ABHANDLUNGEN DER GEOLOGISCHEN BUNDESANSTALT
Abh. Geol. B.-A. | ISSN 0378-0864 | ISBN 978-3-85316-058-9 | Band 65 | S. 169–179 | Wien, 10. 11. 2010
Fifty Years of Geological Cooperation between Austria, the Czech Republic and the Slovak Republic

Grindstone Mining in Gosau – the Classical Locality of the Ressen Formation (Lower Campanian, Gosau, Upper Austria)

Harald Lobitzer[1], Gyöngyi Lelkes-Felvári[2], Franz Ottner[3], Marcela Svobodová[4] & Lilian Švábenická[5]

5 Text-Figures, 2 Plates

Österreichische Karte 1:50.000
Blatt 95 St. Wolfgang

Northern Calcareous Alps
Calcareous nannofossils
Upper Gosau Subgroup
Sandstone petrology
Ressen Formation
Palynomorps
Campanian
grindstone
Gosau

Contents

Der Gosauer Schleifsteinbruch – Locus Classicus der Ressen-Formation (Untercampan, Gosau, Oberösterreich)

Zusammenfassung

Die Umgebung der Gosauer Schleifsteinbrüche ist die klassische Lokalität der Ressen-Formation. Kommerziell vertriebene Wetzstein-Produkte wurden petrologisch untersucht. Weiters wurden Proben der sandig-mergeligen Überlagerung des ökonomisch genutzten Sandsteins im Gosauer Schleifsteinbruch im Hinblick auf kalkiges Nannoplankton, Palynomorphen und Mineralogie studiert. Das Vorkommen des Nannoplankton-Taxons *Broinsonia parca parca* spricht für ein frühes Untercampan-Alter (Nanno-Zone UC14a sensu Burnett, 1998) am Beginn der mergeligen Überlagerung, die als Abraum verworfen wird.

Abstract

The grindstone quarries represent the classical region of the Ressen Formation (Upper Gosau Subgroup). Commercial grindstone products (whetstones) from Gosau were analyzed from a petrological point of view. In addition the marly caprock-layers on top of the economically exploited silt/sandstones were studied stratigraphically by means of calcareous nannoplankton and palynomorphs and also from a clay-mineralogical point of view. The presence of the nannofossil taxon *Broinsonia parca parca* evidences zone UC14a sensu Burnett (1998), which confirms an early Lower Campanian age for the beginning of the marly caprock sedimentation.

1 Harald Lobitzer: Lindaustraße 3, A 4820 Bad Ischl, Austria. harald.lobitzer@aon.at
2 Gyöngyi Lelkes-Felvári: Hungarian Natural History Museum, Department of Mineralogy and Petrology, Ludovika tér 2, H 1083 Budapest, Hungary.
3 Franz Ottner: Universität für Bodenkultur, Institut für Angewandte Geologie, Peter Jordan Straße 70, A 1190 Wien, Austria. ottner@mail.boku.ac.at
4 Marcela Svobodová: Institute of Geology, v.v.i., AS CR, Rozvojová 269, CZ 165 00 Praha 6, Czech Republic. msvobodova@gli.cas.cz
5 Lilian Švábenická: Czech Geological Survey, Klárov 131/3, P.O.Box 85, CZ 118 21 Praha, Czech Republic. lilian.svabenicka@geology.cz

Early Exploration

The Gosau grindstone, which was mined on Mt. Ressen or "Löckermoosberg" (Text-Fig. 1), repeatedly was the subject of scientific investigations in the early time of geological research in the Austro-Hungarian monarchy. The famous German geologist Leopold von Buch visited the Salzkammergut along with Alexander von Humboldt in 1797. Buch (1802) defined the lithology of the Gosau grindstone as "red and white quartz pieces in a yellow-brown clayey matrix". Also Lill von Lilienbach (1830) dealt with these commercially exploited sandstones. The Bohemian natural scientist August Emanuel Reuss (Text-Fig. 2) described in 1854 the "grindstone layer" even more precisely as fine-grained sandstone, consisting of angular and sharp quartz grains, which are bound by clayey-calcareous cement. Friedrich Simony (1889–1895) described in his unique monography of the Dachstein area also the grindstone mining in Gosau (Text-Fig. 3). Most of the later more comprehensive papers dealing with the geology of the Gosau region also refer to the peculiar grindstone mining on Mt. Ressen. For instance Kittl (1903) describes briefly the *"Schleifsteinbrüche am Löckermoos: On top of the fossil-rich marls of the Hofergraben follow marls poor in fossils ... and the slightly SSE dipping sandstones without fossils [of the Schleifsteinbrüche] represent the top of the sequence ..."*.

