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The Paleobiogeographic Distribution of the Late Cretaceous Fauna of Arabia and Surrounding Areas

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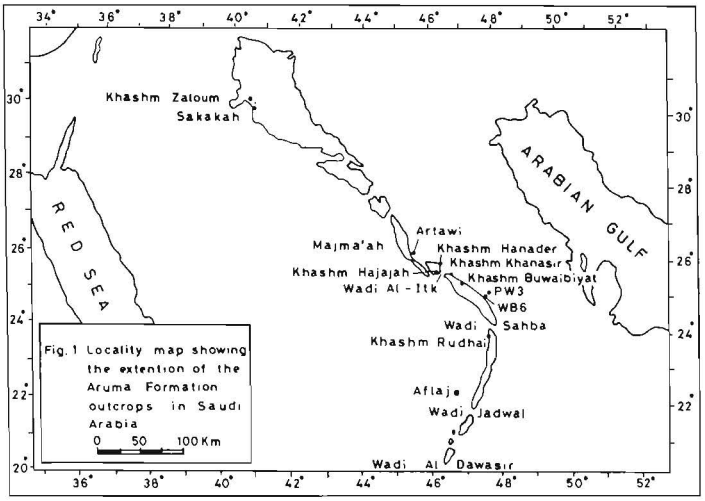
ABSTRACT. Comparisons of the marine invertebrate faunas recorded from the Aruma Formation of Saudi Arabia with those recorded from adjacent countries lead to the recognition of strong faunal links with northern Africa during Turonian ? – Coniacian times and with Iran and southern India during the Santonian. During the Maastrichtian, the Arabian fauna had a wide distribution, extending east to northern India, Afghanistan, Pakistan, Iran, Baluchistan and Iraq and west into northern Africa, Spain and Portugal and perhaps other parts of southwestern Europe.

Steineke and Bramkamp (1952) gave the name Aruma Formation to the Upper Cretaceous sequence that outcrops on the Al-Aramah Plateau from Wadi Al-Dawasir in the south to the vicinity of the town of Sakakah in the north and thence beyond the Iraqi-Saudi border (see location map given in Fig. 1).

On the basis of its foraminiferal content, the Aruma Formation was considered by Powers *et. al.* (1966) to be of Campanian to Maastrichtian age. Subsequently, El-Asa'ad (1977) studied the macrofossils as well as the foraminifera and ostracods of the Aruma Formation in central Saudi Arabia and recognized nine faunal zones in the formation, ranging from Turonian ? – Coniacian to late Maastrichtian (Fig. 2)

Material Used in the Present Study

Macrofossils were collected from seven sections along the Aruma outcrops in central Saudi Arabia at the following localities: the vicinity of Sakakah; the Majma'ah to Artawi trail; the area northwest of Wadi Al-Itk (Khashm Hajajah-Khashm Hanader); the area south of Wadi Al-Itk (Khashm Khanasir-Hifnah vil-



