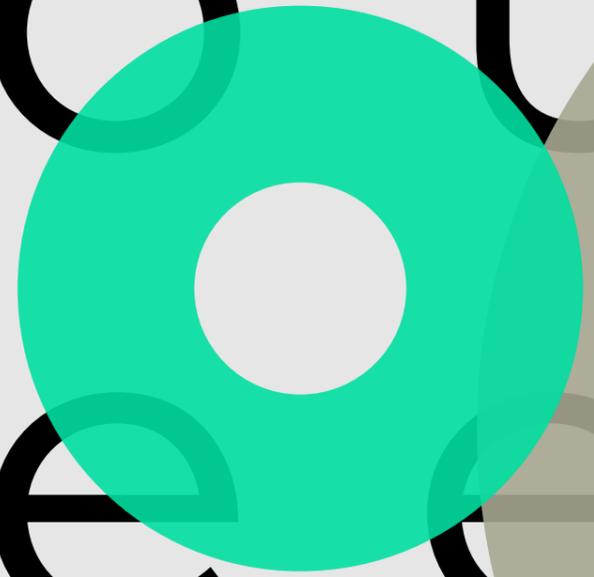




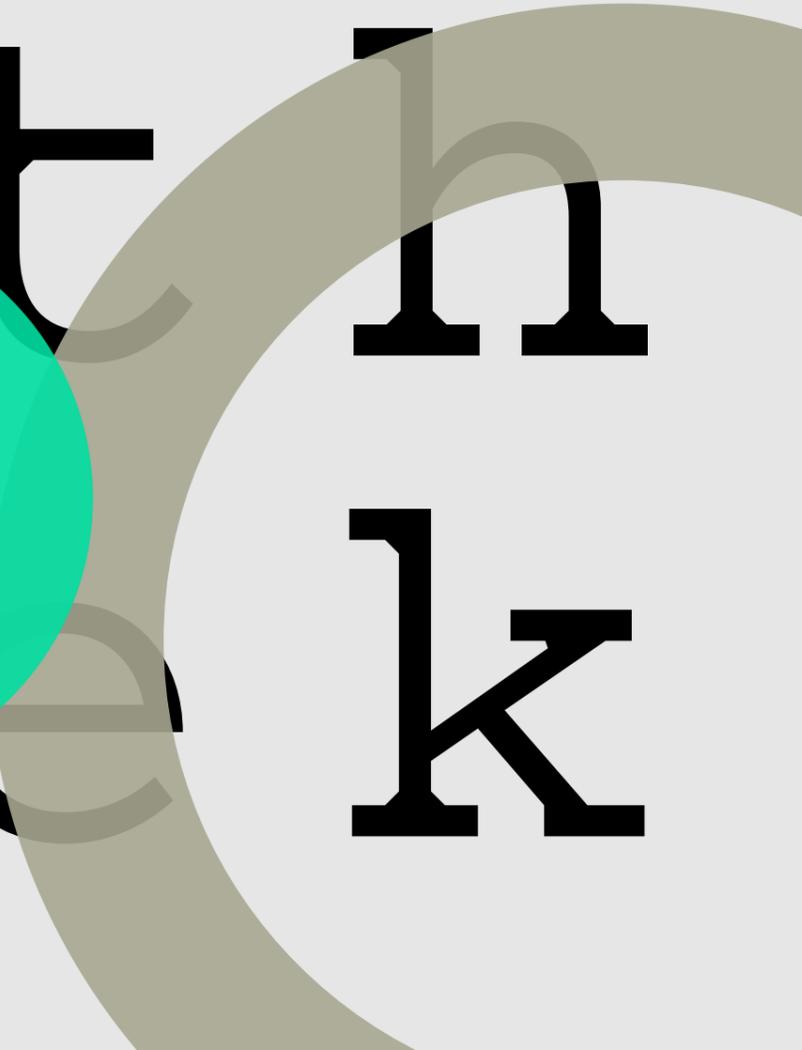
m e t



o t e



t h k





A collaboration between a
designer, a conservator and
the workspace MAKE Eindhoven to
explore the casting, finishing
and patination of bronze,
learning by doing.

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metallotheek

Patination is the application of a corrosive layer of chemicals on a metal. It allows you to add a wide variety of color and texture on the surface, a little like how you may treat a ceramic object with a glaze. Even though an object's smooth casting skin can show off the skill of its maker, making it the ideal finish for many, there are more ways to add an extra layer to the surface of your work.

Patination can take place by spraying, as well as dipping, or brushing. Atmospheric conditions such as heat, pressure, and humidity also play a role in the result. The metal surface can be sandblasted first, and polished as well.

Even though many artists and designers work with unique pieces, it may be useful for them to work with iterative forms. For this reason, different methods of mold making were used to find an appropriate method of repeating a shape. The 'lost wax method' was used, based on a mold of a 3D print; we used wax models based on a CNC milled plaster mold; and used the 3D print itself as the lost element. For the metallotheek a repeating form, albeit in varying sizes, was chosen that would show the effect of patina on a curved surface.

For these experiments we repeated a set of 9 bronze rings (90% copper, 10% tin) 9 times, to come to 81 different surface treatments. Every ring in this collection has a unique punched letter-number code that contains the combination of mold (3 types), patina solution (9 recipes), and method of application (9 techniques). This information is also available digitally by scanning the QR code.

Together they form the Metallotheek: a set of instructions to inspire you to get started, we invite you to experiment and add your own outcomes to this archive!



collaboration

Metallotheek brought together a group of people who all work with metal in their daily lives, but do so in varying fields of practice. Experts from metallurgy, metal conservation, and architectural design each have their very own perspective on what makes metal beautiful. Rather than to aim for that one perfect product, we set out to showcase a wide range of methods of casting and treating bronze. The results can be recreated by following the accompanying recipes, which are free to use. Many experts use their own undisclosed patination recipes, which can make it difficult for newcomers to know what's possible.

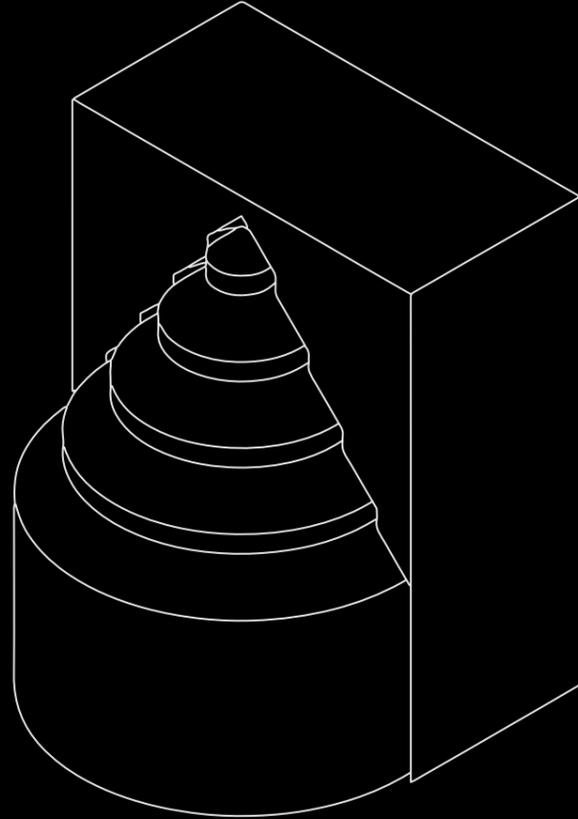
The initial intention of Metallotheek was to encourage architects to learn more about the materials they prescribe in their designs. Not knowing the limits and possibilities of a raw material like metal reduces the architect to someone who simply picks a product from a catalog. The process of casting and treating metal for the purpose of new works is equally educational for metal conservators, whose expertise center on the the process of degradation, rather than on creation. And finally, the workshop itself can learn from the new techniques that metal conservators and architectural designers bring in.

An example of where all disciplines came together to experiment with something new is the use of 3D printing. The use of 3D printers is more common in architectural design as it requires an understanding of CAD software. The printed object is used in a similar manner as in the more traditional lost-wax method. The resulting casting skin and patination are revealed to be quite particular, as can be seen in the microscopic photographs. This investigation of the material up close

requires particular tools that are specific to metal conservation. The printed objects were not used as a mold, instead they are only used once. Following the directions of the metallurgists, casting canals were included already in the 3D printed object.

The patination process, despite our best efforts to specify the materials and techniques used, will probably give slightly different outcomes when reproduced as it will not be possible to exactly repeat factors like surroundings, time, temperature, humidity and endless others from a recipe. We have documented the patina of each of the rings visually, and these unchanging images can be compared to the physical patinas, which will change and alter over time. These changes in the colour and intensity of the patinas that will occur over time are an investigation in their own right. We hope that if the patinas are ever damaged, this documentation can be used as the inspiration for the re-patination of the rings.

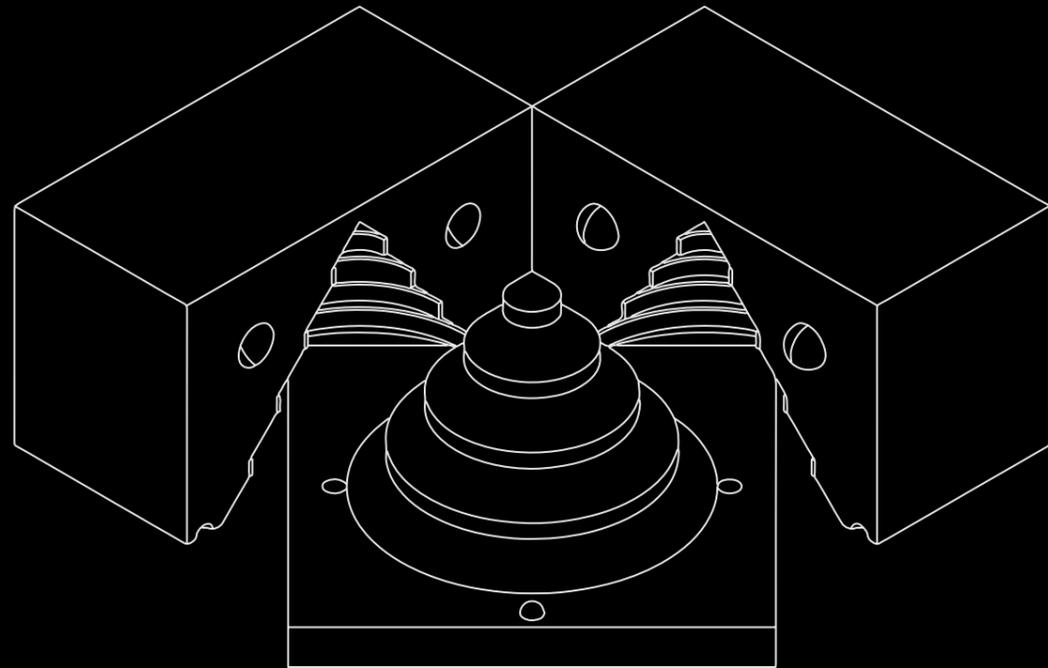
mold making



lost wax
mold from
3d print

(ring series 1-2-3)

