ACTA UNIVERSITATIS SZEGEDIENSIS

ACTA
MINERALOGICA-PETROGRAPHICA

FIELD GUIDE SERIES

Volume 11 **Szeged, 2010**

ANDREA MINDSZENTY

Bauxite deposits of Gánt (Vértes Hills, Hungary)

20th General Meeting of IMA · Budapest, 21–27 August, 2010

IMA2010 FIELD TRIP GUIDE HU3

Published by the Department of Mineralogy, Geochemistry and Petrology, University of Szeged

ACTA MINERALOGICA-PETROGRAPHICA
established in 1923

FIELD GUIDE SERIES

HU ISSN 0324-6523
HU ISSN 2061-9766

Editor-In-Chief
Elemér Pál-Molnár
University of Szeged, Szeged, Hungary
E-mail: palm@geo.u-szeged.hu

Guest Editor of this Volume
Gábor Papp
Hungarian Natural History Museum, Budapest, Hungary
E-mail: pappmin@ludens.elte.hu

This volume was published for the
375th anniversary of the
Eötvös Loránd University, Budapest.

EÖTVÖS UNIVERSITY PRESS

The publication was co-sponsored by the
Eötvös University Press Ltd., Budapest.

IMA2010 (www.ima2010.hu) is organised in the frame of the ELTE375 scientific celebration activities.

Editorial Office Manager
Anikó Batki
University of Szeged, Szeged, Hungary
E-mail: batki@geo.u-szeged.hu

Editorial Address
H-6701 Szeged, Hungary
P.O. Box 651
E-mail: asviroda@geo.u-szeged.hu

The Acta Mineralogica-Petrographica is published by the Department of Mineralogy, Geochemistry and Petrology, University of Szeged, Szeged, Hungary

ISBN 978-963-306-043-8

On the cover: View of the major boundary fault of the Bagolyhegy open pit, Gánt, Hungary.
Photo: Andrea Mindszenty.

ACTA Mineralogica Petrographica

ACTA MINERALOGICA-PETROGRAPHICA, FIELD GUIDE SERIES, VOL. 11, PP. 1–11.

Bauxite deposits of Gánt (Vértes Hills, Hungary)

ANDREA MINDSZENTY[1]

[1] Department of Physical and Applied Geology, Eötvös L. University, Pázmány Péter sétány 1/C, Budapest, H-1117 Hungary; andrea@iris.geobio.elte.hu

Table of contents

1. Introduction to bauxite geology

Bauxites are products of subaerial chemical weathering formed under humid tropical to subtropical conditions and characterized by residual concentrations of hydrous Al, Fe, and Ti. They may be associated with weathering crusts developed in the Intertropical Zone on the surface of silicate rocks (= **lateritic bauxites**), or may occur as more or less continuous, mainly redeposited, soil-like blankets covering the karstified surface of carbonate rocks (= **karst bauxites**) (Bárdossy, 1982; Bárdossy & Aleva, 1990).

For a long time bauxites were considered as mineral raw materials only, and were treated accordingly. The first isolated attempts to consider bauxites as ordinary sedimentary rocks date back to the 1960s and concern mainly those called “karst bauxites”. The latest comprehensive review of karst bauxite sedimentology was published by D’Argenio & Mindszenty (1995).

Karst bauxites occurring in otherwise continuous carbonate successions indicate periods of subaerial exposure and humid tropical climate. They can also provide detailed (local, regional and global) paleoenvironmental information about those periods which, because of non-deposition or erosion, are not represented by marine sediments (~ unconformity- or disconformity-related “lacunae”).

Most authors agree that the **source material** of karst-related bauxites is polygenetic. Any igneous, metamorphic, ophiolitic or sedimentary rock, exposed to humid tropical conditions, provides ferrallitic weathering products that may be converted to bauxite when transported to a karst terrain by surface waters or wind, and perhaps mixed with pyroclastics plus residue from *in situ* weathering of carbonate rocks. Bauxitization may begin already during the transport of the weathered material and continue after deposition. Bauxitization tends to conceal primary depositional structures, due to substantial geochemical/textural changes. However, the karstic environment, because of its particular topography, provides for repeated reworking and short-range (so called *parautochthonous*) transport of the unconsolidated sediment, resulting in textures resembling those brought about by primary depositional processes. Clear distinction of the two is not always possible, and along with the careful study of the bauxite itself, may also require other pertinent geological information to be considered.

Based on the intensity of post-depositional bauxitization, deposits can be qualified as predominantly autochthonous or allochthonous.

In bauxite geology **allochthony** means that the sediment was bauxitized elsewhere and was deposited on its present site after considerable fluvial or mass-movement type transport (Nicolas & Lecolle, 1968; Nicolas, 1970; Valeton, 1972, 1991; Combes, 1984, 1990). **Autochthony** on the other hand means that the prebauxitic material was bauxitized in situ as a result of processes similar to **ferrallitization**. This early bauxitization may have been interrupted or not by recurrent (local) small scale (dm to cm) mechanical transport (= parautochthonous redeposition) resulted/accompanied by sheet-wash, soil-creep, little slumps or other small-scale mass-movements on the dissected karst terrain. Autochthony therefore does not necessarily mean that the prebauxitic material is, in itself, exclusively of local origin (*i.e.*; dissolution residue of the bedrock). On the contrary, in most cases there is ample evidence that the prebauxitic material was brought to the karst terrain by wind or water-induced transportation (Nicolas & Lecolle, 1968; Nicolas, 1970; Bárdossy *et al.*, 1977; Mindszenty, 1983; Mindszenty *et al.*, 1988, 1991).

Autochthony is thought to be indicated texturally by in situ seggregational or accretional ooids (the outernmost crusts of which show a gradual transition towards the surrounding matrix). Non-spherical grains are mainly intraclasts in this group. Matrix and ooids/intraclasts are of identical **geochemical facies** (see explanation below). In the case of mudstone-type (or pelitomorphic) bauxites, autochthony can not be recognized on the basis of texture alone. Autochthony on the large scale is reflected by the regular pattern of alumina-enrichment within the deposit (high-alumina bauxite occurring as a rule at places of optimum paleodrainage within the karstic sinkhole (Nia, 1967; Balkay, 1973; Valeton, 1976; Bárdossy, 1982).

Allochthony on the other hand is shown by a generally high diversity of ooids/pisoids and clastic grains (which all have abrupt contacts toward the surrounding matrix), by the presence of bauxite pebbles and by the capriciously changing grade of the ore within the deposit. Very frequently the geochemical facies of ooids and pisoids varies and is markedly different from that of the matrix. Among the non-spherical grains non-bauxitic extraclasts also occur in this group. The pattern of alumina enrichment is irregular within the deposit; large-scale cross stratification, graded bedding *etc.* may be apparent on the macroscopic and microscopic scale.

Parautochthony (Komlóssy, 1967; Bonte, 1970; Bárdossy, 1982) or "*allochtonie relatif*" (sensu Combes, 1990) is characterized by an apparently clastic texture (with abundant intraclasts), but also with clear signs of in situ formed textural elements (faint accretion rims around intraclasts, *etc.*) and commonly with a regular pattern of alumina-enrichment on the large scale. There may or may not be a difference between the geochemical facies of matrix and grains. Stratification, if exists at all, occurs on the microscopical scale only.

As pointed out recently by Valeton (1991), allochthony-autochthony-parautochthony are not absolute categories. To qualify a given deposit needs careful study and it is always the predominant characters on the basis of which we may decide whether the bauxite is allochthonous rather than just parautochthonous. Within one and the same deposit there may be parts exhibiting clear signs of autochthony alternating with undoubtedly allochthonous parts. Recognition of the areal distribution of predominantly allochthonous and autochthonous lithotypes may in fact help to understand the sometimes not at all simple story recorded by a given deposit (Combes, 1984; Mindszenty, 1983, 1984, 1991).

Mineralogy and geochemistry of karst bauxites faithfully record the redox conditions of the depositional environment. Since redox conditions are principally controlled by the relative position of the paleo-groundwater table (high water table → stagnant groundwater, reducing conditions; low water table → unobstructed drainage, oxidizing conditions) karst bauxites are excellent paleotopographic indicators

The geochemistry of the depositional/diagenetic environment of bauxite formation can be characterized at its extremes as "vadose" and "phreatic" (Fig. 1). **Vadose bauxites** deposited high above the groundwater table, are characterized by equally oxidized nature of matrix and ooids/intraclasts and by predominant hematite and/or goethite as primary iron minerals accompanied by gibbsite and/or boehmite. They are rich in "bauxitophilic" trace elements like V, Co, Ni, Cr, Zr and in some cases also in REEs, which are preferentially concentrated at the bottom of the vertical profile.

Phreatic bauxites, on the contrary, have a less oxidized (or even reduced), pale-coloured matrix, poor in trivalent iron, sometimes accompanied by likewise pale ooids and/or intraclasts. Their main iron minerals are goethite, siderite and/or pyrite, with or without chlorite (mainly chamosite) accompanied by diaspore and/or boehmite as alumina minerals. They may also contain recognizable traces of more or less decayed plant material. Chemical analyses show that phreatic bauxites have a characteristically weak trace element "signal", and no regular distribution of the trace elements can be observed in the vertical profile either.

