

# 35. Supplementary Remarks on the Siluro-Devonian of Chöl-Tagh, Eastern T'ien-Shan

By

Gerhard Regnéll

## I. Introduction

While working in Central Asia as head geologist of the Sino-Swedish Expedition under the leadership of Dr. SVEN HEDIN, in the years 1927-1933, ERIK NORIN brought together important and extensive collections of rocks and fossils from different areas and geologic horizons. From 1928 to 1931 NORIN carried out geological reconnaissances in the Chinese T'ien-shan where he was able to establish the wide distribution of Lower Palaeozoic beds. These were dealt with in a magnificent memoir (NORIN 1941) which supplied a wealth of fresh information on the geology of these tracts.

The palaeontological material was placed in the hands of various students. The present writer had the good fortune to be entrusted with the elaboration of fossil faunas of the so-called Arphishmebulaq Series (NORIN 1935, p. 188; 1941, p. 52). A prominent rôle in these faunas is played by corals, which form the object of a report published by me (REGNÉLL 1941). It has been my intention to devote a second paper to the description of the rest of the fauna, but unfortunately these plans have not been carried into effect so far, for different reasons. A discussion of the Arphishmebulaq faunas from general points of view was reserved for the projected paper.

It goes without saying that the large body of literature that has appeared during the last twenty years includes many papers which have a bearing on the determination of fossils found in the Arphishmebulaq Series, and on the interpretation of their stratigraphic significance. Nor is it surprising that quite a lot of papers of this kind have been published in the USSR, which means, unfortunately, that they cannot easily be utilized by many scientists in the western world who are unable to break through the linguistic barrier set by the Russian language. I am also well aware that numerous relevant papers in Russian have undoubtedly escaped my notice. I would point out that I have definitely not aimed at even an approximately complete list of the pertinent literature, and it should be emphasized that the present note does not include a revision of the actual fossil material, which is no longer at my disposal. Rather, the purpose of the following lines is to review, in the light of subsequent

research, some opinions expressed and some results achieved in my paper of 1941. They will be presented more or less in the same order as that in which they are found in my paper.

Arpishemebulaq is situated approximately at lat.  $42^{\circ}0'N$ , long.  $88^{\circ}53'E$ . The geologic features of the area were described by NORIN (1935, pp. 188–189; 1941, pp. 52–55).

## II. Comments on the fossils

In this section, diverse taxionomic and nomenclatural questions will be discussed briefly.

1. It may be appropriate first to say some few words about the general classification of the Anthozoa as far as relevant to the matter in hand.

There is no universally accepted name for the group of corals referred to by me in 1941 as “Tetracoralla”. It is true that this term may still be met with in authoritative texts (e.g. LECOMPTE 1952, p. 419, and, moreover, frequently in other texts in French). SCHINDEWOLF (1952, p. 160) has pleaded thought-provokingly for a revival of FRECH’s “Pterocorallia”. But British, American, and Russian authors with few exceptions favour the time-honoured “Rugosa” of MILNE-EDWARDS & HAIME. This is the case also in the Treatise on Invertebrate Paleontology (HILL 1956, p. F256), which may claim in a certain degree to be normalizing for the usage.

Of major importance are the classification and contents of the Tabulata. Following certain older writers they were ranked by me (REGNÉLL 1941, p. 21) as an order of Octocorallia. This obviously was a premature step. The points in which they differ from octocorals were summarized by JONES & HILL (1940, p. 196), LECOMPTE (1952, p. 506), and HILL & STUMM (1956, p. F450). BAYER (1956, p. F181) declared that “we will probably never know if any of the older tabulates are octocorals”.

There have been many different opinions on the systematic position of the Heliolitida, as appears from a table compiled by H. FLÜGEL (1956*b*, p. 61). In several papers published after 1955 and, accordingly, not listed by FLÜGEL, the Heliolitida are not recognized as being tabulates (FLÜGEL 1956*b*, p. 63; STASIŃSKA 1958, p. 185; DUBATOLOV 1959, p. 203; and others). But it should be noted that in the Treatise on Invertebrate Paleontology the heliolitids are classified as a family of Tabulata (HILL & STUMM 1956, p. F450). I am not sure that this procedure will be accepted by subsequent specialists.

In my paper of 1941, the term “variety” has been used in a sense which is not in accord with recent practice. It should be substituted by “subspecies”.

