The Natural History of Ooliths: Franz Ernst Brückmann's Treatise of 1721 and its Significance for the Understanding of Oolites

Robert V. Burne[1], J. Chris Eade[2], & Josef Paul[3]

[1]Research School of Earth Sciences, The Australian National University, Canberra ACT, Australia. e-mail: robert.burne@anu.edu.au
[2]Visiting Fellow, Centre for Asian Societies and Histories. The Australian National University, Canberra ACT 0200, Australia. e-mail: jceade@gmail.com
[3]Abt. Sedimentologie, Umweltgeologie, Geowissenschaftliches Zentrum der Universität, Goldschmidt-Str. 3, 37077 Göttingen. e-mail: jpaul@gwdg.de

Schlüsselwörter: Oolithe, Brückmann
Keywords: Oolites, Brückmann

Zusammenfassung

Franz Brückmann schrieb 1721 seine erste Abhandlung über Oolithe. Wir stellen hier eine Übersetzung des lateinischen Originaltextes ins Englische vor. Brückmann beschreibt die Herkunft des Namens Oolith und seine Synonyme; interpretiert Oolithe als Ansammlung von Fisch-Eiern; klassifiziert sie als Steine; gibt Auftreten und Häufigkeit an; erklärt das Ablagerungsmilieu und Prozesse der Versteinerung und die große Menge der gefundenen Eier; beweist ihre biologische Herkunft und ihre biologischen Beziehungen; unterscheidet die Oolithe von den Pisolithen und gibt Orte an, wo sie gefunden werden. Wir kommentieren Brückmanns Text, besprechen die Wirkung seines Werkes und verfolgen die Forschung über Oolithe bis zum frühen 20. Jahrhundert. Wir schließen, dass Brückmanns Abhandlung am besten als Überblick anzusehen ist, der eine Grundlage für spätere Forschungen bildete. Sein wichtigster Beitrag war, Oolithe eher als Anhäufungen von biologischen Überresten als „Spiele der Natur" (lusus naturae) anzusehen. Einige von Brückmanns Zeitgenossen, wie Da Costa und De Saussure zweifelten, dass Fischeier versteinern können und – obgleich sie die biologische Herkunft einräumten – zogen es vor, sie als mineralische Konkretionen zu betrachten. Große Neuerungen in der Stratigraphie, Paläontologie, Mikrobiologie, Mikroskopie, vergleichenden Sedimentologie und Petrologie mußten stattfinden, bevor im 19. Jahrhundert signifikante Fortschritte von Brückmanns Interpretationen gemacht werden konnten.

Abstract

Franz Brückmann wrote his treatise on oolites in 1721. We present here an English translation of his Latin text which describes the following topics; derivation of the name "oolith" and its synonyms; interpretation as accumulations of fish-eggs; classification as stones; occurrence and diversity; environments of deposition and processes of lithification; explanations for the large quantities of eggs found; evidence for their biological origin; evidence for their biological associations; the distinction between ooliths and pisoliths; and localities of occurrence. We provide a commentary on Brückmann's text, and then review the impact of his work by tracing the subsequent development of research on Oolites up to the early twentieth century. We conclude that Brückmann's treatise is best regarded as a review paper that provided a platform for later research. His most significant contribution was to view oolites as accumulations of petrified biological remains rather than as "sports of nature". Some of Brückmann's near contemporaries such as Da Costa and De Saussure doubted that fish eggs could lithify and, although conceding their sedimentary origin, preferred to regard them as mineral concretions. Major developments in the sciences of stratigraphy, palaeontology, microbiology, microscopy, comparative sedimentology, and petrology would be required before more significant advances could be made on Brückmann's interpretations.

Nachdruck aus: HALLESCHES JAHRBUCH FÜR GEOWISSENSCHAFTEN, Band 34, Halle (Saale), 2012.
Martin-Luther-Universität Halle-Wittenberg. ISSN (print) 1432-3702, ISSN (digital) 2193-1305.

1. Introduction

Oolites are limestones composed of spherical, concentrically laminated carbonate grains (ooids) generally up to about two millimetres in diameter. The lithology is represented in all geological periods. Brückmann (1721) would have been most familiar with the spectacular oolites of the Lower Buntsandstein (Lower Triassic) of northern and central Germany (Kalkowsky 1908, Paul et al. 2010). Here the constituent ooids can have diameters up to one centimetre and the oolite beds, varying in colour between brownish, reddish and white, are up to seven metres thick.

Humans have known and utilized oolites since ancient times. The celebrated Late Palaeolithic (24,000 and 22,000 years BCE) statuette, "the Venus of Willendorf" is carved from oolite (MacCurdy 1908, Szombathy 1909). Archaeologists have recently found a knife of Neolithic age (about 3 000 BCE) and some small Late Bronze Age (about 1100 -700 BCE) axes made from Buntsandstein oolite at Heeseberg (Heske et al. 2010). Many oolitic limestones form excellent building stones. In England Jurassic oolite (originally known as "Free-Stone") have been used to construct much of the City of Bath, several Colleges of both the Universities of Oxford and Cambridge, the British Museum and many of the buildings designed by Sir Christopher Wren for London's reconstruction following the Great Fire, most notably St Paul's Cathedral. In the USA Mississippian Oolite from Indiana also makes an excellent building stone and has been used to construct many of the buildings of Indiana University, the Pentagon, and even parts of the Empire State Building in New York. Oolitic sand makes beautiful natural beaches in places such as the Bahamas. These are very popular for recreational activities because the round white grains are both relatively cool and smooth. At sometime in antiquity unconsolidated ooid sands were transported from North Africa to build a pleasure beach that is still used today at Cedraea, Sedir Adasi, in present-day Turkey, (Özhan 1990, El-Sammak & Tucker 2002). Cleopatra and Antony may have undertaken this remarkable early feat of coastal engineering in 33 BCE when Antony's legions were based near Ephesus and when the couple were celebrating their relationship with a number of extravagant indulgences (Preston 2009, Goldsworthy 2010).

Pliny (77-79 AD) makes the first scientific mention of the rocks we now term "oolites". He calls them "Hammites", notes that they are "similar in appearance to the spawn of fish", and classes them as precious stones. Agricola (1546) includes them in his treatise *De Natura Fossilum*, Book V, under the name "Ammonites" - "formed from sand in such a manner that it has the appearance of fish roe and inside it sometimes has the same form and even the same colour and texture". He later (Book VII) notes; "Some rock is similar in appearance to fish roe such as that found between Eisleben and Seberg". This interpretation is reflected in the name Rogenstein (roestone), which has been used for this lithology in Germany since medieval times. Hooke (1665) published the first a microscopic examination of an oolitic limestone from Kettering, England in his famous work *Micrographia*. He notes that the grains "…appear to the eye, like the Cobb or Ovary of a *Herring*, or some smaller fish". When magnified he saw that they have concentric structures that can be compared with the "shell", "white" and "yolk" of an egg. He noted that the grains lacked fine structures typical of plants or bones and suggested that the rock was formed "from a substance once more fluid, but afterwards by degrees growing harder, almost after the same manner as I supposed the generation of Flints to be made". He considered the globular structure to be the result of the disruption of this immiscible liquid phase by the "workings and tumbling of the sea".

It was Brückmann who wrote the first scientific treatise devoted entirely to oolites in 1721. He followed Volkmann (1720) in using the name "oolithos", a Greek translation of the German "Rogenstein" or "Eierstein". Brückmann describes oolites from several localities and horizons around the Harz Mountains in northern Germany, and also mentions occurrences in southern Germany and Switzerland. Brückmann was not the first scientist to use the term oolith, but he was the first who gave a detailed description of their characteristics including sizes of grains, colours, internal structures and regional occurrences. In this paper we present an English translation of Brückmann's Latin text and then discuss the scientific significance and historical importance of his descriptions and interpretations.

2. Brückmann's Treatise Translated

2.1. Biographical and Bibliographical Notes

Franz Ernst Brückmann (Fig. 1) was born on the 27th September 1697 in Marienthal, a small village near Helmstedt, some 30 km east of the city of Braunschweig (Brunswick). He attended the "Klosterschule" at Ilfeld and went on to study medicine at the University of Jena from 1716-1720. After graduation Brückmann settled as a physician in Weferlingen, east of Helmstedt, where his father had acted as local magistrate. In 1725 he received a doctorate from the University of Helmstedt and left Weferlingen for Braunschweig. In 1728 he moved to Wolfenbüttel, eventually becoming Court Physician to the Duke of Braunschweig. From 1747 he also held

Fig. 1 Portrait of F. E. Brückmann, 1737

the position of Assessor for the Collegium Medicum in Braunschweig. He had a passion for geoscience, especially mineralogy, and his work as a physician allowed him to pursue these interests. An important inheritance from a Hungarian uncle enabled him to travel widely and accumulate both a large library and a fine collection of geological specimens. Brückmann authored numerous publications in the fields of theology, natural sciences and mining. He was honoured by election to both the Imperial Academy of Sciences and the Royal Prussian Academy of Sciences. He died on 21st March 1753 at Wolfenbüttel in Lower Saxony.

The Mineralogical Biographical Archive provides an online annotated bibliography of Brückmann's writings at <http://www.mineralogicalrecord.com/libdetail.asp?id =218> (viewed 13/11/10).

“Specimen Physicum exhibens Historicam naturalem Oolithi“ is Brückmann's first publication. It was published in Latin in Helmstedt in 1721, the year that Brückmann graduated from Jena. From the signature on Page 4 of the first edition we learn that the writing of the treatise was completed at Weferlingen on 4th February 1721, just 3 months past Brückmann's 23rd birthday. Though a remarkable work for somebody so young, it does reflect a certain academic immaturity.

The 1721 edition has two dedications that give some insight into Brückmannn's situation at the time. The first, on page 2, honours **Rudolph Christian Wagner** (cited as patron and a supporter) who was vice-rector of the university at Helmstedt. Wagner had earlier been private secretary to Leibniz, and remained his close friend throughout his life. In 1701 Wagner was made professor of mathematics and later professor of physics and doctor of medicine. Brückmann presumably went on to complete his Doctoral studies under Wagner. The second dedication extends over pages 3 and 4, and honours **Hermann Frideric Teichmeyer** (1685-1746) (cited as a supporter and a patron) professor of experimental philosophy at Jena from 1717 where he lectured in anatomy, surgery, medical-jurisprudence and botany and clearly had made a great impression on the youthful Brückmann.

“Specimen Physicum exhibens Historicam naturalem Oolithi“ was reprinted in 1728 on pages 127-140 of Brückmann's “Thesaurus Subterraneus, ducatis

Brunsvigii" which was published in Braunschweig. This edition lacks the original dedications and the volume is dedicated instead to **August Wilhelm**, Duke of Braunschweig and Lüneburg. Changes from the 1721 edition include a prefatory note and footnotes in German that update information, and the repositioning of the original figures to lie between pages 126 and 127 is explained. The text is otherwise identical to that of the 1721 edition, though works cited are now included in the list of references at end of the volume.

Notes on the Translation

Our translation of the text is based on a microfilm copy of the 1721 edition in the Library of Göttingen University. The translations of the footnotes are from a copy of the 1728 edition in the Ernst Mayr Library of the Harvard University (available on-line at <http://www.archive.org/details/thesaurussubterr00brkm> (viewed 21/May/2012).

Another copy of the 1728 edition has been digitized by the Max Plank Institute for the History of Science, Berlin, and is available on-line at:-

<http://echo.mpiwg-berlin.mpg.de/ECHOdocuViewfull?url=/mpiwg/online/permanent/library/TMRDQQA0/pageimg&pn=8&viewMode=images&ws=2&mode=imagepath> (viewed 23/5/12).

