Devonian to Basal Permian Lithostratigraphy in Southwestern Hakkari: A Perspective from Northern Arabian Mixed Carbonate-Siliciclastic Platform*

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Abstract

The Middle Devonian-Lower Carboniferous succession in the Amanos Mountains to the west and in the Hakkari area to the east of the Hazro High are known as the Zap Group, divided into the Yiginli (Middle-Late Devonian) and Köprülü formations (Late Devonian-Early Carboniferous). The Group is overlain by the Late Permian Gomaniibrik Formation. The thickness of the Yiginli Formation, in the Hakkari-Çukurca area, ranges between 200 and 300 m. The vertebrate and microflora remains indicate a Famennian age for the top of the Yiginli Formation. Brachiopod samples recently collected from the Zap River Valley area allow to establish an Upper Givetian age for the upper middle part of the Yiginli Formation which was until now considered as Famennian on the basis of its micropaleontological contents. In particular, the presence of Atypids excludes an age younger than Lower Frasnian.

Studied brachiopods come from shell concentrations of various clayey-silty levels. The Köprülü Formation represents a variety of marine environments ranging from agitated shallow marine to muddy shelf conditions – below fair weather wave base – and then a return to more restricted shallow marine facies in the upper part. The Köprülü Formation was measured and investigated along the Zap 1 and Zap 2 sections located on the north-east of Köprülü village, 8 km northwest of Cukurca. The Köprülü Formation can be subdivided into three new members. The lower member is composed of dark to grayish limestone and sandy limestone representing the transgressive phase covering the continental deposits of the Yiginli Fomation. The corals described here were collected in this member. The coral assemblage is mainly composed of small non-dissepimented solitary corals belonging to the genera Rotiphyllum, Zaphrentites, cf. Gorizdronia, gen. et sp. indet. and Amplexizaphrentis, including a new species, A. zapense, and the dissepimented coral Caninia aff. cornucopiae. The middle member is composed of thinly laminated dark grey calcareous shales and siltstones; several sandstone layers are also intercalated. The upper part of this middle member is characterized by carbonate concretions embedded in sandy limestone. The fossils, including bivalves are well preserved in this member. The
myalinid bivalves, with a few posidonid bivalves have been observed in dark grey calcareous shale horizons. The upper member is dominated by massive grayish sandy/dolomitic limestone with some dark shale intercalations.

**Selected References**


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My presentation is divided into three main vital points concerning the study.

1. The first part is the introduction where the locations and field observation data about the sections are presented [(Köprülü (Devonian), Zap and Şort Dere (Carboniferous)].
2. The second part is giving few examples of the faunal analysis that are used to construct the lithostratigraphy and the other staff for the Devonian and Carboniferous successions.
3. The third part is the results and conclusions derived from this study.
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Geological map of the Zap Valley showing the position of the studied sections (Gourvennec & Hoşgör 2012)

- Mesozoic carbonates
- Harbol limestones (Gormanilbrik Fm.-U.Permain)
- Köprüülü Fm. (L.Carboniferous)
- Yiğinli Fm. (Devonian)
- Seydişehir Fm.- Şort Tepe Fm. (U.Cambrian to U.Ordovician)

Şort Dere section (Denayer & Hoşgör 2014) — Lower Carboniferous roggose corals- Köprüülü Fm.

Zap sections (Zap 1 & Zap 2) (Hoşgör et al., 2012) — Lower Carboniferous bivalvs- Köprüülü Fm.

Köprüülü section (Gourvennec & Hoşgör 2012) — Middle Devonian brachiopods-Yiğinli Fm.

Zap section (Higgs et al., 2002) — Devonian-Lower Carboniferous microfloras- Yiğinli and Köprüülü Fm.

