MINISTRY OF ECONOMY . GEOLOGICAL SURVEY OF IRAN



Contributions to the Paleontology and Stratigraphy of Iran, Part 1

Geological Survey of Iran, Report No. 19, 1971

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Eccene Fish Remains from the Pabdeh Formation North of Ilam A. Haghipour and A. Brants

> Upper Permian Corals from Julfa Helmut W. Flügel

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THE JURASSIC BADAMU FORMATION IN THE KERMAN REGION, WITH REMARKS ON THE JURASSIC STRATIGRAPHY OF IRAN

K. Seyed-Emami Technical Faculty, University of Tehran and Geological Survey of Iran

ABSTRACT

The Jurassic Badamu Formation in the Zarand trough, north of Kerman, Iran, shows greatest lithologic variation and maximum (150 m) thickness within and along the axis of the trough; outside and along the trough margin, the formation consists of up to 20 m of limestone. The lower contact of the Badamu is marked by the first appearance of "grammoceratoid" ammonites and the upper contact by the last appearance of "stephanoceratoid" ammonites; this fixes a late Early Toarcian to Middle Bajocian age for the formation.

The Badamu fauna shows a remarkable resemblance to European faunas in beds of the same age. Mediterranean forms, however, are almost completely missing and there is no faunal relationship with the Zagros fauna or that of the Indo-Malagassian realm. Thus, during Early Toarcian to Middle Bajocian time, land, subject to periodic marine transgressions, was present in south-central Iran, dividing the Zagros trough from the central and north Iranian basins.

A complete description of the ammonites present (103 species) is not given in this paper; but five new species and two new subspecies are described and illustrated.

INTRODUCTION AND ACKNOWLEDGEMENTS

The Badamu Formation is named after the village of Badamu and Kuh-e-Badamu (Badamu Mt) 24 km west of Kerman (Fig. 1, 2). This formation has been well known for many years because of its stratigraphic position, rich fauna, and its use in mapping the coal-bearing Jurassic deposits in the Kerman area.

This paper is in part a summary of two previous studies of the Badamu Formation by the author. The first study dealt with the ammonite fauna and contained a complete description of all species present (Seyed-Emami, 1967). The second was more stratigraphic in nature and was prepared at the request of the National Iranian Steel Corporation (Seyed-Emami, 1968). The present paper includes new stratigraphic, lithologic, paleogeographic, and paleozoographic information as well as a description of five new species and two new subspecies of ammonites. Plates of the entire ammonite fauna and the ranges of all species, however, are presented here.

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Fig. 1. Locality map of Iran.



Fig. 2. Geographic distribution of the Badamu Formation.

PREVIOUS WORK

Tipper (1921) first described the formation known as Badamu Limestone at Kerman and recognized its importance in the mapping of the Jurassic coal deposits. He believed the limestone was Late Liassic in age (Fig. 3) and mentioned the following fauna from the area southwest of Ravar*:

Belemnites sp. of the canaliculati and hastati groups Oxynoticeras sp. (= Leioceras cf. opalinum) Harpoceras sp. of the falciferum and normanium groups (= Brasilia n. sp.) Stephanoceras sp. (= ? Otoites aff. contractus) Dactylioceras sp. (= ? Stephanoceras sp. indet.) Dactylioceras sp. (= ? Stephanoceras sp. indet.) Pecten sp. Pholadomya sp. Trigonia sp. Pinna cf. lanceolata Sowerby Rhynchonella sp.

At Badamu he found :

Belemnites sp. Pecten leus Sowerby Plagiostoma sp. Waldheimia sp.

Böhne (1932, p. 141) recorded from the "Bademun Mountains" (= Badamu), 24 km west of Kerman, about 4 m of bluish-grey limestone that contained belemnites, ammonites, and many other fossils of Early Dogger age.

Cox (1936) studied the pelecypods of Tipper's collection; he believed, in accordance with Spath (1936), that they were Bajocian in age. The following forms were mentioned :

Pseudomelania cf. procera (Etudes and Delongchamps) Trigonia sp. Modiolus (Pharomytilus) plicatus Sowerby Lima sp. Pleuromya unioides (Roemer) Ostrea sp. indet. Chlamys sp. indet. Variamussium pumilum (Lamarck) Ctenostreon sp.

The cephalopods of Tipper's collection were studied by Spath (1936). These conisted of 17 ammonites from southwest of Ravar. Spath believed that these fossils represented the Lower Dogger ammonite zones Opalinum to Humphriesianum (Fig.6). The

^{*} The author has been able to re-examine many of the fossils collected by previous workers. The generic and specific names in parentheses indicate the author's re-identification of the fossils.



Fig. 3. Time relations of Jurassic formations in Iran.

fossils described were:

Euaptetoceras sp. indet. (=?E. amaltheiforme Vacek) Planammatoceras cf. eudmetum Buckman Witchellia aff. pavimentaria (Buckman) Leioceras cf. lineatum Buckman Leioceras aff. bifdatum Buckman Leioceras aff. bifdatum Buckman Leioceras cf. opalinum (Reinecke) Brasilia opalinoides (Ch. Mayer) Vacek sp. Brasilia? n. sp. Graphoceras (Ludwigella) aff. formosum (Buckman) (= G. concava (Sowerby)) Stephanoceras sp. indet. (= Kumatostephanus) Otoites aff. contractus (Sowerby) Belemnites sp. indet.

Huber and Stöcklin (1954) surveyed the coal region of Hojedk and mentior (c "The Dogger-Limestone member" as being 30 - 40 m of sandy limestone that contair (c besides pectinids and forams, the following ammonites:

Stephanoceras sp. Harpoceras sp. Belemnites cf. canaliculatus

These were believed to be Late Lias to Early Dogger in age.

The Badamu Limestone was investigated more intensively by Huckriede, Kürster and Venzlaff (1962). They called it "Lias-Dogger Cephalopdenkalk" and mentior $\epsilon \epsilon$ a rich fauna from localities between Kerman and Saghand. They believed that the Badamu was Middle Lias to Early Dogger in age. The following ammonites were meationed:

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Arieticeras sp. indet. (= Pleydellia distans Buckman)

Dumortieria sp. (= D. mactra (Dumortier)) ·

Tmetoceras scissum (Benecke)

Leioceras cf. opalinum (Benecke) (= L. comptum (Reinecke))

Leioceras cf. bifdatum Buckman (= L. comptum (Reinecke))

Ludwigia costosa (Quenstedt)

Ludwigia murchiosonae (Sowerby) / concava (Sowerby)

Ludwigia sp. (= L. (Graphoceras) concava (Sowerby)

Ludwigia sp. indet.

Hammatoceras insigne (Schubl.)

Hammatoceras subinsigne (Oppel) (= Pseudammatoceras dumortieri (Prinz))

Sonninia (Poecilomorphus) sp. (partly = S. (P.) schlumbergeri Haug)

(partly = S. (P.) sulcata Buckman)

Emileia sp. (= Emileia macrocephala (Quenstedt))
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Other fossil groups found included the following corals, brachiopods, pelecypods gastropods, and Vermes:

? Hydrozoa Thamnastraea sp. Montlivaultia sp.

Micrabacia sp. Zeilleria sp. Terebratula helena Bayle Belemnopsis sp. Trichites sp. Hinnites velatus (Goldfuss) Hinnites sp. Plagiostoma cf. gigantea (Sowerby) Ctenostreon proboscidea (Sowerby) Lopha sp. Modiola plicata (Sowerby) Pholadomya sp. Homomya sp. Gresslya sp. Ceromya aalensis Quenstedt Pleuromya unioides (Roemer) Pleurotomaria sp. Pseudomelania sp. Promathildia sp. Bourgetia sp. Serpula sp.

In a study of the ammonites and stratigraphy of the Badamu Limestone near Kerman the author (Seyed-Emami, 1967) discussed the paleogeography, described 103 species of ammonites (including 7 new species), and was able to show that all of the western European ammonite zones from Bifrons to Humphriesianum (late Early Toarcian to Middle Bajocian) were represented.

Seyed-Emami's (1968) unpublished stratigraphic study of the Badamu Formation in the area of the Zarand trough (Fig. 1) also contained much new data on the lithology of the formation. Much of the information in that report is incorporated here.

BADAMU FORMATION

Lithology and Thickness

Outside of and along the borders of Zarand trough* (e.g., at Hojedk and Eshkeli; see Fig. 4), the Badamu Formation consists of up to 20 m of uniform, dark-grey, relatively thick-bedded, light yellow-brown weathering sandy-oolitic limestone that occasionally has marly partings and is very fossiliferous. To the north, the Badamu contains many sandy, silty, and calcareous beds, and its thickness increases rapidly. For example, 150 m of limestone, siltstones, and sandstones at Gel-Tud correspond to 12 m of limestone at Hojedk.

However, these beds are of little value for stratigraphic correlation as they are of limited lateral extent and change in lithology. For example, in the middle of the Badamu

^{*} Named by Huckriede et al. (1962) for the basin between Gel-Tud and Hojedk (Fig. 2).





Fig. 4. Correlated sections of the Badamu Formation between Gel-Tud and Eshkeli. (The Badamu type locality is at Titu.) Formation, to the north and along the axis of the Zarand trough, a sandstone horizon of about 20 to 50 m thickness is present. To the south and along the margins of the trough, however, this horizon splits into soft sandstones, siltstones, and limestones; and at Eshkeli, Hojedk, and outside the Zarand trough, these beds are not present at all. Also, the sandstone horizon is time-transgressive; at Dar-e-Gor it belongs mostly to the Sowerbyi ammonite zone but at Darbitkhun it corresponds to the somewhat older Upper Aalenian Stage. Thus, correlation over long distances on the basis of lithology has to be done with caution.

In general, it can be stated that clastic coarse-grained rocks predominate along the axis of the Zarand trough, and the formation is also thickest along the axis. The clastic rocks decrease in both grain size and quantity from north to south. Along the margins silty and calcareous rocks predominate and the thickness is reduced.

Definition and Limits

At Hojedk, Eshkeli, and outside the Zarand trough, definition of the Badamu Formation is relatively easy. In these areas, the Badamu Formation consists of about 5 to 25 m of limestone that is easily recognizable, lying as it does between silty and shaly deposits.

To the north and within the Zarand trough, definition of the Badamu is less clear, as the formation contains many sandy, silty, and calcareous beds and the upper and lower contacts are not sharp. To define the Badamu lithologically, it is necessary to look for laterally consistent and easily recognizable members near the base and the top of the formation.

The author and the Russian geologists who have been working in the Kerman area have tried to define the Badamu limits as the first and last marine transgressions between Coal Zone C in the underlying Shemshak Formation and Coal Zone D in the overlying Hojedk Formation. However, this is not a workable definition, as there are numerous marine beds near the base and the top that are of limited lateral extent; furthermore these beds contain no index fossils that can be used for correlation. Further, even within Coal Zone D there are marine layers that are fossiliferous. Thus it is evident that the only consistent means for defining the Badamu Formation is on the basis of fossils.

The upper limit of the Badamu Formation is therefore defined as a few metres of thick, dark-grey, oolitic limestone that is generally fossiliferous and contains "stephanoceratoid" ammonites. In some areas to the north there is an extremely sandy, violet-weathering limestone about 20 m above the dark-grey, oolitic limestone. The violet-weathering limestone has yielded only a few pelecypods and no ammonites and is easily distinguishable from the dark-grey limestone in the field. This is important as the violet-weathering limestone is considered to be above the top of the Badamu Formation.

Throughout the investigated region, there is an extremely sandy limestone, about 1 to 3 m thick, that contains pelecypods and belemnites. This could be taken as the base of the Badamu. However, the next limestone 30-60 m higher in the sequence contains "grammoceratoid" ammonites which can be more specifically dated. This

bed, therefore, is considered to be the base of the Badamu Formation.

Thus, based on fossils, the lower limit of the Badamu Formation is considered to be the first "grammoceratoid" ammonite-bearing limestone unit and the upper limit is considered to be the last "stephanoceratoid" ammonite-bearing limestone unit. Lithologically, based on these paleontologic limits, the Badamu Formation begins with a dark-grey, oolitic limestone and ends with a similar unit.