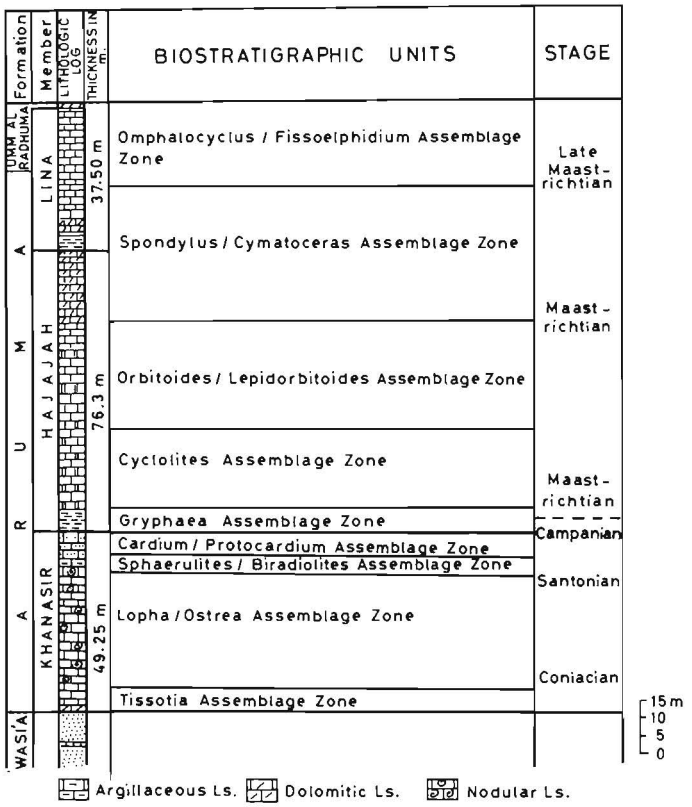


Fig.2 Reference section of Aruma Formation around Wadi Al-Itk Showing its Litho- and Biostratigraphic Subdivisions. After El-Asa'ad (1977)

lage); Khashm Buwaibiyat-Rumhiyah village; Wadi Sahba and the vicinity of Wadi Jadwal-Aflaj (see Fig. 1).

Larger foraminifera and ostracods were picked from the sample of wells No. WB6 and No. PW_3 and were also studied in thin sections of samples collected at outcrop.

The systematic study of the fossils collected from the Aruma succession in central Saudi Arabia led to the recognition of one hundred and sixty species, of which ten are Foraminifera, four Porifera, fourteen Anthozoa, sixty Bivalvia, thirty four Gastropoda, Six Nautiloidea, nine Ammonoidea, ten Echinoidea and thirteen Ostracoda. A full faunal list is appended.

The fossils identified were compared by the writer with museum types and comparative collections, especially those from Middle East housed at the Geological Museum of Cairo, the Sedgwick Museum, Cambridge University, and the British Museum of Natural History in London. Internal reports prepared and published by the United States Geological Survey as well as pertinent literature and Catalogues available at King Saud University, Cairo University, Cambridge University, the Geological Museum of Cairo and the British Museum in London were all referred to.

Paleobiogeography

The fauna of the Aruma Formation, ranging from Coniacian to late Maastrichtian in central Arabia, has a broad distribution, extending far into adjacent areas. These are from east to west: western India, Pakistan, Iran, Baluchistan, Iraq, north Africa, Spain and Portugal and perhaps western Europe (Table 1 and Fig. 3).

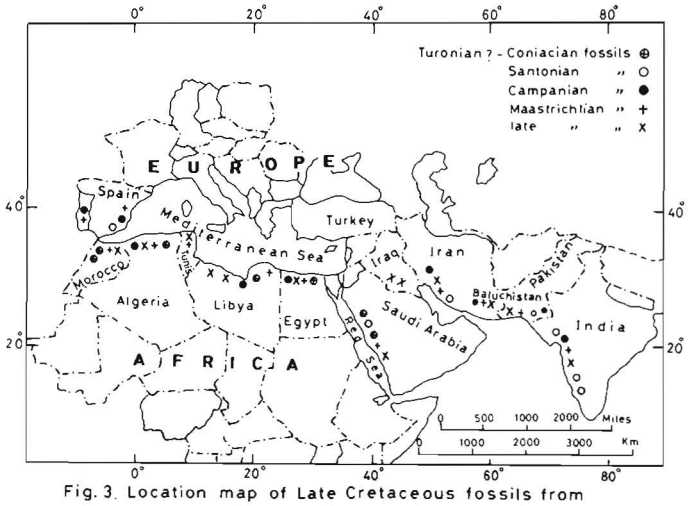


Fig. 3. Location map of Late Cretaceous fossils from central Arabia and Surrounding countries

Table 1. Paleogeographic distribution of the late Cretaceous fauna of Arabian and surrounding areas.