Şort Dere section (Janvier et al., 1984) — Devonian-Lower Carboniferous Vertebrate Fauna- Yiğinli and Köprüülü Fm.
The Devonian and Lower Carboniferous of the Arabian Plate is represented in Southeastern Anatolia by sedimentary sequences observed from west to east in the Amanos Mountains, Hazro High and Hakkari area.
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- Yığını Fm. (Devonian)
- Seydişehir Fm.- Şort Tepe Fm. (U.Cambrian to U.Ordovician)

new sections
- Şort Dere section (Denayer & Hoşgör 2014) → Lower Carboniferous rugose corals- Köprülü Fm.
- Zap sections (Zap 1 & Zap 2) (Hoşgör et al., 2012) → Lower Carboniferous bivalves- Köprülü Fm.
- Köprülü section (Gourvennec & Hoşgör 2012) → Middle Devonian brachiopods- Yiğını Fm.

old sections
- Zap section (Higgs et al., 2002) → Devonian-Lower Carboniferous microfloras- Yiğını and Köprülü Fm.
- Şort Dere section (Janvier et al., 1984) → Devonian-Lower Carboniferous Vertebrate Fauna- Yiğını and Köprülü Fm.
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Stratigraphic column of the studied units with detailed succession in the Köprülü section (after Janvier et al. 1984, Ghienne et al. 2010, Gourvennec & Hoşgör 2012).
Stratigraphic column of the Devonian-Carboniferous units with detailed succession in the Zap and Şortdere-Şortepe sections (after Janvier et al. 1984, Higgs et al., 2002).
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Stratigraphic column of the studied units with detailed succession in the Köprülü section (after Janvier et al. 1984, Ghienne et al. 2010, Gourvennec & Hoşgör 2012).

Stratigraphic column of the studied units with detailed succession in the Köprülü section (after Janvier et al. 1984, Ghienne et al. 2010, Gourvennec & Hoşgör 2012).

A–E – Dicamara sp. cf. D. prunulum • F–M – Plectospira ferita • N–R – Cyrtina intermedia • S–Z – Cyrtospirifer cf. C. verneuili- Scale bar = 1 cm
Devonian to Basal Permian Lithostratigraphy in Southwestern Hakkari: A Perspective from Northern Arabian Mixed Carbonate–Siliciclastic Platform

Stratigraphic column of the studied units with detailed succession in the Köprülü section (after Janvier et al. 1984, Ghienne et al. 2010, Gourvennec & Hoşgör 2012).
The Hakkari province (SE Turkey) provides some sections through the Paleozoic of the Arabian Plate and thus a good occasion to collect and analyze Lower Carboniferous corals and bivalves (posidonoid and myalinids) in order to constrain the palaeobiogeographic settings of this poorly known area of Middle East as a key location at the transition between the eastern and western parts of the Palaeotethys Ocean.
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- Zap sections (Zap 1 & Zap 2) (Hoşgör et al., 2012) — Lower Carboniferous bivalvs- Köprülü Fm.
- Köprülü section (Gourvennec & Hoşgör 2012) — Middle Devonian brachiopods-Yiğınlı Fm.

**old sections**
- Zap section (Higgs et al., 2002) — Devonian-Lower Carboniferous microfloras- Yiğınlı and Köprülü Fm.
- Şort Dere section (Janvier et al., 1984) — Devonian-Lower Carboniferous Vertebrate Fauna- Yiğınlı and Köprülü Fm.
The upper member consists mainly of limestones and dark grey shales. The limestones are grey to dark grey and massive. They contain variable amounts of sand size quartz grains to form sandy limestones that are locally replaced by dolomitic sequences. This member thickness of 7m at Zap 1 and 8m at Zap 2 sections.

The middle member’s thickness decreases southward, from 7m at Zap 1 to 5m at Zap 2. The succession in the middle member is represented by an alternation of thinly laminated dark grey calcareous shales and siltstones. The upper part of this middle member is characterized by carbonate concretions embedded in sandy limestone. The fossils, including bivalves and cephalopod remains are well preserved in this member. *P. becheri* has been observed in dark grey shale horizons.

The thickness of the lower member is 5m at Zap 1 and Zap 2 sections, respectively. The basal parts of the lower member at Zap 1 and Zap 2 represent transgressive carbonates throughout the area and consist of hard, dark grey to light pink limestones and sandy limestones.
The page contains a stratigraphic diagram with the following formations:

- **Harbol Formation**
- **Köprülü Formation**
- **Yığınıli Formation**

The diagram also includes sample numbers and various rock types indicated by color coding:

- **Dolomite**
- **Sandy Limestone**
- **Limestone**
- **Dolomite quartzes**
- **Silstone**
- **Dark grey shale**

