Mitt. Abt. Geol. Paläont. Bergb. Landesmus. Joanneum | Heft 35 | Graz 1975

Pfenderina (Foraminifera) from the Jurassic Sediments of Ethiopia

Aziz T. MANSOUR, Houston

With 4 plates

Abstract

The genus *Pfenderina* HENSON, 1948 represents an important stratigraphic marker in the Jurassic sediments of Ethiopia. A cf. form of a known species (*Pfenderina salernitana* SARTONI and CRESCENTI, 1962) is recorded and illustrated from Bathonian and younger strata. The taxonomic background of the genera *Pfenderina* and *Pseudopfenderina* HOTTINGER, 1967 is discussed in the light of the Ethiopian material to check the validity of the latter genus.

Fig. 1 LOCATION MAP

Introduction

This study is a part of an all-out study of the Jurassic foraminifera in the surface and subsurface sediments of Ethiopia. It was carried out between the years 1971 and 1973 within the general exploration program of Tenneco Oil Co. in Ethiopia. Later in 1972, Texaco Inc. and Standard Oil Co. of California joined Tenneco as partners in its efforts to explore for oil and gas in this country.

The material of this study derives from four deep wells and three surface sections (see text—figure 1). All of the thin sections used here are stored in the research laboratory of Tenneco Oil Co. in Houston.

The genus *Pfenderina* occurs in Ethiopia together with several other members of the so-called "Middle Eastern Jurassic fauna" such as *Pseudocyclammina jaccardi, Everticyclammina virguliana, Kurnubia palastinensis, Trocholina palastinensis, Rhapydionina deserta-amiji, Orbitopsella praecursor* ... etc. It was, however, chosen to be studied separately because of its stratigraphic importance and the somewhat intermingling of its different species as shown in the literature. So, to attain a clear picture of its taxonomic background, a chronologic review of the literature is presented below.

We feel deeply indebted to the managements of Tenneco Oil Co., Texaco Inc. and Standard Oil Co. of California for permission to publish this paper. Particular thanks are due Tenneco Oil Co. for allowing us to use their research facilities and work on this paper on company's time. We also would like to express our personal thanks to Dr. Jan E. VAN HINTE (EPR-Houston) for reviewing the manuscript. Thanks are also due Mrs. M. M. RAINWATER for editing and typing the text and to my wife for her help in translating many French references. Thanks are also due Mr. F. R. ALLCORN (Tenneco's Senior Technician) for his valuable technical help.

Pfenderina and related forms as seen and dealt with by different authors

Pfenderina was erected by HENSON in 1948 based on *Eorupertia neocomiensis* described by PFENDER in 1938 from the Valanginian of Provence (France) and on his own material from the Middle East. PFENDER (1938) stated in her French description that a characteristic feature of this form is the reticulate "wall", and although she used the word "muraille" for wall, we believe that she was referring to the axis (or the central column) rather than to the wall as being reticulate or „guilloche". This is simply because she referred to fig. 7, pl. XVI in her paper which shows a clear reticulate axis and not wall. HENSON (1948a) made the same observation and he concluded that: p. 610 "PFENDER evidently misinterprets the orientation of her section shown in pl. XVI, fig. 7...".

His diagnosis of the genus is largely the same as that of Pfender for her *Eorupertia neocomiensis*. He described the axial core or the central column as: p. 609 "... due to thickening of shell material which occasionally shows an irregular, reticulate texture in sections; ...".

SMOUT and SUGDEN (1962) erected the family *Pfenderinidae* to include the genera *Pfenderina* Henson, 1948, *Kurnubia* Henson, 1948 and *Meyendorffina* AROUZE and BIZON, 1958. This family was later reduced in rank to a subfamily by LOEBLICH and TAPPAN (1964). SMOUT and SUGDEN saw PFENDER's (1938) original "aspect guilloche" of the chamber walls as caused by either a secondary growth of rhombic crystals or by: p. 582 "...the perforations of the apertural part of the septa and by the labyrinthic passages in the endoskeleton of the central part of the chamber..." They gave this very clear and detailed description of the inner structural elements of the tests of *Pfenderina*: p. 584 "Typically the chambers are low and rather oval, each occupying a considerable part of the base and overlapping the axis of coiling. An outer, crescentic part of the chamber is empty and the part of the septum covering this is imperforate. The large remaining inner part of the chamber is occupied by endoskeleton in which there are labyrinthine passages and the corresponding part of the septum is perforated by the pores of the cribrate apertures." They then went on to state that: p. 584 "...the aggregation of the infilled parts of the chambers form an axial columella." On the same page (p. 584) they wrote that: "In the earlier chambers of the test the labyrinthine passages were infilled during the life of the organism and the columella ... is solid in this part. A secondary intercameral foramen is present in each septum in the form of a circular aperture. These foramina lie in what amount to a spiral groove in the margin of the columella." They also cite, with clarity and simplicity, several generic differences between *Pfenderina* und *Kurnubia* where, as HENSON (1948) originally suggested, the absence of subepidermal partitions in *Pfenderina* is the major difference between both genera.

BRUN in a paper published in 1962 on a Middle Liassic new species (*Pfenderina butterlini*) from Morocco apparently accepted PFENDER's description of the wall as being "guilloche" or reticulate and went on to establish that *Pfenderina* does possess subepidermal partitions contrary to HENSON's original diagnosis of the genus. These subepidermal partitions are particularly visible in the tangential sections. They are perpendicular to the principal partitions and never reach the center of the test. This, according to BRUN, makes the difference between *Pfenderina* and "*Valvulinella*" or *Kurnubia* difficult to establish because HENSON (1948 a) cited the absence of subepidermal partitions in *Pfenderina* as the only difference between both genera. BRUN maintained the "*Valvulinella*" described by HENSON (1948 a) still as an independent genus from *Kurnubia* but he admitted their similarity. For simplicity, we regard here his remarks on "*Valvulinella*" as pertaining to *Kurnubia,* because the validity of *Kurnubia* to include HENSON's "*V. jurassica*" and "*V. wellingsi*" is out of the question. According to BRUN's examination of many sections of *Kurnubia* it appears to him that in this form the subepidermal partitions perpendicular to the epidermis do not reach the septa. They form rather "subepidermal alveolar canals" similar to those observed in *Pseudocyclammina*. According to BRUN also, there exists some ambiguity in HENSON's description of *Kurnubia* because HENSON writes that in *Kurnubia* "there is a well-marked sub-epidermal cellular layer". BRUN then stated that we cannot talk about true subepidermal partitions in *Kurnuvia,* but rather about subepidermal alveolar canals. In *Pfenderina,* on the contrary, although the secondary partitions do not reach the center, they are perpendicular to the epidermis and the septa. He then points out that the micropaleontological vocabulary should differentiate between "subepidermal partitions" and "subepidermal alveolar canals". This difference, according to him, is essentially the following: subepidermal partitions perpendicular to the epidermis and to the septa as in *Pfenderina,* versus subepidermal alveolar canals as in *Kurnubia*. Apparently unaware at the time of his paper, of

SMOUT and SUGDEN's paper, BRUN then emended the genus *Pfenderina* on the basis of his new species *Pfenderina butterlini*. His emendation largely stresses the presence of secondary subepidermal partitions which are perpendicular to the principal partitions.

