

SACRIFICIAL ANODE VHS-8339 - ZN ALLOY - MODERN TIMES

Artefact name Sacrificial anode VHS-8339

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

Urt /artefacts/367/

∨ The object



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

Credit HE-Arc CR.

∨ Description and visual observation

Description of the artefact 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.

Type of artefact Submarine part

Origin Submarine "Mesoscaph" from Auguste Piccard

Recovering date The sacrificial anodes (?) might have been added when the submarine was used in the sea.

Chronology category Modern Times

chronology tpq A.D. ▾

chronology taq A.D. ▾

Chronology comment 1970 _ 1974

Burial conditions / environment Outdoor atmosphere

Artefact location Swiss Museum of Transport, Luzern, Lucerne

Owner Swiss Museum of Transport, Luzern, Lucerne

Inv. number VHS-8339

Recorded conservation data 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)

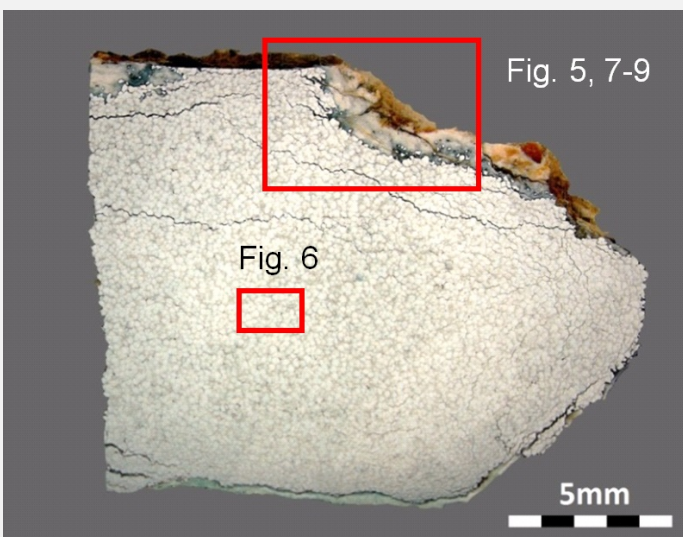


Fig. 3: Micrograph of the cross-section showing the location of Figs. 5 to 9,

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.

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

Complementary information

Nothing to report.

∨ Analyses and results

Analyses performed:

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

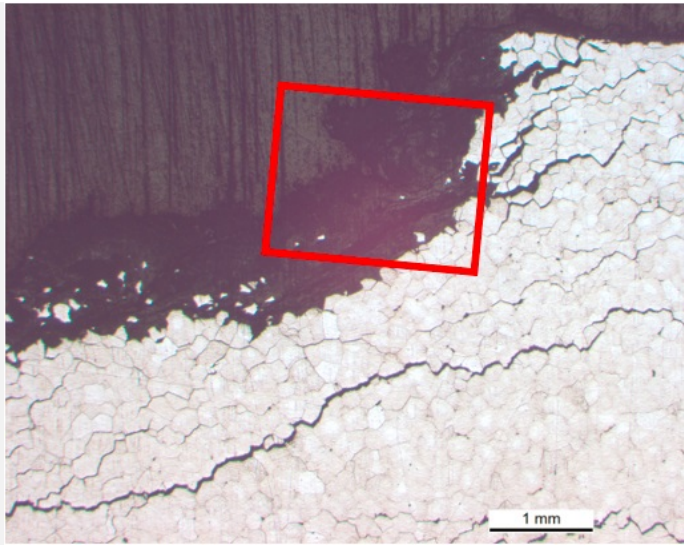
∨ Non invasive analysis

∨ 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.

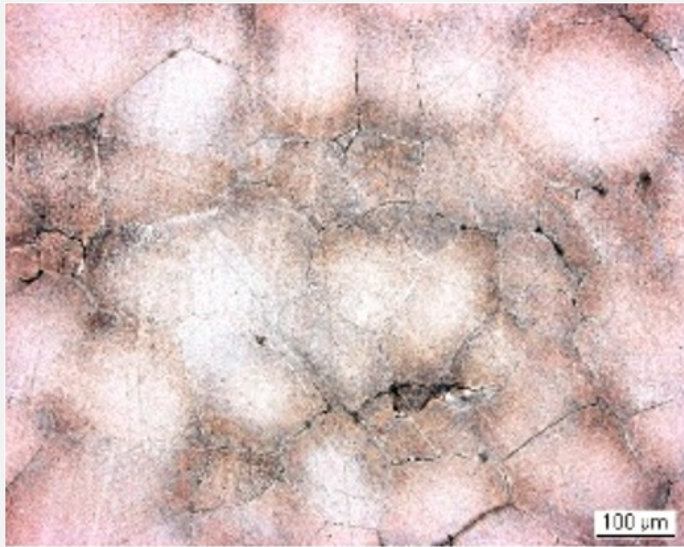
Elements	Zn	Al	O	Total
Metal	95	0.8	1.6	97

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,

Microstructure	Recrystallized structure (polygonal grains)
First metal element	Zn
Other metal elements	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.