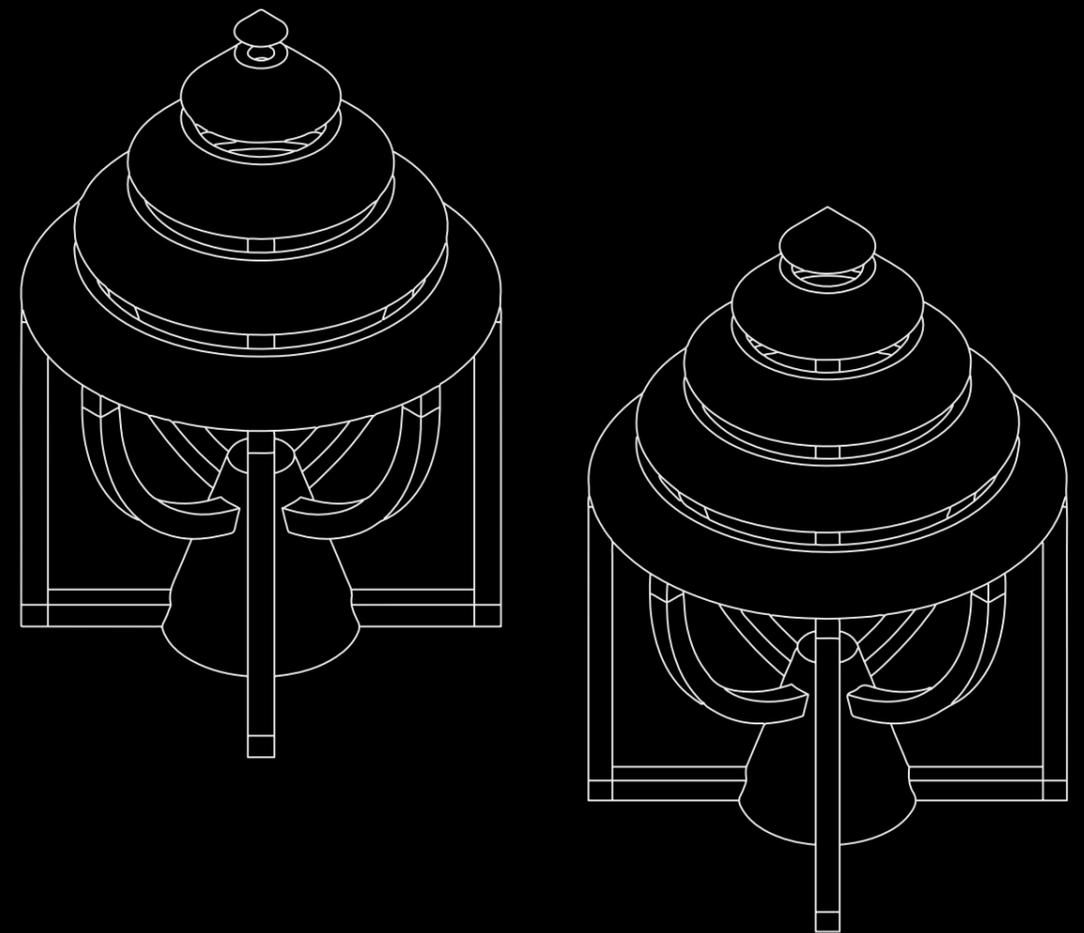
We 3D printed the parts of the three part mold and then used these parts to cast the plaster molds. We cast multiple wax models in the mold that were used for lost wax casting method. Each wax model gets cast in a plaster mold that is suitable for bronze casting, the wax disappears during a firing process.



lost wax mold by cnc milling

(ring series 4-5-6)

In order to make a more precise mold, we cast massive blocks of plaster and used CNC milling to make the mold. We cast multiple wax models in the mold that were used for lost wax casting method. Each wax model gets cast in a plaster mold that is suitable for bronze casting, the wax disappears during a firing process.



3d print as lost wax

(ring series 7-8-9)

The 3D print can be directly used, replacing the wax, in the lost wax method. The filament will melt just as wax does. This may leave some residue, depending on the filament used for printing. Each 3D printed model gets cast in a plaster mold that is suitable for bronze casting, the 3D print disappears during a firing process.

patination

Patination is a chemical reaction on metal which forms desirable coloured products on the surface. From the endless different recipes that can be used for patination solutions, we have chosen nine for our experiments. This choice was based on the range of colours that all these patinas offer and on the safety of the user when applying the patination solutions.

The reaction of your patination solution with the bronze surface works best if your surface is clean: dust and grease-free, otherwise your results may come out patchy. Cleaning the surface can be done mechanically by blasting or sanding, or chemically by using a solvent like acetone, ethanol or white spirit, or dipping in a strong acid. As a final preparatory step before patination, rinse your surface with water and dry it using heat.

When applying the patina, make sure you are working safely- if you feel unsure about what you are doing, ask for help. Look at the material safety data sheets of the chemicals you are using to see if they can be harmful, and set up your workspace so that you can protect yourself. Keep yourself safe from chemical fumes or dusts by working in a well-ventilated space or in a fume cupboard. Use a respirator, eye protection and gloves if necessary- this holds true when mixing the patination solutions as well as when applying the patina. Do not wear gloves that can melt when working with heat.

After you have patinated your bronze surface to the hue and saturation you want it will be necessary to rinse your object to stop the chemical reaction. Rinse with hot and cold water and wash the surface with a soft brush or sponge. Be gentle when rinsing and cleaning your patinated surface, as this may be fragile and could be damaged.

application

For this project we chose eight different ways to apply the patination solutions to our rings, and each different method of application caused a radically different patina. Other methods of patination are possible, and we encourage you to try different techniques! The ninth piece of every set of rings has not been patinated, this shows the casting skin.

Be aware that everything in the world is made of "chemicals", and that the tools you use to apply your patination solution can take part in your patination reaction, and change the patina. Use a non-reactive borosilicate glass as a container when working with heat or acids. Avoid using plastics when using heat. For brushing applications, use an inexpensive paintbrush made of natural fibres, such as a hog hair brush.

-
- A Applied on the untreated casting skin surface: repeated brush applications of the patination solution on bronze heated with a blow torch.
 - B Applied on a sandblasted surface: repeated brush applications of the patination solution on bronze heated with a blow torch.
 - C Applied on a sandblasted surface: repeated brush applications of two different patina solutions on bronze heated with a blow torch.
 - D Applied on a sandblasted surface: repeated brush applications over the course of ten days on room temperature bronze.

- E Applied on a sandblasted surface: boiling of the bronze in a heated patination solution.
- F Applied on a sandblasted surface: buried in wood chips soaked in patination solution for a week.
- G Applied on a sandblasted surface: single dip of bronze heated with a blow torch in heated patination solution.
- H Applied on a sandblasted surface: held in the vapour of a heated patination solution.
- I The untreated casting skin surface: no patination.

recipe 1

To make 250 ml:

Make a mark at the 250 ml volume level on your container
Fill container with about 100 ml water
Add copper sulphate 5 g (KOPER (II) SULFAAT)
Add copper acetate 5 g (KOPERACETAAT)
Add potassium aluminium sulphate 5 g
(KALIUMALUMINIUMSULFAAT)
Add water to 250 ml mark

- A This patina requires high heat and repeated application. Reaction is slow to start, but once it does it develops quickly. Continued heating can burn the patina.
 - B Same as A.
 - C Application of this patina solution, followed with a cupric nitrate solution for verdigris patina (25 g of copper (II) nitrate in 250 ml of water). Cupric nitrate solution should be used sparingly as it overwhelms other patinas.
 - D Moderate effect when applied at room temperature. Let patination solution pool on the surface to form a verdigris sheen patina.
 - E Results are streaky, needs multiple applications for a more even olive colouring.
 - F Forms variations in the gloss of the different coloured patches.
 - G Surface changes as it is dipped, reaction difficult to control.
 - H More development of patina in areas held closer to the boiling liquid.
-

For images of these patinas see page 32.

recipe 2

To make 250 ml:

Make a mark at the 250 ml volume level on your container

Fill container with about 100 ml water

Add potassium permanganate 5 g (KALIUMPERMANGANAAT)

Add copper sulphate 15 g (KOPER (II) SULFAAT)

Add water to 250 ml

A Only a gentle flame is needed for this patina to form, overheating may dull and darken the patina.

B Same as A

C Application of this patina solution, followed with a cupric nitrate solution for verdigris patina (25 g of copper (II) nitrate in 250 ml of water). Cupric nitrate solution should be used sparingly as it overwhelms other patinas.

D Patina forms after only a couple of applications.

E Some variations in gloss.

F Patina forms quickly.

G Difference in patina where the metal was closest to the boiling patination solution.

H Results in a patchy patina.

For images of these patinas see page 34.

recipe 3

To make 250 ml:

Make a mark at the 250 ml volume level on your container

Fill container with about 100 ml water

Add acetic acid (99,5% pure) 20 ml (AZIJNZUUR)

Add ammonium chloride 5 g (AMMONIUMCHLORIDE)

Add sodium chloride 5 g (NATRIUMCHLORIDE)

Add copper acetate 2 g (KOPERACETAAT)

Add potassium bitartrate 2 g (KALIUMWATERSTOFTARTRAAT OFTEWEL WIJNSTEEN)

Add copper carbonate 5 g (KOPERCARBONAAT)

Solution will now start foaming, leave for 24 hours until settled

Add water to 250 ml

A High heat and repeated application will form a dark green crust which rinses off to reveal the milder patina.

B Same as A.

C Application of this patina solution, followed with a silver nitrate patination solution for silver (recipe 7: 5 g of silver nitrate in 250 ml of water). The heat necessary for developing this patina burns the silver patina.

D Formed an emerald green crust, which rinses off to reveal the milder patina.

E Darkened the metal.

F Development of a textured patina.

G Patina does not cover the entire ring and flow lines are visible, multiple dips can even this out.

H Resulted in a patchy patina.

For images of these patinas see page 36.

recipe 4

To make 250 ml:

Make a mark at the 250 ml volume level on your container

Fill container with about 100 ml water

Add sodium thiosulphate 60 g (NATRIUMTHIOSULFAAT)

Add copper acetate 10 g (KOPERACETAAT)

Add citric acid 10 g (CITROENZUUR)

Add water to 250 ml

Let solution age for four days before applying.

- A Heat very gently, as local heat differences will give different coloured patinas. This patina can easily be burned to make the colours less vibrant.
- B Same as A. The lighter tone of the sandblasted surface shows the colours better.
- C Application of this patina solution, followed with a silver nitrate patination solution for silver (recipe 7: 5 g of silver nitrate in 250 ml of water). This dulled both patinas.
- D Resulted in a patina of metallic colours.
- E Went through the range of orange, blue and violet to black.
- F Development of a textured patina.
- G Results in a very even patina.
- H The full range of colours occurs before culminating in the black.

These patinas are not light-fast. A UV-resistant lacquer can be used to keep the patinas from fading.

For images of these patinas see page 38.

recipe 5

To make 250 ml:

Use an inert borosilicate glass (BOROSILICA GLAS) container to store this solution

Make a mark at the 250 ml volume level on your container

Fill container with about 100 ml water

Add ammonium persulphate 5 g (AMMONIUMPERSULFAAT)

Add sodium hydroxide 15 g (NATRIUMHYDROXIDE)

Add water to 250 ml

- A Only low heat is necessary to develop the patina.
- B Same as A.
- C Application of this patina solution, followed with a cupric nitrate solution for verdigris patina (25 g of copper (II) nitrate in 250 ml of water). Cupric nitrate solution should be used sparingly as it overwhelms other patinas, but here the underlying patina greatly muted the verdigris colour.
- D Resulted in a blue crust, which rinses off with water to reveal a milder patina.
- E Due to the selective evaporation of ammonium persulphate a few grains need to be added to the solution every minute.
- F There was no visible development of a patina.
- G Resulted in an even patina.
- H Patina formed in droplet shapes.

For images of these patinas see page 40.

recipe 6

To make 250 ml:

Make a mark at the 250 ml volume level on your container

Fill container with about 100 ml water

Add acetic acid (99.5% pure) 75 ml (AZIJNZUUR)

Add sodium chloride 15 g (NATRIUMCHLORIDE)

Add ammonia (25% pure) 15 ml (AMMONIA)

Allow solution to settle

Add ammonium chloride 15 g (AMMONIUMCHLORIDE)

Add water to 250 ml

A Apply high heat and repeated application, then heat till glowing and quench in water to form patina.