2. The Rugosa play a subordinate part in the coral fauna of Arpishemebulaq. One species was assigned by me to *Lindströmia*, with a question-mark. It is true that this determination still seems to me to be reasonable, but it is fair to

point out that authors do not agree upon the validity of the genus. Among authors who have not expressed doubt of the status of *Lindströmia* are WEISSER-MEL (1943*a*, p. 7; 1943*b*, p. 24) and SOSHKINA (1952, p. 64). HILL (1956, p. F258) suggested that *Lindströmia* may be identical with *Stereolasma* SIMPSON. LECOMPTE (1952) did not record the genus at all. The relations of *Lindströmia* to *Syringaxon* and other corals having an axial structure more or less of the same kind were discussed by SCHOUPPÉ (1951).

Since the internal structure of *Amplexus*? sp. indet. (REGNÉLL 1941, p. 13) is not known, we are pretty much at a loss in seeking to judge of the probability of the determination. LECOMPTE (1952, p. 483) warned against homeomorphs which do occur in different lines of development of Silurian, Devonian, and Carboniferous forms. To HILL (1956, p. F264), *Amplexus* is an exclusively Carboniferous genus. Alternatively, the Arpishmebulaq species is reminiscent of *Tryplasma* (Silurian, maybe Ordovician, to Lower Devonian); the structure of the septal apparatus is decisive.

A few forms in the Central Asiatic material were identified tentatively as *Dokophyllum*? sp. indet. While recognized as an individual genus by LECOMPTE (1952, p. 467), *Dokophyllum* WEDEKIND was placed in the synonymy of *Ketophyllum* WEDEKIND by HILL (1956, p. F300).

For very good reasons HILL (1939, p. 248) introduced a new informal category called "Cystimorphs" to include "Rugose Corals in which the vertical skeletal elements are much reduced, and the corallum is constructed almost entirely of arched horizontal skeletal elements, none of which extend completely across the lumen". It was emphasized that cystimorphs may have originated repeatedly in different lineages; they are confined to the Silurian and Devonian. LECOMPTE (1952, pp. 457, 458) did not refer *Cystiphyllum* to his "Cystimorphes".

Among cystimorphs recorded in my paper of 1941, *Teratophyllum hedinii* REGNÉLL and *T.(?)* sp. indet. do not seem to require any further comment. The correct name of the family to which they belong is, however, Goniophyllidae DYBOWSKI, 1873, which has priority over Calceolidae LINDSTRÖM, 1883. The generic assignment of *Cystiphyllum cylindricum laticyste* REGNÉLL may be sound, but in view of the fairly scanty fossil material available caution bids me place the generic name within quotation marks. The same will be true of *Cystiphyllum corniculum* REGNÉLL. The relations between *Cystiphyllum*, *Diplochone*, and *Microplasma* have become clearer. It can hardly be doubted that all of them are independent genera (see, e.g. WANG 1948, p. 33), although in practice it may not always be easy to discriminate one from the other. Moreover, in contradistinction to WANG (1948), both LECOMPTE (1952, p. 461) and HILL (1956, p. F316) do not place *Diplochone* in the same family as the two other genera mentioned. HILL refers to the genus as "?*Diplochone*". As far as known, *Diplochone* is restricted to Middle Devonian beds, while *Cystiphyllum* appears as early as in the Llandovery and ranges at least to the end of the Silurian. According to HILL (1956, p. F313), *Microplasma* is Middle and Upper Silurian.

Several species have been described, however, from the Middle Devonian. It is beyond the scope of the present note to discuss whether these are genuine representatives of *Microplasma* or not.

3. Since 1941, our knowledge of the morphology and generic and specific differentiation of the Tabulata has increased greatly. It does not reduce the value of contributions by authors in many different countries if we state that the long stride forward in this field is due mainly to the intense work carried out in the USSR by B. S. SOKOLOV (1951-1955), V. N. DUBATOLOV (1959), and others. I am not aware of the existence of any investigations of Tabulata (or, for that matter, of any other fossil groups) from the same area and stratigraphic horizon as those dealt with by me in 1941. A paper by KOVALEVSKY (1956) of undoubted interest in this context has unfortunately not been available to me.