SARTONI and CRESCENTI (1962) identified a new species, *Pfenderina salernitana,* from Bathonian and Callovian strata of the Southern Appennines which is closely related to *Pfenderina neocomiensis* (PFENDER 1938). This new species comes closest to our Ethiopian material both stratigraphically and paleontologically. However, some differences in the internal structure of both materials restrained us from identifying our material as *Pfenderina salernitana* sensu strictu. These differences and our views of *P. salernitana* will be discussed elsewhere in this paper.

REDMOND (1964) in his paper on the *Pfenderinidae* of the Jurassic of Saudi Arabia stated that: p. 251 "the endoskeletal material mentioned by SMOUT and SUGDEN does not lie within the chamber cavity itself but, instead, outside of it, forming a labyrinthine filling between a porous apertural plate and the anterior wall of the corresponding chamber". More important, REDMOND (1964) subdivides the *Pfenderinidae* on the basis of the presence or absence of the secondary infilling of the labyrinthine passages in the central part of the test, into two subfamilies, *Pfenderininae* with secondary infilling during the life of the individual, and *Kurnubiinae* without. REDMOND then emended the genus *Pfenderina* on the basis of his above stated observation that the endoskeletal material lies outside the chamber cavity. He further notes that BRUN's (1962) *Pfenderina butterlini*: p. 255 "is neither a *Pfenderina* nor a member of the *Pfenderina* nor a member of the *Pfenderirinae,* and thus cannot serve as a valid basis for emendation of *Pfenderina*". He cites the following differences to support his point of view: *Pfenderina butterlini* BRUN (1962): p. 255 "lacks the apertural apparatus of the *Pfenderinidae*", "shows no evidence of secondary infilling during the life of the individual", the "walls of the chambers do not show the characteristic outward taper of the *Pfenderininae*" and finally "there is no semblance of a solid central core or subcameral tunnel". REDMOND then describes two new species of *Pfenderina* (*gracilis* and *inflata*) of which he publishes photographs of isolated specimens but no thin sections. The outside appearance of this new material, its stratigraphic range and its geographical location (just across the Red Sea) make it highly probable that this Saudi Arabian material and our Ethiopian material are identical. The lack of thin-section photographs of this material does not permit the justification of this probability at this time. REDMOND also records two other better known species (*neocomiensis* and *trochoidea*) and erects three new genera: *Pfenderella, Sanderella* and *Steinevella* belonging to the same new subfamily *Pfenderininae*.

Finally, based on the remarks made by REDMOND (1964) about *Pfenderina butterlini* BRUN, 1962, HOTTINGER (1967) erected the new genus *Pseudopfenderina* and chose BRUN's *P. butterlini* as his genotype. HOTTINGER had many random sections of identical material from the Middle Liassic of Morocco. He suggested that his and BRUN's Liassic forms represent the older member of the family of *Pfenderinas* which differs from the genera *Pfenderina* and *Pfenderella* in the absence of a "subcameral tunnel" as defined by REDMOND. HOTTINGER further gives an astonishingly detailed description of the internal structure of *Pseudopfenderina* based on his random sections. He disagrees with BRUN on the subject of the subepidermal partitions for he stated in his valuable work on the Moroccan Mesozic foraminifera that: p. 87 (translated from the French) "The chamber has simple external partitions. It does not possess supplementary exoskeletal structural elements like those *Kurnubia* and *Praekurnubia* have". His description of the endoskeletal columellar apparatus resembles in general, the description of SMOUT and SUGDEN's (1962) new family *Pfenderinidae*. HOTTINGER's description seemingly differs from SMOUT and SUGDEN's in the absence of a "secondary intercameral foramen" sensu SMOUT and SUGDEN (1962) or "subcameral tunnel" sensu REDMOND (1964).

HOTTINGER (1967) also mentioned the presence of a new species *Pseudopfenderina* (n. sp.) in his Moroccan material. According to him, it is always accompanied by *P. butterlini* but a smaller form than the true *P. butterlini*. For lack of enough material, he did not give a detailed description of this new species. It is worth mentioning here that a very similar small-size form was recognized in our Ethiopian material. In the beginning stages of our research, it was mainly differentiated from the more abundant, larger and better developed *Pfenderina* by its smaller size, and was designated by the unofficial name "dwarf *Pfenderina*" (group no. 3 in the following pages). It will be discussed in more detail elsewhere in this paper.

The Ethiopian material lacks any isolated specimens, and although this material is very abundant, the fact that there are no isolated specimens for oriented thin sections, limited very much our ability to study and record their internal structure, and accordingly to examine the many small details described by the many authors and to check their validity. Therefore, it is worth mentioning here that our identification of the Ethiopian material is based solely, like most paleontological works, on comparison of published descriptions and photographs. We have not seen or compared our material with actual specimens described in the literature.