B Same as A.

C Application of this patina solution, followed with a silver nitrate patination solution for silver (recipe 7). The silver nitrate completely covered the first patina.

D Only moderate reaction, very translucent.

E Formed a metallic patina.

F Development of a very matte textured patina.

G Resulted only in a general darkening of the surface.

H Formed a metallic patina.

For images of these patinas see page 42.

recipe 7

To make 250 ml:

Make a mark at the 250 ml volume level on your container

Fill container with about 100 ml of water

Add silver nitrate 5 g (ZILVERNITRAAT)

Add water to 250 ml

A Application at low heat gives an immediate effect, continued heating may burn the patina.

B Same as A.

C Application of this patina solution, followed with a cupric nitrate solution for verdigris patina (25 g of copper (II) nitrate in 250 ml of water). Cupric nitrate solution should be used sparingly as it overwhelms other patinas. The heating required to develop the cupric nitrate patina darkened the silver patina.

D Patina easily forms evenly over the surface. Repeated applications give added sheen.

E Resulted in an extremely even patina.

F Development of a textured metallic patina.

G Darkened the silver patina.

H Resulted in a metallic patina.

These patinas are not light-fast. A UV-resistant lacquer can be used to keep the patinas from darkening.

For images of these patinas see page 44.

recipe 8

To make 250 ml:

Make a mark at the 250 ml volume level on your container

Fill container with about 100 ml water

Add ammonium persulphate 25 g (AMMONIUMPERSULFAAT)

Add copper (II) sulphate 1 g (KOPER (II) SULFAAT)

Add ammonia (25% pure) 5 ml: add 1 ml at a time and
allow to settle (AMMONIA)

Add water to 250 ml

A High heat and repeated application necessary.

B Same as A.

C Application of this patina solution, followed with
a silver nitrate patination solution for silver
(recipe 7: 5 g of silver nitrate in 250 ml of
water).

D Forms an intense green-blue colour crust, which
rinses off leaving a translucent patina.

E Resulted in a translucent patina, with brighter
areas clustered around casting defects.

F Development of a white translucent top layer, needs
extra rinsing.

G Resulted in a dark patina with brighter highlights.

H Resulted in an even darkening.

For images of these patinas see page 46.

recipe 9

To make 250 ml:

Make a mark at the 250 ml volume level on your container

Fill container with about 100 ml water

Add iron (III) chloride (40%) 60 ml

(IJZER (III) CHLORIDE)

Add water to 250 ml

A Heat metal gently while applying patination liquid.
Patina appears quickly, and can easily be burned
unevenly.

B Same as A.

C Application of this patina solution, followed with a
cupric nitrate solution for verdigris patina (25 g
of copper (II) nitrate in 250 ml of water). Cupric
nitrate solution should be used sparingly as it
overwhelms other patinas.

D Resulted in lighter coloured patina where the
patination solution pooled.

E Resulted in a very even light patina.

F Development of a metallic patina.

G Resulted in a patchy patina.

H Resulted in an even patina, with a light metallic
sheen.

For images of these patinas see page 48.

