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The Early Miocene Lignite Deposit of Oberdorf N Voitsberg (Styria, Austria) | Editor: F.F. Steininger

Pyroclastic Deposits from the Middle Miocene Stallhofen Formation

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Styria
Pannonian Basin
Styrian Basin
Lignite
Middle Miocene
Pyroclastics

Österreichische Karte 1 : 50.000
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Pyroklastika aus der mittelmiozänen Stallhofen-Formation

Zusammenfassung

Das Kohle führende Unter-Miozän von Oberdorf/N Voitsberg wird von der Stallhofen-Formation (Mittel-Miozän) überlagert. Diese enthält in den basalen Anteilen rhyolithische, teilweise zu Bentonit alterierte Tuffe/Tuffite (Lobmingberg-Member). Die als Fallablagerungen interpretierten Tuffe/Tuffite werden petrographisch, geochemisch und granulometrisch charakterisiert und hinsichtlich ihrer Herkunft, Altersstellung, Eruptions- und Anreicherungsmechanismen diskutiert.

Abstract

The lignite deposits of Oberdorf opencast mine (Lower-Miocene) are overlain by the Stallhofen Formation (Middle Miocene) which includes tuffs/tuffites (Lobmingberg Member) in its basal parts. These rhyolitic tuffs are partly altered to bentonite and interpreted as subaqueous fallout tephra. They are characterized by their petrography, geochemistry, and granulometry and discussed according to their origin, stratigraphy as well as mechanisms of eruption and sedimentation.

1. Introduction

At Lobmingberg, west of the Chapel survey marker 611 at an elevation of 565 m, a rhyolitic tuff/tuffite is situated above a fine-grained, lacustrine/fluvial basal member of the Badenian (Middle Miocene) Stallhofen Formation. Parts of the volcanic glass are altered to bentonite (EBNER, 1981; EBNER & GRÄF, 1982; AIGNER et al., 1984). The tuff/tuffite forming one single layer (up to 480 cm thick) and dipping 3° to the east is defined as a lithostratigraphic member (Lobmingberg Member) of the Stallhofen Formation (EBNER & STINGL, this volume).

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2. Idealized Section Description

The tuff/tuffite was deposited on fine-grained, silty/sandy sediments of a low-energy fresh water environment with *Capaea* sp., *Pomatias gaali* (WENZ), and *Celtis lacunosa* (REUSS) (MAURIN, 1959). These sediments form a sharp contact with the tuff. The tuff has idiomorphic biotite platelets up to the mm range and when fresh the tuff is dirty-gray but dries to a chalky-white appearance with desiccation cracks. The bottom 60 cm are free from any sedimentary contamination and distinguished by numerous layers of ellipsoid to round accretionary lapilli (∅ 2–4 mm; lapilli tuff). This is overlain by up to 420 cm of reworked tuff/tuffite containing more or less large quantities of sand with components of metamorphic origin (reworked tuff/tuffite). Significantly, the base of the lapilli tuff from several to as much as 60 cm is altered to a dense green-gray bentonite (basal bentonite). Even in this bentonite, the altered ghost remnants of the accretionary lapilli are observable.

The boundary between the lapilli tuff and the reworked tuffs is a bedding plane marked by occasional load casts. In the underlying lapilli tuff, burrows (∅ up to 3 cm) are present. Where coarser sediments are present in the reworked tuff/tuffite, graded bedding can be observed.

The reworked tuff/tuffite has a continuous transition to the overlying gray-green, silty sediments, or it is truncated along an erosional surface and overlain by poorly sorted sandy gravels. Generally, in sections with fine clastic material the tuff/tuffite is thicker than in sections with an erosional surface followed by gravels.

3. Type Section: Lobmingberg Member

Major features of the petrography, granulometry, and geochemistry of the tuff/tuffite at the type section of the Lobmingberg Member (west of the chapel by survey marker 611) are documented in Text-Fig. 1.