Recent research shows that depositional and diagenetic facies are not necessarily identical. Bauxites deposited in

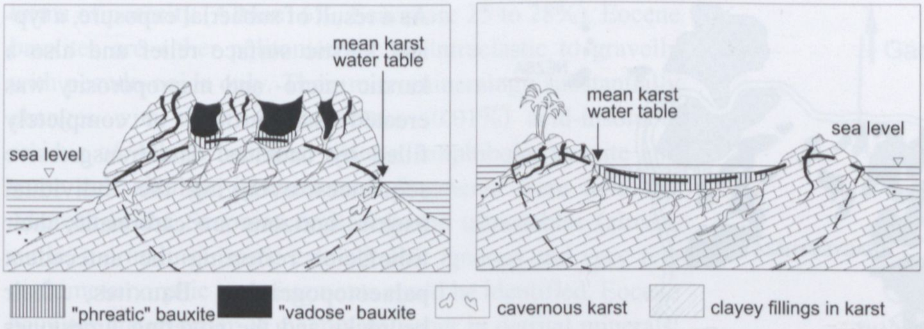


Fig. 1. Cartoon showing the difference between vadose and phreatic bauxites.

vadose facies under conditions of free drainage may become subject to phreatic conditions (impeded drainage) during and after incipient burial and may therefore be altered mineralogically and geochemically. The response to the changing conditions seems to depend on the degree of lithification (*i.e.* irreversible mineralization) the sediment attained before burial.

Textures/structures of bauxites and the geometry of the karst morphology they fill, may also be informative in the context of the paleorelief. Bauxites found in deep sinkholes of high-level karst terrains, are mainly characterized by *in situ* formed textural elements, whereas those occurring in shallow topographic depressions of low-level karst terrains, may be rich in coarse (pebble-size) transported grains and often show large-scale crossbedding and other sedimentary structures which clearly show that prior to deposition the sediment was subject to considerable transport.

Detailed studies of several karst bauxite deposits showed that there was a close correlation between the geochemical and lithological facies of bauxites and the karst morphology they were associated with. Vadose bauxites are generally characterized by the predominance of autochthonous/parautochthonous textures and often fill sinkholes of considerable depth, whereas those qualified as phreatic by their mineralogy and geochemistry, often show allochthonous textures and fill a shallow karst relief. The reason for the correlation is obviously the fact that both the geochemistry of the depositional environment and the character of the karst features are essentially controlled by the position of the karst surface as related to the karstic water table: deep vadose karst facilitates early diagenetic processes to take place under conditions of free drainage resulting in vadose bauxites. This is possible only when the depositional environment is situated sufficiently high above the water table. On the contrary, shallow karst relief is expected to form close to the water table where impeded drainage results in the formation of phreatic bauxites.

It follows from the above that **depositional** and **diagenetic facies** are in fact closely related. Bauxites having been deposited in a close-to-phreatic environment are more likely to contain abundant organic matter because the lack of oxygen slows down the otherwise rapid destruction of plant detritus even under tropical conditions. Therefore, much more than their "vadose" counterparts, they are likely to be altered during burial and reflect late-diagenetic phreatic environments (loss of trivalent iron, sideritization or pyritization)

It is this correlation between lithofacies, underlying karst morphology and the paleoposition of the depositional environment (as related to the karstic water table) which makes bauxites so useful in the reconstruction of paleorelief.

Detailed studies proved that these principles can usefully be applied when trying to reconstruct the conditions of bauxite formation. **Paleogeomorphological reconstructions** of bauxitiferous terrains on the regional scale show that the lithological/geochemical facies of bauxites, when combined with the type of the underlying karst morphology, may reveal information about the relative paleo-altitude of larger crustal segments as well.

Paleogeographic reconstructions can be refined considerably by detailed studies of selected bauxite deposits when paying particular attention to (i) the lithofacies of the immediate bedrock/cover and (ii) the nature of the underlying karst. Syn- to postdepositional tectonic events, otherwise possibly overlooked, can be postulated, and in many cases the "empty" stratigraphic gap can be "filled" by a sequence of climatic and/or tectonic events otherwise not even suspected.

Micromineralogical studies have shown that the HCl-insoluble residue of bauxites can provide information also about the geology of the surrounding non-carbonate terraines and thus can be used to monitor the denudation history of adjacent exposed areas

Plate-tectonics scale reconstructions of the paleorelief/ paleogeography of bauxitiferous regions show that bauxites, in addition to their obvious economic merit, have quite a lot to offer to sedimentary geology and tectonics as well.

2. Karst bauxites in Hungary

Hungary's Transdanubian Central Range (TCR) is well known for its Cretaceous–Early Tertiary bauxites (Fig. 2), which for a long time have been considered among the most important mineral resources of Hungary. They belong to the group of karst bauxites (overyling karstified carbonate rocks) and occur at major regional unconformities of Albian, Turonian/Senonian and early Eocene age.

All three bauxite events have traditionally been considered as having been introduced by (tectonically controlled) uplift and followed likewise by tectonically controlled subsidence and the concommittant relative sea-level rise.

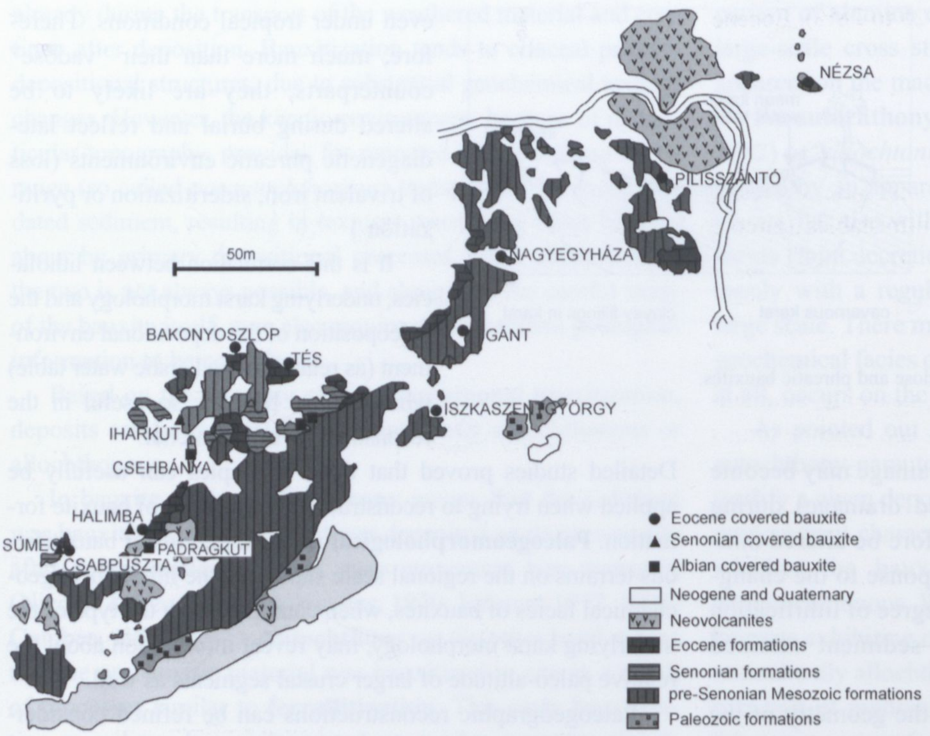


Fig. 2. Bauxite deposits in the Transdanubian Central Range.

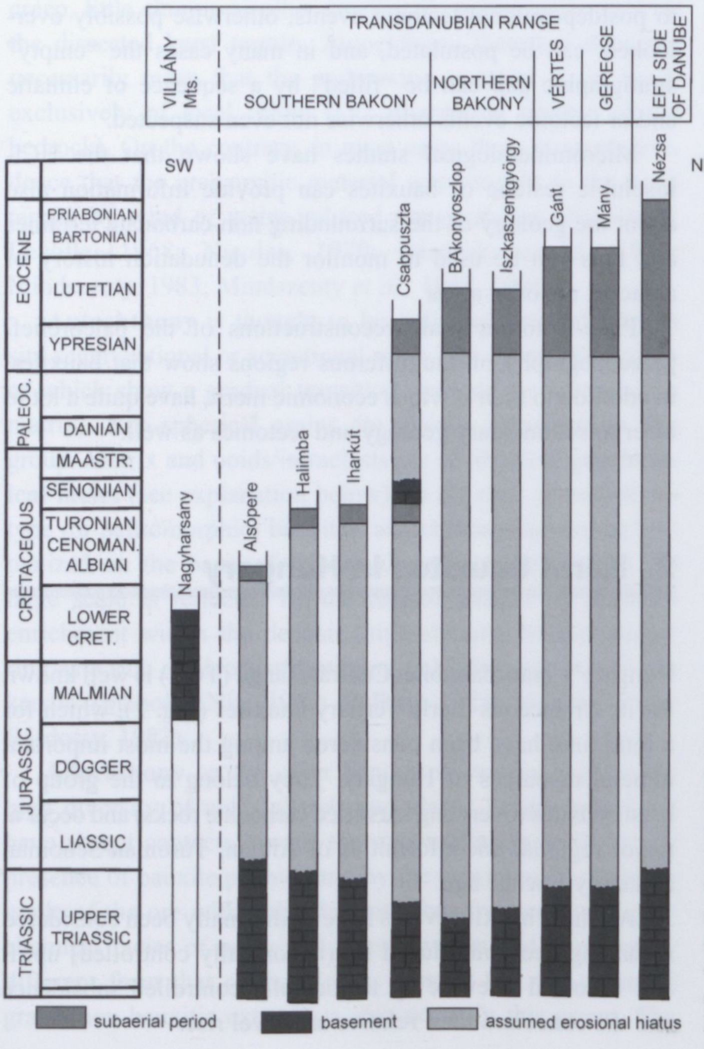


Fig. 3. Stratigraphic position of karst bauxites occurring at major regional unconformities in the Transdanubian Central Range (TCR) and in South Hungary (Villány) (stratigraphy of the Eocene coverbeds after Nagymarosy & Báldi-Beke (1988).