results



set 1

For recipe see page 21

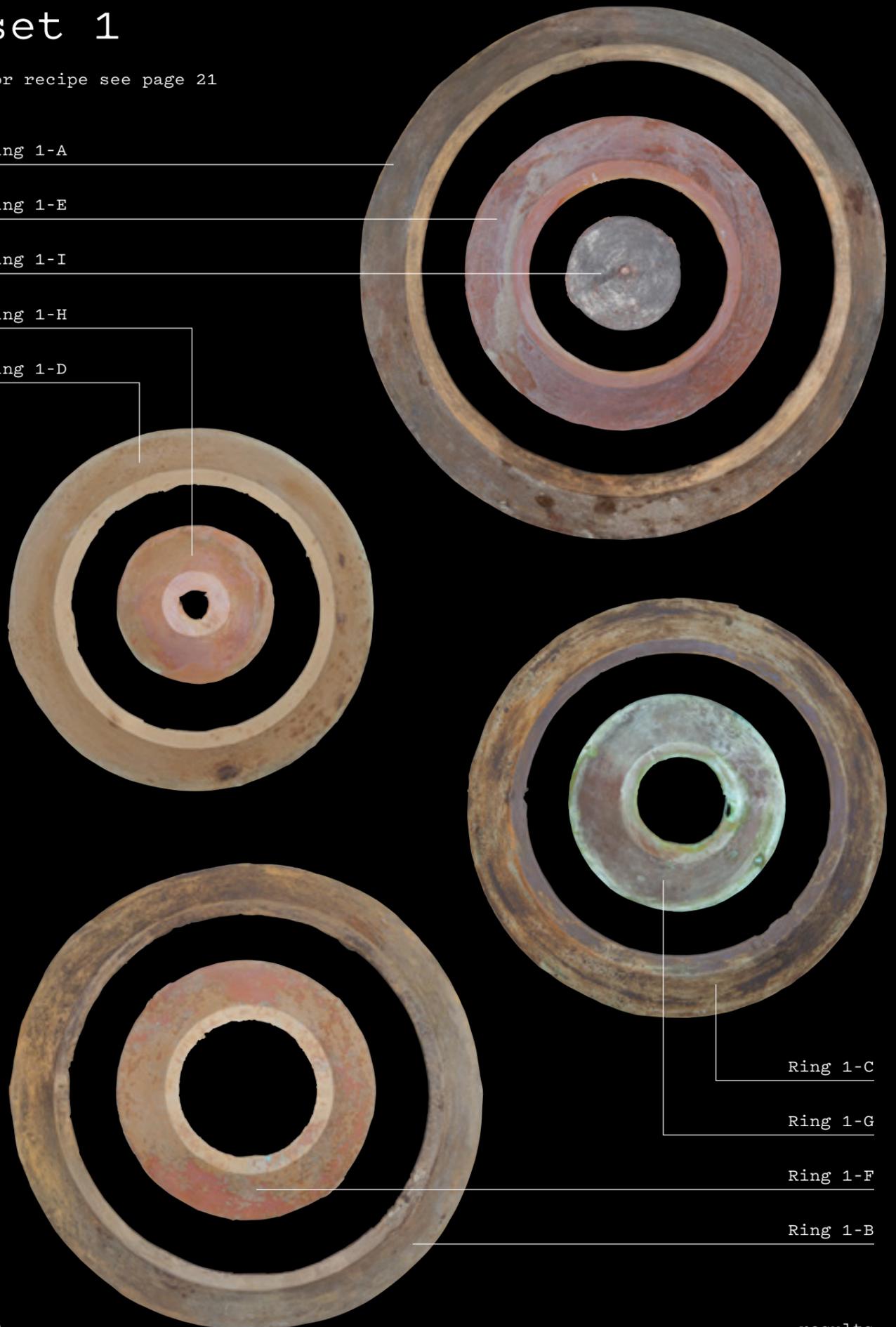
Ring 1-A

Ring 1-E

Ring 1-I

Ring 1-H

Ring 1-D



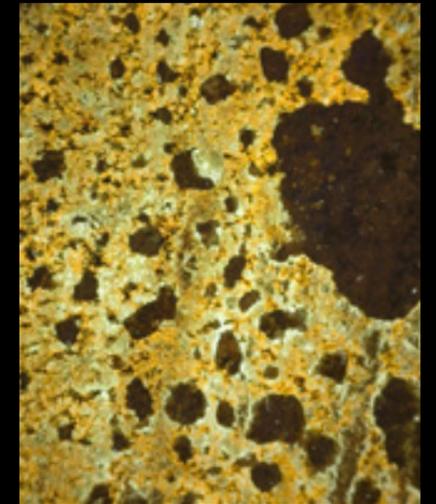
50× magnification



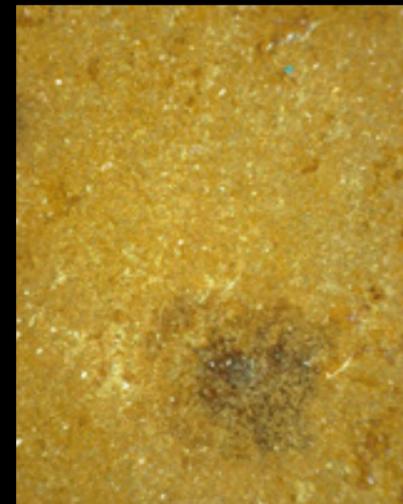
Ring 1-A



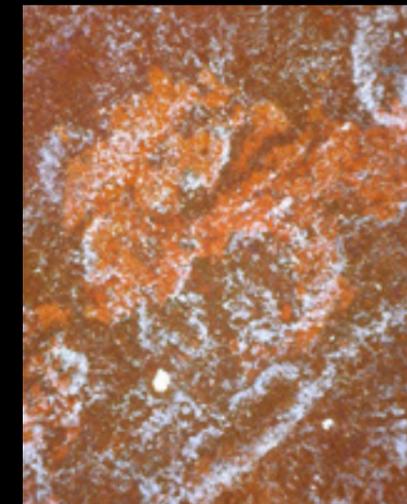
Ring 1-B



Ring 1-C



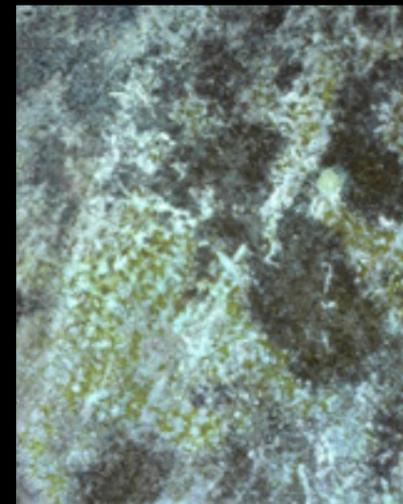
Ring 1-D



Ring 1-E



Ring 1-F



Ring 1-G



Ring 1-H



Ring 1-I

set 2

For recipe see page 22

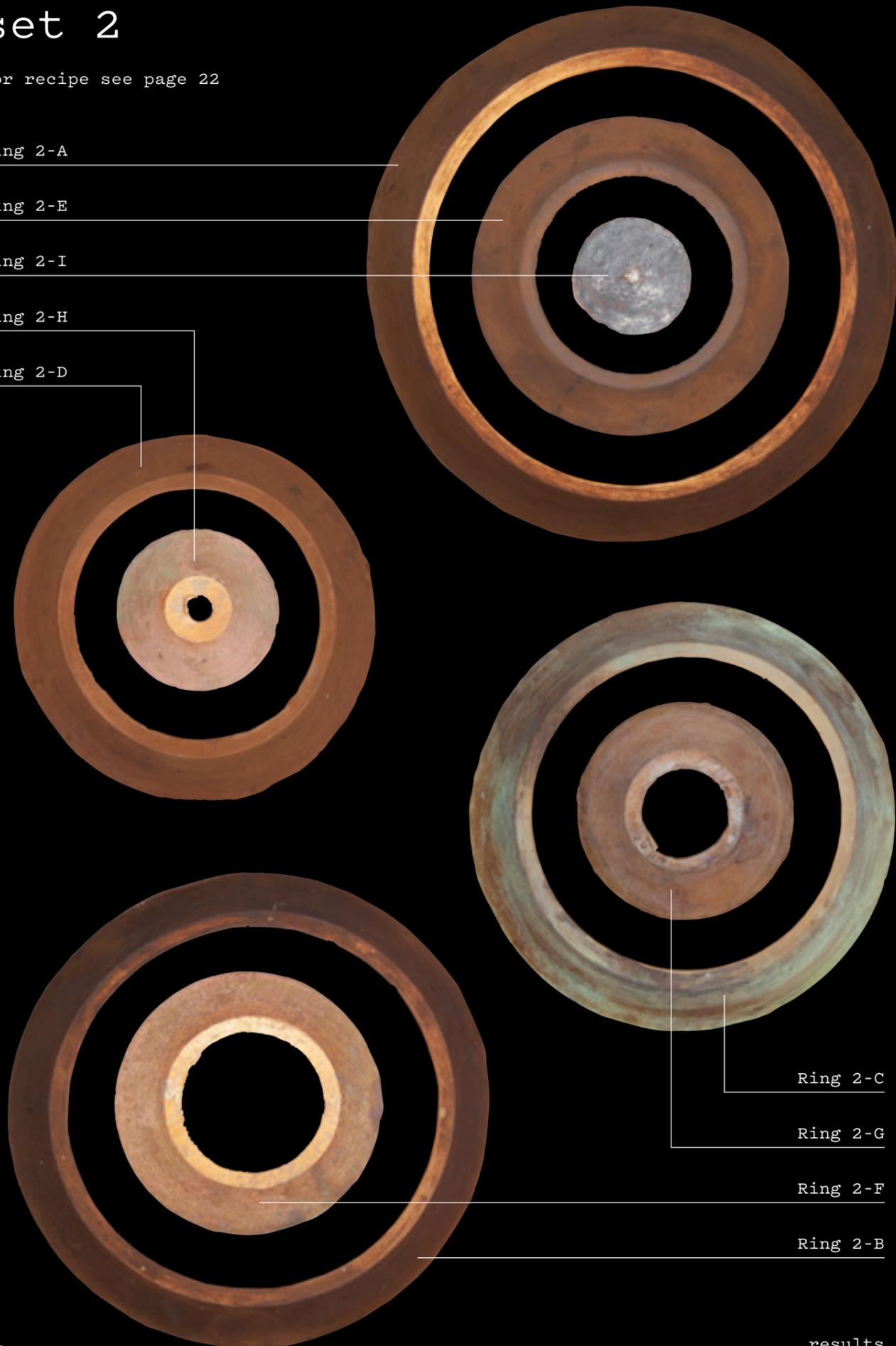
Ring 2-A

Ring 2-E

Ring 2-I

Ring 2-H

Ring 2-D



Ring 2-C

Ring 2-G

Ring 2-F

Ring 2-B

50× magnification



Ring 2-A



Ring 2-B



Ring 2-C



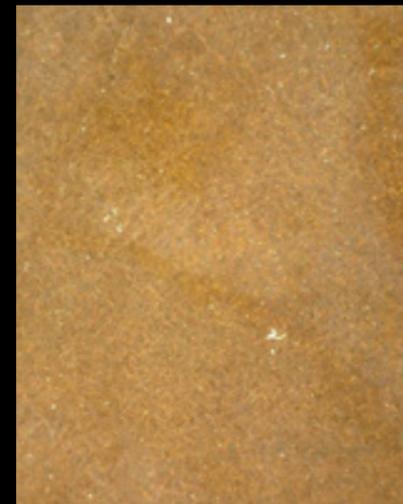
Ring 2-D