Favositids are a dominant element in the Siluro-Devonian fauna of Arpish-mebulaq. I found it necessary to erect three new subspecies ("varieties") of *Favosites gothlandicus*. One of these, *F. gothlandicus norini*, was said to hold in certain respects an intermediate position between *F. gothlandicus* and *F. goldfussi* (REGNÉLL 1941, p. 24), and it was argued that the species last mentioned are closely related, *F. gothlandicus* lying in the direct ancestry of *F. goldfussi*. The latter would fittingly be called *F. gothlandicus goldfussi*, concurring with views expressed even by NICHOLSON (1879, pp. 52, 54). Much the same way of reasoning was followed by HILL & JONES (1940, pp. 191-194) in describing a probably Lower Devonian coral fauna from New South Wales. Owing to war conditions their paper came to hand only several years later. HILL & JONES established evidence of *F. goldfussi* being "a member of the *F. gothlandicus* group which survived into the Middle Devonian with only slight modifications" but found evidence "insufficient at present to merge *F. goldfussi* in forma *forbesi* and forma *multiplora*". As pointed out by HILL & JONES, a similar attitude was taken up by LECOMPTE (1939, pp. 87-88). WEISSERMEL (1943b, p. 20), on the other hand, suggested that *F. gothlandicus* had developed into the Middle Devonian *F. basalticus* (about which see LECOMPTE 1939, p. 106), *F. gothlandicus globularis* WEISSERMEL acting as a morphologically and chronologically connecting link.

The hypothetical close relationship between *F. gothlandicus* and *F. goldfussi* is hardly tenable any longer, as demonstrated by recent authorities. Both forms were discussed thoroughly by SOKOLOV (1951, pp. 78-86; 1942b, pp. 24-27) who stated expressly that there are apprehensible morphological differences of the magnitude as to constitute clear-cut species. Subsequent authors (e.g. STASIŃSKA 1958, p. 189; DUBATOLOV 1959, p. 30) consent tacitly to that opinion. SOKOLOV (1952, p. 26) pointed, *inter alia*, to differences in the intimate wall structure. A similar observation was made by JONES (1941, p. 53).

A parallel case to that now touched upon is represented by *F. gothlandicus forbesi* vs. *F. eifelensis* NICHOLSON. Some of the authors quoted in the preceding

paragraphs have had reason to comment on this matter as well. It will not be necessary to give additional references in this context. I only wish to direct attention to the statement made by WEISSERMEL (1941, p. 180; 1943b, p. 26) that the typical *forbesi* is confined to the Silurian, while a number of "varieties" appear in the Devonian. Irrespective of whether this is true or not, I think it would be remarkable if fossil species had invariably shown the decorum to become extinct before the conclusion of each geological period, particularly so in areas where conditions of environment do not seem to have changed greatly. Long-ranging species do exist in *Favosites* as shown recently by PHILIP (1960a, p. 193) in the case of *F. squamuliferus* ETHERIDGE (Upper Silurian to Middle Devonian).

Returning to species of the *Favosites gothlandicus* group present in the Arpishmebulaq fauna, *F. gothlandicus aberrans* REGNÉLL has been recorded from beds on the Siluro-Devonian boundary (ef<sub>1-2</sub>) in the Carnic Alps in Austria (VON SCHOUPPÉ 1954a, p. 409), and from the topmost Ludlow (ef<sub>1</sub>) in the neighbourhood of Graz (VON SCHOUPPÉ 1954b, p. 3; 1954c, p. 163). VON SCHOUPPÉ (1954a, p. 411) remarked on *F. gothlandicus aberrans* that it cannot be taken for granted that we have to do with a subspecies distinct from *F. g. gothlandicus*, because it may be an ecologically conditioned adaptation of the latter. The same would apply to *F. gothlandicus spinosus* REGNÉLL. FLÜGEL (1956a, pp. 37-38) found a certain agreement between *F. gothlandicus aberrans* and *F. gothlandicus forbesi*. Further, VON SCHOUPPÉ (1954c, p. 163) suggested that *F. forbesi nitidulus* POČTA from the Lower Ludlow of the Barrandian is in part identical with *F. gothlandicus aberrans*. FLÜGEL (1956a, p. 39) recorded *F. cf. gothlandicus aberrans* from an approximately corresponding horizon in the Palaeozoic of Graz. At the other extreme, D. LE MAITRE (1952, p. 66) indicated an affinity between *F. graffi distortus* LE MAITRE from the Lower Devonian (Emsian) of Saoura (Algeria) and *F. gothlandicus aberrans*. Finally, *F. hidensis* KAMEI from the Lower Devonian of West Japan is said by HAMADA (1959b, p. 208) to be closely related to *F. gothlandicus aberrans*.