Species	Spain & Portugal	North Africa	Baluchistan	Iran	Pakistan	Western India
Age: Santonian to late Maastrichtian						
Foraminifera						
Rotalia cf. *trochidiformis* (Lamarck)					x	x
Orbitoides tissoti Schlumberger, 1902					x	
Omphalocyclus macroporous (Lamarck)				x	x	
Anthozoa						
Trochosmilia oldhami Duncan						x
Trochosmilia tuba? Fromentel						x
Isastrea morchella (Reuss)						x
Cyclolites depressa Reuss				x		
Cyclolites hemisphaerica Lamarck				x		
Cyclolites undulata Blainville				x		
Goniopora epithecata (Duncan)						x
Bivalvia						
Pseudoheligmus morgani Douvillé				x		
Spondylus calcaratus (Forbes)				x		x
Spondylus subserratus Douvillé				x		
Cardium (Trachycardium) productum J. de C. Sowerby						x
Protocardium hillanum (J. de C. Sowerby)						x
Trapezium carteri (d'Archiac & Haime)						x
Radiolaria mutabilis Stoliczka						x
Biradiolites austinensis Roemer				x		
Ostrea telugensis Stoliczka						x
Ostrea (Alectryonia) diluviana Linnaeus						x
Ostrea (Alectryonia) pectinata Lamarck						x
Lopha dichotoma var. *sollieri* Douvillé				x		

Species	Spain & Portugal	North Africa	Baluchistan	Iran	Pakistan	Western India
Gastropoda						
Keilostoma morgani (Douvillé)				x		
Architectonica karapandiensis (Stoliczka)						x
Cerithium (Fibula) detectum Stoliczka						x
Chemnitzia undosa Forbes						x
Cypraea cunliffei Forbes						x
Drillia morgani Douvillé				x		
Nautiloidea						
Nautilus deluci d'Archiac						x
Nautilus subfleuriausianus d'Archiac						x
Eutrephoceras sphaericum Forbes						x
Ammonoidea						
Puzosia denisoni (Stoliczka)						x
Echinoidea						
Coptodiscus nomiae Cotteau & Gauthier				x		
Age: Campanian – late Maastrichtian						
Foraminifera						
Orbitoides tissoti Schlumberger, 1902		x				
Omphalocyclus macroporous (Lamarck)		x	x			
Anthozoa						
Trochosmilia protectans Noetling			x			
Cyclolites medlicotti Noetling			x			
Cyclolites regularis Leymerie			x			

Species	Spain & Portugal	North Africa	Baluchistan	Iran	Pakistan	Western India
Bivalvia						
Spondylus latus J. de C. Sowerby		x				
Cardium (Trachycardium) productum J. de C. Sowerby		x				
Protocardium hillanum J. de C. Sowerby		x				
Gryphaea cf. *oldhami* Noetling			x			
Ammonoidea						
Sphenodiscus acutodorsatus Noetling			x			
Echinoidea						
Globator martenseni (Checcia-Rispoli)		x				
Age: Early Campanian to Maastrichtian						
Foraminifera						
Monolepidorbis sanctae pelagiae Astré	x					
Bivalvia						
Sphaerulites peroni Choffat	x					
Biradiolites arnaudi Choffat	x					
Gastropoda						
Strombus bellasensis Choffat	x					
Strombus cascaensensis Choffat	x					
Strombus fischeri Choffat	x					
Age: Turonian? – Coniacian						
Ammonoidea						
Tissotia tissoti Peron		x				
Hemitissotia turzoi Karrenberg		x				

Species	Spain & Portugal	North Africa	Baluchistan	Iran	Pakistan	Western India
Ostracoda						
Cytherella aff. *austinensis* Alexander		x				
Cytherella gr. *Cytherella ovata* (Roemer)		x				
Dolocytheridae atlasica Bassoulet and Damotte		x				
Brachycythere angulata Grekoff		x				