The basic differences between *Pfenderina* and *Pseudopfenderina* (= *Pfenderina butterlini*) originated by REDMOND (1964) and later adopted by HOTTINGER (1967) are not clear at all. From the literature, it is evident that the description of the endoskeletal columellar elements by SMOUT and SUGDEN (1962) of the family *Pfenderinidae* which includes *Pfenderina* but not *Pseudopfenderina,* as REDMOND (1964) indirectly indicated, and the description of the same elements by HOTTINGER (1967) of the genus *Pseudopfenderina* are largely the same, excluding the difference of a "solid" columella for *Pfenderina* versus a "spongy" columella for *Pseudopfenderina* which seems to be one of the main differences between both genera. In this connection it is important to state that although our Ethiopian material does not allow us to confirm or deny definitely that the columella was already "solid" during the life of the individual as in *Pfenderina* or "spongy" as in *Pseudopfenderina* (that means if the labyrinthine passages within the columellar region were or were not infilled with secondary deposition during the life of the individual), we strongly tend to believe that it was solid. However, we regard this whole argument of a "solid" versus a "spongy" columella to characterise both genera as an invalid argument because, for example, the original *Pfenderina neocomiensis* (PFENDER), 1938 shows a clear reticulate, in other words "spongy" columella, and *Pfenderina salernitana* SARTONI and CRESCENTI, 1962 has also the same feature (although to a lesser extent). It is also evident from the published photographs of both genera by the different authors that both share the presence of a "spiral groove" or "subcameral tunnel" which puts the validity of the genus *Pseudopfenderina* in doubt for the absence of this feature is the main factor behind the erection of this new genus. These facts and the fact that HOTTINGER's description (1967) of *Pseudopfenderina* resembles very much that of SMOUT and SUGDEN's (1962) of *Pfenderina* lead us to believe that we do not actually have *Pseudopfenderina* and *Pfenderina* as separate genera, but in fact we are dealing with one and the same genus, in which case of course, it will be *Pfenderina*. Also the fact that our material identifies, in lesser or larger degree, with some individual specimens which are published as different species (e.g. *Pfenderina butterlini* in BRUN, 1962, pl. 2, fig. 3 — *Pfenderina neocomiensis* in SMOUT and SUGDEN, 1962, pl. 75, no. 1 middle specimen — *Pfenderina salernitana* in SARTONI and CRESCENTI, 1962, part of pl. 16 — *Pfenderina* sp. in DERIN and REISS, 1966, no. 70 — *Pseudopfenderina butterlini* in HOTTINGER, 1967, pl. 19) lends much support to our suggestion that we are dealing with one and the same genus with different stratigraphic range according to the geographic locality. We have in Ethiopia some questionable Bajocian occurrences, which if enough material is found, could throw some light on this problem and answer the question if *Pfenderina* has originated in Middle Liassic times and has managed to survive and evolve up till the Bathonian and probably higher to the Neocomian (see stratigraphic range of the Ethiopian material).

Introduction to the systematics

In the beginning stages of our exploration, and for the benefit of our day to day work requirements, we subdivided the Ethiopian fauna into four different groups.

These four groups were:

1. The large abundant forms with 4—6 chambers in the equatorial section similar to those illustrated by BRUN, 1962, pl. 2, no. 3 (as *Pfenderina butterlini*); SARTONI and CRESCENTI, 1962, part of pl. 16 (as *Pfenderina salernitana*); DERIN and REISS, 1966, no. 70 (as *Pfenderina* sp.); HOTTINGER, 1967, pl. 19, most of the axial and tangential sections[1] (as *Pseudopfenderina butterlini*); and BRUN, 1969, pl. 2, no. 14 and 15 (as "*Pfenderina*" *butterlini*).

2. The large much fewer forms (than gr. no. 1) with 7—8 chambers in the equatorial section similar to those illustrated by PFENDER, 1938, pl. 16, no. 3, 4 and 5 (as *Eorupertia neocomiensis*); DUFAURE, 1958, pl. 2, no. 5 (as *Pfenderina neocomiensis*); HOTTINGER, 1967, pl. 19, most of the equatorial sections (as *Pseudopfenderina butterlini*).

Although the number of chambers per whorl is considered to have the least taxonomic value, we made this subdivision because more than 80 % of our fauna lies within the first group which has an average of five chambers per whorl and the appearance of a very few forms with an average of more than seven chambers per whorl indicated at that time, an independent group.

---

[1] The citation of similarity of certain sections of HOTTINGER's photographs with both our groups 1 and 2 is an „evidence" that we are dealing, basically, with one and the same species in both groups.

However, a major difference between group no. 2 and *Pfenderina neocomiensis* sensu strictu is the central column which in our material is much smaller in diameter and less clearly reticulate than the true *P. neocomiensis,* as is also the case in group no. 1 and its similar above-mentioned published forms.

3. The "dwarf fauna" which occurs abundantly for example, in Marda Pass surface section (Lat. 9° 25' N., Long. 42° 45' E.). These are tiny specimens which usually have three to four and rarely five chambers in the equatorial section and in many cases are coated with oolites (see pl. 2, fig. 9, 10 and pl. 3, fig. 4, 5, 7, 8, 11, 12, 13 and 14). The fact that these "dwarf forms" occur always in association with, or immediately overlying or underlying the large typical forms of group no. 1 led us to the assumption that they are either phyllogenetically closely related to or actually are a true but younger generation of *Pfenderina.* In a particular case, in Buri surface section (lat. 8° 45' N., long. 42° 50' E.) they were found homogenously spar cemented with pellets of the same tiny size (see pl. 3, fig. 13, 14 and pl. 4, fig. 1). This might indicate that, in some cases, the underwater currents separated the two generations (the adults and the youngsters) according to their size and later deposited them in different places.

Macoin, Schroeder and Vila (1970) described and illustrated several forms of *Campanellula capuensis* from the Barremian of Algeria. This form, in some photographs of the equatorial section (especially pl. 2, no. 12) resembles, to some extent, our "dwarf fauna" but differs from it in the following characteristics:

a) the initial spire of *C. capuensis* is typically trochospiral, whereas in our case, this characteristic feature is not recognized (see pl. 2, fig. 9).

b) the adult test of *C. capuensis* is multi or triserial, whereas ours is exclusively biserial.

c) the central column in *C. capuensis* (if there is any true one) is less developed and defined than in our case.

4. The tiny misleading forms, which were first thought to belong to group no. 3 because of their tiny size and their occurence with them. But a closer look (with a larger magnification) showed that they were unrelated to *Pfenderina,* and were actually dwarf specimens of *Verneuilinoides* (see pl. 4, no. 5, 6, 7, 8, 9 and 12), and accordingly they were excluded from our study.

The reason why we identified our fauna in this paper as a cf. form of *Pfenderina salernitana* Sartoni and Crescenti, 1962 is because we consider it to be identical with only a part of Sartoni and Crescenti's original population of that spezies (see pl. 1, fig. 3). The rest of Sartoni and Crescenti's material including holotype is different from ours and is more closely related to *Pfenderina neocomiensis* (Pfender, 1938). It differs basically from our material in the larger size of the test, in the larger central column and in having more chambers per whorl. Derin and Reiss (1966) published some material from Israel which shows these differences. In their photograph no. 70, they have a specimen exactly identical with our material which they identified as *Pfenderina* sp., and in photograph no. 71, they have a specimen very close to the holotype of *Pfenderina salernitana* which they properly identified as *P. salernitana.*

A great possibility also exists that our material could be identical with Redmond's (1964) new species from Saudi Arabia (*Pfenderina gracilis*) but because he published only photographs of isolated specimens and no thin sections we could not compare both material as we stated before, and accordingly we did not describe our fauna as a new species.

