



## **Corrosion studies and archaeometallurgical heritage conservation in Pacific Ocean basins of Mexico**

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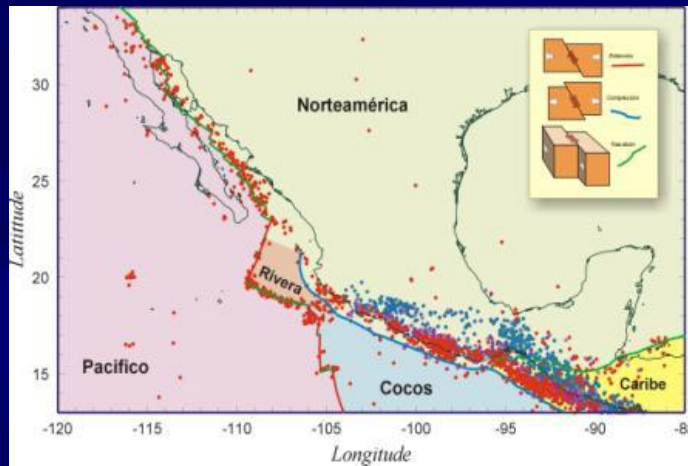


Suva, Fiji. October /2018

# Archaeometallurgical Heritage



# Geography





## Heritage conservation. Morelos

- Railway Heritage studies showed the presence of unexpected chemical compounds in the corrosion products.
- This happened in rural areas where pollution sources are limited.
- Eventually, a volcanic source was proposed.

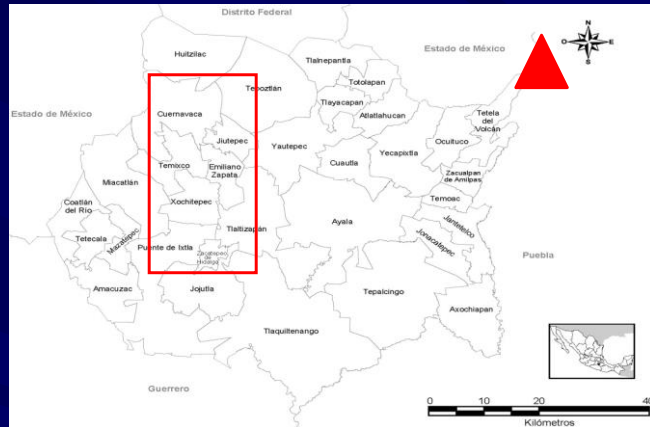


Railway bridge in Barranca Honda, Morelos. Mexico

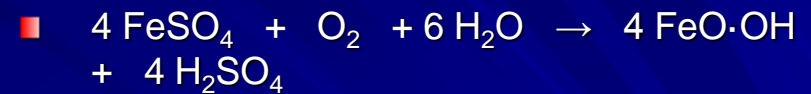
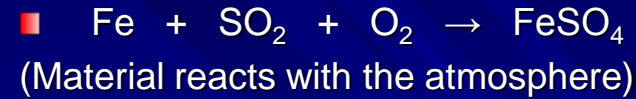
### X-Ray Diffraction results

- $\delta\text{-Fe}_3\text{O}_4$  Magnetite
- $\delta\text{-Fe}_2\text{O}_3$  Maghemite
- FeO Ferric Oxide
- $\text{SiO}_2$  Quartz
- **$\text{FeSO}_4\cdot 7\text{H}_2\text{O}$  Melanterite**
- $\text{Pb}_3\text{O}_4$  Minium

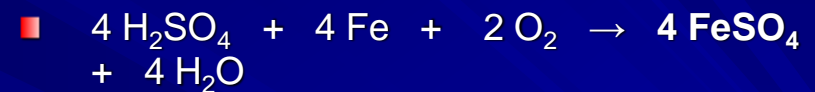
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## Formation of FeSO<sub>4</sub> (Ferrous sulphate)



(Ferrous sulphate reacts with oxygen and water present in the atmosphere)



(Sulphuric acid keeps reacting producing FeSO<sub>4</sub>)

## Athmospheric Corrosion

- SO<sub>2</sub> Industrial residues, cities
- NaCl – Coasts

## Weight loss technique

$$V_{\text{corr}} = (m_i - m_f) / \rho A t$$

where:

$V_{\text{corr}}$  corrosión rate (mm/year)

$m_i$  initial mass (mg)

