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Embrittlement and "Cold Fusion" Effects in Palladium during Electrolysis Experiments

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CHARACTERISTIC PHENOMENA IN THE SO-CALLED COLD FUSION (CF)

- 1989 - Fleishman & Pons → Heat Generation
- 1998 - Mizuno → Heat Generation
  Neutron Emission
  Compositional changes
- 2008 - Mosier-Boss et al. → Heat Generation
  Neutron Emission
  Compositional changes
  Alpha particle emissions

Fleischmann, Pons, Hawkins, 1989. J. Electroanalitical Chemistry
Mizuno, 1998. Infinite Energy Press.
Mosier-Boss, P.A., et al., 2008. Eur. J. of Applied Physics

Cold Fusion vs Piezonuclear Reactions

"A unified interpretation and theory of these phenomena has not been accepted and their comprehension still remains unresolved" (*Preparata 1991*)

Is there a relation between the experimental evidence of the so-called "Cold Fusion", observed during the last two decades, and the Piezonuclear evidence recently observed from fracture of inert and nonradioactive materials?

Phenomena in common:

Neutron Emission

Alpha Emission

Compositional Changes

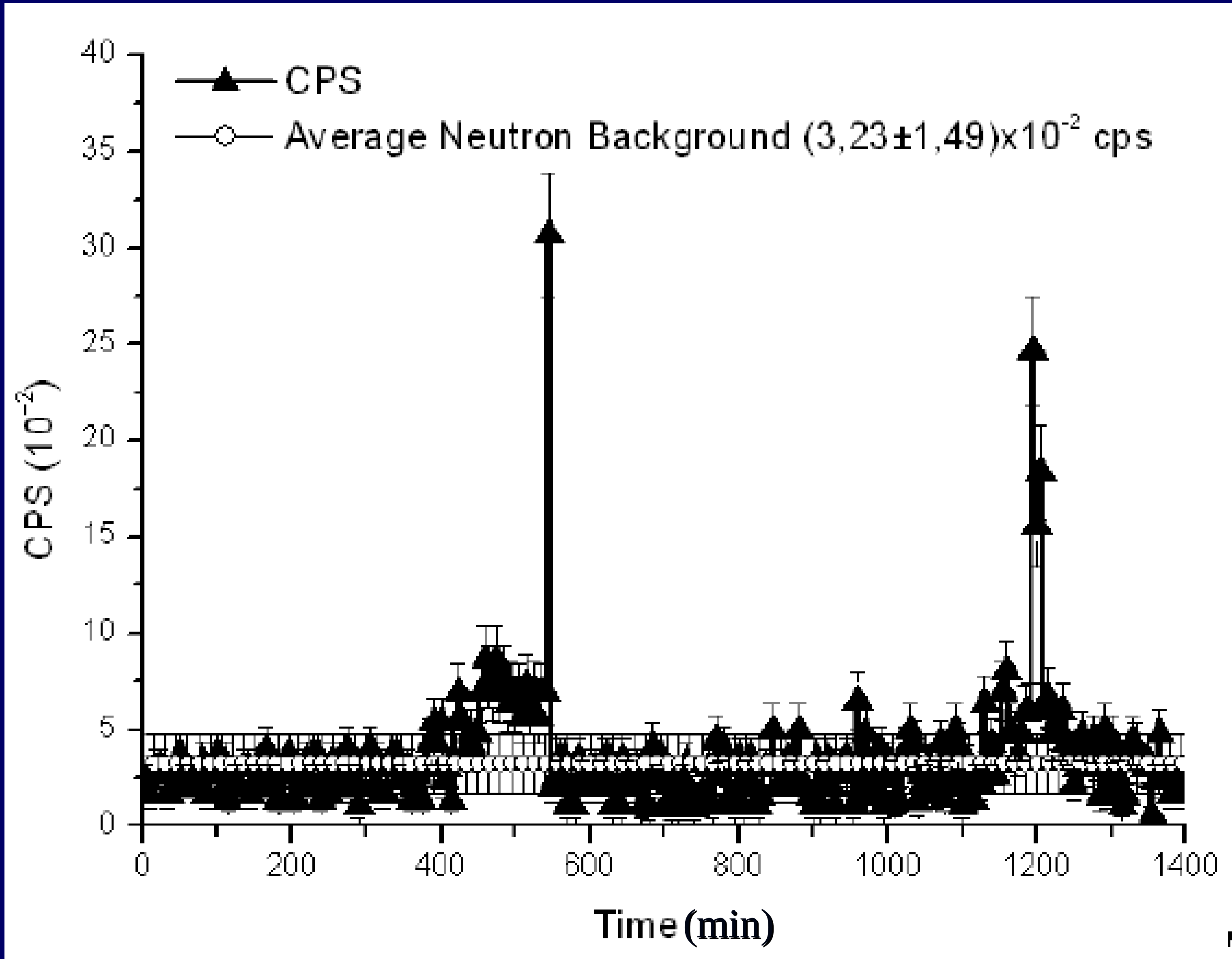
Micro-cracking and Fracture

Experimental Set-up

Electrolytic Cell

Electrodes

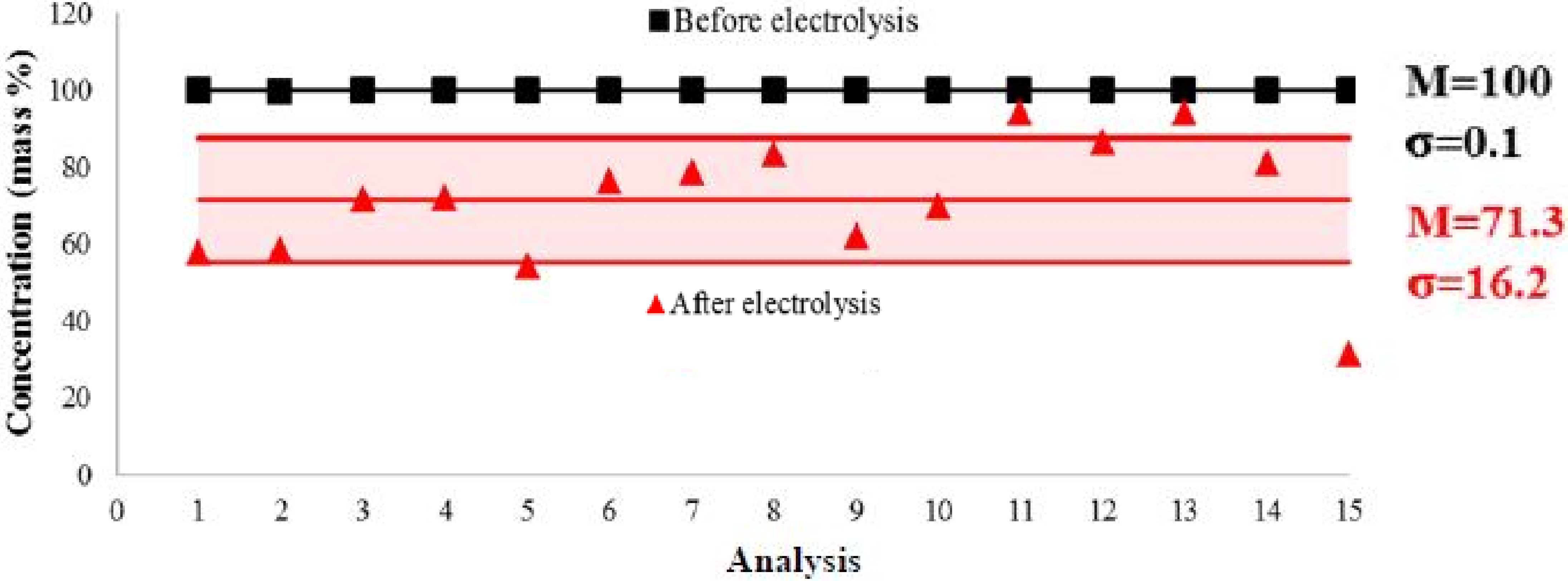
Neutron Emission



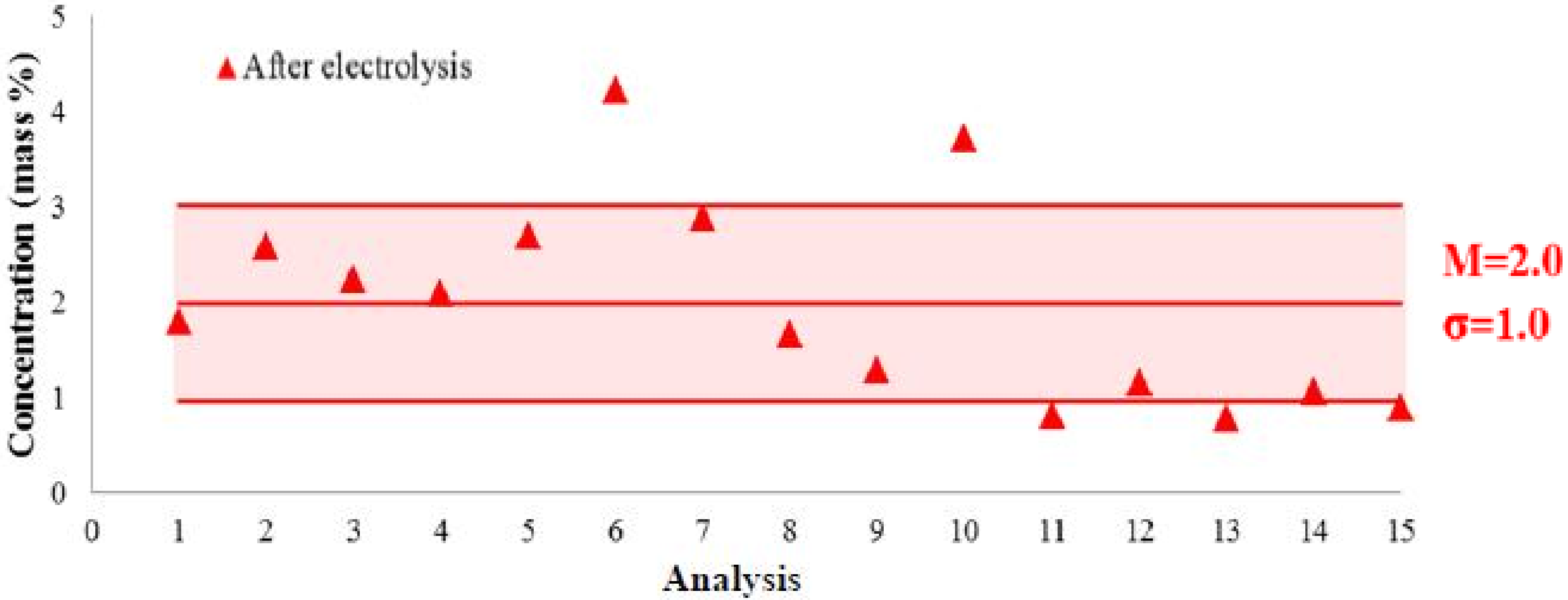
Neutron Emissions between 3 and 7 times the background level.