The transgressional clastic sediments on Mt. Ressen play also a role in Alpine tectonic literature. Brinkmann (1934) postulates a second intergosavian tectonic phase between his middle and upper Gosau, which he called "Ressenphase". He also considers the sandstones of the Ressen Formation to represent in part a lateral equivalent of the Nierental Formation. According to Weigel (1937) the mentioned tectonic movements took place after the late Early Campanian, but considerably earlier as the Maastrichtian. Ganss (1954) deals with the peculiar petrological properties responsible for the excellent quality of the grinding stone: *"hard quartz grains embedded in a tough clayey-marly matrix"*. As Brinkmann before him (1934), he considered the Ressen Formation as being partly coeval with the lower part of the Nierental Formation. A series of more recent papers deals in particular with the depositional environment and the biostratigraphy of the Ressen Formation (e.g. Faupl, 1978; Faupl et al. 1987; Faupl & Wagreich, 1992a, b; Faupl & Wagreich, 2000; Kollmann & Summesberger, 1982; Wagreich, 1988; Švábenická et al., 2003).

Our paper is illustrated by a series of historic photos (Pl. 1, Fig. 1; Pl. 2; Anonymus, 1933).

Text-Fig. 1.
Topographic sketch of the area E of Gosau Mittertal village.
Arrow shows the grindstone quarry site.

Lithology and Palaeoenvironment of the Ressen Formation

Grey turbiditic ("flyschoid") sand- and siltstones with conglomeratic intercalations of the Ressen Formation, which are bedded in a cm–dm scale, represent the base of the Upper Gosau Subgroup, which earlier was called "deeper water Gosau" or – in its lower part – "flyschoid Gosau". The classical locality of the Ressen Formation is situated on the upper part of Mt. Ressen (also called Löckenmoosberg) in Gosau, Upper Austria. It is transgressively overlying a palaeokarst-relief of lagoonal Dachstein Limestone with an unconformity of 120 million years. Enormous quantities of clay and heavily weathered, angular broken mineral grains and – more scarcely – crystalline rock fragments were transported by turbidity currents from the mainland into proximal pelagic environments, where they formed the coarse mass flow and turbiditic sandstone/claystone submarine fan deposits of the Ressen Formation. According to Wagreich (2002) the turbidites thin out within a few kilometers to the NW. Therefore the Ressen Formation in the Hornspitz-Bibereck area does not show thick sandstone sequences as on Mt. Ressen, but is generally more finegrained, consisting predominantly of (marly) sand/siltstones and marls.

Thin-Sections of Ressen Siltstone

Two thin-sections were made from a finer grained and a coarser grained commercial grinding stone product of the Ressen siltstone:

1. Finer grained equigranular siltstone, mean grain-size 30–50 µm, some grains up to 1 mm.

Mineralogy: quartz, plagioclase, potash feldspar, muscovite, biotite (partially replaced by chlorite), chlorite, sparry calcite grains (partially twinned). Accessory minerals include zircon, tourmaline, rutile, apatite, pyrite, limonite, leucoxene. Quartz is often splintery, with aspect ratios up to 1:4.

