Significance of the Bucegi Conglomerate olistoliths in the Albian source-to-sink system from the Carpathian Bend basin in Romania

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Abstract

The presence of exotic blocks (or olistoliths) in sedimentary deposits is usually regarded as an indication of a deepwater slope environment. We evaluate olistoliths accumulated in shallow water at the upper edge of a slope setting using outcrop data. The study area is in the Bucegi Mountains in the southeast “bend” of the Carpathian Mountains in Romania. The studied deposits belong to the Bucegi Formation, a dominantly conglomerate succession of Albian age. The Lower Bucegi member has been accumulated as a large conglomerate submarine fan. The Upper Member forms a shelf-to-trench sedimentary system with deposits dominated by sandstones and conglomerates. The olistoliths are embedded in debris flow conglomerates, most of them from the Bucegi Upper Member, and a lower number from the Bucsei Lower Member. The olistoliths are all located in a small (10 × 20 km) zone, close to the Dambovicioara source area. The olistoliths have been transported into the basin for up to 10 km on relative gentle gradients. The blocks’ deposition is restricted to the shallow-water environment on a narrow low-gradient shelf and in some instances on the upper continental slope. Within the Albian source-to-sink system, the olistoliths occurrence marks the entry zone of the land-derived detrital material into the basin and points to the main sediment transport fairways into deeper parts of the basin.

Introduction

Olistostrome and olistolith terms are used in geology to describe slide deposits, and they come from the Greek words olistoma (to slide), stroma (accumulation), and lithos (stone/rock) (Flores, 1959; Abbate et al., 1970). Olistoliths have been described as large, more than 4 m outsized clasts (Abbate et al., 1970), and they are usually incorporated into a finer surrounding matrix with chaotic texture called olistostrome (Flores, 1959; Abbate et al., 1970). The presence of the olistoliths in the sedimentary deposits suggests important characteristics of the depositional processes and paleoenvironmental settings (Flores, 1959, Cieszkowski et al., 2009, 2012). More recent classifications of deepwater sediment transport consider slide/slump deposits as a type of gravity mass transport, and the term “olistostrome” is no longer used (Mulder and Cochonat, 1996).

Numerous olistoliths occur in the deep-water environment (Abbate et al., 1970; Leitch and Cawood, 1980; Fallgater et al., 2017), and usually the deposits that include large blocks are interpreted to be formed on a deep basin margin slope similar to the ones described in this study (Stanley and Hall, 1978).

The aim of this paper is to present a case of olistolith deposition on the outer shelf to the upper slope relatively close to the source area. In a source-to-sink system, these deposits become a sediment fairway marker, evidencing the entrance of the clastic material in the deeper part of the basin.

The main study area is in the western part of the Carpathian Bend (Figure 1b) within the alpine (high-altitude) area of the Bucegi Mountains, at approximately 15–20 km northwest of the town Sinaia (Figure 1). The investigations extended to several adjacent mountainous areas with Albian conglomerate outcrops: the Persani, Baraolt, Ciucas, Postavaru-Piatra Mare, and Codlea Mountains.

Methods

Regional stratigraphy and sedimentology information in concert with detailed outcrop data have been used to make evident the position and role of the olistoliths in the source-to-sink system. To be able to understand the stratigraphy and sedimentology of the area, the first study phase was dedicated to a review of the published data on the Albian deposits in the Carpathian bend area. The stratigraphic distribution schemes of the units that compose the Albian Bucegi Conglomerate units (Murgeanu and Patrulius, 1963; Patrulius, 1969) have been modified, according to the updated sedimentological research presented in this study.

Special attention was given to the stratigraphic and genetic correlation of the Albian conglomerates, which

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crop out in distinct areas from the Carpathian Bend zone, for the subregional reconstruction of the paleoenvironments and basin evolution.

Field work was carried out to collect stratigraphic and sedimentologic data from the outcrops. The lithology of the olistoliths from the Bucegi Conglomerate proved their extra-basinal character, and this helped in understanding the relationships of the large blocks with the surrounding coarse-grained (sandstone to conglomerate) matrix. The location of the olistoliths was established through field mapping (Patrulius, 1969; Jipa et al., 2013) combined with satellite image analysis.