PALLADIUM ELECTRODE

Palladium (–28.7%)

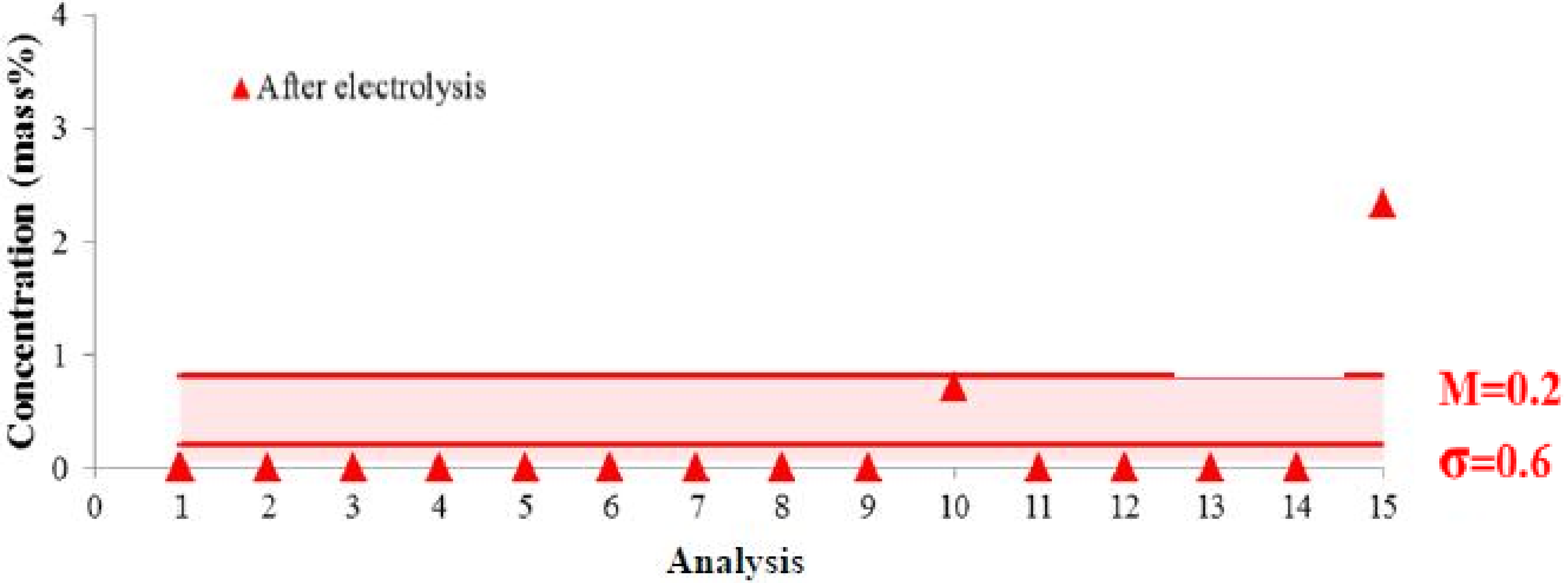


Iron (+2.0)

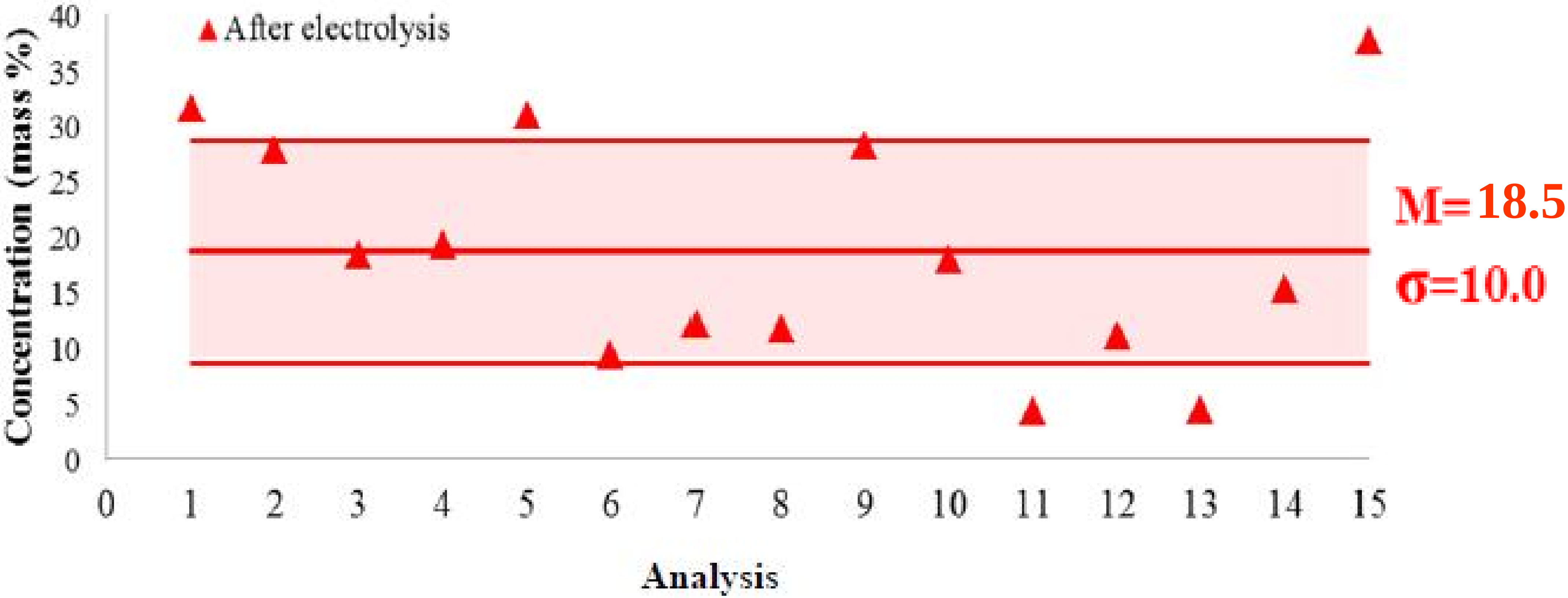


After electrolysis
Concentration (mass %)
Analysis
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
M=2.0
σ=1.0

