

ASPECTS OF EARLY JURASSIC ROMANIAN PALAEOBOTANY AND PALYNOLOGY. PART VI. ANINA, AN EXCEPTIONAL LOCALITY

Mihai E. POPA¹

Abstract: Exceptional plant and animal fossils were recorded from Anina, formerly known as Steierdorf, a well known fossiliferous, coal mining locality in the South Carpathians, Reșița Basin. The Steierdorf Formation, Hettangian – Middle Toarcian in age, yields a highly diverse and exceptionally preserved land flora, known since the XIX-th Century. The Early Jurassic flora of the Steierdorf Formation is represented by bryophytes, pteridophytes and gymnosperms, counting more than 120 taxa. This flora yields well preserved cuticles, and in situ spores and pollen, it is associated with numerous trace fossils, generated by insects or reptiles, while the plant-animal interactions are highly diverse too. Anina offered unrivaled research opportunities, thanks to underground and open cast mining activities which date back to 1792. Three-dimensional studies within the Steierdorf Formation's deposits were possible thanks to underground mining works, permitting a highly detailed paleontological research, with high paleoecological and stratigraphic significance and resolution. This paper explores the rich paleontological heritage of Anina as a possible fossil-Lagerstätte locality, and it also approaches geological heritage conservation aspects.

Key words: Anina, South Carpathians, Jurassic, Steierdorf Formation, paleobotany, paleozoology, sedimentology, geological heritage, geoconservation.

INTRODUCTION

Anina, formerly known as Steierdorf, represents the most important locality for Jurassic paleobotany in Romania, due to its high diversity in fossil plant species, for the high degree of preservation of these fossils, but also due to the high influence in the paleobotanical literature since 1850 till today.

Anina occurs in the central part of the Reșița Basin, South Carpathians, Getic Nappe, it is one of the oldest coal mining centers in Romania, where the coal extraction began in 1792. Since then, extensive coal mining was undertaken, with the opening of numerous coalfields and mines in the area. Such mining works permitted the intensive deposit of barren, fine grained sandstone material, very rich in fossil plants, in sterile dumps covering large areas within and around Anina. In autumn 2006, the underground mining in Anina is scheduled to be closed, due to the economical difficulties faced by the coal company and to a tragic mining accident which took place in January 2006.

GEOLOGY

The Lower Jurassic continental deposits are confined to the Steierdorf Formation (Bucur, 1991, 1997), including in the original definition three members: the Doman Member (Lower Hettangian), the Valea Tereziei Member (Hettangian – Sinemurian) and the Uteris Member (Pliensbachian – Middle Toarcian). The coal bearing sequence is represented by the Valea Tereziei Member, conformably overlying the coarse, conglomeratic Doman Member, and being overlain by the bituminous shales confined to the Uteris Member.

More stratigraphic details were given by Popa (1997, 2000a, b), therefore they will be not repeated here.

Anina occurs in the center of the Reșița Basin, a Mesozoic basin with Lower Jurassic – Late Cretaceous sediments. Due to Alpine Austrian and Laramian folding phases, these deposits were folded and faulted along a series of important alignments oriented approximately North-South, with significant structures like the Anina Anticline, Bradet Syncline, Natra Anticline, etc. These structures are disharmonic, with different configurations in underground mining horizons, such being the case of the Bradet Syncline, mined from the Anina Anticline. Anina locality occurs along the Anina Anticline, the most significant structure for coal extraction, all mining coalfields, with their pits and open cast mines occurring along the flanks or tips of this structure. Highly intensive coal mining was developed since the XVIII-th century, this giving a unique opportunity for plant collecting, mainly during the last 15 years of paleobotanical studies. Several facies of the Lower Jurassic coal measures were identified, the central facies being recorded as the Anina facies, yielding eight coal seams. Other important continental facies are the Bradet and the Doman facies, also rich in coal and fossil plants.

Modern geological studies were undertaken by Răileanu *et al.* (1957, 1961) and Bucur (1991, 1997), the latter author establishing the formal stratigraphy of the Mesozoic and Palaeozoic formations of the Reșița Basin.

