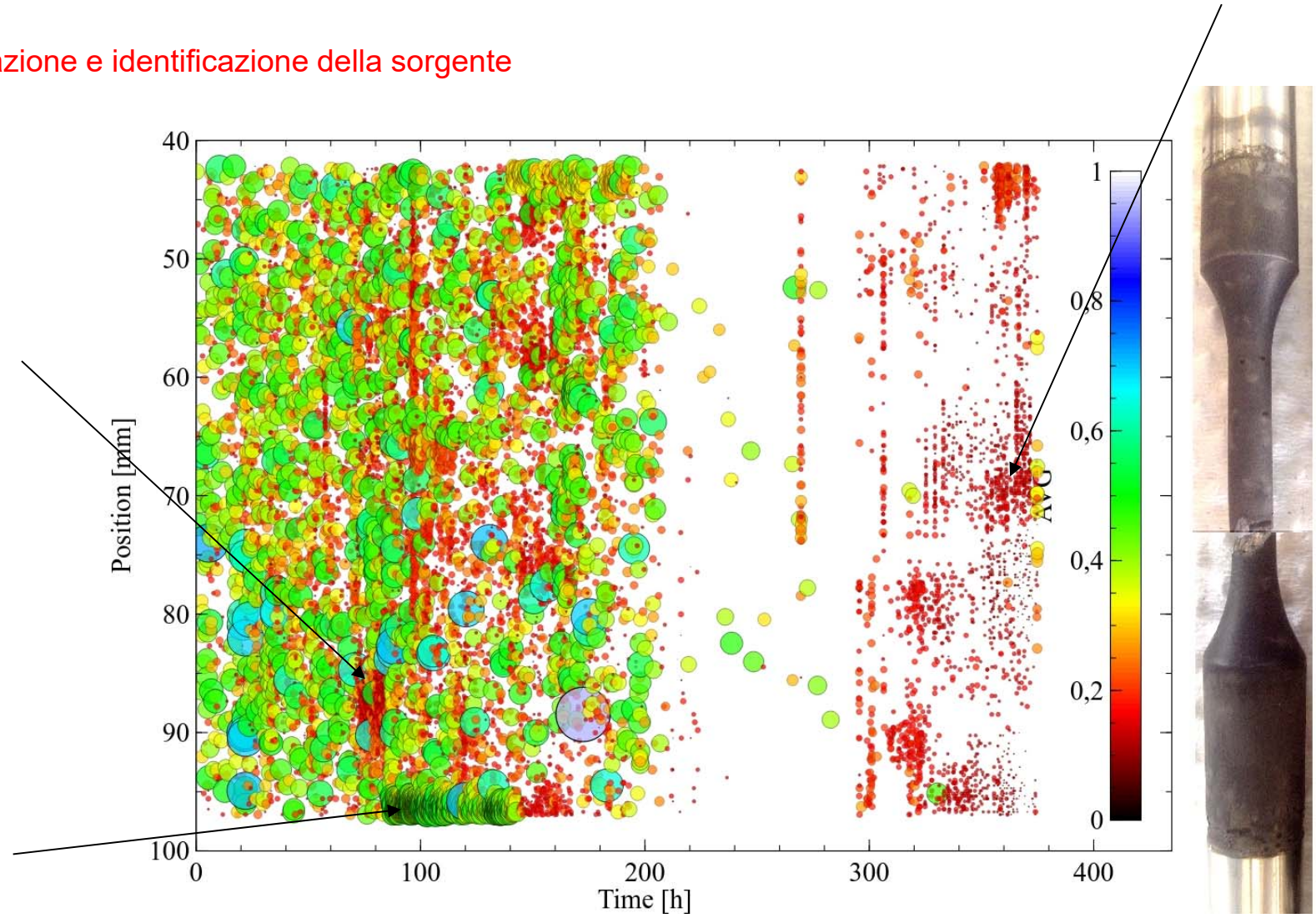
Esempio: acciai inossidabili martensitici in Tiosolfato + NaCl



Analisi uni/bi-variata

Esempio: acciai inossidabili martensitici in Tiosolfato + NaCl

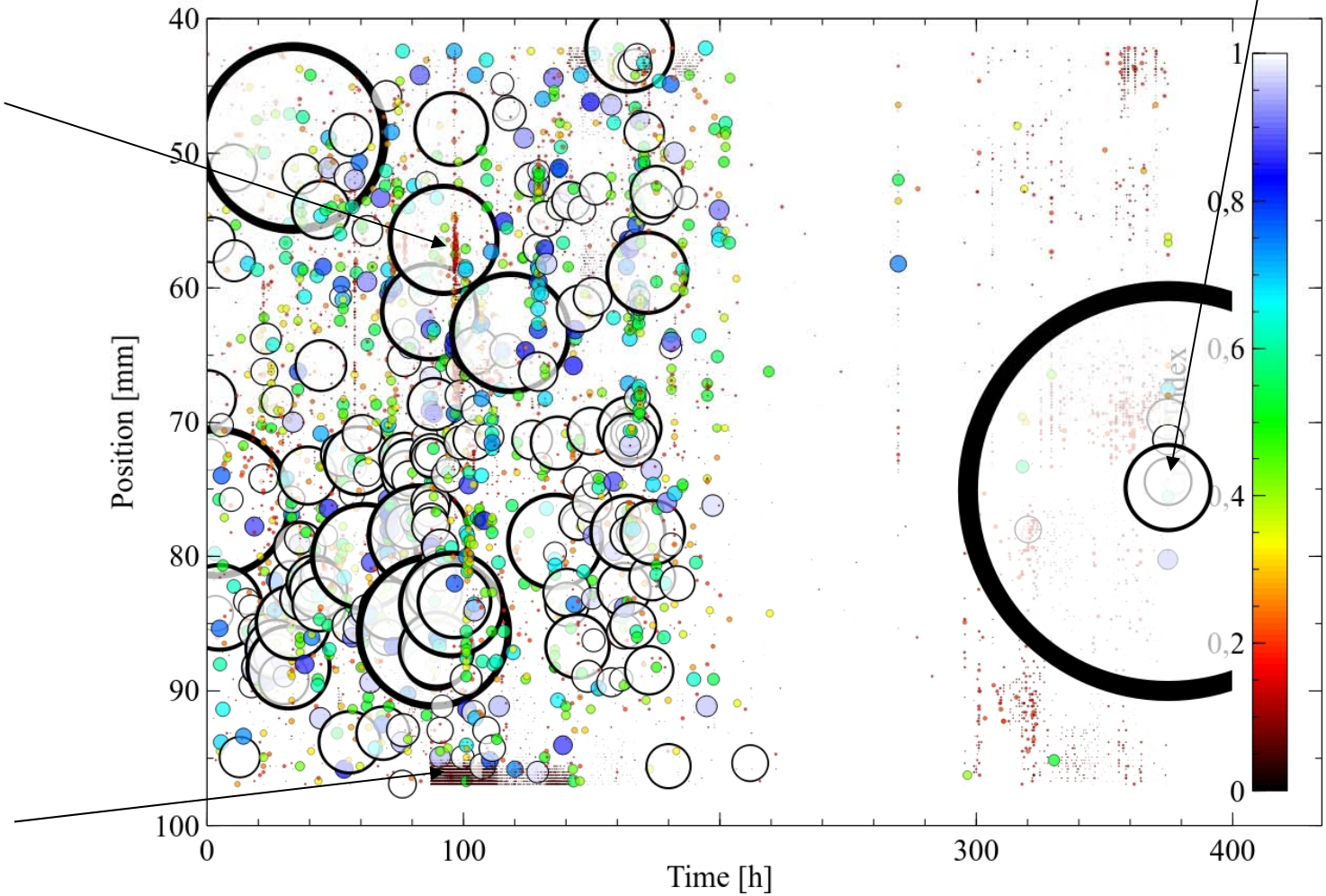
Localizzazione e identificazione della sorgente