In my original description (REGNÉLL 1941, p. 26), I produced *F. bohemicus* BARRANDE for comparison with *F. gothlandicus aberrans*. According to HILL & JONES (1940, p. 192), the species mentioned should probably be referred to *F. g. gothlandicus*. On the other hand, it has been made genotype of *Squameofavosites* ČERNISHEV (see e.g. DUBATOLOV 1959, p. 48; according to this author, p. 221, *Sq. bohemicus* occurs in Ludlow beds in T'ien-shan).

A few specimens from Central Asia were assigned by me to *F. yermolaevi* B. B. ČERNISHEV (REGNÉLL 1941, p. 26), on sufficiently sound evidence, as it seems. *F. coreanicus* OZAKI which was mentioned in that connexion should probably be referred to *Parastriatopora* SOKOLOV (ČUDINOVA 1958, p. 45; yet cf. HAMADA 1960, p. 169). *F. cf. yermolaevi* was recorded by SOKOLOV (1952a, p. 56) from the Kaugatuma (K<sub>3</sub>, Middle Ludlow) of Saaremaa (Island of Oesel), Estonia.

*Favosites interstinctus* REGNÉLL is undoubtedly one of the most interesting favositids in the Arpishmebulaq fauna due to the narrow tubes intercalated between the corallites. In a transverse section these tubes appear as three-radiate, occasionally four-radiate, swellings at the junction point of corallite walls. I was inclined to agree with ČERNISHEV in interpreting these features as tubes occupied by parasites or commensalists rather than as a normal element of the coral colony (REGNÉLL 1941, p. 29). A majority of the authors who have been confronted with this phenomenon favour a similar view, which has been expounded in the first place by SOKOLOV (1948; 1955, p. 137). The anomalous structures were considered to have been brought about by action of certain worms (*Chaetosalpinx* SOKOLOV, and others). The problem has recently been scrutinized by SCHINDEWOLF (1959, p. 314 *et seq.*). In addition to references given by SCHINDEWOLF, the following ones may be cited: IVANOV & MJAGKOVA (1955, p. 37), HECKER (1957, p. 38; 1960, p. 33), STASIŃSKA (1958, p. 185 *et seq.*; cf. also Pl. 3, fig. 2 and Pl. 4, fig. 4), and DUBATOLOV (1959, p. 279).

SCHINDEWOLF (1959) pointed out, rightly, that stellate structures of the kind illustrated in *Favosites interstinctus* may not be directly comparable with circular tubes present in several species (referred to "*Parafavosites*").

In a paper, which was unknown to me in 1941, PORFIRJEV (1937, p. 33) erected the new genus *Asteriophyllum*. PORFIRJEV's description and figures (Pl. 5, fig. g; reproduced in LECOMPTE 1952, p. 511) make it evident that *Favosites interstinctus* is a good deal reminiscent of *Asteriophyllum aenigmaticum* PORFIRJEV. SOKOLOV (1955, p. 153) did not recognize *Asteriophyllum* but placed it under the synonymy of *Favosites*. PHILIP (1960a, p. 205) does not agree with SOKOLOV in making commensalists or symbionts responsible for the stellate intermural spaces. Yet he, too, thinks it best to regard *Asteriophyllum* as a synonym of *Favosites*, although for entirely different reasons (PHILIP 1960a, p. 189). It is questionable if the commensalist theory is applicable in the case of *F. interstinctus*. It is true that in a longitudinal section the stellate structures show up as spaces devoid of tabulae, but, as it seems, devoid as well of a separate wall (cf. REGNÉLL 1941, p. 28).

PHILIP (1960a, p. 203) found that *Favosites interstinctus* is close to *F. moonbiensis* ETHERIDGE, from the Middle Devonian of Eastern Australia. This species, in its turn, has been compared with *F. (Pachyfavosites) markovskiyi* SOKOLOV, from the Middle Devonian of the Urals and Central Asia (SOKOLOV 1952b, p. 47). Genotype of *Pachyfavosites* is *Calamopora polymorpha* var. *tuberosa* GOLDFUSS (SOKOLOV 1952b, p. 43), assigned to *Thamnopora* by LECOMPTE (1939, p. 104) and others.