The petrography of components of the lapilli tuff is defined by volcanic glass, clay alteration products of the glass, magmatic phenocrysts, and accretionary lapilli. In the tuff/tuffite, where accretionary lapilli are totally absent, additional sedimentary material is present.

The content of volcanic glass can be as high as 80 %. The glass component is clear/transparent to whitish/dull and with grain sizes up to 0.3 mm. In morphology, the glass components contain coarse, thick-walled glass shards (length/thickness 5 : 1 to 10 : 1) partly altered to clay, shard fragments, and highly vesicular shards. The "rim type" accretionary lapilli (SCHUMACHER, 1988) are composed of the finest glass and clay material. In the basal bentonite, examination by x-ray diffractometric methods revealed no significant quantities of glass.The idio- to hypidiomorphic phenocrysts are sometimes aggregated with glass, and occasionally they contain glass and glass/gas inclusions. The following mineral species were identified as phenocrysts: kaersutitic hornblende, pyroxene (hypersthene), biotite, rutile, ilmenite, magnetite, apatite, zircon, orthite, quartz (pseudomorphs after beta-quartz), plagioclase, and sanidine. The dominant minerals are plagioclase, biotite, and hypersthene. Sometimes, the ends of the hypersthene and hornblende crystals are etched.

Among the clay minerals, expandable clay minerals are dominant. Illite, muscovite and occasional traces of kaolinite are without quantitative significance. The expandable clay minerals are dioctahedral and have essentially a smectitic character with alternating contents of non expandable illitic and chloritic layers (interstratified minerals). The purest smectite was found at the top (Text-Fig. 1: 21) of the reworked tuffite. In the basal bentonite more than 90 % of the x-ray crystalline material is represented by clay minerals (smectite-rich interstratified minerals).

The components from the metamorphic source area include rounded rock fragments (gneiss and micaschist) and minerals which are especially concentrated to the coarser grain-size fraction of the reworked tuff/tuffite. The light minerals include undulatory extinguishing quartz (as the principal component in the upper part of the reworked tuff/tuffite) and muscovite. Fluvially transported heavy minerals include garnet, zoisite, kyanite, epidote, titanite, rutile, green hornblende, and apatite.

Heavy minerals deriving from a metamorphic hinterland (Austroalpine crystalline) can be found in the clastic basal sediments and the reworked tuff/tuffite. For the lapilli tuff, the heavy mineral assemblage is characterized by magmatic phenocrysts. The index minerals for sediment contamination include garnet ($>$50 %), zoisite ($>$20 %), epidote, kyanite, and green hornblende. There are also some other minerals present which are classified as a "mixed" assemblage in Text-Fig. 1. Their source area could be two-fold, either magmatic or metamorphic, and can be only recognized by the habit of the minerals. These minerals are not suitable for discriminating between primary and reworked tuff.