Analisi uni/bi-variata

Esempio: acciai inossidabili martensitici in Tiosolfato + NaCl

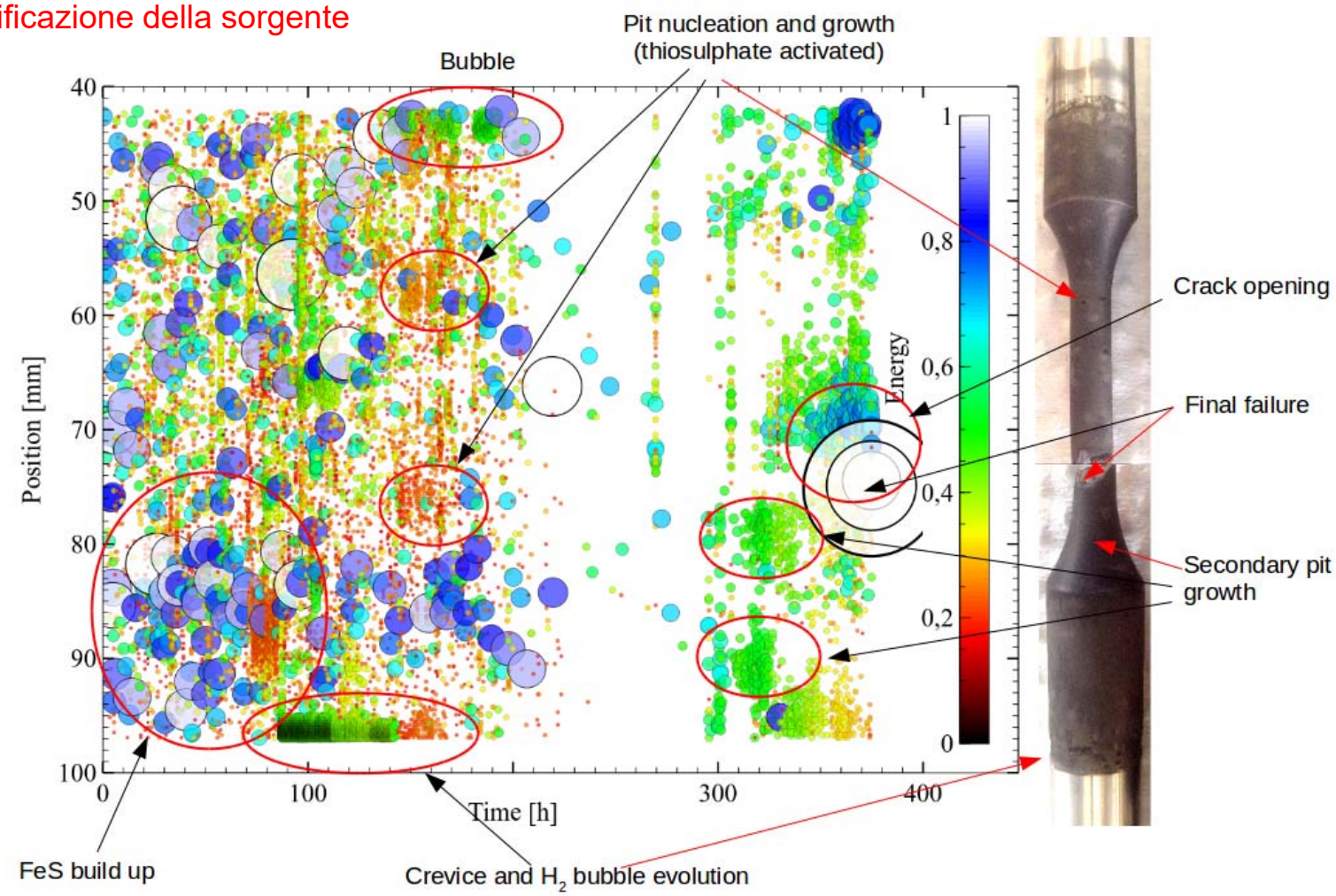
Localizzazione e identificazione della sorgente



Analisi uni/bi-variata

Esempio: acciai inossidabili martensitici in Tiosolfato + NaCl

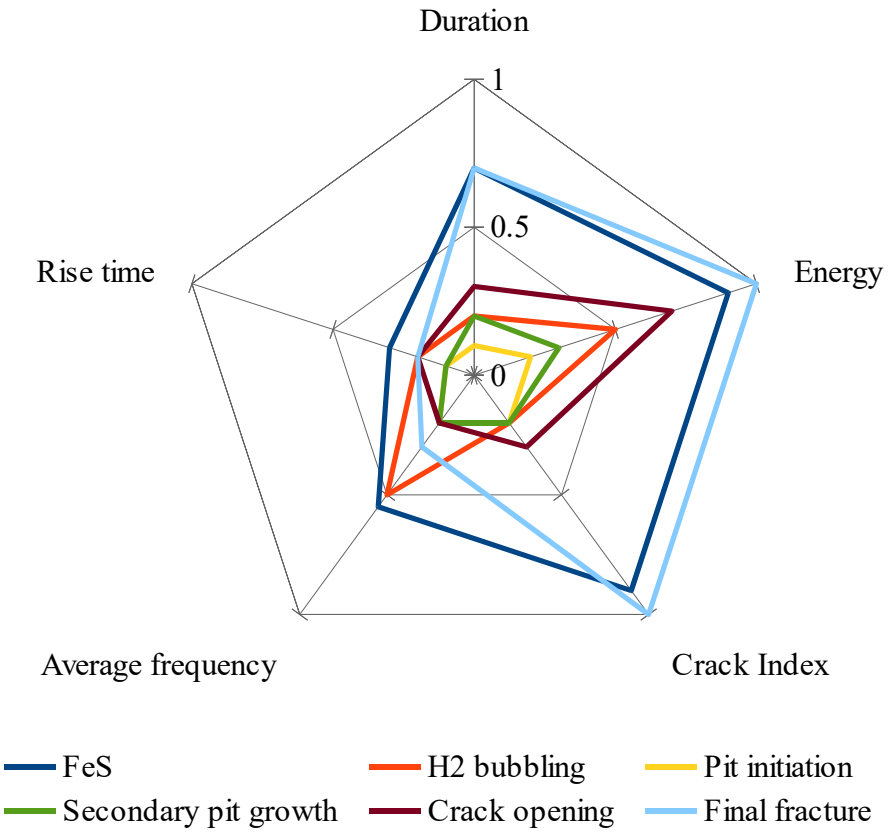
Localizzazione e identificazione della sorgente



