RUEDESDORF OPENCAST LIMESTONE MINE - A GEO-HIGHLIGHT NEAR BERLIN, GERMANY

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Aerial view of the opencast mine from East to West
Phot.: CEMEX Zement GmbH 2009
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Purpose

This compilation was assembled at the suggestions of Open University student Gisela Lunkwitz. It is intended to offer a general geological and more specifically a sedimentological introduction for professionals and students of geosciences, hobby-geologists, and for visitors with interest in geology who come to see this unique opencast mine. This is not a field guide leading the visitor from outcrop to outcrop nor is it a review of existing scientific work. It is meant to provide an overview and show specific features of particular interest, selected subjectively by the compiler on the basis of many visits to the mine in nearly 25 years. Several of the structures or fossils shown are found at several stratigraphic levels, not only where indicated in this compilation.

All visitors must keep in mind at all times that they visit a fully operational mine and that the operating company - CEMEX Zement GmbH - is obliged to enforce strict safety regulations. There is only one very simple rule: It is strictly prohibited to enter the mine without prior permission and without guidance of authorized staff. Various types of trips into and around the mine and other information are offered by the Museumspark Ruedersdorf (MPR; see section 11.1).

Why Highlight?

Geomorphology and near-surface geology of Berlin and the surrounding State of Brandenburg are determined by processes of deposition and erosion in the glacial and interglacial periods of the Quaternary; in general the upper 50 to 100 m of the substrate were formed in this way. Below follow Tertiary deposits including lignite layers; they are up to 200 m thick. Further down follows a Mesozoic sequence of terrestrial and marine sedimentary rocks deposited in the Central European Basin.

This sequence of up to 2,900 m thickness is well known from boreholes drilled in a comprehensive oil and gas exploration program. Outcrops are extremely rare; where they occur - as in Ruedersdorf - they are due to local upward movement of Upper Permian salt, which formed structures such as pillows and diapirs; in the process of formation they pushed the overlying rocks upwards.

In Ruedersdorf the rocks of Mid-Triassic period were lifted. In this way a welcome resource of building material came to the surface. It has now been mined for over 750 years, first in small quarries by hand, today in the large opencast mine - an area of about 4 x 1 km and about 100 m deep - using big machinery. With the advancing faces of mining a three dimensional picture developed. As byproduct, a paradise for geologists was created - a very special geo-highlight.

Acknowledgements

Thanks are due to the CEMEX Zement GmbH for permitting this compilation and for contributing to it. 36 colleagues/authors contributed to an earlier field guide (Schroeder, 1992/1993; see 12.2) and the proceedings of a Symposium on Ruedersdorf held in 1991 (Schroeder, 1995; see 12.3). As editor I benefitted immensely from their knowledge; nine students and young geoscientists at the Technical University of Berlin contributed theses and/or publications (12.2).

In particular Prof. K.-B. Jubitz (†) led the way into the mine, to its work, its history, and into scientific research. In addition over the years A.G. Cepek (†), A. Düring, K. Else, A. Koszinski, and H.-J. Streichan generously shared their experience on various subjects and/or facilitated my work for science and for the public education. Several collectors, among them E. Barsch, C. Donner, A. Düring, and H.-J. Streichan, gave permission to present fotos of their specimens. Information was provided or confirmed by H. Hagdorn, J. Hofmann, R. Kienitz, M. Meng, and M. Menning. This compilation was substantially supported by B. Dunker (art) and M. Thiel (PC techniques), both TUB. E. Bielefeldt, J. Hofmann (MPR), G. Lunkwitz (OU), G. Schirrmeister, and P. Whiteley (OU) as native English speaker corrected the proofs.
The Municipality of Ruedersdorf near Berlin

Position / Coordinates: 52°28’ N; 13°47’ E
Elevation: 62 m above sea level
Surface Area: 70.11 km²
Parts of the Municipality: Ruedersdorf (including Tasdorf and Kalkberge), Hennickendorf, Herzfelde and Lichtenow
Inhabitants: 15,093 (31.12.2012)

Economy / Enterprises:
- Cemex Zement GmbH (Cement)
- Fels-Werke GmbH (Lime Sandstone, Fertilizer)
- DHL (Postal service); Immanuel Hospital GmbH
- Berolina Metallspritztechnik Wesnigk GmbH

Cultural Activities:
- „Kulturhaus“ (Theater, Concerts, Exhibitions etc.)
- Museumspark (Mining, Geology; Exhibitions & Monuments; see section 11.1)

History:
- 1235: Founded by the clerical order of the Cistercians; remains under the authority of that order
- 1308 - 1319: Ruedersdorf first mentioned in history
- 1557: R. taken by the Duke of Brandenburg
- 1618 - 1648: Destroyed during the 30-years-war
- Further development: Growth as mining activities responded to the need of construction material, especially in Berlin.
- 1992: „Amt Ruedersdorf“; official incorporation
- 2003: Municipality receives present configuration
Fig. 1.2 Opencast Limestone Mine of Ruedersdorf and Surroundings [Contribution: Schroeder, art: Dunker]

See section 11.1 for detailed map of the Museumspark (SW portion).

Base: OpenStreetMap; License CC-BY-SA 20
2 Geological Context

Fig. 2.1 TIME - The Age of the Layers in the Opencast Mine of Ruedersdorf - Time: Millions of Years -

Subdivisions of the Triassic

- Upper T. = Keuper
- Middle T. = Muschelkalk
- Lower T. = Buntsandstein

Triassic Layers in the Opencast Mine of Ruedersdorf (scaled to time)

- Upper Muschelkalk
- Middle Muschelkalk
- Lower Schaum-Muschele(kalk)
- Wellenkalk
- Röt = Upper Buntsandstein

T - Thickness of the layer (not to scale)

T-Thickness of the layer (not to scale)

Note: Subdivisions and times refer to the "German Triassic"; they differ from those applied elsewhere in Europe.

(Sources: Stratigraphische Tabelle von Deutschland 2015 & *Menning u.a., 2016) [Contribution: Schroeder]
Ruedersdorf is/was located in the Central European Basin; during Muschelkalk time it was generally a shallow sea. Its morphology was complex including swells and basins, ridges and grabens. Some of the shallower parts were exposed when the sea level was low, also some parts were barred by ridges thus had a restricted water circulation.

The sediments were mainly limy sands and muds, largely formed from skeletal particles or their fragments; the composition varied with depth and other ecologically relevant factors. In areas with restricted circulation and evaporation, dolomites, gypsum/anhydrite and various salts were deposited. In Ruedersdorf the entire suite of sediments from coarse to fine carbonates and the suite of evaporites from carbonates to sulfates are represented.

Close to landmasses clastic particles = sand to clay derived by weathering from various rocks at the land surface were carried into the sea and mixed with carbonate materials in various proportions; however, due to its distance from landmasses only fine clastic materials reached Ruedersdorf.
As in the North German Lowland generally, in Eastern Brandenburg the geology is characterized by structures of Permian Zechstein salts. Due to their low density, the salts - mainly anhydrite and halite - respond to the pressure of overlying strata by moving upward where and when these strata permit. Differences in load/thickness may induce the upward movement of the salts in certain locations. The movement is significantly enhanced by fractures. Structures vary in shape: salt pillows assume the shape of bulges, while salt diapirs form vertical plugs; the overlying strata are deformed as they are pushed or dragged upward; diapirs may penetrate overlying strata and in this way reach the surface.
The section shows that salts were not only moving upward, but also sideways so that the material could form bulges such as pillows and diapirs. Where salts were diminished or depleted, depressions of compensation were formed; overlying strata were deformed and may have moved downward. At the surface basins may have developed and accommodated thicker layers of subsequent sediments than in areas without structures.

Further, salts rarely moved all the way up at once, but often in two or more steps at different times. As a result, in a given position strata of different ages may have been affected in different ways and different intensities.
Zechstein salt pillow overlain by deformed Triassic sedimentary rocks in and below the opencast limestone mine; originally all has been covered by Pleistocene deposits.