**Geologic setting**

*The Lower Cretaceous sedimentary succession*

The Bucegi Conglomerate makes up the upper part of the Lower Cretaceous stratigraphic succession from the Carpathian Bend zone. Three lithostratigraphic formations (Sinaia, Moroeni, and Bucegi) have been separated within this succession (Murgeanu and Patrulius, 1963; Murgeanu et al., 1963; Patrulius, 1969; Figures 2 and 3a). The Leaota-type Precambrian crystalline rocks and their Jurassic calcareous cover represent the geologic basement of the Lower Cretaceous deposits from the Carpathian Bend area (Figure 3).

The Sinaia Formation (Upper Tithonian — Valanginian) is more than 2000 m thick and consists of a fine-grained, dominantly calcareous lower member, and a coarser-grained mixed sandy and detrital calcareous upper member. The Haueri-Aptian Moroeni Formation is 1500–2000 m thick and consists of fine-grained, silty turbidites at the base that transition upward into coarser and thicker sandy turbidites. The Haueri-Lower Barremian deposits, formerly regarded as the top member of the Sinaia Formation, are assigned in this paper to the basal part of the Moroeni Formation. The Moroeni Formation becomes coarser grained and thicker bedded upward and outlines a coarsening-upward mega cycle, with the Bucegi Formation at the top.

The Bucegi Formation (informal name — the Bucegi Conglomerate) is a sedimentary succession, up to 2000 m thick, predominantly composed of well-bedded, but poorly sorted and common structureless conglomerates. The Lower Member of the Bucegi Formation includes a basal subunit (the Lower Bucegi Conglomerate of Murgeanu and Patrulius, 1963; Figure 2) that is transitional between the Upper Aptian sandstone flysch-facies deposits of the Moroeni Formation and the conglomerates of the Bucegi Lower Member (previously named the Middle Bucegi Conglomerate; see Figure 2). The Bucegi Upper Member (previously the Upper Bucegi Conglomerate; see Figure 2) succession starts with coarse-grained poorly sorted conglomerates with decimeter- to meter-thick sandstone interbeds. The upper part of the Upper Bucegi Conglomerate Member (previously the Babele Sandstone unit; see Figure 2) is dominantly sandy with a well-developed, lateral conglomerate facies.

**Table 1.** Lithostratigraphy of the Lower Cretaceous deposits from the Sinaia-Bucegi area (Carpathian Bend). The Bucegi Formation lithostratigraphy presented refers only to the northern Bucegi Mountains area geologic setting.

<table>
<thead>
<tr>
<th>Age</th>
<th>Litho-stratigraphy</th>
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<tbody>
<tr>
<td><em>Cretaceous</em></td>
<td></td>
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<tr>
<td>Early Cretaceous</td>
<td></td>
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<tr>
<td>Albian</td>
<td>Bucegi Formation (Traditional name: Bucegi Conglomerates)</td>
</tr>
<tr>
<td>Aptian Barremian-Hauterian</td>
<td>Moroeni Formation (Traditional names: Rasty Aptian flysch, Upper Sinaia Beds)</td>
</tr>
<tr>
<td>Valanginian Berriasian - Late Tithonian</td>
<td>Sinaia Formation (Traditional name: Sinaia Beds, lower and middle horizons)</td>
</tr>
<tr>
<td><em>Upper Cretaceous</em></td>
<td></td>
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**Figure 1.** Study area location in (a) Europe, (b) Romania, and (c) the Bucegi Mountains.
In the absence of recognizable fossils for dating, the stratigraphic position provides the argumentation for the Albian age of the Bucegi Formation. The conglomerate lithostratigraphic unit of Bucegi Formation overlays fossiliferous Aptian deposits of the Moroieni Formation, and it is overlain by Vraconian (Late Albian)-Cenomanian deposits.

**Tectonics**

The central part of the Lower Cretaceous in the study area is marked by the occurrence of a complex Sinaia Formation anticline (Figure 3a). The anticline was uplifted during the Aptian and Albian times, forming a “haut fond”-type submerged high (Zamura High; Figure 4). Westward of the Zamura High, the Albian deposits are conglomeratic (Bucegi Conglomerate). The Albian-age, turbidite facies deposits of the Bobu Beds and Curbiciortical Flysch deposits are predominant in the area eastward from the Sinaia Formation upraise (Figure 3a).