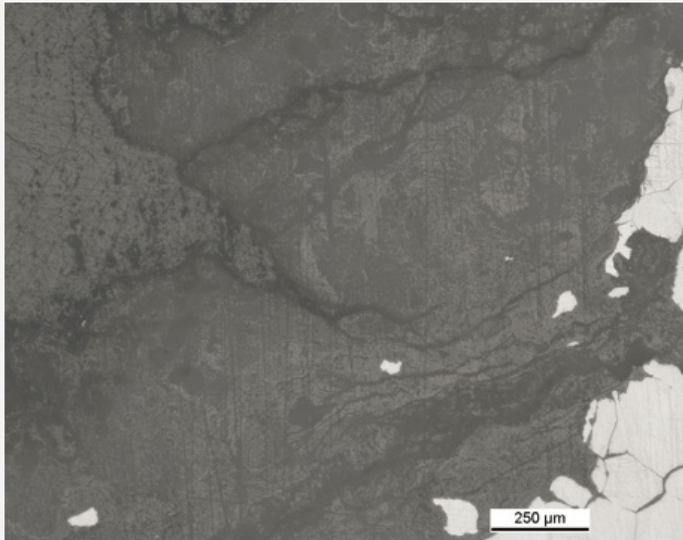


Fig. 7: Micrograph showing the metal - corrosion products interface from Fig. 5 (detail), unetched, bright field,

Credit HE-Arc CR.

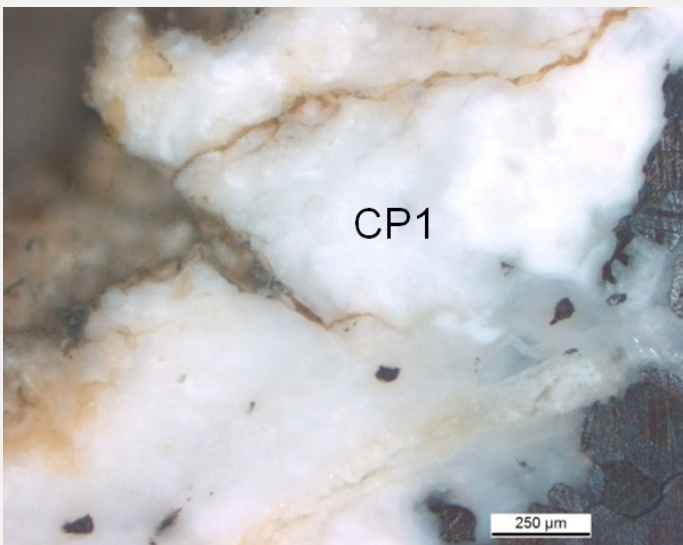


Fig. 8: Micrograph (same as Fig. 7) corresponding to the stratigraphy of Fig. 4, unetched, polarised light. We observe in dark-grey the metal, in white the corrosion crust separated by brown cracks including remnant metal,

Credit HE-Arc CR.

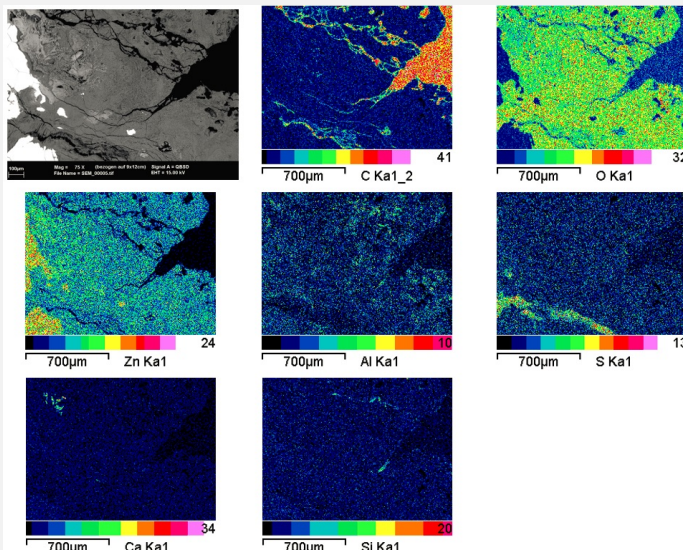


Fig. 9: SEM image, BSE-mode, and elemental chemical distribution of most of the area of Fig. 7 (reversed picture). Method of examination: SEM/EDS, Laboratory of Analytical Chemistry, Empa,

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, Credit HE-Arc CR.

∨ 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