Systematics

Family Pavonitidae LOEBLICH and TAPPAN, 1961

Genus *Pfenderina* HENSON, 1948

Pfenderina cf. *salernitana* SARTONI and CRESCENTI, 1962

Plate 1, fig. 1, 4, 6, 7, 9 and 10; Plate 2, fig. 2-10;
Plate 3, fig. 1, 3-5, 7-14; Plate 4, fig. 1-4

For comparison:

1962 *Pfenderina salernitana* — S. SARTONI and U. CRESCENTI, part of pl. 16.
1966 *Pfenderina* sp. — B. DERIN and Z. REISS, no. 70.

Correlation with other species: Our forms differ from *Pfenderina neocomiensis* (PFENDER), 1938 mainly through their smaller and less reticulate central column (columella). Also more than 80% of our material has fewer chambers per whorl (average 5) than *P. neocomiensis* (average 7). In some individual cases we encountered other forms with seven chambers or more with a relatively larger central column (see pl. 3, fig. 1 and 3 and pl. 4, fig. 3). Also the younger age of the forms (L. Cretaceous and Kimmeridgian) suggests that they are more closely related to the predominately L. Cretaceous *P. neocomiensis* than they are to the older *Pfenderina salernitana*. But because we lack any free specimens for oriented thin sections, we are unable at this time to determine their proper identity.

Our forms further are easily differentiable from *Pfenderina trochoidea* SMOUT and SUGDEN, 1962 which is so low trochospiral that, in thin sections, it appears almost planispiral.

As we stated above, we believe that *Pfenderina salernitana* SARTONI and CRESCENTI, 1962 should be divided into two forms: one closely related to our fauna (see pl. 1, fig. 3), and the second is very much related to *P. neocomiensis* (PFENDER), 1938, a fact which SARTONI and CRESCENTI also admitted in their paper where the different stratigraphic range of their fauna (Bathonian — Callovian) helped justify the erection of their new species.

Another species to consider in our correlation is *Pfenderina butterlini* BRUN, 1962 which in spite of BRUN's erroneous observation that it shows subepidermal partitions, its choice by HOTTINGER (1967) as the genotype of *Pseudopfenderina* and its older stratigraphic range (Pliensbachian), shows a striking similarity to our fauna (see pl. 1, fig. 2) and the fauna recorded by DERIN and REISS (1966) from the Bathonian of Israel and identified as *Pfenderina* sp. As we showed in the generic review of *Pfenderina*, the erection of the genus *Pseudopfenderina* HOTTINGER, 1967 is not justified and accordingly the name *Pfenderina butterlini* BRUN, 1962 should regain its validity.

Stratigraphic range of the Ethiopian material

The Ethiopian *Pfenderinas* derive from Bathonian and younger strata. This age dating is based on the fact that the *Pfenderinas* are always directly overlain by *Kurnubia palastinensis* HENSON, 1948 which, in its turn is occasionally overlain by

Pseudocyclammina jaccardi (SCHRODT, 1894). Below our *Pfenderinas* comes a relatively thick, scarcely fossiliferous interval of probable Bajocian to Upper Liassic age. Then the Middle Liassic follows with its unmistakable *Orbitopsella praecursor* (GÜMBEL, 1872).

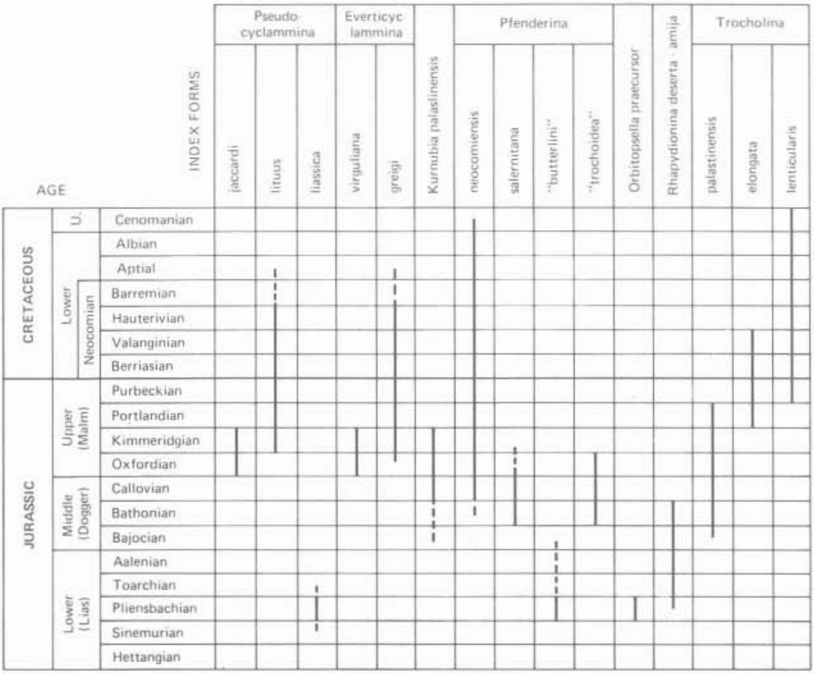


Fig. 2. Biostratigraphic range chart of some important index Foraminifera of the Jurassic and Lower Cretaceous in Ethiopia and worldwide.

In some particular sections we even have some *Pfenderinas* of probable younger age (than Bathonian). These sections are:

1. Abred well no. 1 (at 1560 m) with *Pseudocyclammina jaccardi*. Age: Upper Oxfordian — Kimmeridgian.
2. Callafo well no. 1 (at 3830-3840 feet). Age: Kimmeridgian (see pl. 3, fig. 3).
3. Calub well no. 1 (at 3660—3780 feet). Age: Lower Cretaceous (see pl. 3, fig. 1).
4. Ganale Doria surface section (samples I-27-3 and 4) with *Pseudocyclammina jaccardi*. Age: Upper Oxfordian — Kimmeridgian (see pl. 2, fig. 7 and 8).

Although the record of stratigraphic range of such a fauna in different parts of the world lends much support to the idea that these younger occurrences are in situ, we also leave the possibility of the reworking of the material open until solid proof to the contrary is found.