We have not translated the introductory dedications. We give in parentheses original words or terms for which a translation is either ambiguous or not quite clear to us. We have translated the Latin "Conch" as "Shell-fish". We do not use the term "oolite" retaining instead Brückmann's terms "oolithos" etc. Similarly we do not translate his Latin terms for the constituent grains "ova, ovum, ovule etc". We have adopted the modern spelling of place names; the old place names used by Brückmann are included in Appendix (i). Words or phrases marked with an asterisk are explained in the Appendix (ii). Biographical notes on the authors mentioned by Brückmann are given in Appendix (iii). His references to the literature are included in our reference list and identified thus †. The translations of the footnotes from the 1728 edition are shown in italics. Though carefully prepared, this translation should not be regarded as definitive. We have closely followed the structure of the original with the consequence that our grammar is awkward and the style decidedly stilted. Interested scholars are encouraged to consult the original Latin text.

2.2. The English Translation

Francis Ernest Brückmann

TREATISE (SPECIMEN PHYSICUM*)
establishing
The Natural History of Ooliths
Or
The eggs of fish and shell-fish turned into stone

Helmstedt

Printed by Salomon Schnorr
1721

Preface to 1728 edition:

*We have already described this stone in 1721 in another work (specimen *) which has been out of print for a long time. We will add here, as foot-notes, only things which we have learned since then.*

TREATISE establishing THE NATURAL HISTORY OF OOLITHS.

§. I. When I started to deal with *Ammonites*, a round grain of stone, appearing to the eye greater or lesser, and to present more detailed description and delineation of them, a few noteworthy things arose concerning their naming. The stone took its name from *ammos*, sand, because the grain and *lapilli* of which it consists show a likeness to sand. It is also called Ammite, Hammonite, and more properly Oolith, from the Greek for egg and stone, or stone egg / egg-stone or stony egg, because the round grains of which it is composed are like the eggs of fish or shell-fish. The Germans in various Teutonic dialects call it Rogenstein, Regenstein, Fisch-Regenstein, Rögestein, scattered (verschwemte) and petrified (versteinte) Eyerstöcke, or Rogen.

§. II. Oolith is a class of stone composed of infinite petrified animal bodies; or, Oolith appears to be nothing other than the eggs of fish and other marine animals, e.g. shell-fish, turned into stone, exhibiting mineralised shell, albumen, and yolk to the aided (*armatus*) eye. A crude witness to a massive flood.

§. III. We place it in the category of stone, a hard and rigid substance, not pliable and not dissolving in water or oil, as our experiments confirm. However, our stone is not of one kind but differs among itself by turns, partly the size of eggs, partly by colour, partly by solidity **(A)**. Martin Ruland in his *Dictionary of Alchemy* p. 40 s.v. Ammonite, distinguishes between this same great Ammonite, big *Regenstein* and smaller, little *Regenstein* (called fish eggs in the dialect of many people); but the size of the eggs varies in many ways, as is seen from Figures I, II, III. These three species have round eggs not only in the cortex but in the innards themselves through the whole substance of the stone. But I found another species, exceeding the others in solidity, in the district of the Duchy of Halberstadt called Hamersleben, which when broken up reveals to the eye not round eggs, but pure triangles of which the basis is the circumference of the eggs but the cusps tend all to the centre; for an illustration, see Figure X. Frederic Lachmund in his treatise called *Oryktographia* Hildesheimensis*, p. 37, says Hammites, Rögenstein are so composed from sand that, so far as their shape goes they are like fish eggs, sometimes like sodium carbonate (*nitrum*) as to composition and colour. This class of stone is found in Saxony towards Alfeld and Hildesheim, as large as a walnut (*nucis juglandis*), sometimes bigger. Agricola Bk. V of Fossils [*De Natura Fossilium*] [states]: „I found a fairly large [one] in gravel, sub-purple in colour, which resembles (refert) a salmon egg." Johann Jacob Scheuchzer describes an iron Hammonite at Kaiseraugst in his Weekly *Erzehungen der Natur Geschichten des Schweitzerlandes*, no. 27, p. 106. As for the difference in colour and solidity, that which is found plentifully here in Weferlingen is for the most part brown, tending to reddish, not uncommonly also white: Oolith which is composed of tiny round eggs, is brown, and with white *ovule*s, but in the centre, as to the yolk, it shows red, a great delight to the eye. This stone takes a polish, which, when a while ago I traveled to the Harz Mountains to see the sights of nature and works of art of the Harz Mountains, I gave to a man of Nordhausen who polished alabaster, to polish it. This polished stone (so fine is the polish) elegantly shines and the *ovule*s stand out more, and indeed the *ovule*s in the middle that are horizontally dissected by the polishing, shine only on the outer of the cortex and albumen; but those that are truly cut across where no more yolk is left, shine completely and the diversity of the substance, the shell, albumen, yolk can be seen by the naked eye.

Georg Anthon Volkmann who recently published *Silesiam Subterraneam*, in quarto, describes Oolithos Massiliensis, whose eggs he says are entirely white of various size. Some are of the size of the seed of Millet, poppy or Sinapus; the earth, with the matrices in which the eggs lie, is also white, etc. **(B)**

(A) *If the ovula are large, the stone gets other names; the largest are called Pisolithi and Orbias; but which are not described here; the other species Meconites has ovula of the sizes of poppy seed and the third Cenchrites has the size of millet and it may be possible to make more species; at the Nußberg near Brunsvig, the Meconites and Cenchrites have four kinds of colours.*

(B) *In the Nußberg, these stony ovaria have various colours; some are yelllow, others white, others brown and they lie in a red or brown matrix, others are grey.*

§. IV. We have seen the differences of this stone and the diversity of its species. We now turn to something else, namely to the origin of these little bodies. As for the globosity and roundness, no one will deny that this is not difficult see with the unaided eye. Whether these round corpusculae are of animal origin there is much dispute among the experts: while some grant to us that the origin is animal and others, as we said a little before, see them as petrified and mineralised marine animal eggs; others resort to a sport of nature, and others ascribe them to some Ancient Creator making shapes of the earth's stones; and others find other causes. We leave to each his free opinion; in the meanwhile we will draw upon and examine the arguments that are directed towards the destruction of the opinion that we draw from the most learned in natural science, Büttner, Baier, Scheuchzer, the shining lights of their fatherland, to none unknown among the learned by their midnight-oil works, and by others not of inferior rank. But first it is our pleasure to reveal our opinion concerning the path and force by which the eggs came into our region, also the means of petrification.

The path and force by which so great heaps of eggs **(C)** came to our regions, remote from the ocean and mountainous to boot, was alone some universal flood commonly called a cataclysm, which also the aforementioned lights of science, before us, Scheuchzer, Büttner, Baier, and Ray, and much evidence fully establishes. The stony hardness that these eggs exhibit, is to be ascribed to some petrifying liquid (*succus*), we believe.

For when, from the intolerable iniquity and evil of man, the divine torches welled up and the divine numen opened the deepest springs of the earth and the cataracts of heaven, divine catastrophe followed: beneath which the whole globe was as it were divided: above, terrestrial with muddy watery things; watery with terrestrial, animal and vegetable with sand, a sludge of earth of various kinds, and as I may say, buried together which as time passed coalesced into one lump, which mass by petrifying liquid or mineral (which by others is called Archaeus of the earth) saturated in many places, made heavy and consolidated (*impleta*), turned into stone or mineral, this stony metamorphosis not only of fish and shell-fish eggs but endless other animals and vegetables whose various parts, of which an account, if to make one of it, would require a special treatise.

(C) *In the Nußberg, so much Rogenstein is extracted that houses can be built and streets paved daily. Also the St. Andreas Church, a large building in Braunschweig, is made of this stone.*

§. V. The group of those who refer our Hammonite to the mineral kingdom convince themselves that the main argument against the eggs is their quantity, for they try to prove from their huge and almost uncountable number the weakness and fragility of our opinion that these *ovaria* are of animal origin; for they say that no one can easily be persuaded in himself to be presented with an infinite number of petrified eggs all of animal origin, and from this are they not better supposed mineral? To which in the following manner we reply. We will not be able to fix on the truth of this by any reasoning that there are, to be sure, numberless such eggs turned into stone, they can still nonetheless have been eggs of animals and the unspeakable number of animality, as I may say, nothing could reduce. Leeuwenhoeck, the famous anatomist, examined the shell-fish ovary and left in his writings that it consisted of 1,728,000 *ovule*s, which the celebrated anatomist Dn.D. Langius, the book *De Orig, lapid*, p. 48 cites and entirely agrees. If therefore one shell-fish has so many *ovule*s how much could not a infinity of shell-fish produce and thousands of fishes with which the seas and rivers abound, genera and species, for the marine kingdom is said to rejoice in more kinds of fish and shell-fish than the vegetable kingdom has of plants, besides, this Oolith is not found everywhere and in all regions but only here and there; e.g. in certain totally rocky places neighbouring the Harz Mountains exhibit nothing else than this kind of rock; again, in Halberstadt and especially around the settlement of Weferlingen where the land is not so much covered with them but still stony, from where the stone for building is quarried **(D)**. For which no other reason can be assigned than that a global wind (*Aeolus macrocosmicus*), ruling during the flood and stirring the waters, drove the eggs flowing in the waters of the flood to certain places; for the whole realm, and whole regions lack them and as must further be said, the multitude still sets before our eyes the fecundity of the formerly blessed world and its divine diversity before the flood.

(D) *From the Nußberg, there are many 100 cartloads picked up.*

§. VI. They bring another argument who think *Oolite* is to be taken rather for a sport of nature than for true mineralised animals. It is of this sort of quality and tendency: they say they are given *ovula* of such smallness that they scarcely exceed the size of the smallest poppy seed in mass **(E)**, and they are the smaller because they were of necessity suffocated in the immense floods of the universal cataclysm and changed into confusion by the inevitable necessity of Chaos: they firmly persuade themselves that it is therefore much safer to attribute the *ovula* to a sport of nature. But the consequence of this argument is not by that token secure, but is false and labours under this mistake: they could certainly be suffocated, could be changed in the confusion of Chaos. We along with those that have a simpler alternative (Büttner, Scheuchzer and Baier), consider that the ovaria, in face of this miserable turmoil, piled up in certain places by the strength of the wind and changed again, stayed submerged in mud and filth, which being soft preserved it undamaged and less torn about. And while the water of the flood dried up, mineral vapours and stone-making liquids (*succi*), to which various names are given, permeated not only through the very layers of the earth but through all that in them came in the way; numberless they communicated their power successively both to the animal and the vegetable kingdom, congealed them and turned to stone, which made stone in this our age; they belong to the community of the mineral kingdom. However we admit these ovules could be pressed together in the universal flood in the manner described, but we are compelled to admit that in modern times they appear mineralised, not compressed and torn about. Moreover the *ovula* of this stone to the aided eye show a cortex or shell, albumen and yolk, **(F)** complete lamellas and coverings, one upon the other, which stated parts of the egg can be better seen in a polished stone, which also let it be admitted by those who refer to our stone as a sport of nature.

(E) *The smallest species of the Nußberg is dark red and so small that it is hardly seen by eyes. It is present in a stratum of the so-called Grossebruch (Large Quarry).*

(F) *Ferrandus Imperato, Histor. Natural. Lib. XXIV, Cap. XXVII, pag. 761: If the Rogenstein is laid into fire, it will be very finely calcined and gets white like snow, but as the gluten is also burnt, it will be breakable and disintegrates into powder.*

§. VII. One particular Hammite demolishes the opinion of those who deny our Oolith to be the remains of this deplorable state. Baier, Büttner make mention of this and Volckmann in his *Silesia subterranea*. They gather together in their *Lithophilacium**, among the rarer, rocks that exhibit not only eggs but the foetus of Mytuli, striated shell-fish, turbinulate, Entrochoi, Asterias, corals and other marine (organisms) within the said Ooliths, whose images may be found conveniently in the cited works. **(G)** Büttner in *Rud. dil. test.* p.233 examines a certain fissile stone from Eisleben, which shows with one face fish, on the other grain here and there. Whether this is to be taken as a fish *ovule*, when fish are observed in its vicinity the well-known author leaves others to say. Langius, already cited above, exhibiting together stones ovules and shell-fish gave them a particular name and called them matrices of shell-fish, as can be seen in his *Hist. lapid.* fig. Silesia, rich in this species of stone, has other examples.