**Posidonia becheri** is noted as a microspore assemblage.
The distribution of *P. becheri* was restricted to the Early Carboniferous of South China (Renjie and Daoping, 1993), NW Belgium (Demanet, 1938), North England (Hind, 1901), Germany (Kulm Basin) (Amler, 2004; Koenen, 1879; Nicolaus, 1963; Paul, 1939, 1941; Roemer, 1854), Poland (Walbrzych Basin) (Nicolaus, 1963; Zakowa, 1958), Portugal (Roemer, 1876), Spain (Cantabrian Mountains) (Amler and Winkler Prins, 1999), and NW Turkey (Zonguldak Basin) (Okan and Hosgör, 2007) and is regarded as a good indicator for tropical and sub-tropical climatic conditions. All of these localities are considered Peri-Gondwanan and/or Avalonian terranes that were rifted off the NW Gondwanan margin and collided with Baltica by the closure of the Rheic Ocean.
During the Late Devonian-Early Carboniferous, these terranes were located to the North of Palaeotethys and the northern shelf of the Palaeotethys covered vast areas in central Europe. The Istanbul-Zonguldak terrane assemblage the Zonguldak Basin was attached to the central and SE European terrane assemblages. The SE Anatolian terrane, on the other hand, was located southeast of the former and attached to Arabia. Based on these data, together with a single finding from Morocco our specimens from SE Turkey are the only occurrences from the northern platform of Gondwana at the southern Palaeotethyan margin, as shown in

*Posidonia becheri* Bronn, 1828 from the Tournaisian of SE Turkey: A palaeobiogeographical implications
The Sort Dere section (GPS 37°17′05.08″N 43°32′25.78″E) is situated on the southern limb of the Çukurca Anticline, cropping out along the northern flank of the valley and exposes the Yıgınlı and Köprülü formations. About 50 samples were collected near the base of the Köprülü Formation. The fossil material comes from two bioclastic silty limestone levels where solitary rugose corals are numerous, together with brachiopods, sponges spicules and bryozoans.

Hosgör et al. (2012) subdivided the Köprülü Formation in three informal members. The lower member (5–7 m-thick) is made of limestone and sandy limestone, dark to grayish in color, representing the transgressive phase covering the continental deposits of the Yıgınlı Formation. The corals described here were collected in this member. The middle member (5–7 m-thick) is composed of calcareous shale and siltstone, usually laminated and dark-colored. Several sandstone layers are intercalated within this mudstone unit. The upper member is dominated by massive grayish limestone, often sandy or dolomitized, with some dark shale layers. This last member is 1–8 m-thick.

This study is based on c. 150 thin sections made through 51 mainly completed, rock-free small solitary corals.
Solitary non-dissepimented rugose corals from the Şort Dere section.

1–5: *Amplexizaphrentis zapense* Denayer & Hoşgör, 2014

6a–d: *Zaphrentites parallela* (Carruthers, 1910),

7: *Amplexizaphrentis* sp.,

8–11: *Rotiphyllum cf. simulatum* Fedorowski 2009

12a–d: Gen. et sp. indet., specimen

13, 16: *Amplexizaphrentites zapense* Denayer & Hoşgör, 2014., external view

14: *Zaphrentites parallela*, ex.v., specimen

15: *Rotiphyllum cf. simulatum*, ex.v., specimen

(scale bar: 10 mm)
Solitary dissepimented and non-dissepimented rugose corals from the Şort Dere section

1–4: *Caninia aff. cornucopiae* Michelin in Gervais 1840.

5–10: cf. *Gorizdronia* sp.

11–12: *Caninia aff. cornucopiae* Michelin in Gervais 1840.
Small solitary horn-shaped non-dissepimented corals are common in mixed carbonate–siliciclastic facies, independent of the age or palaeogeographical position. Table 1 summarizes the diversity of such assemblage in some well studied localities. Usually, the number of taxa is low and the ratio number of species/number of genera is close to 1, indicating a weak disparity. The presence of columnellate and/or disseminated taxa is occasional, witnessing the ability of some “complex” coral (e.g. Caninia aff. cornucopiae) to colonize less favorable environments.