Analisi uni/bi-variata

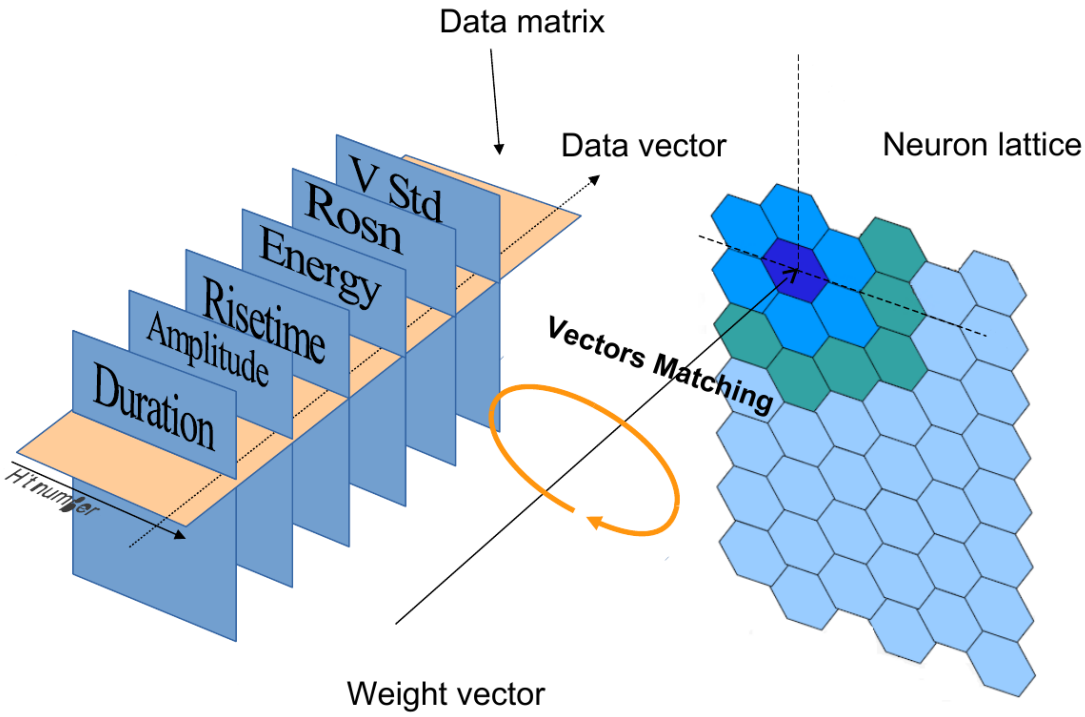
Esempio: acciai inossidabili martensitici in Tiosolfato + NaCl

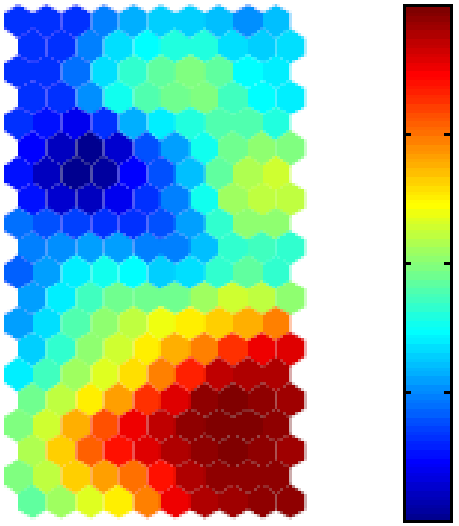
Localizzazione e identificazione della sorgente