(G) *There are no shell-fish (mussels) in the Rogenstein of the Nußberg; but we found at that hill a snailstone a lapidem pentagonum, which can be seen at Tab. II, Fig. II a flattened Echinum. which will be mentioned at the second Thesaurus.*

§. VIII. Many confuse this stone with Pisolith, which however differs not only as to the cortex but also as concerns the farinaceous white medulla, certain of which kind can be seen in certain Lithophilacia*. Besides the stone in which the pisoliths lie is not so hard as Hammite. They can also more easily be dislodged and extricated from the stone matrix and large Ooliths that sometimes adhere so firmly to their matrix that they admit of a shiny and elegant polish like marble. The other specific differences I do not touch upon, when what can be said about pisolith and phacolith worthy of note I propose for a future publication.

§. IX. As for its native place or country (for I call it patria where it is at present found) around Weferlingen in the Duchy of Halberstadt, it is found in thousands of hundredweight. **(H)** From which circumstance I came to publish this. If other geological reports are desired we will find them in various places. Thus David Sigismund Büttner, *Rud. div. test.* Plate XXVII no. 17 shows us Ooliths all from eggs of various size sent to the author from Vienna.**(I)** He also makes mention of *Ichthyolith mansfeldensis* which on the other side exhibits various round grains. And it is found also in the county of Mansfeld in sandy excavation not far from the town of Schraplau according to Büttner in his *Corallographia subterr.* The author while he shows various illustrations of stone, e.g. shell-fish, laevia, gyrata, echinata, pryphata, echinata, gryphata, dentata, ferrata, murices, turbines, neritae, entalia, &c and where they are found, he says among them are Hammitites or petrified fish ovaries: cap VIII, p. 51; and Johan Jacob Bayer in his *Oryctographia* Norica* cap. VII *De petrif*. ... univ: he recognises Heimburg and Sulzberg in the territory of Nürnberg as the home of this stone, he says in the place cited „I show in Tab VI Fig 31 a body of sublute eggs in a block of stone; often met in Heimburg and Sultzberg“, but he shows a much better image in Fig 30 mixed up together from ovules and what seem much to exceed them in size, from the smallest shell-fish, nautilus, turbins, etc. Nor is Switzerland devoid, as can be seem in many places in J. J. Scheuchzer, op. var. He shows us an elegant Plate in his *Phys.* Pt. II, p.69. G.F. Mylius, *Memorabil. Saxon. subterran.* Pt. II, p.69 (writes) that the ways around Ascherleben and Alsleben and other villages near the Harz are full (of *oolite*s), whole quarries of this species are found and moreover they are dispersed at various localities in our country of Saxony & c. Boëthius de Boot in his *Hist. lapid.* II cap. 236 and Fred. Lachmund, *Oryktographia* Hildesheimensis* p.37. They are also found in Saxony near Alfeld and Hildesheim, the size of walnuts (*nucis juglandis*), sometimes bigger; nor is this stone unknown in Silesia and can be seen in many places in Georg Anthon. Volckmann *Silesia. subterr.* where various Plates are found. What further evidence is required (Quid ergo pluribus opus)? **(K)**

(H) *In the often mentioned Nußberg yields thousand hundredweights of several species.*

(I) *We searched very eagerly in the area around Vienna anno 1723 and 1724, but we did not find the smallest track or trace of Rogenstein, but there were abundant fossilized shell-fish and snails.*

(K) *Between Hamersleben in the Duchy of Halberstadt and Helmstedt, we find a quarry at an old tower near the road, where much Rogenstein is present; among them were the most beautiful dendrites; from which are not mentioned by any authors.*

§. X. This then is what we wished to publish on petrified eggs of fish and shell-fish, fragments of the true Flood, monuments and witnesses of the divine wrath in the simplicity (*tenuitas*) of a young man (*pro tenuitate juvenalis ingenii in lucem edere voluimus*), seeking from readers that they will examine it with an equable mind and if perhaps they find it unsatisfactory to pardon it. Nor do I think any will be a severe and exact judge of youthful industry but prefer from their thinking to add the opinion (*animos addere*) to that of one attempting such matters. industry but prefer from their thinking to add the opinion (*animos addere*) to that of one attempting such matters.

3. Commentary on the Text

Comments are made on each of Brückmann’s ten chapters. A title is suggested for each chapter.

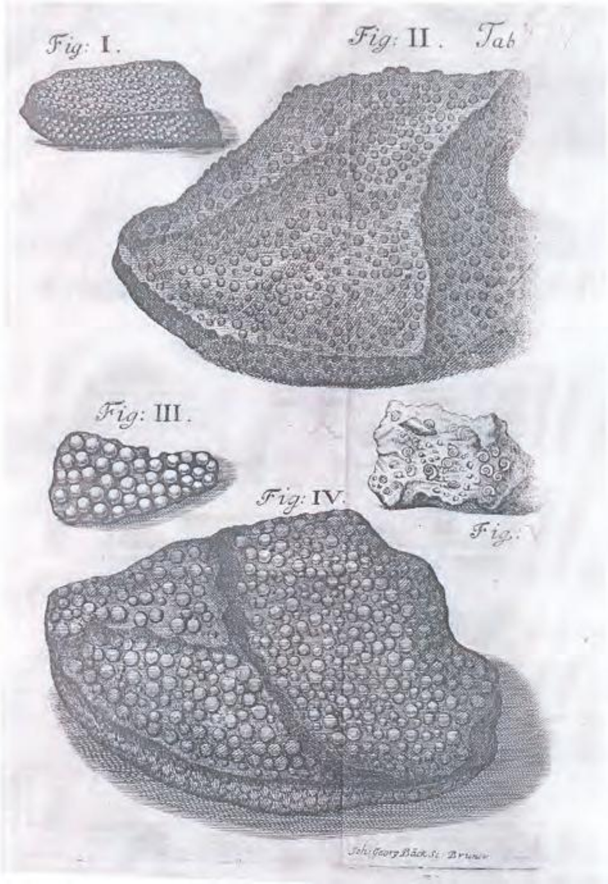

Plate 1 Brückmann's figures I – V

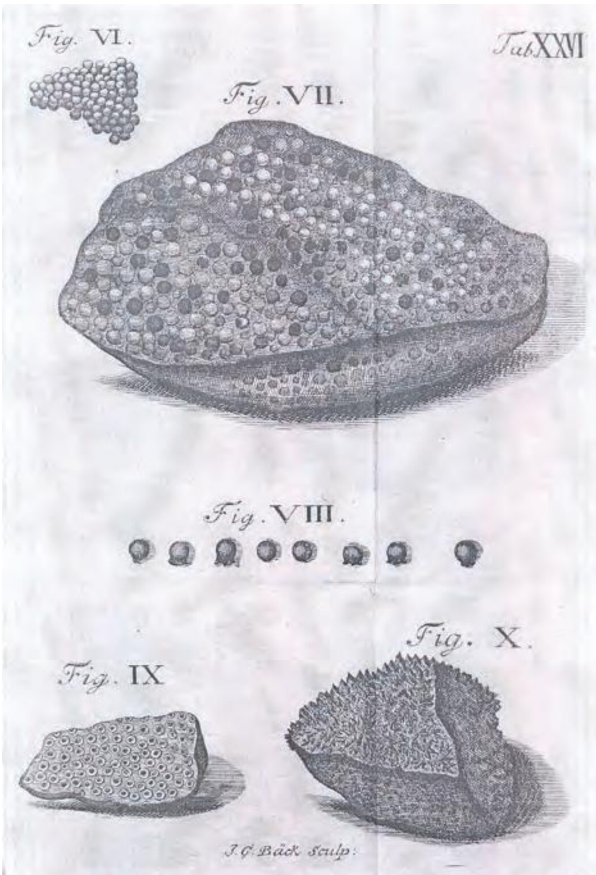

Plate 2 Brückmann's figures VI – X

§ I- Introduction and origin of the name Oolith

Brückmann discusses the various names by which the lithology has been known. The name "Ammite" derives from Pliny (77-79) who notes that "Hammites is similar in appearance to the spawn of fish: there is also a variety of it which has all the appearance of being composed of nitre (sodium carbonate), except that it is remarkably hard". Da Costa (1757) summarises some of the confusion that had arisen in interpreting Pliny's description. The derivation of this name is clearly from the Greek Ammos (= sand). Immediately following the description of Hammites, Pliny goes on to describe "Hammonis Cornu" which was "reckoned amongst the most sacred gems of Aethiopia: it is of a golden colour, like a ram's horn in shape, and ensures prophetic dreams, it is said". The name Hammonis Cornu (= "the Horn of Ammon") makes reference to the legend of Bacchus (or some say Hercules) and his soldiers being lost in the desert and being saved by the appearance of a ram that led them to an oasis. The grateful Bacchus established a temple there to Jupiter, who he renamed "Ammon", because of the sandy surroundings (for details of this story see Lempriere 1822). In reality the name Ammon is the Greek adaptation of Amon, the god of Ancient Thebes (Breasted 1944), and its predecessor the Kushite god Amun to whom a temple had been built at the Oasis of Ammonium (modern Siwa). Amun of Napata was frequently depicted as a ram-headed human figure with forward curving horns typical of the species *Ovis platyura aegyptiaca* (Welsby 1998, p. 75). The stones that Pliny refers to as "Ammonis Cornu" are pyritised fossil Ammonites that bear some similarity to the shape of a ram's horn. Agricola (1546: 98) also refers to "ammonis cornu" in the vicinity of Hildesheim (from the fortress of Marienburg to the lower city and on to the village of Hasede). Unfortunately Agricola does not refer to "Hammites", but instead uses the term "Ammonites" to refer to a rock "formed from sand in such a manner that it has the same appearance of fish roe and inside it sometimes has the same form and even the same colour and texture". Today these "Ammonis Cornu" are known as Ammonites, and the term "Cornu Ammonis" is used in anatomy to describe regions of the hippocampus in the brain (De Garengeot 1742). To add to the confusion the Ammonites include the genus *Hamites* in which the final coils don't touch each other. These give their name to the "Hamitenschichten" in southern Germany that represent a calm, clayey facies of the Middle Jurassic.

Brückmann proposes the name oolith (Greek "egg stone"). Brückmann was not the first to use this term. Volkmann (1720), for example, wrote "We like to recall also the Oolithi, also known by the people as Hamitae, Ammitae, in German Rogenstein. They are of animal origin, nothing different than roe from water animals which are petrified". While Brückmann uses the Greek form (Oolithi) to describe the rock, he uses the latin (Ovum) to describe the rounded grains of the rock, which he took to be the lithified eggs. It was not until Kalkowsky (1908) that these constituent grains were also given a Greek-based name –"Ooids".

§ II- Interpretation as accumulations of fossil eggs

Brückmann supported the then accepted interpretation that oolites are composed of petrified eggs of fish and shell-fish. He uses either a lens or microscope to examine the internal structure of the grains, and considers that he can see shell, albumen and yolk. He makes no

EXPLANATION OF THE FIGURES (Plate 1 and Plate 2)

Fig I. Tiny ovules that are hardly the size of poppy seed

Fig. II & III. Larger of same

Fig. IV. Ovules of various size in one stone

Fig. V. Reproduced from Baier's *Oryktographia* Norica*. Shows eggs with barely-hatched (exclusos) shell-fish foetuses

Fig. VI. Reproduced from Scheuchzer's *Physica*

Fig. VII. Matrices or empty spaces from ovules and some *ovule*s jumbled in one stone

Fig. VIII. Ovules separated from the matrix

Fig. IX. Ovules horizontally dissected and examined under power where the cortices are in sunlight, albumen and vitellum

Fig. X. The interior composition (substantia) of Oolith from Hamersleben mention of the similar observations of Hooke (1665). Brückmann follows Volkmann (1720) in considering these grains to be the actual remains of eggs, and in concluding that these rocks are indeed evidence of the effects of the Great Flood.