2. Coarser grained equigranular fine-grained sandstone/siltstone, mean grainsize 100–175 µm.

The mineralogy of the clastic grains is similar to the siltstone of finer grain-size described before. In this sample, however, rock fragments can also be recognized: they include microsparitic carbonate clasts with finely disseminated black organic content, showing clear syntaxial border. Accessory minerals are also similar to the finer variety. In this thin section a zoned tourmaline was also observed. Beside some granitoid clasts (quartz + feldspar), different metamorphic rock-fragments occur: very fine-grained graphite-sericite schists, a clast of serpentinite, and of chloritoid-bearing schist. The cement is composed of clay minerals, microcrystalline quartz and carbonate.

Therefore the Gosau grindstone is an equigranular quartz rich sand-/siltstone (showing different mean grain-sizes), in which predominantly angular mineral grains are embedded in a tough clayey matrix.

Text-Fig. 2.
The “geognostic” map of the Gosau valley by August Emanuel Reuss (1854) shows location of grindstone quarries (“Schleifstein-Brüche Auf der Ressen”). In the legend marl and sandstone without fossils are mentioned.

Text-Fig. 3.
The photo by Friedrich Simony from the year 1886 shows one of the grindstone quarries (?or the only one at that time) in about 1300 m altitude.
Grindstone products are prepared for the transport in the valley (Gosau, 736 m).

Provenance of Ressen Siltstones

On the basis of thin section mineralogy the provenance area of Ressen sandstones and siltstones was built up by metamorphic, magmatic and sedimentary rocks.

The greatest contribution was supplied by metamorphic rocks. They include very-low-grade slates, siltstones and quartzites with sericite ± chlorite and generally show a high, finely disseminated organic content. A rock-fragment with very-low-grade characteristics contained also a chloritoid crystal. Coarser-grained muscovite and biotite micaschist fragments witness a subordinate greenschist facies contribution. Only one serpentinite grain was observed in the siltstone.

Magmatic rocks are represented by different, basic to acidic aphanitic to spherulitic devitrified volcanic groundmass fragments. Coarser-grained polycrystalline quartz and feldspar fragments originated from a granitoid source; or else they came from higher-grade metamorphic rocks.

Cherts and microsparitic carbonates are the sedimentary rock contributions. Both in sandstones and siltstones glauconite grains are evenly distributed, moreover coalified particles are also present. Organic components include very scarce foraminifers and echinoid fragments. The accessory minerals (zircon, tourmaline, rutile, apatite, pyrite, limonite, leucoxene) support the conclusions described before.