Description of Type Section (Fig. 5)

(Lo	ocality: Titu, Trench No. 9, about 5 km southeast of village	Seh-Banuyeh.)					
Sequ	uence from top to bottom:	Metres					
	Coal Zone D						
	Sandstone, green-grey, thin-bedded with limonitic concret	ions 10.0					
	Siltstone, olive-green, last 20 m with many sandstone bec	is and .					
	limonitic concretions (base of Hojedk Formation)	100.0					
	Badamu Formation						
9.	Limestone, dark-grey, thick-bedded, sandy, oolitic, partly	knobby,					
	contains pelecypods and belemnites (top of Badamu Forma	tion) 6.5					
8.	Siltstone, olive-green	6.5					
7.	Limestone, dark-grey, relatively thick-bedded, sandy, we	athers					
	pink; some corals, pelecypods, and belemnites	3.1					
6.	Sandstone, fine-grained conglomeratic, contains quartz p	ebbles					
	up to 1 cm in diameter and reworked fragments of sandstor	ne 0.3					
5.	Sandstone, grey, relatively thick-bedded, ripple marks	58.6					
4.	Siltstone, grey-greenish	31.2					
3.	Limestone, dark-grey, sandy, knobby; contains sandy ar	nd marly					
	partings and the following fauna (from top to bottom):						
	(c) Ludwigia (Ludwigia) murchisonae (Sowerby)						
	(Age: Murchisonae Zone)						
	(b) Discocyathus sp.						
	Opis cf. trigonalis (Sowerby)						
	Modiolus sowerbyanus (d'Orbigny)						
	Ctenostreon sp.						
	Pleuromya unioides (Roemer)	,					
	Pecten (Chlamys) sp.						
	Pholadomya iranica Fantini-Sestini						
	(Age: Opalinum Zone (Early Bajocian))						
	(a) Dumortieria moorei (Lycett)						
	Leioceras costosum (Quenstedt)						
	(Age: Levesquei-Opalinum Zone (Latest Toarcian	to Early					
	Bajocian))						
2.	Sandstone, calcareous, thick-bedded						
1.	Limestone, dark-grey, sandy, (base of Badamu Formation)						
	Discocyathus sp.						
	Montlivaultia sp.						

Homomya sp. Pholadomya sp. Lima subcompressa Kiparisova Pseudogrammoceras saemanni (Dumortier) Hammatoceras cf. speciosum (Janensch) (Age: Thouarsene Zone (Late Toarcian))

Total thickness: 163.3

Underlying beds (top of Shemshak Formation) Siltstone, olive-green; upper part with limestone beds and concretions Limestone, dark-grey, strongly sandy; pelecypods and belemnites 0.4



Fig. 5. Type section of the Badamu Formation. See text for key to units.

Depositional Environment and Source of Sediments

Lithology and thickness of the Badamu Formation vary widely over the investigated region owing to different depositional conditions and differential subsidence of the Zarand trough. The greatest thickness of the Badamu and the highest rates of subsidence follow its axis, which corresponds to a line extending from Gel-Tud to Titu (north-northwest to south-southeast; see Fig. 2).

A decrease in grain size as well as in the quantity of clastic sediments from north to south, indicates that their source must lie to the north in the Cambrian and Infracambrian rocks. The composition of the sedimentary rocks at Dahrud, which are marly sandstones, siltstones, and sandy limestones, suggests that the source lies to the north and northeast rather than to the northwest as has been assumed by Huckriede et al. (1962). Detailed sediment studies are necessary to define better the nature and the source of the clastic rocks.

In general, the depositional environment to the north and along the Zarand axis was characterized by unstable conditions and repeated transgressions and regressions. In the southern part of the area and along the margin of the trough, more stable conditions and relatively uniform sedimentation prevailed.

Composition of the Fauna

The faunal composition of the Badamu Formation varies with the lithology and from one locality to another. Most of the fossils are confined to the limestone beds; within the sandy and silty beds, only traces of thin-valved pelecypods are present.

The main fossil groups present in the Badamu Formation are Foraminifera, Vermes, Anthozoa, Bryozoa, Brachiopoda, Pelecypoda, Gastropoda, Cephalopoda, Echinoidea, Ostracoda, and vertebrate remains (teeth of *Selachi*). The most common fossils, however are belemnites, ammonites, and pelecypods.

Ammonite Zonation

The ammonite fauna of the Badamu Formation is, in general, abundantly present in "condensed" zones; outside these zones, ammonites are rarely present. Because the "condensed" zones contain many ammonites in thin units, it appears difficult at first to apply northwestern European ammonite zones to the Kerman area. However, the presence of most of the northwest European ammonite index fossils and the affinity of the other fossils that are present with those in northwest Europe indicate the validity of a similar zonation. Furthermore, in those places from which ammonites have been collected from undisturbed "non-condensed" zones, the succession of the genera and species present is the same as for northwest Europe. For these reasons, it is possible to use the northwest European zonation of the Toarcian and Bajocian not only for the Kerman area but also for most of central and north Iran. (As in any zonation system based on fossils, a rapid spreading of all index fossils is assumed, so that the time factor can be ignored.)

The author accepts with only slight changes a zonation proposed by Spath (1942), Arkell (1956), and Dean et al. (1961) (Fig. 6).

New investigations show the validity of the northwest European ammonite zones in many areas, e.g., northern Alps (Fischer, 1966), Bulgaria (Sapunov and Stepanov, 1962), and in the Caucasus (Neumayr and Uhlig, 1892, p. 114; Beznosov et al., 1962, p. 848). Northwest European zonation can even be used with some restrictions in the Mediterranean realm (Wendt, 1963, p. 62; Geczy, 1959, p. 542). It should be noted that a zonation for the Toarcian in the Mediterranean area proposed by Merla (1932), Venzo (1952), and Donovan (1958) cannot be used in central and northern Iran.



Fig. 6. Toarcian and Bajocian ammonite zonation.

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Character of the Ammonite Fauna

The affinity of the Badamu ammonite fauna with that of northwest Europe has already been mentioned. (Northwest Europe is used in the sense of Dean et al., 1961.) It should also be noted that the ammonite fauna of the Mediterranean realm, even though in part not well known, also shows Upper Toarcian to Middle Bajocian affinities with northwestern Europe. Abundance of *Lytoceras* and *Phylloceras* as well as such forms as *Erycites* and *Docidoceras* characterize the Mediterranean realm; however, only a few specimens of these genera are found in the Badamu Formation. For example, among the more than 500 collected ammonites, only two or three representatives of *Phylloceras* are present. This fact has already been stressed by Spath (1936, p. 20) and Huckriede et al. (1962, p. 88). In addition, *Phylloceras* is scarce in, and *Lytoceras* absent from, equivalent deposits in the Alborz Mountains, northwest Iran, and Julfa (Pompeckj, 1897, p. 824; Bonnet, 1912, p. 321; Riviere, 1934, p. 40).

It is especially noteworthy that these two genera are well represented in deposits of the same age in the Caucasus. As the Iranian Sea must have been connected with the Caucasian Sea, their presence would be expected in Iranian deposits. Their absence, therefore, must indicate special ecologic conditions. This distributional problem has received much attention from investigators in the last century. Neumayr (1883, p. 8-9) has suggested that their absence indicates paleoclimatic differences. But other investigators have thought it to be due to the differing life habits of the ammonites; that is, preference for shallow or deeper water (Pompeckj, 1897, p. 825; Diener, 1912, p. 83; Geczy, 1961, p. 543). Hallam (1969) has recently discussed the faunal realm and facies in the Jurassic and demonstrated effectively the importance of salinity in the distribution of marine fossils. He stated (p. 16): "There is a tendency for Jurassic cephalopods to fall into two categories which may be called pelagic (or stenohaline) and non pelagic (slightly euryhaline)".

The author is inclined to agree with the last-named workers and thinks that the Toarcian and Bajocian fauna of Iran and northwestern Europe represents shallow-water forms (compare with shallow-water plankton, Geczy, 1966, p. 534) and that *Phylloceras* and *Lytoceras* represent deep-water forms (compare with deep-water plankton, Geczy, 1961, p. 543). In addition, salinity seems likely to be of considerable significance in the distribution of fossil fauna in Iran, especially in the marginal basins.

Ecologic Conditions

The fauna of the Badamu Formation shows clearly that the formation is marine. The large amount of sand, some conglomerate layers, and crossbedding indicate a near-shore environment. The oolites, the knobby, uneven appearance of the shoal surface, and the crossbedding indicate a shallow depth and moving water. The thinness of the unit outside the Zarand trough and the presence of bryozoans and worm tubes on shells also indicate a slow rate of deposition.

Large, thick-valved pelecypods (up to 25 cm) and the presence of corals and oolites indicate fairly warm temperatures. The relative abundance of the fauna, locally rich in corals, indicates excellent food availability and aeration of water. The diversity of species signifies an active faunal exchange.

The striking similarity of the Badamu ammonite fauna to that of the northwest European realm and the relatively few new (different) species present indicate a permanent open connection with the Tethys Sea to the north.

It should also be noted that ecologic conditions varied within the area of deposition of the Badamu Formation. Along the borders of the Zarand trough and in the tectonically stable areas conditions were rather homogeneous; but within the Zarand trough rapid changes in sediment types resulted in changes of faunal conditions.

Age of the Formation

Tipper (1921) considered the Badamu Formation to be Late Lias in age. Spath (1936) showed the presence of the Opalinum to Humphriesianum ammonite zones (Fig. 6) in the area of Ravar, indicating Early and Middle Bajocian. Huber and Stöcklin (1954) indicated a Late Lias to Early Dogger age. Huckriede et al. (1962) believed the Badamu also contained Middle Lias beds. Seyed-Emami (1967) showed that the Badamu Formation near Kerman contained the northwestern ammonite zones indicative of a late Early Toarcian to Middle Bajocian age. As defined in the present study it comprises the Bifrons to Humphriesianum ammonite zones.

Lias-Dogger Boundary

Because of continuous sedimentation, the Lias-Dogger boundary cannot be based on lithology; but it can be fixed on the basis of paleontologic data, again by ammonites. Corresponding to northwestern Europe and the area of the Caucasus, the author defines the Lias-Dogger boundary by the last appearance of the ammonites *Pleydellia* and *Dumortieria* and the first appearance of the ammonite *Leioceras*. At places where no ammonites are present, the placing of the boundary is arbitrary. Sometimes pelecypods of the group *Inoceramus dubius* are useful, as they are especially abundant in rocks of Late Lias and Early Dogger age.

Badamu Formation Equivalents in Central Iran and Alborz

Northwest of the Kerman area (i.e., northeast of Yazd), the Badamu Formation, here underlain by the Shemshak Formation and overlain by the Baghamshah Formation, shows lithologic and paleontologic features similar to those in the type area. It may be up to 180 m thick, and the limestone section is split in the middle by a sandstone zone (N. Valeh, pers. comm.). The lower limestone unit contains the same fauna as in the Kerman area, and the ammonite zones from Fallaciosum to Concava (Late Toarcian to Early Bajocian) are present. The upper limestone unit did not contain any ammonites, and Middle Bajocian fossils have not yet been found. Again, a connection of this area with the Tethys must be assumed.

Farther north, east of Tabas, in the Shotori Range, there are no known rocks time-equivalent to the Badamu Formation of the Kerman area. The Badamu Formation as described from that region (Stöcklin et al., 1965; Ruttner, et al., 1968) is younger than the Badamu Formation at Kerman. Though lithologically similar, the Badamu Formation in the Shotori Range corresponds paleontologically to the Dalichai Formation in the Alborz and contains Late Bajocian and Bathonian ammonites. Thus, a time equivalent of the Kerman Badamu must be stratigraphically below the Shotori Badamu; quite possibly, the time equivalent is of different lithology.

Stöcklin et al. (1965, p. 34) reported the occurrence of poorly preserved fossils in the Shemshak Formation; these are possibly of the same age as those in the Kerman Badamu. Badamu-aged rocks (i.e., Kerman Badamu) may also be present in the region west of Tabas, which to-date has not been investigated in detail.

East of the Shotori Range, in the surroundings of Ferdows, J. Eftekhar-nezhad (Geological Survey of Iran) has recently collected fossils (*Kumatostephanus, Sonninia*) like those in the upper part of the Badamu Formation at Kerman.

Farther to the north in the Alborz, conditions were similar to those that prevailed in the Yazd area. A marine transgression occured in the Late Toarcian and during the whole of Aalenian; this transgression is reflected in the marine "upper sandstone" of Assereto (1966). In Middle Bajocian time a marine regression from the Alborz occurred (Assereto, 1966; Seyed-Emami, 1967) that corresponded in time partly to the marine regression in the Yazd and the north Kerman regions. In the Alborz the regression continued during the time span corresponding to the Sowerbyi, Sauzei, and Humphriesianum ammonite zones (Middle Bajocian); the next transgression resulted in the deposition of the Dalichai Formation (Late Bajocian and younger).

In the Kerman region, however, the above-mentioned Middle Bajocian ammonite zones do occur. Only within the Zarand trough is there evidence of a regression during the Late Aalenian and early Middle Bajocian.

The upper part of the "Upper carbonaceous Series" in the Alborz (Assereto, 1966) corresponds partly to Coal Zone D of Kerman, which lies about 50 to 200 m above the Badamu Formation. At Kerman terrestrial to lagoonal deposition with rare marine incursions persisted to the end of the Jurassic (Hojedk Formation, Bidou Formation, Pectinid beds with salt and gypsum, Garedu Red Beds; see Fig. 3). In the Alborz, however, there was a return to purely marine conditions with the deposition of the Dalichai and Lar Limestone Formations (Middle to Upper Jurassic).