Analisi multivariata - SOM

Analisi multivariata - SOM

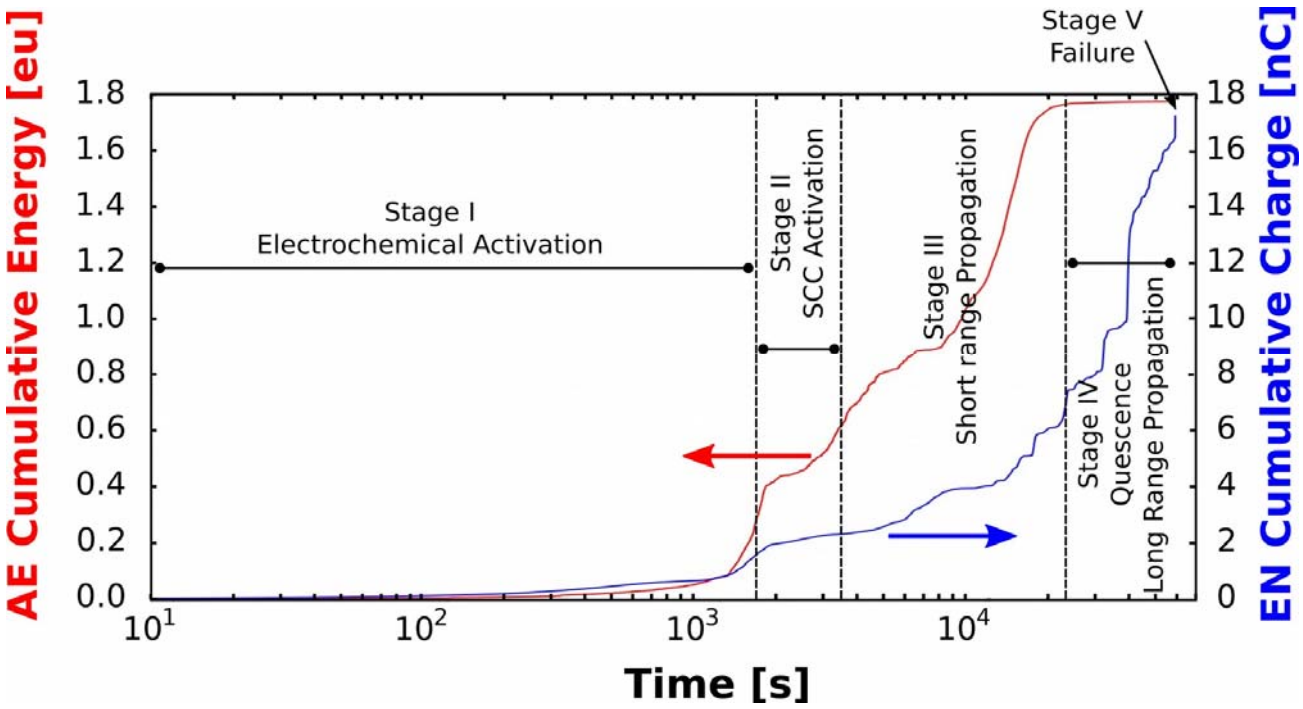




Analisi multivariata - SOM

Esempio: acciai inossidabili martensitici in 14-4 PH in $MgCl_2$

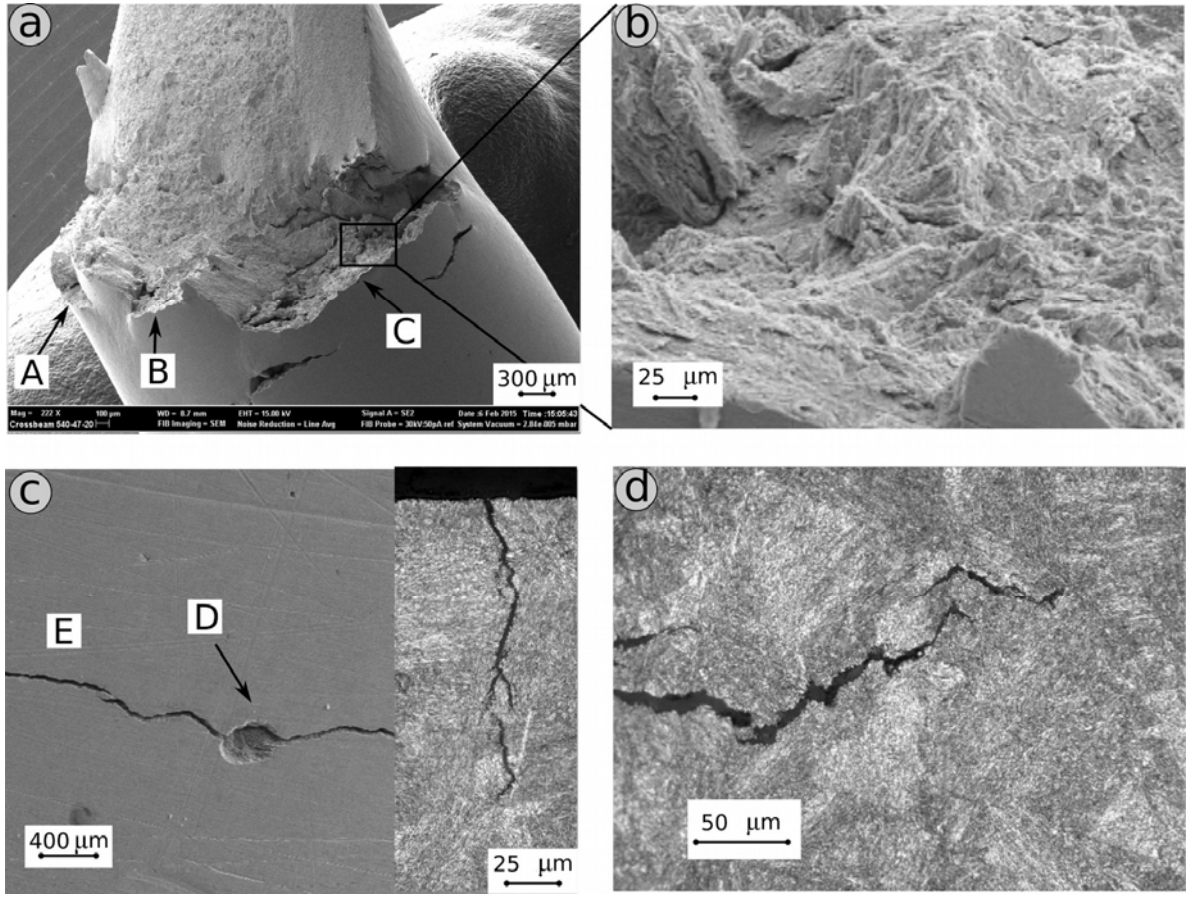
Identificazione dei processi e valutazione dei fenomeni nel tempo (EA + EN)