As a result of subaerial exposure, a typical karstic surface relief and also a karstic micro- and macroporosity was created and partially or completely filled by bauxites. The transgressive sequences overlying the individual bauxite horizons are carbonatic, their lithofacies reflecting the antecedent palaeotopography. Bauxites, their bedrocks and the covering limestones have been studied in detail by generations of geologists, mainly from the stratigraphical, sedimentological and economic geological points of view (Vadász, 1951; Balkay, 1966; Bárdossy, 1961, 1980; Szantner & Szabó, 1969; Szőts, 1953). To correlate bauxites with the structural evolution of the Transdanubian Central Range was attempted by Vadász (1951), Dudich & Komlóssy (1969), Szantner *et al.* (1986). More recently, based on an integrated study of bauxites, their associated bedrocks and the early diagenetic features of their cover, Mindszenty (1994) and Mindszenty *et al.* (2000) attempted to incroporate bauxites into the currently available paleogeodynamic reconstructions. They concluded that the observed distribution of bauxites in the TCR is in accordance with the foreland-type deformation controlling Cretaceous and partly also Eocene deformation of the area, put forward by Tari (1994). In this context, Cretaceous bauxites can be considered as weathering products formed and partly redeposited on the apex and the flanks of a migrating gentle forebulge, in the Senonian already involved in thrusting. In the Eocene, the geodynamic scenario seems to have changed inasmuch as the morphology of the deposits shows the imprints of large-scale strike-slip movements, probably related to the beginnings of the "escape" of the Transdanubian Range from its original East-Alpine position (Kázmér & Kovács, 1985).

Lithofacies and micromineralogy of the three bauxite horizons (Fig. 3) are different. Albian and Senonian bauxites, though both displaying distinct oolitic-pisolitic textures are different in terms of porosity (Albian: 6%, Senonian: 25 to 28%). Eocene bauxites are either pelitomorphic or intraclastic to gravelly with pesudo-ooids only. Their micromineralogy substantially changes with time: in the scarce (0.01%) acid-insoluble residue of Albian bauxites, titanite, amphibole, kyanite and some calc-alkaline igneous rock fragments were detected, whereas in the Senonian ones only the ultrastables (zircon, rutile, tourmaline), some calc-alkaline igneous and very few anchimetamorphic rock fragments could be identified. Eocene bauxites are an order of magnitude richer in detrital minerals, in addition to the ultrastables, they abound in higher metamorphic minerals and rock fragments (garnet, staurolite, sillimanite, kyanite) euhedral volcanogenic zircon and ilmenite grains and even some volcanic rock fragments of trachytic texture were identified in them. Zircon grains were fission-track dated as Eocene by Dunkl (1992) pointing to contemporaneous volcanic activity contributing to the pre-bauxitic material.

3. Gánt bauxite occurrence, Vértes Hills

3.1 Research and mining history

The "cradle" of Hungarian bauxite mining, the Gánt deposit, was discovered by a Transylvanian mining engineer, J. Balás, in 1924. The discovery was one of the results of the desperate effort of Hungarian geology after World War I, to find new mineral resources within the country which, as a result of the Peace Treaty of Trianon, has lost two thirds of its territory including all its former prosperous mining districts.

Mining activity began here in 1925. and was followed soon by the first scientific descriptions of bauxite (Telegdi Roth, 1927; Vadász, 1927; Pobozsny, 1928; Gedeon, 1932 and Dittler, 1930). Ever since then the locality has attracted many mineralogists, geochemists, paleontologists and structural geologists to study the peculiarities of both bauxite and its cover (Szőts, 1938, 1953, 1956; Kiss, 1953; Strausz, 1962, 1964; Kopek, 1965, 1980; Bignot *et al.*, 1985; Deák, 1967; Vörös, 1969; Bárdossy, 1961, 1980; Szantner & Szabó, 1969; Mihály, 1975; Farkas *et al.*, 1982; Mihály & Vincze, 1984 and Germán-Heins, 1994)

By 1936 with 500,000 tons per year Hungary became the third-largest bauxite producer of the world. Due to the discovery of further deposits both around Gánt and at other localities of the Transdanubian Range, production has steadily increased until after 1989, when it totalled to almost 3 million tons per year (from open-cast and underground mines). In Gánt exploitation peaked in the mid-1950s with 477,000 tons per year from five large open pits. Since then it has gradually declined until the mid-1980s, when it was finally closed. The Bagoly-hegy open pit (Fig. 4), where J. Balás started the exploration in 1924, was converted into a geological park in the early 1990s by the Bakony Bauxite Mines company.

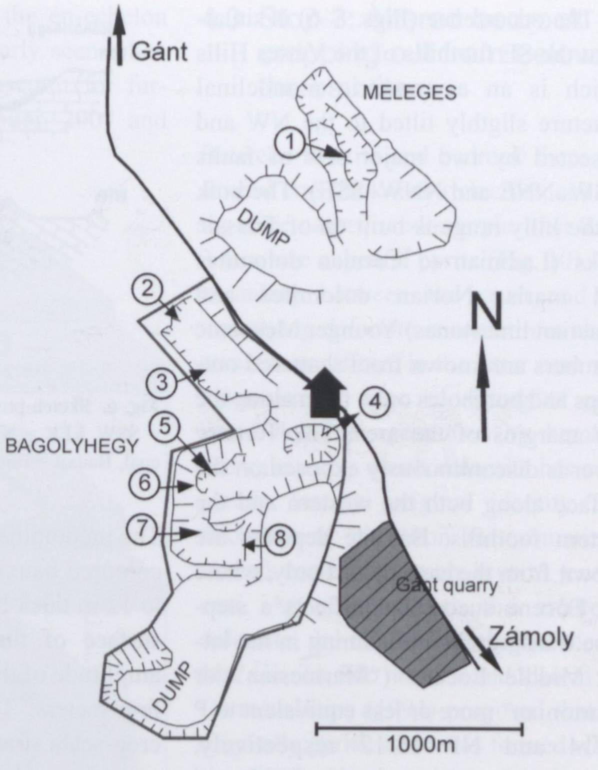


Fig. 4. General view of the abandoned bauxite pits in the vicinity of Gánt.

3.2 General geology

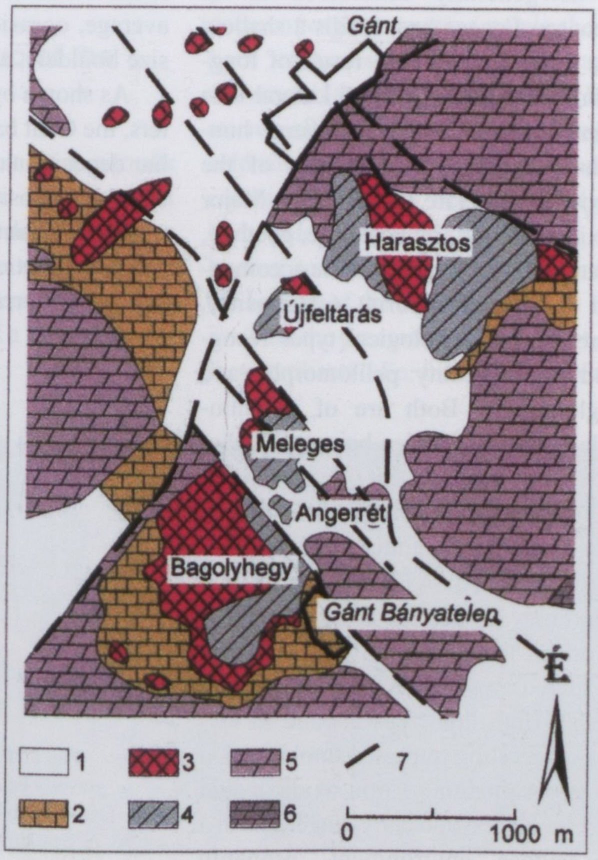


Fig. 5. Geological sketch map of the Gánt bauxite occurrence.

