

# SACRIFICIAL ANODE VHS-8339 - ZN ALLOY - MODERN TIMES

**Artefact name** Sacrificial anode VHS-8339

**Authors** Marianne. Senn (EMPA, Dübendorf, Zurich, Switzerland) & Christian. Degrigny (HE-Arc CR, Neuchâtel, Neuchâtel, Switzerland)

**Urt** /artefacts/319/

## ∨ The object



Fig. 1: The submarine and the anode (www.verkehrshaus.ch),

Credit HE-Arc CR.

## ∨ Description and visual observation

<b>Description of the artefact</b>	The artefact could be a weight or sacrificial anode of a submarine (Fig. 1). It is surrounded by a whitish brown-grey corrosion crust. The broken metal has a greyish shiny colour, whereas the metal part that is cut has a silvery appearance. Dimensions: L = 4.9cm ; WT = 95g.
<b>Type of artefact</b>	Submarine part
<b>Origin</b>	Submarine "Mesoscaph" from Auguste Piccard
<b>Recovering date</b>	The sacrificial anodes (?) might have been added when the submarine was used in the sea.
<b>Chronology category</b>	Modern Times
<b>chronology tpq</b>	<input type="text" value="1970"/> A.D. ▼
<b>chronology taq</b>	<input type="text" value="1974"/> A.D. ▼
<b>Chronology comment</b>	1970 _ 1974
<b>Burial conditions / environment</b>	Outdoor atmosphere
<b>Artefact location</b>	Swiss Museum of Transport, Luzern, Lucerne
<b>Owner</b>	Swiss Museum of Transport, Luzern, Lucerne
<b>Inv. number</b>	VHS-8339
<b>Recorded conservation data</b>	Not conserved

## Complementary information

The anodes were produced by Horton Maritime.

Study area(s)



Fig. 2: Location of sampling area,

Credit HE-Arc CR.

Binocular observation and representation of the corrosion structure

Stratigraphic representation: none.

MiCorr stratigraphy(ies) – Bi

Sample(s)

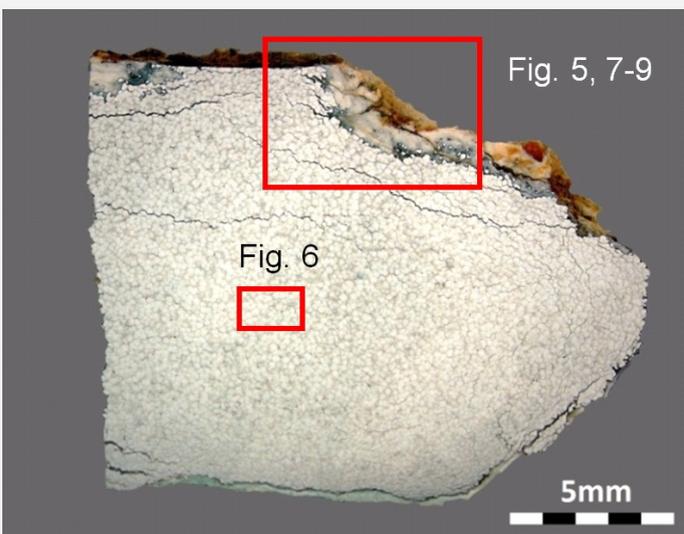


Fig. 3: Micrograph of the cross-section showing the location of Figs. 5 to 9,

Credit HE-Arc CR.

Description of sample

The sample (Fig. 3) shows a cross-section from the sacrificial anode (Fig. 2). The thickness of the corrosion crust is variable. Dimensions: L = 17mm; W = 14mm.

<b>Alloy</b>	Zn Alloy
<b>Technology</b>	Cast and annealed
<b>Lab number of sample</b>	VHS-Mq-1
<b>Sample location</b>	Empa (Marianne Senn)
<b>Responsible institution</b>	Swiss Museum of Transport, Luzern, Lucerne
<b>Date and aim of sampling</b>	07/09/2009 metallography

#### Complementary information

Nothing to report.

#### ∨ Analyses and results

##### *Analyses performed:*

Metallography (unetched), Vickers hardness testing, SEM/EDS.