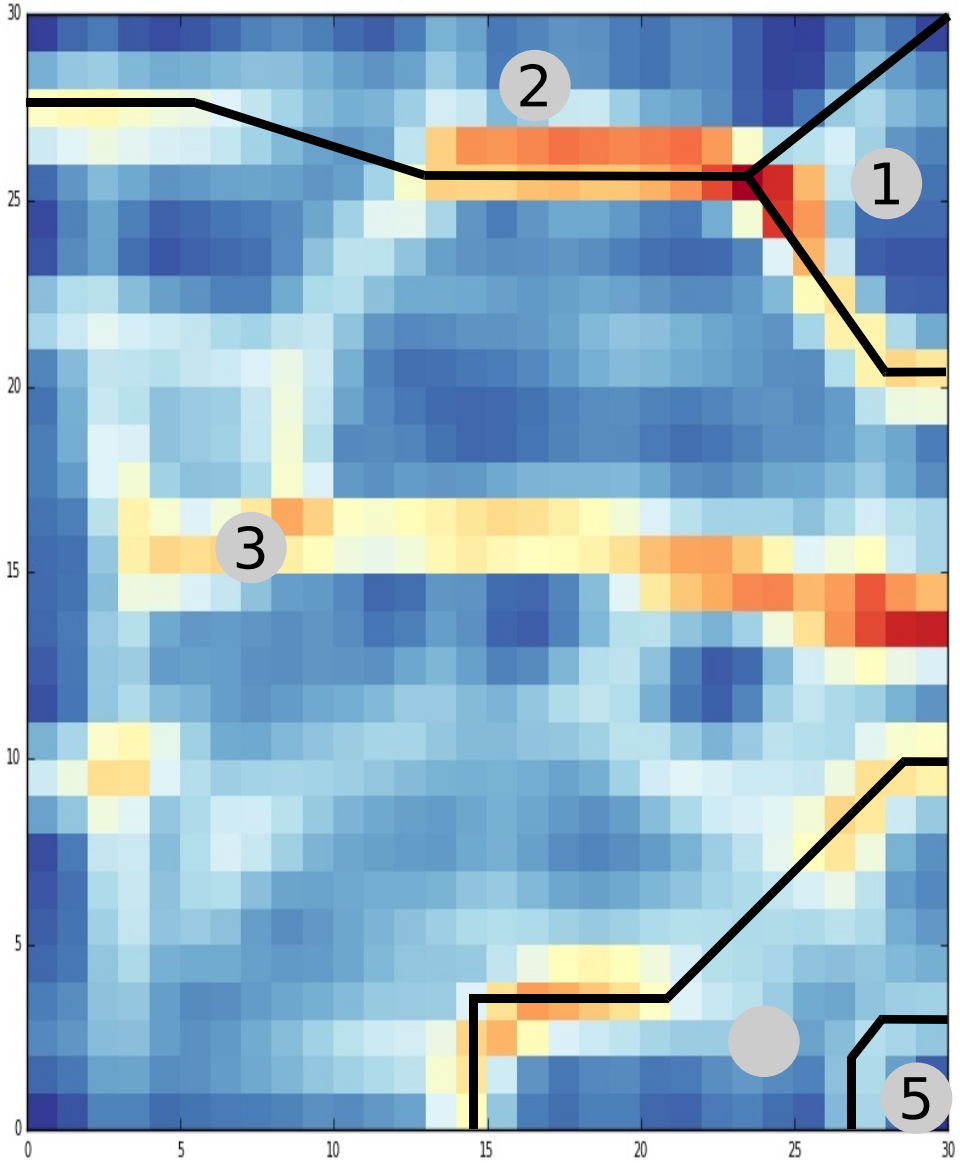


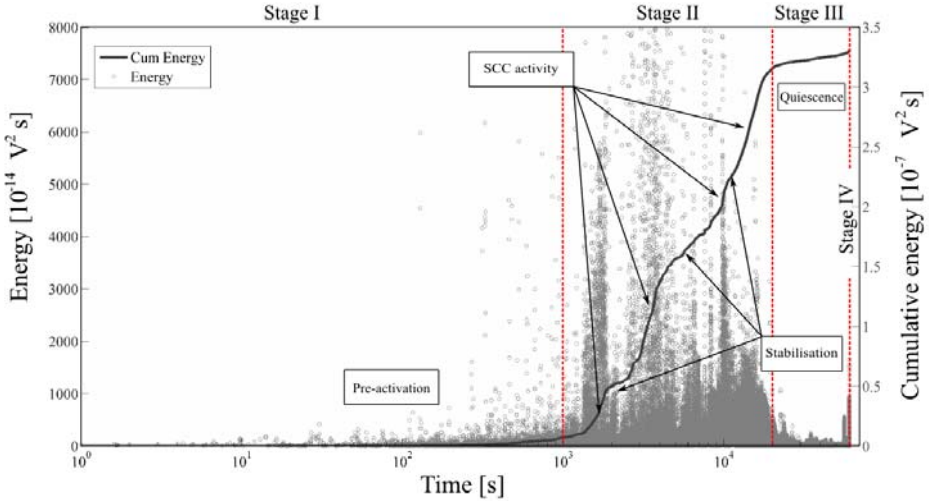
Analisi multivariata - SOM

Esempio: acciai inossidabili martensitici in 14-4 PH in $MgCl_2$

Identificazione dei processi e valutazione dei fenomeni nel tempo







Regione 1: Incubazione

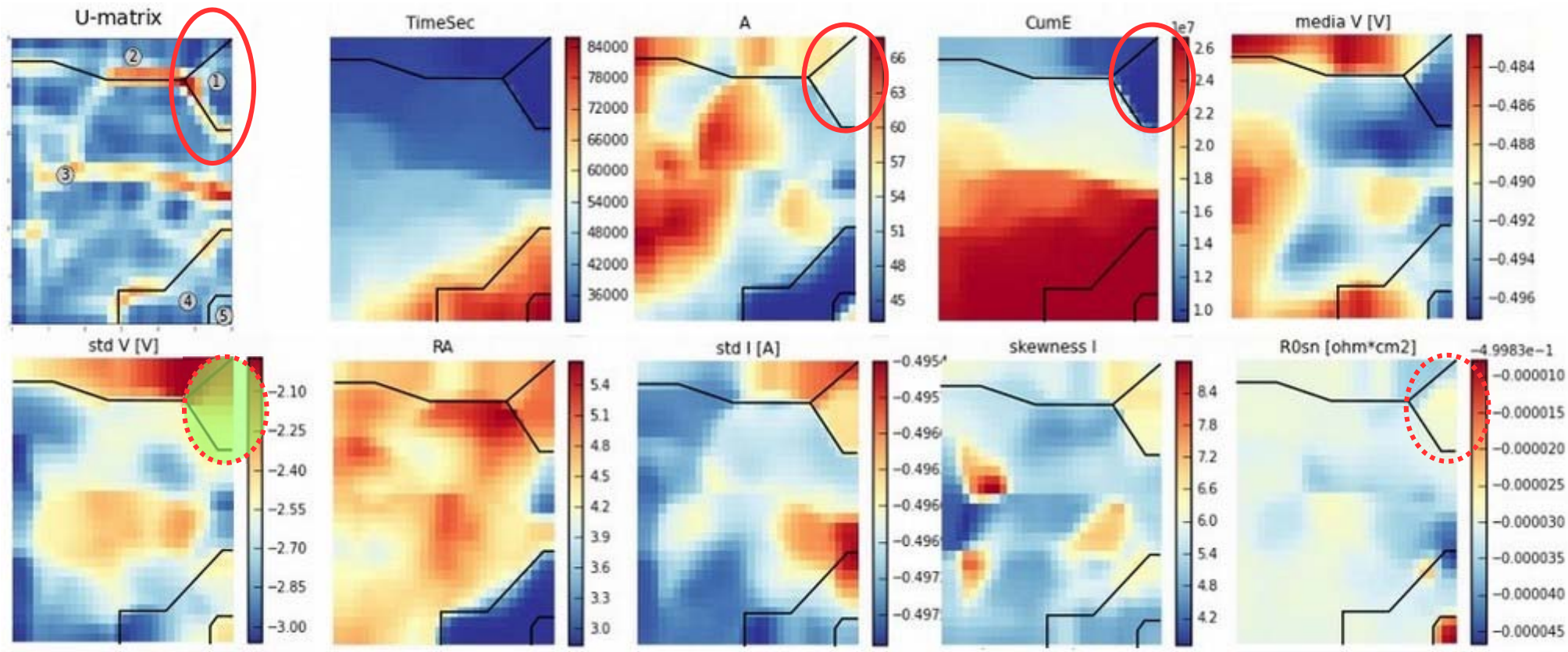