Ring 2-E



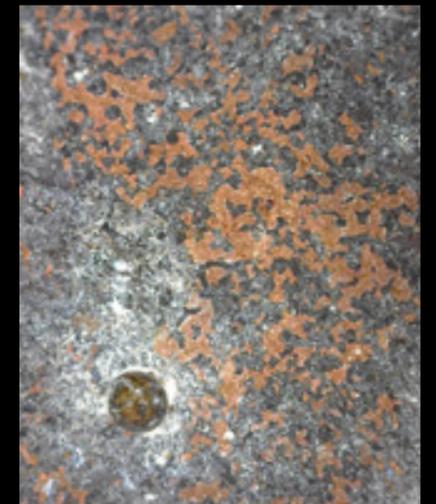
Ring 2-F



Ring 2-G



Ring 2-H



Ring 2-I

set 3

For recipe see page 23

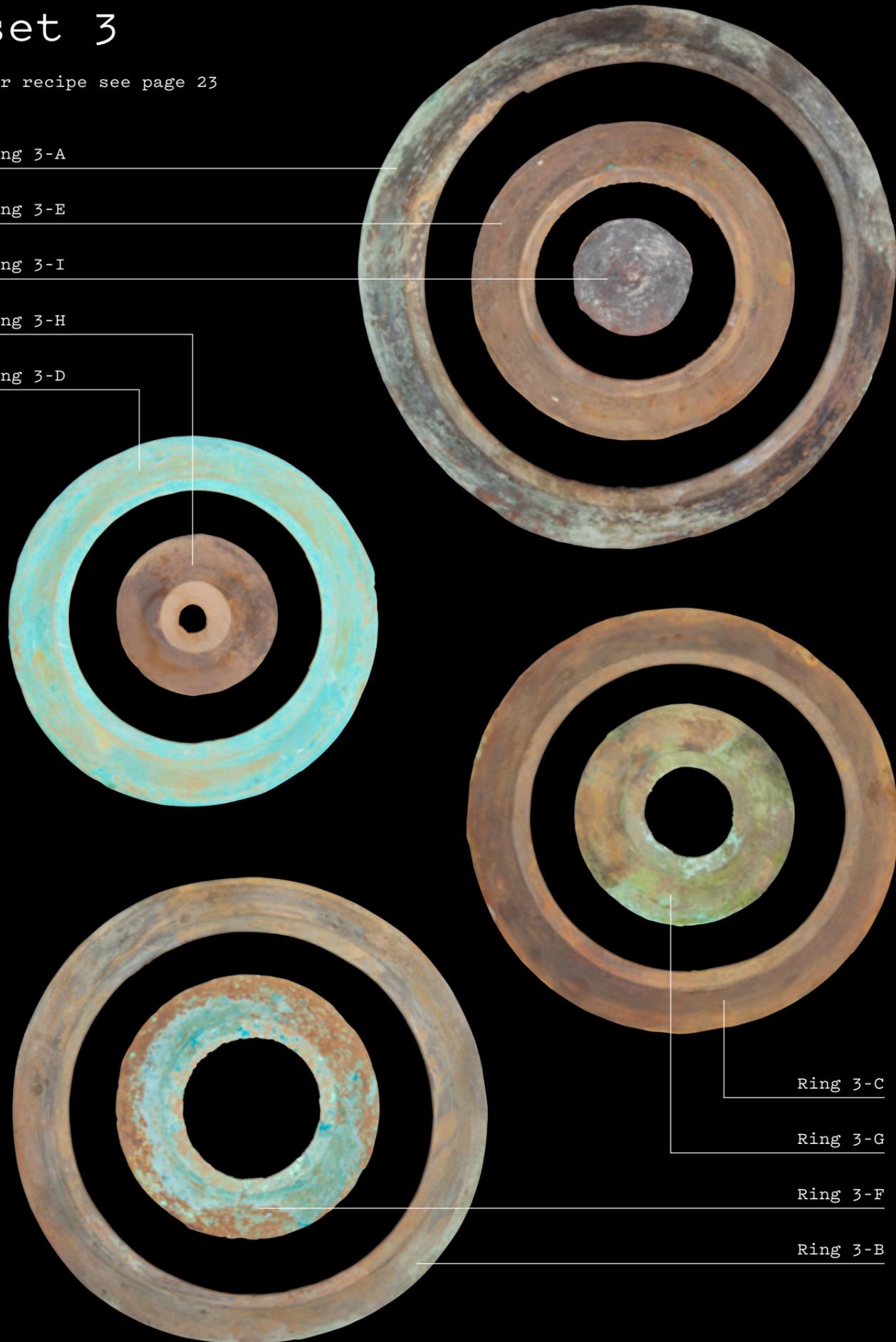
Ring 3-A

Ring 3-E

Ring 3-I

Ring 3-H

Ring 3-D



Ring 3-C

Ring 3-G

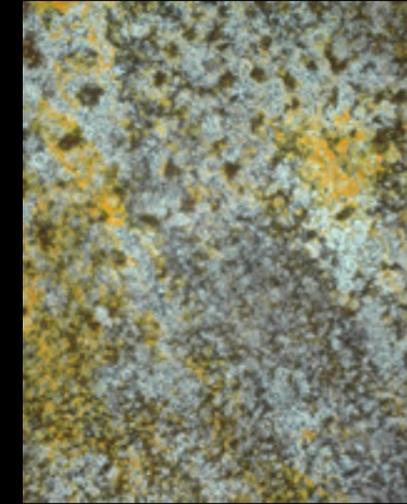
Ring 3-F

Ring 3-B

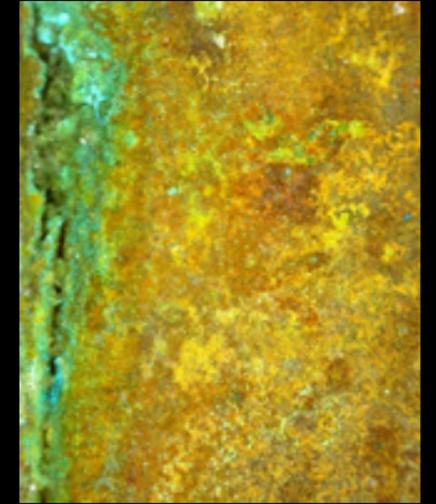
50× magnification



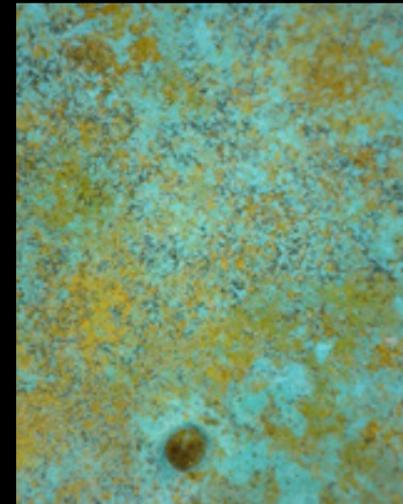
Ring 3-A



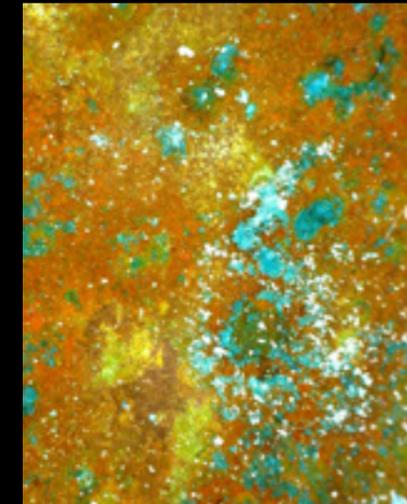
Ring 3-B



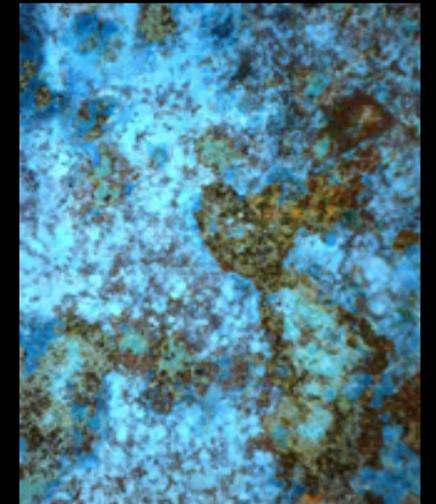
Ring 3-C



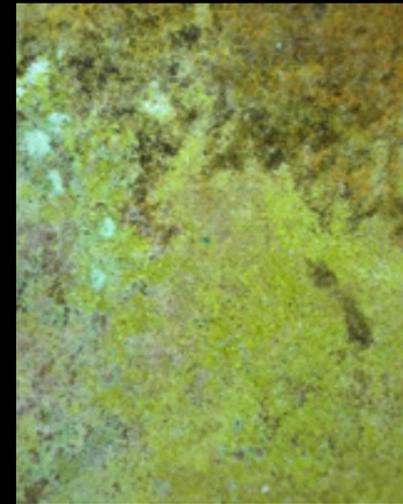
Ring 3-D



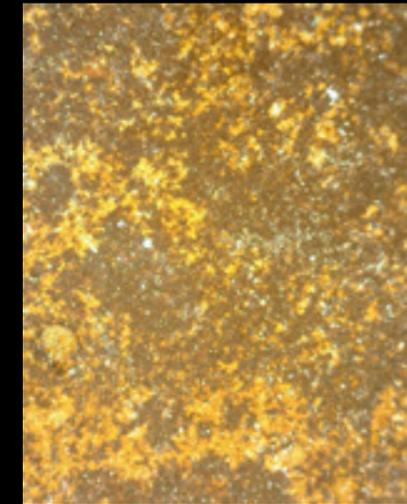
Ring 3-E



Ring 3-F



Ring 3-G



Ring 3-H



Ring 3-I

set 4

For recipe see page 24