The following species encountered in central Arabia, and ranging from Santonian to late Maastrichtian have been recorded by various authors from western India: *Spondylus calcaratus* Douvillé, *Cardium (Trachycardium) productum* J. de C. Sowerby, *Procardium hillanum* d'Archiac & Haime, *Radiolites mutabilis* Stoliczka, *Ostrea (Alectryonia) pectinata* Lamarck, *O. (A.) diluviana* Linnaeus and *O. telugensis* Stoliczka were all recorded by Stoliczka (1870-1871). *Cerithium (Fibula) detectum* Stoliczka, *Cypraea cunliffei* Forbes, *Architectonica karapandiensis* (Stoliczka) and *Chemnitzia undosa* Forbes were all recorded by Stoliczka (1867-1868). Subsequently, Stoliczka (1873) recorded *Trochosmilia tuba* Fromentel and *Isastrea morchella* (Reuss). *Trochosmilia oldhami* Duncan and *Goniopora epithecata* (Duncan) were originally described by Duncan (1880). Vredenburg (1928) recorded *Nautilus subfleuriausianus* d'Archiac and *N. deluci* d'Archiac. Moreover, *Rotalia* cf. *trochidiformis* Lamarck was recorded by Davies (1932), *Eutrephoceras sphaericum* d'Archiac by Forbes (1845), *Puzosia denisonianum* (Stoliczka) by Wadia (1961) and *Trapezium carteri* d'Archiac & Haime by d'Archiac & Haime (1853-1854).

Species ranging from Santonian to late Maastrichtian in central Arabia, and known to occur in Pakistan, are as follows: *Rotalia* cf. *trochidiformis* (Lamarck) was recorded by Davies (1932), *Orbitoides tissoti* Schlumberger by Marks (1962) and *Omphalocyclus macroporous* (Lamarck) by Nagappa (1959). In Iran, the following species were recorded: *Pseudoheligmus morgani* Douvillé, *Spondylus subserratus* Douvillé, *Lopha dichotoma* var. *sollieri* Douvillé, *Keilostoma morgani* (Douvillé) and *Drillia morgani* Douvillé. All of these were originally described by Douvillé (1904). *Omphalocyclus* cf. *macroporous* (Lamarck) was recorded by Sampo (1969), *Spondylus calcaratus* Forbes by Stoliczka (1870-1871) and *Biradiolites austinensis* Roemer by Douvillé (1904). *Coptodiscus nomia* Cotteau and Gauthier was originally described by Cotteau and Gauthier (1921); fide Kier (1972). *Cyclolites depressa* Reuss and *C. undulata* Blainville were observed by the writer in the collections of the British Museum of Natural History, Nos. B-38946 and

R-38939 respectively, while *Cyclolites hemisphaerica* Lamarck was also observed in the Sedgwick Museum, Cambridge (No. F-4247).

Species of Campanian – late Maastrichtian age that occur in both central Arabia and Baluchistan include: *Trochosmilia protectans* Noetling, *Cyclolites medlicott* Noetling, *Gryphaea* cf. *oldhami* Noetling and *Sphenodiscus acutodorsatus* Noetling. All were originally described from Baluchistan by Noetling (1897 a) while *Omphalocyclus* cf. *macroporous* (Lamarck) was recorded by Nagappa (1959) and *Cyclolites regularis* Leymerie by Noetling (1897 b). In north Africa, the following species were recorded: *Orbitoides tissoti* Schlumberger by Neumann (1958), *Omphalocyclus* cf. *macroporous* (Lamarck) from Algeria by Drooger (1952), *Cardium (Trachycardium) productum* J. de C. Sowerby from Tunisia by Pervinquière (1912), *Protocardium hillanum* J. de C. Sowerby from Egypt by Fourtau (1917) and *Spondylus latus* J. de C. Sowerby by Abbass (1962) from Egypt. Finally *Globator martenseni* (Checcia-Rispoli) which was originally described by Checcia-Rispoli (1932); fide Kier (1972).

Species of late Santonian/lower Campanian to Maastrichtian age that are known from both central Arabia and Spain and Portugal include: *Sphaerulites peroni* Choffat, *Biradiolites arnoudi* Choffat, *Strombus fischeri* Choffat, *S. bellasensis* Choffat and *S. cascaesensis* Choffat. All of these were originally described from Portugal by Choffat (1901-1902). *Monolepidorbis sanctae pelagiae* Astré was recorded by Batailler (1947).