The Lower Cretaceous deposits of the Carpathian Bend zone are part of the Ceahlău Nappe tectonic unit, a component of the East Carpathian Moldavide Nappe System (Sândulescu, 1984). During the deposition of the Moroieni and Bucegi Formations, the vertical orogenic movements of the Mid-Cretaceous Austrian Phase have been active (Patrulius, 1969). The uplift movement rates increased during the accumulation of the Bucegi Conglomerate, with the uplift affecting mostly the source area, but have also been actively deforming sediments in the Albian basin area (Patrulius, 1969).

**Data presentation and discussion**

**The Albian conglomerates of the Carpathian Bend submarine fan**

**Areal distribution**

The Albian conglomerates extend within a large area from the Carpathian Bend zone. Presently, after being separated by large scale postsedimentation erosion processes, the Albian conglomerates crop out in several areas, where they make up the framework of several mountainous massifs (Figure 3a). On the outskirts of the crystalline basement rocks massifs are the conglomerates of the Bucegi Mountains (Figure 3a–1) and Codlea area (Figure 3a–2). The Postavaru-Piatra Mare conglomerates appear in the middle of the Carpathian Bend zone (Figure 3a–3), and the Albian conglomerates from Persani (Figure 3a–4), Baraolt (Figure 3a–5), and Ciucas Mountains (Figure 3a–6) at the eastern and northern margin of the Carpathian Bend zone.

**Stratigraphic and lithologic correlation**

No fossil remains were found in the Carpathian Bend conglomerates. The Albian age was assigned to them.
because they overlay Late Aptian deposits and are overlain by Vraconian (Late Albian)-Cenomanian deposits (Murgeanu and Patrulius, 1957; Popescu, 1958; Sândulescu, 1964; Patrulius et al., 1967).

Unlike the Bucegi Formation succession (Figure 2), the Persani, Baraolt, Ciucas, Postavaru-Piatra Mare, and Codlea conglomerates are not showing an upper sandstone-conglomeratic upper member. However, based on similar lithologic and facies features (Figure 5) and because they are part of the same genetic unit (Albian conglomerates deep-sea fan), the Albian Carpathian Bend conglomerates are correlated with the Lower Member conglomerates of the Bucegi Formation.

The Albian conglomerate fan

The interpretation of all the Carpathian Bend Albian conglomeratic occurrences as a submarine fan was initially made by Murgeanu et al. (1963) and is supported by data presented by Mihăilescu et al. (1967) and Patrulius et al. (1967) (Figure 4a). The fan model is for the most part based on the diverging/fan-like pattern trend shown by the Albian paleocurrent system that indicates the origin of the separated conglomerate outcrops as deposits of a large submarine fan.

The Carpathian Bend Albian conglomerate deposits with a fan geometry were interpreted by Mihăilescu et al. (1967) as a shallow-water sedimentary accumulation deposited in a water depth below the storm wave base. Stanley and Hall (1978) reveal the deep-sea fan nature of the Carpathian Bend Albian conglomerates, and they compare Bucegi deposits with a modern depositional setting in southern France, where the Alps form steep, instable slopes that deliver coarse sediments into the Mediterranean Basin. The high frequency of the debris flow structures of the Bucegi Conglomerate, the fan-like transport pattern, and the regional stratigraphy and facies distribution are the main arguments presented by Stanley and Hall (1978) for the deepwater (infraneritic to deep marine) depositional environment of the Albian conglomerate fan.

The slope fan

The Bucegi Lower Member conglomerates extend up to the edge of the Dambovicioara source area (Figure 4b). This means that the sheet-like conglomerate beds of the Carpathian Bend Albian interpreted as a deep-sea fan, extend westward, and also cover the upper part of the continental slope. Consequently, the deep-sea fan can be considered a basin margin slope fan (Allen and Allen, 2005).