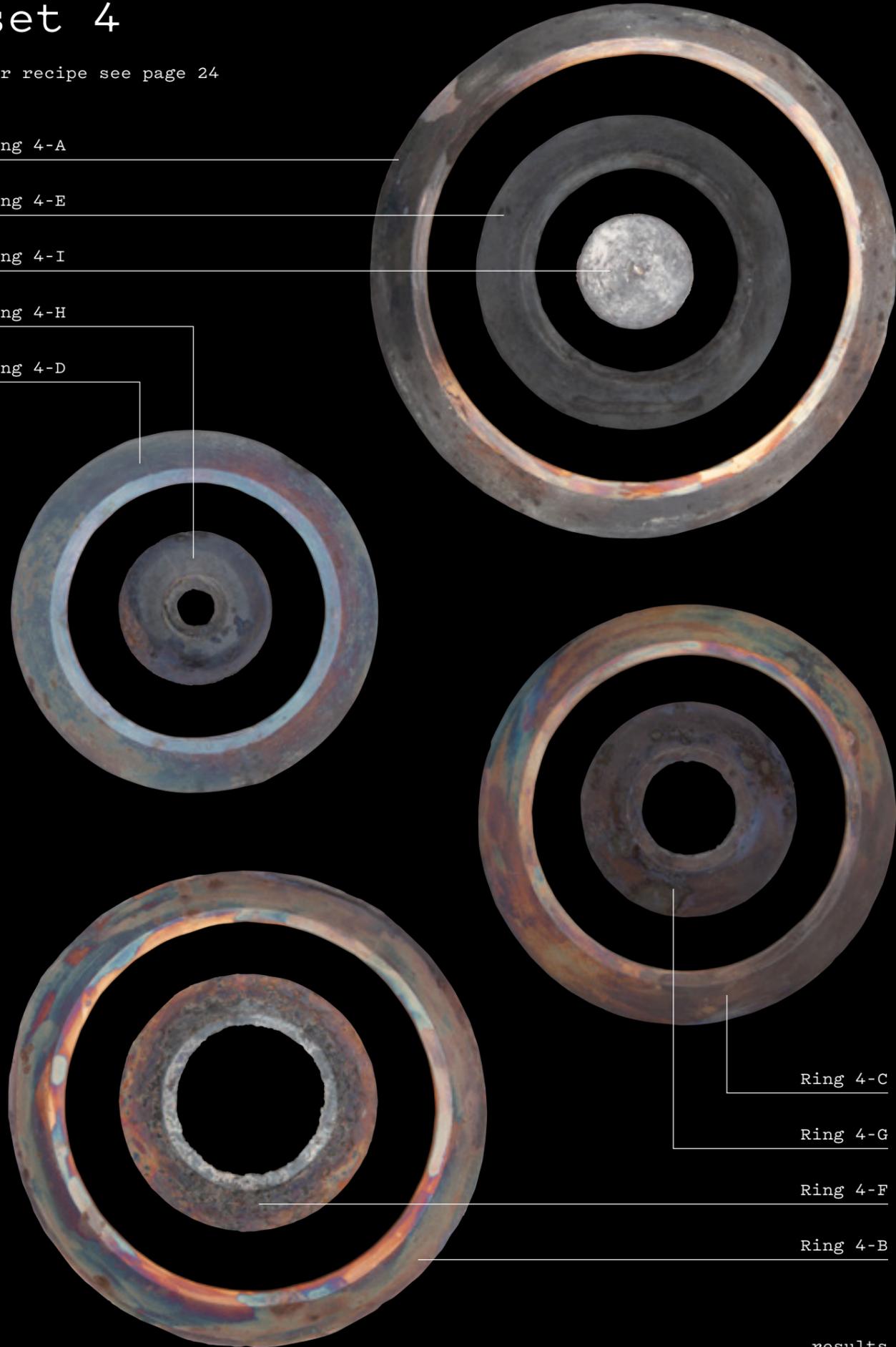
Ring 4-A

Ring 4-E

Ring 4-I

Ring 4-H

Ring 4-D



Ring 4-C

Ring 4-G

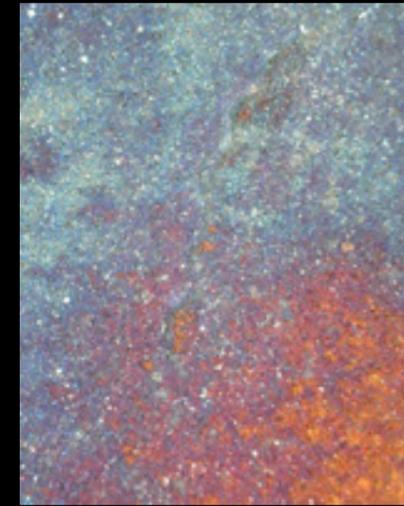
Ring 4-F

Ring 4-B

50× magnification



Ring 4-A



Ring 4-B



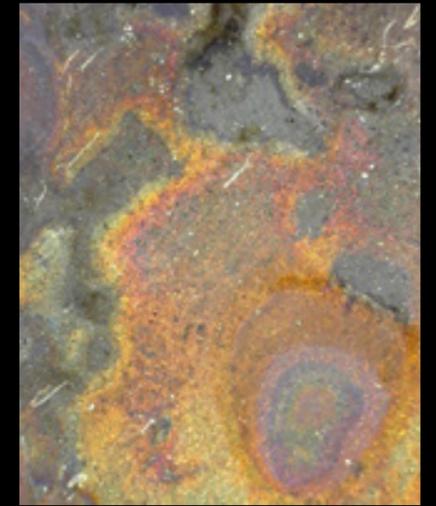
Ring 4-C



Ring 4-D



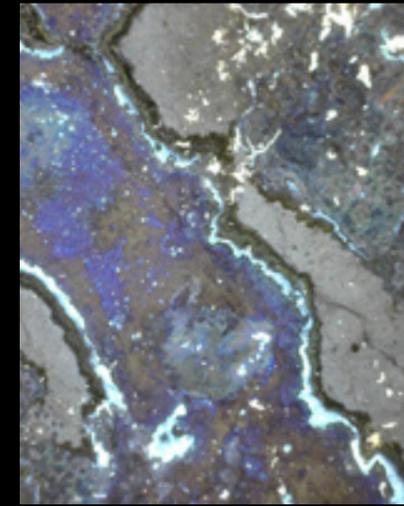
Ring 4-E



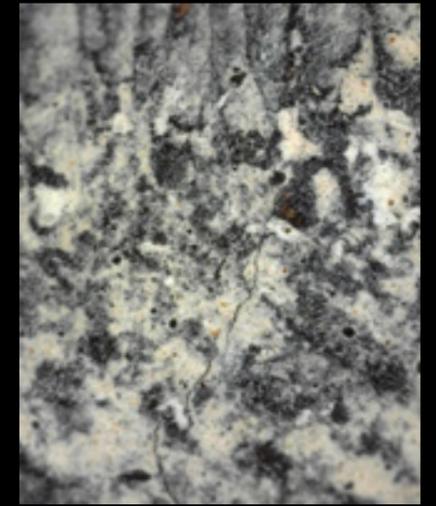
Ring 4-F



Ring 4-G



Ring 4-H



Ring 4-I

set 5

For recipe see page 25

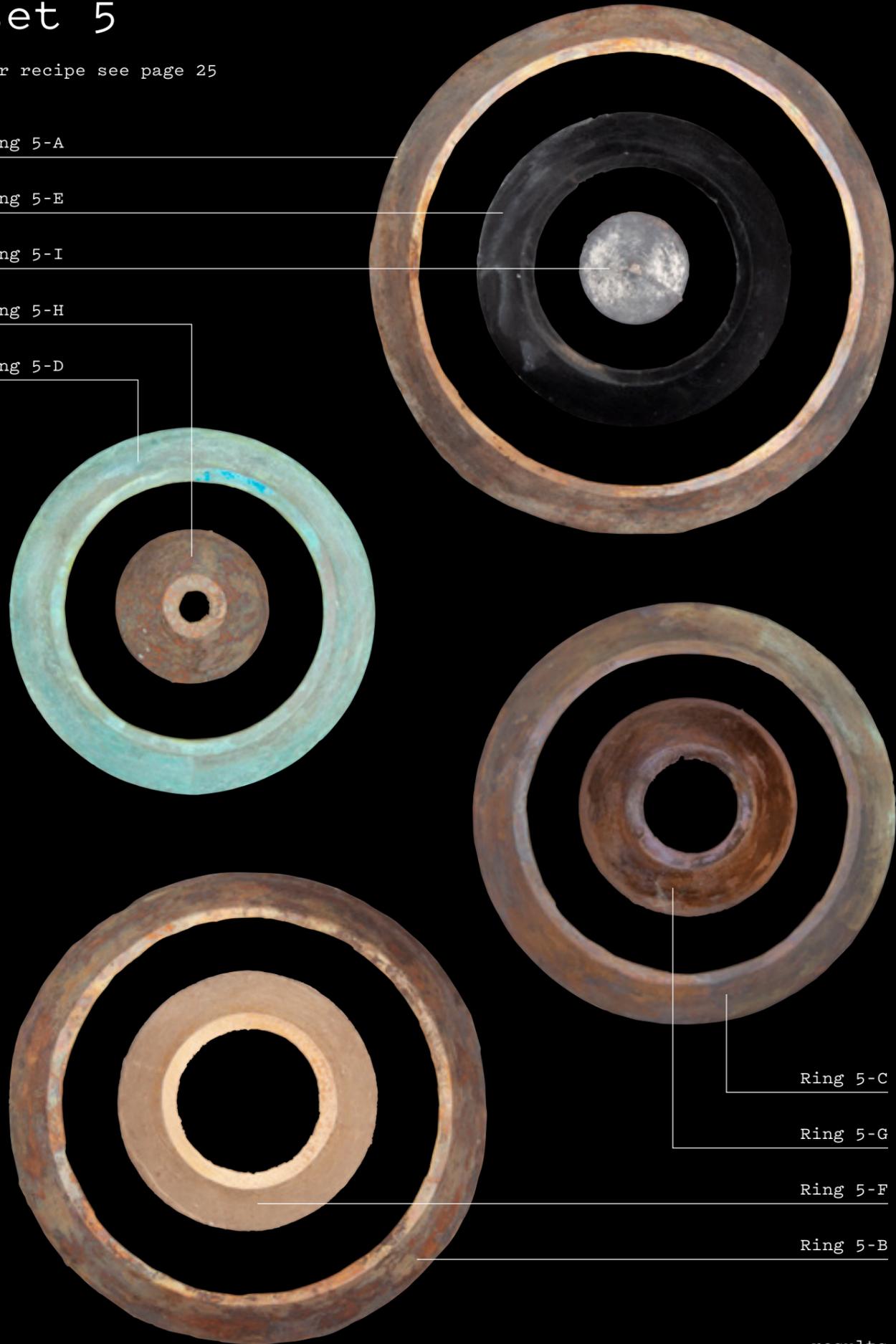
Ring 5-A

Ring 5-E

Ring 5-I

Ring 5-H

Ring 5-D



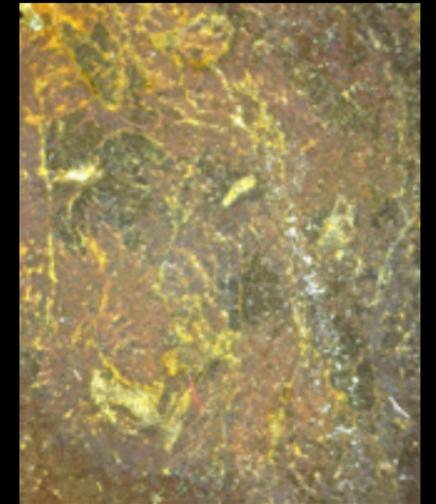
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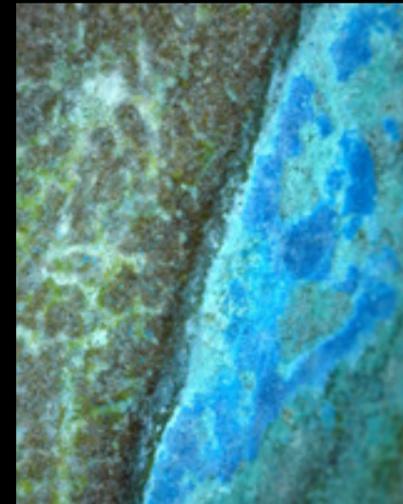
Ring 5-A