Calcium (+0.2)

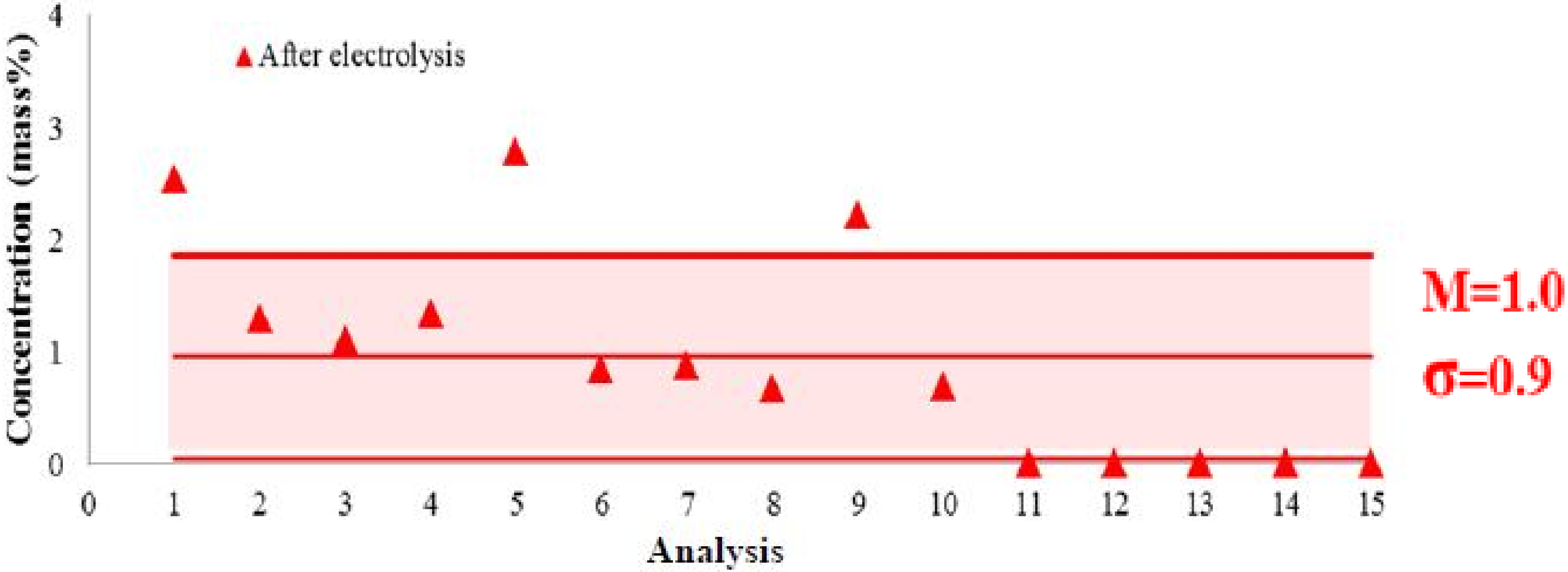

Concentration (mass%)
After electrolysis
Analysis
M=0.2
σ=0.6
0
1
2
3
4
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Oxygen (+18.5)

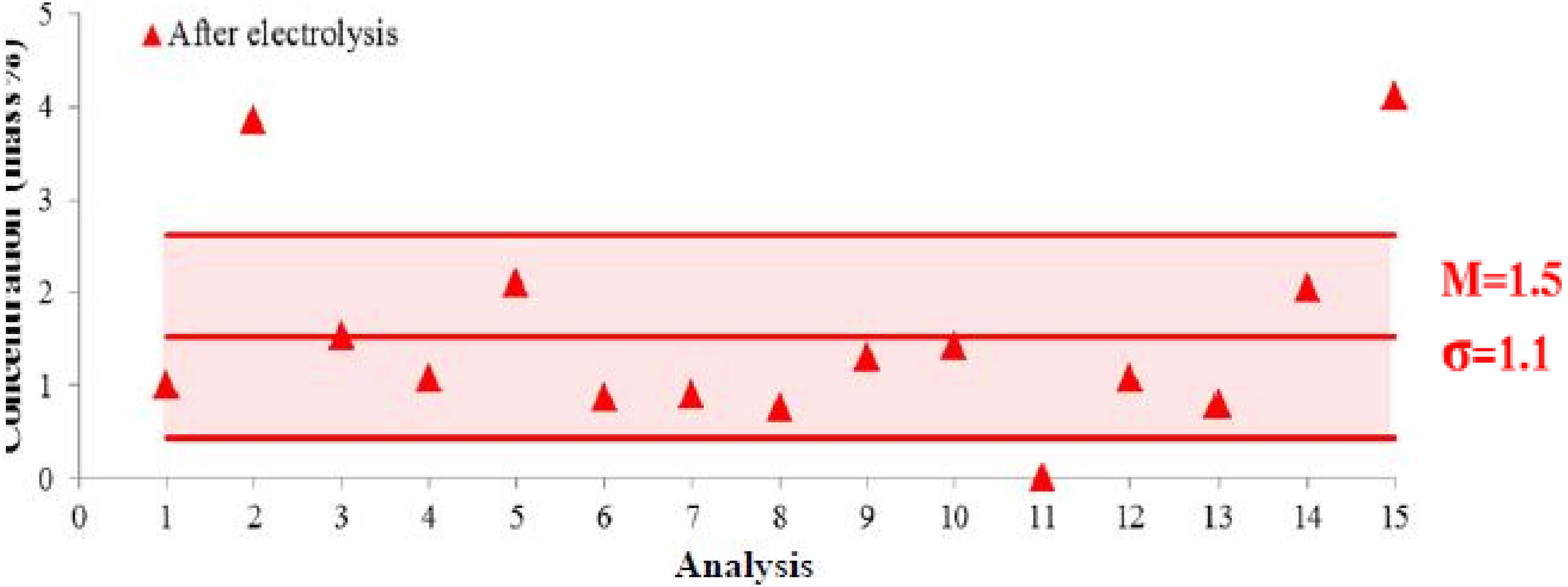


After electrolysis
Concentration (mass %)
0
5
10
15
20
25
30
35
40
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Analysis
M=18.5
σ=10.0