In the western parts of central Iran and in easternmost Iran there is no known marine phase that could correspond to the Badamu Formation of the Kerman region.

PALEOGEOGRAPHY OF IRAN

General Remarks

Late Triassic epeirogenic and orogenic movements have been reported from different parts of Iran, the Caucasus, and Afghanistan, but their importance has been underestimated by previous workers, as noted by Stöcklin et al. (1965, p. 57). The tectonic events that took place in Late Triassic time in central Iran, particularly at the northern foot of the Zagros Ranges, are of great importance in the paleogeography of the Jurassic. As noted later in this report, tectonic movements in this area caused sharp faunal and lithologic differences between the Zagros trough on the one hand and central and northern Iran on the other. Harrison (1937, p. 292) distinguished in southwestern Iran, from south to north, three tectonic units: (a) a unit in which only Pliocene folding has occurred; (b) a unit in which Pliocene and Late Cretaceous movements are recorded; and (c) a unit in which Late Triassic - Early Jurassic as well as Late Cretaceous and Pliocene movements are recorded. Stöcklin (1968, p. 1240) wrote: "The most important result of these Late Triassic movements in Iran was the splitting of the Paleozoic platform into two parts, which subsequently took entirely different courses of structural development. The line separating the two parts of the platform is the same as that which was apparent as a facies divider during the Infracambrian and which later, during the Alpine or ogeny, developed into the main Zagros thrust line."

A zone northeast of this line, which is partly equivalent to Stöcklin's (1968) Sanandaj-Sirjan Ranges and extends from south of Hamadan to Borujerd, south of Esfahan, Sirjan, and north of Bampur (?), corresponds to an uplift which divides the Central Iranian Basin from the Zagros geosyncline. The absence of marine deposits of Late Triassic - Early Jurassic age along this zone and the lithologic-faunistic differences on both sides of it indicate that this uplift is Late Triassic in age.

The southeast extent of the uplift is not known. To the northwest, it extends to the lakes of Urmia and Van, and it probably has had a temporary connection with the central Anatolian (Holder, 1964, p. 488, Bremer, 1962, p. 200) and Rhodope massifs.

Land existed more or less throughout the Jurassic but was definitely flooded by the Late Barremian - Early Aptian marine transgression.

During Early and Middle Triassic time, almost all of Iran was covered by a rather uniformly shallow sea that contained a fauna showing European-Mediterranian affinities as well as Indo-Pacific ones. Except for some faunal pecularities, the associations are very persistent throughout Iran. However, with the emergence of central and northern Iran in Late Triassic time, the lithologic and faunal uniformity was brought to an abrupt end.

The Zagros geosyncline was not affected by these movements and continued in its marine development. Central, eastern, and northern Iran were divided into many uplifts and islands which were separated by rapidly subsiding troughs. In the Jurassic, coal was formed along the borders of the troughs.

Only by following the above historical interpretation can the widespread and uniform clastic deposits of the Upper Triassic and Lower Jurassic, locally with thicknesses greater than 2000 m, be explained. The rapid supply of clastic sediments and also partly the euxinic conditions may account for the absence or poverty of the fauna.

The "continental" ("paludal", "littoral", "fluviatile-lagoonal", "liminic" terrestrial") facies of these deposits assumed by most previous authors must be questioned. Probably a large part of these rocks has been deposited in a marine environment, but in one characterized by a heavy supply of clastic material reflecting strong tectonic unrest. Calcareous rocks with more abundant fauna such as the Badamu Limestone represent time intervals of reduced tectonic activity and slow subsidence.

This unstable period of regressions and transgressions continued in central Iran until the Late Jurassic and indicated the approach of the Late Cimmerian orogeny, during which central Iran was intensively modified by pre-Middle Cretaceous folding and emergence. 22



Fig. 7. Paleogeographic map of Iran during Late Toarcian and Early Bajocian. (Dotted = terrestrial; white = marine)



(Dotted = terrestrial; white = marine)

Late Toarcian - Middle Bajocian Geography

During Late Toarcian to Early Bajocian time (Fig. 7), the entire northern part of Iran, termed the Marginal Alborz Basin, was covered by a shallow sea. To the southeast a marine gulf outlined a Central Iranian Basin and extended to the Kerman area. This gulf probably terminated north of Bampur at an uplift that formed between Triassic and Jurassic time (Seyed-Emami, 1967, p. 153). Apparently there was no connection to the eastern part of the Zagros geosyncline nor to the Baluchestan and Indian Oceans. To the north the shallow sea was connected to the Tethyan "Caucasian-Turkmenian" geosyncline and to the "North Anatolian" trough. Except for short phases of marine transgression, the eastern most parts of Iran and large parts of Afghanistan were terrestrial; this was probably true for the entire Jurassic (Greisbach, 1886; Furon, 1941; Hinze and Grabert, 1964). In northeast Afghanistan, however, several marine incursions took place in late Bajocian to Callovian (Grabert, 1964) and in the Kimmeridgian (Hinze, 1964). The connection to the east and to the Pacific area was via Turkmenistan, Pamir, Tibet, and western Indochina. The transgressions of the Hindukush occurred via this northern seaway. The western part of central Iran (i.e., north of the Zagros Mountains) may well have been covered by a shallow sea at this time. However, this is not shown on the paleogeographic sketch map, as no marine fossils from this area have been found that would confirm such an assumption.

Along the northern foot of the Zagros an uplift divided central Iran from the Zagros geosyncline; the latter continued to develop independent of the rest of Iran and was connected to the Dinarids via Taurus and western Greece; this is indicated by certain lithologic and faunal similarities.

During Middle Bajocian time (Fig. 8) there was an extensive marine regression that was not confined to Iran. Large areas of the Alborz and northwestern Iran were emergent; only the Central Iranian Basin in eastern central Iran, although much restricted, remained covered by the sea. In the Zagros geosynoline, paleogeographic conditions remained much the same as during Late Toarcian and Early Bajocian time.

The north-south trend of the Central Iranian Basin was probably determined at an early date. Furon (1941) called it the "Ural-Oman axis". He compared it with the similar trend of the Oman Ranges and believed that it represented a Hercynian feature. Gansser (1955) referred to it as the "Oman line"; he and Stöcklin (1961), however, rejected Hercynian building along this trend. Stöcklin et al. (1965, p. 63) considered it as a fracture between the "Lut block" on the east and the "Tabas block" on the west and as inherited from an "Assyntic" north-south trend (Stöcklin, 1968).

PALEOZOOGRAPHY AND GEOGRAPHY OF THE JURASSIC STAGES

Hettangian

Fossiliferous marine Hettangian is not known from central and northern Iran. In the Zagros Mountains (southwestern and southern Iran) this epoch corresponds presumably to the lower part of the Neyriz Formation, which consists of thin-bedded, rubbly dolomite and greenish shale and conformably overlies the marine, Triassic Khaneh-Kat Formation, so that the presence of Hettangian rocks can be assumed.

Sinemurian

Dates from Sinemurian ammonites are too uncertain and sporadic to allow exact conclusions on the paleozoographic and paleogeographic conditions of Iran during this time. Yet it must be concluded that marine influences in the central Iranian Liassic were stronger than has been believed heretofore.

Stahl (1911, p. 13) mentioned a questionable Arietites bisulcatus (Brug.) from the area of Hamadan, in western-central Iran. Douglas (1937; in Arkell, 1965, p. 380) reported Vermiceras aff. scylla (Reynes) from the area between Yazd and Esfahan; the same author also reported Phylloceras, Lytoceras, Eoderoceras and Oxynoticeras from the Makran area in southeastern Iran. Huckriede et al. (1962, p. 82) also mentioned Arietites from the Kerman area.

Thus, considerable parts of central Iran could have been occupied by a shallow sea. Perhaps, also, there was a periodic connection via Kerman-Bampur to the northern Makran (Harrison, 1943).

Deposits with plant remains and coal seams indicate mainly continental condition in northern and eastern Iran. M.H. Nabavi (Geological Survey of Iran) recently found *Arietites* and *Vermiceras* in the Semnan area, in the central Alborz. In southwestern Iran the upper part of the Neyriz Formation or the lower part of the Surmeh Formation, with its famous *Lithiotis* fauna, may belong to the Sinemurian. However, ammonites that would allow an exact dating have not yet been found.

Pliensbachian

As noted for the Sinemurian, little is known about this epoch in Iran. Some marine intercalations in the Shemshak Formation of central Iran may belong to it. Kühn (1938, p. 78-79) reported from the eastern part of the Yazd area a carbonaceous Rhaetic-Jurassic sequence with a pink, argillaceous, sandy, and partly conglomeratic limestone containing some corals and brachiopods; this limestone is probably Middle Liassic in age. It should be noted that the reporting of *Liparoceras* and *Androgynoceras* from the Tabas area in Stöcklin et al. (1965, p. 37) is the result of misidentifications by the present author. Middle Liassic ammonites have also been reported from the Alborz, but the present author has not been able to examine these forms. Also, Assereto et al. (1968, p. 17) have some doubts on the presence of Domerian.

Lorenz (1964, p. 21) mentioned *Amaltheus margaritatus* (Mont.) from the upper part of the Shemshak Formation in the upper Karaj Valley. Allen bach (1966, p. 36) reported *Amaltheus* sp. from the Shemshak Formation near Imamzadeh-Hashem. Dedual (1967, p. 31) also reported *Amaltheus* sp. from the upper part of the Shemshak Formation near Ab-e-Sar in the lower Karaj Valley.

A simultaneous transgressive phase is also known from the Upper Pliensbachian of the Caucasus.

"Grammoceras normanianum" mentioned from the central Alborz by Douvillé (1904, p. 540) is a misidentification. As noted by Arkell (1956, p. 373), G. normanianum is probably G. thouarsense from the Upper Toarcian and not from the Middle Liassic as suggested by Douvillé.

SEYED-EMAMI

In southwestern Iran, marine conditions are indicated for the Middle Liassic (?) in the lower part of the Surmeh Formation; ammonites, however, have not yet been found.

Lower Toarcian

From the Lower Toarcian of Iran, only a few ammonites are known. The discovery of *Peronoceras* near Kerman indicates that the lower part of the Badamu Formation is in part high in the Lower Toarcian. Marine, ammonite-bearing Lower Toarcian is also reported from parts of the Alborz. Rivière recorded *Dactylioceras* (1934, p. 112, pl. 5, Fig. 4) and *Hildoceras bifrons* (Brug.) (1931, p. 73; 1934, p. 31) from the central Alborz. Allenbach (1966, p. 33) reported *Dactylioceras* cf. commune (Sow.) from the upper part of the Shemshak Formation at Sarbandan, near Damavand. Also, M. H. Nabavi (Geological Survey of Iran) recently found *Dactylioceras* and *Phymatoceras* in the Shemshak Formation in the area of Semnan. A *Harpoceras* reported by Gansser (1955, p. 283) from the area between Qazvin-Hamadan is to be revised; probably it is *Pseudogrammoceras* from the Upper Toarcian.

An endemic fauna with *Bouleiceras* and other forms is known from the Lower Toarcian of Baluchestan (Spath, 1936b), central Arabia (Arkell, 1952), and Madagascar (Thevenin, 1908). Representatives of this fauna are not known from the Zagros or from central and north Iran. This fauna indicates a separate marine province, which according to Arkell (1952, p. 300) had a connection to the Mediterranean Sea via the Sinai Peninsula. Certainly the sea at Kerman was connected northward to the Turkmenian and Caucasian Seas. Despite the lack of ammonite remains, marine conditions must be assumed for the Zagros region during this time. This stage corresponds probably with the lower part of the Surmeh Formation, which consists of massive dolomitic limestones with abundant *Lithiotis* shells (James and Wynd, 1965, p. 2188).

Upper Toarcian

Marine deposits of this age are widespread in north and central Iran. This Late Toarcian transgressive phase flooded large areas from the Caucasus to Turkmenia and probably there were temporary connections to the Pacific area. The southern part of the Tethyan sea, as a shallow basin, overflowed large parts of Northern Iran and extended eastward via Tabas-Yazd to the Kerman area. This gulf, termed here the "Central Iranian Basin", ended south of Kerman; there was no connection to the Baluchestan Sea or the Zagros geosyncline. As noted earlier, the Zagros geosyncline was separated from the central Iranian Basin by a large northwest-southeast uplift. Because of a lack of fauna, an extension of the gulf to western central Iran cannot be confirmed.