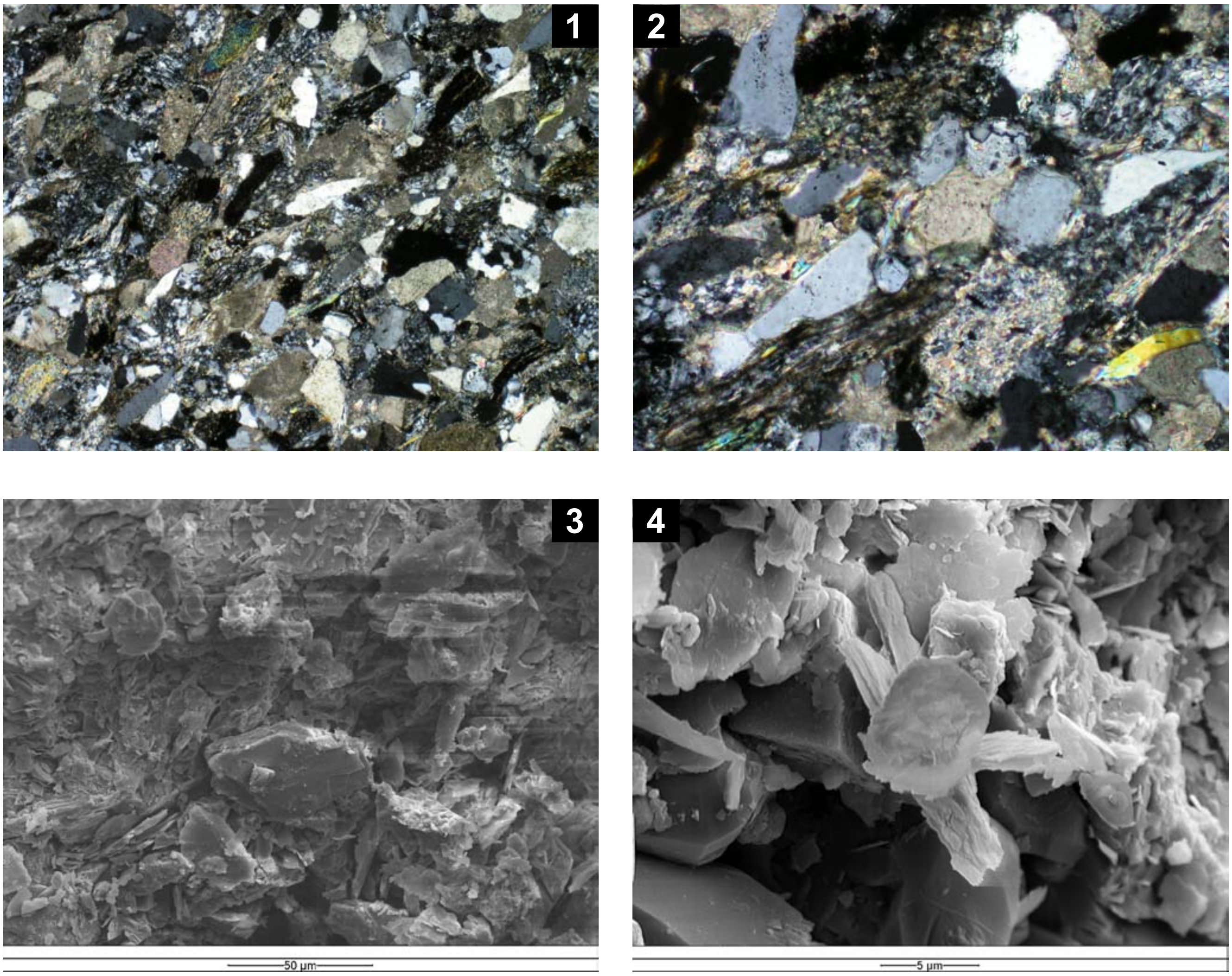
Why does the Gosau Grindstone grind so well?

So far we did not examine the grindstone by geotechnical methods. Therefore our interpretations are based only on petrological investigations in thin-sections and by SEM. The Gosau grindstone is a quartz rich sandstone known as Ressen Formation. The predominantly angular mineral grains are embedded in a tough matrix composed of clay minerals, microcrystalline quartz and carbonate (Text-Fig. 4). Rounded grains would scratch rather than grind, whereas the edges of angular grains regularly break away during grinding and polishing leaving the grinding function intact. Another important feature is a uniform grain size for each grindstone type. Angular mineral grains resulted from an especially long lasting weathering on the mainland. Caused by a rising sea level repeated marine transgressions transported tremendous amounts of intensively weathered sharp-edged mineral and rock debris via turbidity currents into deeper marine areas. Due to different specific weight and floating properties the material was separated into coarse, medium and fine grain sizes. Layers enriched in heavy minerals, sometimes breccias/conglomerates (Pl. 1, Fig. 3), are characteristic for the bottom of layers, while coaly plant debris often is spread on the bedding surfaces (Pl. 1, Fig. 2).

Ressen sandstone slabs of minor quality are used up to the present for the construction of local tourist trails (Text-Fig. 5).

The Schleifsteinbruch Caprocks (Upper Part of the Ressen Formation)

The Ressen Formation in the lower and middle part comprises a sequence of well bedded sandstones with soft and brittle fine-bedded (sandy) marl intercalations and conglomerates. On the bedding surfaces of the sandstones sometimes coalified plant debris (also small coal particles) can be observed. Except of scarce trace fos-



Text-Fig. 4: Petrology of Gosau-whetstones.
1: Thin-section of a commercial whetstone product (Ressen sandstone) showing angular mineral (mostly quartz) grains in a clayey matrix.
2: Thin-section of a commercial whetstone product (Ressen sandstone) showing angular mineral (mostly quartz) grains in a clayey matrix.
3: SEM micrograph of fine-grained Ressen sandstone (whetstone) showing angular mineral (mostly quartz) grains in a clayey matrix.
4: SEM micrograph of very fine-grained Ressen siltstone (whetstone) showing angular (mostly quartz) grains in a clayey matrix.

sils (*Planolites* s.l.) the sediments seem to be unfossiliferous. The sandstone of the grindstone quarry is overlain by well exposed caprocks of (sandy) marls. At present the basis of the grinding stone is not cropping out; however, Reuss (1854) mentions *"grey, thin-bedded sandy marls, which underlay the grinding stone"*.