The interpretation of the deposits as a slope fan implies that the Albian conglomerate fan was prograding into a basin with variable bathymetry, ranging from shallow water to the west in the area of the uppermost slope to deepwater environments at the base of the slope toward the east.

Deep-sea fan versus shelf to trench

Stanley and Hall (1978) assign a deep-sea fan origin to the whole Bucegi Albian sedimentary succession. However, the Bucegi Upper Member, with a dominant lithology consisting of sandstones associated with conglomerates and siltstones, evolved in a different way, compared with the Lower Member sediment accumulation. The Babele Sandstone unit (part of the Upper Member), with lithology and sedimentary structures different from the Albian Deep-Sea Fan conglomerates (the Bucegi Lower Member), was assigned to a shallow-water/shelf paleoenvironment by Olariu et al. (2014). The conglomeratic lower part of the Upper Member deposits evolved along with the Babele Sandstone, so both units share a shelf origin. The Babele Sandstone deposits are replaced southward and later westward (Figure 4b) by deepwater sandy-silty and gravelly grain-sized sediments, which accumulated in a steep, elongated, and trench-like basin.

Consequently, the Albian Bucegi Formation commenced with the Lower Member conglomerates accumulated as a deep-sea fan unit (Figure 4b). The Carpathian Bend Albian conglomerates (the Persani, Baraolt, Ciucas, Postavaru-Piatra Mare, and Codlea rudites) are also part of this fan unit. The upper part of the Albian Bucegi Formation (Upper Member), developed in a shelf-to-slope setting in a trench-like sedimentary basin (Figure 4b).

The olistoliths incorporated in the Bucegi Conglomerate

Olistoliths occur at several stratigraphic levels in the Lower Cretaceous succession from the Carpathian Bend zone, similar to other Carpathian (Ciezkowski et al., 2012) or Apennines areas...
(Lucente and Pini, 2008). The olistoliths from the Albian Bucegi Conglomerate are the most numerous and can be studied in large continuous outcrops accessible for measurements (Figures 6 and 7).

Olistoliths location

All the olistoliths (Jurassic limestones or crystalline rocks) from the Bucegi Conglomerate are irregularly distributed in a small area (9 × 5 km) in the northern part of the Bucegi Mountains (Figure 6a). The lithology of most olistoliths (more than 90%) consists of late Jurassic limestones that are still in place westward of the studied outcrops (Figure 3). The olistoliths vary in size from several meters to 200 m (Figure 7). Albian conglomerates are exposed only in a few kilometer-long outcrops in the Bucegi Mountains. Only three isolated, small Jurassic limestone blocks have been observed in the Persani and Ciucas Mountains, at the northern and eastern margin of the Carpathian Bend zone. From the basin margin (source area), the olistoliths have been transported into the basin for up to 10 km.

Olistoliths size and shape

The olistoliths size varies from several to 200 m. The largest block is the “Velicanul Mare” olistolith (200 m long and 40 m thick) in the Bucegi Conglomerate (Patrulius, 1969). However, most of the olistoliths are 5–10 m large. The 10–30 m long blocks are significantly less frequent, and larger than 30 m olistoliths are rare. Only three Jurassic limestone blocks are in the 100–200 m size range. The crystalline rock olistoliths are much smaller (seldom larger than 10 m) compared with the limestone olistoliths. The olistoliths embedded in the Bucegi conglomerates are elongated, irregularly subrounded blocks (Figure 7).

Olistoliths frequency

In the Bucegi Formation, there are olistoliths in the Lower Member, as well as in the Upper Member conglomerates, but their distribution is unequal. According to the information offered by the Patrulius (1969) on Bucegi geologic map, 80 olistoliths (84%) belong to the Upper Member conglomerates (Figure 6b). Out of these, 70 blocks (71%) are embedded in the conglomeratic facies of the Babele Sandstone unit, at the top of the Bucegi Conglomerate succession. The conglomerates from the base of the Upper Member include only nine olistoliths (9%). Patrulius (1969) maps 15 olistoliths (16% from the total number) from the upper part of the Lower Member conglomerates (Figure 6b).

