SACRIFICIAL ANODE VHS-8339 - ZN ALLOY - MODERN TIMES

Artefact name	Sacrificial anode VHS-8339
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Url	/artefacts/705/

The object

Credit HE-Arc CR.

Fig. 1: Sacrificial anode (left) from submarine "Mesoscaph" (right) (www.verkehrshaus.ch),

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	1970 A.D.
chronology taq	1974 A.D.
Chronology comment	
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)

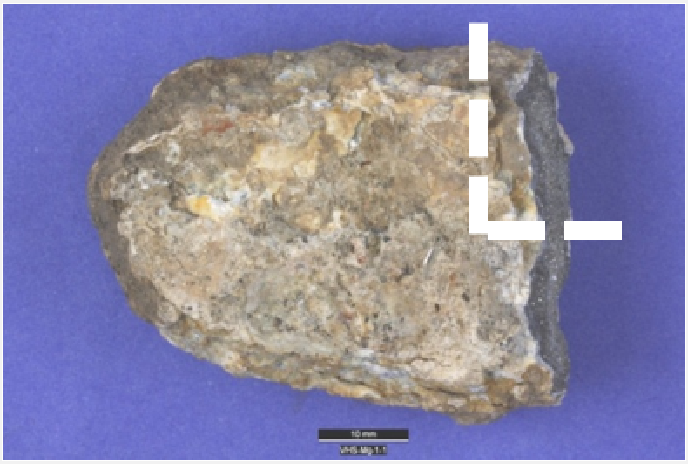

Credit HE-Arc CR.

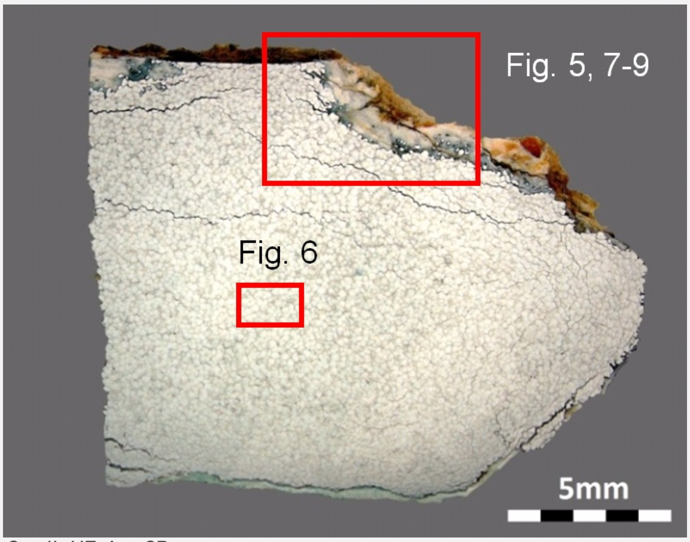
Fig. 2: Location of sampling area,

Binocular observation and representation of the corrosion structure

Stratigraphic representation: none.

MiCorr stratigraphy(ies) – Bi

Sample(s)



Credit HE-Arc CR.

Fig. 3: Micrograph of the cross-section of the fragment sampled from the sacrificial anode showing the location of Figs. 5 to 9,

Description of sample

The sample (Fig. 3) shows a cross-section from the fragment of 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.

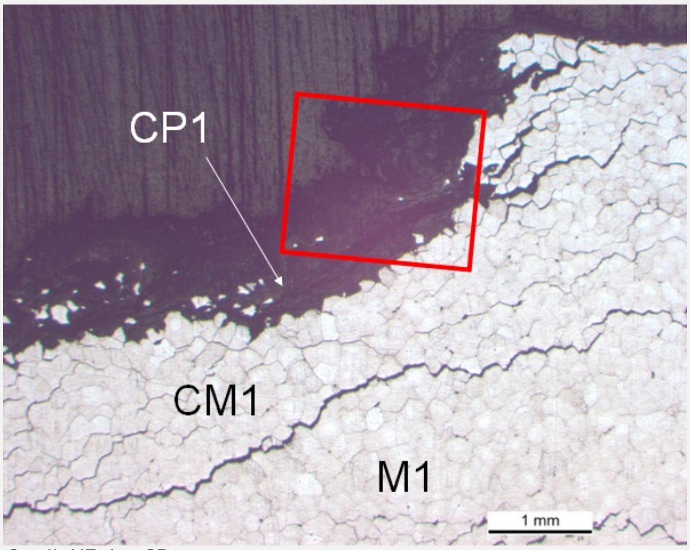
Non invasive analysis

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,

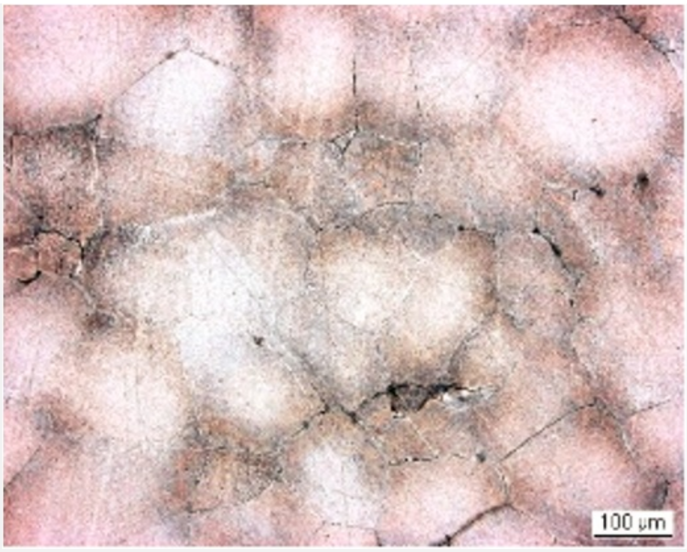


Fig. 6: Micrograph of the metal sample from Fig. 3 (detail), etched,

Credit HE-Arc CR.