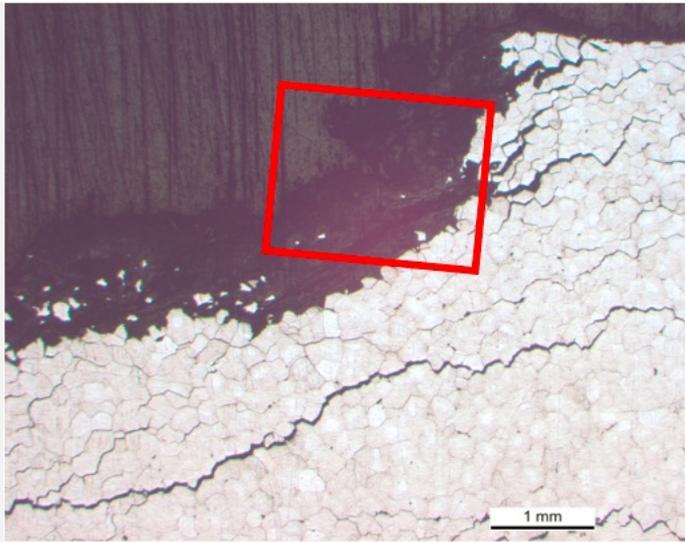
#### ∨ Non invasive analysis

#### ∨ Metal

The remaining metal is an almost pure zinc alloy (Table 1). The oxygen content is not from the original alloy, but is due to secondary corrosion. The metal grains are visible without etching and present a polygonal structure (Figs. 5 and 6). The structure is recrystallised after annealing. The recrystallization of zinc alloys begins at room temperature.

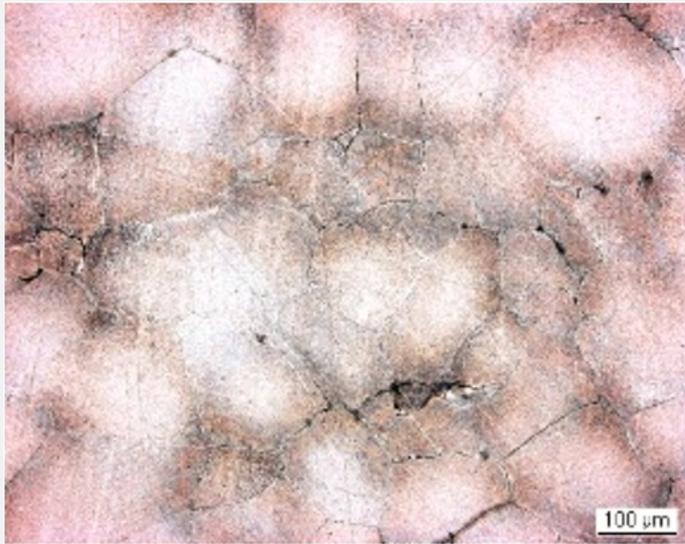
Elements	Zn	Al	O	Total
Metal	95	0.8	1.6	97

Table 1: Chemical composition (mass %) of the metal. Method of analysis: SEM/EDS, Lab Analytical Chemistry, Empa.



Credit HE-Arc CR.

Fig. 5: Micrograph of the metal sample from Fig. 3 (reversed picture, detail), unetched, bright field. Extensive intergranular corrosion is visible. The rectangle marks Fig. 7,



Credit HE-Arc CR.

Fig. 6: Micrograph of the metal sample from Fig. 3 (detail), etched,

<b>Microstructure</b>	Recrystallized structure (polygonal grains)
<b>First metal element</b>	Zn
<b>Other metal elements</b>	Al

**Complementary information**

Nothing to report.

✧ Corrosion layers

Extended intergranular corrosion has developed in the metal structure (Figs. 5, 6). The metal is covered by a corrosion crust that is hardly visible in bright field and which contains remnant metal (Fig. 5). On most of the sample the corrosion crust is uniform. In areas we see cracks (Fig. 7) appearing as brown lines separating the corrosion crust (Fig. 8). In bright field the corrosion crust appears grey containing dark-grey zones (Fig. 7). Under polarized light, the corrosion crust appears white with darker parts including remnant metal (Fig. 8). It contains Zn and O as well as S along some cracks (Table 2 and Fig. 9).

Elements	O	Al	Zn	Total
Light-grey corrosion part	23	<	77	98
Dark grey corrosion part	38	0.6	68	106

Table 2. Chemical composition (mass %) of the corrosion layer from Figs. 7 and 9. Method of analysis: SEM/EDS, Laboratory of Analytical Chemistry, Empa.

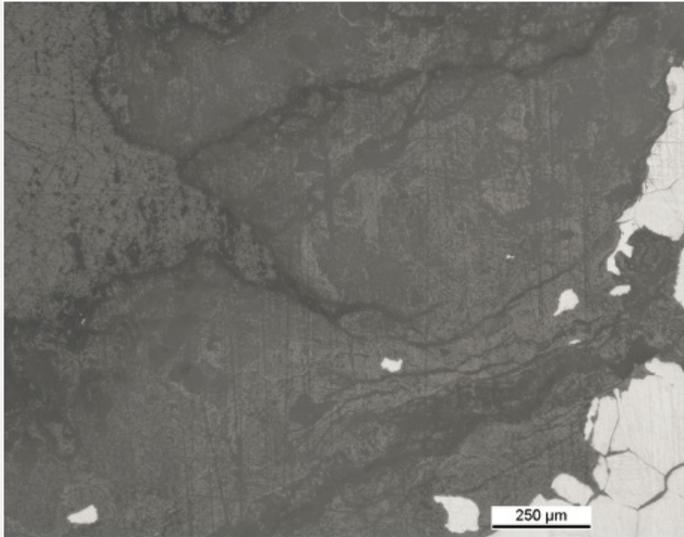


Fig. 7: Micrograph showing the metal - corrosion products interface from Fig. 5 (detail), unetched, bright field,

Credit HE-Arc CR.