*Detailed information on Muschelkalk units in columnar stratigraphic section 3.2

[After Wagenbreth & Steiner, 1982; modified by Schroeder, 1993 & 2014; art: Dunker]
3 STRATIGRAPHY

Fig. 3.1 Generalized Section across the Opencast Mine of Ruedersdorf: Sequence and Dip of Layers - Floors of Mining

N
Pleistocene Cover

Original Land Surface

Upper Muschelkalk

Middle Muschelkalk

Schaumkalk*

Wellenkalk*

Lower Muschelkalk = Röt

Myophoria-Beds

Upper Buntsandstein = Röt

+35 m

+5 m

25 m

-55 m

Floors** in the Opencast Mine

<FW**

<FW**

50 m

Dips range from 15° - 30° N

100 m

*In this section (and in other parts of this compilation) the subdivisions of the Lower Muschelkalk are designated by traditional and commonly used names. Formal as well as more detailed subdivisions and lithological information are presented in the columnar section 3.2.

**For technical reasons the height of the faces of work (FW) has been reduced from 30 m to 10 or 15 m; as a result there are additional floors and more “steps” in the mine.

[After Schwahn & Böttcher, 1974 & Streichan, 1990, with additional information from Koszinski; contribution: Schroeder; art: Dunker]
**Fig. 3.2 Columnar Section of Triassic Layers Cropping out in and around the Open cast Mine of Ruedersdorf** [After Zwenger, 1993; Zwenger & Koszinski, 2009; Schroeder, 2010; Menning et al., 2016; Kramm & Hagdorn, in prep.; Koszinski, pers. com.; contribution: Schroeder; art: Dunker]

<table>
<thead>
<tr>
<th>Rocks</th>
<th>Lower Muschelkalk (mu)</th>
<th>Middle Muschelkalk (mm)</th>
<th>Upper Muschelkalk (mo)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wellenkalk (mu₁α)</td>
<td>Schaumkalk (mu₁β)</td>
<td></td>
</tr>
<tr>
<td><strong>Röt</strong>&lt;sub&gt;(so 3)&lt;/sub&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Röt</strong>&lt;sub&gt;Fm&lt;/sub&gt;</td>
<td>246,3 (millions)</td>
<td>245,5 (of years)</td>
<td>244,2 (Time not to scale)</td>
</tr>
<tr>
<td>Jena Formation*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>66 m</td>
<td>73 m</td>
<td>65 m</td>
</tr>
</tbody>
</table>

- **Geochemically - technologically defined units of Ruedersdorf**

**Limestones**

- **Röt**
- Middle Muschelkalk
- Upper Muschelkalk

**Dolomites**

- Wellenkalk (mu₁α)
- Schaumkalk (mu₁β)

**Marls**

- Upper Muschelkalk
- Middle Muschelkalk

**Gypsum**

- Upper Muschelkalk

---

*Terminology of the German Stratigraphic Commission; Subcommission Permian / Triassic*

**The geochemically-technologically defined units are characterized on the basis of their composition, particularly the contents of CaO, MgO and (Na₂O + K₂O) (Schwahn & Böttcher, 1974; Walter, 1993). The variations are of importance for each specific use of the raw material: Rocks from particular units are taken selectively and/or mixed with those from others to obtain the bulk composition required for a given product. For example, the limestones for cement are taken from up to six locations /units.*
**Fig. 4.1 Deposition in Shallow Marine Environments During Periods of Lower Muschelkalk** [After Schroeder, 2010; Grafik: Dunker]

- **Shoal**
  - with sandbars (see fig. 6.2-2b)
  - high energy

- **Platform Inner Ramp**
  - very shallow
  - decreasing energy

- **Depression Basin**
  - gradually deeper

- **Environment of Deposition**
  - Sealevel
  - 8-15 m Wave Base
  - 15-20 m Storm Wave Base

- **Sediment**
  - Sedimentary Rock
  - Extension Period

- **Deposition in Shallow Marine Environments**
  - Coarse, bio-calciurudite to calcarenite*
  - Limestone
    - Ooids
    - Carbonate Skeletal Particles
    - Oolitic
    - Dense, fine grained, partly marly

- **Schaumkalk**
  - Thick, fine grained, partly crinoidal
  - 100s m, km, 10s km

- **Wellenkalk**
  - Very thick
  - 100s m, km, 10s km

*Distinguished by grainsize: arenite = 0.063 - 2 mm; rudite < 2 mm
Wellenkalk - General Characteristics
Medium to fine grained limestone to marl; layers of mm to few tens of cm thickness vary significantly in composition (clay contents of 15 - 35 weight %) and hence in hardness.

Various bivalve shells up to several centimeters in size are the most abundant skeletal materials = fossils; they either form coquinas (a kind of shell hash) and thus coarse limestones, pavements on the bedding planes, or float in finer material.

Fig. 5.1 - 1 Fresh outcrop of Wellenkalk; general view [Phot.: Schroeder, 2014]

Fig. 5.1 - 2 Fresh outcrop of Wellenkalk, closer view; the variations in hardness are readily apparent. [Phot.: Schroeder, 2012]

Fig. 5.1 - 3 Wellenkalk in color: Fresh rocks exhibit various shades of grey; where water is present either moving along joints (as in this example) or from the surface, iron oxides produce shades of rusty red: Fig. shows bedding surface bordered by joints. [Phot.: Schroeder, 2012]
5.2 Bedding

The name „Wellenkalk“ refers to the uneven horizontal surfaces separating the layers; in vertical section (Fig. 5.2 - 1) they remind one of waves (= „Wellen“ in German, hence the name). However, as Fig. 5.2 - 3 shows there is no preferred orientation as in waves, but an assemblage of irregularly shaped and distributed depressions and bumps, both from cm to few dm laterally, and cm vertically.

These are not primary sedimentary structures, but formed after deposition in sequences of sediments with various densities due to mineral composition and water content; in response to gradually increasing overburden lateral variations lead to differential thickening and thinning of layers. The resulting bumps and depressions may become more pronounced in the course of further lithification and alterations, and flasers or nodules may be formed.

Fig. 5.2 - 1 Horizontal surfaces = bedding „planes“ in Wellenkalk shown in vertical section appearing wavy [Phot.: Schroeder, 2014]

<< Fig. 5.2 - 2 Bedding surfaces in Wellenkalk: range of configurations; most common are „waves“ and flasers [After Zwenger, 1993; Schroeder, 2014; art: Dunker]

>> Fig. 5.2 - 3 Horizontal bedding surface in Wellenkalk showing irregular arrangement of depressions and bumps [Phot.: Schroeder, 2014]
5.3 Erosional Channels

Many bedding surfaces of the Wellenkalk exhibit erosional channels. The top surfaces of beds are marked by excavation i.e. hollows, the bottom surfaces bear ridges which are the fillings of channels of the next bed below.

5.3-1 Erosional Channels on Bedding Surface: Formation and Preservation

[Contribution: Schroeder; art: Dunker]

Fig. 5.3 - 2 Cast (C) of a small channel formed by water currents on/in the bedding surface of Wellenkalk. a: Level of bedding surface at top; b: Top-down-view to show cast as ridge.

[Coll. Hartfeldt; Phot.: Schroeder, 2014]

Fig. 5.3 - 3 Erosional channel filled with coarse bioclastic material carried in during an intermittent high energy regime, possibly a storm; later the filling and adjacent bedding surface were covered by „normal“ fine sediments in a low energy regime.

[Coll. 1993 + Scan. 2014: Schroeder]
5.4 Storm Deposits

A storm deposit results from and records a single event: A storm hits the shallow marine basin. With its high energy it churns up the bottom, picks up the sediment and keeps it in suspension in turbulent water of high energy. Sediment is eroded; a more or less scalloped surface (E) cuts into the older sediments. Skeletal material such as bivalves or snail and/or semi-consolidated sediment forming clasts as well as surrounding fine materials are removed and kept in suspension.

When the storm recedes the material is dropped, the coarsest first with finer components mixed in; there is no time for thorough sorting. Upward the finer components dominate. The thickness of such storm deposit (S) generally is in the range from mm and to about 10 cm. Thereafter under „normal“ conditions the usual finer sediments (N) are deposited.