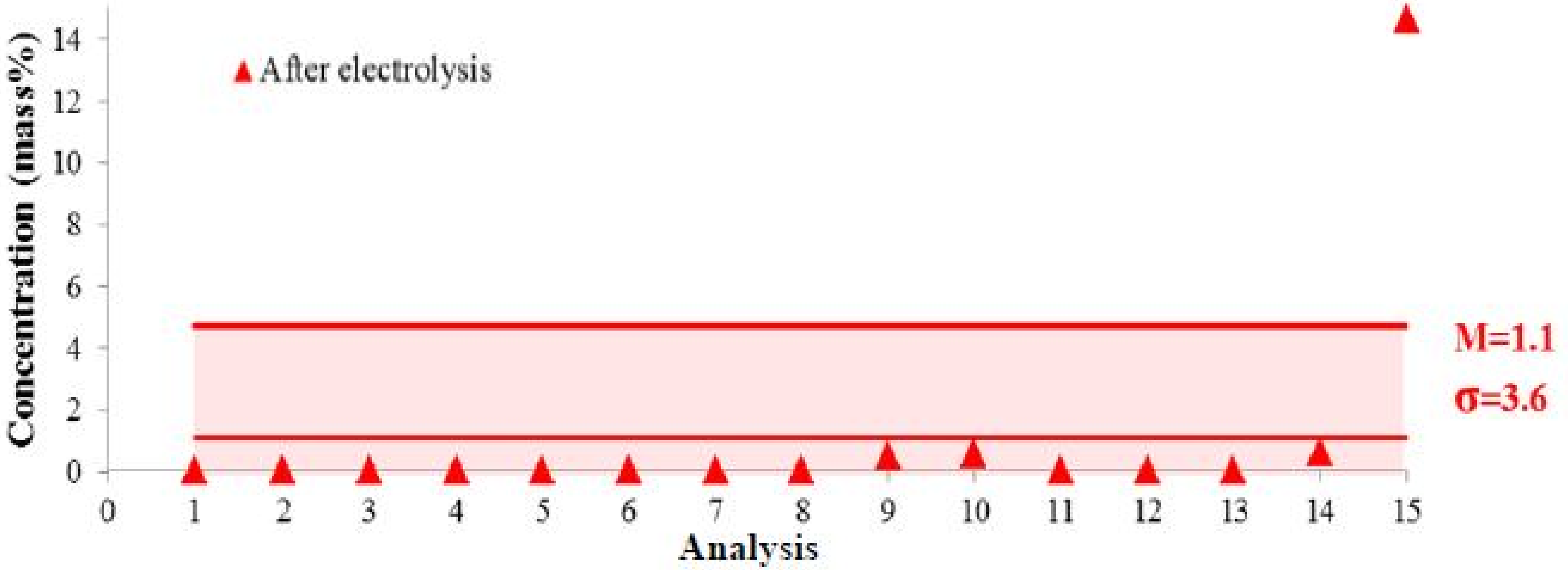
Magnesium (+1.0)



Potassium (+1.5)



Silicon (+1.1%)



After electrolysis
Concentration (mass%)
0
2
4
6
8
10
12
14
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Analysis
M=1.1
σ=3.6

Element concentrations before and after the Electrolysis

	Mean Values						
	Pd	Fe	Ca	O	Mg	K	Si
After 0 hours (%)	100.0	0.0	0.0	0.0	0.0	0.0	0.0
After 20 hours (%)	71.3	2.0	0.2	18.5	1.0	1.5	1.1

FIRST GENERATION REACTION (assumed)

$$Pd_{46}^{106} \rightarrow Ca_{20}^{40} + Fe_{26}^{56} + 10 \text{ neutrons} \qquad (1)$$

➡ **Pd(−28.6%) = Ca (+10.8%) + Fe (+15.1%) + neutrons (+2.7 %)**

SECOND GENERATION REACTIONS

$$Fe_{26}^{56} \rightarrow 3O_8^{16} + He_2^4 + 4\ \text{neutrons} \qquad (2)$$

Fe (−15.1 %) = O (+12.9 %) +He (+1.1 %) + neutrons (+1.1)

$$Ca_{20}^{40} \rightarrow O_8^{16} + Mg_{12}^{24} \qquad (3)$$

Ca (−1.6 %) = O (+0.6 %) + Mg (+1.0 %)

$$Ca_{20}^{40} \rightarrow 2O_8^{16} + 4H_1^1 + 4\ \text{neutrons} \qquad (4)$$

Ca (−5.9 %) = O (+4.7 %) + H (+0.6 %) + neutrons (+0.6 %)

The calculated O increase of 18.2% is very close to the experimental value of 18.5%.