Olistoliths transport

Most of the blocks are entirely embedded in conglomerates — the dominant “matrix” of the olistoliths (Figure 7). Four thick units with many large olistoliths are continuous and have been mapped over a few-kilometer distance in the Upper Member of the Bucegi Conglomerates (Figure 8). The units are individual beds tens of meters thick and have a normal graded trend with larger (decimeter) clasts at the bottom (Figure 8). Olistoliths are usually in the middle or at the top of the thick event beds (Figure 8). Around the olistoliths, the structure of the conglomeratic matrix shows no changes in texture, such as shear, dewatering, flow “shades,” or preferential sorting. The olistoliths appear as large, outsized clasts, which

Figure 6. Areal and stratigraphic distribution of the olistoliths embedded in the Bucegi Conglomerate. Primary information from Patrulius (1969).

Figure 7. Three large Jurassic limestone olistoliths, embedded in Albian conglomerates, from the Northern Bucegi Mountains.
moved en masse in the framework of the gravitational flow of the conglomerate matrix. The poorly sorted nature of the sediment and the lack of internal structures and normal grading suggest the flow was most likely a subaqueous debris flow.

Olistoliths provenance

The origin of the Bucegi Conglomerate olistoliths was assessed by identifying the lithology of the clasts (in the context of the Bucegi Conglomerate clasts source), as well as by direct observation of the olistoliths (by comparison of limestone blocks with in situ calcareous formations from the Dambovicioara source area). The divergent fan-like pattern of the Albian paleocurrent system (Figures 5 and 8), and particularly its persistent divergent currents over a large, outspreading zone, is a good provenance indicator of the Bucegi Conglomerate clastic material. Using the paleocurrent directions measured in the field, Mihăilescu et al. (1967) and Patrulius et al. (1967) point out the Dambovicioara zone and the adjacent crystalline rocks of Leaota Mountains as the Bucegi Conglomerate source area. The petrographic investigation of the Bucegi Conglomerate noncalcareous clasts (Anastasiu et al., 2015) confirmed the Leaota Mountains as the main source area, but it also identified rocks that sourced from areas presently buried or eroded. Patrulius (1969) carries out a comparative paleontological and facies study between the older limestone

![Figure 8](image_url)

**Figure 8.** Units (or beds) of the Upper Member of Bucegi Conglomerate that contain olistoliths. (a) Large outcrops (hundreds of meters thick) of four conglomerate units containing olistoliths (from Jipa et al., 2013). The outcrops are located between the Jepilor and Cerbului Rivers in Figure 6. (b) Sketch with the four thick conglomerate units interfingering with the Babele Sandstone interpreted to be deposited in a shallow-water environment. (c) Tens of meters thick conglomerate beds of unit/bed one with large olistoliths. (d) Closeup photo of the graded bed containing olistoliths. Note the great thickness of the bed.
olistoliths embedded in Hauterivian to Albian deposits from the Bucegi area, and the Jurassic limestones underlying the Bucegi Conglomerate. The comparison study concluded that analyzed exotic limestone blocks are sourced from the Jurassic calcareous cover of the Leaota crystalline terrains and from Dambovicioara zone (Figures 5 and 8).

**Sedimentary paleoenvironment of the olistoliths**

The olistoliths and the olistolith-bearing deposits of Bucegi Conglomerate share the same provenance, transport, and sedimentation history. The sedimentary paleoenvironment of the Bucegi Conglomerate olistoliths is the same as the sediment accumulation setting of their embedding conglomerates.

**Significance of the olistoliths location**

An evident feature of the whole Bucegi Formation olistoliths is their concentrated distribution (higher frequency) to the west, in a zone in the vicinity of the Dambovicioara source area (Figure 4b). Consequently, it can be inferred that the olistoliths accumulated at the basin periphery (basin margin) a shallow-water area.

**Olistoliths of the Upper Member**

Taking into consideration the sandstone-dominated lithofacies, as well as the sediment traction current structures, with fluctuating transport trends, Olariu et al. (2014) conclude that the Babele Sandstone accumulated in a subaqueous basin margin to shelf (nonmarine to marine) sedimentary environment. The conglomerates with olistoliths that interfinger with the Babele Sandstone unit (Figure 8) have a similar sedimentological genesis and evolution (Olariu et al., 2014) that implies the entire Upper Member succession formed in a shelf setting; westward in proximal areas they possibly formed as alluvial deposits. Because the olistoliths are commonly embedded within the conglomerates (approximately 84%; Figure 6b), it is inferred that they accumulated in a shallow-water, shelf, and nonmarine environment.