It is fascinating to consider the rates of deposition: The average rate for 139 m thick deposits during 2.1 Million years of Lower Muschelkalk amounts to about 0.7 mm per year; in contrast while the recess/decline of a storm lasts, i.e. in a period of hours or at most days centimeters of sediment were deposited.

Fig. 5.4 - 1 Storm deposit composed mainly of shell material
[Coll. 1990 + Phot. 2006: Schroeder; art: Dunker]

Fig. 5.4 - 2 Storm deposit composed mainly of lithoclasts
[Coll. 1990 + Phot. 2006: Schroeder; art: Dunker]

N - Normal fine grained sediment; E - Erosional surface; S - Storm deposit

Fig. 5.4 - 3 Sequence of closely spaced storm deposits in Wellenkalk; variations in shape, thickness and grain-sizes reflect different regimes
[Coll. 1992 + Scan 2014: Schroeder]
5.5 Fossils Fig. 5.5-1 Shallow Marine Organism Assemblage of the Wellenkalk (Lower Muschelkalk)

[Contribution: H. Hagdorn, 1992; adaption: Schroeder; art: Dunker]

1 The lowest unit shown is a storm deposit = tempestite of coarse grained bioclastic material topped by a pavement of bivalve shells (see section 5.4)

2 Above follows a layer of carbonate mud enclosing organisms living within the sediment, among them the pelecypods Myophoria incurvata (a), Myophoria vulgaris (b; Fig. 5.5 - 5), Palaeonucula goldfussi (c), Hoernesia socialis (e; Fig. 5.5 - 4) and the scaphopod Dentalium torquatum (d); the tubular bioturbation Rhizocorallium irregularare (f; Fig. 5.6 - 1, - 2, - 3) was formed in soft mud; it offered shelter and feeding to an arthropod.

3 On the sediment surface live the pelecypods Plagiostoma lineatum (g; Fig. 5.5 - 2), the wide shell of which protects it from sinking into the mud, and Entolium discites (h), smaller individuals of the latter are attached by the byssus to algae. Gastropods such as Loxonema obsoletum (i), Omphaloptycha gregaria (j; Fig. 5.5 - 3), Polygyrina sp. (k) and Worthenia leysseri (l) are feeding on microbial mats and algae.

Fig. 5.5 - 2 Shell pavement Plagiostoma sp. on bedding surface [Coll. Düring; Phot.: Schroeder, 2004]

Fig. 5.5 - 3 Omphaloptycha sp.; gastropods with shells dissolved, but sedimentary filling preserved [Coll. Streichan; Phot.: Schroeder, 2004]
**Fig. 5.5 - 4** Pavement of the pelecypod *Hoernesia socialis* in Wellenkalk [Coll. Streichan; Phot.: Schroeder, 2004]

**Fig. 5.5 - 5** Ammonoid cephalopod *Beneckeia buchi* from the Wellenkalk: Note large living chamber on top and crinkled septa (= Partitioning walls between chambers) called suture line. The details of these lines with their lobes are characteristic of different ammonoid groups. [Coll. Barsch; Phot.: Schroeder, 2004]

**Fig. 5.5 - 6** Ammonoid cephalopod *Beneckeia buchi* from the Wellenkalk: Note large living chamber on top and crinkled septa (= Partitioning walls between chambers) called suture line. The details of these lines with their lobes are characteristic of different ammonoid groups. [Coll. Barsch; Phot.: Schroeder, 2004]

**Fig. 5.5 - 7** Tooth of the shark *Hyodus multiplicatus* [Coll. Barsch; Phot.: Schroeder, 2004]

**Fig. 5.5 - 8** Brittle star *Aspidurella streichani* from Wellenkalk [Coll. Streichan; Phot.: Schroeder, 2004]
5.6 Trace Fossils

Numerous organisms live either on the bottom of the sea or below it within the uppermost decimeters of soft sediment. They leave tracks on or burrows in the sediment; the burrows may be filled after use and form spaghetti or sausage like bodies. Many trace fossils cannot be attributed to a particular organism; therefore paleontologists have developed a specific classification of trace fossils.

In the Wellenkalk Rhizocorallium sp. is common: The burrow is U-shaped and was formed probably by an arthropod, moving ± horizontally between beds.

Fig. 5.6 - 1: Rhizocorallium sp. fillings on the top of a Wellenkalk bedding surface. [Phot.: Schroeder, 2012]

Fig. 5.6 - 2: Vertical outcrop with subcircular sections of Rhizocorallium sp (R) fillings in Wellenkalk. Note also alternating hard and soft layers. [Phot.: Schroeder, 1992]

Fig. 5.6 - 3: Complex burrow of Rhizocorallium sp. with branching U-shaped portions from the Wellenkalk; the small bent ridges (B) between the outer casts indicate the gradual advance (>) of burrow in direction to the U. For details see Helms, 1995. [Specimen found in Ruedersdorf by Granat in 1978; kept in the Naturkunde Museum Berlin, Phot.: Kleeberg, 1993]
5.7 Early Deformations

In the Wellenkalk deformations of sediments start immediately after deposition when the mud is still soft; higher contents of water and clay minerals promote early deformation; further a slope of the bottom is conducive, also triggering mechanisms such as storms or earthquakes.

Sliding is the first process to become effective; layers may be folded and wrapped like a piece of wet cloth gliding down on a slope. Slidings can be seen on the bedding surface (Fig. 5.7 - 1) and in vertical sections (Fig. 5.7 - 2).

Slab joints (= also: „sigmoidal joints“) are interpreted to result from forced expulsion of water from the sediment triggered by earthquakes. In sequences of layers slab-joints may form selectively in some, but not in other layers, depending on water and mineral contents. For details see Dualeh, 1995 a & b).
5.8 Secondary Minerals

Secondary minerals are formed later than the rock enclosing them. **Pore water** is the decisive agent in the process of formation: its composition - components and acidity -, the rate of water movement as well as the physico-chemical environment in the rock determined by temperature and pressure. **Composition of minerals** is determined by dissolution of primary or earlier secondary components, or by import of ingredients from outside the present rock. **Space:** Primary pores between grains and cement or secondary pores formed by dissolution of primary components or of secondary minerals formed earlier as well as joints resulting from structural deformation. The **spatial relationship** of different secondary minerals (A sits on B) provides information on the sequence of formation = relative age. **Timing:** Starting immediately after lithification over millions of years to the present day such minerals may be formed in several phases or generations: The time/age of any phase of mineralization is rarely assessed; sometimes it can be related to phases of structural deformation providing space in joints. In Ruedersdorf the Wellenkalk is particularly rich in secondary minerals; most abundant are celestine (SrSO₄; also called celestite), calcite (CaCO₃), pyrite (FeS₂) and marcasite (FeS₂). For details see Bautsch & Damaschun, 1993 & 1995.

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**Fig. 5.8 - 1** Blue Celestine (SrSO₄) from Wellenkalk [Coll. + Phot.: Düring, 2014]

**Fig. 5.8 - 2** Celestine from Wellenkalk; red color due to intergrown fine hematite crystals [Coll.;TU Berlin Mineralogie; Phot.: Schroeder, 2014]

**Fig. 5.8 - 3** Pyrite precipitated along joints [Photo: Schroeder, 2004]

**Fig. 5.8 - 4** Pyrite along joint - detail [Coll. & Phot.: Schroeder, 2014]

**Fig. 5.8 - 5** Marcasite in nodular growth [Phot.: Schroeder, 2004]
Schaumkalk: General Characteristics

These rocks are well sorted grainstones; the dominant particle diameter is about 0.2 - 0.5 mm, the maximum is about 2 mm. The major components were originally ooids (see part 6.2); using a hand lens one notes immediately that mainly molds of the original grains make up the rock. (Details: Friedel, 1995 a) It should be noted, though, that in many layers of the Schaumkalk ooids or their dissolution vugs are absent. The non-carbonate portion is less than 3 %; as result the rock is much harder than the Wellenkalk. The color of the fresh rock is light to yellowish grey or beige. The layers of cm to several dm are distinct; internally they frequently exhibit crossbedding with bed dipping 12 -15° and channels.