Species of Turonian ? – Coniacian age that are common to north Africa (Epypt, Algeria, Libya, Morocco) and central Arabia are: *Cytherella* gr. *cytherella ovata* (Roemer) and *Dolocytheridea atlasica* Bassoulet & Damotte, recorded from Algeria by Bassoulet and Damotte (1969). *Brachycythere angulata* Grekoff and *Cytherella* aff. *austinensis* Alexander were recorded from Egypt by Van Den Bold (1964). *Tissotia tissoti* Peron was originally described from Algeria by Peron (1896-1897) and *Hemitissotia turzoi* Karrenberg has been observed by the writer in the collections of the Sedgwick Museum, Cambridge, No. F-11667.

Only a few species of late Maastrichtian age are common to Arabia and Iraq; these include: *Omphalocyclus* cf. *macroporous* (Lamarck), recorded from Iraq by Smout (1954) and *Monolepidorbes douvillei* Astré recorded by Grimsdale (1952).

Conclusions

During Turonian ? – Coniacian times, there were strong similarities between north Africa and Arabia. This is perhaps due to a period of tectonic adjustment that affected the Middle East in early late Cretaceous time, as is shown by an important erosional episode and depositional hiatus, postdating the deposition of Turonian but preceding the onset of early Senonian sedimentation, which can be recognized over some of the linear structures in the region (Dunnington *et. al.* 1959 and Sampo 1969).

Marine links and faunal interchange between Arabia, Iran, Pakistan, western and southern India began during Santonian times. During the Campanian – Maastrichtian, Arabian faunas extended eastwards through southern Iraq, western Iran, Baluchistan, Pakistan and southern India and through north Africa into Spain and Portugal.

A Tethyan faunal province was in existance during late Cretaceous times, and extended from southwestern Europe to north Africa, central Arabia, western and southern India.

The paleobiogeographic distribution of the fauna of Arabia and adjacent countries was influenced and controlled by regional movements and tectonic development during early late Cretaceous times.

During the Campanian – Maastrichtian, one of the greatest marine transgressions of all time linked the shallow marine basin covering central Arabia with the wide and length Tethys seaway.

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Appendix: Faunnal list of the aruma formation (late Cretaceous) in central Saudi Arabia.

Species	Age					
	Turonian	Coniacian	Santonian	Campanian	Early Maastrichtian	Late Maastrichtian
Foraminifera						
Rotalia cf. *trochidiformis* (Lamarck)					x	
Globotruncana havanensis Voorwijk					x	
Monolepidorbis douvillei Astré					x	
Monolepidorbis sanctae pelagiae Astré				x		
Orbitoides apiculatus Schlumberger, 1962					x	
Orbitoides gensasicus (Leymerie, 1851)					x	
Orbitoides tissoti Schlumberger, 1902				x		
Lepidorbitoides (Lepidorbitoides) macgillavryi Thiadens, 1937					x	
Lepidorbitoides (Asterobsis) rooki (Vaughan and Cole, 1932)					x	
Omphalocyclus macroporous (Lamarck)					x	
Porifera						
Scytalia radiciformis Phillips		x				
Doryderma cf. *benetti* Hinde		x				
Siphonia pyriformis Goldfuss		x				
Hallirhoa cf. *costata* (Lamouroux)		x				
Anthozoa						
Trochosmilia oldhami Duncan					x	x
Trochosmilia protectans Noetling					x	x
Trochosmilia tuba? Fromentel					x	x
Favites tenuiseptata Duncan					x	
Isastrea morchella (Reuss)					x	
Siderastrea (Siderastrea) sp.				x		
Cyclolites arabicus sp. nov					x	
Cyclolites depressa Reuss				x		
Cyclolites elliptica Lamarck					x	
Cyclolites hemisphaerica Lamarck				x		
Cyclolites medilicotti Noetling					x	
Cyclolites regularis Leymerie					x	
Cyclolites undulata Blainville					x	
Goniopora epithecata (Duncan)				x		