Microstructure Recrystallized structure (polygonal grains)

First metal element Zn

Other metal elements Al

Complementary information

Nothing to report.

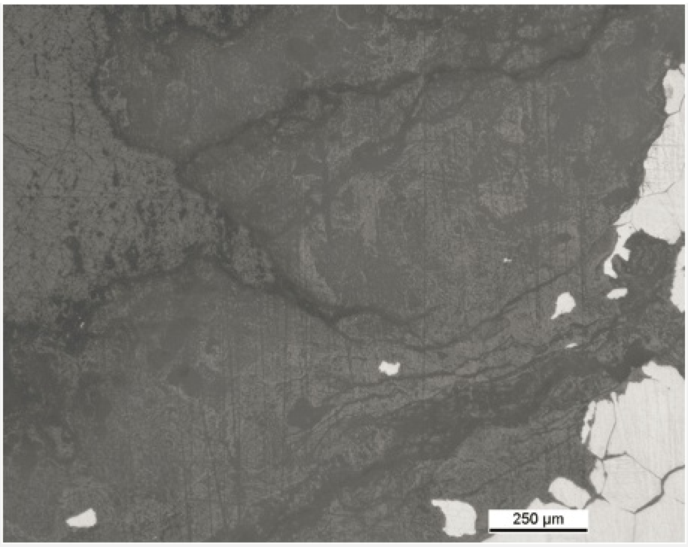
Corrosion layers

Extensive intergranular corrosion / cracking 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).

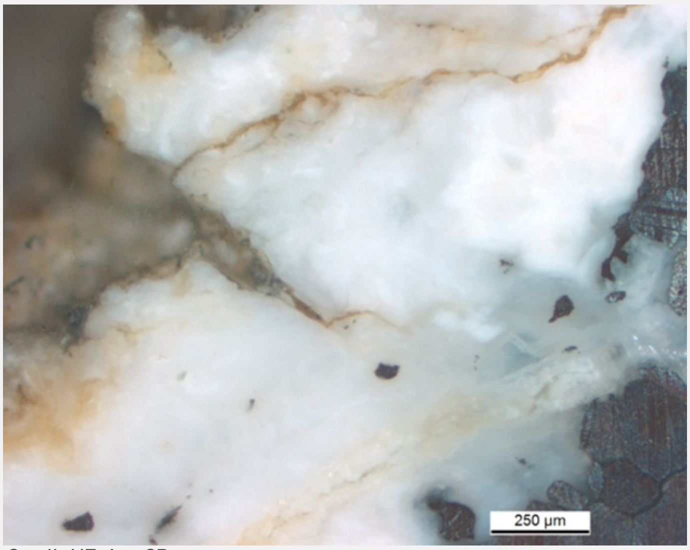
Elements	O	Al	Zn	Total
Light-grey corrosion part	23	<	77	98
Dark grey corrosion part	38	0.6	68	106

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,

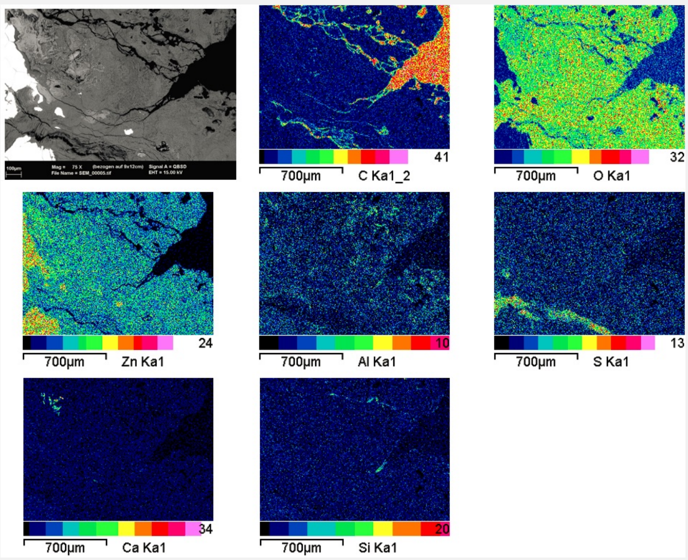


Credit HE-Arc CR.



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 Empa.

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,

Corrosion form	Internal cracking
Corrosion type	zinc pest

Complementary information

Nothing to report.

MiCorr stratigraphy(ies) – CS

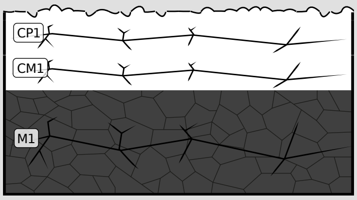


Fig. 4: Stratigraphic representation of the fragment sampled from the sacrificial anode in cross-section (dark field) using the MiCorr application. The characteristics of the strata are only accessible by clicking on the drawing that redirects you to the search tool by stratigraphy representation. This representation can be compared to Fig. 5, 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. Extensive intergranular corrosion/cracking has developed in the metal structure, probably indicating the beginning of zinc pest.

References

References on object and sample

References object

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

References sample

2. MIFAC-métal cat. 29.

References on analytic methods and interpretation