§ III- Classification, occurrence and diversity

The systems of classification available to Brückmann were based on a descriptive rather than a genetic understanding of geological specimens. Pliny (77 - 79 AD) was the first to classify oolites when he placed "Hammites" among the precious stones. Agricola (1546) proposed a similar classification in his *De Re Fossilium*, Book V where "Ammonites" are classed as a species of the second genera of stones – gems. Brückmann, who was aware of both these works and also of the classification system proposed by Boëtius de Boodt (1609), classes the oolithi as stones. He describes several varieties, depending on the size and composition of the grains. These include Scheuchzer's (1705-1707) description of iron oolithi from Kaiseraugst, and the Oolithos Massiliensis described by Volkmann (1720). Oolithos Massiliensis is known today as *Dirina massiliensis*, lichens of both a circular shape and white colour that are reminiscent of ooids. Pitton de Tournefort (1694) had earlier described this species in his book "Elements de botanique" as an autonomous class of plants. Brückmann mentions not only oolites from Lower Buntsandstein localities, but also oolites of other stratigraphic positions (Tab. 1). There are Upper Jurassic oolites in the areas of Alfeld, Hildesheim and Weferlingen in northern and central Germany. The iron oolites from Kaiseraugst in Switzerland and from localities near Nürnberg in southern Germany were probably only known to him from the literature. Brückmann mentions ooids the size of walnuts. This may be based on a misreading of Agricola (1546). On page 99 in the paragraph following his description of *Ammonites* (i.e. Oolithos in the sense of Brückmann) he mentions:-"A certain genus of stone is found in Saxony near Alfeld and Hildesheim the size of a walnut or even larger. They belong to the same genus that I shall describe in Book Seven". We consider that these "Walnuts" are clearly different from ooliths in size and structure. It is possible that they are concretions or intraclasts composed of cemented clusters of ooids.

§ IV- Environment of deposition and process of lithification

In 1721 the influence of the Church was still strong enough for scientists of the time to strive to correlate scientific interpretation with Biblical teachings. This atmosphere certainly limited the free development of scientific theories, as is clearly demonstrated in the writings of John Ray (1721). Edwards (1967) has described the late 17th century and early 18th century as the "heyday of the Diluvianists" who believed in a universal flood and cited as evidence for it the remains of marine organisms preserved in rocks far from any sea. This theory at least allowed that fossils were the remains of life forms that had been transported by the flood. While Brückmann mentions those who see oolites as "sports of Nature" or as shapes fashioned by an "Ancient Creator", he cites Scheuchzer, Büttner, Baier and Ray to support his interpretation that the oolithi were composed of the eggs of marine animals transported by the Great Flood and rapidly accumulated in one large deposit. Brückmann, in an attempt at objectivity, starts this chapter with a descriptive rather than a genetic name for grains that make up the oolites. Everywhere else he refers to them as "ova", but in here they are described as "little bodies" or "corpusculae". Brückmann considered that these were indeed eggs transported by the waters of the Great Flood in a soft, unlithified state and accumulated in vast numbers. These deposits were then indurated after deposition by a percolating petrifying liquid comparable to the "succus lapidenscens" of Agricola (1544). Brückmann does not consider the possibility that there may have been several periods of inundation depositing beds of Oolithi at different times. He makes no mention of the the suggestion of Hooke (1705) that repeated alterations in the distribution of land and sea had occurred and that they were caused by earthquakes which gave rise to the successive elevation of strata containing marine fossils – a concept that presaged the theory of stratigraphy and the use of fossils as chronological indices (Smith 1815). Brückmann could not have been aware of Leonardo Da Vinci's earlier unpublished arguments against a single global inundation for the origin of fossils in uplifted strata far from the sea (reproduced in Edwards 1967, p. 16-18), though, through his patron Wagner, he may have been aware of the then unpublished views of Leibniz (1749).

A footnote to this chapter mentions that oolithi were used for paving streets, building houses, and even St Andrew's Church in Braunschweig (Fig. 2). We suppose that Brückmann mainly studied oolites in quarries from which building material was being extracted. In most of these localities Lower Buntsandstein rogenstein is generally not of sufficient quality to be used as a facing or Free-stone. In medieval and early modern times, transport of heavy stones was very expensive. Therefore, people generally used stone from quarries in the immediate vicinity to build their churches and houses. Most private houses in Germany were half-timbered and consisted of wood and loam. Only sacred buildings, town halls, guild halls and the houses of wealthier people were built of

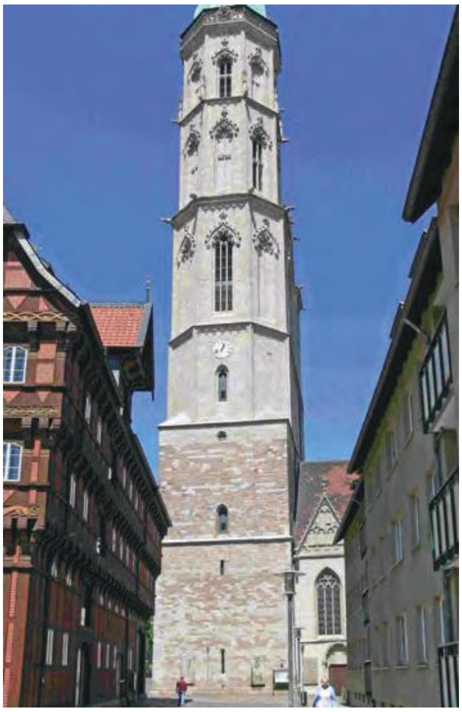

Fig. 2 The spire of the Andreas Church in Braunschweig. The lower part is built mostly of red and white rogenstein whereas the upper part consists of white Muschelkalk freestones.

stone (Fig. 3, 4). The distance between the quarry and the building site was in most cases 10 km or less. The rocks from the quarries Brückmann mentioned and described, were generally not used for building churches or houses, but rather for constructing walls and or as cobblestones to pave roads. The Rogenstein contrasts with the excellent building stones provided by Jurassic oolites in England and Mississippian Oolites in America. The oolites from Alfeld and Hildesheim are probably from quarries in Upper Jurassic rocks, the Kimmeridge Beds and the Korallenoolith (Corallian Oolite; Vinken 1974). Both units consist at the greater part of oolites. They were already being exploited in Brückmann's time.

§ V- Explanation for the large quantities of eggs involved

Brückmann presents evidence to support the suggestion that eggs could be produced in large numbers, and that the sheer quantity of grains does not preclude a biological origin. He cites the work of Antoni van Leeuwenhoek the pioneering microscopist and microbiologist who first established that huge quantities of ova and spermatozoa are produced by organisms. Brückmann proposed that their vast concentration in certain localities was a result of them having been driven together by wind-generated currents. In this he follows Volkmann (1720) who said (p. 156, §7) "They occur individual or mostly in heaps, as they hang together in statu naturali in slime. Their enormous number indicates the great fertility of the first world. The often observed dissimilarity of the eggs proves that the power of wind and waves has driven together all sorts like roe".

§ VI- Evidence for a biological origin

Brückmann attempts to counter the argument that the oolithi are sports of nature and therefore not of biological origin. He refers to Chaos, the name used at the time for initial, formless state of the universe. He concedes that though the oolithi now belong to the Mineral Kingdom as a result of later lithification, he argues that the original eggs belonged to the animal kingdom. They were initially soft and were concentrated by winds and then buried in soft mud allowing the preservation of their structure and prevented them from being torn up. He repeats the argument that the *ovula* have an internal structure of concentric lamellae that he considers show a cortex or shell, the albumen and a yolk. In these conclusions he again follows Volkmann (1720) who stated „.After grinding down to the centre of the small eggs, it is possible to see the small peels (tunica), the white and the yolk, and also by the naked eye the breed".

§ VII- Evidence for biological association

To give further support to his argument for a biological origin Brückmann here cites a number of

Fig. 3 The old market place of Braunschweig. From left: the clothiers' Guild Hall, the Martini Church and the Old Town Hall. All these medieval buildings are made of red rogenstein from the Nussberg.

examples of oolites that contain ovules associated with the remains of other marine organisms.

§ VIII- Ooliths are distinct from pisoliths

Brückmann emphasizes that oolites are not to be confused with Pisoliths or Phacoliths. He tantalizingly promises to document these differences in a later publication (not so far identified).

§ IX- Oolith localities

Here Brückmann describes several other authors' accounts of oolite localities. It is significant that Büttner was sent samples from Vienna, but there is no indication that the samples actually came from outcrops in the vicinity of Vienna. Büttner's decription of a specimen that on one side shows the cast of a fossil fish (Ichthyolithi mansfeldensis) and on the other side exhibits various round grains is not evidence for a juxtaposition of fossil fish and fossilized fish eggs as Brückmann suggests. The Ichthyolithi of

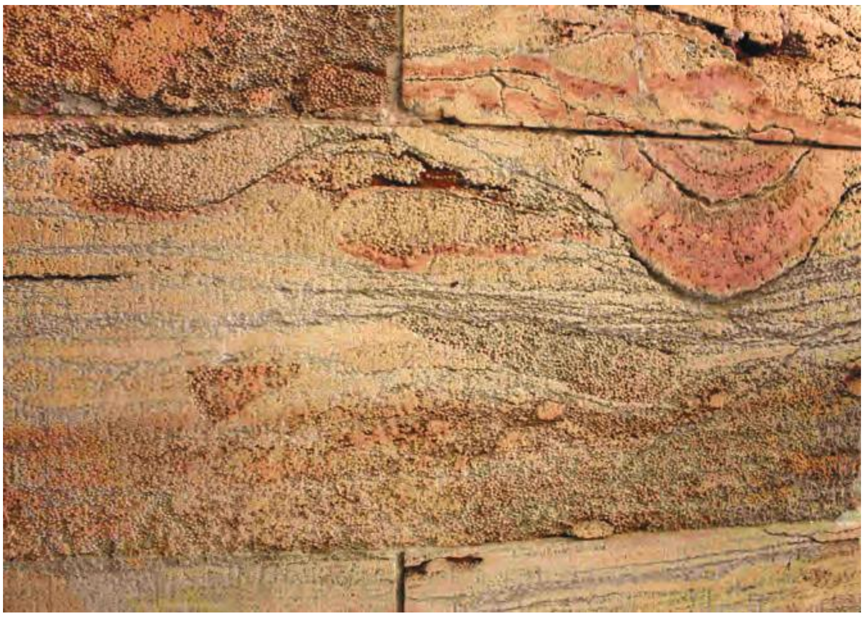

Fig. 4 Freestones of the Old Town Hall: Oolites and a stromatolite dome. The freestone block has been placed upside down. Thickness of the freestone is about 30 cm.

Mansfeld are now identified as *Palaeoniscum freieslebeni* of the Upper Permian Kupferschiefer. The round grains described by Büttner may well be small spherical grains of bitumen that Dr S. Brandt (pers.comm. 2010) reports occurring on some bedding planes at a specific horizon of the Kupferschiefer seam which is restricted to the area of Mansfeld and Eisleben.

§ X- A youthful request

In his concluding chapter the 23 year old Brückmann appeals for the reader to take his youth and inexperience into consideration when judging his conclusions that Oolites are petrified eggs of fish and shell-fish, deposited during the Great Flood.