**Olistoliths of the Lower Member**

A smaller number of olistoliths, representing approximately 16% of the total Albian olistoliths (Figure 6b), are embedded in conglomerates of the Bucegi Lower Member. These olistoliths are located in the same area as the Upper Member blocks, close to the edge of the Dambovicioara source area. Within the Albian conglomeratic fan (including the Persani, Piatra Mare, Ciucas, and Postavaru Mountains), the Lower Member olistoliths are located at the upper margin of the fan; that is on the upper continental slope, in a relative steep gradient area, probable on the shelf or slightly deeper water environment. According to the peripheral location of the olistoliths occurrence zone adjacent to the more frequent olistoliths of the Bucegi Upper Member, this environment could even represent a shelf edge of a relatively narrow shelf zone.

The Bucegi Conglomerate olistoliths are incorporated in subaqueous mass transport complexes that are tens of meters thick (Figure 8), but differ significantly from the typical mass transport complexes of deepwater environments, including large blocks that are typically classified as slides (Moscardelli and Wood, 2008), which have kilometers as imaged on seismic (Dunlap et al., 2010). The dimensions of the Bucegi deposits with olistoliths might be similar with small mass transport complexes (Minisini et al., 2007), but the dominant matrix of the beds incorporating olistoliths is coarse sandstone to conglomerate (Figures 5 and 8) rather than mudstone or sandstone (Abbate et al., 1970; Leitch and Cawood, 1980). The coarse grain size (conglomerate) suggests that the beds containing olistoliths were not generated by slope failures, but rather from subaerial fluvial/alluvial environments and deposited subaqueous.

**Olistoliths within Albian source-to-sink systems at the Carpathian Bend**

Regional lithofacies variation within the Albian deposits at the Carpathian Bend is first described by Contescu (1967), who suggests the linkage of the Bucegi Conglomerate with the Albian-age turbidites toward the east because the age equivalent turbidite deposits are also overall fining toward the east. Contescu (1967) argues for an Albian basin with regional eastward sediment transport for the conglomerate (interpreted here as shelf and slope deposits) and basin-floor turbidite deposits.

**Lower Member source-to-sink system**

The distribution of the main geologic units (Figure 9) and their sedimentological genesis outline a complete source-to-sink (S2S) system that includes an erosional subaerial area and a subaqueous shallow and deep-depositional area. Within this S2S system, the sediment source was the highland in the Dambovicioara area that delivered sediments onto the basin floor of the Carpathian fore-deep basin, forming the turbidites of Bobu, Teleajen, and Black Schist strata, bypassing the continental slope area (Albian conglomerate deposits; Figure 9). The sedimentary system that links the Lower Bucegi Conglomerates to the turbidite beds of Bobu Strata, is named the source-to-sink of the Lower Member Bucegi Conglomerates. The Lower Member conglomerates are coeval with the Ciucas, Postavaru-Piatra Mare, Persani, Baraolt, and Codlea Conglomerates (Figures 3 and 9).

**Upper Member source-to-sink system**

Starting from the Bucegi Mountains toward the area south of the Leaota Mountains, in the upper part of the Bucegi Formation, a distinct Babele Sandstone source-to-sink system was active. The Babele Sandstone deposits accumulated on the shelf as a continuation of the alluvial deposits sourced from Dambovicioara area (Figure 9). Toward the south and west, the Babele Sandstone interfingers with the conglomerates and normal graded sandstone beds that alternate with thin bedded turbidites. The coarse clastic deposits eroded and sourced
from Dambovicioara area have been transferred along the basin toward the south and west, within a long and narrow basin (similar to a trench) bounded by the Zamura Uplift (Figure 9). In this study, the olistolith bearing Babele Sandstone that interfingers with Bucgei Conglomerates is called the source-to-sink system of the Upper Member of the Bucgei Formation.