Fig. 6.1 - 2 Schaumkalk outcrop in close-up view; the distinct layers in cm to several decimeters thickness are readily apparent [Phot.: Schroeder, 2014]

Fig. 6.1 - 3 Cross-bedding in Schaumkalk, part of a sandbar system (See Fig. 6.2 - 2 b) [Phot.: Schroeder, 2014]
Ooids are grains up to 2 mm in size formed in very shallow marine high-energy environments. As nuclei particles are kept in motion and/or in suspension: each is encrusted by successive layers of calcium carbonate, that is of crystals of the minerals aragonite or calcite precipitated from sea water; the resulting fabric is comparable to successive peels of an onion. The shape of the grains is spherical to ellipsoidal = egg shaped, hence the name ooid (derived from the greek word "oon" = egg).

Once grains become too heavy or the energy moving them decreases, they are deposited, characteristically in a series of sandbars with cross-bedding as typical sedimentary structure.

Oolite, the rock composed of ooids, is formed by precipitation of carbonate cements = crystals in various shapes and sizes in the space between the grains.

At an undeterminable time after lithification the ooids may be dissolvd by pore waters leaving cavities in shapes of spheres or eggs rendering the appearance of foam (= "Schaum" in German), hence the name Schaumkalk.

Fig. 6.2 - 1 >>>
Vertical section of a “Schaumkalk” rock showing the pores due to dissolution of ooids = the bubbles of the “foam”
Phot.: Schroeder, 2015]

Fig. 6.2 - 2 [After Zwengen, 1993; Schroeder, 2012]
a Ooids are grains up to 2 mm in size formed in very shallow marine high-energy environments. As nuclei particles are kept in motion and/or in suspension: each is encrusted by successive layers of calcium carbonate, that is of crystals of the minerals aragonite or calcite precipitated from sea water; the resulting fabric is comparable to successive peels of an onion. The shape of the grains is spherical to ellipsoidal = egg shaped, hence the name ooid (derived from the greek word “oon” = egg).
b Once grains become too heavy or the energy moving them decreases, they are deposited, characteristically in a series of sandbars with cross-bedding as typical sedimentary structure.
c Oolite, the rock composed of ooids, is formed by precipitation of carbonate cements = crystals in various shapes and sizes in the space between the grains.
d At an undeterminable time after lithification the ooids may be dissolvd by pore waters leaving cavities in shapes of spheres or eggs rendering the appearance of foam (= “Schaum” in German), hence the name Schaumkalk.
6.3 Geopetal Structures

Fig. 6.3 - 1
Geopetal structure in Schaumkalk, a fossil spirit level indicating the original horizontal orientation
[Phot.: Schroeder, 2012]

Fig. 6.3 - 2
Geopetal structure - indicator of original horizontal level formed in the process of embedding bivalve shell
[After Schroeder, 2012; adaption Schroeder, art Dunker]

1a + b: A shell is deposited on the bottom of the sea inside down.
2 During subsequent sedimentation the shell protects the space below (GP) which may remain empty or - in the course of diagenesis - may be filled partly or completely by crystals of various minerals.

6.4 Fossils

Fig. 6.4 - 1
Gastropod Undularia scalata from the Schaumkalk; the shell has been dissolved, a cast of the internal sediment is preserved.
[Coll.: Barsch; Phot.: Schroeder, 2004]

Fig. 6.4 - 2
Grinding tooth of Placodus gigas, a marine reptile; teeth resemble paving stones
[Coll.: Barsch; Phot.: Schroeder, 2004]
Hardgrounds are formed during **periods of no sedimentation**; the fossil record consists mainly of **sessile organisms**, for example crinoids, calcareous tube worms, and the oyster-like *Placunopsis*, in addition to traces, burrows and borings.

3 At the highest tier above the hardground live filter-feeding crinoids, among others *Encrinus brahli* (g1); often the basal disk is all that is preserved (g2)

2 On the sea bed the brittle star *Aspidurelia streichani* (Fig. 5.5 - 8), the pelecypod *Placunopsis* (d) and the tentaculid *Microconchus valvatus* (e), formerly erroneously identified as *Spirorbis*. Among the freely moving grazing organisms is the gastropod *Undularia scalata* (f; Fig. 6.4 - 1)

1 Within the rock, the tube of *Balanoglossites triadicus* (a, Fig. 6.5 - 2 and -3) was formed by a worm in firm, but not yet lithified sediment; in contrast the small tubes called *Trypanites weissi* (b, Fig. 6.5 - 3 and -4) were bored after lithification.
6.5 „Maggot Layers“ and Hardgrounds  Schaumkalk deposition was repeatedly interrupted; during these breaks sediment of the top 5 - 10 cm was subject to intensive bioturbation. The irregularly winding = maggot-shaped tubes probably burrowed by worms into the soft carbonate sand were about 0.5 - 1 cm in diameter and in the order of 10 - 20 cm long. In trace fossil nomenclature they are called Balanoglossites triadicus. They were either later filled with sediment or else remained empty and are preserved as tubes. In the process of burrowing and filling the sediment surface became irregular and marked by craters and bumps. Some of these layers were lithified and became hardgrounds; burrowing in the soft sediment was followed by boring in the hard rock: Tubes 1 - 2 mm in diameter and a few cm in length were formed; they are called Trypanites weissei.

Fig. 6.5 - 1 Series of „maggot layers“ in Schaumkalk (M 1 - 5) shown on exhibit G 1 in the Jubitza Place to Experience Rocks (see 11.2) [Phot.: Schroeder, 2014]

Fig. 6.5 - 2 „Maggot layers“ in Schaumkalk: H = horizontal surface with craters and bumps; V = Vertical section [Phot.: Schroeder, 2014]

Fig. 6.5 - 3 >> Hardground in Schaumkalk; horizontal surface showing holes of Balanoglossites (B) and Trypanites (T) [Phot.: Schroeder, 2014]

Fig. 6.5 - 4 >> Hardground in Schaumkalk; vertical broken face with borings of Trypanites [Phot.: Schroeder, 1996]
6.6 Stylolites

Stylolites (from the Greek: *stylos* - pillar and *lithos* - stone) are contact surfaces marked by irregular and interlocking penetration of the two sides with *columns, pits and teeth* on one side fitting into the counterparts on the other side; the dimension of interpenetration is mm to cm.

Stylolites are formed in the course of diagenesis when carbonate is dissolved under pressure at points of grain-to-grain contact. The direction of contacts depends on the prevailing pressure regime, which may be caused by overburdening or structural tensions.

Insoluble residues, for example of clay or iron oxide, provide black, gray or rusty-redish color to the thin line of contact. More details offer Friedel (1993, 1995) and Dualeh (1995).
Fig. 7.1 - 1: NS section of Middle Muschelkalk as studied in 1993 by Lorenz; at that stage of exploitation the entire stratigraphic sequence was exposed. Due to the low durability and variation lithology this part of the Triassic profile is rarely exposed in Central Europe: Jubitz called it „The section of the century”. By 2014 mining operations have removed this section. Do not look for it! [Phot.: Schroeder, 1993]

Fig. 7.1 - 2: Closer view of outcrop in a sequence of alternating strata from the Middle Muschelkalk showing variations in thickness and hardness of layers. [Phot.: Schroeder, 2014]
Middle Muschelkalk -

General characteristics

Three marine carbonate sections are separated by two sequences of alternating strata consisting of dolomitic marls, up to 90% dolomite, and increasingly upward gypsum layers. The sequences contain few fossiliferous carbonate layers. The section reflects two cycles of a shallow marine environment gradually becoming more and more restricted and evaporitic, and then gradually returning to normal marine conditions. The general picture becomes more complicated by intermittent fluctuations of sea level (see Fig. 7.2) as indicated by fossiliferous carbonates in the sequences of alternating strata. While the thickness of Middle Muschelkalk rocks in the subsurface boreholes is about 80 m, in near surface profiles and in outcrops the gypsum deposits have been removed by solution, thus the thickness in the opencast mine has been reduced by 15 to 20 m (Lorenz, 1994; 1995; Jubitz, 1996).
7.2 Evaporite Sedimentation

Depending on temperatures and positions of sea level / seawater inflows, conditions may range from highly restricted / evaporitic to normal marine. Correspondingly, in a given location sediments from gypsum to shallow marine biogenic carbonates may be deposited; particular types of sediment recur with time, that is in vertical profile. Characteristic sequences or cycles of sediments and rocks record the course of environmental changes. Depending on morphology, input, and other conditions similar variations may develop in horizontal direction.