In the Kerman area the following ammonite genera are present: ?Polyplectus, Pseudogrammoceras, Phlyseogrammoceras, Pleydellia, Dumortieria, and Hammatoceras. This fauna is identical with that known from the Caucasus and northwestern Europe. Except for *Hammatoceras** all genera have been reported from different parts of north Iran (Weithofer, 1889; Böhne, 1891; Stahl, 1897, 1911; Douvillé, 1904; Fischer, 1915; Rivière, 1932; Bailey et al. 1948; Dellenbach, 1964; Stöcklin et al. 1965; Allenbach, 1966; Fantini-Sestini, 1966; Steiger, 1966; Dedual, 1967; M. Alavi and F. Golshani (Geological Survey of Iran, personal communication)).**

Thus a connection between the Central Iranian Basin and the Caucasian sea by the Alborz Marginal Basin can be assumed.

Because of the lack of systematic investigations on Upper Toarcian ammonites, it is not easy to follow the paleozoographic routes to northwestern Europe. The most direct connection from the Caucasus would be through northern Turkey, from where only few Upper Toarcian ammonites have been reported (Otkun, 1942, pp. 16-17). This continued east of the Rhodope massif, which probably formed a joint uplift with the Central Anatolian massif. No connection to the Mediterranean Sea across Anatolia and Greece is indicated. North of the Rhodope massif, in the latitude of Belgrade, there were two connective ways to northwestern Europe: one via Hungary the Carpathians and northern Alps, the other via the Dinarids, Apennines, Sicily, and North Africa. North Africa has clear faunal affinities with the Rhone Basin and northwestern Europe. Judging by the fauna it must be assumed that only the connection via the northern Alps existed in the Late Toarcian.

Only Hammatoceras was influenced from the Mediterranean and southern Alpine areas. The transgression of the Tethyan sea in an eastern direction connected this area temporarily with the Indonesian Archepelago via the Great Balkan Range, Pamir, Tibet, and western Thailand. This is indicated by ammonite faunas. Sorgel (1913) described from Jefbie in the Misol Archipelago (Indonesia) the following Upper Toarcian ammonites: Harpoceras aalense Ziet; H. cf. radians gigas Quenst.; H. cf. variabilis var dispansum; H. cf. toarcense d'Orb. In addition, Kruizinga (1926) mentioned ammonites from the Sula Islands. His Grammoceras kiliani n. sp. (pl. 1, fig. 2) probably has affinities with Pseudogrammoceras samanni; his Harpoceras ariethiforme n. sp. was considered by Arkell (1956, p. 440) to be a Fuciniceras, but the present writer believes rather that it is related to Pseudogrammoceras quadratum.

Kruizinga's Hammatoceras molucanum Cloos belongs, according to Arkell (1956, p. 440), to the Upper Toarcian and not to the Bajocian as assumed by Kruizinga. Komalargun and Sato (1964, p. 153) also considered it as an Upper Liassic species showing some likeness to Hammatoceras insigne.

The central Iranian Basin was not connected to the Zagros geosyncline, which shows a Liassic facies of its own consisting of dolomitic limestones (lower Surmeh Formation).

^{*} A single example of *Hammatoceras insigne* (Schubler) has been recently collected by M. H. Nabavi (Geological Survey of Iran) from the Shemshak Formation of the Semnan area.

^{**} Upper Toarcian and Aalenian ammonites, described by the above-mentioned authors have been partly revised by Seyed-Emami (1967).

SEYED-EMAMI

Aalenian (Lower Bajocian)

In the Aalenian of the Kerman district the following genera and subgenera of ammonites are present: Tmetoceras, Leioceras, Staufenia, Ludwigia, Ludwigella, Graphoceras, Pachammatoceras, Pseudammatoceras, Planammatoceras, Eudmetoceras, Euaptetoceras, Rhodaniceras, Erycites, and Haplopleuroceras.

Except for the Hammatoceratinae, the fauna is closely related to the northwest European forms. Hammatoceratinae show trends to the marginal basins of the Mediterranean Sea, especially to the Rhone Basin. The connection with northwest Europe by this time was rather via Sicily and North Africa than via the northern Alps.

Lack of thorough investigation makes it difficult to reconstruct the exact route of migration. From the Alborz Mountains several Aalenian marine fossils are known. Douvillé (1904, pl. 26, figs. 8, 9) illustrated two ammonites as *Ludwigia murchisonae* (Sow.). His fig. 9, however, is *L.* (*Ludwigella*) aff. arcitenens Buckm., and his fig. 8a,b *Leioceras* aff. costosum (Quenst.); but the determination of an Aalenian age is correct. Fischer (1915, p. 266) mentioned a *Ludwigia* sp.; the present writer had occasion to see this form and thinks that it is *L.* (*Ludwigella*) arcitenens Buckm. M. Alavi (Geological Survey of Iran) has collected *Ludwigia* in the Damghan area; and M.H. Nabavi recently found *L.* (*Ludwigella*) rudis and *L.* (*Graphoceras*) concava in the Shemshak Formation of the Semnan area.

The above-mentioned ammonites indicate that the Opalinum, Murchisonae, and Concava Zones are present in parts of the Alborz.

N. Valeh (Geological Survey of Iran) has also found *Leioceras*, *Ludwigia*, and *Planammatoceras* in the Yazd area.

One might assume a marine connection via northwest and west Iran, Mesopotamia, and Lebanon to northern Africa in Aalenian, especially Late Aalenian, time. But there is no evidence to support this assumption, and the connection is more likely to have been via northern Anatolia and Greece. No ammonites are yet known from the Lower Aalenian of Anatolia, however, but from the Upper Aalenian a few have been reported by Bremer (1966), including *Eudmetoceras amaltheiforme*, known also from Kerman.

Northeastwards, connections existed to the Turkmenian trough and from there to the Pamir region. In Late Aalenian and early Middle Bajocian time connections probably existed to the Pacific area and South America; this is indicated by the presence of *Eudmetoceras klimakomphalum* at Kerman, in the Sula Islands, and in the Argentinian Cordilleras. Again no connection is discernable to the Zagros trough, which belonged to a different marine province. This stage, however, may be represented in the lower part of the Surmeh Formation.

Middle Bajocian

Sowerbyi Zone

In the transitional beds between the Concava and Sowerbyi Zones at Kerman we find the following genera: Zurcheria, Docidoceras, and Bradfordia; somewhat higher in the section Sonninia and Poecilomorphus appear. The fauna is closely related to that of northwestern Europe. The great affinity of the fauna of Kerman at the boundary

of the Concava and Sowerbyi zones to that of Sicily (Renz, 1915; Wendt, 1963) and North Africa (Lelièvre, 1960) is remarkable.

The reconstruction of the migration route is more difficult than for the Aalenian because the Sowerbyi Zone represents a regressive phase and very little is known about the faunas from Iran, the Caucasus, Anatolia, and the Balkans. Fischer (1915, p. 267) was inclined to assume from some pelecypods the presence of marine beds representing the Sowerbyi Zone in the Alborz. Rivière (1943, p. 40), on the other hand, could not prove the presence of this zone in the Alborz , nor did later investigations confirm its existence there. Ammonites from this zone, however, have been reported by Bonnet (1912, p. 321) from the Julfa Valley in the southern Caucasus. So a regional regression in North Iran and parts of the Caucasus must be accepted, but with connection of the Kerman basin to the Turkmenian-Caucasian sea via Tabas-Ferdows and the Kopet Dagh. Judged by the fauna, the connection to northwest Europe must have run via the northern Balkans, Sicily, North Africa, and the Rhone basin.

To the east, in the Himalayan-Pacific area, the Sowerbyi Zone is known to be represented by the ammonite genera *Sonninia* and *"Fontannesia"* in Tibet (Arkell, 1953), western Australia (Arkell and Playford, 1954), and the Argentinian Cordilleras (Gottsche, 1878; Burkhardt, 1903). These forms show only distant relationships with the coeval fauna of Kerman, and they have a more or less endemic character.

Probably no connection existed to the south; ammonites of the Sowerbyi Zone are not known from the Zagros area.

The few forms of "Witchellia" known from Madagascar (Collignon, 1958, pl. 5, Figs. 28-30) show no affinities with the Kerman fauna.

Sauzei-Humphriesianum Zone

Besides Sonninia and Dorsetensia, the genera Emileia, Otoites, Kumatostephanus, Stemmatoceras, Skirroceras, Stephanoceras, and Normannites are also known from Kerman.

This fauna is also most closely related to that of northwestern Europe. The abundance of the genus *Kumatostephanus* in the deposits of Kerman is remarkable, as it has been known previously only from northwestern Europe. Again a connection via the northern Balkans, Hungary, and the northern Alps to middle and northwestern Europe seems probable, the paleogeographic conditions in Iran being very similar to those of the Sowerbyi Zone.

Rivière (1943, p. 36) reported from the central Alborz ammonites from the Dalichai Formation, including typical Upper Bajocian and Bathonian forms which he attributed to the Middle Bajocian "zone à *Emileia sauzei* to *Witchellia romani*" - viz, *Cadomites* aff. *bigoti* Munier-Chalmas (=? Normannites), Stephanoceras subcoronatum Oppel (=? Stemmatoceras), Cadomites braikenridgii d'Orbigny, non Sowerby (=? Normannites orbigny Buckman).*

All ammonites reported from the Middle Jurassic Dalichai Formation of the Alborz by other workers indicate Upper Bajocian and younger stages (Erni, 1931; Lorenz, 1964; Dellenbach, 1964; Stöcklin et al., 1965, etc.). Therefore, the writer has

^{*} Names in parenthesese represent corrections by the author.

some doubts on the correctness of Rivière's identifications. Failure to locate Rivière's collection, however, has made adequate revision impossible, his descriptions and plates being insufficient for this purpose. The "Middle' Bajocian forms reported from the Tabas area by Stöcklin et al. (1965, p. 36) and identified by the author proved on a later revision to be Upper Bajocian and Bathonian forms also. The only Middle Bajocian ammonite from Alborz (Talesh area) (*Stephanoceras humphriesianum*) has been collected by R.G. Davies (Geological Survey of Iran).

Recently, J. Eftekhar-nezhad (Geological Survey of Iran) collected in the Ferdows area ammonites which included forms such as *Sonninia* and *Kumatostephanus* indicating the presence of the Sauzei Zone in this area.

Some faunal connections existed with the east and the Pacific area: the "Stephanoceras" reported by Boehm (1912, pp. 9, 10) from New Guinea is doubtless related to the genus *Kumatostephanus* in the Kerman area, and the genera *Emileia* and *Otoites* reported by Gottsche (1818) from the Argentinian cordilleras show some affinities with forms at Kerman.

To the south there was still no connection with the Zagros geosyncline, and deposition of the Surmeh Formation continued.

The Stephanoceras reported by Gray (1949, p. 207) from southeast of Shiraz is possibly a misidentification.

The ammonite fauna of the Middle Bajocian of central Arabia (Arkell, 1952) has an endemic character and shows no affinities with the fauna of Kerman.

Upper Bajocian to Upper Jurassic

No Upper Bajocian ammonites are found at Kerman. Continental or continentally influenced conditions prevailed in the Late Bajocian, and the main coal horizon of Kerman is in deposits of this age. Ammonite faunas from north, east, and west Iran indicate marine conditions for Late Bajocian to Late Jurassic time in these areas (Douglas and Wylie, 1937; Erni, 1931; Rivière, 1934; Lorenz, 1964; Stöcklin et al., 1965; Steiger, 1966; Allenbach, 1966; Dedual, 1967; Meyer 1967; Assereto et al., 1968).

It is possible that the land which existed between central and south Iran was flooded west of Kermanshah and east of Bampur. This transgressive phase extended through the Bathonian and Callovian and had its climax in the Oxfordian.

From Callovian onward some Indian and Malagasian trends appear in the fauna of eastern Iran. But as far as can be judged, the fauna of central and north Iran, not only of the Jurassic, but of the whole of the Mesozoic, is very closely related to the European-Mediterranean realm, and only slight affinities with the Indian and Pacific realm can be discerned. In latest Jurassic time there was a regional regression in central and parts of north Iran, which was related to Late Cimmerian orogenic movements and general uplift. In the Zagros and parts of the Alborz, on the other hand, Late Jurassic marine deposition continued without interruption into the Cretaceous.

In short, the central and north Iranian Lias comprises clastic deposits ranging from a few metres to several thousand metres thick. The abundance of plant remains and coal seams indicates terrestrially influenced conditions; these were interrupted by short marine transgressions. The first significant marine transgression in the Alborz region took place in Domerian time (Upper Pliensbachian), whereas in parts of central Iran it may have started in the Sinemurian*. A regional transgression affecting all of north and eastern central Iran is known to have taken pelac in the Upper Toarcian. But not till the Late Bajocian transgression (regression in the Kerman area) did marine conditions become stable, clastic deposits being largely replaced by marl and limestone.

In all of southwest and southeast Iran, marine deposition with over 1,000 metres of carbonatic sediments persisted; however, because of the lack of ammonites no exact classification can be made.