PALEOBOTANY

The first paper on fossil plants of Anina was published by Foetterle (1850), followed by the

¹ University of Bucharest, Faculty of Geology and Geophysics, Laboratory of Palaeontology, 1, N. Balcescu Ave., 010041, Bucharest, Romania. E-mail: mihai@mepopa.com, Tel: +4 (021) 314-3508 ext. 128, Fax: +4 (021) 318-1557.

monographs of Ettingshausen (1852), and of Andrae (1855). These two monographs introduced new taxa of Early Jurassic plants, such being the case of various pteridosperms (e.g. *Thinnfeldia*, an influential taxon in the late XIX-th and XX-th Centuries). Other monographs of the Anina flora were published by Semaka (1962), and Givulescu (1998), followed by those of Popa (1998, 2000a). Givulescu (1998) and Popa (2000a) gave a detailed historical discussion with regard to the paleobotanical researches in Anina, so these researches will not be discussed here.

The flora of Anina is a typically compressive flora. Since 1850, bryophytes, pteridophytes and gymnosperms were recorded in Anina from various locations, mainly from sterile dumps. Very few occurrence data were recorded before 1990, such exceptions being the contributions of Humml (1957, 1963, 1969). Popa (1992) gave the first detailed underground occurrences for the fossil flora. Also Popa (2000a) described the first liverwort (*Hepaticites* cf. *arcuatus*), from the Ponor Quarry. Pteridophytes are represented by sphenopsids (e.g. *Schizoneura carcinoides*, a major coal generator), lycopsids (*Isoetes* sp.) and ferns, with Osmundaceae, Dicksoniaceae, Schizeaceae, Matoniaceae, Dipteridaceae and Incertae sedis. As for Gymnosperms, pteridosperms are particularly diverse (e.g. *Pachypteris rhomboidalis*), as well as cycadales, bennettitaleans, ginkgoaleans and conifers. A detailed review of the Anina paleoflora was given by Popa (2000a, b).

Anina is highly important also due to the paleoecological record of its plants. Plant assemblages, recorded within the same stratigraphic levels, with surface distribution control in underground mining works, permitted the reconstruction of phytocoenotical relationships, of preferred habitats for various species, of taxa distribution in two dimensions for various stratigraphic levels, and of their coal generating character. Also, the three-dimensional collecting possibilities permitted to obtain a precise phytostratigraphical image for the Valea Tereziei Member, with the identification of a floral change at the Hettangian-Sinemurian boundary (Popa, 2000a, b), linked to a climate change cause.

PALEOZOOLOGY

The Ponor Quarry yielded the first Mesozoic tetrapod footprints in Romania (Popa, 2000a, c), with *Batrachopus* cf. *deweyi*, collected from the southern end of the open cast mine. Other types of animal traces were recorded, but they are still under current study. Plant-animal interactions are also widely recorded, related to boring and leaf cutting by insects (Givulescu and Popa, 1994). For the Middle and Upper Jurassic formations, as well as for the Cretaceous ones, the paleozoological heritage is again very rich, with diverse and well preserved faunal associations.

HERITAGE AND GEOCONSERVATION

The geological and paleontological heritage in the area around the Anina town is quite remarkable, Anina deserving the status of a fossile-Lagerstätte locality. The plant fossils are highly diverse and exceptionally preserved as compressions and impressions, as well as casts of all types and sizes. Sometimes, entire plants were buried, such being the case of a *Phlebopteris woodwardii* fern in Ponor Quarry. Plants with almost all organs could be also collected, such as *Pachypteris speciosa*, *Zamites aninaensis*, *Zamites schmiedelii*, etc. The Steierdorf Formation is repeatedly outcropped along the western flank of the Anina Anticline, in several open cast mines showing excellent sedimentary and magmatic structures, as well as stratigraphic boundaries between various Mesozoic formations.

The underground mining works offer a unique and remarkable opportunity for fossil plant collecting, a situation that permits to obtain a three-dimensional image of fossil plant distribution within the Lower Jurassic deposits of the Reșița Basin. This opportunity also permitted to obtain detailed paleoecological and phytostratigraphical images within the Steierdorf Formation, with the separation of the Hettangian and Sinemurian stages in the sequence of the Valea Tereziei Member (Popa, 2000a, b).

