THE ETCHING OF IRON BEFORE THE INVENTION OF ETCHED INTAGLIO PRINTING PLATES, 1200-1500

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Introduction

It was probably not later than 1500 that the Augsburg armourer Daniel Hopfer (c. 1470-1536) started etching flat iron plates in order to print them like copper engravings. By that time he was accomplished in decorating iron armour by means of etching. How he came to his invention is not known, etching decorations in iron was already practised since the 13th century.[1] A parallel development is the engraving and printing of copper plates practised in Germany from around 1430 and in Italy after the middle of the 15th century.[2] The first copper engravings were printed by hand by rubbing the back of the printing paper. From 1460-65 plates are printed on a roller press, a kind of mangle, in the Upper Rhine region and in Italy (Mantua, Florence) from 1470.[3] Hopfer combined the techniques of etching an image in a flat iron plate with printing this plate with ink on paper by means of a roller press. In that way he invented etched intaglio printmaking. Metals, stone, glass, ivory and bone can be corroded by an etchant, usually a strong mineral acid or else a mixture of various salts in vinegar or water, and occasionally a lye is found. There are three ways to create a design on the object to be etched. The simplest is to paint or draw with the mordant on the surface of the object. This will give some discolouration or matting of the surface. More effective is to paint the design with a resist or ground, such as molten wax or oil paint, on the surface. Next the object is covered with an etchant or placed in a tray with an etching fluid, which corrodes the bare metal. The other method is to completely cover the surface of the object with a ground, draw the design into it with a needle and next let the

1. Harzen 1859; Köhler 1897; Landau & Parshall 1994, p. 323; Williams 1934.
2. Geisberg 1923, p. 26; Levenson 1973, p. XV.
3. Bocquentin 1993, Vol. 1, p. 10-15, 59.

mordant act upon the metal, stone or whatever material. Both these methods create a tangible relief and both techniques are described from early on.

Antecedents

The materials for etching are available around the world and the chemistry is the same everywhere. One can therefore imagine that it is possible to find examples of objects with etched decoration in various corners of the Earth and in various periods.[4] A very early example is the corrosion of semi-precious stones, such as carnelian, agate and chalcedony. The oldest of such objects are from the Middle East and date from before 2,700 BC. Through trade they appeared from the Crimea and West Siberia, to China, to South India later in time, and here was still a production site in what is presently Pakistan in the third quarter of the 19th century.[5] Presently the technique is performed in India again for low-rate work.[6] The technique is simple. A pattern is drawn on the bead with a paste which contains an alkali such as sodium carbonate as its reactive ingredient. The stone is placed in a clay holder, heated for some minutes and a chemical reaction takes place between the paste and the stone. The effect is local discolouration of the surface. There is no relief and layers of tiny white "bubbles" can be seen in cross sections with microscopic enlargement.[7]

From Mesopotamia we move further East to China. Bronze mirrors, swords and spear points from the mid-5th century BC (late Chou and Han periods) show typical, etched patterns. The metal shows a clear, lighter discoloration due to chemical changes at the place of etching, and etched patterns on swords and spear points have a shallow relief. What chemical process was used is not known.[8] Inscriptions in intaglio in a number of late Chou (4th-2nd century) bronzes are of such a character that they cannot be easily explained as to be made by casting or engraving. The edges of the grooves are flat, irregular and undercut, which suggests an etching technique using a ground and an etchant. Further explanation is waiting, while considering the Chinese of the Han period (2nd century BC-2nd century AD) were versed in chemistry.[9] A similar kind of decoration is observed with Egyptian copper alloy objects from around 2000 BC to Roman times.[10]

Crossing the Pacific Ocean to North America and travelling further across the Rocky Mountains to Arizona we arrive at the Gila River valley, North of

4. Smith 1981, p. 277-281.
5. Beck 1933.
6. Information kindly supplied by Dolores Snel.
7. Francis 1980, p. 24.
8. Chase & Franklin 1979, p. 243-256; Loehr 1956, p. 204-205.
9. Pope 1967-1969, vol. 2, p. 141, 146-147, fig. 182, 183, 187.
10. Ogden 2003, p. 160.