SUMMARY

The Badamu Formation near Kerman is a relatively thin limestone unit; farther north it is thicker and lithologically more complex, consisting of sandstone, siltstone, and limestone beds. These differences in lithology and thickness have been caused by differences in the depositional environment. Great thicknesses of clastic rocks in the axial part of the Zarand trough indicate strong subsidence. Along the margins of this trough and outside it, stable conditions are indicated by the deposition of only a few metres of uniform limestone.

It can be shown that the rate of subsidence of the trough not only varied in different parts of the trough but also changed with time. The resulting lithological variations make it impossible to correlate distant sections on the basis of lithology only.

The boundary between Lias and Dogger also cannot be fixed on lithology but must be based on paleontological evidence. It is determined by the last appearance of the ammonites *Pleydellia* and *Dumortieria* and the first appearance of *Leioceras*.

The lower and upper limits of the Badamu Formation are fixed by the first appearance of "grammoceratoid" ammonites and the last appearances of "stephanoceratoid" ammonites. The age of the Badamu Formation ranges from the upper Bifrons to the lower Humphriesianum ammonite zones (late Early Toarcian to Middle Bajocian).

There is a striking similarity between the fauna of the Badamu Formation and that present in the coeval strata of northwestern Europe; in both, typical Mediterranean forms are almost entirely missing. It is important to note that there are no resemblances between the faunas of the Badamu and those of the Indo-Malagassian and Arabian realm or the region occupied by the Zagros geosyncline. This fact can be explained by uplift of the northern Zagros hinterland during Late Triassic to early Middle Jurassic time.

During Torcian and Bajocian times, the entire northern part of Iran, termed here the Marginal Alborz Basin, was covered by shallow water, and the Central Iranian basin represented a marine gulf that extended to the Kerman area and was limited in the south by an arc-shaped uplift, which barred communication with the Zagros

^{*} More recent investigations in the Alborz (Semnan area) by M.H. Nabav, Geological Survey of Iran, (pers. comm.) indicate that there was a marine transgression in parts of North Iran in Sinemurian times.

geosyncline. Both basins (Alborz and central Iran), however, were connected with the Caucasian-Turkmenian geosyncline.

Extensive marine regressions occurred during Middle Bajocian time in northern Iran. The Central Iranian Basin, although much restricted, remained the only marine embayment in eastern Iran during this time.

DESCRIPTION OF NEW AMMONITE SPECIES FROM THE BADAMU FORMATION

Abbreviations used in this section are as follows:

- D = Diameter
- U = Umbilical width
- W = Whorl width
- H = Whorl height
- Pr = Primary ribs
- Sr = Secondary ribs

Family Hildoceratidae

Genus Pseudogrammoceras

Pseudogrammoceras n.sp.? Plate 1, Fig. 7

Grammoceras audax Buckman, Krimholz, 1961, p. 57, pl. 3, fig. 4.

Material: 1 specimen, Bibi-Hayat (1964-409-SE).

Description: A narrow umblicated form of the Pseudogrammoceras fallaciosum group, showing a rapid increase in whorl height.

The whorl section is, in the inner whorls, broad-oval and assumes a triangular, high-oval shape in the later whorls. The ventral region is moderately broad and carries a hollow keel.

The rib pattern is simple and strongly falcoid. On the inner whorls the ribs are sharp and protruding; later they became broad and blunt.

Comparison: The specimen shows close similarity to the form illustrated by Krimholz (1961), which is wholly unrelated to G. audax Buckman (1904, Suppl. p. 132, pl. 28, figs. 4-6). It seems to represent rather a new form of the *fallaciosum* group. The differences from the forms of this group are shown in the table opposite.

Age: Late Toarcian (Fallaciosum Subzone).

P seudogrammoceras	Umbilical Width	Whorl Section	Whorl Width	Ribbing
fallaciosum	Wide	high oval	narrow	rather fine
expeditum	rather narrow	high oval	narrow	fine
cotteswoldiae	rather narrow	rectangul raoval	rather narrow	rather fine
n.sp.?	rather narrow	thick oval	rather thick	coarse

Family Hammatoceratidae

Genus Hammatoceras Hyatt, 1867

Hammatoceras tipperi n.sp. Plate 2, Figs. 16,17; Plate 9, Figs. 1a, 1b, 2

Derivation of Name: In honour of G.H. Tipper, who first described the ammonitebearing limestone of Badamu.

Type Locality: Badamu Formation northeast of Bibi-Hayat.

Horizon: Levesquei Zone.

Diagnosis: A new serpenticone species of the genus *Hammatoceras*, with wide and flat umbilicus. The ribs consist of short primaries, building small and round tubercles above the umbilicus; from each of these, two secondary ribs extend to the somewhat flat keel.

Material: 2 specimens, Bibi-Hayat (1964-539-SE, -405-SE).

Dimensions:

	D(mm)	U(%)	H(%)	W(%)	No.
Holotype	61.3	47	30	26	539
Paratype	61.0	46	31	26	405

Description: The holotype measures 75mm and consists of five visible whorls. It is a highly evolute form with an oval, dome-shaped whorl section. The outer whorl is higher than it is thick and there is only a small overlap between the successive whorls.

The umbilicus is flat and widely open. Beyond about D = 35 mm, a distinct umbilical shoulder with a low, vertical umbilical wall appears. The whorls are widest on the inner quarter of the flanks and narrow gradually towards the venter. The venter is moderately wide, rounded, and has a keel of medium height.

The sculpture consists of short primaries, which do not reach to the umbilical seam. They are particularly distinct on the last whorl, where they occupy about the interior quarter of the flank. In the broadest part of the flank they form small, round tubercles, which are particularly strongly developed on the inner whorls within about D = 25mm, where they occupy a large part of the flank. On the outer whorls the tubercles become flatter. From each tubercle two blunt, moderately coarse ribs extend to the keel. Towards the venter the ribs become stronger and bend slightly forward. In the inner whorls there is occasionally one additional intercalated rib. At D = 73 mm 34 tubercles and 68 secondary ribs were counted.

The paratype has been cut in two. The inner whorls are broadly oval and considerably thicker than they are high. In the course of ontogeny the height increases faster than the width, resulting in an oval whorl section. The suture line is partly visible on the paratype; it is strongly differentiated and denticulated, and the lateral lobe is deep and asymmetrical.

Comparisons: The present form is very similar to *H. perplanum* Prinz (Merla, 1934, pl. 3, fig. 2) but differs from it in having a sharper whorl section, longer primaries, and a higher keel. From *H. clavatum* Merla (1934, pl. 3, figs. 3 and 4) it is distinguished by stronger evolution and by the slow increase of the whorl height. There is some similarity also with *H. procerinsigne* Vacek (1886, pl. 14, figs. 10-13), from which the new form differs by considerably closer spacing of the ribs, greater width of the whorls, and in detail of the suture line.

From other species such as H. insigne, H. speciosum, and H. porcarellense the new form is easily distinguished by its wide umbilicus and small whorl width.

Age: Upper Toarcian (Levesquei Zone).

Genus Pseudammatoceras S. Elmi, 1963

Pseudammatoceras stahli n.sp. Plate 2, Fig. 18; Plate 8, Figs. 6a, b

Derivation of Name: In honour of A.F. Stahl, to whom we owe the first geological map of the area and many other contributions to the geology of Iran.

Type Locality: Badamu Formation, northeast of Bibi-Hayat.

Horizon: Opalinum Zone.

Material: 1 specimen (1964-538-SE).

Dimensions:

D(mm)	U(%)	H(%)	W(%)	No.
39.8	35	39	35	538

Description: Somewhat compressed and rather evolute form with oval to slightly trapezoidal whorl section. The whorls are moderately thick and overlap each other immediately above the tubercles. The greatest whorl width is in the inner third of the flanks. The umbilicus is fairly deep, with a rounded umbilical shoulder and a short, steep umbilical wall. The venter is fairly wide and has a flat, blunt, hollow keel.

The sculpture is moderately accentuated. Around the umbilicus are rounded and slightly elongated nodes. From each node two or three ribs branch, being at first weakly developed, but becoming stronger on the ventrolateral region, where they bend gently forward and extend up to the keel. At D = 40 mm 11 nodes and 27 secondary ribs have been counted on half of the whorl. Short rib stems are indicated.

The character of the suture line and of the body chamber is not known.

Comparisons: Renz (1925, p. 1, Figs. 3a, 3b) illustrates as Hammatoceras diadematoides Mayer, aff. doliae Buckm., a form closely related to *P. stahli*. However, *P. stahli* has a greater number of nodes, and the ribs are more closely spaced. Moreover, judging from Renz's illustration, *P. stahli* seems to be narrower.

Age: Lower Aalenian (Opalinum Zone).

Genus Planammatoceras Buckman, 1922

Planammatoceras planiforme planum n. subsp. Plate 3, Figs. 4 and 5; Plate 10, Figs. 5,6, and 7

Derivation of Name: Planus (Lat.) = flat; from the extremely flat test.

Type Locality: Badamu Formation, northeast of Bibi-Hayat.

Horizon: Murchisonae Zone.

Material: 5 specimens from Bibi-Hayat (1964-403-SE, -464-SE, -466-SE, -475-SE, -477-SE); No. 477 at D = 120 mm is still a phragmocone.

Dimensions:

	D(mm)	U(%)	H(%)	W(%)	No.
Holotype	77.6	39	34	(17)	464

Diagnosis: A large, compressed subspecies of the genus *Planammatoceras*, having a high rectangular to oval whorl section. The umbilicus is wide and flat. The venter is narrow and shows distinct ventrolateral shoulders. A hollow keel of medium size is present.

The sculpture is rather fine and consists of long, straight primary ribs, which in the middle of the flank branch into two or three secondary ribs.

Description: The holotype is a phragmocone of D = 95 mm; it is a flat and widely umbilicated form. The narrow, high-rectangular whorls overlap the successive whorls by about one-third. The umbilicus is extremely flat, with a sharp and distinct umbilical shoulder and a short, steep umbilical wall. The flanks are even and nearly parallel.

The venter is narrow and wedge-shaped, with a distinct ventrolateral shoulder. A hollow keel of medium height is present.

The sculpture consists of fine straight primary ribs, which start at the umbilical shoulder and extend beyond the middle of the flank, where they branch into two rather fine secondary ribs. These are nearly parallel to the straight primary ribs; on the external side the ribs bend slightly forward, but do not entirely reach the keel. A few interclatory ribs, which start at the branch points, are present.

The suture line is strongly denticulated. The lateral lobe is trifid and distinctly deeper than the external lobe; it conforms perfectly with that of *P. planiforme planiforme*.

Comparisons: P. planiforme planum shows a close resemblance to P. planiforme planiforme in the rib pattern as well as in the suture line. The new subspecies, however,

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differs in its more compressed test, rectangular whorl section, wider and flatter umbilicus, and its gentle ventrolateral shoulder.

It is distinguished from *P. hosourense* Sato (1954) by its coarser, straight ribs, somewhat wider umbilicus, and the character of the suture line.

Age: Middle Aalenian (Murchisonae Zone).

Genus Erycites Gemmellaro, 1886

Erycites spathi n.sp. Plate 3, Figs. 11 and 12; Plate 10, Figs. 8a, 8b

Derivation of Name: In honour of L.F. Spath, who has described a part of the ammonite fauna of Ravar.

Type Locality: Badamu Formation northeast of Bibi-Hayat. Horizon: Aalenian.

Diagnosis: A new species of the genus *Erycites* with a narrow, deep umbilicus in the inner whorls, and a whorl section considerably wider than high. Later whorls are distinctly more evolute, showing a decrease in width in relation to height. Particularly characteristic is the rib pattern, which consists of long, sharp primary ribs and retroverse secondary ribs, the latter oblique to the former. The venter is rounded and has a flat keel.

Material: 1 specimen of more than 70 mm diameter, the last whorl of which is strongly weathered, (1964-407-SE); and another specimen (1964-509-SE). Both from Bibi-Hayat.

Dimensions:					
	D(mm)	U(%)	H(%)	W(%)	No.
	20.8	30	43	55	451
	42.0	40	35	40	407
Holotype	74.0	49	26	27	407

Description: The holotype has at D = 40mm a rather evolute test, with a whorl overlap of about one-third and a whorl section which is considerably higher than it is wide. At D = 70mm the whorl section is circular to oval, and the overlap is only small. The umbilicus is deep in the inner whorls, but flattens later. The more or less distinctly developed flank is gently inclined towards the umbilicus. The inner whorls have a distinct umbilical shoulder and a vertical umbilical wall, but later the umbilical shoulder is rounded and not as distinct. The venter is rounded and has a flat, blunt keel.

The sculpture consists of rather strong sharp primary ribs, which start at the umbilical shoulder and branch at the curve to the venter regularly into two, somewhat weaker, secondary ribs. The retroversal secondary ribs stand slightly oblique to the primary ribs; on the venter they bend slightly forward and reach the keel.