$m_f$  final mass (mg)

$\rho$  density (mg/mm<sup>3</sup>)

$A$  exposed area (mm<sup>2</sup>)

$t$  duration of exposition (year)

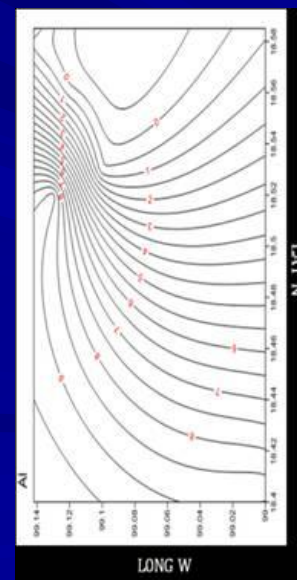
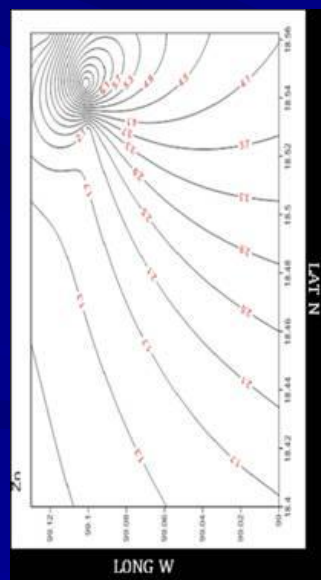
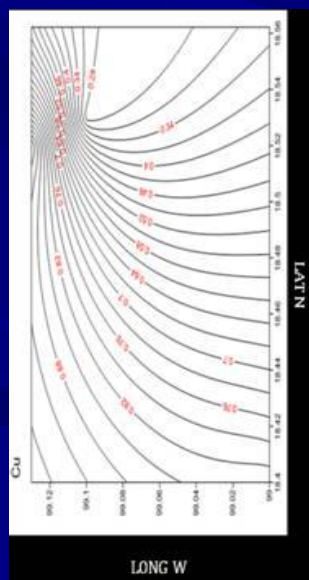
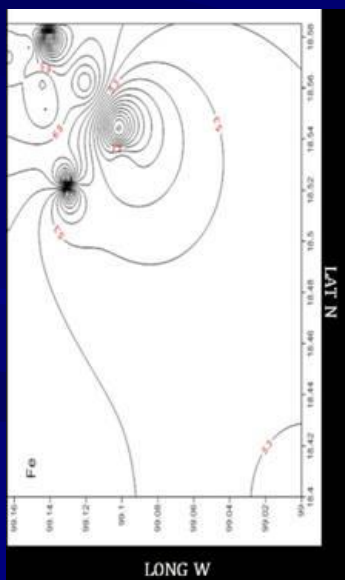
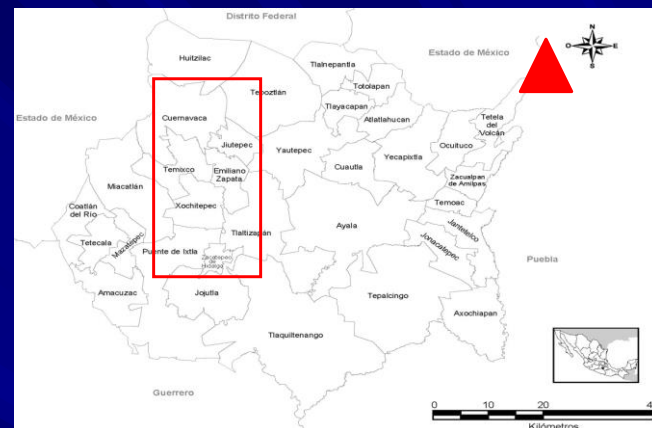


(Sarmiento-Bustos, E. et al. Including Hernández-Escampa)

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## Corrosion rates: Carbon steel

Station - 1995	VC Fe ( $\mu\text{m}/\text{year}$ )	Station - 2012	VC Fe ( $\mu\text{m}/\text{year}$ )	% Increase
Chamilpa	2.240	UAEM	8.903	397
Civac	2.230	Centro Jiutepec	4.916	220



C, Cu, Zn, Al (Sarmiento-Bustos. E. et al. Including Hernández-Escampa)