the Gulf of California. Once an agricultural people lived here. They are called the Hohokam by archaeologists and may have inhabited the valley from the 4th century BC until after 1400 AD. The Hohokam seem to have been trading with coastal tribes or travelling there themselves, as many marine shells are found in archaeological diggings. These shells are often decorated by carving, cutting and painting, but occasionally they show a relief which is clearly etched. The etching shows by the irregular edges of the grooves, rounded corners and undercutting of the edges. One such object has remains of pitch, which was used as a resist. The argument was that the chalk of the shell is easily corroded by a mild acid such as fermented juice (vinegar) from the local *saguaro* cactus fruit. A test showed that painting a design with a resist and leaving the shell in this vinegar for three days was enough to produce the same results as observed with the originals.[11] Experimentation by the present author etching a sea shell with strong vinegar produced a relief of 0.2 mm in twelve hours.

Pattern welding

The above examples are incidental and isolated in time and place, there have been no mutual connections and there are no developments towards modern printmaking. The European techniques of "pattern welding" and "copper gilding on iron" therefore come closer. In Europe, during the early middle ages and before, iron sword blades and spear heads were constructed by so-called "pattern welding," a term introduced by Herbert Maryon in 1948. Pattern welding is a metal craft practised in Europe from the 3rd century to the end of the 10th century, gradually disappearing afterwards. The technique is still used in various East and South-East Asian countries, famous are the Japanese sword blade and the Java kris.[12] By the earliest forms of this technique strips of pure and carburized iron were welded into a bar and next folded double once to be forged into a tough blade. Pattern welded weapons are found from the 4th century BC (Etruscan examples) and the 2nd century BC (Celtic examples), developed further from the 2nd century AD onward and came to full bloom during the Merovingian and Carolingian periods, with export of the arms forged in this manner to Eastern Europe in later centuries.[13] Pattern welded swords were in great demand by the Normans invading the empire and by tribes threatening the Eastern borders of Charlemagne's territory. That was reason why the Carolingian administration tried to prohibit export of armour and weapons to these enemy clients.[14] Pattern welding should not be confused with the production

11. Gladwin 1965, p. 148-151; Haury 1967, p. 677, 680.
12. Böhne 1963, p. 227; Javaansch handschrift 1981, p. 33-34; Smith 1965, p. 8-9.
13. Aitchison 1961, p. 225-226, 253-257; Anteins 1966; France-Lanord 1964, 321, 326-327; Glosek & Kajzer 1977; Kirpicnikov 1986, p. 15; Neuman 1927; Panseri 1965, p. 37, 39; Sachse 1993, 116-117; Tylecote 1992, p. 66, 68.
14. France-Lanord 1952, p. 417; Salin 1957, p. 279-281.

of Wootz steel, practised in India and the Middle East, and called "damascening" after the city of Damascus where the technique was applied. The technical differences with the latter are the production method of the steel, which is tempered slowly in order not to disturb the crystallisation process, by a higher carbon content and by the presence of traces of the metal Vanadium in the ore which creates a hard and tough alloy. The patterns made by damascening are more complex and refined than the patterns in the earlier pattern welded blades.[15]

In the technique of pattern welding thin bars of hard, carburised (0.3-0.6 % carbon) and soft (pure) iron are welded together to create tough blades which stay sharp. The smith can fold and hammer the iron of the blade in various patterns, which patterns are disclosed by polishing or "etching" the metal.[16] What technique the European medieval smith applied to disclose the welded patterns is unknown, although the general acceptance is that the blades were etched, as this gives best results. A possible reference to etching may be found in a letter Cassiodorus (490-585), as secretary to Theodoric the Ostrogoth, wrote to Thrasamond, King of the Warnorii sometime between 523 and 526. Thrasamond sent two swords as a present to Theodoric. Cassiodorus thanks him for that and describes how shiny they are, how smooth their edges are shaped and that "the centres are hollowed out with beautiful grooves, (that) seem to undulate with worm-like marking" (*media pulchris alveis excavata quibusdam videntur crispari posse vermiculis*).[17] To distinguish between carburized and non-carburized iron differences in shades of colour are enough. Colour hues are created by polishing followed by rubbing the metal with a weak acid, which is the technique for damascene steel.[18]