The paratype, an immature specimen, with maximum diameter D = 120 mm, consists of five visible whorls. The whorl section is considerably thicker than it is high,

the umbilicus narrow, funnel-shaped, and very deep. The primary ribs have a slightly wider spacing than on the holotype; at D = 20 mm the holotype has 21, the paratype only 19, primary ribs. The oblique position of the secondary ribs in relation to the primary ribs is particularly well shown in the paratype.

Comparison: The new form differs from E. personatus Fossa Manchini (in Merla, 1934, pl.2, fig. 3) and also from E. elaphus Merla (pl. 4, fig. 5) by the more distinctly developed flank, longer primary ribs, and above all by the oblique position of the secondary ribs relative to the primary ribs. Another closely related form is E. fallifax Arkell (pro A. fallax Benecke, 1856), which is distinguished by finer umbilical ribs and a greater number of secondary ribs. The rib pattern conforms excellently with that of E. cf. reussi Hauer (in Lelièvre, 1960, pl. 7, fig. 1) The latter, however, has somewhat coarser ribs, the whorl section is wider, and the keel is replaced by a flat external band. In spite of these differences the writer thinks that E. cf. reussi has to be considered as the most closely related to the new species.

The rib pattern of *E. spathi* is remarkably similar to that of the younger genera *Abbasites* and *Ambersites*, which must have evolved from *Erycites*.

Age: Aalenian.

Family Sonninidae

Genus Zurcheria Douvillé, 1885

Zurcheria kermanensis n.sp. Plate 4, Fig. 14; Pl. 12, Figs. 13a,b,c

Derivation of Name: From the town of Kerman in southeastern central Iran.

Type Locality: Badamu Formation about 3 km west-northwest of the village of Badaman.

Horizon: Boundary between Concava and Sowerbyi Zones.

Diagnosis: Flat, compressed ammonite of the genus Zurcheria, with wide umbilicus and rectangular whorl section. The sculpture consists of straight, sharp ribs, which are projected forward on the venter and cross it without interruption. A rudimentary keel is present.

Material: 1 specimen from Badaman (1964-13-SE); 2 specimens from Bazargun (1964-121-SE, -164-SE).

Dimensions:

	D	U%	Н%	W%	No.
Holotype:	20.5	41	35	32	13
	23.5	40	33	30	121

Description: The holotype is half of an internal mould, of D = 45mm, with the shell partly preserved. It is a wide-umbilicated form with a low rectangular whorl section.

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The greatest thickness of the whorl is close above the umbilicus, and the flanks converge slightly towards the venter. The umbilicus is open and shallow, with rounded shoulders and vertical wall. The venter is moderately wide, slightly rounded, and has a very flat keel.

The sculpture consists of simple, straight, sharp ribs with medium spacing; they originate on the umbilical wall and project forward on the venter, crossing it without interruption. On the umbilical as well as on the ventro-lateral shoulders the ribs are slightly accentuated. On the inner whorls up to D = 10mm the ribs consist alternately of a fine and a somewhat coarser rib. The coarser ribs possess distinct nodes and are reminiscent of *Spinammatoceras pugnax* (Vacek, 1886). The shell shows fine growth lines, which are parallel to the ribs and, like these, cross the venter. The suture line is partly visible; it is differentiated but only slightly denticulated.

Comparisons: The new species has some similarity to Z. *ubaldi* Douvillé (1884) but differs in having a distinctly wider umbilicus and narrower spacing of the ribs; in addition, Z. *Kermanensis* has a faint keel. A closely related form is illustrated by Lelièvre (1960, pl. 6, Fig. 14) as Z. cf. *pertinax* Vacek; it conforms especially well with the new species in the rib pattern of the inner whorls. Lelièvre mentions also the presence of a faint keel. Unfortunately it is not clear from the description whether the ribs traverse the venter; therefore this form can be considered only conditionally as synonymous with Z. *kermanensis*.

Its sharp ribs, slightly accentuated at the umbilical and ventro-lateral shoulder, and the weakly developed keel are very reminiscent of the genus *Haplopleuroceras*, especially *H. subspinatum* Buckman. The latter, however, possesses a well developed keel with distinct external furrows. *Z. kermanensis* may thus be considered as an intermediate form between the genera *Haplopleuroceras* and *Zurcheria*.

Age: Uppermost Aalenian.

Family Stephanoceratidae

Genus Stemmatoceras Mascke, 1907 Subgenus Kummatostephanus Buckman 1922

Stemmatoceras (Kumatostephanus) kumaterum persicum n.subsp. Plate 4, Figs. 18, 19, 20, 21; Plate 14, Figs. 1-5

Derivation of Name: From persicus (Lat.) = Persian.

Type Locality: Badamu Formation, about 300 m north of the tunnel entrance of the Hojedk coal mine.

Horizon: Sauzei Zone.

Diagnosis: A new, large (180 mm) subspecies of the subgenus Kumatostephanus with medium to wide umbilicus (43-50%) and an oval whorl section, which is thicker than it is high.
The sculpture consists of rather sharp proverse ribs in the inner whorls, starting at the umbilical seam and forming small and rounded nodes at the ventrolateral region and branching into two ventral ribs.

Material: 7 specimens from Hojedk (1964-701-SE, -702-SE, -706-SE, -707-SE, 709-SE, -770-SE, -771-SE; 1 specimen from Ravar (1964-355-SE), 1 specimen from Bazargun (1964-101-SE); 1 specimen from Badaman (1964-4-SE).

Dimensions.							
	D(mm)	U(%)	H(%)	W(%)	PR	SR	No.
	64.0	50	31	44	28-30	-	4
Paratype	75.0	45	32	42	26	-	706
	78.0	45	31	44	-	-	701
	88.0	46	32	-	26-27	-	771
Holotype	91.0	45	32	40	27	75	707
	151.0	48	-	37	28	-	709

Dimonsions

Description: The holotype is a rather evolute specimen with an oval whorl section thicker than it is high.

The successive whorls overlap each other about 30%. The umbilicus is open and rather deep, the umbilical shoulder rounded, and the umbilical wall nearly vertical. An even, well developed umbilical wall exists, expecially on the last whorl preserved. The passage from the flank to the venter is well rounded.

The sculpture in the inner whorls consists of rather sharp and proverse primary ribs, starting at the umbilical seam. From D = 40 mm, owing to a slight egression of the whorls, the small nodes at the end of the primary ribs and the branching points in the umbilicus become visible. From about D = 55 mm the primary ribs deviate from the umbilical seam and develop into somewhat elongated and blunt tubercles, which are particularly accentuated above the umbilicus; towards the middle of the flank they become flatter and bifurcate on the outer third of the flank into two broad blunt secondary ribs, which cross without interruption the strongly curved venter. An additional intercalatory rib, starting at the branching point, is present.

The paratype is still a phragmocone at D=80 mm and conforms well with the holotype in its general features. As some whorls were broken, the rib pattern of the inner whorls could be studied more accuarately. At D=30 mm the primary ribs, which startat the umbilical seam, extend to the ventrolateral region, froming small, round nodes and branching into two ventral ribs. Additional intercalatory ribs are rare at this stage. On the outer whorls the ribs are identical with those of the holotype.

On some of the paratypes the suture line is partly visible. It is rather strongly denticulated, with a deep, trifid lateral lobe, which is not as deep as the external lobe. In general, it shows great similarity to that of *Normannites*.

Comparisons: The writer was able to see a cast of the holotype of Stemmatoceras (Kumatostephanus) kumaterum kumaterum (Buckman, 1922, pl. 345, A.B.). The specimens from Iran agree closely with it in some features.

S. (K.) kumaterum kumaterum has generally a somewhat denser rib spacing, and the primary ribs are somewhat sharper on the middle whorls and not as bulging as

in the new subspecies; moreover it shows a thicker whorl section of the inner whorls, whereas the section of the outer whorls (at about D = 150 mm) is nearly the same as in the new subspecies.

Among the specimens from Kerman are thicker forms with coarser ribbing, which the writer is inclined to attribute to S. (K.) perjucundum (Buckman, 1927, pl. 712, A.B.).

S. (K.) kumaterum persicum and S. (K.) perjucundum agree perfectly with S. (K.)kumaterum in the inner whorls to about D = 60 mm; but the younger whorls have a thicker whorl section and coarser ribbing.

It must be emphasized, however, that the two species are linked by several intermediate forms.

The similarity of the inner whorl section in all species of the genera Stemmatoceras and Normannites is noteworthy.

Age: Middle Bajocian (Sauzei Zone).

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STRATIGRAPHIC RANGE TABLE OF THE AMMONITE FAUNA OF THE BADAMU FORMATION

	TOARCIAN						BAJOCIAN									
Ammaonites from the Badamu Formation	tenuicostatum	falciferun	bifrons	variabilis	thouarsense	levesquei	opelinum	murch i sona e	CONCAVE	sowerbyi	sauzei	humphriestanum	subfurcatu	garant iana	parkinsoni	
Phylloceras sp																
Peronoceras sp	· · ·		_													
Pseudolioceras compactile (SIMPSON)					-										<u> </u>	
<pre>?Polvplectus cf. bicarinatus (ZIETEN)</pre>												<u> </u>			<u> </u>	
Pseudogrammoceras quadratum (IAUG)															<u> </u>	
Pseudogrammoceras saemani (DUMORTIER)			1													
Pseudogrammoceras fallaciosum (BAYLE)			(
															Н	
Pseudogrammoceras cotteswoldiae BUCKMAN		•													Η	
Pseudogrammoceras (n.sp				<u> </u>											Η	
Phylseogrammoceras dispansum (LYCETT)															H	
Plevdellia distans (BUCKMAN)																
Plevdellia aalensis (ZIETEN)																
Plevdellia subcompta (BRANCO)							-									
Plevdellia costula (REINECKE)							-									
Dumortieria mactra (DUMORTIER)							-									
Dumortieria moorei (LYCETT)						-	-									
Tmetoceras scissum (BENECKE)							_					_				
Leioceras opalinum (REINECKE)																
Leioceras costosum (QUENSTEDT)																
Leioceras aff. costosum (QUENSTEDT)													_	-	H	
Leioceras subcostosum BUCKMAN															Η	
Leioceras comptum (REINECKE)															Н	
Leioceras cf. paucicostatum RIEBER															Η	
Leioceras striatum (BUCKNAN)	-			-											Н	
Leioceras gracile BUCKMAN															Η	
Staufenia (Costileioceras) sinon (BAYLE)															H	
Stautenia (Costileioceras) sehndensis (HOFFMANN)		_											-		Η	
Ludwigia (Ludwigia) bradfordiensis (BUCKMAN)			-					_								
Ludwigia (Ludwigalla) rudis (BUCKMAN)								-							1	
Ludwigia (Ludwigella) carinifera (BUCKMAN)								_								
Ludwigia (Ludwigella) [®] tolutaria (DUMORTIER)																
Ludwigia (Ludwigel'la) cf. glevensis (BUCKMAN)															┦	
Ludwigia (Ludwigella) aff. vibrata (BUCK/MAN)									_						H	
Ludwigia (Ludwigella) arcitenens (BUCKMAN)															-	
Ludwigia (Graphoceras) concava concava (SOWERBY)															-	
Ludwigia (Graphoceras) concava decora (BUCKMAN)											-				-	
Ludwigia (Graphoceras) tutcheri (BUCKAMN)															-	
Ludwigia (?Graphoceras) munda (BUCKNAN)												L			-1	
Hammatoceras speciosum JANENSCH									·					1	1	
Hammatoceras norcarellense ROVAPELIT															1	
lammatoceras tipperi n.sp			-												1	
Nammatoceras aff. victorii BONARELLI		_]	
Pachammatocoras aff. pachu BUCKNAN.															1	
Pscudammatoceras cf. subinsigne (OPPEL)]					ļ	
Pscudammatoceras dumortieri dumortieri (PRINZ)								-							1	
Pseudammatoceras aff. dumortieri (PRINZ)								-							-	
Pseudammatoceras guliense (RENZ)															ł	