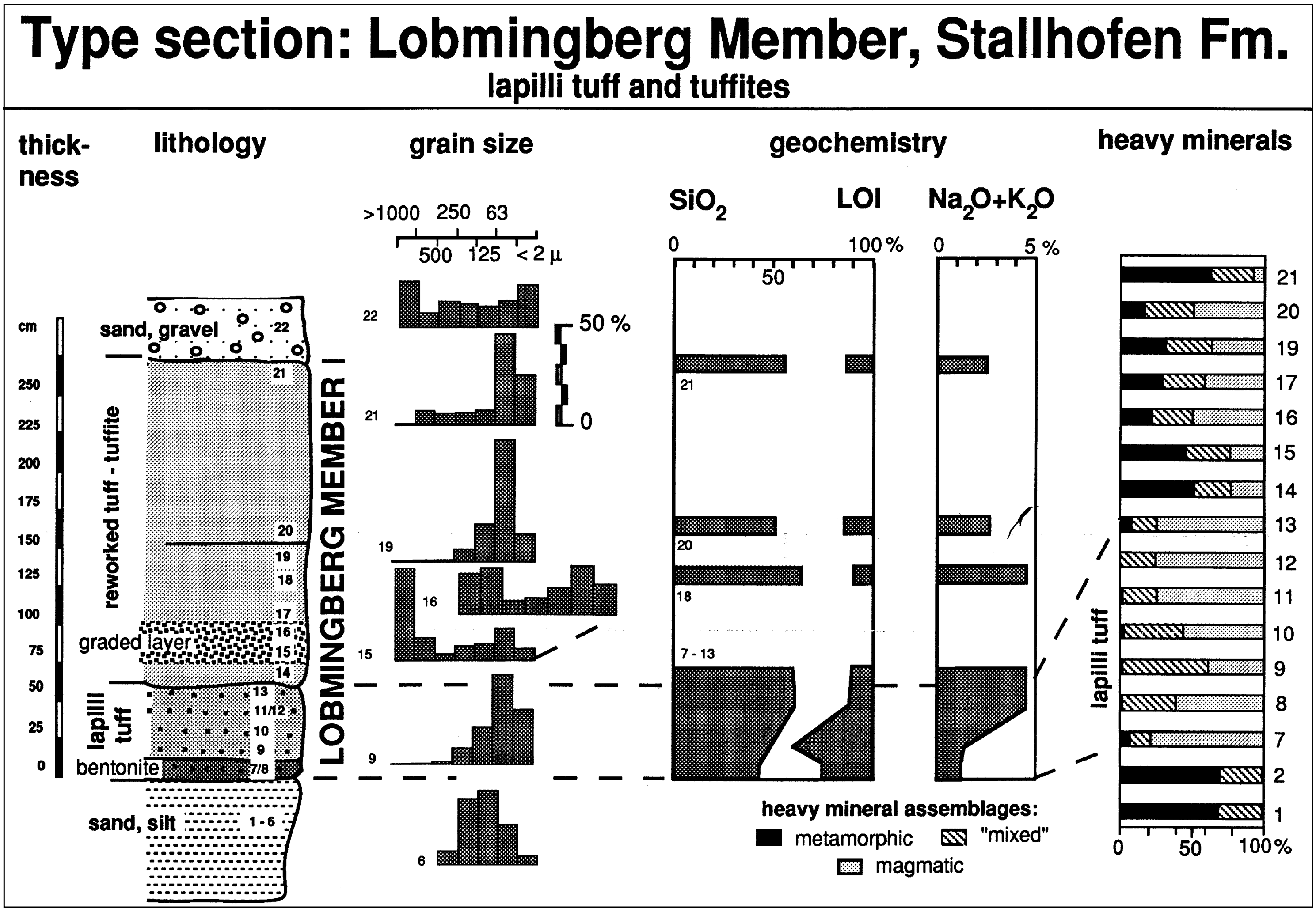
The rock preparation for grain size analysis used a high-voltage, electric-pulse disintegrator. Therefore, the measured distribution does not absolutely correspond to those of the ash cloud, because welded aggregates and accretionary lapilli could be (partly) broken and further postdepositional bentonitization was accompanied by decreasing grain size.

In the present study, 60–85 % of the components of the lapilli tuff are $<63\mu$m with the clay component comprising 16–38 % (normalized with round quartz grains, and measured in a Lumosed particle analyser). Portions greater than 0.25 mm are very rare. In the reworked tuff/tuffite, the degree of sedimentary contamination is expressed by the portions larger than 125 μm. At the base of a graded portion of the reworked tuffite (Fig. 1: 15, 16) the proportion of grains $>$1 mm is 47–68 %. Above this layer fine grained material of variable sedimentary contamination increases to the top of the type section. At the start of the following sandy gravels materials $<$63 μm are already present in high proportions (35 % in Text-Fig. 1: 22).

The geochemistry of the tuff/tuffite is controlled by strong alteration, sediment contamination, and fractionation by aeolian transport. Therefore the bulk composition is not suitable for indicating the source area of the tuff.