The occurrence (Figs. 5–6) is situated at the SE foothills of the Vértes Hills which is an asymmetric monoclinal structure sligthly tilted to the NW and dissected by two major sets of faults (SSW–NNE and NNW–SSE). The bulk of the hilly range is built up of Triassic rocks (Ladinian to Carnian dolomites and marls, Norian dolomites and Rhaetian limestones) Younger Mesozoic members are known from scattered outcrops and boreholes only, from along the SW margins of the area. The Tertiary cover is discontinuously exposed on the surface along both the western and the eastern foothills. Bauxite deposits are known from the eastern part only, where the Eocene succession reflects a stepwise transgression, beginning in the latest Middle Eocene ("Marinesian" or "Bartonian" more or less equivalent to P 12/14 and NP 16/17 respectively, according to Bignot *et al.*, 1985 and Pálfalvi, 2007).

The bauxite occurs at a major regional unconformity between Late Triassic and late Middle Eocene strata and is generally considered as of Paleocene-Eocene age. It fills a shallow karst relief formed as a result of long-lasting subaerial exposure. Lateral size of individual deposits is several hundreds of meters, the thickness of the bauxite is moderate (10 to 15 m) Major bauxite minerals are: boehmite, goethite, hematite, kaolinite and anatase accompanied by minor chlorite (chamosite). There are two lithological types recognized at this locality: pelitomorphic and conglomeratic. Both are of medium-grade with the pebbles being of higher grade (Al_2O_3: 31.6%, SiO_2 1.5%), while the muddy, pelitomorphic material, though richer in alumina (Al_2O_3 46.9%) is richer also in SiO_2 (11.3%). According to Bárdossy (1961), the average grade of the ore in the Gánt area (all lithotypes considered) was Al_2O_3 50.0% and SiO_2 16.0%). Both lithotypes abound in textures suggesting repeated mobilization and reprecipitation of iron oxide, a sign of accumulation and early diagenesis in a semi-vadose environment, probably close to the paleo-groundwater table.

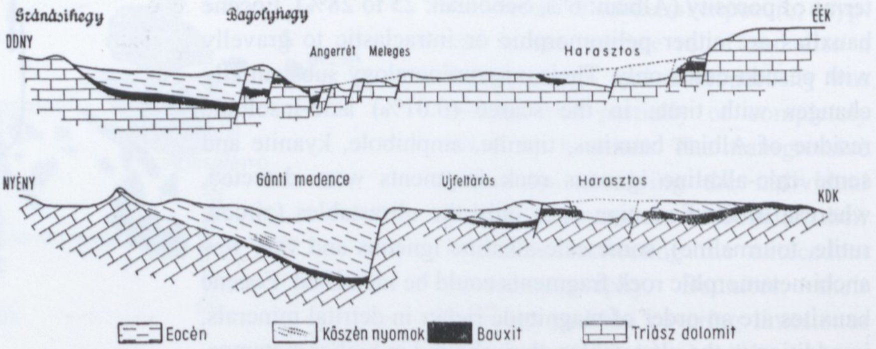


Fig. 6. Sketch-profiles across the Gánt bauxite occurrence (original by Vadász, 1951). Legend: DDNY = SSW, ÉÉK = NNE; NYÉNY = WNW, KDK = ESE; Eocén = Eocene, Kőszén nyomok = Traces of coal, Bauxit = Bauxite, Triász dolomit = Triassic dolomite.

The predominantly pale red to yellowish coloured bauxite forms an extensive 10 to 12 m thick blanket over the karstified surface of the Triassic bedrock. The amplitude of the karstic mezo- relief is a few meters. The bauxite displays outcrop-scale stratification with the moderately to poorly sorted conglomerate layers forming irregular intercalations in the muddy "matrix". The conglomerate may be matrix-supported or clast-supported, the clasts are rounded to subrounded and 0.5 to2.0 cm in size on the average, occasionally with 10 to 20 cm size boulders, as well (Figs. 7–8).

As shown by its sedimentary characters, the Gánt bauxite is of a rather peculiar depositional type. Unlike most karst bauxite deposits it is not simply the result of parautochthonous transport of the polygenetic weathering product on the karstic terrain. It displays the signs

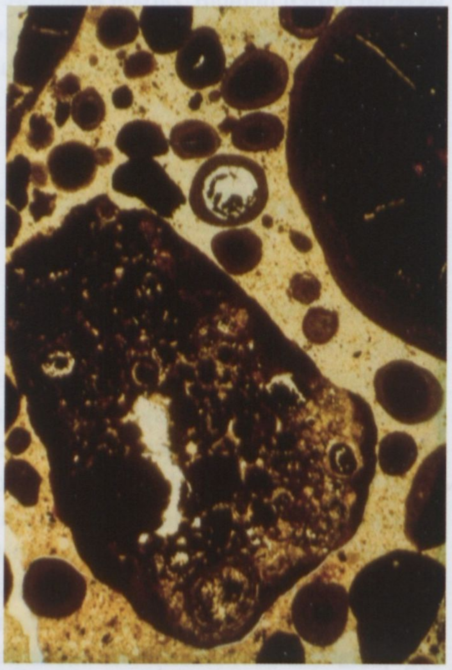


Fig. 7. Thin section photomicrograph of gravelly bauxite from the Bagolyhegy deposit (width of the photo is ~1 mm).

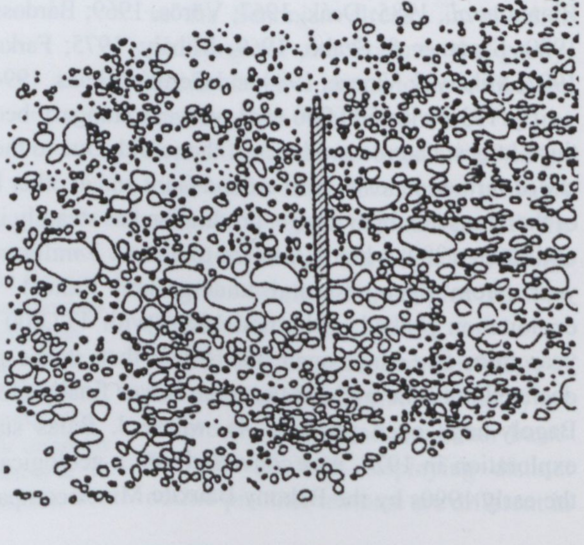


Fig. 8. Field sketch of gravelly bauxite from the Gánt-Bagolyhegy open pit by A. Szarka in Mindszenty *et al.* (2010) (pencil for scale)

of true allochthony and, as shown by its coarse, chaotically organized conglomeratic textures, it was apparently deposited on a shallow karst terrain from episodic mudflows / debrisflows probably triggered by synsedimentary faulting.

The once continuous extensive bauxite blanket is dissected by numerous postdepositional (mostly Late Tertiary) faults, some of them clearly visible in the visited outcrop.

4. Gánt Bagolyhegy abandoned open pit: Field trip stops

Though vegetation has already partly overgrown the walls of the abandoned quarry, it is still spectacular inasmuch as all the important characteristics of this peculiar deposit can be studied in details.

The visited part is an elongate pit roughly perpendicular to the main road connecting Gánt-bányatelep (Gánt mine) with the village of Gánt.

Boulders of the altered bedrock and the most important members of the transgressive cover sequence crop out either form below the vestiges of bauxite left over by mining or in the quarry-walls. Post-depositional faulting is obvious on the northern side of the quarry (right below the little Mining Museum) and also at the far end of the quarry towards the east.

4.1 Stop 1: General view of the quarry and tectonic elements visible on the quarry wall

The rocky cliff below the Mining Museum is a steep fault plane with oblique striae on its surface suggesting that movement along the plane was mainly lateral with only a slight normal component. A fine example of a meter-scale relay-ramp (Fig. 9) transferring the movement from one of the en-echelon faults to the other is clearly seen when looking towards the Museum (for further information, see Fodor, 2007 and Budai & Fodor, 2008).

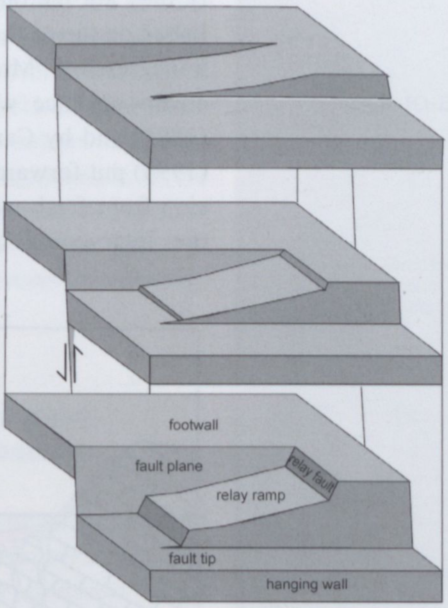


Fig. 9. Development of a relay-ramp (Peacock & Sanderson, 1994).