Certain specimens in the Arpishmebulaq fauna were referred by me to *Angopora jonesi* REGNÉLL. Some authors have suggested that *Angopora* is a synonym of *Thecia*. In reality, *Angopora* is undoubtedly a valid genus characterized by distinct features of organization (cf. LAFUSTE 1958, p. 412).

A question of debate that has received much attention in the recent literature

is the proper classification of favositids with thickened walls, and, particularly, the relation between *Thamnopora* STEININGER and *Pachypora* LINDSTRÖM. For a full review of the opinions of different writers reference is made to ČUDINOVA (1958, pp. 5–20). ČUDINOVA (1958, p. 42) even places *Thamnopora* and *Pachypora* in different sub-families of Thamnoporidae, namely, in accordance with SOKOLOV, *Thamnopora* in Thamnoporinae SOKOLOV, and *Pachypora* in Striato-porinae SOKOLOV.

Two species from Arpishmebulaq were included in *Thamnopora* by me (REGNÉLL 1941, pp. 36, 40). Both were mentioned by ČUDINOVA (1958, pp. 13–14) but without any further comment. According to the original description (REGNÉLL 1941, p. 40), *T. tubifera* has moderately thick walls, a feature that makes it suggestive of thick-walled species of *Favosites*. HAMADA (1959b, p. 205) assigned *T. tubifera* to *Favosites* but admitted (p. 207) that the boundary between dendritic species of *Favosites* with a peripheral thickening of the corallite walls and *Thamnopora* is arbitrary.

*Thamnopora* is essentially post-Silurian. But at least one species, *T. khalfini* DUBATOLOV, originates from beds of Ludlow age (ČUDINOVA 1958, pp. 117, 121, 122; DUBATOLOV 1959, p. 74, 220).

*Alveolites* should not be referred to the Favositidae (cf. REGNÉLL 1941, p. 43) but, according to SOKOLOV (1955, p. 185), to the family Alveolitidae.

### III. Geologic age of the Arpishmebulaq Series

A critical examination of the coral faunas from Arpishmebulaq has demonstrated the need of certain comparatively slight nomenclatural emendations, but has left the determination of the fossils largely unaffected. In consequence, it unfortunately does not contribute any conclusive stratigraphic evidence to replace the fairly vague statement in my report of 1941.

The fauna collected at loc. 11 in the reef-limestone in the north-eastern limb of the anticline at Arpishmebulaq is comparatively less ambiguous than those of the south-western limb. A Lower Devonian flavour of the fauna at loc. 11 results from the presence of representatives of *Thamnopora* and thick-walled *Favosites*. No species but *Favosites gothlandicus aberrans* has subsequently been recorded, errors in determination excepted, from outside Central Asia, namely from Austria where the species mentioned would range from Lower Ludlovian beds into the Devonian.

While corals predominate at loc. 11, a more varied fauna is present in the grey limestone at loc. 16 that forms the lowest fossiliferous division of the south-western limb of the anticline. This fauna has not yet been described, but it is known to include, *inter alia*, *Encrinurus* sp. and *Dicaelosia* “(*Bilobites*)” sp. (REGNÉLL 1941, p. 55).

According to general opinion, trilobites of the family Encrinuridae do not appear in post-Silurian deposits (e.g. Treatise on Invertebrate Paleontology.

Pt. O. 1959, p. O 446). On discussing the occurrence of *Encrinurus* in a supposedly Lower Devonian fauna from the Oberharz, VON GAERTNER & SOLLE (1959, p. 556) searched the literature but found no definite record of Encrinuridae from post-Upper Ludlovian beds. But they thought it quite possible that *Encrinurus* would have seen the dawn of Devonian times in areas with marine conditions persisting into the Devonian. As a matter of fact, *Encrinurus* has been recorded even from the Middle Devonian, namely the Kennett formation in California. However, as noted by COOPER *et al.* (1942, p. 1769), there is no unequivocal evidence of the age of the formation, and in the correlation chart accompanying the paper mentioned it is indicated that the Kennett formation may be Silurian in part. Additional comments on the occurrence of *Encrinurus* near to the Siluro-Devonian boundary have recently been made by HAMADA (1959*a*, p. 78, table 1, showing the stratigraphic range of Encrinuridae in China; 1959*b*, p. 205: in Asia encrinurids are not known from Devonian deposits), and PHILIP (1960*b*, p. 154: Upper Silurian *Encrinurus* from Tasmania; cf. GILL 1958, p. 105).