Regione 2: Attivazione

Regione 3: Propagazione

Regione 4: Quiescenza

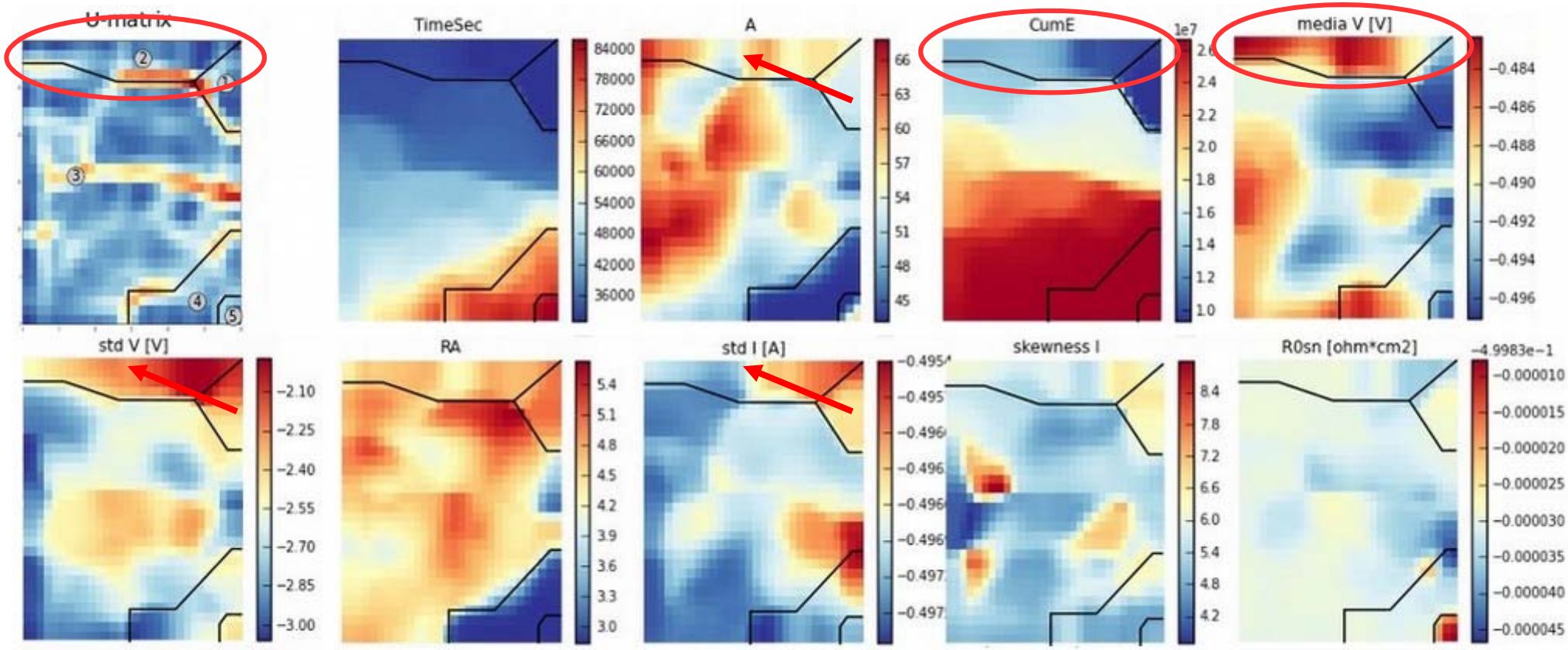
Regione 5: Frattura

Incubation region: electrochemical mechanisms



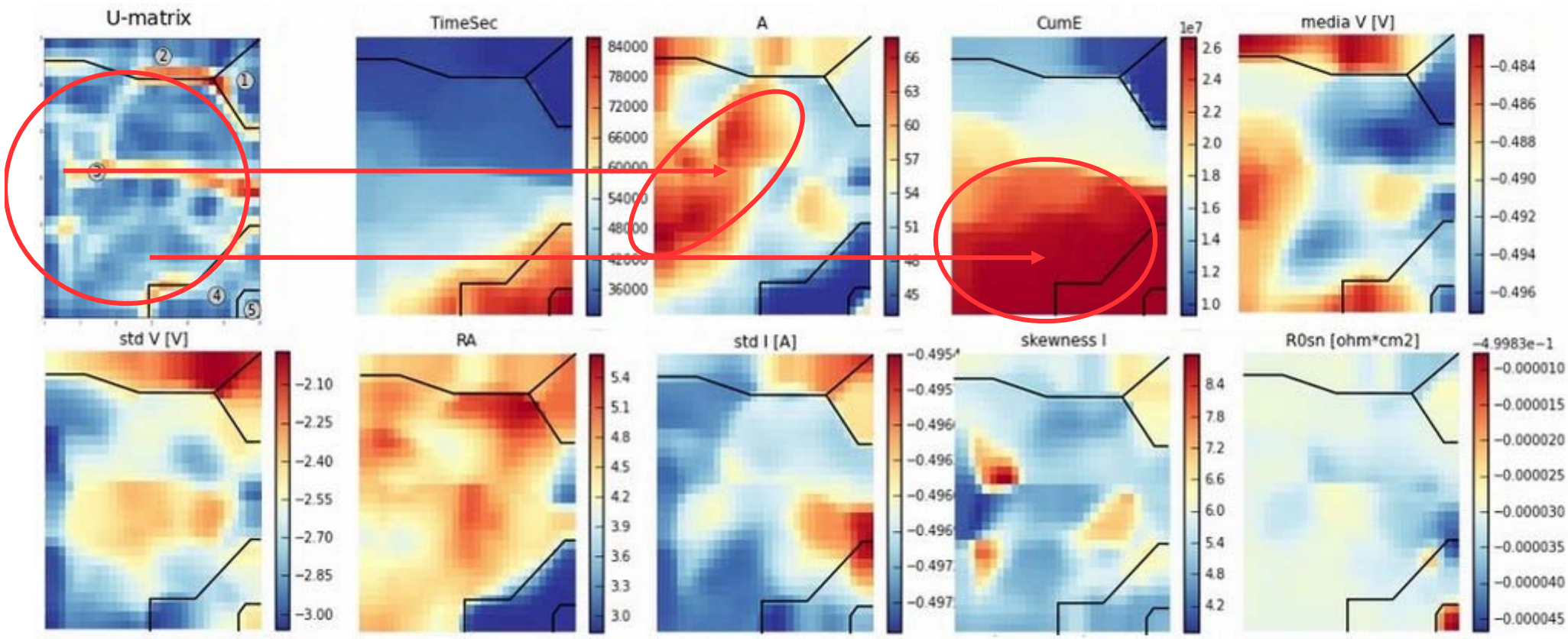
Low AE amplitude and Cumulative energy. Medium EN R_{0sn} and growing Std V)