Ring 5-B



Ring 5-C



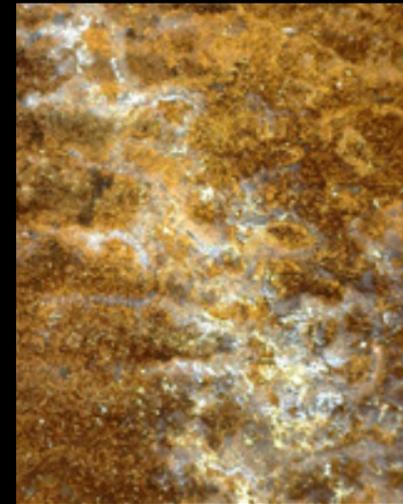
Ring 5-D



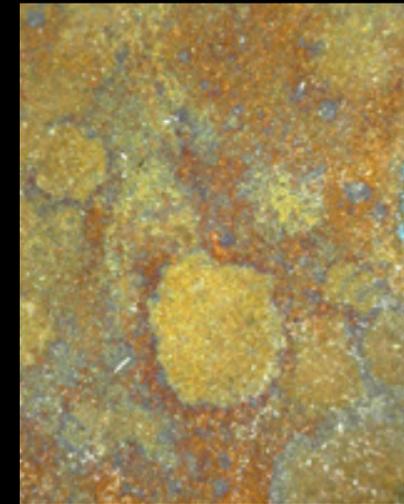
Ring 5-E



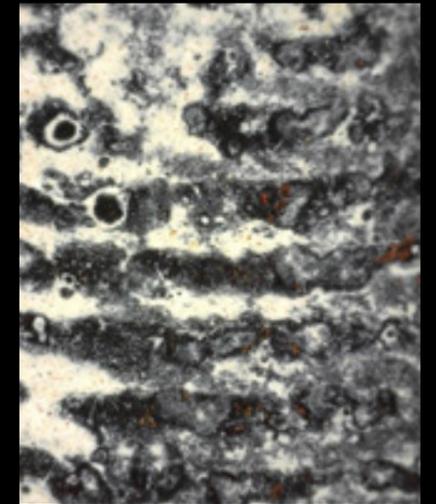
Ring 5-F



Ring 5-G



Ring 5-H



Ring 5-I

set 6

For recipe see page 26

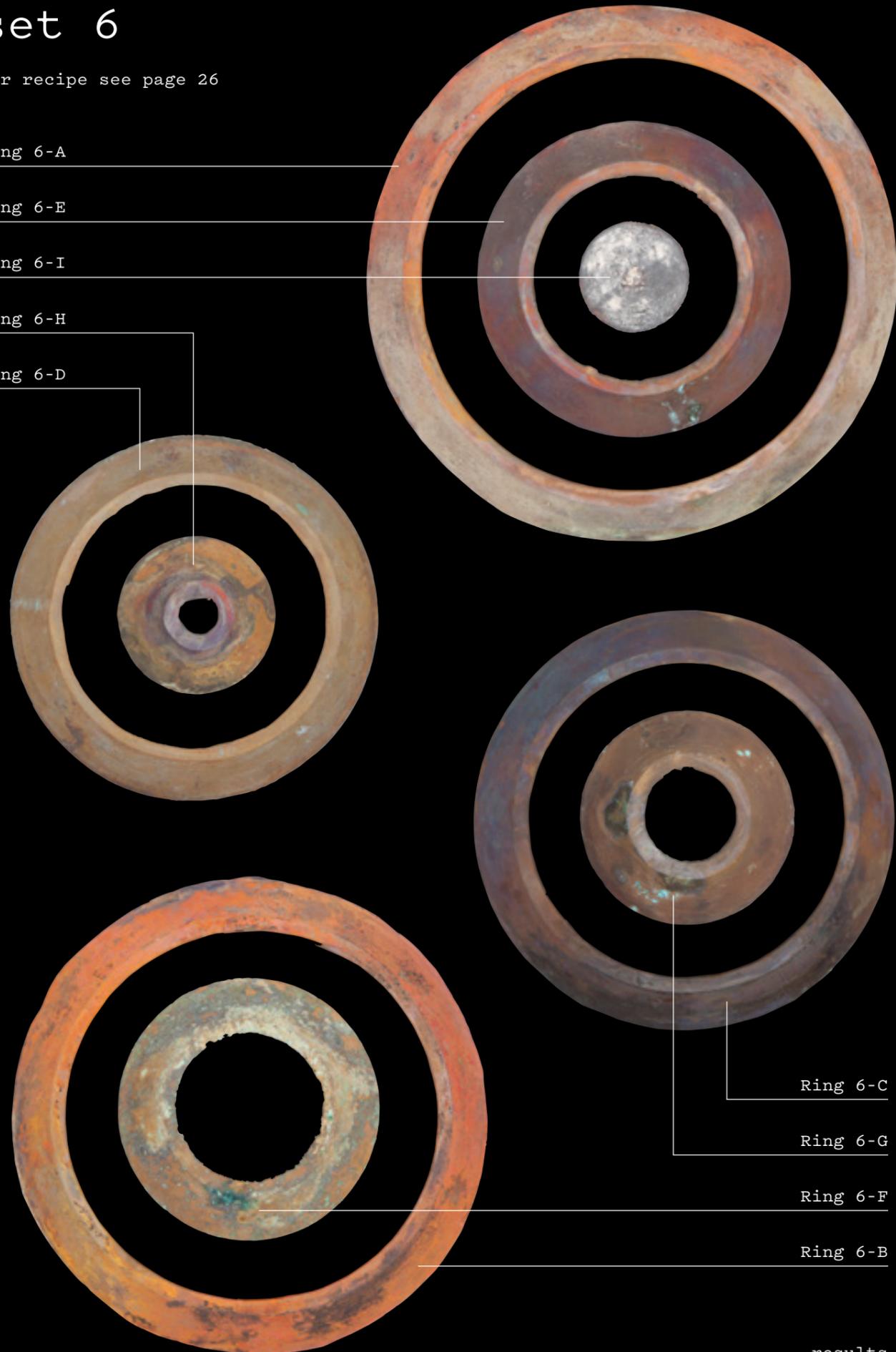
Ring 6-A

Ring 6-E

Ring 6-I

Ring 6-H

Ring 6-D



Ring 6-C

Ring 6-G

Ring 6-F

Ring 6-B

50× magnification



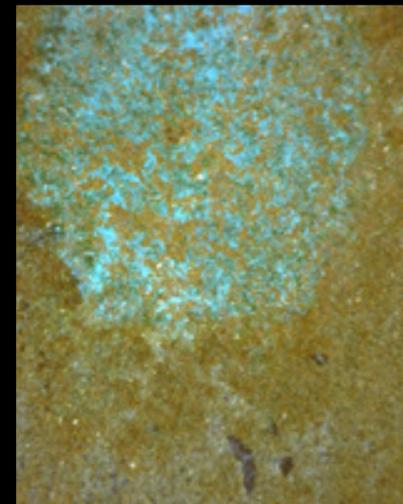
Ring 6-A



Ring 6-B



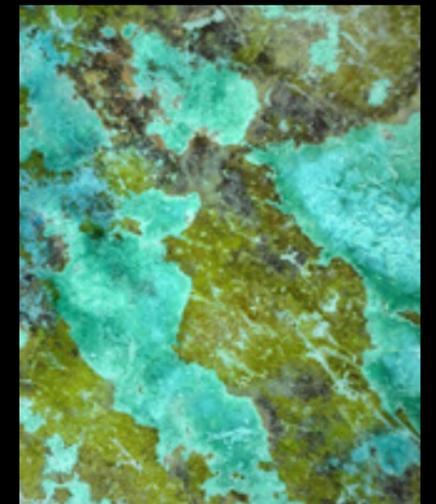
Ring 6-C



Ring 6-D



Ring 6-E



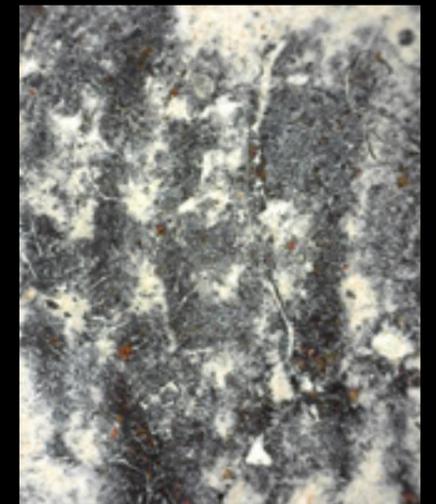
Ring 6-F



Ring 6-G



Ring 6-H



Ring 6-I

set 7

For recipe see page 27

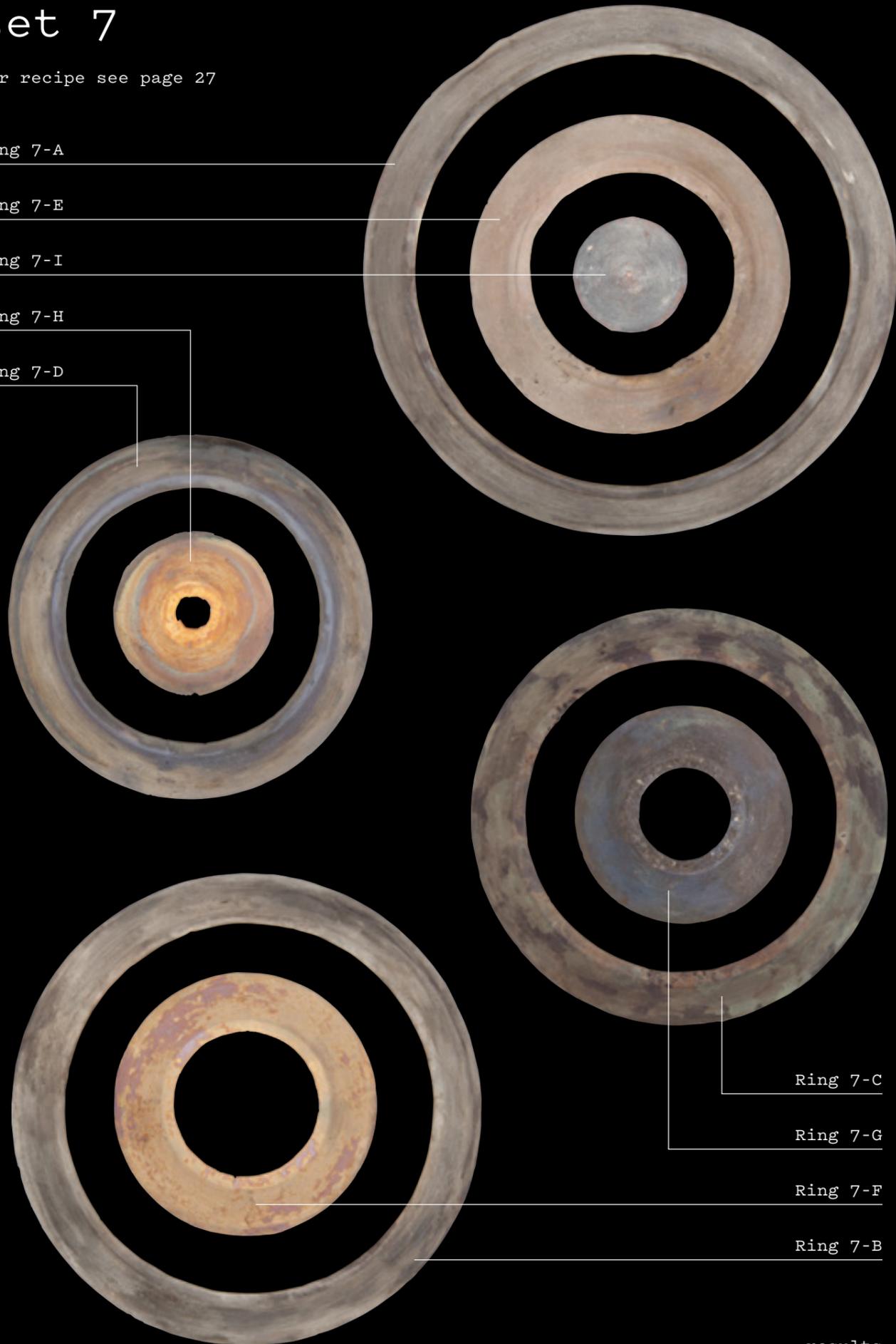
Ring 7-A

Ring 7-E

Ring 7-I

Ring 7-H

Ring 7-D



Ring 7-C

Ring 7-G

Ring 7-F

Ring 7-B

50× magnification



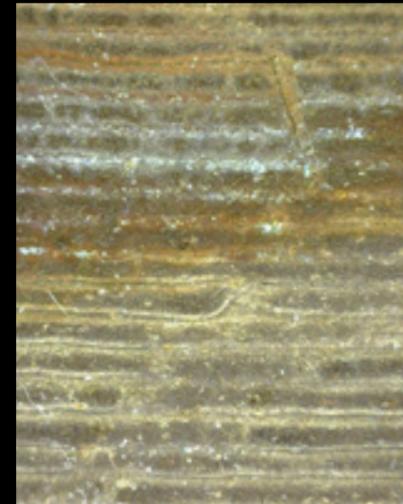
Ring 7-A



Ring 7-B



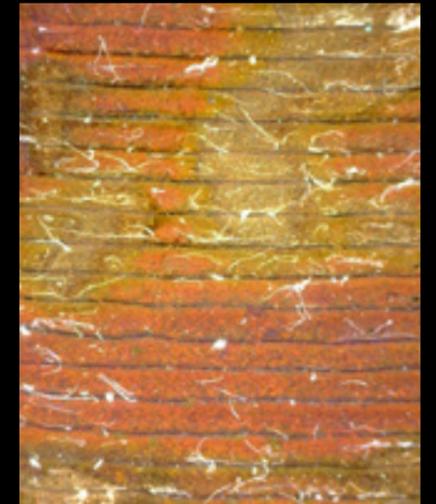
Ring 7-C



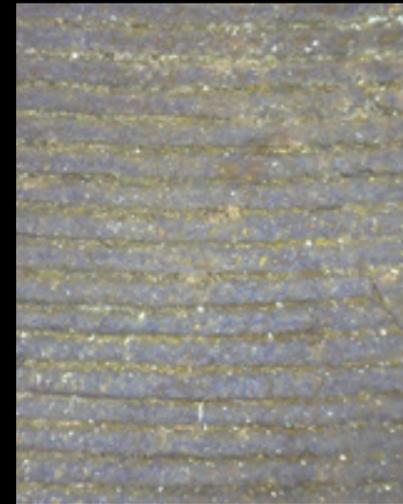
Ring 7-D



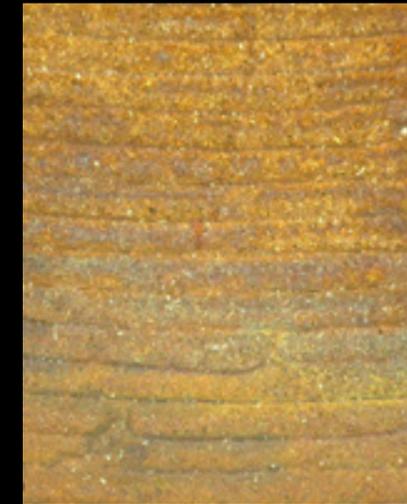
Ring 7-E



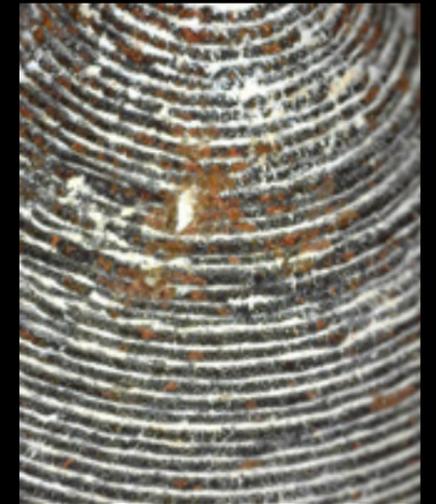
Ring 7-F



Ring 7-G



Ring 7-H



Ring 7-I

set 8

For recipe see page 28

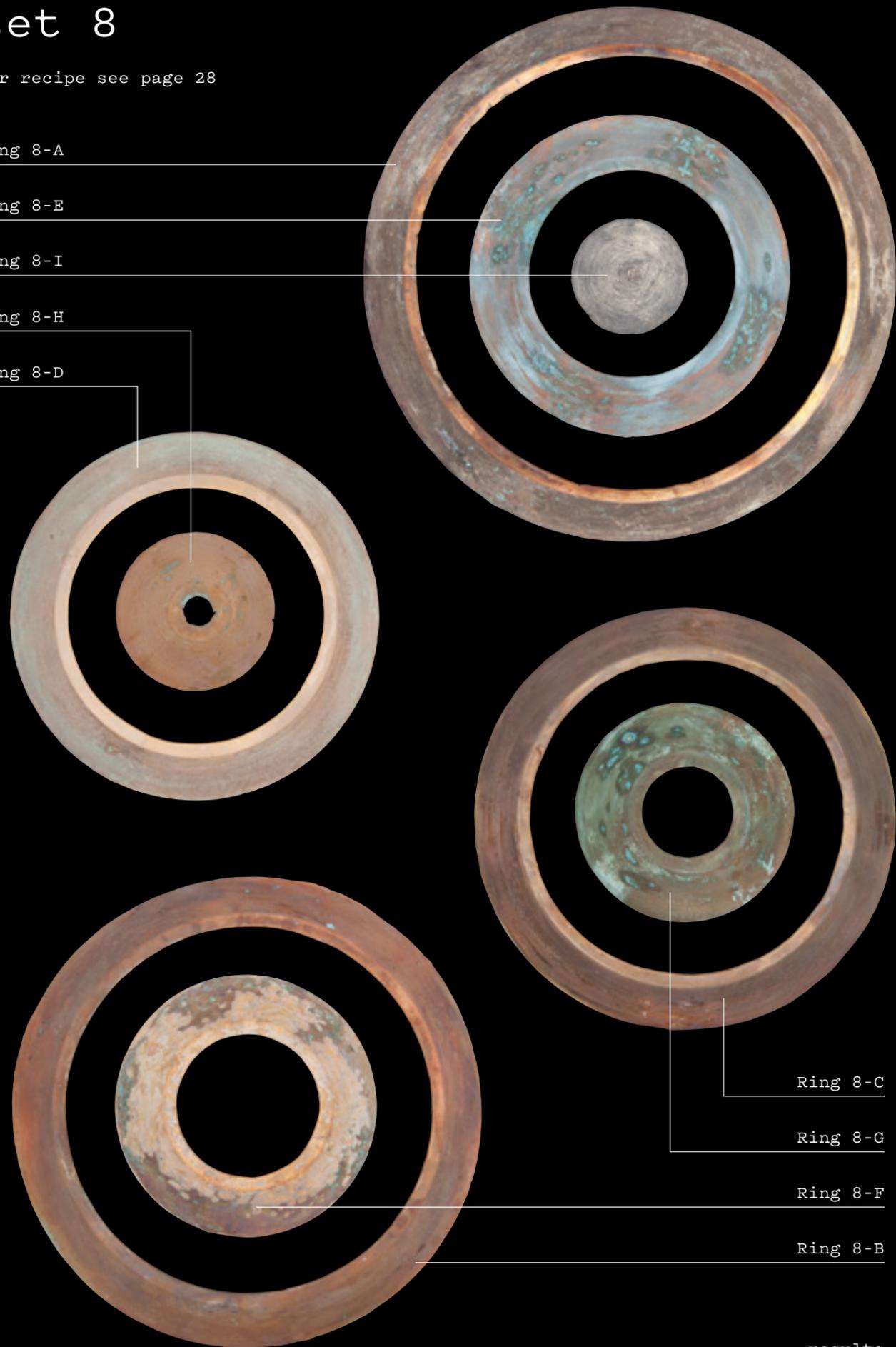
Ring 8-A

Ring 8-E

Ring 8-I

Ring 8-H

Ring 8-D



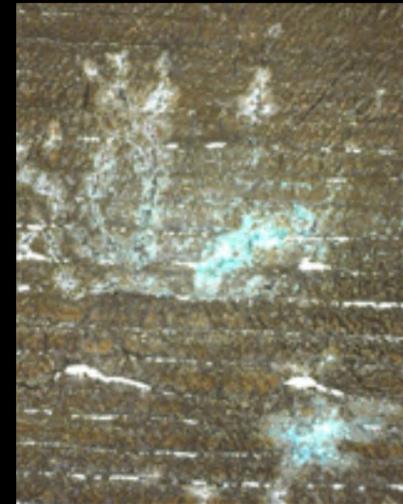
Ring 8-C

Ring 8-G

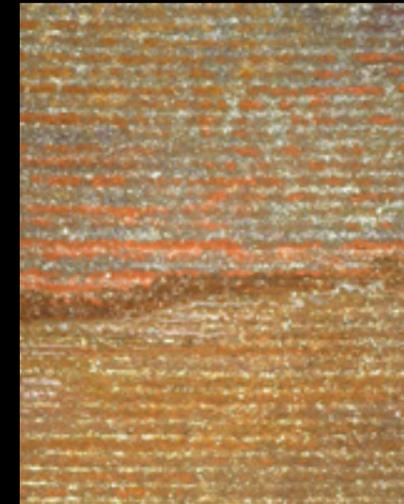
Ring 8-F

Ring 8-B

50× magnification



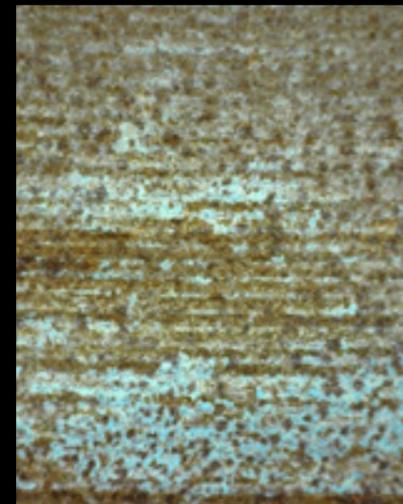
Ring 8-A



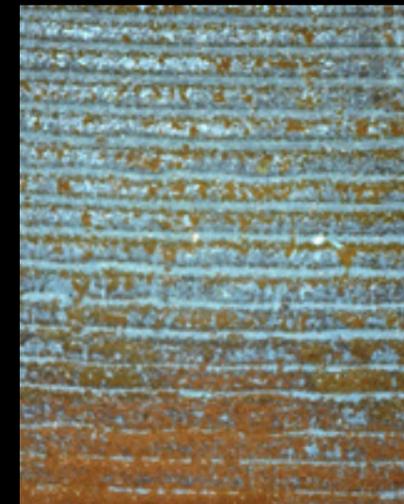
Ring 8-B



Ring 8-C



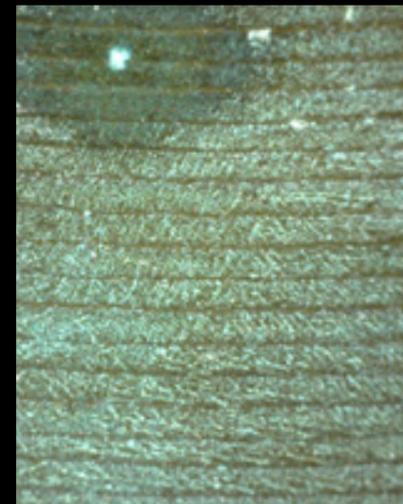
Ring 8-D



Ring 8-E



Ring 8-F



Ring 8-G



Ring 8-H



Ring 8-I

set 9

For recipe see page 29

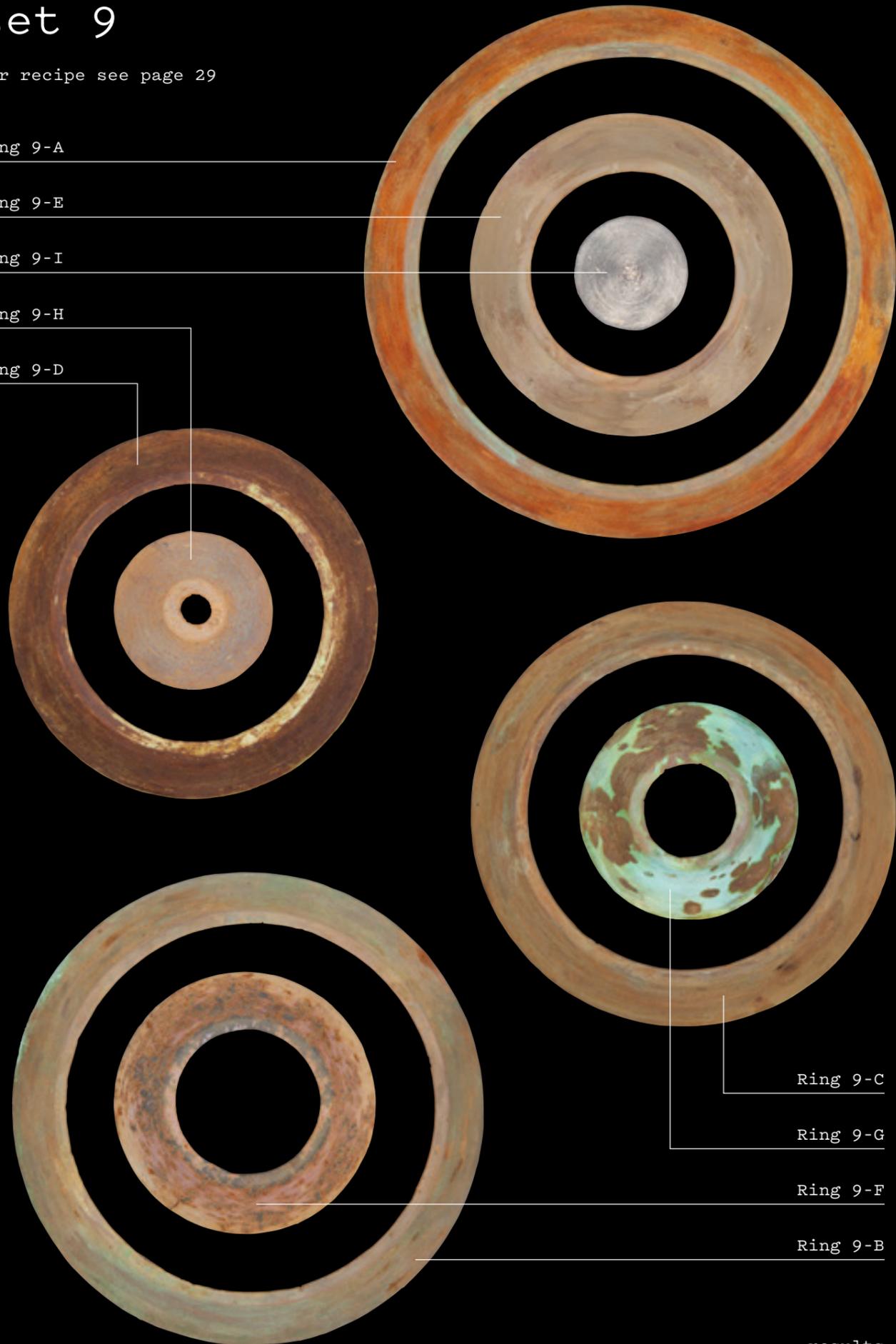
Ring 9-A

Ring 9-E

Ring 9-I

Ring 9-H

Ring 9-D



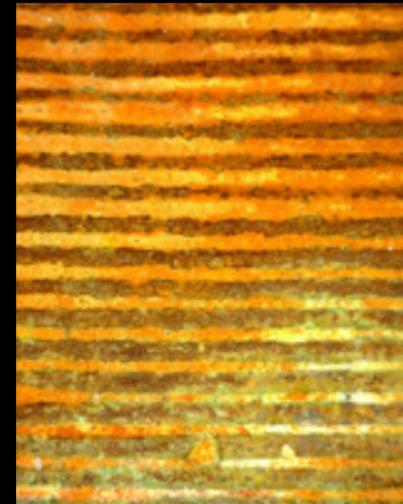
Ring 9-C

Ring 9-G