Considering the experimental residual 0.2% of Ca, and the previously calculated residual 3.3% of Ca, the following two reactions provide a complete matching:

$$Ca_{20}^{40} \rightarrow K_{19}^{39} + H_{1}^{1} \qquad \textbf{(5)}$$

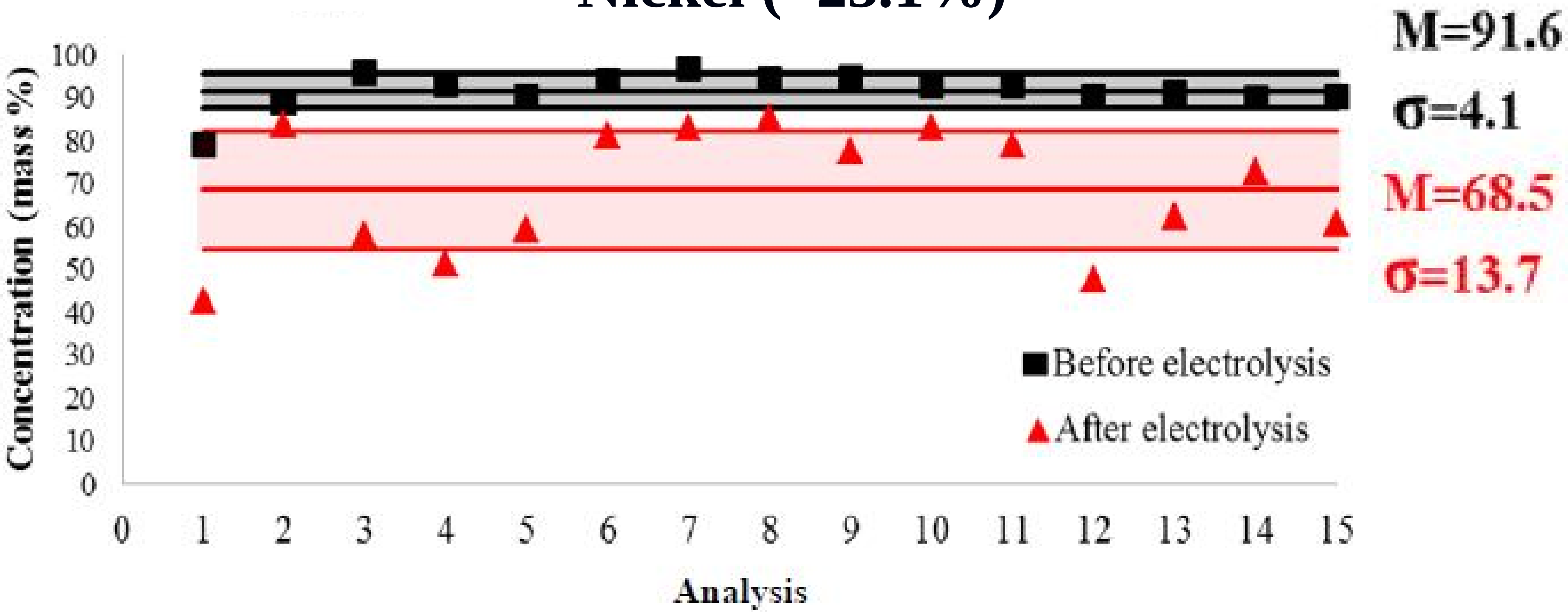
➡ **Ca (−1.5 %) = K (+1.5 %)**

$$Ca_{20}^{40} \rightarrow Si_{14}^{28} + C_{6}^{12} \qquad \textbf{(6)}$$

➡ **Ca (−1.6 %) = Si (+1.1 %) + C (+0.5 %)**

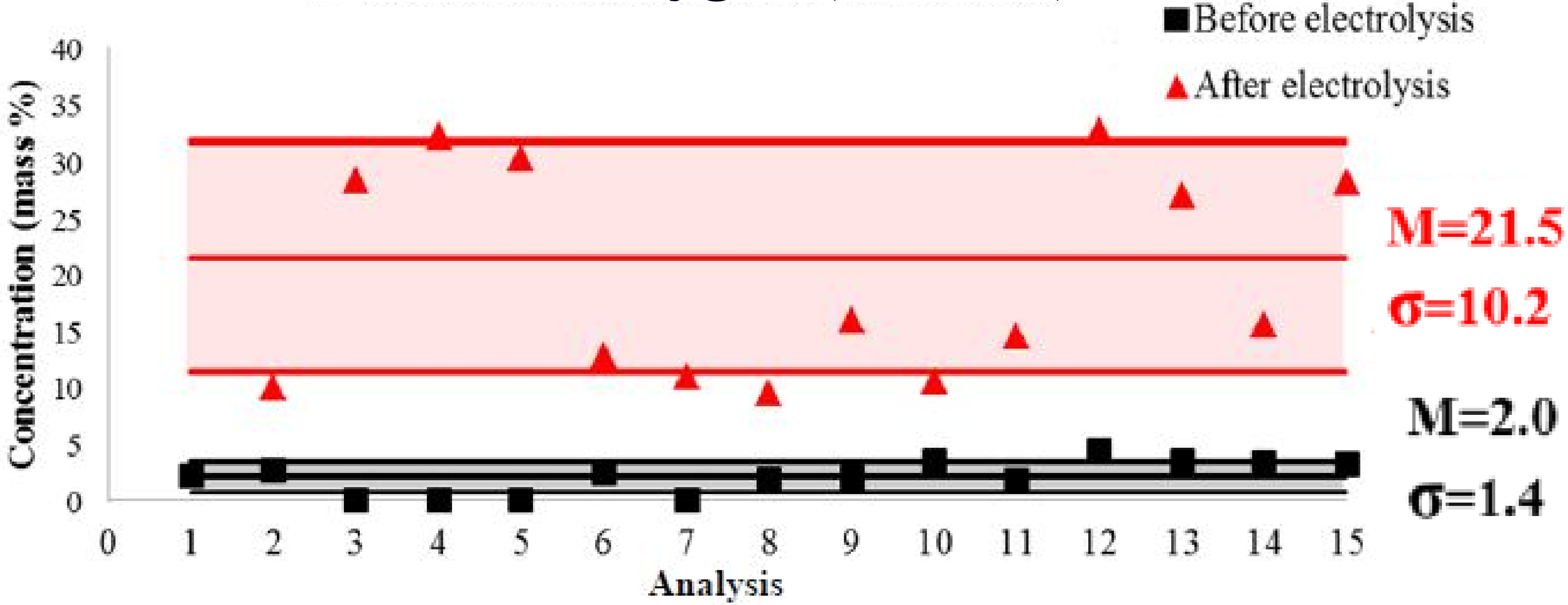
NICKEL ELECTRODE

Nickel (–23.1%)



M=91.6
σ=4.1
M=68.5
σ=13.7
Concentration (mass %)
100
90
80
70
60
50
40
30
20
10
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Analysis
Before electrolysis
After electrolysis

Oxygen (+19.5%)