4. Brückmanns legacy and the subsequent development of the understanding of Oolites

i. Initial impact

Brückmann's treatise was clearly an immediate success. The 1721 edition soon went out-of-print. Brückmann reprinted the work in 1728 as part of a larger volume describing the significance of the contents of 25 specimen cabinets curated for the Duke of Braunschweig (Brückmann 1728). Both these publications seem to have circulated widely. Wallerio (1778) cites Brückmann as an authority on Oolites in his System Mineralogicum published in Vienna. In England Brückmann's 1721 and 1728 editions are the earliest of nine works on Ooliths listed under "Oolithus" in the 1799 catalogue of the Library of the Sir Joseph Banks (Dryander 1799). The 1728 work also appears in the 1813 catalogue of the library of the British Museum. Evidence of the work's impact is demonstrated by the fact that very soon after their publication Brückmann's conclusions began to come into question. For instance Da Costa, who used the term "Hammites" was unimpressed by the fish-egg explanation proposed by Scheuchzer, Baier, Büttner, Volkmann and Brückmann. In his "Natural History of Fossils" of 1757, a work much admired by Linneaus (Rouseau & Haycock 2000). Da Costa concluded that such large concentrations of grains in many different places in the world could not represent fish-eggs, and that fish-eggs were in any case "incapable of petrifaction". He further considered that a single deluge could not explain "the vast quantities and even strata of Hammita being found in different parts of the world". Da Costa (1757) concluded "The granules or grit of this stone, are all true small Stalagmitae or bodies of a crustated structure, being composed of coats or crusts, including one another".

De Saussure (1779) described Oolites from the Jura Mountains and noted that "Plusieurs naturalistes ont regardé les petits grains comme des ovaires de poissons, et ont appelé ces pierres des oolithes, en allemand Rogenstein". While the German term (rogenstein) is acknowledged here, Brückmann's work is not cited. Instead De Saussure names as his source Valmont de Bomare (1764) who, in turn, refers to the "Memoire sur les Oolithes", by Prof. Schmidt of Basle. Schmidt (1762) regarded ooliths as "sports of nature". De Saussure rejected the fish-egg theory because he considered that fish-eggs would putrify rather than become mineralized, though he mentions that crab-eggs conceivably could become lithified. However he concluded that ooliths were "des dépôts ou des crystallisation" formed in agitated waters and rounded by the movement of water during formation, a conclusion reminiscent of that of Hooke (1665).

ii. Oolites and stratigraphy

In Britain the word "Oolite" is used instead of "Oolith". Hutton (1788, p. 252) was perhaps the first to publish this term, which he uses in passing when describing a clast in a limestone conglomerate as "species of oolites marble". Brochant de Villiers is credited by some with first using the term "oolite". In his "Traité de Minéralogie" (1801, p 529) he describes "Rogenstein – L'Oolite". He notes its occurrence in "Sweden, Switzerland and above all in Thuringia (Eisleben, Artern, Klosteroda)" and mentions that "Oolites had been long regarded as an accumulation of petrified fish eggs, but that this idea is unfounded". He does not include Brückmann in his citations. However this work was preceded by Hutton and also possibly by William Smith who Winchester (2001) implies used the term in when naming stratigraphic horizons he superimposed on Taylor and Nayler's circular map of the area around Bath (Fig.17 & page 123 in Winchester 2001). Certainly Warner (1811) uses the term on his "Fossilogical Map" of the same area. In fact William Smith (1815) used the term "Oolite" in a new way to identify stratigraphical units in what is now known as the Jurassic. Since Smith never elaborated on his use of the term, for an explanation of this we have to depend on the account of his good friend, Joseph Townsend (1813) who wrote: "…Oolite, called free-stone......distinguished by Linnaeus under the appellation of *Marmor Hammites*, that is sand marble and is by him particularly noticed in Gothland, Saxony, Thuringia, and the Duchy of Brunswick. It is the Rogenstein and hersenstein of the Germans, so called from the resemblance of its component parts to fish spawn and millet seed.........The name of *Oolite*, i.e. egg stone or spawn stone, from Oos and Lithos, answers well to the appearance of this rock. ...The appellation of *free-stone* is too general". In Smith's usage the stratigraphic units identified as "Oolites" were not entirely composed of Oolitic lithologies. This stratigraphic use of the term soon became generally accepted, for example by 1828 the French are clearly following William Smith's stratigraphical usage (Rozet 1828).

iii. Growth of oolitic grains by carbonate accretion

De La Beche applied and developed Smith's stratigraphic scheme in his role as the first Director of the Geological Survey of Great Britain. He had inherited a property, Halse Hall, in Jamaica (Chubb 1958) and during a visit to the Island in 1823-1824 became perhaps the first scientist to observe the formation of oolitic grains in modern tropical seas. He later noted that in places such as Jamaica waters highly charged in carbonate of lime under gentle to and fro motion in shallow water causes concentric coatings of carbonate of lime to form around small nuclei to form what he termed "oolites" or "oolitic grains"(De La Beche 1851, p. 43, 148). Dana (1872) made similar observations on the formation of "oolite" on beaches associated with coral reefs. He observed that these grains are "usually much smaller than the roe of most fishes, a resemblance which is alluded to in the name".

Just as William Smith's Geological Map revolutionised the science of stratigraphy (Winchester 2001), the work of Henry Clifton Sorby pioneered both modern techniques of microscopical petrology and the discipline of comparative sedimentology (Judd 1908, Folk 1965). He employed both approaches in the study of oolites. At first he refers to "the ovum-like concretions of oolite" (Sorby 1851a, 1851b). Later (Sorby 1879) published detailed descriptions of Jurassic oolites. He discusses their petrology, fossil assemblages and interprets their depositional environments. He considers that some were deposited in still water, others by current action, and concluded that they must have formed in tropical seas. He finds that the oolitic grains were not in fact eggs, but, like De La Beche before him, suggested that they were the product of minute, prismatic crystals of carbonate "mechanically accumulating around a centre, something like the layers in a large rolled snowball". He describes the diagenetic transformation of oolitic grains from concentric to radial structures as a result of re-crystallisation. Sorby also used the term "oolitic grains" for modern ooids he examined from the Bahamas and Bermuda. Unfortunately Sorby (1879) used 'Sprudelstein" or cave-pearls from a mineral spring at Carlsbad as the type examples for this study, and he drew attention to the fact that Bahamian oolitic grains were less perfectly developed (Sellwood 1993).

iv. Microbial Influences on the formation of Oolitic Grains

Walther (1888, 1891) suggested that oolitic grains were formed by the decay of organic tissue. Rothpletz (1892) found oolitic grains within the sediments of Great Salt Lake contain the remains of blue-green algae (cyanobacteria) and concluded that the grains were the product of "lime-secreting fission-algae".

Ernst Kalkowsky produced his landmark paper on "Oolith und Stromatolith im norddeutschen Buntsandstein" in 1908. He had enrolled in the University of Leipzig in 1870 and worked under Prof. Ferdinand Zirkel who had studied the techniques and methods of microscopical petrology with Henry Clifton Sorby. It is therefore likely that Kalkowsky was familiar with Sorby's mechanical theory of the formation of oolites when he commenced his own work on the Buntsandstein examples. In 1893, when Kalkowsky was Professor of Geology and Mineralogy at the University of Jena (Brückmann's Alma Mater), he was contacted by Ludwig Knoop, a local School Teacher, who drew his attention to structures associated with ooliths in the local outcrops of the Buntsandstein that Kalkowsky later named "stromatolithe". Kalkowsky was well prepared for research on the association of oolites and stromatolites, for not only did he have a strong background in both field mapping and microscopic petrography, it seems probable that he discussed this research with both Haeckel (who proposed the term "ecology") and Walther (the founder of comparative sedimentology) who were among his colleagues at Jena. However he moved to Dresden in 1886, and the pressure of the duties of his new post meant that publication of his Buntsandstein research was delayed until 1908. The term "oolith" was so firmly entrenched in usage that Kalkowsky continued its use, even though he thought it "rather stupid" since the constituent grains were by this time clearly known to not be fossilized eggs. For consistency he proposed that these constituent grains be termed "Ooid" and he proposed the term "Stromatolith" for the layered bodies quite different from ooliths but found associated with them, and "Stromatoid" for the individual layers of the stromatolith. Kalkowsky (1908) mentioned that Ooliths had at that time been studied for two centuries. He cites Brückmann's (1721) microscopic observation of shell, white and yolk structures within the grains. Kalkowsky concluded that ooliths and stromatoliths were genetically associated and

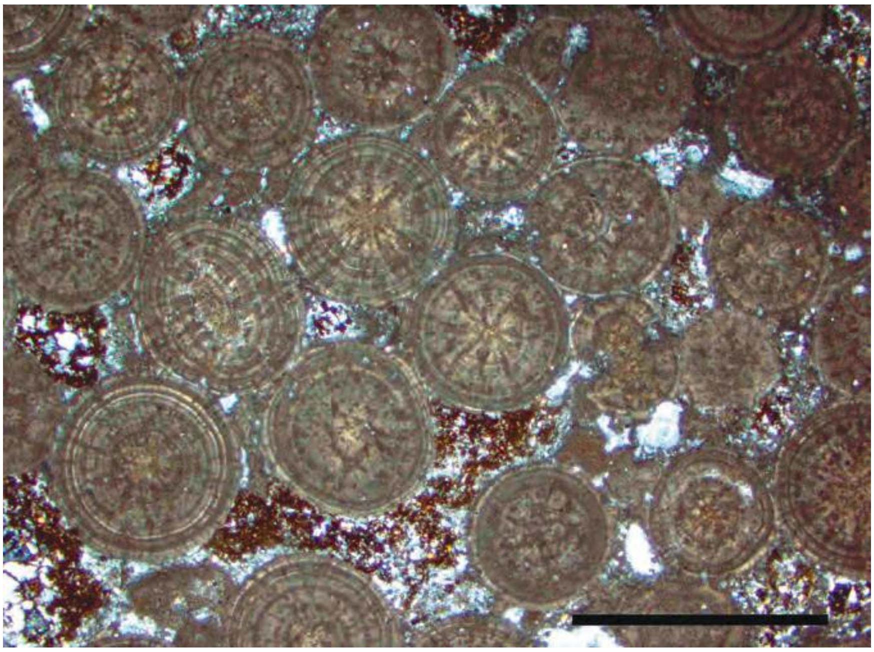

Fig. 5 Buntsandstein oolites in thin section. The oolites are partly recrystallized. Scale: 2 mm. Heeseberg.

that both were produced by minute "phytoorganisms" (Paul et al. 2010).

Later Rothpletz (1915-1916) combined his experiences in Great Salt Lake with these concepts to the study of ancient associations of stromatolites (cryptozoon) and oolites in both Europe and North America, though he does not cite Kalkowsky (1908).

Linck (1903, 1909) was the first scientist to undertake laboratory studies on the formation of oolitic grains. He concluded that aragonite oolitic grains form as a result of calcium sulphate in sea water reacting with sodium carbonate and ammonium carbonate generated by the decay of animal and plant tissue.

Shortly after this, Drew (1911) added calcium sulphate to a culture of marine denitrifying bacteria and found finely laminated carbonate concretions were precipitated. He noted the resemblance between these concretions and oolitic limestones and concluded that the experiment had suggested the manner in which such oolites may have formed. Vaughan (1914) applied these results in scientific research on the extensive deposits of modern ooids on the Bahama Banks.