THE JURASSIC BADAMU FORMATION

	TOARCIAN					BAJOCIAN									
Ammonites from the Badamu Formation	tenuicostatum	falciferum	bifrons	variabilis	thouars ense	lev esquei	opalinum	murchisonae	concava	sowerbvi	sauzei	humphriesianu	subfurcatum	garanti ana	parkinsoni
/seulammatoceras stahli n.sp								l					L		
/sudammatoceras flexuosum ELMI					L										L
Asudammatoceras cf. rugatum (BUCKMAN)															
fstudanmatoceras boveri (ELMI)															
fundammatoceras cf. dolium (BUCKMAN)															
Munamatoceras planiforme planiforme BUCKMAN															
Manamatoceras planiforme planum n. subsp															
Munmatoceras aff. planiforme BUCKMAN	L								_		-				
Manaamatoceras cf. vaceki (BRASIL)			ŀ		1			-						 	
Examplecteras (Euaptetoceras) amplectens (BUCKMAN)	L					L		<u> </u>						L	
Ludaetoceras (Euaptetoceras) amaltheiforme (VACEK)															<u> </u>
fulmetoceras (Euaptetoceras) klimakomphalum (VACEK)														<u> </u>	
udaetoceras (Euaptetoceras) aff, ferrugineum (MAUBEUGE)														\vdash	
Winetoceras (Rhodaniccras) prosphues BUCKMAN										<u> </u>					
freites brevispira MERLA			<u> </u>											L	
Excites spathi n.sp			1							Ŀ.				L	ļ
bycites aff. spathi n.sp															
freites cf. robustus NERLA							·								L
hplopleurocoras subspinatum BUCKMAN		_					_							L	
hplopleuroceras mundum BUCKMAN	L					<u> </u>	<u> </u>			<u> </u>					
brcheria cf. ubaldi DOUVILLE	L								_	<u> </u>			<u> </u>	\square	1
Intheria kermanensis n.sp			L						-				<u> </u>	\vdash	ļ
wulnia (Sonninia) adrica (WAAGEN)				L						<u> </u>				<u> </u>	
Muninia (Sonninia) cf. sowerbvi (SOWERBY)										<u> </u>			<u> </u>		
Senninia (Sonninia) schneegansi GILLET				ļ	<u> </u>		ļ	ļ						ļ	<u> </u>
kominia (?Sonninia) laeviuscula (ŞOWERBY)			I	1	<u> </u>		ļ				L		<u> </u>	┢	\vdash
Smeinia (?Sonninia) pavimentaria (BUCKMAN)					Ì	Ì			L					I	
Maninia (?Sonninia) corrugata (SOWERBY)					<u> </u>	L					–			1	
Sominia (?Sonninia) cf. australica (ARKELL)					L	L							<u> </u>	∔	
uminia (?Sonninia) furticarinata disciformis DORN	<u> </u>			ļ	<u> </u>			<u> </u>	<u> </u>	<u> </u>					
Sminia(Poecilomorphus) schlumbergeri IIAUG	L			1					-						
Suminia (Poecilomorphus) cf. boweri (BUCKMAN)		I					l .			<u> </u>			<u> </u>	<u> </u>	
Sominia (Poecilomorphus) macer (BUCKMAN)					<u> </u>			1	<u> </u>	<u></u>				<u> </u>	<u></u>
Aminia (Poecilomorphus) pinguis pinguis (ROEMER)				L		L						L			
Aminia (Poecilomorphus) pinguis hannoverana HILTERMANN	L	L	<u> </u>	<u> </u>	 	 		_	 			F		 	┥
<pre>kminia (Poecilomorphus) sulcata (BUCKMAN)</pre>		L	Ļ	<u> </u>			 							_	Ļ
与 📾 moinia (Poecilomorphus) varicosa (SOWERBY)		1	<u> </u>		+		<u> </u>					<u> </u>	L	4	
krsetensia sp				\vdash				<u> </u>				1		_	
Indiordia helenac (RENZ)				<u> </u>	-	I			<u> </u>	<u>+</u>		ļ		·	
Indfordia inclusa BUCKMAN			-	ļ		<u> </u>		ļ	<u> </u>					+	+
kidoceras liebi MAUGEUGE	-	<u> </u>	 				L					L	·	+	+
Mileia brochii (SOWERBY)	L							<u> </u>				1			
bilita macrocephala (OUENSTEDT)		L	L			L						1	L	\vdash	
Nuites contractus contractus (SOWERBY)	L		L					ļ		\vdash				<u> </u>	<u> </u>
laites sp		L	<u> </u>						ļ				ļ		1
Mutoceras(Kumatostephanus)Kumaterum persicum n.Subsp		L .					1		<u> </u>			1		\vdash	1
📾 toceras (Kumatostephanus) perjuncundum (BUCKMAN)	-	 	 						L		<u> </u>	1		_	+
Hautoceras (Stemmatoceras) aff. frechi (RENZ)	L	I	l				1		L	L		1	L	I	
kalanoceras (Skirroceras) macrum (OUENSTEDT)		<u> </u>		1	1							<u>t</u>	1		<u> </u>
Manoceras (Stephanoceras) humphriesianum (SOWERBY)	—													1	\downarrow
Munnites sp					ĺ									1	1

PLATES

(All \times 0.9 unless otherwise indicated)

- 1. Pseudogrammoceras quadratum (Haug). G.S.I. 1964-429-SE, Bibi-Hayat,
- 2. Pseudogrammoceras saemanni (Dumortier). G.S.I. 1964-408-SE, Bibi-Hayat.
- 3. Pseudogrammoceras fallaciosum (Bayle). G.S.I. 1964-406-SE, Bibi-Hayat.
- 4. Dumortieria moorei (Lycett). G.S.I. 1964-449-SE, Bibi-Hayat.
- 5. Dumortieria mactra (Dumortier). Hojedk; Bundesanstalt für Bodenforschung, 1 4501.
- 6. Pseudogrammoceras cotteswoldiae Buckman. G.S.I. 1964-410-SE, Bibi-Hayat.
- 7. Pseudogrammoceras n.sp.? G.S.I. 1964-409-SE, Bibi-Hayat. (Holotype.)
- 8. Pseudogrammoceras expeditum Buckman. G.S.I. 1964-448-SE, Bibi-Hayat.
- 9. Pleydellia subcompta (Branco). G.S.I. 1964-568-SE, Bibi-Hayat.
- 10. Pleydellia distans (Buckman). G.S.I. 1964-401-SE, Bibi-Hayat.
- 11. Pleydellia aalensis (Zieten). G.S.I. 1964-544-SE, Bibi-Hayat.
- 12. Leioceras opalinum (Reinecke). G.S.I. 1964-501-SE, Bibi-Hayat.
- 13. Leioceras striatum (Buckman). G.S.I. 1964-315-SE, Ravar.
- 14. Leioceras gracile Buckman. G.S.I. 1964-63-SE, Badaman.
- 15. Leioceras cf. paucicostatum Rieber. G.S.I. 1964-28-SE, Badaman.
- 16. ?Polyplectus cf. bicarinatus (Zieten). G.S.I. 1964-8-SE, Badaman.
- 17. Staufenia (Costileioceras) sinon (Bayle). G.S.I. 1964-322-SE, Ravar.
- 18. Staufenia (Costileioceras) sinon (Bayle). G.S.I. 1964-540-SE, Bibi-Hayat.
- 19. Staufenia (Costileioceras) sehndensis (Hoffmann). G.S.I. 1964-454-SE, Bibi-Hayat.
- 20. Leioceras comptum (Reinecke). G.S.I. 1964-532-SE, Bibi-Hayat.
- 21. Leioceras costosum (Quenstedt). Badaman; Bundesanstalt für Bodenforschung, b 448.
- 22. Leioceras subcostosum Buckman. G.S.I. 1964-37-SE, Badaman.
- 23. Tmetoceras scissum (Benecke). G.S.I. 1964-66-SE, Badaman.



- 1. Ludwigia (Ludwigia) bradfordiensis (Buckman). G.S.I. 1964-300-SE, Ravar.
- 2. Ludwigia (Ludwigia) murchisonae (Sowerby, G.S.I. 1964-841-SE, Hojedk.
- 3. Ludwigia (Ludwigella) rudis (Buckman). G.S.I. 1964-34-SE, Badaman.
- 4. Ludwigia (Graphoceras) concava decora (Buckman). G.S.I. 1964-302-SE, Ravar.
- 5. Ludwigia (Graphoceras) concava concava (Sowerby). G.S.I. 1964-44-SE, Badaman.
- 6. Ludwigia (Ludwigella) carinifera (Buckman). G.S.I. 1964-35-SE, Badaman.
- 7. Ludwigia (Ludwigella) tolutaria (Dumortier). G.S.I. 1964-38-SE, Badaman.
- 8. Ludwigia (Ludwigella) cf. glevensis (Buckman). G.S.I. 1964-70-SE, Badaman.
- 9. Ludwigia (Ludwigella) aff. vibrata (Buckman). G.S.I. 1964-22-SE, Badaman.
- 10. Ludwigia (?Graphoceras) munda (Buckman). G.S.I. 1964-842-SE, Hojedk.
- 11. Hammatoceras speciosum Janensch. G.S.I. 1964-467-SE, Bibi-Hayat.
- 12. Hammatoceras aff. victorii Bonarelli. G.S.I. 1964-400-SE, Bibi-Hayat.
- 13. Pachammatoceras aff. pachu Buckman. G.S.I. 1964-450-SE, Bibi-Hayat.
- 14. Hammatoceras porcarellense Bonarelli. G.S.I. 1964-496-SE, Bibi-Hayat.
- 15. Pseudammatoceras guliense (Renz). G.S.I. 1964-405-SE, Bibi-Hayat. (Paratype.)
- 17. Hammatoceras tipperi n.sp. G.S.I. 1964-539-SE. Bibi-Hayat. (Holotype.)
- 18. Pseudaminatoceras stahli n.sp. G.S.I. 1964-538-SE, Bibi-Hayat. (Holotype.)
- 19. Pseudammatoceras dumortieri dumortieri (Prinz). G.S.I. 1964-402-SE, Bibi-Hayat.



- 1. Sonninia (?Sonninia) pavimentaria (Buckman). G.S.I. 1964-369-SE, Ravar.
- 2. Sonninia (Sonninia) cf. sowerbyi (Sowerby). G.S.I. 1964-779-SE, Hojedk.
- 3. Sonninia (Sonninia) schneegansi Gillet. G.S.I. 1964-48-SE, Badaman.
- 4. Sonninia (?Sonninia) furticarinata disciformis Dorn. G.S.I. 1964-720-SE, Hojedk.
- 5. Sonninia (?Sonninia) corrugata (Sowerby). G.S.I. 1964-700-SE, Hojedk.
- 6. Sonninia (Poecilomorphus) schlumbergeri Haug. G.S.I. 1964-158-SE, Bazargun.
- 7. Sonninia (Poecilomorphus) macer Buckman. G.S.I. 1964-775-SE, Hojedk.
- 8. Sonninia (Poecilomorphus) pinguis pinguis (Roemer). G.S.I. 1964-359-SE, Ravar.
- 9. Sonninia (Poecilomorphus) varicosa (Sowerby). G.S.I. 1964-778-SE, Hejedk.
- 10. Sonninia (Poecilomorphus) pinguis hannoverana Hiltermann. G.S.I. 1964-112-SE, Bazargun.
- 11. Sonninia (Poecilomorphus) sulcata (Buckman). Badamu; Bundesanstalt für Bodenforschung, b 449.
- 12. Bradfordia inclusa Buckman. G.S.I. 1964-124-SE, Bazargun.
- 13. Haplopleuroceras subspinatum Buckman. G.S.I. 1964-120-SE, Bazargun.
- 14. Zurcheria kermanensis n.sp. G.S.I. 1964-13-SE, Badaman. (Holotype.)
- 15. Docidoceras liebi Maubeuge. G.S.I. 1964-155-SE, Bazargun.
- 16. Emileia brochii (Sowerby). G.S.I. 1964-157-SE, Bazargun.
- 17. Emileia macrocephala (Quenstedt). G.S.I. 1964-356-SE, Ravar.
- Stemmatoceras (Kumatostephanus kumaterum persicum n. subsp. G.S.I. 1964-706-SE, Hojedk. (Paratype.)
- 19. Stemmatoceras (Kumatostephanus) kumaterum persicum n.subsp. G.S.I. 1964-355-SE, Ravar.
- 20. Stemmatoceras (Kumatostephanus) kumaterum persicum n.subsp. G.S.I. 1964-770-SE, Hojedk.
- 21. Stemmatoceras (Kumatostephanus) kumaterum persicum n.subsp. G.S.I. 1964-101-SE, Bazargun.
- 22. Stemmatoceras (Stemmatoceras) aff. frechi (Renz). G.S.I. 1964-713-SE, Hojedk.
- 23. Stephanoceras (Skirroceras) macrum (Quenstedt). G.S.I. 1964-807-SE, Hojedk.
- 24. Stephanoceras (Stephanoceras) humphriesianum (Sowerby) G.S.I. 1964-175-SE, Bazargun.



- 1. Pseudogrammoceras saemanni (Dumortier). G.S.I. 1964-408-SE, Bibi-Hayat.
- 2. Pseudolioceras compactile (Simpson). G.S.I. 1964-65-SE, Badaman.
- 3. Pseudogrammoceras expeditum (Buckman). G.S.I. 1964-448-SE, Bibi-Hayat.
- 4. a, b Pseudogrammoceras quadratum (Haug). G.S.I. 1964-860-SE, Hujedk.
- 5. Pseudogrammoceras fallaciosum (Bayle). G.S.I. 1964-406-SE, Bibi-Hayat.
- 6. ?Poloylecus cf. bicarinatus (Zieten). G.S.I. 1964-8-SE, Badaman.
- 7. Phlyseogrammoceras dispansum (Lycett). Alborz; Institut für Paläontologie und Museum der Humboldt-Universität zu Berlin, C 411.
- 8. Pseudogrammoceras cotteswolduae Buckman. G.S.I. 1964-410-SE, Bibi-Hayat.
- 9. Pseudogrammoceras n.sp. ? G.S.I. 1964-409-SE, Bibi-Hayat.