We also have few questionable occurrences of the Ethiopian *Pfenderinas* in strata believed to be of Bajocian age (see pl. 3, fig. 4 and 5).

Bibliography

F. Barbieri: Jurassic microfacies in Western Somalia. — Riv. Ital. Paleont., vol. 74, no. 3, pp. 805—826, pls. 57—61, text — figs. 1—3, Milan 1968.

M. Beyth: Paleozoic-Mesozoic Sedimentary Basin of Mekele Outlier, Northern Ethiopia. — Am. Assoc. Petroleum Geologists Bull., vol. 56, no. 12, pp. 2426—2439, text — fig. 1—7, table 1, Tulsa 1972.

F. Bozorgnia and S. Banafti: Microfacies and microorganisms of Paleozoic through Tertiary sediments of some parts of Iran. — 22 pp., 158 pls., National Iranian Oil Co., Tehran 1964.

L. Brun: Note sur le genre *Pfenderina* Henson, 1948, Description d'une nouvelle espèce (*Pfenderina butterlini*) dans le Domerien du Maroc. — Revue de Micropaléontologie, vol. 5, no. 3, pp. 185—190, pls. 1—2, Paris 1962.

L. Brun: Etude biostratigraphique du Jurassique de la bordure atlasique Nord-Orientale et des Plis Marginaux (Maroc Oriental). — Proceedings 3rd African Micropal. Coll., pp. 185—213, pls. 1—7, text — figs. 1—2, table 1—3, Nidoc, Cairo 1969.

P. Canuti and C. Pirini-Radrizzani: Micro-facies from the upper portion of the Antalo Limestone (Blue Nile Sequence-Ethiopia). — Proceedings 5th African Micropal. Coll., Addis Ababa 1972 (in press).

W. O. Clift: Sedimentary history of the Ogaden District, Ethiopia. — 20th International Geological Congress, Symposium on Oil and Gas Reservoir, vol. I Africa, pp. 89—112, text — figs. 1—4, table 1, Mexico City 1956.

B. Derin and Z. Reiss: Jurassic microfacies of Israel. — Israel Inst. Petroleum, Special publication, 43 pp., 320 photographs, 2 tables, Tel-Aviv 1966.

B. Derin and E. Gerry: Jurassic biostratigraphy and environments of deposition in Israel. — Proceeding 5th African Micropal. Coll., Addis Ababa 1972 (in press).

Ph. Dufaure: Contribution a l'étude stratigraphique et micropaléontologique du Jurassique et du Nécomien, de l'Aquitaine a la Provence. — Rev. Micropaléontologie, vol. 1, no. 2, pp. 87—115, pls. 1—6, text — fig. 1, Paris 1958.

F. R. S. Henson: New *Trachamminidae* and *Verneulinidae* from the Middle East. — Ann. Mag. Nat. Hist., ser. 11, vol. 14, pp. 605—630, pls. 14—18, text — fig. 1, London 1948 (a).

F. R. S. Henson: Larger Imperforate Foraminifera from South Western Asia. — Monogr. British Mus. (Nat. Hist.), 127 pp., 16 pls., 16 text — figs., London 1948 (b).

H. Hölder: Jura, Handbuch der stratigraphischen Geologie Bd. 4. — 603 pp., 158 text — figs., 43 tables, Ferdinand Enke Verlag, Stuttgart 1964.

L. Hottinger: Foraminifères imperforès du Mésozoique marocain. — Notes et memoires du Service Geologique du Maroc, no. 209, 169 pp., 20 pls., 61 text — figs., Rabat 1967.

P. Macoin, R. Schroeder and J.-M. Villa: *Campanellula capuensis* De Castro (Foram.), position systematique et repartition stratigraphique en Algerie. — Proceedings 4th African Micropal. Coll., pp. 248—267, pls. 1—2, text — figs. 1—4, Abidjan (1970).

W. Maync: Microbiostratigraphy of the Jurassic of Israel. — Geol. Surv. Israel, Bull. no. 40, 56 pp., 15 pls., 3 tables, Jerusalem 1966.

Microfacies Italiane. — 35 pp., 145 pls., 2 maps, Agip Mineraria, (San Donato) Milan 1959.

E. Perconig: Microfacies of the Triassic and Jurassic sediments of Spain. — 63 pp., 123 pls., 11 text — figs., E. J. Brill, Leiden 1968.

J. Pfender: Les Foraminifères du Valanginien provencal. — Bull. Soc. Geol. France, vol. 8, 5th series, no. 3—4, pp. 231—242, pls. 13—16, Paris 1938.

R. W. Powers: Arabian Upper Jurassic carbonate reservoir rocks. — in Class. of carbonate rocks, a symposium, Am. Assoc. Petroleum Geologists, Memoir 1, pp. 122—192, pls. 1—8, text — figs. 1—23, table 1, Tulsa 1962.

C. D. Redmond: The foraminiferal family *Pfenderinidae* in the Jurassic of Saudi Arabia. — Micropaleontology, vol. 10, no. 2, pp. 251—263, pls. 1—2, New York 1964.

R. Said and M. G. Barakat: Jurassic microfossils from Gebel Maghara, Sinai, Egypt. — Micropaleontology, vol. 4, no. 3, pp. 231—272, pls. 1—6, text — figs. 1—5, table 1, New York 1958.

R. SAID and M. G. BARAKAT: Foraminifera from subsurface Jurassic rocks of Wadi El-Natrun, Egypt. — Egypt. Acad. Science Proceedings, vol. 13, pp. 1—8, text — figs. 1—9, Cairo 1959.

S. SARTONI and U. CRESCENTI: Ricerche biostratigrafiche nel Mesozoico dell'Appennino Meridionale. — Giorn. Geol., vol. 29, pp. 159—302, pls. 1—42, table 1, Bologna 1962.

A. H. SMOUT and W. SUGDEN: New information on the foraminiferal genus *Pfenderina*. — Palaeontology, vol. 4, part 4, pp. 581—591, pls. 73—76, text — fig. 1, London 1962.

TREATISE ON INVERTEBRATE PALEONTOLOGY. — Part C, Protista 2, vol. 1, R. C. MOORE editor, The Geological Soc. of America and the University of Kansas Press, New York, 1964.