*Dicaelosia* has long been known to appear both in Silurian and Lower Devonian beds. TALENT (1956, p. 76) quoted *D. dimera* (BARRANDE) as occurring in the Middle Devonian of Bohemia, but the horizon given (g<sub>1</sub>, Braník Limestone) is in reality Lower Devonian (CHLUPÁČ 1960, p. 75, table; about *D. dimera*, see also HAVLÍČEK 1956, pp. 542–543, 623). The North American *D. varica* (CONRAD) comes from the Helderbergian and equivalent beds (see, e.g., AMSDEN, 1958, pp. 51–54). *D. biloba* (LINNÉ) which is generally considered to be Silurian of age, has been met with in Lower Devonian strata as well in the USSR and Central Asia (CHODALEWITSCH 1960, pp. 232, 233; MARKOWSKIJ 1960, p. 375; RSHONSNIZKAJA 1960, p. 123). In the north-eastern Balkhash area KAPLUN (1956) drew the Siluro-Devonian boundary above limestones bearing *D. cf. biloba* and other fossils.

NORIN's loc. 19 near the top of the south-western limb of the Arpishmebulaq anticlinal has yielded a few forms which were thought to be Silurian (REGNÉLL 1941, p. 54). To-day they seem to be less convincing in this respect. The generic assignment of *Cystiphyllum cylindricum laticyste* may be open to some doubt. *Plasmopora* is not confined to the Silurian but is found even in the Middle Devonian (HILL & STUMM 1956, p. F 460). Only *Angopora* has not so far been encountered from the Devonian.

To sum up, the Silurian stamp of part of the Arpishmebulaq fauna is less conspicuous than it appeared twenty years ago. It is a delicate task to judge whether the Silurian touch is so weak as to leave the entire formation in the Lower Devonian, as preferred by NORIN (1941, p. 165). A remarkable fact—observed also by ČECHOVIČ (1955, p. 557) on discussing the Upper Ludlow of Central Asia—is the total absence of Halysitidae which, although not lacking in the Lower Devonian, are frequently characteristic components of Silurian coral assemblages (cf. WEISSERMEL 1939, p. 98; HAMADA 1960, p. 175). On the



other hand, *Pleurodictyum* is an equally characteristic cosmopolitan member of Lower Devonian faunas. Yet its absence in the Arpishmebulaq Series may be conditioned by environmental factors (cf. HILL 1957, p. 43) and not necessarily by the time-factor.

The inconsiderable fragment of an acanthaspid found in a relatively low horizon of the series of strata (REGNÉLL 1941, p. 55) renders little help. It was thought to indicate a Lower Devonian age, but subsequently arthrodiroids have been stated to occur even in the Upper Ludlow (GROSS 1958). Moreover, STENSIÖ (1944, p. 2) referred to the Chöl-Tagh specimen as originating from Uppermost Silurian.

ČECHOVIČ (1955) and KOVALEVSKY (1956) have given particular attention to the stratigraphic significance of tabulates and heliolitids in the Silurian of Central Asia. The latter paper was not available to me, but a list of Ludlovian species recorded by KOVALEVSKY may be found in a paper by KRASILOVA (1959, p. 1081) which, moreover, will be of great interest in connexion with working up the pelecypods of the Arpishmebulaq fauna. ČECHOVIČ's investigations relate to the western ranges of T'ien-shan. He recognized four stratigraphically defined coral complexes. Those numbered 3 (Isfara beds) and 4 (*Plectatrypa marginalis* beds) belong to the Upper Ludlow. Division 3 includes many heliolitids and favositids. A comparison with the Arpishmebulaq fauna is rendered difficult, because many species of favositids recorded by ČECHOVIČ (1955, p. 557) are given as manuscript names. The coral fauna in the Marginalis beds is said to be impoverished and fairly monotonous, the tabulates being represented by *Favosites* and a species or two of *Alveolites*. In this case also a couple of names applied to *Favosites* are *nomina nuda*. I am unable to make any detailed comparison with the more or less equivalent faunas in eastern T'ien-shan.