The SiO_2 content of the lapilli tuff (by LOI from 10–34 %) is between 47 and 63 %. Electron microprobe analysis of isolated glass components gave a result of 71 to 79 %. The glass inclusions in hypersthene and hornblende had a SiO_2 content of 69 %.

The chemical analyses of the primary and trace elements were determined for the bulk rock samples as well as three size fractions: $<$6.3 μm, 6.3–20 μm, and 20–63 μm that were split from the samples. This was done to determine if a variance in the geochemical composition could be detected. Si, Mn, Na, Ti, Sr, Y, Sc, Zr, V, Co, Rb, Nb, Sn, Cs, Eu, Hf, Tl, and U correlated weakly to strongly positive (R $>$0,2) with grain size; Fe, Ca, LOI, Ni, Cu, Zn, Mo, Sb, Ta, Pb, Bi, and Th weakly to strongly negative



Text-Fig. 1.
Type section of the Lobmingberg Member.

(R <–0.2), and Al, Mg, P, Ba, Cr, Ga, La, Ce, Pr, Nd, Sm, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, and W having no correlation (–0.2 < R < 0.2).

Age dating of biotite phenocrystals was attempted by W. FRANK (Geochronology Laboratory, University of Vienna). The gas analysis determined that the biotite had lost as much and possibly more than 80 % of the original K content; further they are strongly exfoliated, and hydrated. Under these circumstances, neither the Ar/Ar- nor the K/Ar technique was applicable. Electron microprobe analysis from biotite revealed strong alteration through the depletion of K, Fe, Mg and an enrichment of Si, Al, OH.

4. Interpretation and Discussion of the Results

The tuff/tuffite is a lithostratigraphic member (Lobmingberg Member) of the Stallhofen Formation (EBNER & STINGL, this volume). Dating with Karpathian/Badenian is only possible through indirect means by the regional geologic setting and only then appropriate if the tuff actually can be demonstrated to derive from the Styrian volcanic region (EBNER, 1981; EBNER & SACHSENHOFER, 1991, 1995; BALOGH et al., 1995). The paleomagnetic directions from the tuff corresponds to the framework of the statistical variance for the direction of the east Oberdorf basin (MAURITSCH & SCHOLGER, this volume).

The depositional environment of the tuff/tuffite was a lacustrine/fluvial system with changing water energies. The very sharp boundary over the clayey silts, the layers of the accretionary lapilli, and bioturbation indicate that the lapilli tuff was deposited as primary fallout in a quiet water environment (subaqueous subaerial fallout tephra, FISHER & SCHMINCKE, 1984) of a constant thickness of 60 cm in the actual compacted condition.

The morphometry of the accretionary "rim-type" lapilli indicates, according to SCHUMACHER & SCHMINCKE (1991), surge to co-surge deposition. Taking into account the absence of typical textural features and field observations, and the regional geologic setting the above interpretation is not supported.

In the reworked tuff/tuffite primary tuffaceous material was transported/reworked together with sedimentary material. The source area for the sediment materials was the Austroalpine crystalline in the hinterland of the Voitsberg/Köflach embayment. The varying thickness of the reworked tuff/tuffite (60–420 cm) is caused by differences in current velocities that explain the depositional and erosional phases.

The origin of the tuff is up to now unexplained. The tuff was derived from K-rich magmas of trachyandesitic, dacitic, and rhyolitic composition. In the Styrian basin, the bulk chemistry corresponds only to the rhyolite at Schaufelgraben – Gleichenberg. Nevertheless, the composition of the phenocrysts has very great differences to Miocene Styrian volcanics.

Geochemical, petrographic, and field observations point to a single volcanic event. Highly vesicular shards and pumice fragments as well as bubble wall shards point to a magmatic explosion. Some blocky and poorly vesicular shards are evidence for a hydromagmatic pulse/interaction during the eruption.