Species	Age					
	Turonian	Coniacian	Santonian	Campanian	Early Maastrichtian	Late Maastrichtian
Bivalvia						
Nucula cf. *ovata* Mantell						x
Nucula cf. *pectinata* (J. de C. Sowerby)					x	
Arca gabrielis (Leymerie)			x			
Lithophaga sp.					x	
Pteria pedernalis (Roemer)				x		
Inoceramus aff. *balticus* Boehm		x				
Inoceramus cripssi Mantell		x				
Inoceramus ellioti Gabb					x	
Inoceramus sp.		x				
Inoceramus (Cataceramus) whitneyi Gabb				x		
Inoceramus (Inoceramus) sp.		x				
Inoceramus (Sphenoceramus) sp.		x				
Inoceramus (Endocostea) sp.		x				
Inoceramus (Cremnoceramus) sp.		x				
Pseudoheligmus morgani Douvillé				x		
Neithea sp.					x	
Spondylus calcaratus (Forbes)						x
Spondylus latus J. de C. Sowerby						x
Spondylus subserratus Douvillé						x
Spondylus sp.						x
Anomia laevigata J. de C. Sowerby					x	
Lucina sp.					x	
Opis neocomiensis d'Orbigny			x			
Cardium gigantium Seguenza				x		
Cardium aff. *marquarti* Müller				x		
Cardium (Trachycardium) mayer-eymari, Oppenheim				x		
Cardium (Trachycardium) productum J. de C. Sowerby				x		
Protocardia hillanum J. de C. Sowerby					x	
Protocardia texana Conrad			x			
Protocardia Sp.				x		
Senis warbutoni Forbes					x	
Anisocardia sp.			x			
Trapezium carteri (d'Archiac & Haime)						x
Cyprimeria texana Roemer			x			
Clementia (Flaventia) ovalis J. de C. Sowerby				x		

Species	Age					
	Turonian	Coniacian	Santonian	Campanian	Early Maastrichtian	Late Maastrichtian
Toucasia steinmanni Schnarrenberger				x		
Monopleura sp.						x
Radiolites mutabilis Stoliczka			x			
Praeradiolites sp.			x			
Sphaerulites lusitanicus Bayle			x			
Sphaerulites peroni Choffat			x			
Biradiolites arnaudi Choffat			x			
Biradiolites austinensis Roemer			x			
Pholadomya ambigus J. de C. Sowerby					x	
Pholadomya spectoensis Woods					x	
Homomya sp.					x	
Gryphaea khazzaensis sp. nov.					x	
Gryphaea cf. *oldhami* Noetling					x	
Gryphaea sp.					x	
Gryphaeostrea canaliculata J. de C. Sowerby					x	
Ostrea leymeri Deshayes			x			
Ostrea sollieri Coquand			x			
Ostrea syphax Coquand			x			
Ostrea telugensis Stoliczka			x			
Ostrea (Alectryonia) diluviana Linnaeus			x			
Ostrea (Alectryonia) pectinata Lamarck			x			
Lopha dichotoma var. *sollieri* Douvillé			x			
Lopha dichotoma Bayle				x	x	
Lopha solitaria J. de C. Sowerby			x			
Gastropoda						
Pleurotomaria sp.					x	
Keilostoma morgani (Douvillé)					x	
Architectonica conoideum J. de C. Sowerby					x	
Architectonica karapandiensi (Stoliczka)					x	
Nerineopsis cuckhamsliensis Woods					x	
Cerithium (Fibula) detectum Stoliczka					x	
Cerithium tenouklense Coquand					x	
Scala cf. *dupiniana* (d'Orbigny)						x
Scala (Confusiscala) cf. *dupiniana* (d'Orbigny)					x	
Chemnitzia undosa Forbes					x	
Aporrhais dupiniana Pictet and Campiche					x	