**Table 1**

<table>
<thead>
<tr>
<th>Age</th>
<th>Locality</th>
<th>Facies</th>
<th>Nb. sp./gen.</th>
<th>Dispt. taxa</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Late Emsian–early Eifelian</td>
<td>Istanbul area (NW Turkey)</td>
<td>Deep-water siliciclastic</td>
<td>5/5</td>
<td>0</td>
<td>Kullmann (1973)</td>
</tr>
<tr>
<td>Early Famennian</td>
<td>Harz (Germany)</td>
<td>Deep water carbonate</td>
<td>4/4</td>
<td>0</td>
<td>Weyer (1991)</td>
</tr>
<tr>
<td>Early Famennian</td>
<td>Thuringia (Germany)</td>
<td>Deep water mixed carbonate–siliciclastic</td>
<td>5/5</td>
<td>0</td>
<td>Weyer (2004)</td>
</tr>
<tr>
<td>early Famennian</td>
<td>Sauerland (Germany)</td>
<td>Deep water mixed carbonate–siliciclastic</td>
<td>8/6</td>
<td>0</td>
<td>Weyer (2004)</td>
</tr>
<tr>
<td>Early Famennian</td>
<td>Namur-Dinant Basin (Belgium)</td>
<td>Shallow water siliciclastic</td>
<td>4/4</td>
<td>2</td>
<td>Denayer et al. (2012)</td>
</tr>
<tr>
<td>Latest Famennian–early Tournaisian</td>
<td>Rhenish Massif (Germany)</td>
<td>Deep-water siliciclastic and carbonate</td>
<td>17/13</td>
<td>1</td>
<td>DENAYER AND HOJGOR (2014)</td>
</tr>
<tr>
<td>Late Tournaisian–early Viséan</td>
<td>Baltic coast (NE Germany)</td>
<td>Mixed carbonate–siliciclastic</td>
<td>9/7</td>
<td>1</td>
<td>Webb (1987); Webb and Sutherland (1993)</td>
</tr>
<tr>
<td>Late Tournaisian–early Viséan</td>
<td>Montagne Noire (S France)</td>
<td>Deep-water carbonate</td>
<td>9/7</td>
<td>1</td>
<td>DENAYER AND HOJGOR (2014)</td>
</tr>
<tr>
<td>Late Serpukhovian</td>
<td>Arkansas (USA)</td>
<td>Reefal (thrombolite) limestone</td>
<td>9/8</td>
<td>1</td>
<td>Weyer (1993); Webb (1987); Webb and Sutherland (1993)</td>
</tr>
<tr>
<td>Late Serpukhovian</td>
<td>Oklahoma and Arkansas (USA)</td>
<td>Siliciclastics</td>
<td>11/5</td>
<td>0</td>
<td>DENAYER AND HOJGOR (2014)</td>
</tr>
<tr>
<td>Lower Pennsylvanian</td>
<td>Texas (USA)</td>
<td>Carbonate and siliciclastic</td>
<td>24/10</td>
<td>3</td>
<td>Moore and Jeffords (1945)</td>
</tr>
<tr>
<td>Moscovian</td>
<td>Cantabrian Mountains (Spain)</td>
<td>Carbonate</td>
<td>31/18</td>
<td>0</td>
<td>Rodriguez and Kullmann (1999)</td>
</tr>
<tr>
<td>Late Moscovian</td>
<td>South Urals (Russia)</td>
<td>Warm water carbonate</td>
<td>7/6</td>
<td>0</td>
<td>Kossovaya (2007)</td>
</tr>
<tr>
<td>Late Moscovian (top)</td>
<td>South Urals (Russia)</td>
<td>Mixed carbonate–siliciclastic</td>
<td>7/5</td>
<td>1</td>
<td>Kossovaya (2007)</td>
</tr>
<tr>
<td>Moscovian-Gzhelian</td>
<td>Central USA</td>
<td>Carbonate</td>
<td>24/3</td>
<td>0</td>
<td>Jeffords (1947)</td>
</tr>
<tr>
<td>Cisuralian</td>
<td>Subpolar-Northern Urals (Russia)</td>
<td>Shallow cool water siliciclastic</td>
<td>19/10</td>
<td>0</td>
<td>Kossovaya (2007)</td>
</tr>
<tr>
<td>Cisuralian</td>
<td>Central Urals (Russia)</td>
<td>Deep cool water siliciclastic</td>
<td>8/7</td>
<td>0</td>
<td>Kossovaya (2007)</td>
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<tr>
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<td>South Urals (Russia)</td>
<td>Warm water reefal carbonate</td>
<td>8/6</td>
<td>0</td>
<td>Kossovaya (2007)</td>
</tr>
<tr>
<td>Guadalupian</td>
<td>Arctic Canada</td>
<td>Carbonate</td>
<td>8/6</td>
<td>0</td>
<td>Fedorowski and Bamber (2001)</td>
</tr>
</tbody>
</table>
Early Carboniferous (c. 340 Ma) reconstruction of the Palaeotethys Ocean and its margins (modified form Stampfli et al. (2002)) with position of the discussed areas along the northern margin of the Gondwana.