List of Caprock Samples

Sample No. GO3: Marls overlying the sandstone in the grinding stone quarry (Schleifsteinbruch), which is quarried in small scale by Mr. Manfred Wallner.

Sample No. GO3A: brittle grey marls from the western part of the quarry;

Sample No. GO3B: soft, ochre weathered marls from the eastern part of the quarry.

Mineralogy

The bulk mineralogical composition of the two marl samples (Nos. GO3A/GO3B) from the top-set of the Schleifsteinbruch is rather homogenous. Calcite (12/24 mass-%) is present in moderate amounts, dolomite (7/4 mass-%) and feldspar (mostly plagioclase 5/8 mass-%) in rather low amounts. The predominant mineral group are the layer silicates (63/53 mass-%), which are represented mainly by muscovite and chlorite. Also traces of paragonite are present.

Also the clay mineralogical composition of samples Nos. GO3A/GO3B is quite homogenous. Illite (61/64 mass-%) predominates, chlorite (25/24 mass-%) can be found in moderate amounts, while smectite (11/10 mass-%) occurs in rather low quantities and kaolinite (3/2 mass-%) only in very low contents.

From the mineralogical composition it can be concluded, that the provenance region of the marls consisted of slightly metamorphic rocks rich in mica and chlorite.

Palaeontology and Biostratigraphy

Foraminifers

Above mentioned basal caprock sandy marls were washed for microfossils, however, despite of one poorly preserved specimen of the foraminifer *Ataxophragmium* in sample No. GO3A, no microfossils were found. This taxon is without any stratigraphic value (determination courtesy of Mrs. Lenka Hradecká, Czech Geological Survey, Prague).

Calcareous nannofossils

Sediments of samples Nos. GO3A, B provided very poor (1–3 specimens per 1 field of view of the microscope) and poorly preserved nannofossils. Placoliths are etched and mostly in fragments. Nannofossil assemblages contain rare specimens of *Lucianorhabdus cayeuxii* (both species A and B sensu WAGREICH, 1992) and rare specimens of *Broinsonia parca parca*. On rare occasions, *Rucinolithus hayi* and *Arkhangelskiella cymbiformis* are present. *Broinsonia parca parca* evidences zone UC14a (BURNETT, 1998), that is correlated with the lower part of Lower Campanian.

Concerning the Lower Campanian marker species *Broinsonia parca parca*, it is not easy to distinguish sometimes this subspecies from the other one of *Broinsonia parca expansa,* its first occurrence is mentioned from the uppermost Turonian (LEES, 2008). Probably transitional forms of *B. p. expansa-parca* were observed in sample No. GO3A. Unfortunately, their identification was problematical due to the poor preservation of specimens. Well identifiable specimens of *Broinsonia parca parca* were only found in sample GO3B. They show the following phenomena: 1. relatively large placolith, 2. broadly elliptical in outline, 3. broad outer rim, 4. approximately the same size of outer rim and central area in short axis of ellipsoid.

WAGREICH (1992) mentioned the first occurrence of *Lucianorhabdus cayeuxii* species B ("curved forms") within the upper part of the Santonian in the Lower Gosau Group of Austria.

Palynomorphs

Both marine microplankton and spore-pollen assemblages were studied. The preservation of most palynomorphs was rather poor and the quantity was low. Sample No. GO3B provided palynomorphs for biostratigraphical and palaeoecological evaluation.