Species	Age					
	Turonian	Coniacian	Santonian	Campanian	Early Maastrichtian	Late Maastrichtian
Aporrhais lamellifera Kaun Hawen						x
Aporrhais marginata J. de C. Sowerby					x	
Pterodonta deffisis Thomas and Peron						x
Pterodonta ovata d'Orbigny						x
Strombus bellasensis Choffat						x
Strombus cascaensensis Choffat			x			
Strombus fischeri Choffat					x	
Strombus (Eustrombus) sp.				x		
Cypraea costacensis Stewart					x	
Cypraea cunliffei Forbes						x
Megalocypraea sp.						x
Tylostoma pallaryi (Peron & Fourtau)						x
Tylostoma sp.					x	
Buccinum cf. *qualtinum* d'Orbigny					x	
Sycostoma pervinquieri (Boelenev)					x	
Fasciolaria laevis Kaun Haven					x	
Vasum sp.					x	
Volutoderma sp.						x
Rostellinda pergaensis Boelenev				x		
Lyria subcrassicostata Basse					x	
Drillia morgani Douvillé					x	
Drilluta curta Boelenev				x		
Nautiloidea						
Nautilus deluci d'Archiac						x
Nautilus subfleuriausianus d'Archiac						x
Eutrephoceras sphaericum Forbes						x
Cymatoceras sakalavus (Collignon)						x
Cymatoceras subalbensis						x
Cimomia whylliei Newton						x
Ammonoidea						
Puzosia denisoni (Stoliczka)						x
Tissotia sp. 1		x				
Tissotia tissoti Peron		x				

Species	Age					
	Turonian	Coniacian	Santonian	Campanian	Early Maastrichtian	Late Maastrichtian
Tissotia sp. 2		x				
Hemitissotia sp.		x				
Hemitissotia turzoi Karrenberg		x				
Paratissotia sp.		x				
Sphenodiscus acutodorsatus Noetling						x
Indoceras sp.				x		
Echinoidea						
Hypodiadema sp.		x				
Coptodiscus nomiae Cotteau & Gauthier		x				
Globator martenseni (Checcia – Rispoli)					x	
Iraniaster affinidouvillei Kier					x	
Iraniaster affinimorgani Kier			x			
Iraniaster sp. 1			x			
Iraniaster bowersi Kier				x	x	
Iraniaster sp. 2			x			
Proraster sp.					x	
Proraster granti Kier			x			
Ostracoda						
Cytherella aff. *austinensis* Alexander	?	x				
Cytherella gt. *Cytherella ovata* (Roemer)	?	x				
Bairdia pseudoseptentrionalis (Mertens)	?	x				
Bairdia roemeri Deroo	?	x				
Dolocytheridae atlasica Bassoulet and Damotte	?	x				
Brachycythere angulata Grekoff	?	x	x			
Neocythere sp.	?	x	x			
Cythersis grekovi Damotte	?	x				
Cythersis namousensis Bassoulet and Damotte	?	x				
Xestoleberis obesa Van Den Bold	?	x				

التوزيع الجغرافى الحيوى القديم لأحياء العصر الطباشيرى المتأخر فى المملكة العربية السعودية والمناطق المجاورة لها

غالب محمد الاسعد

قسسم الجيولوجيا - جامعة الملك سعود - المملكة العربية السعودية .

ان مقارنة أحافير الأحياء اللافقارية البحرية القديمة من عمر الطباشيرى المتأخر والتى وجدت فى صخور متكون العرمة فى المملكة العربية السعودية بمثيلاتها من المناطق المجاورة للمملكة قد قادت الى اثبات حدوث اتصالات حيوية قديمة واضحه مع شمال افريقيا اثناء عمر التورونى الكونياسى ومع ايران وجنوب الهند أثناء عمر السانتونى .

أثناء عمر الماسترختى حدث انتشار واسع لهذه الأحياء فامتدت شرقا الى شمال الهند ، افغانستان ، باكستان ، ايران ، بالوخستان والعراق كما امتدت غربا الى شمال افريقيا ، اسبانيا والبرتغال وربما أجزاء من جنوب غرب اوربا .