The expandable clays (bentonite) are alteration products of the volcanic glasses. Geochemically, the alteration represents a decrease of SiO_2, alkali elements, and the increase in Al_2O_3, MgO, and LOI. This trend is seen in all of the grain size fractions split from samples from coarser to finer fractions. A measure for the degree of alteration is the LOI with a corresponding decrease of Si, Na, K, Ba, Rb, Cs and U as well as a corresponding increase in the Mg and Fe content as reported by FISHER & SCHMINCKE (1984: Fig. 12–22) and HÖLLER et al. (1976).

In order to develop a tephrochronology of Tertiary tuffs only the following methods would be effective if radiometric dating is not working: geochemistry of elements which do not correspond to grain size fractions, the study of phenocrysts, the scanning electron characterization of pyroclastic particles in thin sections or 3D as well as the morphometry and composition of accretionary lapilli.

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References

AIGNER, H., EBNER, F. & Ch. SCHMID (1984): Methoden zur Substanzschätzung am Beispiel ausgewählter Bentonit- und Glastuffvorkommen in der Steiermark. – Arch. Lagerst.forsch. Geol. B.-A., **5**, 7–14, Wien.

BALOGH, K., EBNER, F. & C. RAVASZ (1994): K/Ar-Alter tertiärer Vulkanite der südöstlichen Steiermark und des südlichen Burgenlandes. – Jubiläumsschrift 20 Jahre Geol. Zusammenarbeit Österreich-Ungarn, Teil 2, 55–72, Wien.

EBNER, F. (1981): Vulkanische Tuffe im Miozän der Steiermark. – Mitt. naturwiss. Ver. Stmk., **111**, 39–55, Graz.

EBNER, F. & W. GRÄF (1982): Bentonite und Glastuffe der Steiermark. – Arch. Lagerst.forsch. Geol. B.-A., **2**, 31–45, Wien.

EBNER, F. & R.F. SACHSENHOFER (1991): Die Entwicklungsgeschichte des Steirischen Tertiärbeckens. – Mitt. Abt. Geol. Paläont. Landesmus. Joanneum, **49**, 96 S., Graz.

EBNER, F. & R.F. SACHSENHOFER (1995): Paleogeography, subsidence and thermal history of the Neogene Styrian basin (Pannonian basin system, Austria). – Tectonophysics, **242**, 133–150, Amsterdam.

EBNER, F. & STINGL, K. (1998, this volume): Geological Frame and Position of the Early Miocene Lignite Opencast Mine Oberdorf (N Voitsberg, Styria, Austria). – In: STEININGER, F.F. (ed.): The Early Miocene Lignite Deposit of Oberdorf N Voitsberg (Styria, Austria), Jb. Geol. B.-A., **140**/4, 403–406, Wien.

FISHER, R.V. & H.-U. SCHMINCKE (1984): Pyroclastic rocks. – 422 p., Berlin – Heidelberg – New York – Tokyo (Springer).

HÖLLER, H., KOLMER, H. & U. WIRSCHING (1976): Chemische Untersuchungen der Umwandlung glasiger Tuffe in Montmorillonit- und Kaolinit-Minerale. – N. Jb. Miner. Mh., **1976**, 456–466, Stuttgart.

MAURIN, V. (1959): Aufnahmsbericht 1958 über Blatt Köflach-Voitsberg (1:10.000). – Verh. Geol. B.-A., **1959**, 223–226, Wien.

MAURITSCH, H.J. & SCHOLGER, R. (1998, this volume): Palaeomagnetism and Magnetostratigraphy from the Early Miocene Lignite Opencast Mine Oberdorf (N Voitsberg, Styria, Austria). – In: STEININGER, F.F. (ed.): The Early Miocene Lignite Deposit of Oberdorf N Voitsberg (Styria, Austria), Jb. Geol. B.-A., **140**/4, 429–432, Wien.

SCHUMACHER, R. & H.-U. SCHMINCKE (1981): Internal structure and occurrence of accretionary lapilli – a case study at Laacher See Volcano. – Bull. Volcanol., **53**, 612–634.

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