C. VIOTTI: Resultats stratigraphiques du sondage Puerto Cansado 1 du Bassin Cotier de Tarfaya. — in Le Bassin Côtier de Tarfaya (Maroc meridional), vol. 1 Stratigraphie, Service Geol. Maroc Mem. No. 175, pp. 225—249, pls. 1—6, Rabat 1966.

Address of the author: Dr. A. T. MANSOUR, Tenneco Oil Co., P. O. Box 2511, Houston, Texas 77001, USA.

Plate 1

Fig. 1: *Pfenderina* cf. *salernitana* Sartoni and Crescenti, 1962, El Kuran well no. 1, 5120—30 feet, Upper Bathonian, equatorial section, approx. x 20.

Fig. 2: "*Pfenderina*" *butterlini* Brun, 1962, original photograph after Brun (1962).

Fig. 3: *Pfenderina salernitana* Sartoni & Crescenti, 1962, original photograph after Sartoni and Crescenti (1962) from the L. Callovian — U. Bathonian of Italy for comparison with fig. 1, equatorial section, x 34.

Fig. 4: *Pfenderina* cf. *salernitana* Sartoni and Crescenti, 1962, El Kuran well no. 1, core no. 2 (5215 feet), Bathonian, axial section (partly tangential in the upper portion), approx. x 80.

Fig. 5: "*Pfenderina*" *butterlini* Brun, 1962, original photograph after Brun (1962) from the Middle Liassic of Marocco for comparison with fig. 4, axial section (partly tangential in the upper portion), x 60.

Fig. 6: *Pfenderina* cf. *salernitana* Sartoni and Crescenti, 1962, El Kuran well no. 1, core no. 2 (5215 feet), Bathonian, equatorial and axial sections, approx. x 20.

Fig. 7: *Pfenderina* cf. *salernitana* Sartoni and Crescenti, 1962, El Kuran well no. 1, core no. 2 (5189—5228 feet), Bathonian, equatorial and tangential sections, approx. x 20.

Fig. 8: *Pfenderina salernitana* Sartoni and Crescenti, 1962, original photograph after Sartoni and Crescenti (1962) from the L. Callovian — U. Bathonian of Italy, equatorial sections (slightly oblique), x 34.

Fig. 9: *Pfenderina* cf. *salernitana* Sartoni and Crescenti, 1962, El Kuran well no. 1, core no. 2 (around 5200 feet), Bathonian, equatorial section, approx. x 20.

Fig. 10: *Pfenderina* cf. *salernitana* Sartoni and Crescenti, 1962, El Kuran well no. 1, core no. 2, (5215 feet), Bathonian, both axial section (lower specimen is magnified in fig. 4), approx. x 20.

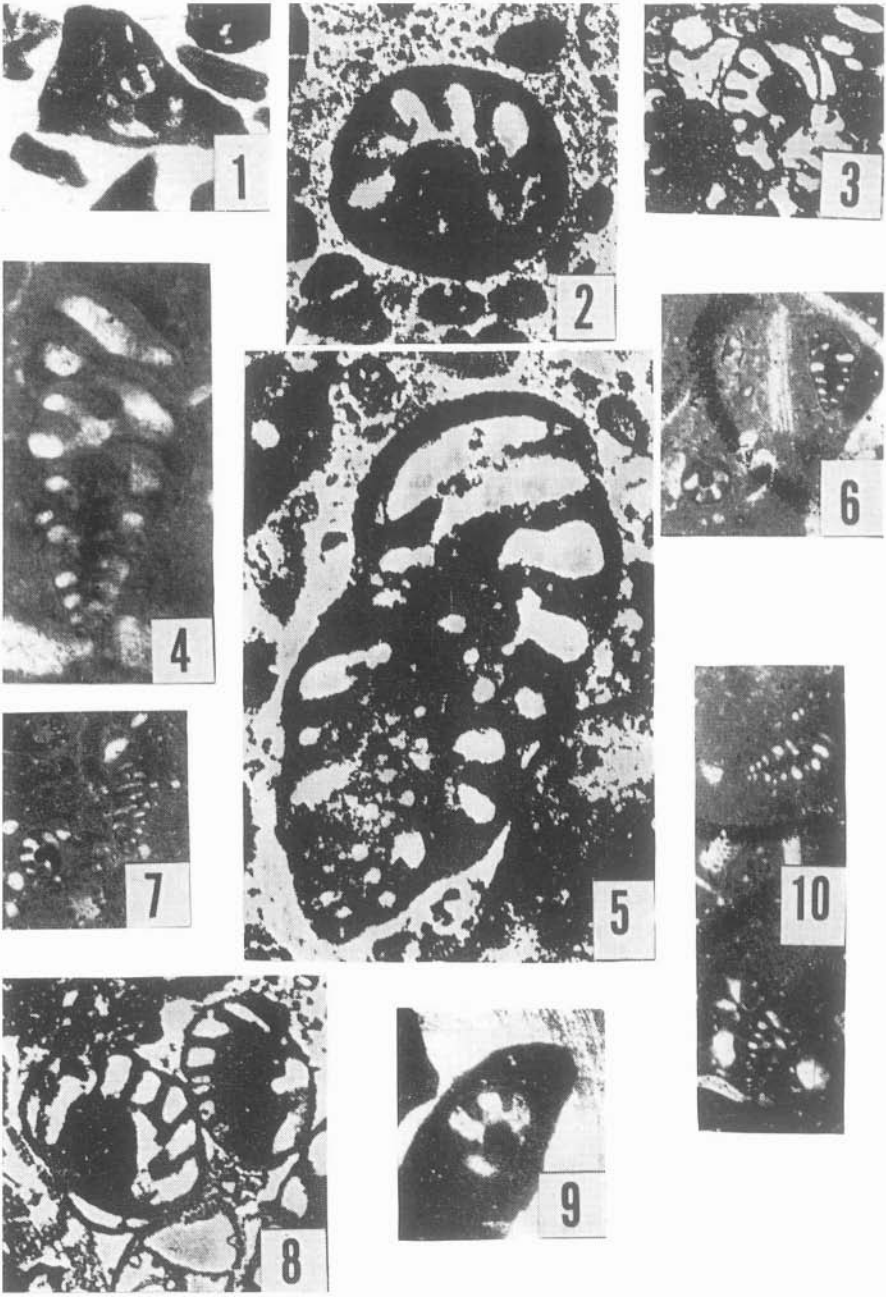


Plate 1

Plate 2

Fig. 1: *Pseudopfenderina butterlini* (BRUN), 1962, original photograph of a model reconstructed by Hottinger (1967), tangential and oblique sections.
HOTTINGER meant to exaggerate the free height of the chambers in the umbilical area to show the pillars and the complexity of this zone. Original magnification was x 5000 (see attached cm. scale).