Fig. 7.2 Environment of Deposition of Evaporitic Salts (Carbonates and Sulfates) as Formed During the Period of Middle Muschelkalk [After Schroeder, 2010; art: Dunker]
7.3 Gypsum

Virtually no primary evaporitic gypsum has been preserved - noticeable few in near-surface occurrences or outcrops. After several stages of dissolution precipitation of several forms followed, e.g. crystalline or fibrous gypsum. (For examples see exhibits N 1 and N 2 on the Jubitz Place to Experience Rocks; see section 11.2.)

Fig. 7.3 - 1 Fibrous gypsum consisting of delicate fibers of tenth of a mm in diameter oriented parallel to each other and perpendicular to the bedding planes a close-up view b typical appearance in outcrops [Phot.: Schroeder, 2014]

Fig. 7.3 - 2 Gypsum filling solution cavities a empty (E) and full ones (<G); note irregular shapes due to dissolution; b full cavities [Phot.: Schroeder, 2014]

Fig. 7.3 - 3 Gypsum crystals grown into the open space of a cavity [Phot.: Schroeder, 2014]
7.4 Mud Cracks Mud cracks are irregular networks of fractures, often crudely polygonal. They result from shrinkage of fine grained sediments such as clay, silt and mud, including lime mud. Shrinkage is caused by exposure to and drying at the atmospheric surface: In an otherwise marine environment they indicate a drop in sea level. Mud cracks occur in various parts of the section, particularly in Middle and Upper Muschelkalk; they are also observed at the present surface on the floors of the opencast mine, demonstrating: Observations of present processes provide the key for understanding past processes and their products.

Fig. 7.4 - 3 Formation and preservation of mud cracks
[Af ler Schroeder, 2012; art: Dunker]

Fig. 7.4 - 4 Mud cracks from the present floor of the opencast mine
[Phot.: Schroeder, 2014]
7.5 Fossils  During much of the Middle Muschelkalk period conditions were adverse to marine life. However, there were intervals with very favourable conditions. Such conditions are recorded by fossil-bearing horizons described by Picard (1916). The fauna is very similar to that of the Lower Muschelkalk. In addition, spectacular vertebrate fossils were found here.

\[ \text{Fig. 7.5 - 1} \]
\[ \text{Nothosaurus rabii} \]
Schroeder*, an amphibian reptile
\[ \text{a Fossil skeleton from the underside.} \]
\[ \text{b Reconstruction of the skeleton by P. Dienst & F. Neugebauer. Both fossil and reconstruction are on exhibit in the Museum für Naturkunde in Berlin. [Phot.: a Schroeder, 2004; b: Kleeberg,1992] * No relation to the present compiler} \]

\[ \text{Fig. 7.5 - 2} \]
\[ \text{Nothosaurus marchinus, lower jaw} \]
[Coll.: Barsch; Phot.: Schroeder, 2004]

\[ \text{Fig. 7.5 - 3} \]
\[ \text{Coprolites = Fossil excrements of saurians} \]
[Coll.: Barsch; Phot.: Schroeder, 2004]
Upper Muschelkalk - General characteristics

Normal marine conditions returned to the basin once regional passages were opened, and a sequence of marine limestones was deposited. Some of the beds are characterized by special fossils (e.g. *Myophoria* sp.), others by special structures (hardgrounds, intraclasts, mud cracks) or by mineralogical features such as chert nodules or glauconite contents.
8.2 Petrographic Features

8.2.1 Intraclast Limestone

As in the formation of the deposit shown in Fig. 5.4 - 2, in this case a storm tore up a mud layer and picked up clasts; however, here the matrix was coarser grained, thus it was hydromechanically much closer to the clasts; as a result the clasts are not grading upward, but floating in the matrix.

Fig. 8.2 - 1 Storm deposit with mud clasts floating in sandy matrix [Coll. 1992 & Scan 2014: Schroeder]

Chert nodules are found in distinct beds of the Upper Muschelkalk. SiO₂ derived either from seawater or from biogenic sources such as sponges replaced carbonate.

Fig. 8.2 - 2 Partly silicified chert nodule from the Upper Muschelkalk [Coll. 1992 & Scan 2014: Schroeder]

8.2.2 Silicified Limestone

8.2.3 Glauconite Limestone

Glauconite refers to a group of Fe-Al-sheet-silicate minerals with varying potassium contents. They are alteration products of other clay minerals, e.g. biotite, and are formed by weathering in marine environments.

Fig. 8.2 - 3 Glauconite limestone from the Upper Muschelkalk

a Vertical section, polished surface; bivalve shells and fragments thereof are embedded in limemud; green ellipse-shaped glauconite grains marked by <G [Coll. 1993 & Scan 2014: Schroeder]

b Oblique fracture of glauconite limestone; glauconite grains marked by <G. [Coll. & Phot.: Schroeder, 2014]
Near-surface geology of Berlin and Brandenburg, indeed of northern Germany and northern Poland, is dominated by glacial geology: During the Pleistocene time large sheets of inland ice advanced from Scandinavia in southerly and southeasterly directions, shaped the surface and left deposits, each with its own series of glacial geomorphological features and corresponding deposits:

1. **Terminal moraines** = ridges of poorly sorted clastic sediment = till containing erratic boulders of decimeter and some meters size

2. **Outwash plains** with sand deposited by melting waters

3. **Pradolinas** = wide valleys draining melting water toward the North Sea

4. **Ground (= basal) moraine** = plateau at the rear of the terminal moraine composed of poorly sorted clastic material deposited by the inland ice

Nine major glacial advances - and numerous minor ones - have shaped the region during the last about 600,000 years; the earlier ones reached farthest-south, the later ones less and less. Of these, seven have crossed the Ruedersdorf area. The map (Fig. 9.1) shows two advances which crossed - Warta (S III W; about 135,000 years ago) and Brandenburg (W 1 B; 21,000 years ago) - and two which did not: Frankfurt (W 1/2 F; 18,400 years ago) and Pommeranian (W 2 P; 15,200 years ago).

A variety of glacial deposits including those left by Elsterian and early Saalian advances have been found in and around the Ruedersdorf structure; they were studied in great detail by A. G. Cepek (among others 1993; 1995). In view of spectacular Pleistocene morphology and outcrops elsewhere in Brandenburg, the Quaternary section of this compilation is limited to three special aspects.
Fig. 9.2 Glacial Geomorphology in the Area Surrounding Ruedersdorf

[Majored Weichselian Ice Margin (Terminal Moraines) of Stages W1/2F - Frankfurt W2P - Pommeranian]

Major Direction of Respective Ice Movement

Moraine Plateau

Pradolina with Flow-Direction

9.3 Glacial Striations and Potholes

The location of Ruedersdorf is of eminent importance for the understanding of Pleistocene advances of inland ice. In 1875 the swedish geologist Otto Torell investigated glacial striations and potholes on the top surface of the limestone layers; reported before by Sefdorn in 1836. They clearly indicate that the ice did not swim, but was pushed across the underlying rock surface. These features were exposed again 1991 - 1995 and found by K.-B. Jubitz and H.-J. Strechan.

**Striae** are grooves scratched by rocks which were frozen in the ice at its base and moved across a rock surface below the ice.

**Potholes** are more or less cylindrical cavities formed underneath the inland ice: Depressions in the substrate were enlarged and deepened by subglacial meltwater eddies containing sand and pebbles as abrasive agents.