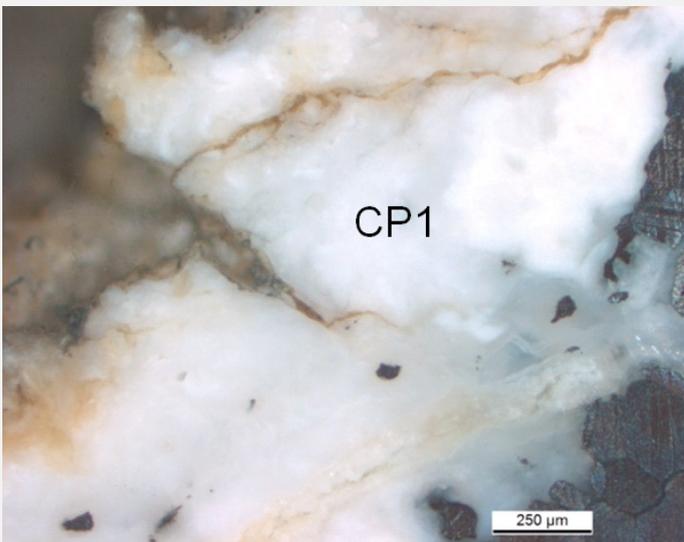


Fig. 8: Micrograph (same as Fig. 7) corresponding to the stratigraphy of Fig. 4, unetched, polarised light. We observe in dark-grey the metal, in white the corrosion crust separated by brown cracks including remnant metal,

Credit HE-Arc CR.

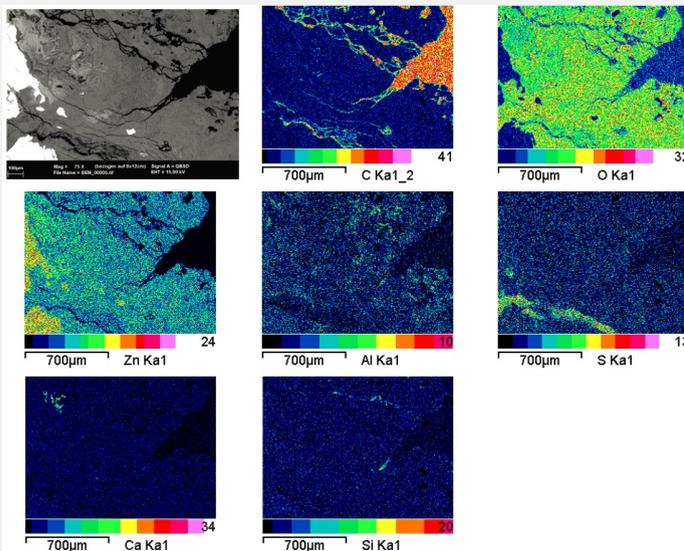


Fig. 9: SEM image, BSE-mode, and elemental chemical distribution of most of the area of Fig. 7 (reversed picture). Method of examination: SEM/EDS, Laboratory of Analytical Chemistry, Empa,

Credit Empa.

Corrosion form

Uniform - intergranular

Corrosion type ?

## Complementary information

Nothing to report.

### ∨ MiCorr stratigraphy(ies) – CS



Fig. 4: Stratigraphic representation of the object in cross-section using the MiCorr application. This representation can be compared to Fig. 8.

### ∨ Synthesis of the binocular / cross-section examination of the corrosion structure

Corrected stratigraphic representation: none.

### ∨ Conclusion

The artefact is possibly either a weight or a sacrificial anode. However, it is made of a cast and annealed zinc alloy which makes the interpretation as a weight implausible. In contrast an interpretation as a sacrificial anode is more likely. It is known that zinc alloy sacrificial anodes are used to protect marine propellers especially in salt water. The thick corrosion layer seems to consist of oxides or hydroxides. The origin of the sulphur along some of the cracks is unclear.

### ∨ References

#### *References on object and sample*

##### **References object**

1. Auskunftsbblatt der Sammlung des Verkehrshauses der Schweiz, Inventarnummer VHS-8339.

##### **References sample**

2. MIFAC-métal cat. 29.

#### *References on analytic methods and interpretation*