Fig. 2: *Pfenderina* cf. *salernitana* SARTONI and CRESCENTI, 1962, El Kuran well no. 1, core no. 2 (5189—5228 feet), Bathonian, axial section (partly tangential in the upper portion), approx. x 80.

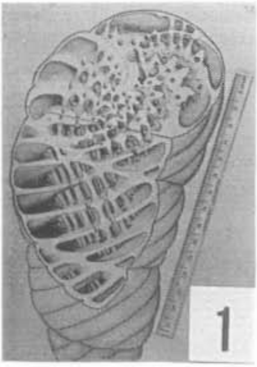
Fig. 3: *Pfenderina* cf. *salernitana* SARTONI and CRESCENTI, 1962, El Kuran well no. 1, core no. 2 (5215 feet), Bathonian, axial and equatorial sections, approx. x 20.

Fig. 4 and 5: *Pfenderina* cf. *salernitana* SARTONI and CRESCENTI, 1962, El Kuran well no. 1, core no. 2 (5189—5228 feet), Bathonian, both axial sections (fig. 4 slightly tangential in the upper portion), approx. x 20.

Fig. 6: *Pfenderina* cf. *salernitana* SARTONI and CRESCENTI, 1962, El Kuran well no. 1, core no. 2 (5215 feet), Bathonian, all three specimens axial sections (the lower specimen with more than 6 chambers), approx. x 20.

Fig. 7 and 8: *Pfenderina* cf. *salernitana* SARTONI and CRESCENTI, 1962 and *Pseudocyclammina jaccardi* (SCHRODT), 1894, Ganale Doria surface section, sample I-27-3, U. Oxfordian — Kimmeridgian, the Pfenderinas are probably reworked?, fig. 7 axial section and fig. 8 equatorial section, both Pseudocyclamminas are axial sections, approx. x 20.

Fig. 9 and 10: *Pfenderina* cf. *salernitana* SARTONI and CRESCENTI, 1962, surface section, sample D-2-7, Lowest Bathonian, small specimens of group no. 3 (see p. 7), axial sections (both photographs are of the same specimen), fig. 9 x 80, fig. 10 x 20.


1


2


3

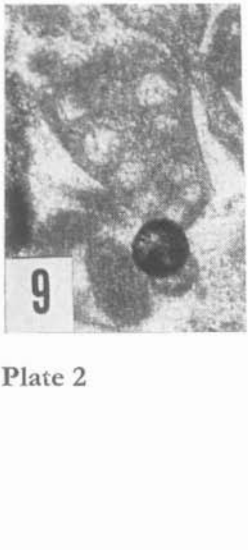

4


5


6


7


8


9


10

Plate 2

Plate 3

Fig. 1: *Pfenderina* cf. *salernitana* SARTONI and CRESCENTI, 1962, Calub well no. 1, 3670—80 feet, Lower Cretaceous, equatorial section, approx. x 20.

Fig. 2 and 6: *Pfenderina neocomiensis* (PFENDER), 1938, original photograph after PFENDER (1938) from the Valanginian of France for comparison with fig. 1 and 3, equatorial sections, x 40.

Fig. 3: *Pfenderina* cf. *salernitana* SARTONI and CRESCENTI, 1962, Callafo well no. 1, 3830—40 feet, Kimmeridgian, equatorial section, approx. x 20.

Fig. 4 and 5: *Pfenderina* cf. *salernitana* SARTONI and CRESCENTI, 1962, Callafo well no. 1, 6200—10 feet, highest Bajocian?, equatorial sections (both photographs are of the same specimen), fig. 4 x 20, fig. 5 x 80.

Fig. 7 and 8: *Pfenderina* cf. *salernitana* SARTONI and CRESCENTI, 1962, Buri surface section, sample D-2-7, highest Bathonian, equatorial sections (both photographs are of the same specimen), fig. 7 x 20, fig. 8 x 80.

Fig. 9: *Pfenderina* cf. *salernitana* SARTONI and CRESCENTI, 1962, El Kuran well no. 1, core no. 2 (5189—5228 feet), Bathonian, oblique equatorial section, approx. x 20.

Fig. 10: *Pfenderina* cf. *salernitana* SARTONI and CRESCENTI, 1962, El Kuran well no. 1, 5310—20 feet, Bathonian, oblique equatorial section, approx. x 20.

Fig. 11 and 12: *Pfenderina* cf. *salernitana* SARTONI and CRESCENTI, 1962, Buri surface section, sample D-2-7, highest Bathonian, equatorial sections (both photographs are of the same specimen), fig. 11 x 20, fig. 12 x 80.

Fig. 13 and 14: *Pfenderina* cf. *salernitana* SARTONI and CRESCENTI, 1962, Buri surface section, fig. 13 is from sample D-2-8 and fig. 14 is from sample D-2-16, both Bathonian, mixed axial and equatorial sections homogeneously spar cemented with pellets of the same small size, approx. x 20.