Experimentation shows that just leaving iron in a bath of vinegar is not effective as the vinegar is not acidic enough. The iron discolorates (micro-etching) but no tangible relief is created. Suspending an iron object above a vinegar bath to expose it to its vapours in combination with oxygen in the air makes it rust quickly. When the rust is brushed off after a week it leaves a shallow (>0.1 mm) relief. It is conceivable that a similar action continued for a month or so would etch the weaker iron in a pattern welded blade more than the harder iron. After cleaning and polishing an agreeable structure will appear. A reference to exposing iron to a mild acid is given by Diodorus Siculus (fl. 60-30 BC). He describes the swords of the Iberian Celts as "two-edged and wrought of excellent iron." According to him, they did bury "plates of iron in the ground and leave them there until the rust has eaten out (περιφαγοντοσ) what is weak in the iron and what is left is only the most unyielding, and of

15. Sachse 1993, p. 36, 94, 162-163, 165; Verhoeven 1998.
16. Böhne 1963, p. 230-233; Jones 1997, p. 1-3; Sachse 1993, 28-29; Smith 1965, p. 4.
17. Cassiodorus, Variarum, V, 1; Salin 1957, p. 273-274, nr. 247; Smith 1965, p. 6-7.
18. Allan 1979, p. 86; Verhoeven 1998, p. (4).

this they then fashion excellent swords." The humic acid in combination with the oxygen present in the soil will have made the iron rust. By next scraping off the rust a piece with a higher proportion of carburised iron is left, which can be forged into a tougher blade. Thus interpreted this passage does not seem to refer to pattern welding of the swords themselves, but to an intermediate stage in the process of preparing a harder quality iron with veins of the softer iron left.[19]

The terminology used in literature on pattern welding may cause misunderstandings. Commonly the term "etching" is used, while the action of the acidic fluids will have been superficial only. The term "micro-etching" would be more appropriate, in the sense of merely changing (matting, discolouring) the surface of the metal in stead of creating a tangible relief by true etching.[20]

Another misunderstanding concerning etching may rise from the observation of iron swords dug up after two millennia, and next cleaned and further prepared. We do not have pristine, polished and patterned blades of that period, so do not know how they looked like originally. A centuries-long stay in a mild acidic environment may create a form of relief due to the differences in chemical behaviour of the two kinds of iron. Subsequent conservation treatment may further cause an aesthetic effect which is away from the object's original appearance.

However, the exception is a kind of decoration practised by Celtic smiths. Iron weapons have been found in Celtic burial mounds and dredged from rivers. The mass found from close to the village of La Tène in the lake of Neufchâtel in the West of Switzerland dates from the 2nd and 1st century BC and is particularly interesting for the present discussion. The sword blades are skilfully decorated with a variety of means among which *etched* decorations of geometric patterns are conspicuously present. Some of the blades show a clear and tangible relief with smooth raised part while the recessed parts are coarse. This can only have been produced by partially covering the metal with a resist, such as molten wax or pitch, and etching away the iron around it.[21]

It is tempting to think there might be some kind of relation between the Celtic swords with their simple, etched relieves and late mediaeval swords with their elaborately etched decorations. These are similar kinds of objects, decorated by means of acids and resists, and produced in the same regions. However, the distance in time is large spanning a turbulent period in European history and as long as this relation is not properly researched there is a better candidate for the origin of the late mediaeval etching of armour, a form of copper plating, which is used in "gilding" iron.[22]

19. Diodorus Siculus, Book V, XXXIII, 3-4; France-Lanord 1964, p. 321; Oldfather 1952, vol. 3, p. 184-187.

20. My thanks to Allan Williams for elucidating this matter.

21. France-Lanord 1964, p. 323-324, pl. II-VI; Wyss 1968, p. 664-672, Taf. 3-5.

22. Smith & Hawthorne 1974, p. 49, n. 98.

Copper plating

There was a fair knowledge on chemistry available in the middle ages and within the reach of our subject there are dozens of recipes for gilding iron which are corrosive, too. In this kind of gilding process the object is placed in a copper salt solution, and due to electrolytic action between the copper ions in the solution and the iron object metallic copper is plated onto the iron. This serves as a ground upon which the gold was applied. The oldest known recipe for this manner of gilding is in the Lucca manuscript from around 800. It explains to mix equal parts of copper sulphate, alum and common salt (*calcitarim et alumen Asianum equis ponderibus et sal similiter*) and to dissolve this in water. Together with another part of gum tragacanth this makes a gel which can be applied onto the iron object locally, the gel keeping the solution in place.[23] The same recipe can be found in later manuscripts, such as in the Codex Matritensis (c. 1130).[24] Oakeshott shows a 10th century sword blade with what may be an example of this technique of copper plating.[25]