A stated in the introductive part, the Hakkari area forms the northern part of the Arabian Plate which belongs to the northern margin of the Gondwana continent during Early Carboniferous times.

The Turkish Taurides, Iran and Afghanistan areas are easily comparable from a faunal point of view, composed of both non-dissepimented and dissepimented solitary rugose corals.

The Sinai and Hakkari assemblages show a strong similarity, both being dominated by small solitary non-dissepimented corals.
Paleogeographically the Late Ordovician to Early Carboniferous of northern Arabia suggests that North Africa and Arabia formed a broad stable continental shelf on the northern margin of the Gondwana supercontinent bordering the Paleo-Tethys Ocean.

Studies of the Devonian–Early Carboniferous rocks in the north of Arabian plate show that they were deposited in either terrestrial or shallow marine environments.

Cocks et al., 2002.
Typical shallow-marine deposits - mixed siliciclastic-carbonate facies - are recorded in southern Turkey, northern Syria and northern Iraq. The Kaista Formation is composed mostly of sandstones with minor shales and carbonates. The Ora Formation consists of marine shales and minor carbonates in most parts of Iraq, except around the type area of Ora, where the carbonates are thicker. Towards Syria the formation becomes dominated by sandstone. The Harur Formation consists of shallow marine carbonates and clastics, thickest in Syria (200 m). (Juboury & Hadidy, 2008; Gourvennec & Hoşgör, 2012, Hoşgör et. al, 2012).
Conclusions

• Brachiopods recently collected from the Zap River Valley area –Köprülü section (SE Turkey) allow to establish a Middle Devonian (upper Givetian) age for the upper middle part of the Yığınlı Formation which was until now considered as Famennian on the basis of its micropaleontological contents and of its relative position in the series.

• In the Hakkari area (SE Turkey), the Early Carboniferous, represented by the Köprülü Formation, crops out in the Zap sections and Sort Dere section in the Zap river valley. The Köprülü Formation was measured and investigated along the Zap 1 and Zap 2 sections located on the north-east of Köprülü village. The Köprülü Formation can be subdivided into three new members.

• The lower member is made of dark to grayish limestone and sandy limestone representing the transgressive phase covering the continental deposits of the Yığınlı Formation. The corals described here were collected in this member. The coral assemblage is mainly composed of small nondissepimented solitary corals belonging to the genera Rotiphyllum, Zaphrentites, cf. Gorizdronia, gen. et sp. indet. and Amplexizaphrentis, including a new species, A. zapense, and the dissepimented coral Caninia aff. cornucopiae. The middle member is composed of thinly laminated dark grey calcareous shales and siltstone. Several sandstone layers are also intercalated. The upper part of this middle member is characterized by carbonate concretions embedded in sandy limestone. The fossils, including bivalves are well preserved in this member. The myalinid bivalves, with a few posidonid bivalves have been observed in dark grey calcareous shale horizons. The upper member is dominated by massive grayish sandy/dolomitic limestone with some dark shale intercalations.

• At the generic level, the taxa from Zap Anticline are known in many other areas of the world, a situation that was expected in the context of increasing cosmopolitanism observed during the Givetian and later.

• The coral assemblage is similar to that described from the the Sinai Peninsula (NE Egypt). The Sinai and Hakkari area were part, during the Early Carboniferous, of the northern margin of the Gondwana, and edged northward by a carbonate platform, today dismembered and incorporated in the Alpino-Himalayan orogen within the Turkish Taurides, northern Iran and Afghanistan. Those areas contain coral assemblages sharing several taxa with the Hakkari and Sinai but have a higher diversity. The Köprülü Formation gives an idea of the coral fauna that lived in the southern Arabian mixed carbonate–siliciclastic platform.

• The remaining genera are worldwide distributed. These data are consistent with the closure of the Rheic between Gondwana and Laurussia at this time and with a relatively narrow, incipient Palaeotethys.