Bucher (1918) noted that the descriptions of Drew (1913) and Vaughan (1914) suggested that oolites were formed from colloidal calcium carbonate. He drew attention to the work of Schade (1909, 1910) who had studied the origin and structure of urinary calculi such as gallstones. Schade found that the transformation from an emulsion colloid to solid state gave rise to calculi with a radial crystalline structure if the emulsion was of pure composition, but if other colloidal impurities were present then co-precipitation gave rise to calculi with a concentric structure. These findings were applied by Bucher (1918) to explain the genesis of Oolites and Spherulites.

v. Subsequent Research

Almost two centuries after Brückmann's review had appeared, Brown (1914), who favoured an inorganic origin for oolites, published his own review of the development of scientific research on oolites and oolitic texture. He cites Hooke's work on the "Kettering Stone", but makes no mention of Brückmann's treatise. Extensive research has been undertaken on ooids and oolites since 1914 and this has been summarised in several review papers by, among others, Simone (1981), Peryt (1983), and Siewers (2003). Although very significant advances have been made since 1914, these reviews serve to reconfirm the conclusion of Cayeux (1935) that the amount of conclusive information on the formation of ooids is small compared with the large number of published papers.

vi. Modern Terminology

By 1970 confusion over the use of the terms oolith, oolite, and ooid had become endemic in English-language publications. For example the term with "oolith" was often used to refer to the constituent grains rather than the lithology itself (see for example Bathurst 1971). Teichert (1970) proposed that the terminology be rationalized. He advocated dropping the term oolith, while retaining the term oolite for the lithology and ooid for the constituent

Tab. 1: Stratigraphic chart of the Mesozoic in Germany and northern Switzerland. Bold = oolites mentioned by Brückmann. In parentheses: minor important oolites.

			North Germany	South Germany
Cretaceous	Upper			
	Lower		(iron oolite)	
Jurassic	Upper	Tithonian	oolite	(oolite)
		Kimmeridgian	oolite	(oolite)
		Oxfordian	**Corallian Oolite**	
	Middle	Callovian		
		Bathonian		iron oolite
		Bajocian		oolite
		Aalenian		**iron oolite**
	Lower	Toarcian		
		Pliensbachian	(iron oolite)t	*(oolite)*
		Sinemurian	(iron oolite)	iron oolite
		Hettangian		
Triassic	Upper	Rhaetian		
		Norian		
		Carnian		
	Middle	Ladinian		
		Anisian	(L. Muschelkalk)	
	Lower	Olenekian		
		Indusian	Rogenstein	

grains. It is interesting that Teichert, although educated in Germany, seemed completely unaware of Brückmann's treatise or the other 18th century German uses of the term “oolith”, [e.g. Volkmann (1720) and Schröter (1771)] and mistakenly attributes the term to De Saussure.

5. Conclusions

Brückmann's interpretations follow the accepted conservative contemporary scientific opinion that was in keeping with the theological teachings of the time. His work was also limited by the primitive classifications available for describing geological materials that were most often procured to augment collections curated for rich and powerful people. Brückmann himself provided interpretations for the contents of the 25 specimen cabinets assembled for August Wilhelm, the Duke of Brunswick (Brückmann 1728), and reproduced his 1721 treatise as part of the explanation for the contents of the 25th Specimen Cabinet. Many noted scientists of the period gained employment by cataloging and furnishing specimens for the “Steinkabinet” and “Kunst und Naturalienkabinet” of the aristocracy (Friess 1982). Townsend (1813) remarks on visiting “the cabinets of France” as a very important part of his geological travels. In the absence of concepts of uniformitarianism (Hutton 1798), geological succession (Smith 1815), biological evolution (Darwin 1859), or facies relationships (Walther 1893, 1894) these collections could only arranged by classifications that were little more than lists compatible with an Earth History dominated by the generally held religious belief in a single Biblical Flood. This represented a considerable barrier to the understanding of geological processes and delayed the realization that similar marine lithologies could be produced by separate marine inundations recurring at quite different times. Scientists who challenged the accepted view were either reluctant to have their theories published until after their deaths (Hooke 1705, Leibniz 1749), contrived to avoid even their posthumous publication (Da Vinci), or modified their views to accord with theological teachings of the day (Ray 1721, Townsend 1813).

Brückmannn's treatise on ooliths represents a comprehensive review of the state of knowledge on the subject at the time. His key observations and interpretations had virtually all been previously published by others. These earlier works are generally, though not always, appropriately cited. Taking all his descriptions into account, Brückmann was a good observer. His statements are comprehensible and seem to be reliable. Brückmann does seem to be puzzled by the problem of accumulating large deposits of soft fish-eggs without deforming or destroying them. Despite problems with the fish-egg theory, he insists that ooliths are of biological origin. Unfortunately the virtual complete ignorance of microbiology in the eighteenth century would have prevented him from properly assessing the feasibility of plausible alternative biological origins for oolitic grains. Brückmann clearly considered that fossils found in rocks were the remains of marine organisms, and showed some basic understanding of processes of transport, deposition and lithification. After a strong initial impact, Brückmann's work was largely overlooked after 1813. Nevertheless his work represents a significant step in the evolution of the understanding of this enigmatic but important lithology. The wealth of scientific research on oolites and ooids since 1721 clearly shows that Brückmann's closing plea that. "*(his readers) will examine (this work) with an equable mind and if perhaps they find it unsatisfactory to pardon it. Nor do I think any will be a severe and exact judge of youthful industry but prefer from their thinking to add their opinion to that of one attempting such matters*"... has subsequently been enthusiastically endorsed.

Appendix i.

Stratigraphic Positions of Oolite Horizons in Germany and Switzerland

There are several **oolite beds** in various stratigraphic positions around the Harz Mountains:

1. Upper Permian, Zechstein, Staßfurt Carbonate, SW of the Harz Mts., 0 - 50 m, marine - hyperhaline, rare associated fauna.

2. Lower Triassic, **Buntsandstein**, Rogenstein, N and S of the Harz Mts., several beds, 0-7 m, freshwater to brackish, no fauna known.

3. Middle Triassic, Lower and Upper **Muschelkalk**, around the Harz Mts., some metres thick, marine, associated with marine fauna, like bivalves.

4. Middle Jurassic, Bathonian, Bajocian N of the Harz Mts.

4. Upper Jurassic, **Corallian Oolite**, from NW to NE of the Harz Mts., 0-60 m, marine to hyperhaline, rare fauna.

5. Upper Jurassic, Tithonian, NW of the Harz Mts., 14 m thick *Oolite*s correlated with stromatolites, evaporitic environment.

Oolite Localities mentioned by Brückmann

Alfeld: between Göttingen and Hannover in Lower Saxony. The 65 m thick Upper Jurassic Korallenoolith crops out there. Some beds contain concretions and intraclasts which consist of oolites. Their sizes vary between one and ten cm.

Braunschweig (Brunsvig): capital of the Duchy Braunschweig. Many churches, guild halls and the old townhall are built of rogenstein from the Nussberg.

Eisleben (Isleb): Rogenstein crop out near the town and at the slopes of the Süßer See.

Halberstadt: town in Saxony-Anhalt, outcrops of Upper Muschelkalk. About 10 km NW of Halberstadt, the Lower Buntsandstein with rogenstein horizons is outcropping.

Hamersleben: NE of the Harz Mts., between Halberstadt and Helmstedt where Brückmann lived; the next outcrop of Buntsandstein oolites is about 7 km north of Hamersleben.

Heimburg: in Franconia, the site of exploitation of iron oolites since the 18th century.

Hildesheim: NW of the Harz Mts. in Lower Saxony. There were quarries of the Upper Jurassic Corallian Oolite in the Galgenberg (gallow hill) and the

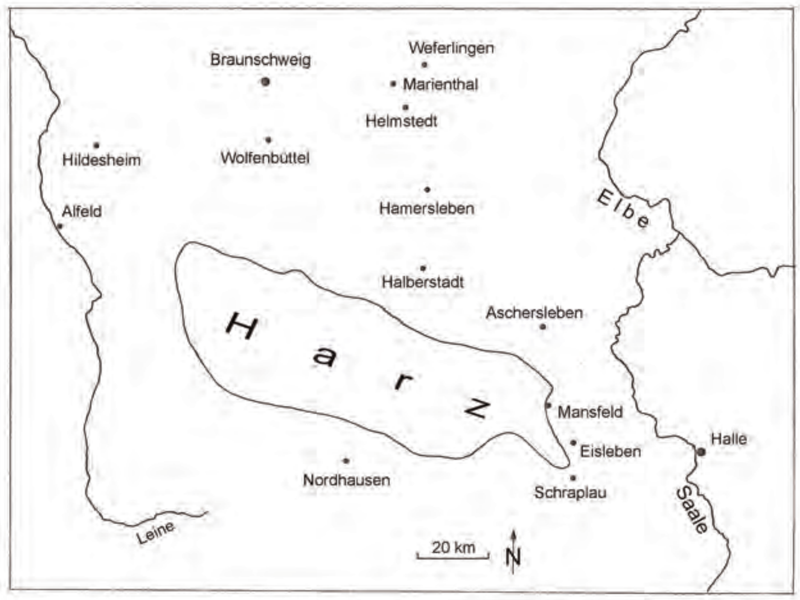

Fig. 6 Map of localities around the Harz Mts. mentioned by Brückmann

Steingrube (stone pit). The Steingrube was first mentioned 1324 as quarry and burning place of witches (Horst 1970). The Korallenoolith is about 50 m thick and consists of the Lower Oolite, an intercalation of limestones, and the Upper Oolite. The ooids are up to 2 mm thick (Schulze 1975). As a result of weathering their colour may change between brownish, yellowish and whitish hues. Weathering may also be responsible for the break-down of oolitic llimestones to a powder-like substance, the "nitrum" or soda of Brückmann.

Kaiseraugst (Augusta Raurica): in Switzerland near Basel at the foot of the Jura Mountains. The Jura Mountains south of Basel contain an 80 m thick oolite horizon, the Hauptrogenstein formation which is of Bathonian age (Gonzales & Wetzel 1996). Additional, there are several horizons of iron oolites. Their age is Bajocian (Middle Jurassic).

Mansfeld: E of the Harz Mts, near Eisleben, situated in the Rogenstein area of the Buntsandstein.

Nordhausen (Northus) south of the Harz Mts: There are outcrops and quarries of Zechstein and Buntsandstein with oolite horizons. Near Nordhausen, the Werra-Anhydrit (first cycle of Upper Permian Zechstein) contains gypsum concretions with large crystals which were used until 100 years ago as alabaster spheres. There was an extensive fabrication of such things starting perhaps already in medievial times.

Nussberg: The Nussberg quarry mentioned by Brückmann (1728) was a large Rogenstein quarry first mentioned 1265 or 1271 (Ohm 2002). It is named after a patrician and entrepreneur Nottsberch who exploited the Nussberg for rogenstein. Many medieval and early modern buildings in Braunschweig were constructed from Nussberg. Now it is part of a park within the town. It is mostly cultivated with many trees. Twenty years ago there was a vertical section of seven or eight metres displaying oolites associated with large stromatolites.

Schraplau (Scraplau): 13 km SE of Eisleben, Situated at the margin of the rogenstein area.

Sülzburg (Sultzburg): town about 40 km SE of Nürnberg, iron oolites of Middle Jurassic are exploited in the 17th and 18th century.

The Hartz Mountains (Sylvae Hercyniae): in medievial times these mountains were covered in forests, known as the Hercynian Forest. However there was a more or less complete deforestation in the 18th century due to mining activities. The area is now known as the Harz or the Harzgebirge.

Weferlingen (Weferling): east of Helmstedt and near the outcrops of Lower Buntsandstein Rogenstein.

Appendix ii. Glossary of Publication Terminology

Lapidary: A catalogue of mineral and rock types, together with their properties and uses.

Lithophylacium: Derived from the term for "Guard House" this word refers either to a museum collection of geological specimens, or to the catalogue of such a collection.

Oryktographia: Literally "a description of diggings" this term refers to what today might be termed a geological handbook or guide to a region.