4.2 Stop 2: Close-up of the relay-ramp

Close-up view of the fault plane permits the observation of the fault breccia along which worn, powdered dolomite clasts are already partly missing while the breccia is strongly cemented by calcite displaying a kind of a boxwork texture.

4.3 Stop 3: Altered bedrock cropping out from below the bauxite

Between bauxite and bedrock there is a several cms thick iron-rich crust, consisting of hematite pseudomorphs after 0.5 to 3 mm size euhedral pyrite (Fig. 10). The boundary between the crust and the underlying dolomite is sometimes sharp, sometimes diffuse, in the latter case with a transitional zone consisting of powdered dolomite, cemented by hematite and calcite, by which dolomite has completely lost its original identity. The thickness of the "iron metasomatized" altered zone may reach several tens of cms. As compared to the unaltered dolomite, the crust is clearly enriched in Mn, Cu, Zn, Mo and Co and also in As. Germán-Heins (1994) proposed that the originally pyritic crust was formed when, shortly after the deposition of the bauxite, tectonically controlled subsidence resulted in relative sea-level rise and, as the first sign of transgression, the bottom of the bauxite deposit was flooded by saline pore-waters from below. Anaerobic decay of organic matter (mainly the vestiges of terrestrial vegetation trapped underneath the bauxitic mud-flow) led to microbially mediated early diagenetic sulphate reduction. Sulphur has readily combined with the not yet stable iron hydroxide phases of the bauxite thus leading to the precipitation of pyrite at the bottom of the deposit.

That the precipitation of pyrite has in fact "utilized" Fe from the bauxite is

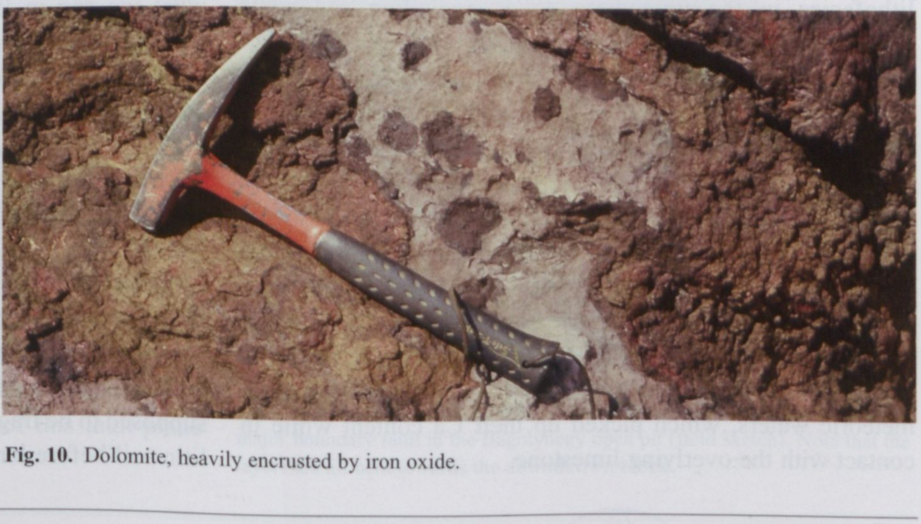


Fig. 10. Dolomite, heavily encrusted by iron oxide.

shown by the pale deferrificated bauxite halo around the encrusted bedrock cliffs protruding from below the bauxite. Pyrite could have been oxidized, when the deposit became in contact with oxidizing meteoric waters again. This could have happened either during any one of the oscillatory phases of the Eocene transgression itself, or later on, during telogenesis of the Gánt bauxite deposit.

4.4 Stop 4: Coal seam at the base of the Eocene cover

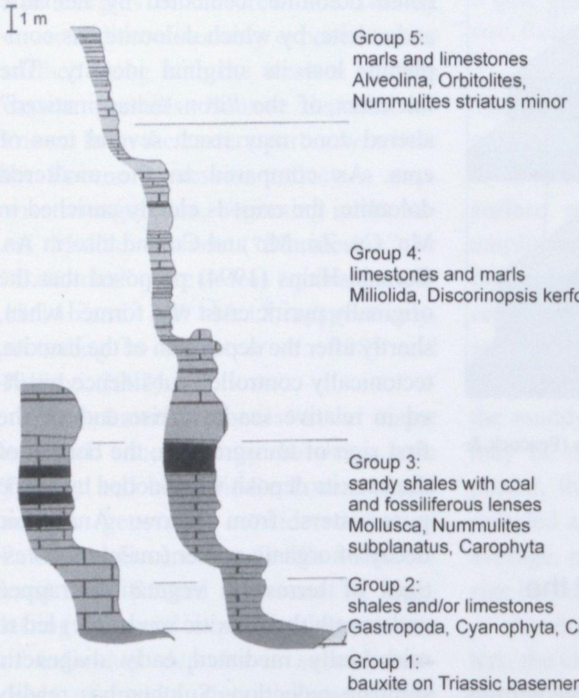


Fig. 11. Transgressive cover sequence from above the Gánt bauxite (after Bignot *et al.*, 1985).

On the dissected karst terrain, transgression (Fig. 11) began wiht the slow upraisal of the ground water table. Depending on the meso-topography and the relative elevation of the bauxite-covered terrain, this has resulted in a mosaic of various lithofacies in the immediate cover, including sediments deposited in smaller or larger fresh-water ponds and/or marshes. On transgression the normal sequence would be fresh-water pond → fresh-water marsh → brackish marsh → brackish lagoon → restricted marine lagoon → open marine lagoon, however, as a result of the oscillating transgression, these facies may also repeatedly reappear one above the other.

Stop No. 4 shows one of the thin coal seams above the underlying (not visible) sediments of the fresh-water pond. Coal-rank of the exposed seam is "lignite". As a result of recent weathering in the outcrop, it is full of tiny little gypsum crystals formed on interaction with downward percolating meteoric waters, which picked up their Ca content while in contact with the overlying limestone.

Stop 4a Characean-rich fresh-water limestone – ("blue hole" deposit?)

Characean-bearing fresh-water limestone occurs in the form of large erratic blocks at the bottom of the quarry. Though they are not *in situ*, in the present abandoned quarry they are the only proofs of the fresh-water pond established on top of the bauxite at the beginnings of the Eocene transgression. Microfauna and flora of the Bagolyhegy cover-sequence were studied in detail by Bignot *et al.* (1985) and by Carannante *et al.* (1994). Carannante *et al.* (1994) put forward that the trajectory of he Gánt transgression from fresh-water to brackish then schizohaline (without intervening desiccation events) and finally marine would be comparable with the depositional sequence described by Rasmussen & Neumann (1988) from the Bahamas: They suggested that this kind of transgression is a result of the antecedent karst topography. It is similar to what we see in the case of the inland blue-holes of the Bahamas and it should be called "internal" transgression as opposed to the conventional "Waltherian" overland transgression (Fig. 12).

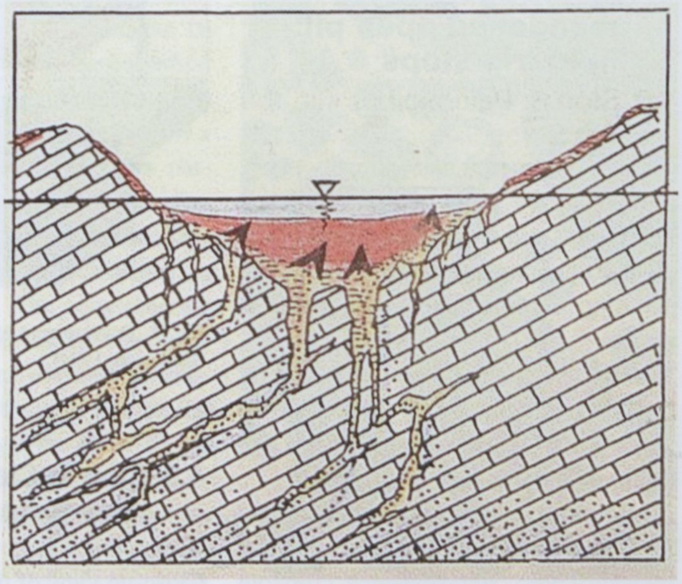


Fig. 12. Cartoon showing the idea of "internal" transgression (*sensu* Carannante *et al.*, 1994).

4.5 Stop 5: Pelitomorphic bauxite

Light red bauxitic mudstone, called pelitomorphic bauxite is exposed in the side wall of the open pit. There are small (2 to 3 mm) yellowish-brown goethitic grains (intraclasts or small nodules) scattered in the muddy hematitic matrix. They are supposed to be fragments of pedofeatures formed in the ferrallitic soil before landscape stability was ended and the material became involved in large-scale resedimentation by the aforementioned mudflows/debrisflows.

