

Carboniferous and Triassic conodonts from Syrian boreholes

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ABSTRACT – A sparse but important collection of conodonts recovered from four boreholes in north-eastern and central Syria contains *Neogondolella mombergensis*, which is the first record of Triassic conodonts from Syria. The Carboniferous rocks are characterised by species of *Gnathodus* which indicate the presence of late Tournaisian to late Viséan strata.

THE CARBONIFEROUS OF SYRIA

Prior to 1960, knowledge of the Carboniferous rocks of Syria was very limited partly because strata of this age are poorly exposed. The earliest reference to the Carboniferous rocks of Syria was by Dubortret (1932), who reported the occurrence of Lower Carboniferous strata in the Abd-Al-Aziz mountain region. Later Weber (1964), Wolfart (1967) and Ponikarov (1969) described the deposits of the Carboniferous System in Syria. Yankauskas (1976), with the help of geologists from the Syrian Petroleum Company, studied the microfossils of the Palaeozoic formations, which had been penetrated at depth in different parts of Syria. Acritarchs in particular were used to determine the geological age of these deposits. Stoppel (1970), reported the occurrence of conodonts in Lower Carboniferous rocks outcropping in the Abd-Al-Aziz mountain. This is the only previously published record of conodonts in Syria.

The only outcrop of Tournaisian rocks in the whole of Syria occurs in the Abd-Al-Aziz anticline, within the Twal-el-Aba-Sinjar rampart. It consists of 21 m of thinly stratified marine shale, with intercalations of sandstone and limestone. The rocks occur as a fault-bounded block forming a dismembered unit surrounded by Cretaceous beds. They are fossiliferous containing the brachiopods *Chonetes* sp., *Laguessianus* sp., *Spirifer* aff. *S. tournaisiensis* and *Buxtonia scabricula*. The exact nature of the outcrop is not certain, but it is most probable that the Carboniferous represents an exotic block, or an upthrown block within Cretaceous rocks.

In other parts of Syria, the Carboniferous deposits are unexposed being overlain by a thick sedimentary cover of deposits of Mesozoic-Cenozoic age. Consequently, a number of deep boreholes have been drilled in different areas to enable the buried formations to be studied. Study of the borehole data has established that marine Lower Carboniferous deposits occur at depth over most of Syria with a thickness of up to 1100m in the north-eastern part (in the Markada Borehole – 101). They

become thinner towards the central part, being about 338 m in the Dalaa Borehole and 310 m in the Doubayat Borehole. Lower Carboniferous deposits are absent from the extreme southern portion of the country. The deposits show regional variations in facies. In the southern and central part of Syria (in the Tenf and Swab Boreholes), they are represented by sandstones, intercalated with grey argillites and cream coloured dolomites with fragments of coal and fossil wood. These rest unconformably on Silurian rocks at Tenf and on Ordovician rocks at Swab. They are overlain unconformably by carbonates of Upper Cretaceous age. In the northeast of Syria (in the Markada – 101 and El-Bowab Boreholes) the Lower Carboniferous is represented by massive, black, schistose, argillites with intercalations of dolomite, which rest unconformably on Silurian rocks at Markada and on Ordovician rocks at El-Bowab. They are overlain unconformably by Triassic deposits. Wolfart (1967) found spores in the boreholes at El-Bowab and Al-Barde, which indicated that the Lower Carboniferous is conformably overlain by rocks of Upper Carboniferous (Stephanian – Westphalian and Namurian) age.

THE LOCATION OF THE BOREHOLES AND SAMPLES PROCESSED FOR CONODONTS

Samples from boreholes at four selected localities in north-eastern and central Syria (Fig. 1) were studied in an attempt to establish a biostratigraphic zonation utilising conodonts.

The boreholes studied were those of Swab-1, Markada-101, Jbissa-207 and Roumylan-6. The numbering system follows that employed by the Syrian Petroleum Company.