The dinoflagellate cyst assemblage consists of *Spiniferites membranaceus* and of *Dinogymnium*, namely *Dinogymnium acuminatum* EVITT et al., *Dinogymnium denticulatum* (ALBERTI) EVITT et al., *Dinogymnium curvatum* (VOZZHENNIKOVA) LENTIN & WILLIAMS. *Dinogymnium denticulatum* was recorded so far from the Santonian and Campanian–Maastrichtian sections (EVITT et al., 1967).

Dinogymnium acuminatum was recorded from the Coniacian–Maastrichtian (WILLIAMS & BUJAK, 1985). *Odontochitina operculata* (O. WETZEL) DEFLANDRE & COOKSON also appears.

Pteridophyte spores consist of schizaeaceous forms – *Cicatricosisporites* sp. and *Plicatella* sp.

Triporate pollen from the Normapolles group are represented by *Minorpollis* sp., *Pseudoplicapollis* sp., *Oculopollis* cf. *principalis, Oculopollis* sp., *Interporopollenites* sp. and *Hungaropollis* sp. The dominance of *Oculopollis* pollen and the presence of *Hungaropollis* pollen correspond to the Late Santonian – Early Campanian age (GOCZÁN et al., 1967).

Rare redeposition of the Permian age (bisaccate pollen aff. *Lueckisporites* sp.) was observed (KLAUS, 1963; LESCHIK, 1956).

Text-Fig. 5.
Sandstone slabs are used up to the present for the construction of local tourist trails.

Palaeoecological Remarks

From the palaeoecological point of view, the presence of the dinoflagellate cyst of the genera *Odontochitina* and *Dinogymnium* reflects an environment with salinity fluctuations. The "flyschoid" sediments primarily were deposited in a shallow marine environment (MAY, 1977) and subsequently transported by turbidity currents into the open sea, where they form proximal fan deposits.

Acknowledgements

Mr. Manfred Wallner (Gosau) supported our study with representative grindstone-specimens. Field work was financed by the bilateral cooperation project between the Czech and Austrian Geological Surveys. This paper is a contribution to the Research program AV0Z30130516 of the Institute of Geology, v.v.i. AS CR. Study of calcareous nannofossils was carried out in the frame of the Research Goal of the Czech Geological Survey MZP0002579801. We thank Hans-Georg Krenmayr (Austrian Geological Survey, Vienna) for discussions of sedimentary structures and Helga Priewalder for SEM-investigations of selected grindstone samples. Historic photos provided by Robert Reiter & Siegfried Gamsjäger (both Gosau).

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Received: 13. September 2010, Accepted: 14. October 2010

Plate 1

Fig. 1: Contemporary grindstone quarry with 60 years old machines for grindstone cutting.

Fig. 2: Exposure of Ressen Formation along the forest road from Gosau Hintertal to the grindstone quarry. The sequence is dominated by sandstones and intercalated marls.

Fig. 3: Meter-thick conglomerate bed in proximal turbidites of the Ressen Formation along the forest road from Gosau Hintertal to the grindstone quarry.

Fig. 4: Bedding surface with spectacular loadcasted ripples in the Ressen Formation of the grindstone quarry (slab in property of Franz Fasl, Gosau).

Fig. 5: Drilling core of grindstone showing cross-bedded sandstone.

Fig. 6: Bedding plane of Ressen sandstone with coalified plant debris.

Fig. 7: Ressen sandstone with mineralized (?Fe/Mn) marl clasts.

Fig. 8: Ressen sandstone with mineralized (?Fe/Mn) marl clasts.