The Heraclius manuscript, originally dating from the 10th century, has a number of gilding recipes. Two of them tell to cover iron with a layer of copper before actual gilding. The first one explains to dissolve three parts of *atramentum* and one part of common salt in vinegar. The iron object is placed in the solution and is covered with a thin layer of copper. The other recipe prescribes alum, *sal gemma* (common salt in a particular crystalline form) and *calcanthum* in vinegar, with the same effect. This is the same recipe as in the Lucca manuscript and the Codex Matritensis. Thereafter the layers are covered with gold dissolved in mercury, heated, the mercury evaporates and the gold is left on the surface.[26]

The *atramentum*, *c(h)alcant(h)um* and *calcithari(u)m* are terms for salts containing various sulphates and more commonly known as "vitriol," it will have been rich in solvable copper(2) sulphate ($CuSO_4$).[27] Experimentation with plain copper sulphate dissolved in water shows immediate copper plating when iron is dipped into the solution or is rubbed with it. Prolonged exposure of iron in the solution shows a minor corrosion after a few days. Adding kitchen salt etches the iron immediately, because the chlorine in the salt propels the chemical reaction, and when there are equal amounts of both the biting goes fast. Copper acetate dissolved in vinegar works slower, but addition of

23. Biblioteca Capitolare di Lucca ms. 490, fol. 221v; Lucca 2003, p. 102-103, 176.

24. Biblioteca Nacional, Madrid, Ms. A.16, recipe nr. (81) fol. 203r, col. a; with thanks to Stefanos Kroustallis and Mark Clarke.

25. Oakeshott 1981, pl. 48.

26. Ilg 1970, p. 64-67, nr. XVII; Merrifield 1849, p. 222-225.

27. Guineau 2005, p. 88-89 ("atramentum"), p. 179-180 ("calcanthe-calcater"), p. 237-238 ("colcothar"), p. 773-775 ("vitriol"); Perego 2005, p. 529 ("Colcotar"); Stijnman 2006, Appendix 3: "Terms for 'vitriol'."

kitchen salt or sal-armoniac plates the iron in a minute. Etching the shallowest relief with these mixtures takes some hours.

Nitric acid

Another way of etching metals is by means of nitric acid. The oldest description for the distillation of a liquid with a strong dissolving action is in the manuscript *Liber de inventione veritatis* written by "Geber' around 1300. It prescribes dry distillation of one pound of vitriol (Fe_2SO_4 or $CuSO_4$) with half a pound of saltpetre (NH_4Cl) and a quarter of a pound of alum ($K_2SO_4.Al_2(SO_4)_3$). The distillate has a strongly dissolving property and therefore is nitric acid (HNO_3). Further addition of sal-ammoniac (NH_4Cl) creates *aqua regia.* This is a mixture of one part of concentrated nitric acid and three parts of concentrated hydrochloric acid (HCl), and the only acid capable of dissolving gold. The distillation of nitric acid is also known from Byzantine manuscripts from the end of the 13th century as well as from other 14th century Western manuscripts.[28] The author "Geber" may be identical with the Franciscan lector Paulus de Tarento working in Assisi in the late 13th century and originally from the south of Italy. The name "Geber" was used first by 14th century Western scholars to refer to an Arab scholar and is derived from "Jabir." There are more persons called by that name, but in our case the likely candidate is Jabir Ibn Hayyan (fl. 8th century) who mainly worked in Bagdad. A voluminous compendium of treatises known as the *Corpus Jabirianum* is attributed to him, but most, if not all, of the works are compiled only a century later.[29] It might also contain a description of the distillation of nitric acid.[30] The literary evidence is not strong enough to attribute the actual production of nitric acid to an 8th century Arab scholar, but at least the transition of oriental knowledge to occidental scholars was stimulating and by 1300 nitric acid is known in Europe. The *Corpus* encompasses all ancient sciences, is usually associated with alchemy and astrology, but also contains practical techniques such as the chemistry of salts, production of steel and illumination of manuscripts. Alchemy arose in Hellenistic Egypt, more particular in Alexandria in the 2nd and 3rd century AD and was partly based on the chemical knowledge present there. Knowledge of Alexandrian alchemy was taken over by Islamic scholars from the 8th century. Greek or Syrian texts were translated into Arabic, their contents studied and further developed by them. Arab alchemy was