I – THE SWAB BOREHOLE Swab is located to the south of the city of Dier-Al-Zor. Four cores were taken from different horizons at the depths indicated. The samples studied were as follows:–

Core 5: (0.9 Kg)	1251.85 m	Light grey siltstone with very thin streaks of dark grey shale.		1382.90 m	sandstone cemented by dolomite.
				1384.65 m	
				1386.80 m	
				1383.75 m	
Core 6: (5.2 Kg)	1296.80 m	Dark grey, thin laminated fossiliferous shale.			Light grey sandstone cemented by silicified material, interbedded with very thin beds of black micaceous shale.
	1297.60 m				
	1298.70 m	Dark grey, coarse, crystalline dolomite intercalated with dark grey laminated shale, containing conodonts.			
	1299.80 m				
	1330.30 m	Dark grey, coarse, crystalline dolomite, with pure crystalline barite.	Core 8: (3.25 Kg)	1491.85 m	White sandstones with siliceous cement.
				1496.80 m	
				1493.70 m	Light grey sandstone intercalated with thin streaks of micaceous shale.
Core 7: (5.05 Kg)	1379.95 m			1498.75 m	Dark grey laminated shale.
	1380.90 m	Light grey microcrystalline			

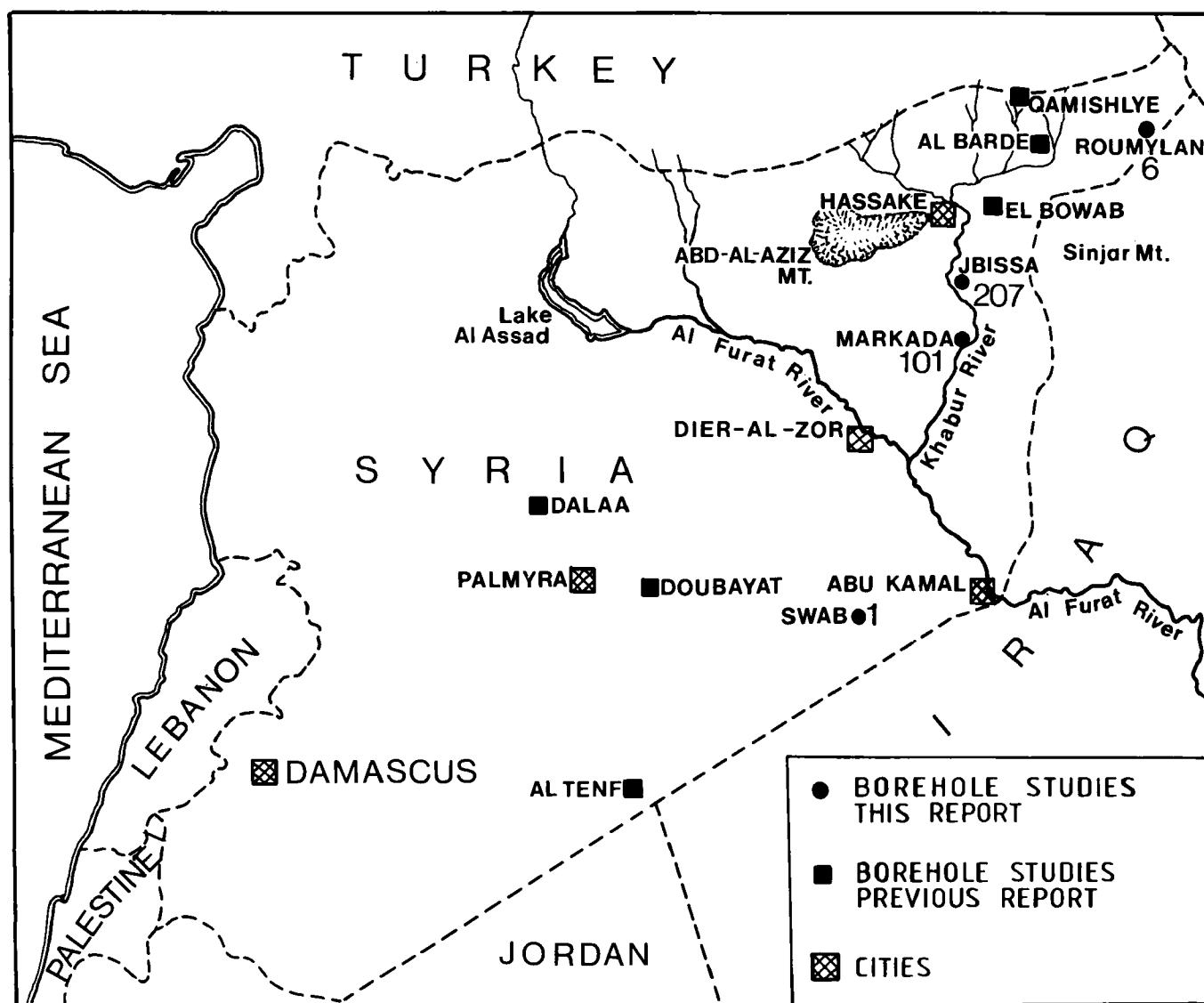


Fig. 1. Locality map showing sites of boreholes.

II – THE MARKADA BOREHOLE-101 Markada is situated on the east bank of Khabur River. Four cores were taken from different horizons at the depths indicated. The following samples were studied:–

Core 18: (5.9 Kg)	3117.80m	Dark grey microcrystalline dolomite, intercalated with streaks of dark grey laminated shale. The dolomite partly fractured, the fractures filled with calcite.
	3120.30m	
	3122.45m	
Core 19: (2.8 Kg)	3123.80m	Red brown, sandstone, cemented by ferruginous material.
	3125.10m	
Core 20: (3.5 Kg)	3361.90m	Black laminated shale containing foraminifera, spores and conodonts.
	3362.60m	
	3363.80m	
Core 20: (3.5 Kg)	3428.95m	Dark grey, microcrystalline limestone, interbedded with thin, black fossiliferous shale.