<< Fig. 9.3 - 1 Glacial striae (= scratch marks) in limestones on top of the Middle Muschelkalk (MM) outcrop on the „Felsmauer“ (see Fig. 7.1 - 3) of 1991 - 1995  
[Phot.: Schroeder, 1995]

<< Fig. 9.3 - 2 Potholes in limestones on top of the Middle Muschelkalk outcrop in 1991 - 1995 with well rounded abrading pebbles (PE) found in the holes  
[Phot.: Schroeder, 1995]

Fig. 9.3 - 3  >>  
K.-B. Jubitz on the top surface of the Middle Muschelkalk limestone (MM) exposed in the course of mining operations and visible 1991 - 1995; in the background remnants of the Quaternary cover (QC).  
[Phot.: Schroeder, 1995]
9.4 Subglacial Channels  Subglacial channels are formed in the rock underneath the inland ice by meltwater descending through crevasses and cracks in the ice and flowing below the sole of the ice. In the rock below, faults and joints provide the nuclei for the excavation of channels. The abrasive agents are sand and pebbles carried by the water.

Course: The opencast mine is crossed in NS direction by the „Kreuzbrueckenspalte“ (= KBS; the name refers to a bridge connecting northern and southern rim of the mine from 1840 - 1974). The more spectacular southern portion of KBS was removed in the course of mining.

Morphology: The KBS extended in NS direction for about 1000 m across the opencast mine and cut through some Middle Muschelkalk, but mainly through Schaumkalk and Wellenkalk, and further down into the Upper Buntsandstein. Depth reaches to 50 m under the Triassic surface. Width and shape of cross-section depended on lithology: In the Wellenkalk (Fig. 9.4 - 1) the walls of the gorge were steep; some steep-sided U-valleys were merely 5 m wide. In the Schaumkalk at present (2014) seen at the northern side of the mine - a wide open V-is characteristic (at the top about 50 - 80 m wide; Fig.9.4 - 2). The rocks in the walls were smoothed and laterally excavated by abrasion.

Fill: Mainly Pleistocene sands, among them some coarser layers with pebbles and finer ones with silt and clay (for details see Hoffmann, 2004). Amber also was found in the fill.

The Kreuzbrueckenspalte was and still is a textbook example of a subglacial channel (Schroeder, 1995).
9.5 Lake Laach Volcanic Ash

A remarkable phenomenon found in the Quaternary deposits is the layer of Lake Laach Volcanic Ash (= Tephra) in the outcrop called Paddenluch, located at the northern rim of the opencast mine (part of the „No-go“ area). It has been studied in great detail by Strahl (2005) and Kossler (2010). The small depression of 750 m length and 65 - 125 m width was cut by the mining operations: An E - W section of 10.56 m in height was opened above limestones of Middle and Upper Muschelkalk age. The depositional environment was a lake, formed in Late Weichselian time and gradually filled from Late Weichselian time (~ 16,000 years ago) to medieval times.

This volcanic ash is remarkable because Lake Laach is part of the Eifel Mountains located near Bonn, that is about 500 kilometers away from the Paddenluch. The Eifel area is known for its Quaternary volcanic activity of the last 700,000 years. Six phases of activity are recognized, the last one was caused by the eruption of Lake Laach Volcano; the ash was spread by wind over a very large area. The age is about 13,000 years (discussed in detail by Kossler, 2010). While near Lake Laach the thickness of the ash layer reached more than 50 m, in the Paddenluch it is only 1 - 2 cm. Nevertheless it is a dated marker bed of Mid-European importance.

In the Paddenluch outcrop this layer - as the over- and underlying lacustrine sediments - has been plastically deformed in some places by gliding.
Fig. 10.1 Use of Mineral Resources from the Ruedersdorf Mine

| Historic Use | Historic and Present Use | Company
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Röt</td>
<td>Lower Muschelkalk</td>
<td>CEMEX Zement GmbH</td>
</tr>
<tr>
<td></td>
<td>Wellenkalk</td>
<td><a href="http://www.cemex.de/">www.cemex.de/</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ZementwerkRüdersdorf.aspx</td>
</tr>
<tr>
<td></td>
<td>Middle Muschelkalk</td>
<td>Fels-Werke GmbH</td>
</tr>
<tr>
<td></td>
<td>Schaumkalk</td>
<td>Lime plant Ruedersdorf</td>
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<tr>
<td></td>
<td></td>
<td><a href="http://www.fels.de/en/index.html">www.fels.de/en/index.html</a></td>
</tr>
<tr>
<td></td>
<td>Upper Muschelkalk</td>
<td></td>
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</tbody>
</table>

- **Clay for ceramics and bricks**: Historic Use
- **Stones for dry masonry and pavement slabs**: Historic Use
- **Dimension stones for construction and decoration**: Historic and Present Use
- **Dimension stones for construction and decoration**: Historic and Present Use
- **Cement clinker rockmeal**: Historic and Present Use
- **Fine fraction <35 mm**: Historic and Present Use
- **Fine ground high-calcium lime (<0.1 mm)**: Historic and Present Use
- **Hydrated high-calcium lime**: Historic and Present Use
- **Sand-lime bricks**: Historic and Present Use
- **Autoclaved aerated concrete**: Historic and Present Use
- **Further processing in other plants or companies**: Historic and Present Use
- **Gypsum**: Historic and Present Use
- **Dimension stones for construction and decoration**: Historic and Present Use
- **Fertilizer**: Historic and Present Use
- **Neutralization of effluent**: Historic and Present Use
- **Purification of exhaust gas**: Historic and Present Use
- **Rehabilitation of contaminated sites**: Historic and Present Use

Internet site:
Table 10.1 History: Selected Data on *Mining, **Processing and ***Transportation in Ruedersdorf

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1220 - 1250</td>
<td>Beginning of limestone quarrying</td>
</tr>
<tr>
<td>1250 - 1804</td>
<td>Quarrying on the +35 m floor</td>
</tr>
<tr>
<td>1550</td>
<td>Construction of Woltersdorf Lock</td>
</tr>
<tr>
<td></td>
<td>&gt; connection to Spree-Waterways</td>
</tr>
<tr>
<td>1768 - 1806</td>
<td>Boom of Ruedersdorf limestone</td>
</tr>
<tr>
<td>1801 - 1804</td>
<td>Construction of Heinitz Canal including tunnel</td>
</tr>
<tr>
<td>1804 - 1863</td>
<td>New method of exploitation: Fracture and fall using blasting powder and (since 1831) slow matches</td>
</tr>
<tr>
<td>1776</td>
<td>Construction of 2-chamber-kiln</td>
</tr>
<tr>
<td>1802</td>
<td>Construction of Rumford kiln (Type in operation until 1875)</td>
</tr>
<tr>
<td>1815 - 1816</td>
<td>Construction Bülow Canal including tunnel</td>
</tr>
<tr>
<td>1828</td>
<td>Construction of Belltower (destroyed 1975, rebuilt 2005)</td>
</tr>
<tr>
<td>1833 - 1844</td>
<td>Lowering the mine floor to groundwater level</td>
</tr>
<tr>
<td>1864 - 1950</td>
<td>Mining on 2. floor (30 m below groundwater level)</td>
</tr>
<tr>
<td>1869 - 1872</td>
<td>Connection to the external railsystem</td>
</tr>
<tr>
<td>1871 - 1877</td>
<td>Construction of a battery of 18 shaft kilns, in operation</td>
</tr>
<tr>
<td>1885</td>
<td>Beginning of cement production \ till 1967</td>
</tr>
<tr>
<td>1888</td>
<td>Production of hydraulic lime</td>
</tr>
<tr>
<td>1905 -1906</td>
<td>Construction of annular kiln (extended 1913)</td>
</tr>
<tr>
<td>1913</td>
<td>Production of sand-lime bricks</td>
</tr>
<tr>
<td>1925</td>
<td>Production of bagged lime</td>
</tr>
<tr>
<td>1935</td>
<td>Production of crushed rocks</td>
</tr>
<tr>
<td>1940</td>
<td>Production of reinforced concrete (prefabricated parts)</td>
</tr>
<tr>
<td>1945 -1947</td>
<td>Dismantling and removal of vital machinery to the Soviet Union as relocations</td>
</tr>
<tr>
<td>1947 - 1952</td>
<td>Rebuilding various processing plants</td>
</tr>
<tr>
<td>1950 - 1991</td>
<td>Mining down to 60 m below groundwater level sub-surface drainage system taking water to Kriensee</td>
</tr>
<tr>
<td>1953</td>
<td>Large borehole shooting (lateral removal of slices)</td>
</tr>
<tr>
<td>1952 / 1956 / 1966</td>
<td>**Cement plants 2 / 3 / 4</td>
</tr>
<tr>
<td>1990</td>
<td>Readymix GmbH takes over mining operation</td>
</tr>
<tr>
<td>1991 - 1993</td>
<td>*Reconstruction of the opencast mine</td>
</tr>
<tr>
<td>1995</td>
<td>**New shaft kiln (DC current - inverse flow regenerative kiln)</td>
</tr>
<tr>
<td>1999</td>
<td>Fels-Werke GmbH takes over lime plant</td>
</tr>
<tr>
<td>2000</td>
<td>First certification of environmental managing system</td>
</tr>
<tr>
<td>2005</td>
<td>Cemex OstZement GmbH takes over operation</td>
</tr>
<tr>
<td>2007</td>
<td>*Hydraulic saddle block excavator in operation</td>
</tr>
</tbody>
</table>