28. The Liber de inventione veritatis is part of the Summa perfectionis, Bayerische Staatsbibliothek, München, Ms. Lab. 353, end of the 13th century; Beltran 1998, p. 505; Forbes 1970, p. 63, 86; Geber 1922, p. 8, 113-114, 179; Geber 1928, p. 223-224; Karpenko & Norris 2002, p. 1002; Stijnman 2006, Appendix 3: "Terms for 'vitriol';" Von Lippmann 1971, p. 175; Walden 1952, p. 6-7.

29. Newman 1985, p. 77, 79, 81, 88, 90; Singer 1948, p. 49-50.

30. Singer 1954-1984, vol. 2, p. 356.

introduced in Southern Europe in the 12th and 13th century by means of translations of Arabic manuscripts into Latin, and scholars in Toledo were particularly active in this field.[31]

With this we have two different methods of corroding metals, coming from two different backgrounds, one from the practical crafts and the other from scholarly research. Etching iron with a salt mixture is easy and the chemicals are readily procurable. Nitric acid is well suited for etching iron and copper, but is more complicated to obtain. Although known in the Western world in the 14th century, a first invention does not mean nitric acid was produced commercially or was available to everyone immediately. Saltpetre, the source of the nitrogen in the nitric acid, is used for a variety of purposes and for the production of gunpowder it is essential. As a result nitric acid was produced on a larger scale in Venice from the 15th century. Larger scale production of nitric acid began in France, and possibly also in Germany, in the 16th century.[32]

Etching iron

A resist or ground is missing in these first mentionings. With both methods they just say it corrodes metals, there is no control of where the metal is corroded. Proof of decorating iron, steel and other metals by means of etching a relief of some form comes from a recipe in a 14th century *Secretum Philosophorum*, which is thought to have originated in the 13th century. The term for the acid is *corrosivum*, oil-paint is applied as resist and after etching the grooves are coloured. This comes close to intaglio printmaking, as the next step would be printing this colour onto a sheet of paper.[33] A printed book called *Pro conservanda sanitate* was published in Germany in 1531. The introduction says it is a publication of a manuscript compiled by the French bishop Vitalis de Furno (1260-1327), discovered by the abbot Laurentius in the monastery of Eberbach and entrusted by him to Schoeffer for publication. No copy of this manuscript seems to be known and the attribution to Vitalis de Furno is uncertain.[34] The text on distilling a "water" good to dissolve all metals explains to grind one pound of saltpetre with one pound of vitriol (*corprosse*, corrected to *corporossae*), to mix this with alcohol and distil it twice. This second water coming from the distillation colours wool yellow and dissolves or liquefies all metals, calcined stones and the like, which means it is nitric acid,

31. Hanegraaff 2005, vol. 1, p. 22, 27-28, 30-32, 35.

32. Agricola 1950, p. 441-442; Biringuccio 1959, p. 183-188; Forbes 1970, p. 86-87; much concerning the early history of acids I owe to my discussions with Basil Hunnisett and especially Mark Stevenson.

33. British Library Ms. Add. 32622, fol. 12r, under the heading "Grammar;" Williams 1935, p. 88, n. 63.

34. De Furno 1531, fol. aij-r; Von Lippmann 1971, p. 175.

but no connection is made with etching a relief in metal.[35] Such information is found only further on, where the corrosion of iron or steel (*ferrum vel corallum*) is explained in chapter CCLXXI. The mordant is made of plant ashes, copper acetate (*Viridis graeci seu Verdeti*) and urine or vinegar. The iron object is dipped into melted wax to cover it completely, letters and figures are drawn into the wax down to the iron, and the object placed in the etching liquid. It is left in it for some days until one sees the letters and figures are bitten into the iron [Note: *De Furno 1531*, p. 226; *Von Lippmann 1971*, p. 181.].

There are more 14th century recipes for distilling nitric acid and "gilding" (copper plating) iron with a salts and vinegar mixture. However, in order to recognize a recipe as being for etching a relief in metal objects, it is important that the recipe also describe to use a resist such as wax or oil paint. Ten recipes from five 15th century manuscripts describe how the iron object is either covered with wax, oil-varnish or oil paint and the text or decoration scraped into it with a stylus, where after it is etched. Or, text or decoration is painted onto the iron with oil paint and the metal around it etched away. Additionally a wax wall can be made around the part to be etched to keep the acid, or the etchant is mixed with charcoal powder to an acrid paste which is applied to the part to be etched. Both techniques come in handy for local etching or etching on curved surfaces.