	3429.85m	
	3435.90m	Dark grey, fossiliferous, microcrystalline limestone.
Core 21: (2.5 Kg)	3436.40m	
Core 21: (2.5 Kg)	3752.70m	Light grey sandstone cemented by silicified material, interbedded with thin beds of black, micaceous shale.
	3753.90m	
	3755.80m	
	3757.60m	

III – THE JBISSA BOREHOLE-207 Jbissa is situated 40km to the North of the Markada structure. The following samples were taken at the depths indicated:–

Core 1: (2.2 Kg)	3867.80m	Dark grey sandstone interbedded with black, laminated micaceous shale.
	3869.40m	
Core 2: (2.2 Kg)	3936.90m	Black laminated shale with streaks of grey dolomite.
	3838.70m	Green laminated shale.
	3939.60m	
Core 3: (3.9 Kg)	4146.30m	Dark grey, microcrystalline limestone, which is fractured, the fractures being filled with calcite and barite.
	4147.80m	Black laminated fossiliferous shale.
	4149.85m	Dark grey, microcrystalline limestone.
Core 4: (3.7 Kg)	4178.90m	Black microcrystalline limestone containing conodonts.
	4180.80m	Black shale.
Core 5: (3.0 Kg)	4252.75m	Black laminated shale.

IV – THE ROUMYLAN BOREHOLE-6 Roumylan is situated to the North-east of Syria. The samples were collected from four cores drilled at different depths. The following samples were processed:–

Core 17: (2.5 Kg)	Samples from the intervals 3578 – 3589 m were light grey sandstone intercalated with very thin laminated grey shale.
Core 18: (4.7 Kg)	Samples from the interval 3589 – 3593.50 m consist of black shale with dolomite and barite.
Core 19: (0.9 Kg)	A sample was taken from the interval 3602 – 3604 m. It was a dark grey limestone with shale.
Core 20: (3.5 Kg)	Samples of black limestone and laminated shale were collected from the interval 3618 – 3629 m. They contained brachiopods.
Core 21: (1.0 Kg)	Dark grey, compact, highly argillaceous limestone with some veins of quartz.