Stop 5a Bauxitic conglomerate

Cliffs made up by coarse bauxitic grainstone crop out from below the scree. The grains look like pisoids, they are yellowish-red, more or less spherical and have a yellowish porous coating. When hit and crushed into two with a hammer, it turns out that they are not pisoids but intraclasts mainly reddish in colour, suggesting that they may be redeposited pedogenic nodules or soil fragments. These conglomeratic layers are supposed to have been produced by large-scale soil erosion and resedimentation related to climate deterioration probably coincident with synsedimentary tectonic events (Mindszenty *et al.*, 1989)

4.6 Stop 6: Paleosoil profile (burial gley) developed on top of gravelly bauxite

Right underneath the Eocene cover, the top of the bauxite displays a strange alteration of colour. Pale whitish to grayish, vertical to subvertical mottles abound in the uppermost 1 m of the deposit. They are considered to be drab-coloured root traces, remnants of the last soil profile apparently developed on the bauxitic substratum still under moderately well-drained conditions (root traces are vertical!). Organic matter of this paleosoil was, however, destroyed under anaerobic conditions, when groundwater table began to rise and moderate drainage changed for hydromorphy, resulting in burial gleying in this top layer of the bauxite.

4.7 Stop 7: Fault plane (partly synsedimentary, partly post-mid-Eocene)

Mining activity exposed a major east-west trending normal fault at the far end of the quarry (Fig. 13). The exposed length of the fault is about 300 m. Dissected by the fault plane, the karst relief underlying the bauxite is superbly exposed in this outcrop. Based on the numerous fault striae and assocciated Riedel faults, displacement along the major fault was right-lateral combined with a normal component of about 5 to 6 m (Fodor *et al.*, 2005). The faulted zone was strongly brecciated/powdered, the estimated thickness of the fault breccia being several meters or so. In accordance with its increased porosity, the fault zone was subject to intense cementation mainly by calcite. Subsequent weathering resulted in peculiar boxwork textures best seen on smaller or larger bedrock blocks protruding from below the bauxite in front of the fault plane. Powderization and cementation of the bedrock mainly by calcite and iron oxide is characteristic of this fault-plane related variety of the Triassic dolomite.

Fig. 13. View of the major boundary fault of the Bagolyhegy open pit.

4.8 Stop 8: Sedimentary structures in gravelly bauxite (chaotic texture, soft-sediment deformation)

On the upthrown block of the fault plane of Stop 7, the bauxite displays clear signs of soft-sediment deformation: yellowish conglomerate layers intercalated in the pale red bauxitic

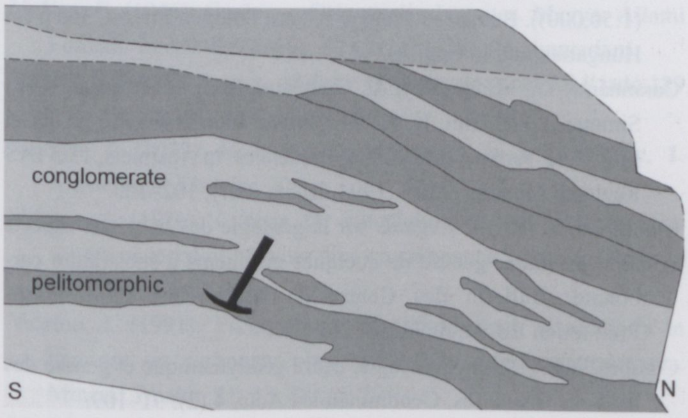


Fig. 14. Alternation of conglomeratic and pelitomorphic bauxite on top of the major boundary fault in the Bagolyhegy open pit (field sketch). Note that the layers are all bent towards the downthrown block.

mudstone are bent downwards, suggesting that displacement along the fault began while the bauxite was still unconsolidated (Fig. 14). The displacement of the Eocene sequence visible on the western wall of the quarry shows that the fault was reactivated after the deposition of the coverbeds as well.

4.9 Stop 9: Top of the open pit

At this stop an overview of the Gánt bauxite occurrence will be presented.

5. References

Balkay, B. (1966): Geology and history of research of bauxite deposits in Hungary. Bányászati Lapok, **99**: 599–603 (in Hungarian).

Balkay, B. (1973): Bauxitization and underground drainage. Travaux ICSOBA, **9**: 151–162.

Bárdossy, Gy. (1961): Geochemistry of bauxites of Hungary. (Special publication of the Geological Institute of Hungary.) Budapest: Műszaki kiadó, 233 p (in Hungarian with French and Russian abstracts).

Bárdossy, Gy. (1982): Karst bauxites. Amsterdam: Elsevier, Budapest: Akadémiai Kiadó, 441 p.

Bárdossy, Gy. & Aleva, G.J.J. (1990): Lateritic bauxites. Amsterdam: Elsevier, 624 p.

Bignot, G., Blondeau, A., Guernet, G., Perreau, M., Poignant, A., Renard, M., Riveline, J., Dudich, E., Gruas, C., Kázmér, M. & Kopek, G. (1985): Age and characteristics of the Eocene transgression at Gánt (Vértes Mts, Transdanubia, Hungary). Acta Geologica Hungarica, **28**: 29–48.

Bonte, A. (1969): Mise en place et évolution des bauxites sur mur calcaire. Magyar Állami Földtani Intézet Évkönyve, **54**: 29–50.

Budai, T. & Fodor, L. (eds) (2008): Geology of the Vértes Hills (Explanatory book to the geological map of the Vértes Hills (1:50,000)). Budapest: Magyar Állami Földtani Intézet, 368 p (in Hungarian and in Engish).

Carannante, G., Mindszenty, A., Neumann, A.C., Rasmussen, K.A., Simone, L. & Tóth, K. (1994): Inland blue-hole type ponds in Mesozoic-Tertiary karst-filling sequences. In Abstracts, 15th IAS Regional Meeting, April, 1994, Ischia, Italy, 102–103.

Combes, J.-P. (1984): Regards sur la géologie des bauxites: aspects recentes sur la genčse de quelques gisements a substratum carbonate. Bulletin des Centre de Recherches Exploration-Production Elf-Aquitaine, **8**: 251–274.

Combes, J.-P. (1990): Typologie, cadre géodynamique et genčse des bauxites françaises. Geodininamica Acta, **4** (2): 91–109.

D'Argenio, B. & Mindszenty, A. (1995): Bauxites and related paleokarst: tectonic and climatic event markers and regional unconformities. Eclogae Geologicae Helvetiae, **88** (3): 453–499.

Deák, M. (1967): Palynological study of the Bagoly-hegy bauxite. Földtani Közlöny, **97**: 224–226 (in Hungarian with French abstract).

Dittler, E. (1930): Die Bauxitlagerstätte von Gánt in Westungarn. Berg- und hüttenmännisches Jahrbuch, **78**: 45–51.

Dudich, E. & Komlóssy, Gy. (1969): Paleogeographical and structural geological contribution to the problem of the age of Hungarian bauxites. Földtani Közlöny, **99**: 155–165 (in Hungarian with French abstract).

Dunkl, I. (1992): Origin of the Eocene-covered karst bauxites of the Transdanubian Central Range of Hungary: evidence from early Eocene volcanism. European Journal of Mineralogy, **4**: 581–595.

Farkas, Zs., Főzy, I., Isaák, A. & Schlemmer, K. (1982): Geology of the Eocene sediments of the new Gánt Bagolyhegy exposure. Földtani Közlöny, **112**: 435–438 (in Hungarian with English abstract).

Fodor, L. (2007): Segment linkage and stress field in transtensional strike-slip fault array: Field examples from the Pannonian Basin. In Cunningham, D.F. & Mann, P. (eds): Tectonics of strike-slip restraining and releasing bends. Geological Society London, Special Publication, **290**: 417–431.

Gedeon, T. (1932): On the cover beds of the Gánt bauxite. Földtani Közlöny, **62**: 203–206 (in Hungarian with German abstract).

Germán-Heins, J. (1994): Iron-rich encrustation on the footwall of the Gánt bauxite (Vértes Hills, Hungary) – evidence for preservation of organic matter under exceptional conditions. Sedimentary Geology, **94**: 73–83.

Kázmér, M. & Kovács, S. (1985): Permian-Paleogene paleogeography along the eastern part of the Insubric-Periadriatic Lineament System: evidence for continental escape of the Bakony-Drauzug Unit. Acta Geologica Hungarica, **28** (1–2): 71–84.

Kiss, J. (1953): Fossils in the Gánt bauxite. Földtani Közlöny, **83**: 68–69 (in Hungarian with French abstract).

Kiss, J. (1955): Recherches sur les bauxites de la Hongrie, I. Gánt. Acta Geologica Hungarica Academiae Scientiarum Hungaricae, **3**: 45–88.

Kiss, J. & Vörös, I. (1965): La bauxite lignitifčre du Mont Bagolyhegy (Gánt) et le mécanisme de la sédimentation de la bauxite. Annales Universitatis Scientiarium Budapestiensis de Rolando Eötvös nominatae, Sectio Geologica, **8**: 67–90.

Komlóssy, Gy. (1967): Contribution a la connaissance de la genčse des buaxites hongroises. Acta Geologica Hungarica Academiae Scientiarum Hungaricae, **11**: 477–489.