A Spanish sword is our earliest etched iron object, apart from the Celtic examples. It was found in the tomb of King Sancho IV of Castile and Leon (d. 1295) in Toledo and it is dated c. 1290. The inscription on the blade just under the hilt is, according to Oakeshott, "undoubtedly produced by true etching" and the introduction of Islamic science in Toledo in this period (see above) supports the presence of etching. Oakeshott also refers to a possible second Spanish example and shows two Italian blades with etched decoration from the 14th century.[36] Decorating armour by means of etching is not yet well studied, but there is enough material to demonstrate it was practised in Italy, Spain and German countries throughout the 15th century, with an increase in activity in the last decades.[37] Paulerinus, reporting from the 1460s, tells about the *sagittinus* who makes missiles and other weapons. He embellishes these with texts and images, which he bites into the iron by means of a salts solution using red oil paint as a resist (*quas eciam cavat cum sale armoniaco et scribit textus et ymagines in eis et ubi fuerit mineum scriptum cum oleo lini, illis non ledetur ferrum aliqua corrosione*).[38]

35. De Furno 1531, p. 13, addenda; Forbes 1970, p. 63-64, 86; Von Lippmann 1971, p. 179.

36. Bruhn Hoffmeyer 1963, p. 15-16; Norman 1964, p. 105, fig. 108; Oakeshott 1981, p. 141-142, pl. 15, 16, 30C, 31.

37. Alexander 1987, p. 24, 25; Gamber 1976-1990, vol. 1, p. 74-75, nr. A49; Mann 1942, p. 19-20, but see Gamber 1976-1990, vol. 1, p. 85; Oakeshott 1981, pl. 42B; Norman 1964, p. 105-107; Tarassuk & Blair 1982, p. 160-161; with thanks to Alheidis von Rohr and to Karen Watts of the Royal Armories in Leeds for references.

38. Biblioteka Jagiello'nska, Cracow, Ms. BJ 257, fol. 188va (Sagittinus); Hadravová 1997, p. 32.

The origin of etching intaglio printing plates is commonly said to have derived from the etching of iron used in the decoration of arms and armour, and the discussion above gives little reason to doubt that. Iron is harder than copper and difficult to engrave, but can be etched with simple mixtures of various salts, commonly containing a copper salt, in water, vinegar or urine. Copper, a semi-precious metal, is corroded less easily. Etching copper can be done with strong nitric acid (20 % or more in volume), but also with a mixture of various salts in vinegar, prepared by boiling it and thereby creating such an acid in the solution. And although there are no historic references to it, experimentation shows that a saturated solution of plain kitchen salt in strong (8 %) vinegar bites a shallow (≈ 0.1 mm) relief in copper in a month time. Etching iron perhaps was not continuous from the late 13th century onward, but at least the knowledge was available and the technique performed at times. Etched decoration of arms and armour became more and more popular with the skills of the armourer flourishing in the 16th and 17th century.[39] In that period etching is used for decorating a variety of objects, such as dishes, locks, beakers and tools, and in a variety of materials such as pewter, bone, ivory, stone, iron, copper and silver.[40] Finally, not to forget, etching is used for making metal printing plates, for both intaglio and relief, up to the day of today.

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39. Gamber 1999; Kren 2005, p. 3; Mann 1942; Norman 1964, p. 59-82; Plattnerkunst 1954, p. 41-43, 60-61, 66-67; Scalini 1997; Von Reitzenstein 1964, ill. 14, 15, 43-45.

40. Bernt 1939, p. 20-21, 192-195; Canz 1976, p. 13; Freudenberg & Mondfeld 1982, p. 141; Haedeke 1963, p. 16, 22-23, 179-180, 347-348, 422-424; Impey & MacGregor 1985, fig. 30-31; Iven 1938, p. 186-187; Pechstein 1985, p. 230, 250, 255, 265, 281, 481; Schopers 1981, p. 33, 35; Wegner 1958, p. 178-179, 184; Weixlgärtner 1911, p. 339-345.

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