THE CONODONT FAUNA

The present study is based upon 55 rock samples, each approximately one kilogram in weight, which were collected from the mainly Lower Carboniferous deposits present in four boreholes in north-eastern and central Syria. Eleven samples contained conodonts. The conodonts were not very abundant and generally occurred as fragments. The Carboniferous fauna is dominated by the genus *Gnathodus*. The numerical distribution of the conodont elements recovered is illustrated (Figs. 2-4).

THE SWAB BOREHOLE: (Fig. 2)

Samples from Cores 5, 7 and 8 failed to yield any conodonts. Samples from Core 6 yielded elements representing 16 species and 7 genera. The composition of the fauna changes through the depth interval 1296.60m to 1300.30m. The species *Gnathodus bilineatus* and *Gnathodus girtyi girtyi* are present at the top and *Gnathodus pseudosemiglaber* characterises the lower interval. *Gnathodus cuneiformis* and *Gnathodus homopunctatus* are found only at a depth of 1297.60m. Samples from the depth range 1297.60 – 1298.70m produced *Gnathodus texanus*. A single specimen of *Gnathodus symmutatus symmutatus* occurs at a depth of 1298.70m.

The occurrence of the species *Gnathodus bilineatus*, *Gnathodus girtyi*, *Gnathodus cuneiformis*, *Gnathodus texanus* and *Gnathodus pseudosemiglaber* in samples from the Swab Borehole allows approximate correlation to be made with the Lower Carboniferous conodont zones recognised in western Europe. The appearance of the species *G. bilineatus* and *G. girtyi* at a depth of 1296.80m. is of considerable importance as they are the

DEPTH IN BOREHOLE (METRES)	SWAB BOREHOLE				
	CORE 6				
	1296·80	1297·60	1298·70	1299·80	1300·30
CONODONTS					
<i>Euprioniodina microdentata</i>		1	1		
<i>Euprioniodina</i> sp.			1		
<i>Gnathodus bilineatus</i>	2				
<i>Gnathodus girtyi girtyi</i>	4				
<i>Gnathodus cuneiformis</i>		3			
<i>Gnathodus homopunctatus</i>		1			
<i>Gnathodus symmutatus symmutatus</i>			1		
<i>Gnathodus pseudosemiglaber</i>		13	4	1	1
<i>Gnathodus texanus</i>		2	1		
<i>Hindeodella ibergensis</i>	4				
<i>Hindeodella</i> sp.	1		2		
<i>Ligonodina roundyi</i>		1			
<i>Lonchodina furnishi</i>	3	2			
<i>Lonchodina</i> sp.		2	2	1	
<i>Neoprioniodus</i> sp.		1			
<i>Ozarkodina plana</i>			1		
Fragments	4	1	13	2	4

Fig. 2. Conodont species, Swab Borehole.

DEPTH IN BOREHOLE (METRES)	MARKADA BOREHOLE							
	CORE 18	CORE 19			CORE 20			
	3120·30	3361·90	3362·60	3363·80	3428·95	3429·85	3435·90	3436·40
CONODONTS								
<i>Apatognathus geminus</i>							2	
<i>Apatognathus</i> sp.							1	
<i>Gnathodus cuneiformis</i>			1		2			
<i>Gnathodus pseudosemiglaber</i>				1	4	5	1	1
<i>Gnathodus texanus</i>			1			1		1
<i>Lonchodina furnishi</i>								2
<i>Lonchodina</i> sp.					1	1		
<i>Neogondolella mombergensis</i>	2							
<i>Neoprioniodus scitulus</i>					1		1	1
<i>Neoprioniodus</i> sp.								1
<i>Spathognathodus scitulus</i>							1	
Genus sp. indeterminate	1							
Fragments	1	1	9	3	6	5	6	1