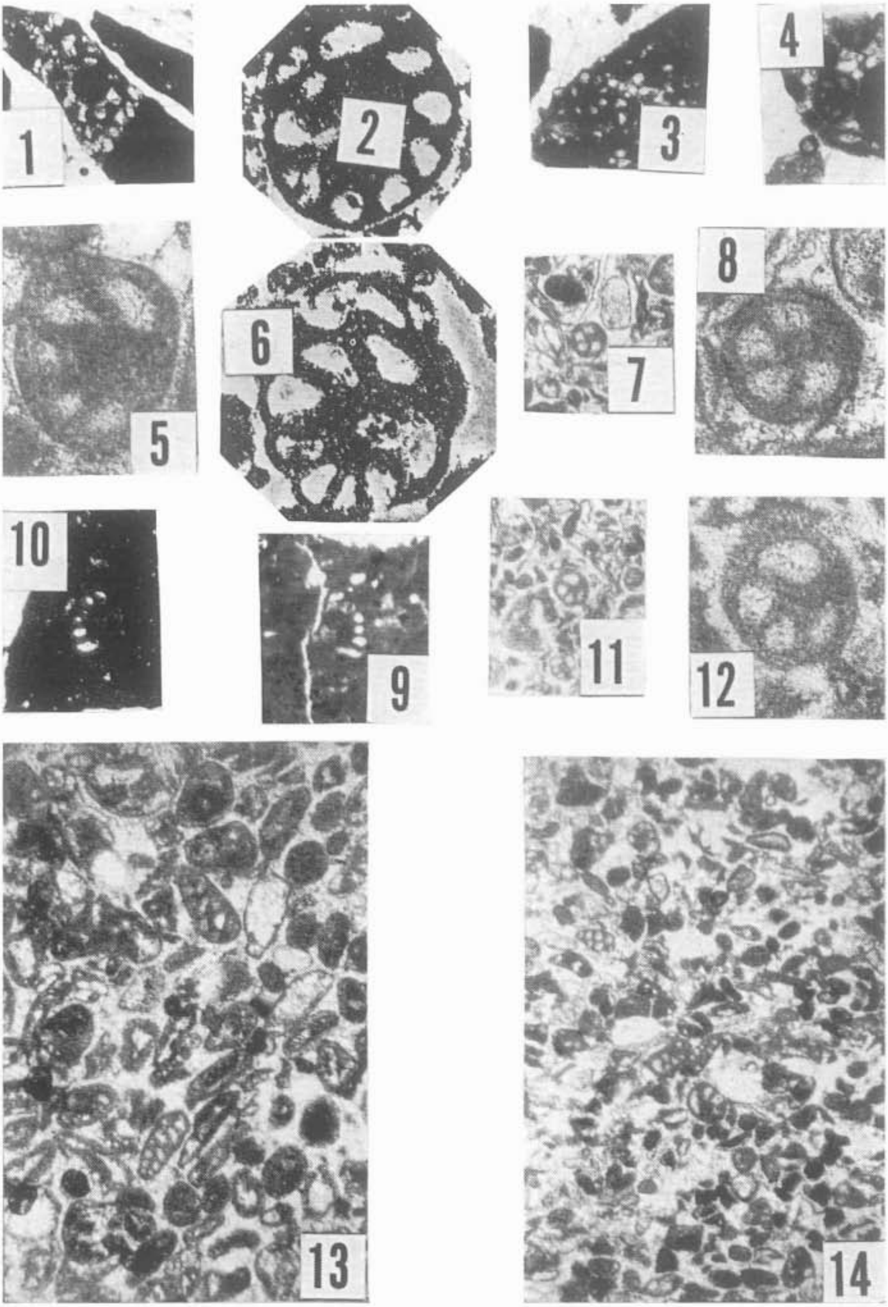


Plate 3

Plate 4

Fig. 1: *Pfenderina* cf. *salernitana* SARTONI and CRESCENTI, 1962, Buri surface section, sample D-2-8, Bathonian, mixed axial and equatorial sections homogeneously spar cemented with pellets of the same size, approx. x 20.

Fig. 2: *Pfenderina* cf. *salernitana* SARTONI and CRESCENTI, 1962, Callafo well no. 1, 5780—90 feet, Bathonian, oblique equatorial section, approx. x 80.

Fig. 3: *Pfenderina* cf. *salernitana* SARTONI and CRESCENTI, 1962, Callafo well no. 1, 3880—90 feet, Kimmeridgian, equatorial section, approx. x 20.

Fig. 4: *Pfenderina* cf. *salernitana* SARTONI and CRESCENTI, 1962, Buri surface section, sample D-2-10, Bathonian, equatorial section, approx. x 20.

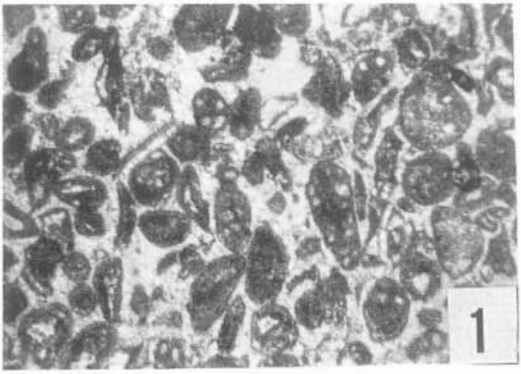
Fig. 5 and 6: *Verneuilinoides minuta* SAID and BARAKAT, 1958, Callafo well no. 1, 5370—80 feet, Callovian, cross section (both photographs are of the same species), fig. 5 x 20, fig. 6 x 80.

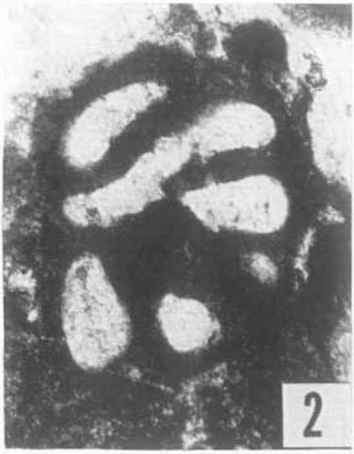
Fig. 7 and 8: *Verneuilinoides minuta* SAID and BARAKAT, 1958, Buri surface section, sample D-2-16, Bathonian, cross section (both photographs are of the same species), fig. 7 x 20, fig. 8 x 80.

Fig. 9 and 12: *Verneuilinoides minuta* SAID and BARAKAT, 1958, Buri surface section, sample D-2-16, Bathonian, cross section (both photographs are of the same species), fig. 9 x 80, fig. 12 x 20.

Fig. 10: *Nautiloculina circularis* (SAID and BARAKAT), 1959, Callafo well no. 1, 3670—80 feet Kimmeridgian, equatorial section, approx. x 80.

Fig. 11: *Verneuilinoides minuta* SAID and BARAKAT, 1958, Buri surface section, sample D-2-16, Bathonian, axial section, approx. x 80.


1


2


3


4

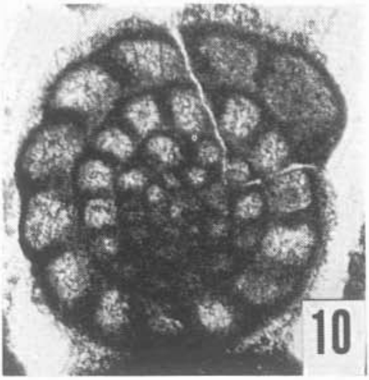

5


6


7


8


9


10


11


12

Plate 4

Zeitschrift/Journal: Mitteilungen der Abteilung Geologie Paläontologie und Bergbau am Joanneum

Jahr/Year: 1975

Band/Volume: 35

Autor(en)/Author(s): Mansour Aziz T.

Artikel/Article: Pfenderina (Foraminifera) from the Jurassic Sediments of Ethiopia. 113-131