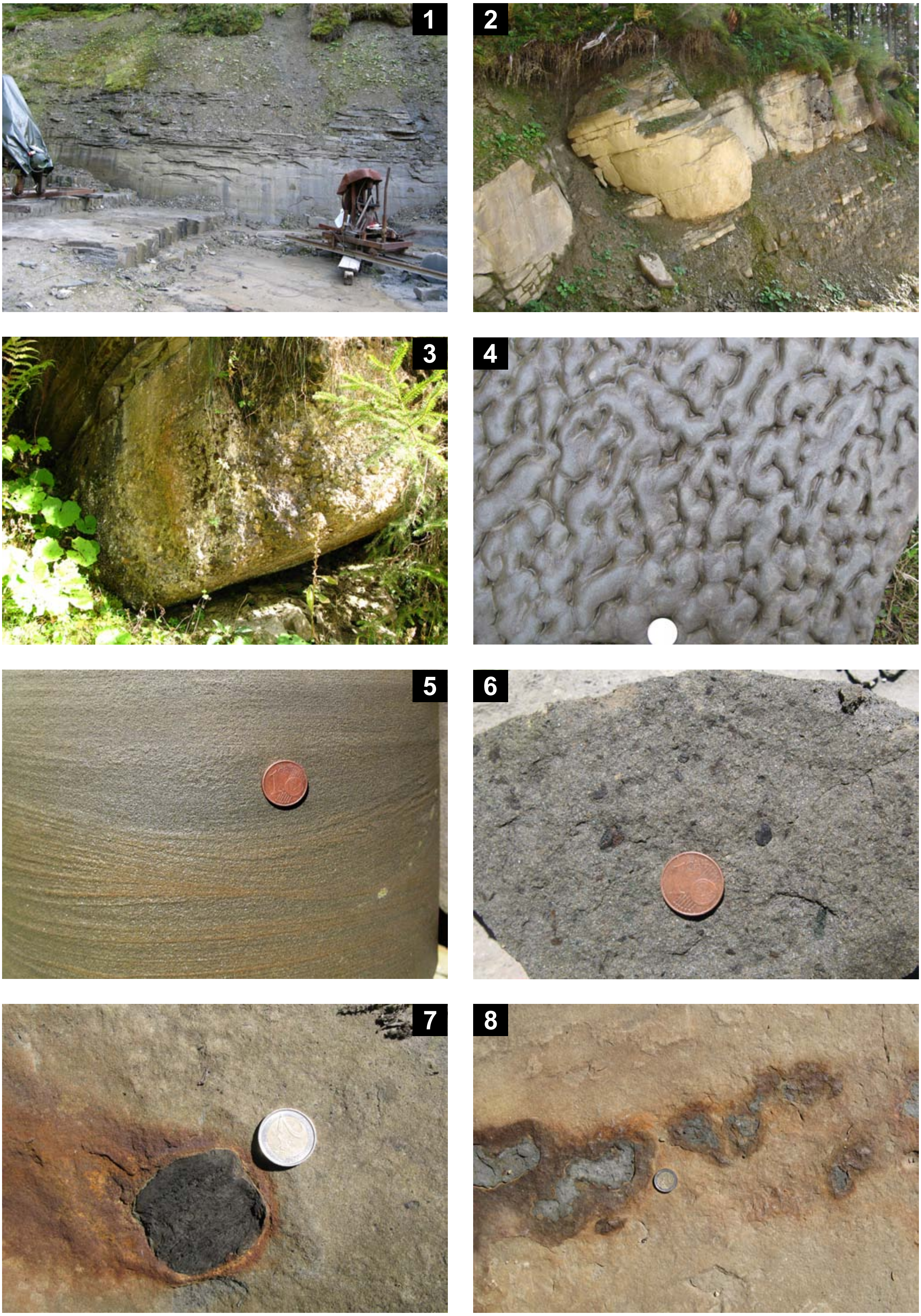
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Plate 2

Fig. 1: Traditional grindstone wheels for sharpening various tools.

Fig. 2: Group of workers proudly presenting a giant grindstone wheel in their quarry.
Note typical shelter and tools.

Fig. 3: Ten years later (1933) proud workers present a giant grindstone wheel, diameter 1.80 m, weight 2000 kg.

Fig. 4: Careful transport of the giant grindstone wheel on a sledge downhill August 4th, 1933.

Fig. 5: Various tools and equipment for grindstone mining (1933).

Fig. 6: Various larger tools and equipment in connection with grindstone mining (1933).

Fig. 7: Punching the grindstone wheel with the “Zweispitz” (double pointed hammer) in 1933.

Fig. 8: Washing the grindstone products before selling – a job for women (1933).


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