- 1. Pseudogrammoceras pachu Buckman G.S.I. 1964-539-SE, Bibi-Hayat.
- 2. Dumortieria moorei (Lycett). G.S.I. 1964--470-SE, Bibi-Hayat.
- 3. Dumortieria mactra (Dumortier). Hojedk; Bundesanstalt fur Bodenforschung, 1 4501.
- 4. Dumortieria moorei (Lycett). G.S.I. 1964-449-SE, Bibi-Hayat.
- 5. Pleydellia subcompta (Branco). G.S.I. 1964-535-SE, Bibi-Hayat.
- 6. Pleydellia subcompta (Branco). G.S.I. 1964-568-SE, Bibi-Hayat.
- 7. Pleydellia subcompta (Branco). G.S.I. 1964-566-SE, Bibi-Hayat.
- 8. *Pleydellia costula* (Reinecke). Alborz; Institut fur Palaontologie und Museum der Humboldt-Universitat zu Berlin, C 410.
- 9. a,b, Pleydellia aff. subcompta (Branco). G.S.I. 1964-534-SE, Bibi-Hayat.
- 10. a,b. Pleydellia distans (Buckman). G.S.I. 1964-401-SE, Bibi-Hayat.
- 11. Pleydellia aalensis (Zieten). (Mould.) G.S.I. 1964-498-SE, Bibi-Hayat.
- 12. Pleydellia aalensis (Zieten). G.S.I. 1964-544-SE, Bibi-Hayat.
- 13. Staufenia (Costileioceras) sinon (Bayle). G.S.I. 1964-540-SE, Bibi-Hayat.
- 14. a,b,c. Staufenia (Costileioceras) sinon (Bayle). G.S.I. 1964-42-SE, Badaman.
- 15. Leioceras comptum (Reinecke). G.S.I. 1964-431-SE, Bibi-Hayat.
- 16. Leioceras comptum (Reinecke). G.S.I. 1964-532-SE, Bibi-Hayat.
- 17. Leioceras comptum (Reinecke). NW Cheshme-Gaz, Bundesanstalt fur Bodenforschung, b 447.
- 18. Staufenia (Costileioceras) sehndensis (Hoffmann). G.S.I. 1964-454-SE, Bibi-Hayat.



- 1. Leioceras subcostosum Buckman. G.S.I. 1964-36-SE, Badaman.
- 2. a,b. Leioceras striatum (Buckman). G.S.I. 1964-315-SE, Ravar.
- 3. a,b. Leioceras opalinum (Reinecke). G.S.I. 1964-501-SE, Bibi-Hayat.
- 4. Leioceras stiatum (Buckman). G.S.I. 1964-307-SE, Ravar.
- 5. Leioceras gracile Buckman. G.S.I. 1964-63-SE, Badaman.
- 6. Leioceras costosum (Quenstedt). G.S.I. 1964-47-SE, Badaman.
- 7. Leioceras costosum (Quenstedt). Badaman; Bundesanstalt fur Bodenforschung; b 448.
- 8. a,b. Ludwigia (Ludwigia) murchisonae (Sowerby). G.S.I. 1964-841-SE, Hojedk.
- 9. Ludwigia (Ludwigia) murchisonae (Sowerby). G.S.I. 1964-110-SE, Bazargun.
- 10. a,b. Ludwigia (Ludwigella) carinifera (Buckman). G.S.I. 1964-35-SE, Badaman.
- 11. Ludwigia (Ludwigella) tolutaria (Durtortier). G.S.I. 1964-38-SE, Badaman.
- 12. Ludwigia (Ludwigella) cf. glevensis (Buckman). G.S.I. 1964-70-SE, Badaman.
- 13. Ludwigia (Ludwigella) aff. vibrata (Buckman). G.S.I. 1964-10-SE, Badaman.
- 14. Ludwigia (Ludwigella) aff. vibrata (Buckman). G.S.I. 1964-22-SE, Badaman.
- 15. Ludwigia (Graphoceras) tutcheri (Buckman). G.S.I. 1964-714-SE, Hojedk.
- 16. Ludwigia (Ludwigella) rudis (Buckman). G.S.I. 1964-34-SE, Badaman.



- 1. Ludwigia (Ludwigia) bradfordiensis (Buckman). G.S.I. 1964-300-SE, Ravar.
- 2. Ludwigia (Ludwigia) bradfordiensis (Buckman). G.S.I. 1964-710-SE, Hojedk.
- 3. Ludwigia ('Graphoceras) munda (Buckman). G.S.I. 1964-842-SE, Hojedk.
- 4. a,b. Ludwigia (Graphoceras) concava decora (Buckman). G.S.I. 1964-301-SE, Ravar.
- 5. Ludwigia (Graphoceras) concava concava (Sowerby). G.S.I. 1964-9-SE, Badaman.
- 6. a,b. Pseudanimatoceras stahli n.sp. G.S.I. 1964-538-SE, Bibi-Hayat. (Holotype.)
- 7. Hammatoceras porcarellense Bonarelli. G.S.I. 1964-442-SE, Bibi-Hayat. (x 1.2)
- 8. a,b. Pseudammatoceras dumortieri dumortieri (Prinz). G.S.I. 1964-402-SE, Bibi-Hayat.
- 9. a,b. Pseudammatoceras dumortieri dumortieri (Prinz). G.S.I. 1964-533-SE, Bibi-Hayat. (X 1.2)























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- a,b. Hammatoceras tipperi n.sp. G.S.I. 1964-535-SE, Bibi-Hayat. (Holotype.) 1.
- Hammatoceras tipperi n.sp. G.S.I. 1964-405-SE, Bibi-Hayat. (Holotype.) 2.
- Pseudammatoceras guliense (Renz). G.S.I. 1964-561-SE, Bibi-Hayat. 3.
- Pseudammatoceras guliense (Renz). G.S.I. 1964-563-SE, Bibi-Hayat. Hammatoceras speciosum Janensch. G.S.I. 1964-467-SE, Bibi-Hayat. 4.
- 5.
- Hammatoceras aff. victorii Bonarelli. G.S.I. 1964-400-SE, Bibi-Hayat. 6.
- 7. Pachammatoceras aff. pachu Buckman. G.S.I. 1964-450-SE, Bibi-Hayat.



- 1. Pseudammatoceras boyeri (Elmi). G.S.I. 1964-447-SE, Bibi-Hayat.
- 2. Pseudammatoceras cf. subinsigne (Oppel). G.S.I. 1964-716-SE, Hojedk.
- 3. Pseudammatoceras flexuosum Elmi. G.S.I. 1964-550-SE, Bibi-Hayat.
- 4. Planammatoceras planiforme planum Buckman. G.S.I. 1964-180-SE, Tidar.
- 5. Planammatoceras planiforme planum n.subsp. G.S.I. 1964-403-SE. Bibi Hayat.
- 6. Planammatoceras planiforme planum n.subsp. G.S.I. 1964-477-SE, Bibi-Hayat.
- 7. Planammatoceras planiforme planum n.subsp. G.S.I. 1964-464-SE, Bibi-Hayat. (Holotype)
- 8. Erycites spathi n.sp. G.S.I. 1964-407-SE, Bibi-Hayat. (Holotype.)
- 9. Erycites brevispira Merla. G.S.I. 1964-455-SE, Bibi-Hayat. (Paratype.)



- 1. a,b. Eudmetoceras (Euaptetoceras) amaltheiforme (Vacek). G.S.I. 1964-2-SE, Badaman.
- 2. a,b. Eudmetoceras (Euaptetoceras) amaltheiforme (Vacek). G.S.I. 1964-3-SE, Badaman. (Inner whorl of a larger specimen)
- 3. a,b. Eudmetoceras (Rhodaniceras) prosphues Buckman. G.S.I. 1964-12-SE, Badaman.
- 4. Eudmetoceras (Euaptetoceras) amplectens (Buckman). G.S.I. 1964-33-SE, Badaman.
- 5. Eudmetoceras (Euaptetoceras) klimakomphalum (Vacek). G.S.I. 1964-719-SE, Hojedk.
- 6. Eudmetoceras (Euaptetoceras) aff. ferrugineum (Maubeuge). G.S.I. 1964-153-SE, Bazargun.



- 1. Sonninia (Sonninia) schneegansi Gillet. G.S.I. 1964-48-SE, Badaman.
- 2. Sonninia (Sonninia) adicra (Waagen). G.S.I. 1964-109-SE, Bazargun.
- 3. Sonninia (?Sonninia) laeviuscula (Sowerby). G.S.I. 1964-846-SE, Hojedk.
- 4. Sonninia (?Sonninia) corrugata (Sowerby). G.S.I. 1964-700-SE, Hojedk.
- 5. Sonninia (Poecilomorphus) varicosa (Sowerby). G.S.I. 1964-778-SE, Hojedk.
- 6. Sonninia (Poecilomorphus) sulcata (Buckman). Badamu; Bundesanstalt fur Bodenforschung, b 449.
- 7. Sonninia (Poecilomorphus) cf. boweri (Buckman). G.S.J. 1964-780-SE, Hojedk.
- 8. Sonninia (Poecilomorphus) pinguis pinguis (Roemer). G.S.I. 1964-359-SE, Ravar.
- 9. Sonninia (Poecilomorphus) pinguis pinguis (Roemer). G.S.I. 1964--357-SE, Ravar.
- 10. Sonninia (Poecilomorphus) pinguis hannoverana Hiltermann. G.S.I. 1964-112-SE, Bazargun.
- 11. a,b,c. Sonninia (Poecilomorphus) macer Buckman. G.S.I. 1964-775-SE, Hojedk.
- 12. Sonninia (Poecilomorphus) schlumbergeri Haug. G.S.I. 1964-158-SE, Bazargun.
- 13. a,b,c. Zurcheria kermanensis n.sp. G.S.I. 1964-13-SE, Badaman. (Holotype.)
- 14. Zurcheria kermanensis n.sp. G.S.I. 1964-164-SE, Bazargun. (Paratype.)
- 15. a,b. Haplopleuroceras subspinatum Buckman. G.S.I. 1964-120-SE, Bazargun.
- 16. a,b. Zurcheria ubaldi Douvillé. G.S.I. 1964-165-SE, Bazargun.
- 17. a,b. Bradfordia helenae (Renz). G.S.I. 1964-117-SE, Bazargun.
- 18. a,b. Bradfordia inclusa Buckman. G.S.I. 1964-124-SE, Bazargun.



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- 1. a,b. Docidoceras liebi Maubeuge. G.S.I. 1964-155-SE, Bazargun.
- 2. a,b. Emileia brochii (Sowerby). G.S.I. 1964-157-SE, Bazargun.
- 3. a,b. Emileia macrocephala (Quenstedt). G.S.I. 1964-351-SE, Ravar.
- 4. a,b. Otoites contractus contractus (Sowerby). G.S.I. 1964-725-SE, Hojedk.
- 5. a,b. Otoites contractus contractus (Sowerby). G.S.J. 1964-156-SE, Bazargun. (Flattened specimen)









- 1. a,b. Stemmatoceras (Kumatostephanus) kumaterum persicum n.subsp. G.S.I. 1964-707-SE, Hojedk. (Holotype.)
- 2. Stemmatoceras (Kumatostephanus) kumaterum persicum n.subsp. G.S.I. 1964-706-SE, Hojedk. (Paratype.)
- 3. Stemmatoceras (Kumatostephanus) kumaterum persicum n.subsp. G.S.I. 1964-770-SE, Hojedk.
- 4. Stemmatoceras (Kumatostephanus) kumatcrum persicum n.subsp. G.S.I. 1964-4-SE, Badaman,
- 5. a,b. Stemmatoceras (Kumatostephanus) kumaterum persicum n.subsp. G.S.I. 1964-701-SE, Hojedk.












SEYED-EMAMI

PLATE 15

- 1. Stemmatoceras (Kumatostephanus) perjucundum (Buckman). G.S.I. 1964-802-SE, Hojedk.
- 2. Stemmatoceras (Kumatostephanus) perjucundum (Buckman). G.S.I. 1964-708-SE, Hojedk.
- 3. a,b,c. Stemmatoceras (Stemmatoceras) aff. frechi (Renz). G.S.I. 1964-713-SE, Hojedk.
- 4. Stephanoceras (skirroceras) macrum (Quenstedt). G.S.I. 1964-718-SE, Hojedk. (× 0.6)
- 5. Stephanoceras (Stephanoceras) humphriesianum (Sowerby). G.S.I. 1964-102-SE, Bazargun. (Flattened specimen.)