Specimen Physicum: Literally a presentation of an idea on a subject in the physical sciences,and probably best translated in present usage as a Treatise. The term is also used for other disciplines, e.g. Specimen Botanicum, Specimen Zoologicum, Specimen Astronomicum etc.

Appendix iii. Biographical notes on Authors mentioned or cited by Brückmann

Georg Agricola, **(Bauer)** (1494-1555): Studied languages and medicine at the universities of Leipzig, Bologna and Padua. Settled as doctor and pharmacist in Joachimsthal. Mayor in Chemnitz, Universal scholar. Founder of geoscience, mining and metallurgy. He mentioned in his famous book "*De Natura Fossilium*" *Oolite*s and interpreted them as fish roe.

Johann Jacob Baier (1677-1735): Studied medicine at the universities of Jena and Halle, 1701 physician in Nürnberg, later in Regensburg. At the age of 27 he was professor of medicine and astronomy at the University of Altdorf/Nürnberg, later personal physician of the Kaiser. He published a book about the petrography of the rocks surrounding of Nürnberg "Oryctographia Norica" in 1708. Brückmann mentioned two localities with iron oolites: Heimburg and Sulzberg. At both localities, iron oolites of Dogger age have been excavated in early modern times (Hornung 1958).

Anselm Boëtius de Boodt (Boëthius de Boot) (1550-1632): Physician and mineralogical advisor in Prague to Emperor Rudolf II. Regarded by some as the father of mineralogy. In 1609 he published "Gemmarum et Lapidum Historia", the most important Lapidary* of the seventeenth Century.

David Sigismund Büttner (1660–1719): Theologian, poet and naturalist from Lichtenstein. He was pastor at Stedten and Schraplau, and then Deacon at Querfurt. In 1710 he published his "Signs and Witnesses to the Flood" which included descriptions of fossil bones from the palaeolithic site at Bilzingsleben. In 1714 he published "*Corallographia Subterania*", the first treatise on a particular fossil group.

Ferrante Imperato (1550–c1631): Italian naturalist and pharmacist. Owned a prosperous pharmacy in Naples and founded that city's Botanical Gardens.

Friedrich Lachmund, (1635-1676): Born in Hildesheim, studied of medicine, became physician in Osterwieck and later in Hildesheim. In 1669 he published "Oryctographia hildesheimensis", a book about rocks, minerals and fossils found near Hildesheim.

Karl Nikolaus Langius (Lang, Lange), (1670–1754): Swiss Doctor and scientist born in Lucerne. He studied at Freiburg, Bologna, Augsburg, Rome and Paris. He was the personal physician of Marie-Ann of Austria up to the time of her marriage to King John V of Portugal in 1708. He then returned to Lucerne. He thought fossils were produced by finely divided, powdery germs which had accidentally entered the earth, and grew without attaining life. Drawing partly on the ideas of his friend Joseph Pitton de Tournefort he wrote his "*Methodus nova et facilis testacea Marina pleraque debits& distinct in suas classes, genera & species distribuendi*", published in 1722 in Lucerne. This is the first zoological book to use the binomial association of genus and species. This system was later adopted by Carl von Linneaus (1707-1778).

Antoni van Leeuwenhoek, (1632–1723): Dutch scientist and manufacturer of microscopes. He is considered to be the first microbiologist. He was born as Thonis Philipzoon. Later he called himself van Leeuwenhoek as his birth-place was near the Leeuwenpoort, the Lion's gate. He ground lenses and constructed special microscopes which allowed a magnification of 270 times. He discovered and described three forms of bacteria and other microscopic organisms. He was also the first to record microscopic observations of muscle fibers, bacteria, spermatozoa and blood flow in capilleries.

Gottlieb Friedrich Mylius, (1675-1726): Secretary of the Elector of Saxony, published 1709 "Memorabilium Saxoniae subterraneae". These are the oldest plates of fossil plants in central Europe.

John Ray (Rajus) (1627–1705): Regarded as the Father of English natural history, he was the first to give a biological definition of the term species. Ray outlined the essential principles of the cycle of erosion. Ray insisted that fossils had once been alive, in opposition to his friends Martin Lister and Edward Llwyd. He wrote „These [fossils] were originally the shells and bones of living fishes and other animals bred in the sea" (Ray 1692). However Ray was torn between theological and scientific interpretations when it came to fossils, concluding on one hand that fossils were "originally formed in the places where they are now found by a spermatic principle" but elsewhere again insisting that "fossils were originally the shells and bones of living fishes and other animals bred in the sea" (Ray 1721).

Martin Ruland the Younger, (1569-1611): Physician and alchemist, physician of Emperor Rudolf II in Prague. His most important work, a dictionary of alchemy was published posthumously 1612.

Johann Jacob Scheuchzer, (1672-1738): Born in Zürich, physician and naturalist. Studied at the University of Altdorf/Nürnberg. Later became a physician in Zürich. He was a prolific author. He initially thought of fossils were 'sports of nature", but later became convinced that they are relics of the deluge. His "Natural History of Switzerland is a major work that covers the climate, topography, hydrology, glaciology, meteorology, mineralogy and fossils of the country. Another important work is his *Physica Sacra* which in later editions (1731-33) contained 745 full page copper engravings of Biblical history from Genesis to the Apocalypse. He also published investigations of climatology, crystallography and palaeontology. He described the skeleton of a giant salamander which was found in Tertiary sediments as the remains of a human being who had perished in the Great Flood.

Georg Anton Volkmann (Volckmann), (1664-1721): Pharmacist in Liegnitz, Silesia. He proposed theory that antediluvian vegetation was of a much higher order than that of today, that plants had degenerated and wholesome, fruitbearing trees had been changed into thorns, thistles and other weeds.

6. References

† References in Brückmann 1721

/193/ †AGRICOLA, G. (1544): De ortu et causis subterraneorum: Libr V; Basel (Froben)

/194/ †AGRICOLA, G. (1546): *De Natura Fossilium*. – Translation by BANDY, M.C. & BANDY, J.A. (1955): Geol. Soc. America. Spec. Pap., 63: 240 p.; New York.

/195/ †BAIER, J.J. (1708): Oryctographia Norica, sive rerum fossilium et minerale regnum pertitentium, in territorio Norimbergensi ejusque vicinia observatuum *succin*ta description – 96p; Nürnberg (Michaelli).

/196/ BATHURST, R.G.C. (1971): Carbonate Sediments and their Diagenesis. – Dev. Sedimentology, 12: 620 p., Amsterdam.

/197/ †BOËTHIUS DE BOODT, A. (1609): Gemmarum et Lapidum Historia, qua non solus ortus, natura, vis et precium, sed etiam modu qua ex iis, olea, salea tincturae, essentiae, arcane et magisterea, arte et chymica confici possint, ostenditur, Opus pricipus, medicis, chymicis, physicis, ac liberalioribus ingeniis utilissimum. – 133p.; Hanau.

/198/ BREASTED, J.H. (1944): Ancient Times, a History of the Early World. 2nd ed., 823 p.; Boston (Ginn).

/199/ BROCHANT, J.M. (1801): Traité de Minéralogie suivant les principes du professor Werner, Rédigé d'après plusiers ouvrages allemands, augmenté des découvertes les plus modernes, et accompagné de notes pour accorder sa nomenclature avec celle des autres mineralogists français et étrangers. Tome Premier. – 644 p.; Paris (Villier).

/200/ BROWN, T.C. (1914) Origin of *Oolite*s and oolitic texture in rocks. – Bull. Geol. Soc. Amer., 25: 745-780; Tulsa.

/201/ BRÜCKMANN, F.E. (1721): Specimen Physicum exhibens Historam naturalem Oolithi. – 28 p.; Helmestadii (Salomonis Schnorri).

/202/ BRÜCKMANN, F.E. (1728) Specimen Physicum exhibens Historam naturalem Oolithi. – In: BRÜCKMANN, F.E. Thesaurus Subterraneus, ducatis Brunsvigii. – 127-140 pp.; (Meisner) Braunschweig.

/203/ †BÜTTNER, D. S. (1710): Rudera diluvii testes, i. e. Zeichen und Zeugen der Sündfluth, in Ansehung des itzigen Zustandes unserer Erd- und Wasser-Kugel, insbesonderheit der darinnen vielfältig auch zeither in Querfurtischen Revieren unterschiedlich angetroffenen, ehemals verschwemmten Thiere und Gewächse. – 314 p.; Leipzig (J. F. Braunen).

/204/ †BÜTTNER, D. S. (1714): Corallographia subterranea seu dissertatio de corallis fossilibus, in Specie, de Lapide Corneo, Horn oder gemeiner Feuerstein. – 68 p., Leipzig (Großschoffen

/205/ CAYEUX, L. (1935): Les roches sedimentaires de France. – T. I-III., 463 p., Paris (Masson et Cie).

/206/ CHUBB, L.J. (1958): Sir Henry Thomas De La Beche. Geonotes, Quarterly Newsletter of the Jamaica Group of the Geologists's Association, De La Beche Memorial Number, p. 1-26 (Kingston, Jamaica).

/207/ DA COSTA, E.M. (1757): The Natural History of Fossils. – Part 1: 294 p; London (L. Davis and C. Reymers).

/208/ DANA, J.D. (1872): Corals and Coral Islands. – 398 p.; New York (Dodd and Mead).

/209/ DARWIN, C. (1859): The Origin of Species by means of Natural Selection. – 502 p.; London (John Murray).

/210/ DE GARENGEOT, R.J. (1742) Splanchnologie ou l'anatomie des visceres, 2: 250-251, 2nd ed., Paris (Osmont).

/211/ DE LA BECHE, H.T. (1851): The Geological Observer. – 695 p.; Philadelphia (Blanchard and Lea).

/212/ DE SAUSSURE, H.-B. (1779): Voyages Dans Les Alpes- Tome 1 § 359: p. 292; Neuchatel (Samuel Fauche).

/213/ DREW, G.H. (1911): The action of some denitrifying bacteria in tropical and temperate seas, and the bacterial precipitation of calcium carbonate in the sea. – J. Marine Biol. Ass. United Kingdom. 9: 142-155. Cambridge.

/214/ DRYANDER, J. (1799): Catalogus Bibliothecae Historico-Naturalis Josephi Banks, 4: Mineralogi, Monographiae Lapidum Calceorum, 143. Oolithus. – p. 129; London, (Bulmer).

/215/ EDWARDS, W.N. (1967): The Early History of Palaeontology 58 p.; London (Trustees of the British Museum [Natural History]).

/216/ EL SAMMAK, A.A. & TUCKER, M.E. (2002): Ooids from Turkey and Egypt in the eastern Mediterranean and a love-story of Antony and Cleopatra. – Facies, 46: 217–228; Erlangen.

/217/ FOLK, R.L. (1965): Henry Clifton Sorby (1826 – 1908), the Founder of Petrography. – J. Geol. Education, 13: 43-47;

/218/ FRIESS, H. (1982): Johann Samuel Schröter (1735-1808) a pioneer in palaeontology. –Arch. Nat. History, 11: 83-98; Edinburgh.

/219/ GEIKIE, A. (1905): The Founders of Geology. – 486 p. London (Macmillan).

/220/ GOLDSWORTHY, A. (2010): Antony and Cleopatra. – 470 p.; London (Weidenfeld and Nicolson).

/221/ GONZALES, R. & WETZEL, A. (1996): Stratigraphy and paleogeography of the Hauptrogenstein and Klingnau Formations (middle Bajocian to late Bathonian, northern Switzerland). – Ecl. geol. Helvetica, 89: 695-720; Basel.