Kopek, G., Kecskeméti, T. & Dudich, E. (1965): Stratigraphische Probleme des Eozäns im Transdanubischen Mittelgebirge Ungarns. Acta Geologica Hungarica Academiae Scientiarum Hungaricae, **9**: 411–426.

Mihály, S. (1975): Paleo-ecological observations from the Middle Eocene of Gánt. Földtani Közlöny, **105**: 75–81 (in Hungarian with English abstract).

Mihály, S. & Vincze, P. (1984): New paleo-ecological observations from the Middle Eocene of Gánt. Földtani Közlöny, **114**: 263–284 (in Hungarian with English abstract).

Mindszenty, A. (1983): Late Senonian morphological evoluiton of the Iharkút karst area as reconstructed on the basis of sedimentological features of the bauxites. Travaux ICSOBA, **18**: 29–38.

Mindszenty, A. (1984): The lithology of some Hungarian bauxites: A contribution to the paleogeographic reconstruction. Acta Geologica Hungarica, **27** (3–4): 441–455.

Mindszenty, A. (1991): Superimposed paleokarst phenomena in the Halimba basin, South Bakony, Hungary. In Field Symposium on Tethyan Cretaceous IGCP Project, Abstracts. Tirana, 28.

Mindszenty, A., Szintai, M., Tóth, K., Szantner, F., Nagy, T., Gellai, M. & Baross, G. (1988): Sedimentological features and depositional environment of the Csabpuszta bauxite (Paleocene/Eocene) in the Souht Bakony Mts (Hungary). Acta Geologica Hungarica, **31** (3–4): 339–370.

Mindszenty, A., Szőts, A. & Horváth, A. (1989): Karstbauxites in the Transdanubian Midmountains. In Császár, G (ed.): Excursion guidebook. IAS 10th regional meeting, Budapest, 24–26 April 1989. Budapest: Geological Institute of Hungary, 11–48.

Mindszenty, A., Gál-Sólymos, K., Csordás-Tóth, A., Imre, I, Felvári, Gy., Ruttner, A. & Böröczky, T. (1991): Extraclasts from Cretaceous/Tertiary baxuites of the Transdanubian Central Range and the Northern Calcareous Alps. Preliminary results and tentative geological interpretation. In Lobitzer, H. & Császár, G. (eds): Jubiläumsschrift 20 Jahre Zusammenarbeit Österreich-Ungarn Teil I. Wien: Geologische Bundesanstalt, 309–345.

Mindszenty, A., Knauer, J. & Mátéfi-Steffler, M. (1994): Superimposed paleokarst phenomena in the Halimba basin (South Bakony, Hungary) – The anatomy of a multiple regional unconformity. In Proceedings, 15th International Association of Sedimentologists Regional Meeting, April 1994, Ischia, Italy, 285–286.

Mindszenty, A., Csoma, A., Török, Á., Hips, K. & Hertelendi, E. (2000): Rudistid limestones, bauxites, paleokarst and geodynamics. The case of the Cretaceous of the Transdanubian Central Range. Földtani Közlöny, **131** (1–2): 107–152 (in Hungarian with English abstract).

Mindszenty, A., Fodor, L., Szarka, A., Almási, I., Monostori, M., Kázmér, M. & Sztanó, O. (2010): Geology of the abandoned bauxite quarries at Gánt. In Palotai, M. (ed.): Geological excursions in the Mid-Hungarian area. Budapest: Hantken Kiadó, 174–213.

Monostori, M. (1975): Ostracode fauna from the Eocene of Gánt (Transdanubian Central Mountains, Hungary). Annales Universitatis Scientiarium Budapestiensis de Rolando Eötvös nominatae, Sectio Geologica, **19**: 75–124.

Nagymarosy, A. & Báldi-Beke, M. (1988): The position of the Paleogene formations of Hungary in the standard nannoplankton zonation. Annales Universitatis Scientiarium Budapestiensis de Rolando Eötvös nominatae, Sectio Geologica, **28**: 3–25.

Nia, R. (1967): Geologische, petrographische, geochemische Untersuchungen zum Problem der Boehmit-Diaspor-Genese in griechischen Oberkreide-Bauxiten der Parnass-Kiona Zone. Doctoral dissertation, University of Hamburg, Germany, 133 p.

Nicolas, J. (1970): Problčme de la genčse des bauxites a mur karstique de France. Magyar Állami Földtani Intézet Évkönyve, **54** (3), 135–164.

Nicolas, J. & Lecolle, M. (1968): Essai de reconstitution paléógéographique de la Provence au Crétacé superieur. Position et âge possible de la roche mčre de la laterite d'ou provient la bauxite. Comptes Rendus de l'Académie des Sciences, **266**, 445–448.

Papp, K. (1897): The Eocene basin of Forna in the Mecsek Mts. Földtani Közlöny, **27**: 473–495 (in German).

Pálfalvi, S. (2007): Reconstruction of the Eocene sedimentary environment of the Vértes Hills on the basis of microfacies investigations. Unpublished PhD Theses, Eötvös L. University. Budapest, Hungary (in Hungarian).

Peacock, D.C.P. & Sanderson, D.J. (1994): Geometry and development of relay ramps in normal fault systems. AAPG Bulletin, **78**: 147–165.

Pobozsny, I. (1928): Bauxite deposits in the Vértes Hills. Földtani Szemle, **1** (5): 215–252 (in Hungarian).

Rasmussen, K.A. & Neumann, A.C. (1988): Holocene overprint of Pleistocene paleokarst: Bight of Abaco, Bahamas. In James, N.P. & Choquette, P.W. (eds): Paleokarst. Berlin: Springer Verlag, 132–118.

Strausz, L. (1962): Paleoecology of the Eocene fauna of Gánt. Földtani Közlöny, **92**: 308—318 (in Hungarian with German abstract).

Strausz, L. (1964): Caecum (Prolongicaecum) prolongatum n. sg. n. sp. (Gastropoda) a Gánt környéki eocénből. A Magyar Állami Földtani Intézet Évi Jelentése 1961-ről, Part II: 259–262 (in Hungarian with German and Russian abstracts).

Szantner, F., Knauer, J. & Mindszenty, A. (1986): Bauxite prognosis. Veszprém: MTA VEAB, 472 p (in Hungarian with English abstract).

Szantner, F. & Szabó, E. (1970): The structural-geological conditions and history of development of Hungarian bauxite deposits. Magyar Állami Földtani Intézet Évkönyve, **54**: 109–130.

Szőts, E. (1938): Early Tertiary formations of the Antalhegy at Mór. Földtani Szemle, Suppl, 42 p (in Hungarian).

Szőts, E. (1953): Mollusques éocčnes de la Hongrie. 1. Les mollusques éocčnes des environs de Gánt. Geologica Hungarica, Series Palaeontologica, **22**, 270 p (in Hungarian and French).

Szőts, E. (1956): L'Éocéne (Paléogéne) de la Hongrie. Geologica Hungarica, Series Geologica, **9**, 320 p (in Hungarian and French).

Tari, G. (1994): Alpine tectonics of the Pannonian Basin. PhD Theses, Rice University, Houston, Texas, USA, 489 p.

Telegdi Roth K. (1927): Die Bauxitlager des Transdanubischen Mittelgebirges in Ungarn. Földtani Szemle, **1**: 33–45.

Vadász, E. (1927): Significance of Hungarian bauxite. Bányászati és Kohászati Lapok, **60**: 376–379 (in Hungarian).

Vadász, E. (1946): Geology of Hungarian bauxites. Magyar Állami Földtani Intézet Évkönyve, **37** (2): 173–286 (in Hungarian).

Vadász, E. (1951): Bauxite geology. Budapest: Akadémiai Kiadó,129 p (in Hungarian).

Valeton, I. (1972): Bauxites. Developments in Soil Science, **1**. Amsterdam: Elsevier, 226 p.

Valeton, I. (1976): Criteria for autochthonous and allochthonous source material of bauxitic ores on carbonaceous rocks. Travaux ICSOBA, **13**: 21–36.

Valeton, I. (1991): Processes of allochthony and autochthony in bauxites on carbonate platforms of the Mediterranean area. Mineral Wealth, **71**: 13–28.

Vörös, I. (1969): Micromineralogical investigation of the bauxite sections of Gánt, Hungary. In Proceedings of the 2nd International Congress of ICSOBA, Budapest, 31–37.

USEFUL NOTES

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

INSTRUCTIONS FOR AUTHORS

General

Acta Mineralogica-Petrographica (AMP) publishes articles (papers longer than 4 printed pages but shorter than 16 pages, including figures and tables), notes (not longer than 4 pages, including figures and tables), and short communications (book reviews, short scientific notices, current research projects, comments on formerly published papers, and necrologies of 1 printed page) dealing with crystallography, mineralogy, ore deposits, petrology, volcanology, geochemistry and other applied topics related to the environment and archaeometry. Articles longer than the given extent can be published only with the prior agreement of the editorial board.