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## OAXACA

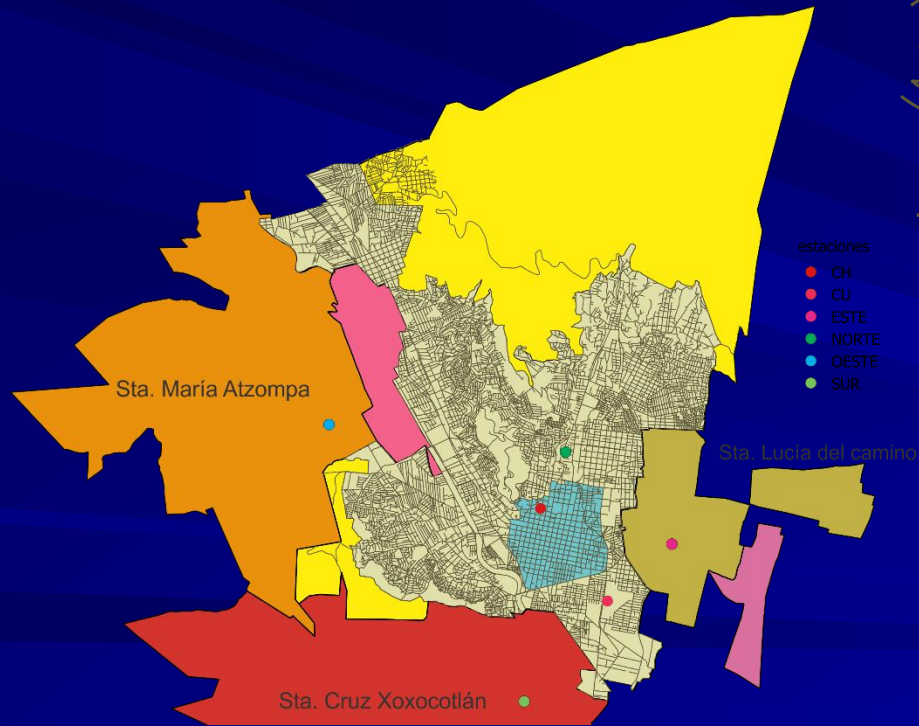
- UNESCO World Heritage
- Absence of archaeometallurgical catalog
- Increase of vehicles since 1980 (7X)
- Atmospheric corrosion unknown
- References. Sevilla, Campeche



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## OAXACA

- Atmospheric corrosion stations
- GIS localization of heritage





# Corrosion studies and archaeometallurgical heritage conservation in Pacific Ocean basins of Mexico

## OAXACA

- Partial results (3 months)
- 10X corrosion in the Historic centre



comparación de resultados ecuación 1 y 2 COBRE		
	ecuación 1	ecuación 2
	mm/años	
	velocidad	velocidad
	Vcorr	vcorr
CH-01	0.000160682	0.00015769
CH-02		
N-01	0.003856372	0.00378456
N-02		
S-01	0.000174072	0.00017083
S-02		
E-01	0.000191926	0.00018835
E-02		
O-01	0.000212011	0.00020806
O-02		
CU-01	0.002515122	0.00246829
CU-02		

comparacion de resultados ecuación 1 y 2 FIERRO		
	ecuación 1	ecuación 2
	mm/años	
	velocidad	velocidad
	Vcorr	vcorr
CH-01	0.0029955889	0.00293981
CH-02		
N-01	0.0003430064	0.00033662
N-02		
S-01	0.0000686013	0.00006732
S-02		
E-01	0.0004319339	0.00042389
E-02		
O-01	-0.0001499065	-0.00014712
O-02		
CU-01	0.0002083446	0.00020447
CU-02		

## Final Considerations

- The method can be applied in different regions yielding a predictive tool for archaeometallurgical conservation management.
- Geographic and territorial scale can also be useful for infrastructure conservation.
- In some cases, other disciplines might be interested in the results, such as urbanism and health studies.
- Similar natural and urban processes might occur in the entire Pacific region.
- Current research in Oaxaca, Mexico.

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■ Sarmiento-Bustos, E., Hernández-Escampa, M., Rodríguez-Acuña, F., y Sarmiento-Martínez, O. Corrosión atmosférica y conservación de materiales y patrimonio histórico en Morelos, México. Congreso internacional de investigación, Academia Journals / Instituto Tecnológico de Celaya. ISSN 1946-5351 (online) y 1948-2353 (CD ROM) 2013

**Thank you for your attention!!!**

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