The upper and lower sediment distribution systems share the same Dambovicioara source area, but the sediment dispersal path and depocenters are significantly different.

Olistoliths in the S2S systems

The Bucgei Conglomerate olistoliths are present in both source-to-sink systems. Erratic blocks of the Upper Member source-to-sink system occur mostly within the conglomeratic facies of the Babele Sandstone and significantly less in the basal conglomerates of the Bucgei Upper Member. The olistolith bearing Upper Member conglomerates have been deposited on the shelf (Olariu et al., 2014). Because the olistoliths are associated with shallow-water deposits (seaward limit of the source area), there is the possibility that in proximal areas to the west, part of the olistoliths were deposited in fluvial, nonmarine environments. In some instances, it is obvious that olistoliths within Babele Sandstone are part of the very thick (20–30 m) conglomerate beds that are normal graded, with coarse-grained sandstone toward the top (Figure 7c). The normal-graded beds at such a large scale suggest a subaqueous depositional setting.

As was mentioned already, a lower number of olistoliths have been identified in the conglomerate deposits of the Lower Member of the Bucgei Formation (Figure 6b) interpreted as slope deposit. All of the blocks of the Lower Member are concentrated in the northern area of the Bucgei Mountains, close to the source area of Dambovicioara (Figure 8). In respect to the area of the Albian Deep-Sea Fan, the olistoliths are preserved in the upper fan (Figure 9). The location in the upper part of the Albian slope fan, as well as the proximity to the source area, suggest that the Lower Member conglomerates embedding the olistoliths have been deposited in a relatively shallow-water environment, at the shelf edge/top of the slope in which the gradients were relatively low. This appears to be the apex area of the conglomerate slope fan. In fact, the Lower Member olistoliths are different from the Upper Member olistoliths because they are preferentially located in a few lens-like sandstone units (Patrulius, 1969) rather than in laterally continuous tens of meters thick beds as in the Upper Member.

Olistoliths S2S marker

The data presented in this study point out that the shallow water (possible alluvial) olistoliths of the Bucgei Formation played a significant part in the separation and structure of two source-to-sink systems. The Bucgei olistoliths indicate the sediment fairway of the subaerially derived detrital flux into the basin, and they implicitly point out the boundary between the source and the sink. For the two time-succeeding Albian source-to-sink systems in the Carpathian Bend zone, the Bucgei olistoliths play the same marker role, in the same areal location. The older source-to-sink system shows a concentration of olistoliths on the outer shelf and upper slope, whereas the younger system has olistoliths concentrated on the shelf, both roughly in the same area of the sedimentary system.

Conclusion

A large number (approximately 100) olistoliths, meters to hundred meters large, have been mapped in the Albian Bucgei Formation. The olistoliths occurrence indicates the sediment sourced from a relative narrow pathway in the Dambovicioara area.

The Lower Member of the Bucgei Formation deposits was interpreted as a fan system, based on paleocurrents orientation and sedimentology, initially as an alluvial to shallow-water, and later as a deep-water fan. The Upper Member of the Bucgei Formation includes sediments of a shelf to narrow and deep, trench-like basin.

The S2S system of the Lower Member extended toward the east into the Bobu turbidites. The second S2S system, of the Upper Member, contains Babele Sandstone in the proximal area and extended to deepwater toward the south.

The Bucgei Conglomerate olistoliths were deposited in relatively shallow water, in the proximity of the source area. They mark the entry point of the clastic material in the basin, for the two distinct Albian source-to-sink systems.

Acknowledgment

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Figure 9. The dual Albian source-to-sink system in the Carpathian Bend area. Lower Member paleocurrent trends after Mihăilescu et al. (1967) and Patrulius et al. (1967). Bobu Bed and Teleajen Bed paleocurrent trends after Contescu (1974).
References
Popescu, Gr., 1958, Contribuţii la stratigrafia Flişului cretacic dintre valea Prahovei şi valea Buzaului cu privire specială asupra văii Teleajenului: Studii şi Cercetări de Geologie III/3-4, 159–199.
Stefănescu, M., 1980, Geological map of Romania, scale 1:50,000: Geological Institute of Romania.

Biographies and photographs of the authors are not available.