The main access point for the underground mining horizons in Anina is Pit I. Known also as the Main Pit, it serves for accessing the Anina North Coalfield (along the Anina Anticline, with Anina, Zona Nouă 1, 2, 3 Scales), as well as the Bradet Coalfield (the Bradet Sector, corresponding in underground mining works to an anticline, although belonging structurally to the Bradet Syncline). The Pit I is scheduled to be closed in autumn 2006.

In the Anina Coalfield, corresponding structurally to the Anina Anticline, the topmost coal seams, such as the coal seams nos. 7 and 8 were exploited along directional galleries and exploitation chambers. The paleoflora here is typically Sinemurian in age, as the Hettangian – Sinemurian boundary occurs between coal seams nos. 3 and 4, along the refractory clay bed, a typical lithological marker in the basin. The quality of the compressions is rather good, the flora being dominated by bennettitaleans (*Zamites* div. sp.), and ginkgoaleans (*Ginkgoites* div. sp.). In the Anina Coalfield, the basal most coal seams were not extracted, as they are thin and braided.

In the Zona Nouă coalfield, several scales were systematically exploited. In these sectors, all coal seams were extracted, the directional, transversal and vertical galleries, alongside with exploitation chambers being extremely rich in fossil plants. The coal seams nos. 0-3 bear a very well preserved Hettangian flora, with Dipteridaceous and Dicksoniaceous ferns, cycadales, etc. (Popa, 2000a, b), while the coal seams nos. 4-8 bear the same Sinemurian assemblages as in Anina

Coalfield. The fossiliferous points are very dense in compressed material. The sphenopsid *Schizoneura carcinoides* is a ubiquitous coal generator, both Hettangian and Sinemurian in age, crossing the Hettangian – Sinemurian boundary undisturbed by climate change, due to its swamp dweller character, continuing to produce vegetal matter in large quantities.

In the Bradet Coalfield, the topmost coal seams are extracted, bearing the same Sinemurian assemblage dominated by bennettitaleans and ginkgoaleans. In all coalfields, directional and transversal galleries show ubiquitous, abundant trunks, very often in large sizes, in transported positions, with clear taphonomy.

The Ponor Quarry is the prime target for geological heritage conservation. It used to be a Site for Special Scientific Interest between 1994 and 2000, while in 2000, its reduced coal reserves made exploitation possible again. The outcrops of the Steierdorf Formation are very rich in plant material, along the western flank of the Anina Anticline. Sedimentary structures, basaltic sills and stratigraphic boundaries are well visible in the Ponor Quarry, all these aspects making it again an excellent candidate for a future SSSI.

The Colonia Ceha Quarry, occurring immediately north of Ponor Quarry, is also rich in plant material, with well outcropped sequences, also an excellent site for geoconservation. In between, the former Ponor Pit occurs, a historical site for the underground mining works in Anina. The Hildegard Quarry has an intermediary position between Pit I and the Colonia Ceha, but its outcrops are less valuable. The Hildegard Pit was closed in the XX-th Century. The Pit IV (also known as the Kolowrath Pit) was still open in the nineties, permitting the access towards the northern coalfields, such as the Anina, Zona Nouă and Bradet Coalfields. Its sterile dumps are particularly rich in fossil plants. Also, the Middle Jurassic marls and limestone outcrop excellently next to it. Along the Tereziei Valley occurs the type section of the Valea Tereziei Member, represented by several good quality outcrops, this site deserving conservation. The Breuner Gallery and the Thinnfeld Pit (related to the former *Thinnfeldia* denomination of *Pachypteris*) lack fossil plants, as their sterile dumps were cleared.

Along the eastern flank of the Anina Anticline, the last open pits were the David Pit, Pit V and Pit II, the latter used for air circulation in the complex mining works. Other important pits were the Kubek and Uteris Pits. Along the eastern flank, outcrops and sterile dumps are rare.

CONCLUSIONS

Anina represents the most important locality yielding Jurassic plants in Romania. The compressive flora is particularly rich and diverse, recorded in underground mining horizons, natural outcrops, sterile dumps and open cast mines. The

Ponor Quarry is the most important site for geoconservation in Anina, followed by the Colonia Ceha Quarry, Valea Tereziei outcrops, and the sterile dumps of Pit I and Pit IV. All these sites deserve the SSSI (Site of Special Scientific Interest) status, due to their paleobotanical, paleozoological, stratigraphic and sedimentological heritage high values. Anina deserves the fossil-Lagerstätte locality status, a status given by its exceptional geological heritage.