Ring 9-F

Ring 9-B

50× magnification



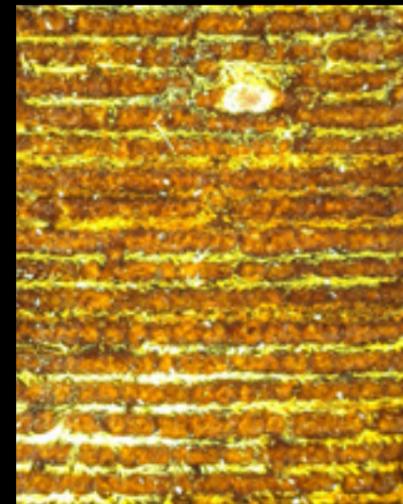
Ring 9-A



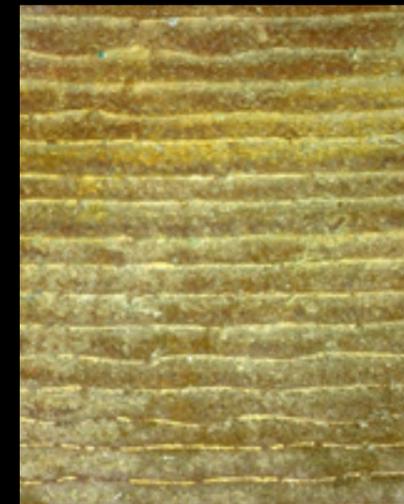
Ring 9-B



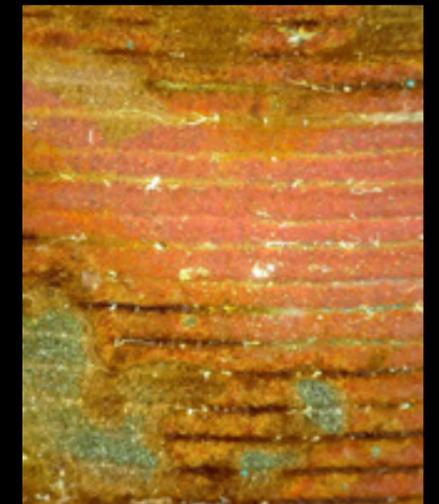
Ring 9-C



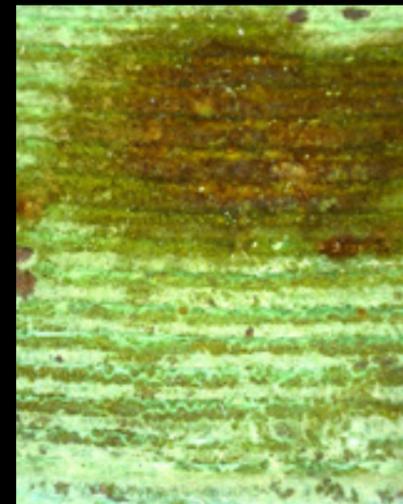
Ring 9-D



Ring 9-E



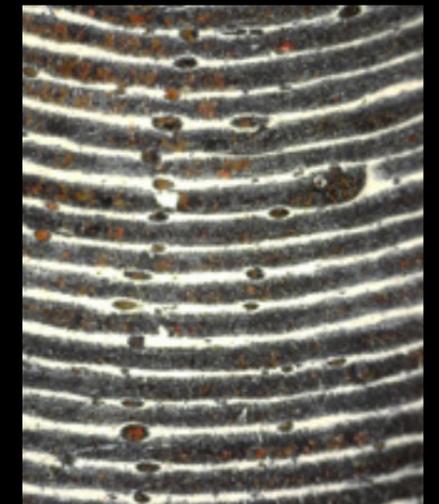
Ring 9-F



Ring 9-G



Ring 9-H



Ring 9-I

about the makers

Laura van Santen

Laura van Santen (°1985, Leiden) is an architect (graduated from TU Delft) and collaborates with Diederik de Koning as la-di-da. The design duo combines knowledge of industrial building processes with a love for craft, oscillating between furniture and architecture. Recently Laura has worked on large scale, ceramic panels during a residency at the European Ceramic Work Centre, as well as developed the design and textile at the Textiellab Tilburg for 4000m2 movable walls in the Lochal Library. She currently teaches at the BA Interior Architecture & Furniture Design at the Royal Academy of Art (The Hague).

Heleen van Santen

Heleen van Santen (°1987, Riyadh) is a metal conservator with a strong interest in manufacturing processes. Her work with sculpture and scientific instruments has incorporated investigations into patination processes to ensure the preservation of historic patinas. As part of her professional doctorate in conservation from the University of Amsterdam she has worked in the conservation departments of the Royal Collections Greenwich (London), the Smithsonian Hirshhorn Museum (Washington D.C.) and the Stedelijk Museum Amsterdam. Currently, she is focusing on clockworks and horology.

reading

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credits

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& Diederik de Koning







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