In the form of two subseries, AMP publishes materials of conferences (AMP Abstract Series) and field guides (AMP Field Guide Series), or, occasionally supplement issues related to other scientific events.

The journal accepts papers that represent new and original scientific results, which have not appeared elsewhere before, and are not in press either.

All articles and notes submitted to AMP are reviewed by two referees (short communications will be reviewed only by one referee) and are normally published in the order of acceptance, however, higher priority may be given to Hungarian researches and results coming from the Alpine-Carpathian-Dinaric region. Of course, the editorial board does accept papers dealing with other regions as well, let they be compiled either by Hungarian or foreign authors.

The manuscripts (prepared in harmony of the instructions below) must be submitted to the Editorial Office in triplicate. All pages must carry the author's name, and must be numbered. At this stage (revision), original illustrations and photographs are not required, though, quality copies are needed. It is favourable, if printable manuscripts are sent on disk, as well. In these cases the use of Microsoft Word or any other IBM compatible editing programmes is suggested.

Language

The language of AMP is English.

Preparation of the Manuscript

The different parts of the manuscript need to meet the instructions below:

Title

The title has to be short and informative. No subtitles if possible. If the main title is too long, an additional shortened title is needed for the running head.

Author

The front page has to carry (under the main title) the full name(s) (forename, surname), affiliation(s), current address(es), e-mail address(es) of the author(s).

Abstract and keywords

The abstract is required to be brief (max. 250 words), and has to highlight the aims and the results of the article. The abstracts of notes are alike (but max. 120 words). As far as possible, citations have to be avoided.

The abstract has to be followed by 4 to 10 keywords.

Text and citations

The format of the manuscripts is required to be: double-spacing (same for the abstract), text only on one side of the page, size 12 Times New Roman fonts. Margin width is 2.5 cm, except the left margin, which has to be 3.5 cm wide. Underlines and highlights ought not be used. Please avoid the use of foot and end notes. Accents of Romanian, Slovakian, Czech, Croatian etc. characters must be marked on the manuscript clearly.

When compiling the paper an Introduction – Geological setting – Materials and Methods – Results – Conlclusions structure is suggested.

The form of citations is: the author's surname followed by the date of publication e.g. (Szederkényi, 1996). In case of two authors: (Rosso and Bodnar, 1995) If there are more than two authors, after the first name the co-authors must be denoted as "et al.", e.g. (Roser et al., 1980).

References

The reference list can only consist of published papers, M.Sc., Ph.D. and D.Sc. theses, and papers in press.

Only works cited previously in the text can be put in the reference list. Examples:

Best, M.G., Christiansen, E.H. (eds.) (2001): Igneous petrology. Blackwell, Edinburgh, 458p.

Upton, B.G.J., Emeleus, C.H. (1987): Mid-Proterozoic alkaline magmatism in southern Greenland: the Gardar province. In: Fitton, J.G., Upton, B.G.J. (eds.): Alkaline Igneous Rocks. Blackwell, Edinburgh, 449–472.

Rosso, K.M., Bodnar, R.J. (1995): Microthermometric and Raman spectroscopic detection limits of CO_2 in fluid inclusions and the Raman spectroscopic characterization of CO_2. Geochimica et Cosmochimica Acta, **59**, 3961-3975.

Szederkényi, T. (1996): Metamorphic formations and their correlation in the Hungarian part of Tisia Megaunit (Tisia Megaunit Terrane). Acta Mineralogica-Petrographica, **37**, 143-160.

Bakker, R.J. (2002): http://www.unileoben.ac.at/~buero62/minpet/Ronald/Programs/Computer.html. Accessed: June 15, 2003.

The full titles of journals ought to be given. In case more works of the same author are published in the same year, then these has to be differentiated by using a, b, etc. after the date.

Illustrations

Finally, each figure, map, photograph, drawing, table has to be attached in three copies, they must be numbered and carry the name of the author on their reverse. All the illustrations ought to be printed on separate sheets, captions as well if possible. Foldout tables and maps are not accepted. In case an illustration is not presented in digital form then one of the copies has to be submitted as glossy photographic print suitable for direct reproduction. Photographs must be clear and sharp. The other two copies of the illustrations can be quality reproductions. Coloured figure, map or photograph can only be published at the expense of the author(s).

The width of the illustrations can be 56, 87, 118, or 180 mm. The maximum height is 240 mm (with caption).

All figures, maps, photographs and tables are placed in the text, hence, it is favourable if in case of whole page illustrations enough space is left on the bottom for inserting captions. In the final form the size of the fonts on the illustrations must be at least 1,5 mm, their outline must be 0,1 mm wide. Digital documents should be submitted in JPG-format. The resolution of line-drawings must be 400 dpi, while that of photographs must be 600 dpi. The use of Corel Draw for preparing figures is highly appreciated, and in this case please submit the .CDR file, as well.

Proofs and offprints

After revision the author(s) receive only the page-proof. The accepted and revised manuscripts need to be returned to the Editors either on disc, CD or as an e-mail attachment. Proofreading must be limited to the correction of typographical errors. If an illustration cannot be presented in digital form, it must be submitted as a high quality camera-ready print.

The author(s) will receive 25 free offprints. On payment of the full price, further offprints can be ordered when the corrected proofs are sent back.

Manuscripts for publication in the AMP should be submitted to:

Dr. Pál-Molnár Elemér
E-mail: palm@geo.u-szeged.hu
Dr. Batki Anikó
E-mail: batki@geo.u-szeged.hu
Phone: 00-36-62-544-683, Fax: 00-36-62-426-479
Department of Mineralogy, Geochemistry and Petrology University of Szeged
P.O. Box 651
H-6701 Szeged, Hungary

Distributed by the Department of Mineralogy, Geochemistry and Petrology, University of Szeged, Szeged, Hungary.

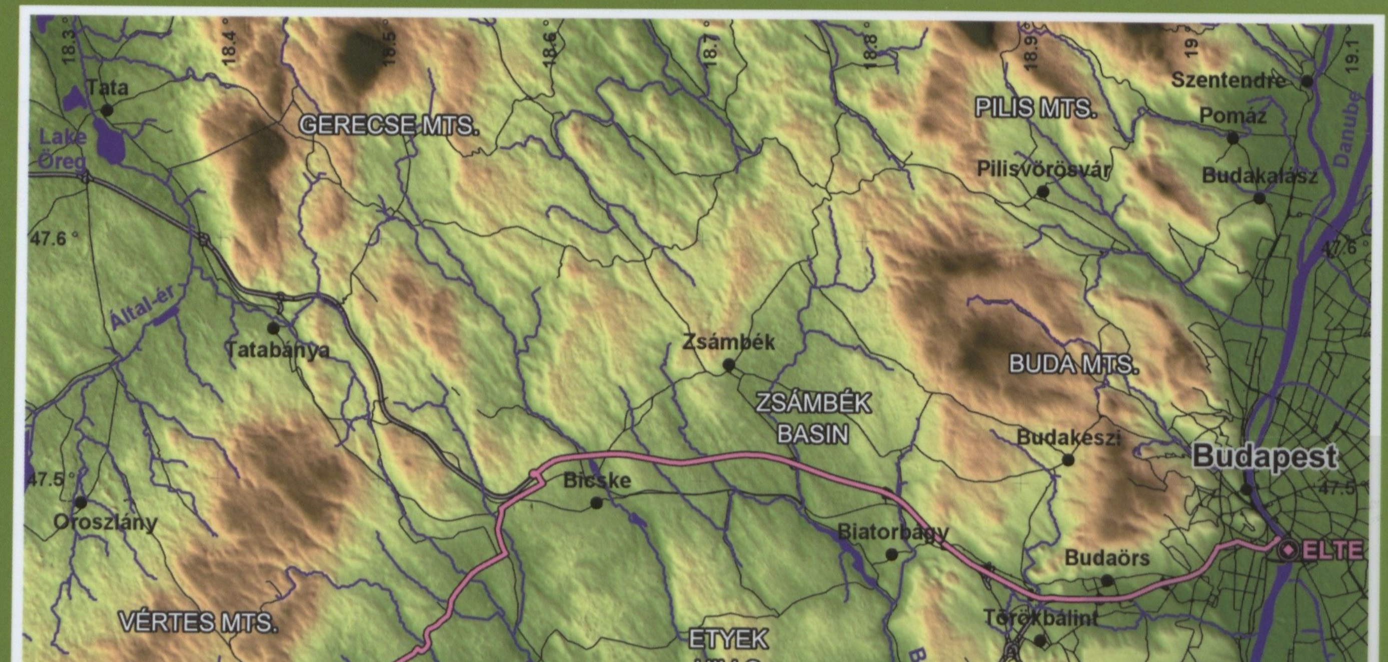
established in 1922

ACTA MINERALOGICA-PETROGRAPHICA FIELD GUIDE SERIES

VOLUME 11 2010

HU ISSN 0324-6523
HU ISSN 2061-9766

MAP OF THE IMA2010 FIELD TRIP HU3



Map provided by the Stockwork Exploration Ltd. (www.stockwork.eu)

Printed in Hungary by mondAt Ltd.