Fig. 3. Conodont species, Markada Borehole.

indices for late Viséan and early Namurian age strata (Rhodes et al. 1969, Higgins 1975 and Meischner 1970). The presence of *Gnathodus homopunctatus* indicates a Viséan age at least to a depth of 1297.60m *Gnathodus texanus* and *Gnathodus pseudosemiglaber* which are present below the first appearance of *Gnathodus homopunctatus* have their oldest stratigraphic occurrence in the *Scaliognathus anchoralis* Zone, which is of late Tournaisian age (Lane, Sandberg & Ziegler, 1980). Despite the low yield of conodonts we suspect the Tournaisian-Viséan boundary to fall within the interval of Core 6.

THE MARKADA BOREHOLE: (Fig. 3)

Samples from Core 21 contained no conodonts. Only one horizon in Core 18 contained conodonts. Samples from the Markada Borehole at a depth of 3120.30m contained two broken specimens of *Neogondolella mombergensis*. The specimens clearly exhibit the fairly broad platform features, which are rounded posteriorly. The platform forms a point at the anterior end and the carina is low. The presence of this species in Core 18 is indicative of a Middle Triassic age (Mosher, 1968). The genus was not recovered from any other sample. It represents the first record of Triassic conodonts from Syria.

Samples from the interval 3363.80m – 3436.40m of Cores 19 and 20 are characterised by the presence of *Gnathodus pseudosemiglaber*. At depth 3362.60m, a single specimen of *G. cuneiformis* occurs together with a specimen of *G. texanus*. The sample from depth 3435.90m produced two specimens of *Apatognathus geminus* together with *Spathognathodus scitulus*. This association indicates that at this level there is a shallow water facies (Austin, 1976). *Gnathodus texanus* occurs again at depths of 3436.40m and 3429.85m.

The presence of *Gnathodus texanus*, *Gnathodus cuneiformis* and *Gnathodus pseudosemiglaber* implies that the rocks present in Cores 19 and 20 of the Markada Borehole are of late Tournaisian-early Viséan age.

THE JBISSA BOREHOLE: (Fig. 4)

Only three samples from the Jbissa borehole at depths of 3869.40m, 4147.80m and 4178.90m in Cores 1, 3 and 4 yielded conodonts. Cores 2 and 5 did not yield any conodonts. The specimens recovered are mostly frag-

mentary, but a few are sufficiently well preserved for generic and specific identifications to be made. The species *Gnathodus pseudosemiglaber* and *Gnathodus cuneiformis* are recognised in Core 4 and *Gnathodus pseudosemiglaber* in Core 3, which implies an age close to the Tournaisian-Viséan boundary.

THE ROUMYLAN BOREHOLE:

All samples from the Roumylan Borehole were devoid of conodonts.

REPOSITORY OF SPECIMENS

The conodont specimens of this study are deposited at the Department of Geology, The University, Damascus.

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DEPTH IN BOREHOLE (Metres)	JBISSA BOREHOLE		
	Core 1	Core 3	Core 4
	3869.40	4147.80	4178.90
CONODONTS			
<i>Gnathodus cuneiformis</i>			6
<i>Gnathodus pseudosemiglaber</i>		3	16
<i>Lonchodina furnishi</i>		1	2
Fragments	3	28	130

Fig. 4. Conodont species, Jbissa Borehole.