/222/ HARRISON, W.J. (1897): A Text-Book of Geology, Intended as an Introduction to the Study of the Rocks and Their Contents. – 343 p.; (Blackie)

/223/ HESKE, I., GREVEN-PETRES, S., POSSELT, M. WIETHOLD, J. (2011): Die jungbroncezeitliche Außensiedlung der „Hünenburg“ bei Watenstedt. Vorbericht über die Ausgrabungen 2005-2007. – Prähist. Z.; Berlin (in press).

/224/ HOOKE, R. (1665): Micrographia: or some Physiological descriptions of Minute Bodies made by Magnifying Glasses with Observations and Inquiries thereupon. –London (Jo. Martyn and Jo. Allestry).

/225/ HOOKE, R. (1705): Discourses of earthquakes, their causes and effects, and histories of several. – In: WELLER, R. (ed.) The posthumous works of Robert Hooke: containing his Cutlerian lectures, and other discourses. – 572 p.; London (Sam. Smith and Benj. Walford).

/226/ HORNUNG, H. (1958): Johann Jakob Baiers Oryktographia Norica nebst Supplementen - In der Übersetzung aus dem Lateinischen von Herrmann Hornung und unter paläontologischer Mitarbeit von Florian Heller-Erlangen erläutert und herausgegeben von B. v. Freiberg-Erlangen. – Erlanger Geol. Abh., 29: Erlangen.

/227/ HORST, U. (1970): Alte naturwissenschaftliche Beobachtungen und Funde aus dem Hildesheimer Raum, neuzeitlich betrachtet. – Z. Mus. Hildesheim, NF., 21:; Hildesheim.

/228/ HUTTON, J. (1788): Theory of the Earth or an Investigation of the Laws observable in the Composition, Dissolution, and Restoration of Land upon the Globe. – Trans. Royal Soc. Edinburgh, vol. I, Part II: 209-304 [Read March 7. and April 4. 1785.] (Edinburgh).

/229/ †IMPERATO, F. (1672): Dell’ Historia Naturale. – 696 p., 2nd ed. Venetia (Presto Combi & La Nou).

/230/ JUDD, J.W. (1908): Henry Clifton Sorby and the birth of microscopical petrology. – Geol. Mag., 5: 193-204; London.

/231/ KALKOWSKY, E. (1908): Oolith und Stromatolith im norddeutschen Buntsandstein. – Z. dt. Geol. Ges., 60: 68-125; Berlin

/232/ †LANGIUS, K.N. (1708): Historia lapidum figuratorum helvetiae ejusque viciniae in qua non solum enarrantur omnia eorum genera species et vires aeneisque tabulis repraesentantur sed insuper adducuntur eorum loca nativa in quibus reperiri solent ut cuilibet facile sit eos colligere modo adducta loca adire libeat. – 165 p., Venetiis & Lucernae. (J. Tomasini; Apud Haeredes G. Hautt & J. J. Halter).

/233/ †LANGIUS, K.N. (1709): Tractatus de origine lapidum figuratorum [microform] : in quo diffusè disseritur, utrum nimirum sint corpora marina a diluvio ad montes translata, & tractu temporis petrificata vel an a seminio quodam e materia lapidescente intra terram generentur, quibus accedit accurata diluvii, ejusque in terra effectuum descriptio : cum dissertatione de generatione viventium, testaceorum præcipuè, plurimorum[que] corporum, à vi plasticâ auræ seminalis hinc inde delatæ extra consuetam matricem productorum. – 80 p.; Lucernae (Felicitatis Hautt).

/234/ LEIBNIZ, G.W. (SCHEIDT, C. L. (ed.) (1749): Summi polyhistoris Godefridi Guilielmi Leibnitii Protogaea: sive de prima facie telluris et antiquissimae historiae vestigiis in ipsis naturae monumentis dissertatio ex schedis manuscript is viri illustris in lucem edita a Christiano Lvdovico Scheidio. Sumtibus Ioh.Guil.Schmidii; Goettingae.

/235/ LINCK, G. (1903): Die Bildung der Oolithe und Rogensteine. – N. Jb. Mineral., Petrol. Paläont. Beil., 16: 495-513; Stuttgart.

/236/ LINCK, G. (1909): Uber die Bildung der Oolithe und Rogensteine. – Jenaische Z. Wiss., 45: 267-278; Jena.

/237/ †LACHMUND, F. (1669): Oryctographia *Hildesheimensis*, sive, Admirandorum fossilium; quae in tracta Hildesheimensi reperiuntur, descriptio iconibus illustrata, cui addita sunt alia de calculis de fontibus. – 80 p; Hildesheim (Jacob Müller).

/238/ LAMPRIERE. J. (1822): A Classical Dictionary. –, 3rd Am. ed.; Philadelphia (Crissy).

/239/ MACCURDY, G.G. (1908): Some Recent Paleolithic Discoveries. – American Anthropologist, 10: 643; Arlington.

/240/ †MYLIUS, G.F. (1709): Memorabilium Saxoniae Subterraneae. Pars Prima. Des Unterirdischen Sachsens Seltsame Wunder der Natur. – 80 p.; Leipzig (Friedrich Groschuffen)

/241/ PAUL, J., PERYT, T.M. & BURNE, R.V. (2010): Kalkowsky’s Stromatolites and *Oolite*s (Lower Buntsandstein, northern Germany). – Lect. Notes Earth Sci., 131: 13-28; Berlin (Springer).

/242/ PERYT, T.M. (ed.) (1983): Coated Grains. – 655 p.; Berlin (Springer).

/243/ PHILLIPS, W. (1818): Selection of facts from the best authorities, arranged so as to form an outline of the Geology of England and Wales. With a Map and Sections of the Strata. – 240 p.; London (William Phillips).

/244/ PITTON DE TOURNEFORT, J. (1694): Elemens de Botanique ou Methode pour Connoître les Plantes. 3 T. – 503 p.; Paris (Imprimerie Royale).

/245/ †PLINY SECUNDUS SENIOR, C. (77–79): Historia Naturalis. – Translation by BOSTOK, J. (1855): Red Lion Court, Fleet Street. London (Taylor and Francis).

/246/ PRESTON, D. (2009): Cleopatra and Antony; Power, Love and Politics in the Ancient World. – 333 p.; New York (Walker & Co).

/247/ †RAY, J. (1692): Miscellaneous Discourses concerning the Dissolution and Changes of the World. – 259 p.; London (Sam Smith).

/248/ RAY, J. (1721): Three Physico-Theological Discourses, concerning I. The Primitive Chaos, and Creation of the World. II. The General Deluge, its Causes and Effects. III. The Dissolution of the World, and Future Conflagration. : Wherein are largely discussed the production and use of mountains; the original of fountains, of formed stones ... With practical inferences. – 2nd ed., 414 p.; London (Sam Smith)

/249/ ROTHPLETZ, A. (1892): Ueber die Bildung der Oolithe. – Bot. Centralbl.; 51: 265–268: Jena.

/250/ ROTHPLETZ, A. (1915-1916): Über die systematische Deutung und die stratigraphische Stellung der ältesten Versteinerungen Europas und Nordamerikas mit besonderer Berücksichtigung der Cryptozoen und Oolithe. 2 vols. 46 + 92 p.; München (Königl. Bayer. Akad. Wiss.).

/251/ ROUSSEAU, G.S. & HAYCOCK, D. (2000): The Jew of Crane Court: Emanuel Mendes Da Costa (1717-91), Natural History and Natural Excess. – History Sci., 38: 127-170; Aberystwyth.

/252/ ROZET, M. (1828): Description geognostique du Bassin du Bas –Boulonnais. – 123 p.; Paris (Selligue).

/253/ †RULAND M. (1612): Lexicon Alchimiae sive Dictionarium. 471 p., Frankfurt (Zachariae Palthenius).
/254/ †SCHEUCHZER, J.J. (1705-1707): Seltsame Naturgeschichten des Schweizer-Lands wöchentliche Erzehlungen. – 27: 106. Zürich
/255/ †SCHEUCHZER, J.J. (1721): Physica Sacra. – 467 p.; Zürich.
/256/ SCHEUCHZER, J.J. (1731-1733): *Physica Sacra* Johannis Jacobi Scheuchzeri.iconibus aenis illustrata procurante & sumtus suppeditante Johannes Andrea Pfeffel. – x p.; Augsburg and Ulm
/257/ SCHMIDT, F.S. (1762): Memoire sur les oolithes. – 23 p.; Basle
/258/ SCHULZE, K.H. (1975): Mikrofazielle, geochemische und technologische Eigenschaften von Gesteinen der oberen Heersumer Schichten und des Korallenooliths (Mittleres bis Oberes Oxfordium) NW-Deutschlands zwischen Weser und Leine. – Geol. Jb., D11: 102 p., Hannover.
/259/ SELLWOOD, B.W. (1993): Structure and origin of limestones. – In: Le Bas, M.J. (ed.) Milestones in Geology. – Geol. Soc. London, Mem., 16: 185-193; London.
/260/ SIEWERS, F.D. (2003): *Oolite* and Coated Grains. – In: MIDDLETON, G.V. (ed.) Encyclopedia of Sediments and Sedimentary Rocks, 502–506 pp. (Springer Reference).
/261/ SIMONE, L. (1981): Ooids: A Review. – Earth Sci. Rev., 16: 319–355; Amsterdam.
/262/ SMITH, W. (1815): A Memoir to the Map and Delineation of Strata of England and Wales, with part of Scotland. – London (John Cary, No 181 Strand).
/263/ SORBY, H.C. (1851a): On the microscopical structure of the Calcereous Grit of the Yorkshire coast. – Qu. J. Geol. Soc., London, 7: 1-6; London.
/264/ SORBY, H.C. (1851a): On the microscopical structure of the Calcereous Grit of the Yorkshire coast. – Proc. West Yorkshire Geol. Soc., 3: 220–224; York.
/265/ SORBY, H.C. (1879): The structure and origin of limestones – Proc. Geol. Soc., London, 35: 56-94; London.
/266/ SZOMBATHY, J. (1909): Die Aurignacienschichten in Löss von Willendorf. – Korrespondenzbl. Dt. Ges. Anthropol., Ethnol., und Urgeschichte, 40: 85-88; München.
/267/ TEICHERT, C. (1970): *Oolite*, Oolith, Ooid: Discussion. – American Ass.Petrol. Geol. Bull., 54: 1748-1752; Tulsa:
/268/ TOWNSEND, J. (1813): The Character of Moses established for veracity as an historian recording events from the creation to the deluge. – 446 p.; Bath & London (Gye; & Longman, Hurst, Rees, Orme and Brown).
/269/ VALMONT DE BOMARE, J.C. (1764): Oolithe – Dictionnaire Raisonné Universel D'Histoire Naturelle, 4: 51-52; Paris (Didot, Musier, De Hansey, Panckoucke).
/270/ VAUGHAN, T.W. (1914): Preliminary remarks on the geology of the Bahamas, with special reference to the origin of the Bahamian and Floridan *Oolite*s. Papers of the Tortuga Laboratory, Carnegie Institute, Washington. Publlication, 128: 1-136; Washington.
/271/ VINKEN, R. (1974): Der obere Jura (Malm) des Hildesheimer Jura-Zuges. – Geol. Jb., A23: 3-56; Hannover.
/272/ †VOLKMANN, G.A. (1720): *Silesia subterranea*. – 347 p. Leipzig (Weidmann).
/273/ WALLERIO, J.G. (1778): System Mineralogicum quo Corpora Mineralia.Tom II. Minerae & Concreta. – Ed. novo, 639 p.; Vienna (Kraussana).
/274/ WALTHER, J. (1888 & 1891): Abh. math.-nat. Classe kgl. Sächs. Akad. Wiss., 14 & 16
/275/ WALTHER, J. (1893, 1894): Einleitung in die Geologie als historische Wissenschaft. – 1055 P., Jena (Fischer).
/276/ WINCHESTER, S. (2001): The Map That Changed The World. – 338 p., London (Viking).