ACKNOWLEDGEMENTS

The author wishes to thank Drs. Zoltán Csiki and Iulia Lazăr for kind support during the editing process, as well as to Dr. Theodor Neagu and Dr. Nicolae Țicleanu for revising the manuscript. This paper is dedicated to the memory of the 7 miners who died on January 14, 2006 during a methane gas explosion in the Anina Pit I underground coal field. This explosion triggered the closure of all underground mining works, in autumn 2006, after more than 200 years of mining in Anina.

REFERENCES

- Andrae, C., 1855. Beiträge zur Kenntniss der fossilen Flora Siebenburgens und des Banates. Jahrbuch der kaiserlich-königlichen geologische Reichsanstalt, III(4): 1-48.
- Bucur, I. I., 1991. Proposition pour une nomenclature formelle des dépôts paléozoïques et mésozoïques de la zone de Reșița-Moldova Nouă (Carpathes Meridionales, Roumanie). Studia Universitatis Babeș-Bolyai, Geologie, XXXVI(2): 3-14.
- Bucur, I. I., 1997. Formațiunile mesozoice din zona Reșița-Moldova Nouă, Cluj-Napoca, 214 pp.
- Ettingshausen, C., 1852. Über die fossilen Pflanzen von Steierdorf in Banat. Jahrbuch der kaiserlich-königlichen geologische Reichsanstalt, III (verh), 194: 1.
- Foetterle, F., 1850. Verzeichniss der an die K.K. geologische Reichsanstalt gelangten Eisendungen von Mineralien, Petrefacten Gebirgsarten u.s.w. Jahrbuch der kaiserlich-königlichen geologische Reichsanstalt, 1(2): 350-358.
- Givulescu, R., 1998. Flora fosilă a Jurasicului inferior de la Anina. Editura Academiei Române, București, 90 pp.
- Givulescu, R. and Popa, M.E., 1994. Eine neue *Dictyophyllum* - Art aus dem unteren Lias von Anina (Rumanien). Documenta Naturae, 84: 42-46.
- Humml, H., 1957. Contributions à l'étude de la flore du Lias inférieur de Steierdorf-Anina. Studii și cercetări științifice, 3,4: 65-74.
- Humml, H., 1963. Catalogul florei fosile păstrate în Muzeul regional al Banatului, Timișoara. Stud. Cerc. St. Agricole, 10: 185-201.
- Humml, H., 1969. Contribuții la flora fosilă a Liasicului inferior de la Steierdorf-Anina. Studii și cercetări de geologie, geofizică, geografie, Secția geologie, 14(2): 385-404.
- Popa, M. E., 1992. The Early Liassic of Anina: New Paleobotanical Aspects. Documenta Naturae, 1-3(74): 1-9.
- Popa, M. E., 1997. Corystospermal pteridosperms in the Liassic continental deposits of Romania. Acta Palaeontologica Romaniae, 1: 81-87.

- Popa, M. E., 1998. The Liassic continental flora of Romania: Systematics, Stratigraphy and Paleocology. *Acta Botanica Horti Bucurestensis*, 1997-1998: 177-184.
- Popa, M.E., 2000a. Early Jurassic land flora of the Getic Nappe, University of Bucharest, Bucharest, PhD thesis, 258 pp.
- Popa, M.E., 2000b. Aspects of Romanian Early Jurassic palaeobotany and palynology. Part III. Phytostatigraphy of the Getic Nappe. *Acta Palaeontologica Romaniaiae*, 2: 377-386.
- Popa, M.E., 2000c. First find of Mesozoic tetrapod tracks in Romania. *Acta Palaeontologica Romaniaiae*, 2: 387-390.
- Răileanu, G., Năstăseanu, S. and Mutihac, V., 1957. Cercetari geologice in regiunea Anina-Doman (zona Reșița - Moldova Nouă, Banat). *Buletin Științific*, II(2): 289-310.
- Răileanu, G., Năstăseanu, S. and Dincă, A., 1961. Geologie de la region comprise entre la Valle de la Nera et le Danube. *Rev. Geol. Geogr.*, V(1): 27-45.
- Semaka, A., 1962. Flora liasica de la Anina (Banat). *Anuarul Comitetului Geologic*, XXXII: 527-569.