Explanation of Plate 1

- Figs. 1, 13, 15, 16. *Gnathodus pseudosemiglaber* Thompson & Fellows Oral view of specimens Sy. 4, 31, 18, 20, 1, 13, sample M.K.20, 3428.95, $\times 54$. 15, 16, sample SWB.6, 1297.60, $\times 66$.
- Figs. 2, 8, 9, 12. *Gnathodus cuneiformis* Mehl & Thomas Oral view of specimens Sy. 29, 5, 21, 33. 2, sample M.K.20, 3429.85, SWB.1298, $\times 56$, sample SWB.6, 1297.80, $\times 72$. 12, sample JB.4178.90, $\times 120$.
- Figs. 3, 7. *Gnathodus texanus* Roundy 3, Lateral view of specimen Sy. 26, sample SWB.6, 1298.80, $\times 45$. 7, Oral view of specimen Sy. 3, sample SWB.6, 1298.80, $\times 53$.
- Figs. 4, 5, 14. *Gnathodus girtyi girtyi* Hass Oral view of specimens Sy. 8, 6, 2, sample SWB.6, 1296.80, 4, 5, $\times 50$, 14, $\times 80$.
- Fig. 6. *Gnathodus symmutatus symmutatus* Rhodes, Austin & Druce Oral view of specimen Sy. 1, sample SWB.6, 1298.70, $\times 68$.
- Fig. 10. *Gnathodus bilineatus* Roundy Oral view of specimen Sy. 13, sample SWB.6, 1296.80, $\times 71$.
- Fig. 11. *Gnathodus homopunctatus* Ziegler Oral view of specimen Sy. 17, sample SWB.6, 1297.60, $\times 92$.
- Fig. 17. *Spathognathodus scitulus* Hinde Lateral view of specimen Sy. 12, sample M.K.20, 3435.90, $\times 53$.
- Figs. 18a, b, 19. *Neogondolella mombergensis* Tatge 18a, 18b Oral and lateral view of specimen Sy. 14, $\times 63$. 19, Lateral view of specimen Sy. 15, sample M.K. 18, 3120.30, $\times 80$.
- Fig. 20. Gen. et sp. indeterminate Lateral view of specimen Sy. 16, sample M.K. 18, 3120.30, $\times 107$.
- Fig. 21. *Lonchodina furnishi* Rexroad Lateral view of specimen Sy. 23, sample SWB.6, 1296.80, $\times 57$.
- Fig. 22. *Neoprioniodus scitulus* Branson & Mehl Lateral view of specimen Sy. 30, sample M.K. 20, 3436.40, $\times 53$.
- Fig. 23. *Lonchodina* sp. Lateral view of specimen Sy. 19, sample SWB.6, 1297.60, $\times 65$.
- Fig. 24. *Ligonodina roundyi* Hass Lateral view of specimen Sy. 22, sample SWB.6, 1297.60, $\times 67$.
- Fig. 25. *Euprioniodina microdentata* (Ellison) Lateral view of specimen Sy. 24, sample SWB.6, 1297.60, $\times 53$.
- Fig. 26. *Hindeodella ibergensis* Bischoff Lateral view of specimen Sy. 28, sample SWB.6, 1269.80, $\times 57$.
- Fig. 27. *Ozarkodina plana* Huddle Lateral view of specimen Sy. 27, SWB.6, 1298.70, $\times 60$.
- Fig. 28. *Lonchodina furnishi* Rexroad Lateral view of specimen Sy. 28, M.K. 20, 3436, $\times 80$.
- Fig. 29. *Lonchodina* sp. A. Lateral view of specimen Sy. 32, M.K. 20, 3429, $\times 65$.
- Fig. 30, 32. *Apatognathus geminus* Hinde Lateral view of specimens Sy. 9, 10, sample M.K. 20, 3435.90, $\times 53$.
- Fig. 31. *Apatognathus* sp. Lateral view of specimen Sy. 11, sample M.K.20, 3435.90, $\times 53$.
- Fig. 33. *Neoprioniodus* sp. Lateral view of specimen Sy. 7, sample M.K.20, 3436.40, $\times 53$.