Activation region: electrochemical mechanisms



Growing AE amplitude and low Cumulative energy. High EN Std V

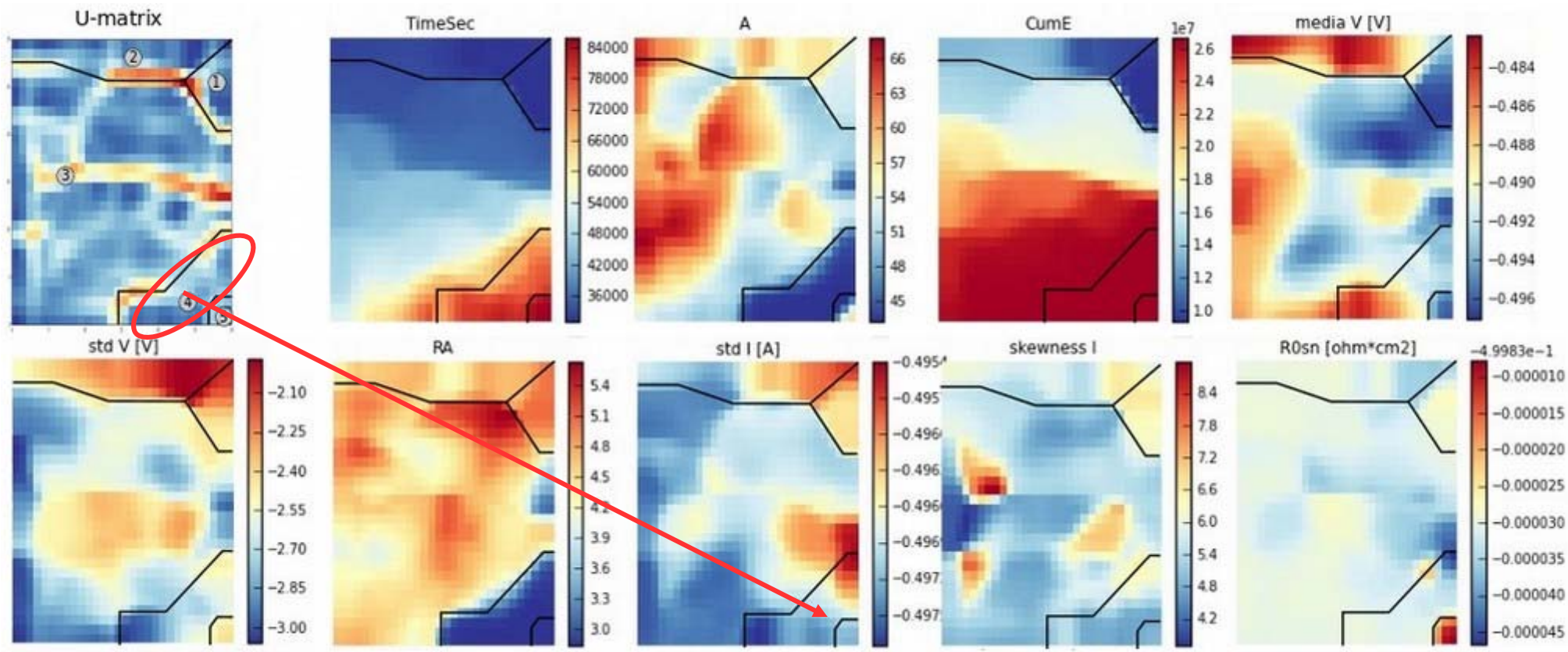
Propagation region: mechanical processes



Two step region. High AE activity, low EN activity. Mechanical processes: short range crack propagation