Main sources: Wendland, 1993 & 1995
Gemeinde Rüdersdorf bei Berlin, Ed., 2010: 775 Jahre Rüdersdorf

Fig. 10.1-1 Opencast mine of Ruedersdorf as shown in a lithograph from 1858
[Artist unknown; producer/publisher of lithograph: J. Stentz, Berlin; Phot.: Schroeder, 2014]
For building purposes Ruedersdorf Muschelkalk mainly was taken from Schaumkalk (in much smaller quantities from Upper Muschelkalk). High CaCO₃ contents as well as thickness and continuity of layers ensure relatively high quality. In view of much poorer quality material from Wellenkalk was used for dry masonry walls, pavement for footpaths and places, locally also for stables.
Fig. 10.2 - 2 Straße der Jugend 29; Ruedersdorf Muschelkalk used for the plinth (P) and as decorative elements in the entrance area, at the corners of the house (C) and marking the border between first and second floor (F)

[Phot.: Schroeder, 2012]

Fig. 10.2 - 3 Church of Kalkberge

a. The outer walls exhibit Ruedersdorf Muschelkalk
b. Examples of many structures to be seen, e.g. Stylolites and cross bedding
c. Mud pebbles

[Phot.: Schroeder, 2012]
Fig. 10.2 - 4  Ruedersdorf Townhall entrance  a Door frame (F), plinth (P), pillar (Pi) and party-wall  b Party-wall with pillars (Pi), tops of pillars (T), bench (B), spheres (S) and pavement slabs (Pa). A search for sedimentary structures and fossils is worthwhile: Details from the plinth: c Geopetal structures = Fossil spirit levels  d Crossbedding with geopetals (in the wall upside down) [Phot.: Schroeder, 2012]

Fig. 10.2 - 5                 >>
Puschkinstr. 3, party-wall
[Phot.: Schroeder, 2014]
10.3 Ruedersdorf Muschelkalk Used for Construction or Decoration in Berlin

From the middle ages to the early 16th century glacial eraticics and bricks were the major building materials used in Berlin. Starting in the 14th century Ruedersdorf Muschelkalk was the only quarried limestone used, although not in large quantities. From the 16th century onward increasing sandstones from Saxony and other relatively nearby areas were brought in.

In the 19th century with the development of transport facilities more and more stones from elsewhere became available; Ruedersdorf Muschelkalk was unable to compete with Triassic and Jurassic limestones from various parts of Germany and neighbouring countries; it was used mainly as filling material in foundations.

Nowadays no stones from Ruedersdorf are used for construction in Berlin. Instead cement and other processed materials come.
10.4 Gas Storage in the Ruedersdorf Salt Structure
Operated by EWE GASSPEICHER GmbH

Although gas storage is only indirectly related to the opencast mine, as an important geo-application of the salt structure it must be mentioned at least briefly in this context. The caverns used for storage were produced by dissolving defined volumes of salt. Presently EWE operates two caverns of about 130 mio. m³ in depths of about 1,000 m, the first since 2007, the second since 2010.

With the gas stored EWE is in the position to supply customers in Brandenburg for 4 months; in this way Ruedersdorf provides increased supply security to the state of Brandenburg.

Geological framework: In our region deposits of Upper Permian / Zechstein age (257.3 - 251 million years) consist of five marine/evaporitic sequences totaling about 1,000 m in thickness. Each sequence grades upward in order of increasing solubility from carbonate through gypsum and halite to potassium salt. There is a considerable variation in thickness between the sequences; they were deformed during and after formation of salt structures.

Table 10.4 - 1 Gas Storage in Ruedersdorf

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Working Gas Volume</td>
<td>approx.130 mio. m³ (Vn)</td>
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<tr>
<td>Withdrawal Capacity</td>
<td>approx.140,000 m³ (Vn)/h</td>
</tr>
<tr>
<td>Injection Capacity</td>
<td>approx. 60,000 m³ (Vn)/h</td>
</tr>
<tr>
<td>Reference gross calorific value</td>
<td>11,100 kWh/m³ (Vn = volume; h = hour)</td>
</tr>
</tbody>
</table>

Data from http://www.ewe-gasspeicher.de/english/gas-storage-ruedersdorf.php
11 RUEDERSDORF FOR VISITORS

11.1 Museumspark Ruedersdorf

The „Museumspark Ruedersdorf“ was founded in 1994 to present geological aspects as well as history and development of mining to the public. For more than 750 years the limestone has been mined, and according to present calculations mining probably will continue until 2062. Inside and around the opencast mine many constructions and buildings were erected to handle and process the broken stone. The Museumspark therefore offers a splendid opportunity to discover limestones, their exploitation, processing and use.

At its entrance the Museumspark offers a leaflet „map of the area Museumspark Ruedersdorf“ in English.

Opening hours of the Museumspark:

- **April - October:**
  - daily 10.00 - 18.00

- **November - March:**
  - daily 10.30 - 16.00

Three walking routes covering various aspects are suggested:
- to Geological Stops
- to Stops of Manufacturing
- to Stops of Transporting Limestone and Historical Monuments

Independently the visitor obtains geological information at the „Jubitz Place to Experience Rocks“ (11.2) and in the „Otto-Torell-House of Rocks“ (11.3)

The Museumspark offers three guided tours:
- **Landrover Tour:** Adventurous drive along the opencast mine (1 hour)
- **Geologic Tour:** Experience geology in the quarry (2 hours)
- **Historic tour:** Enjoyable journey through time (optional 1 - 2 hours)

Information on costs and dates as well as advance registration (required!)

Phone: 03 36 38 – 79 97 97  Fax: 03 36 38 – 79 97 99
E-Mail: kasse@museumspark-kulturhaus.de

Office Contact: Rüdersdorfer Kultur GmbH
Heinitzstraße 41, 15562 Ruedersdorf bei Berlin

Monday to Friday, 07.30 – 16.00
Phone: 03 36 38 / 79 97 – 0  Fax: 03 36 38 / 79 97 – 19
Internet: www.museumspark.de

**Fig. 11.1 - 1**
A landrover tour along the rim of the opencast mine is the best way to get a feeling for its overwhelming dimensions. [Phot.: Museumspark]
Fig. 11.1-2 Ruedersdorf Museumspark: Access, Entrance and Attractions in its Western Part

[Contribution: Schroeder; art: Dunker]

Welcome Center (under construction)

Ticket Office Information Entrance

Bülow Canal & Tunnel

Museumspark

Lime Depot: Coffee Shop and Exhibitions

Jubitz Place to Experience Rocks

Heinitz Canal & Tunnel

Opencast Limestone Mine

Bergbrück

Strausberger Mühlenfließ (Waterway)

Tram Stop “Heinitzstraβe”

Heinitzstraβe

Bülow Canal & Tunnel

Chamber Kiln

Rumford Kilns

Otto-Torell-House of Rocks (Geological Exhibition)

Bell Tower

50 m

[Contribution: Schroeder; art: Dunker]
Historical Monuments

Fig. 11.1 - 3 a Chamber Kiln (1766)

Fig. 11.1 - 3 b Rumford = Ruedersdorf Kilns
During the period of 1802 - 1840 6 kilns were built.