Before electrolysis
After electrolysis
M=21.5
σ=10.2
M=2.0
σ=1.4
Concentration (mass %)
Analysis
0
5
10
15
20
25
30
35
40
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Element concentrations before and after the Electrolysis

	Mean Values				
	Ni	O	Si	Fe	Al
After 0 hours (%)	91.6	2.0	0.3	2.4	0.0
After 20 hours (%)	68.5	21.5	1.1	0.4	1.8

$$Ni_{28}^{59} \rightarrow 3O_8^{16} + 2He_2^4 + 3 \text{ neutrons} \qquad (7)$$

➡ **Ni (−22.1%) = O (+18.0%) + He (+3.0%) + neutrons (+1.1)**

The calculated O increase of 18.0% is not far from the experimental value of 19.5%.

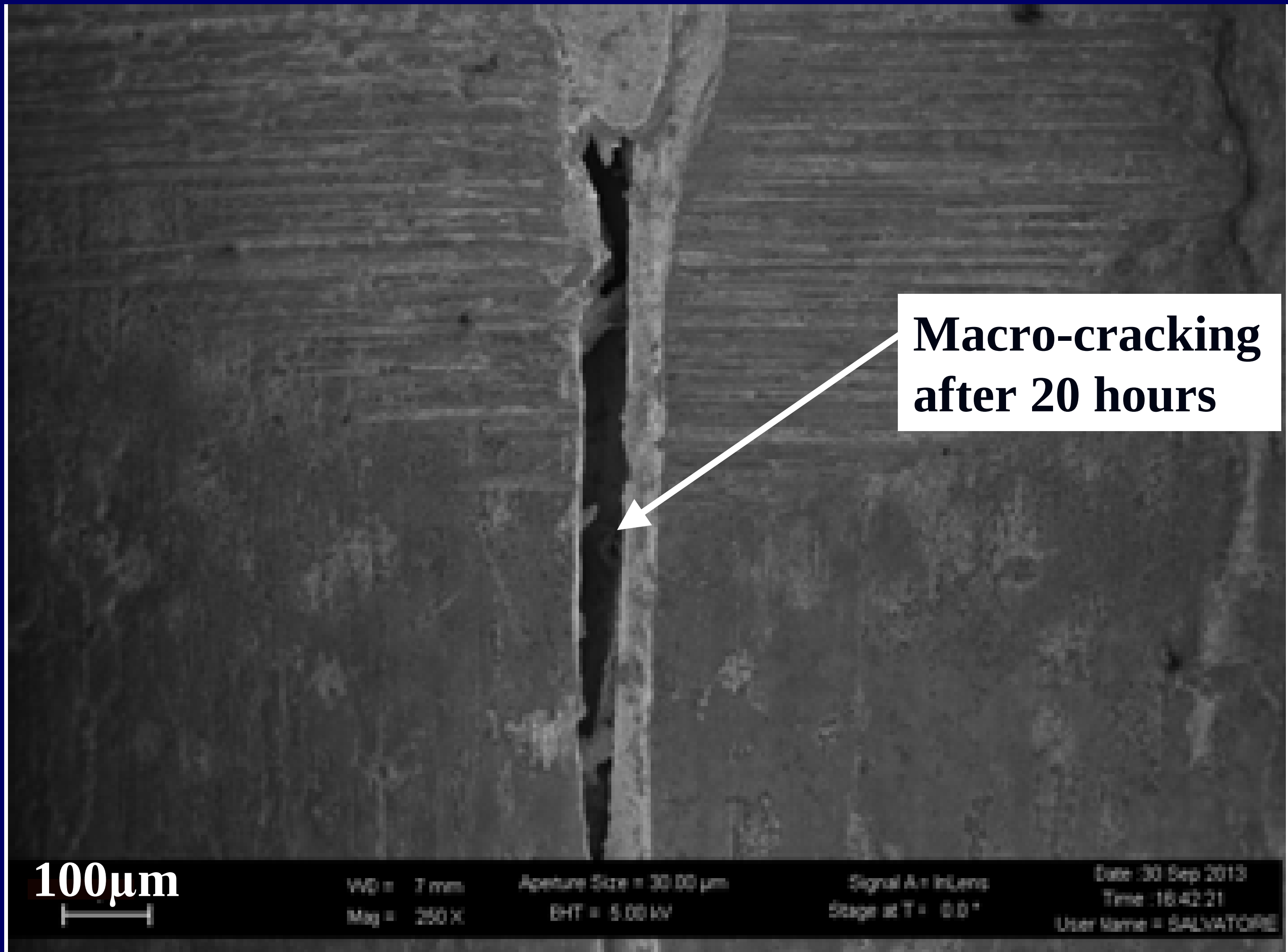
$$Ni_{28}^{59} \rightarrow 2Si_{14}^{28} + 3 \text{ neutrons} \quad (8)$$