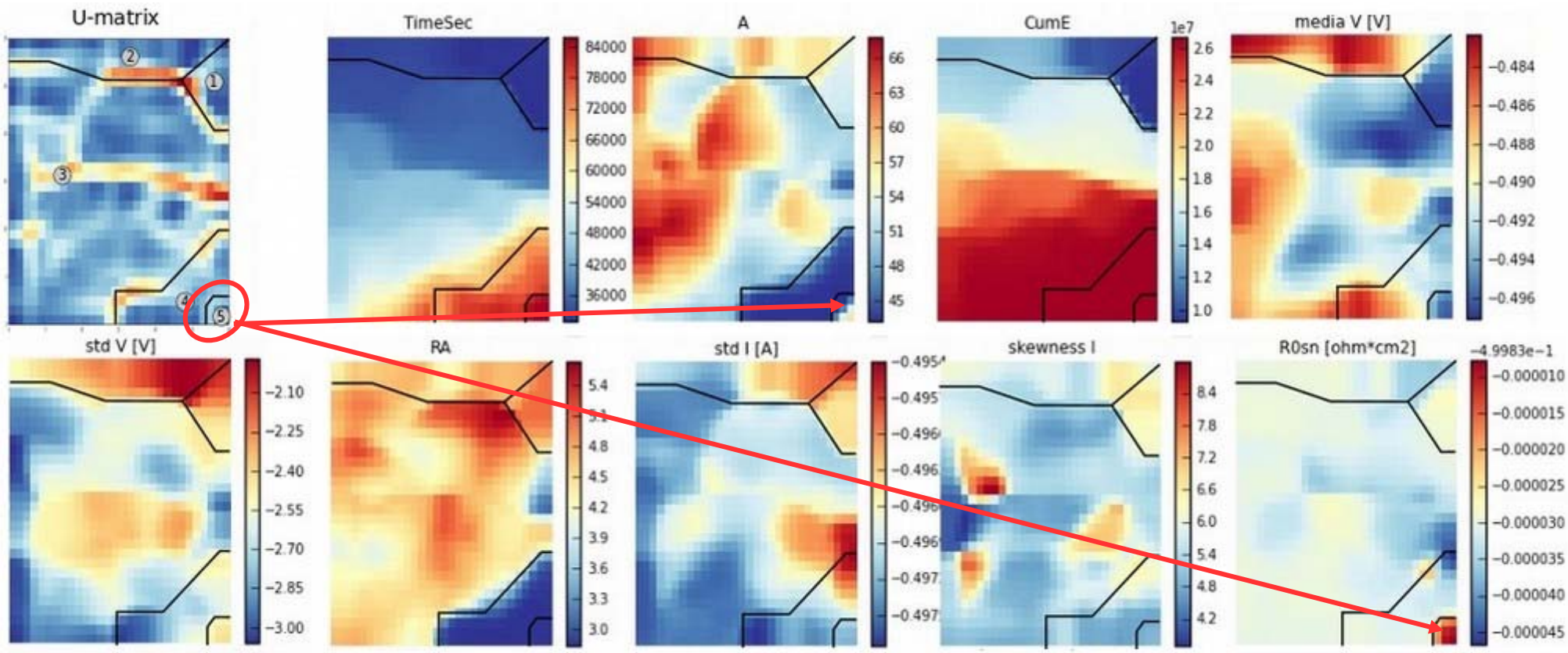
Results and discussion: SOM

Quiescence region: electrochemical mechanisms

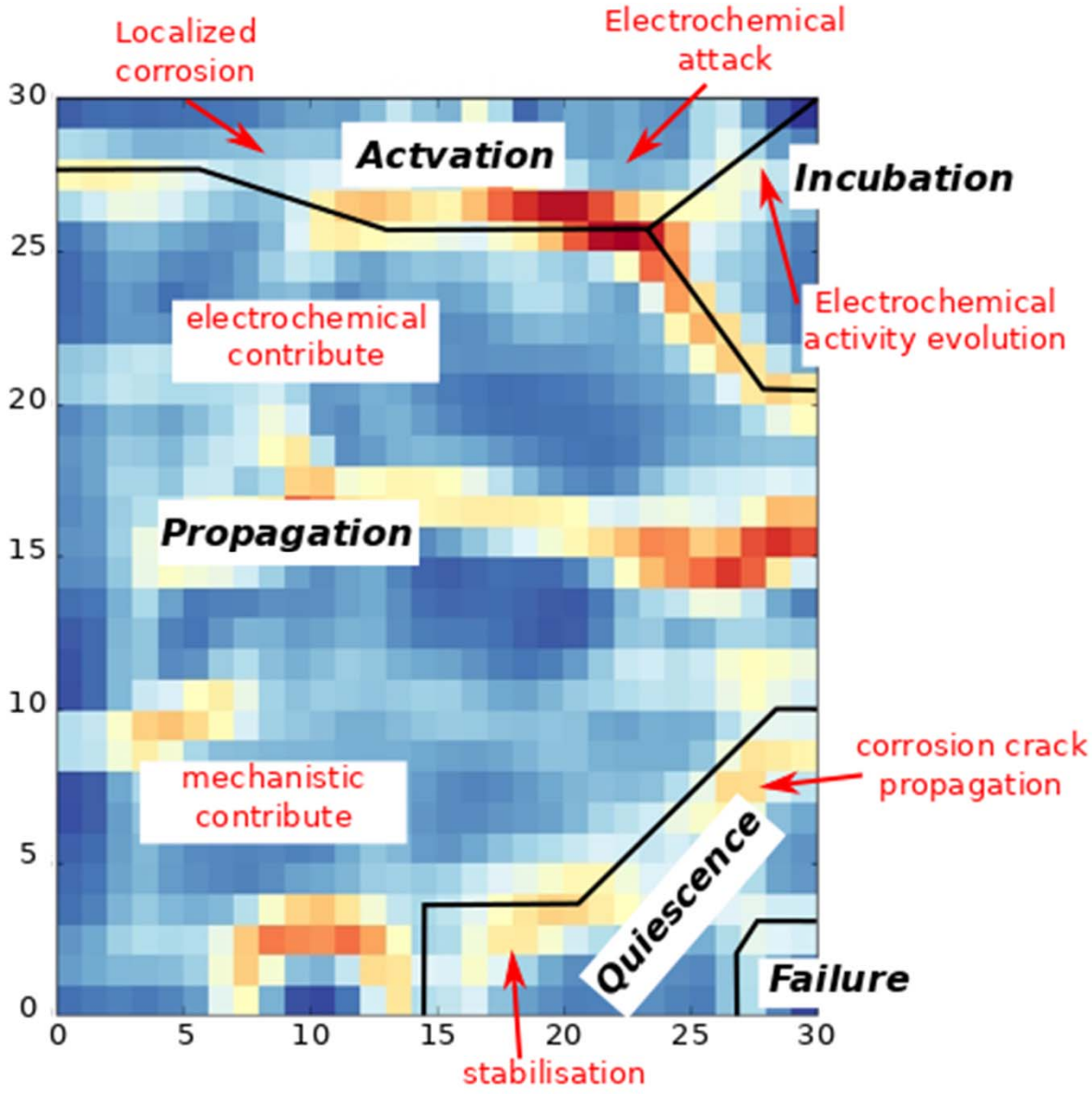


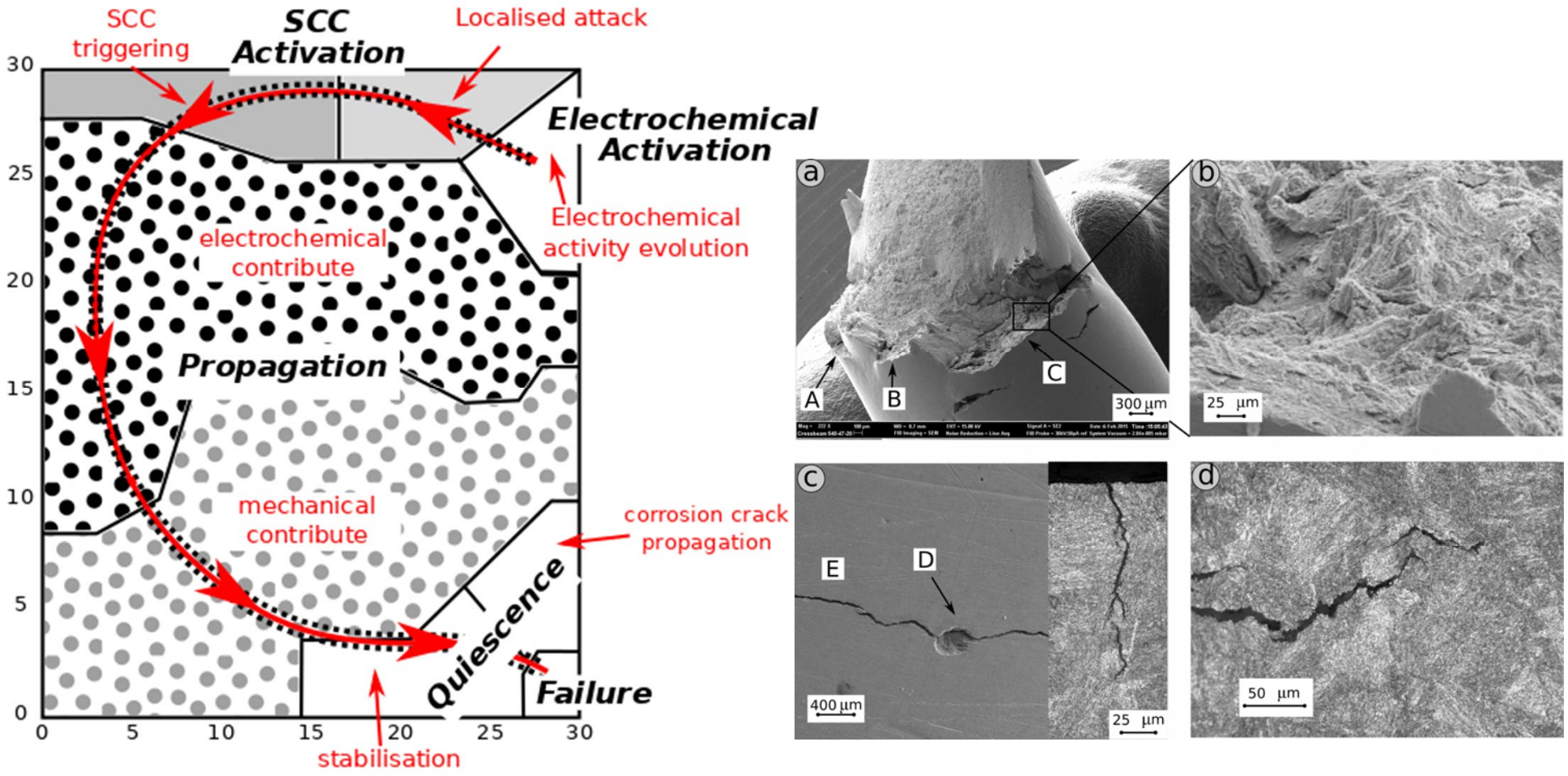
Very low AE activity. High EN Std I. Crack propagation by electrochemical processes at crack tip

Final fracture region: mechanical processes



High amplitude AE events. Sharp increases of R_{0sn} parameter. Final fracture


Localized corrosion
Electrochemical attack
Actvation
Incubation
Electrochemical activity evolution
electrochemical contribute
Propagation
mechanistic contribute
corrosion crack propagation
Quiescence
Failure
stabilisation
0
5
10
15
20
25
30


SCC triggering
SCC Activation
Localised attack
Electrochemical Activation
Electrochemical activity evolution
electrochemical contribute
Propagation
mechanical contribute
corrosion crack propagation
Quiescence
Failure
stabilisation
0
5
10
15
20
25
30
a
b
c
d
A
B
C
D
E
300 µm
25 µm
400 µm
50 µm

Grazie per l’attenzione

…..when we were young