The stratigraphic significance of Devonian (and Upper Silurian) Rugosa has recently been discussed by SPASSKIJ (1960). Since rugose corals in the Arpishmebulaq fauna are few and not well enough known, it can only be stated that they have a general resemblance both to the uppermost Silurian and the lowermost Devonian rugose coral assemblages (SPASSKIJ, 1960, p. 459). Reference should also be made to two important articles by HILL (1957, 1959?).

Opinions of the age of the Arpishmebulaq fauna expressed by different authors are largely univocal. My determination of the fauna as Siluro-Devonian has been generally accepted (WEISSERMEL 1943*b*, p. 13; VON SCHOUPPÉ 1954*a*, p. 436: a genuine mixed fauna; HILL 1957, p. 45: "... possibly in part uppermost Silurian, but is mainly Lower Devonian; it consists almost entirely of Silurian relict genera"; HILL (1959?), p. 159; GILL 1958, p. 109; PHILIP 1960*a*, p. 189).

It is now an established fact, that faunas on the boundary between the Silurian and the Devonian are a mixture of "Silurian species" and "Devonian species" in areas in which marine conditions were prevailing (see, e.g. CHODALEWITSCH 1960, p. 233). This is very true indeed where corals are concerned.

WEISSERMEL (1943*b*, p. 30) even remarked that the boundary, if based on corals, would have to be drawn at a level above that recognized now. HILL (1957, p. 42) pointed out that "characteristically Devonian assemblages of coral genera did not begin to replace the Silurian assemblages until Coblenzian and Emsian times".

It seems to me, therefore, that, for the present, it would be hazardous to assign the beds of the south-west limb of the anticlinal at Arpishmebulaq definitely to the Silurian or definitely to the Devonian. It may be wisest to keep referring to them as "Siluro-Devonian", while there will be sufficient evidence for assigning the beds of the north-east limb to the Lower Devonian.

#### IV. Biogeographic relations of the Arpishmebulaq fauna

It would carry us too far in this connexion to try to reconstruct the geographic situation in Central Asia at the end of the Silurian and the beginning of the Devonian period. Therefore, the subject will be commented upon very briefly.

ERIK NORIN (1941, pp. 159 *et seq.*) gave a masterly summary of the geologic history of T'ien-shan. By recent investigations in areas farther west much fresh information has become available which contributes to our knowledge of the distribution of different types of facies and the extension of the mid-Palaeozoic T'ien-shan geosyncline toward the Urals (Turkestan, Nuratau: ČECHOVIČ 1956; Dzhungarskiy Ala-tau: YUDICHEV 1936; the Balkhash area: KAPLUN 1956; KAPLUN & RUKAVISHNIKOVA 1958; KELLER *et al.* 1958; KRASILOVA 1959; Kazakhstan: KOMAR 1957; SENKEVITCH 1957; BUBLITSCHENKO 1960; see also VON BUBNOFF (1952).

Special papers on Upper Silurian–Lower Devonian stratigraphy and palaeogeography which have bearing on Central Asia have been published recently by NALIVKIN (1960), NIKIFOROVA & OBUT (1960*a*, 1960*b*), and RSHONSNIZKAJA (1960).

All data taken together give us the picture of a sea-way that in Siluro-Devonian times connected the Ural geosyncline with the Central Asiatic geosynclinal area. Very likely, it stretched across south-east Asia to Australia, permitting migration and interchange of faunal elements (SUN 1948; HILL 1957, 1959?; GILL 1958; HAMADA 1959*a*, 1959*b*, 1960).

#### References

- AMSDEN, TH. W., 1958: Haragan articulate brachiopods. *Oklahoma Geol. Surv. Bull.* 78, pp. 9–144, Pls. 1–14. Norman, Okla.  
 BAYER, F. M., 1956: Octocorallia. *Treatise on Invertebrate Paleontology* (Ed. R. C. MOORE), Pt. F, pp. F166–F231. Kansas (Geol. Soc. Amer., New York).  
 BUBLITSCHENKO, N. L., 1960: Terrigene Fazies des Devons in Kazachstan. *Prager Arbeitstagung über die Stratigraphie des Silurs und des Devons (1958)*. Ústř. Úst. Geol. Praha (Ed. J. SVOBODA), pp. 425–436. 1 tab. Praha.