Ni (−1.0%) = Si (+0.9%) + (+0.1) neutrons

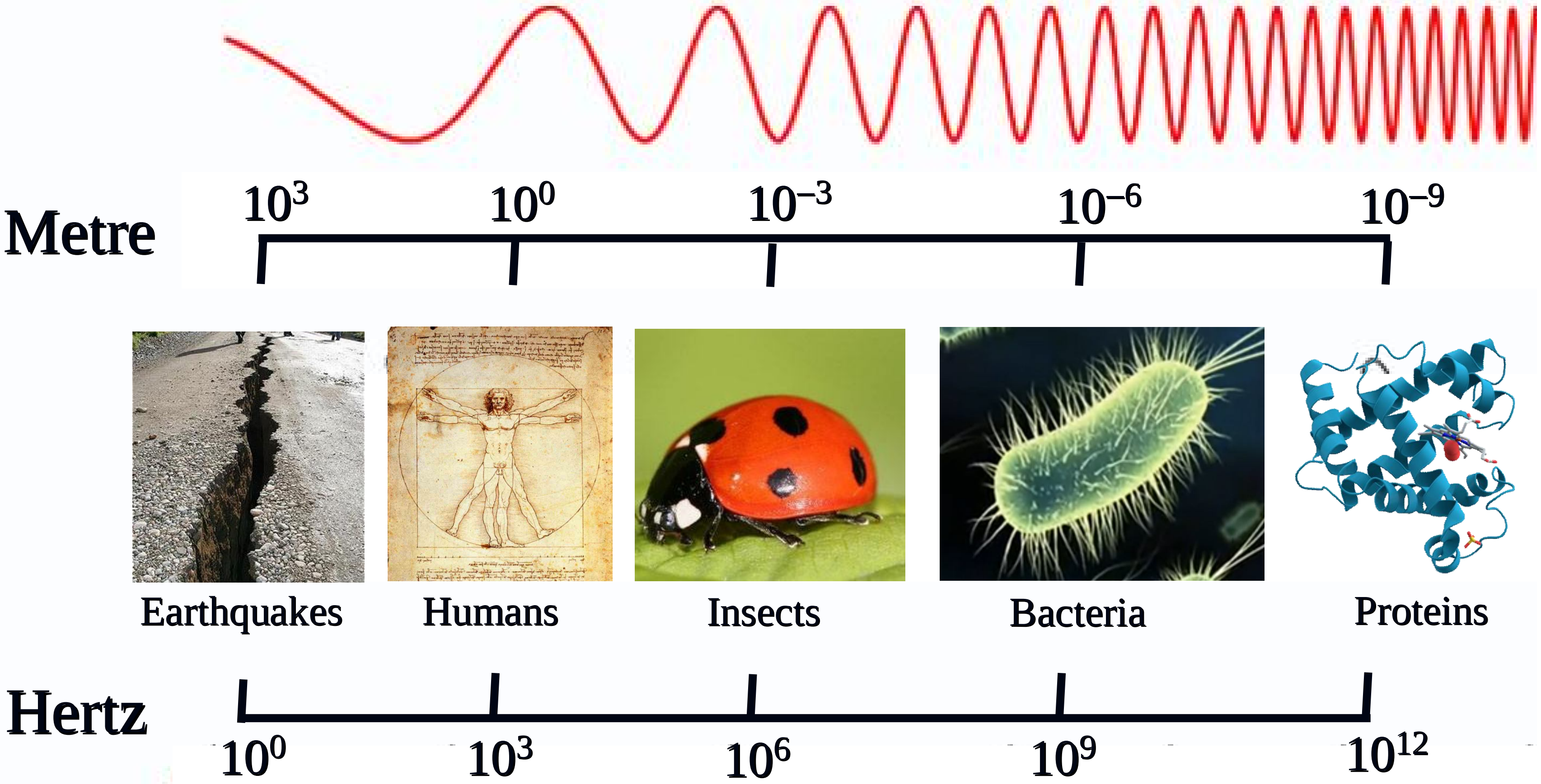
$$Fe_{26}^{56} \rightarrow 2Al_{13}^{27} + 2 \text{ neutrons} \quad (9)$$

Fe (−2.0%) = Al (+1.9%) + neutrons (+0.1)

PALLADIUM ELECTRODE AFTER THE TEST



WAVELENGTH vs FREQUENCY



Wavelength vs Frequency

$$f = \mathrm{v}/\lambda$$

Nano-scale vs TeraHertz

$$10^{12}\,\mathrm{Hz} = \frac{10^{3}\,\mathrm{ms}^{-1}}{10^{-9}\,\mathrm{m}}$$

Frequency vs Energy

$$E = \hbar f$$

TeraHertz vs Vibrational Energy of the Atomic Lattice

$$0.025\ \mathrm{eV} = 6.58 \times 10^{-16}\ \mathrm{eVs} \times 3.8 \times 10^{13}\ \mathrm{Hz}$$

CONCLUSIONS

- Neutron emissions up to one order of magnitude higher than the background level were observed during the operating time of an electrolytic cell.

- The decrement in Pd (−28.6%) at the first electrode seems to be almost perfectly matched by the increments in lighter elements (O, Mg, K, Si).

- The Ni decrement (−23.1%) at the second electrode is matched by O and Si, as well as the Fe decrement by Al.

- Microcrack formation and propagation due to hydrogen embrittlement have a crucial relevance in “Cold Fusion” effect.