Fig. 11.1 - 3 c Lime Depot = "Magazinegebäude" (1666); clock tower (1830)

Fig. 11.1 - 3 d Buelow- Canal Gate (1815 - 1816)

Fig. 11.1 - 3 e Bell Tower (1828, rebuilt 2002 - 2004 using recycled stones)

Note: All buildings of Ruedersdorf Limestone
Surfaces: a - d sawn
c - in part plastered
e - roughly hewn

[All Phot.: Schroeder]
Nature in and around the Opencast Mine

Of course, quarrying and mining operations over the centuries - especially since 1850 - have markedly changed the scenery of the region. That applies to morphology: depressions and mounds, channels and cliffs were formed. Obviously the substrate was altered: Instead of glacial gravel, sand and/or clay there are solid carbonate walls and floors as well as carbonate rich dumps. Accordingly, particular elements of plants and animals with respective preferences arrived and thrived. For example, the cliffs and tunnels of the mine offer places for hibernation to thousands of bats. Molluscs of the Ruedersdorf area have attracted malacologists since 1850; 1993 Haldemann reported his count of 104 species. Bird watchers find their own paradise (Koszynski, 1993) as many birds take wide open mine as refuge area. The flora offers a variety of attractions: 372 fern und flowering plants were found and identified in 2000 by Schulz & Rebele (2003) in the area of the museumspark. There is a lot to discover: Hopefully one day professional and hobby biologists will publish a compilation complementary to this one: „Biological highlights in and around the Ruedersdorf opencast mine“. But even without one: The area is a very popular destination for all friends and observers of nature!
11.2 Jubitz Place to Experience Rocks

The first nine sections of this compilation should have convinced the potential or actual visitor that the opencast mine offers many very interesting geological features. They are distributed all over the mine; a visit is very much worthwhile. However, as pointed out: Ongoing mining operations require safety regulations that can be summarized in one single very simple rule: Do not enter the opencast mine! (except when guided by authorized staff).

The Jubitz Place to Experience Rocks was conceived to give visitors a chance to meet a variety of Triassic rocks from the mine, but meet them outside the mine. That is the simple basic concept of this place. Several specialists have been permitted to seek and select a variety of rock types from different stratigraphic horizons, and the Museumspark has offered this central location for their presentation.

As a visitor you can inspect them from all sides - except for the bottom - and you can touch them: In this way you come to know and understand them: Their respective components, the fossils and the sedimentary structures, for example the bedding. You also learn to appreciate some of the later history of the rock, for example deformation, dissolution of it or of its parts, precipitation of minerals in cracks and cavities. With the information provided on the boards next to each exhibit and in the accompanying flyer you will appreciate the respective features.

Prof. Dr. sc. Karl-Bernhard Jubitz (1925 - 2007) was an eminent regional geologist; before his retirement he worked at the (East-)German Academy research institut „Zentralinstitut für Physik der Erde“. He was a member of several international commissions and working groups. Active in Ruedersdorf from 1950 to his last days, he is probably the one geoscientist most intensively involved in research of the mine and its surroundings. Moreover, he shared his knowledge and enthusiasm with many geoscientists and geohobbyists.

This place bears the name of K.-B. Jubitz to make us gratefully remember his involvement and to honor him for his contributions to science and public education!

HELP PRESERVE THE SITE!

Please, do not take any hammer to this place.

Please, do not remove any rocks from the site! ...not even loose ones!

Climbing the rocks is prohibited because of the danger to people, especially to children, and to avoid damage to the rocks exhibited.

Dogs - with and without leash - are not allowed in this place.

Fig. 11.2 - 1: Visitor exploring exhibit N 2 with eyes and hands [Phot.: Schroeder, 2012]
Fig. 11.2-2 Jubitz Place to Experience Rocks: Map of Exhibits

[After Schroeder, 2010, art: Dunker]
Fig. 11.2 - 3 Jubitz Place to Experience Rocks: Exhibits in Stratigraphic Sequence

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
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<th>H</th>
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<tr>
<td>B1+2</td>
<td>G1-3</td>
<td>I1</td>
<td>K1-3</td>
<td>M1 N1+2</td>
<td>S1</td>
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</table>

**Muscilgelkalk**

- **Wellenkalk**
- **Schaumkalk**

**Middle Muschelkalk**

**Upper Muschelkalk**

---

**Fig.- 11.2 - 3  Jubitz Place to Experience Rocks: Exhibits in Stratigraphic Sequence**

a Position of stones exhibited in columnar section (Fig. extracted from Fig. 3.2)

b General view showing most stones [Phot.: Schroeder, 2012]

A - T geochromically-technologically defined units of Ruedersdorf; see Fig. 3.2
11.3 The Otto - Torell - House of Rocks  
A permanent exhibition on the geological aspects of the opencast mine Ruedersdorf was opened in this building in 2000. It presents posters, diagrams and photographs with texts in combination with rock specimens and fossils. The building honors Otto Torell (1828 - 1900), the swedish geologist, who in 1875 saw and reported on the glacial striations and potholes on top of the Ruedersdorf structure (see section 9.3).

<< Fig. 11.3 - 1 The Otto-Torell-House of Rocks - built 1997 -1999, Architect: W. R. Ernst outside view [Phot.: Schroeder, 2004]

Fig. 11.3 - 3 The Otto-Torell-House of Rocks can be used as an external class room for students of various schools and levels. [Phot.: Schroeder, 2014]

<< Fig. 11.3 - 2: Inside the Otto-Torell-House the visitor is lead through the exhibit along a route defined by the geological sequence of events. [Phot. Schroeder, 2014]
Note: Very little geological information on Ruedersdorf is available in English. Considering the history of the past 60 years that is easily understood. Until 1990 Ruedersdorf was part of East Germany, where English was not the most favored language. Although interesting and “classical”, the region did not fit into the then fashionable context of global tectonics. Further, it was a spot of economic interest; therefore results of research were largely confidential.

The opening of the wall was decisive for scientific exchange: Especially in the early 1990s the doors were wide open, and our East German colleagues readily shared their knowledge ...and they had a lot to tell! However, very few dared say it in English, let alone to publish in English. In Berlin and Brandenburg the exchange between geologists became intensive. Gathering as much regional information as possible was considered an important joint task. A first step was a little guidebook published in two editions (Schroeder, 1992, 1993; p.57). After a very informative symposium in 1991 the material was assembled in a proceedings-volume (Schroeder, 1995; p. 58). The tables of contents are included here to gratefully remember the scientists involved and to offer access to the variety of topics included.

After 1990 it was possible for students from universities of the region to work in and around the mine. In this way a variety of special topics, for example various parts of the profile, were covered in project reports, MSc theses and a doctoral thesis (p. 56), the latter in English by a Somali scientist (Dualeh, 1995). Some other scientists became involved, because the outcrops were simply fantastic. Others - among them the elder „geo-statesmen“ - kept sharing their experience - however, mostly in German.

GEOLOGY

Jubitz, K.-B., & Wasternack, J., 1998: A5 Struktur Rüdersdorf - Klassische Kalklagerstätte (Mittlere Trias, Muschelkalk) im Postsalinaren Deckgebirge Ostbrandenburgs - GeoBerlin 98, Exkursionsführer, Terra Nostra 98/4, p. 35 - 48

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Unification of Germany and specifically of the city of Berlin in 1989 provided for geoscientists of the region an incredible change in professional work and contacts, exchange and perspective. When the Berlin wall came down, everybody realized the extent, variety and quality of the Geo-Community in the region, and general as well as highly specific geo-knowledge was freely shared among colleagues in the East and between East and West. Our Association of presently about 250 members in various institutions and companies – many active, others retired - became a welcome vehicle for activities and exchange: Individual lectures and joint symposia as well as fieldtrips to this day offer chances to present and to receive knowledge on a wide variety of geo-topics.

In ten “Fieldguides to the Geology of Berlin and Brandenburg” published the association offers geo-information on various areas/topics of Berlin and Brandenburg in a style understandable to the public (see map on the right). Public education and geo-conservation (geotopes, national geoparks) continue to be areas of concern and joint activities. In addition, the association provides a network with useful links; it helps in obtaining information and solving various regional problems. [Adapted from Thieke, 2010]