- BUBNOFF, S. VON, 1952: Neue geologische Forschungen im Ural in ihrer grundsätzlichen Bedeutung. *Abh. Deutsch. Akad. Wiss. Berlin. Kl. f. Math. u. Allg. Naturw.*, Jg. 1951: 3. 18 pp. Berlin.
- ČECHOVIČ, V. D., 1955: K voprosu o stratigrafičeskom značenii silurijskich tabul'at i heliolitid srednej Asii [On the stratigraphic significance of Silurian Tabulata and Heliolitida in Central Asia]. *Doklady Akad. Nauk SSSR*, 100, pp. 555-558. Moskva. [In Russian.]
- 1956: O facial'noj zonal'nosti i tipach razrezov silura Turkestan-Nuratinskogo gor'noj systemy (T'jan-šan) [On facies zones and types of sections in the Silurian of the mountains of Turkestan and Nuratau (T'ien-shan).] *Ibid.*, 107, pp. 306-308. Moskva. [In Russian.]
- CHLUPÁČ, I., 1960: Die Grenzsichten Silur/Devon im Barrandium. *Prager Arbeitstagung über die Stratigraphie des Silurs und des Devons (1958)*. Ústř. Úst. Geol. Praha (Ed. J. SVOBODA), pp. 75-96. Praha.
- CHODALEWITSCH, A. N., 1960: Grundsätze der biostratigraphischen Gliederung der unterdevonischen und mitteldevonischen Sedimente des Osthangs des Urals nach der Brachiopodenfauna. *Ibid.*, pp. 231-243.
- COOPER, G. A. (Chairman) *et al.*, 1942: Correlation of the Devonian sedimentary formation of North America. *Bull. Geol. Soc. Amer.* 53, pp. 1729-1794. 1 Pl., 1 Fig. Baltimore.
- ČUDINOVA, I. I., 1958: Devonskie Tamnoporidi južnoj Sibiri [Devonian Thamnoporidae from South Siberia]. *Trud. Paleontol. Inst. Akad. Nauk SSSR* 73. 146 pp., 34 pls. Moskva. [In Russian.]
- DUBATOLOV, V. N., 1959: Tabulati, Heliolitidi i Chaetetidi silura i devona Kuzneckogo Bassejna [Tabulata, Heliolitida, and Chaetetida of the Silurian and Devonian of the Kuznets Basin]. *Trudy VNIGRI*, Vyp. 139. 472 pp., 88 pls. Leningrad. [In Russian.]
- FLÜGEL, H., 1956a: Neue Korallenfaunen aus dem Unterludlow von Graz. *Mitt. Naturw. Ver. f. Steiermark* 86, pp. 32-57. Pls. 3-4. Graz.
- 1956b: Revision der ostalpinen Heliolitina. *Mitt. Mus. Bergbau Geol. Techn. am Landesmus. "Joanneum", Graz*. Mitteilungsh. 17, pp. 55-102. Pls. 1-4.
- GAERTNER, H. R. VON and SOLLE, G., 1959: Über das wahrscheinlich devonische Alter der Graptolithen-Brachiopoden-Fauna des Heibeck-Tales bei Bad Lauterberg (Südharz). *Geol. Jb.* 76, pp. 553-560. Hannover.
- GILL, E. D., 1958: Australian Lower Devonian palaeobiology in relation to the concept of continental drift. *Continental Drift, a symposium*, pp. 103-122. Hobart (Geology Department, Univ. of Tasmania). (Reprinted July 1959.)
- GROSS, W., 1958: Über die älteste Arthrodiren-Gattung. *Notizbl. Hess. L.-Amt Bodenforsch.* 86, pp. 7-30. Pls. 1-3. Wiesbaden.
- HAMADA, T., 1959a: Gotlandian shelly fauna from southwest Japan (I). *Coronocephalus kobayashii*, a new species from the Kuraoka District, Kyushu. *Jap. J. Geol. Geogr.* 30, pp. 71-88. Pl. 6. Tokyo.
- 1959b: On the taxonomic position of *Favosites hidensis* and its Devonian age. *Ibid.*, pp. 201-213. Pl. 16.
- 1960: The Middle Palaeozoic formations in China and Korea. — *Ibid.*, 31, pp. 165-183, 219-239.
- HAVLÍČEK, V., 1956: The brachiopods of the Braník and Hlubočepy limestones in the immediate vicinity of Prague. *Sborník Ústř. Úst. Geol.* 22 (1955). *Odd. Paleontol.*, pp. 535-665 [also sep. pagination, 1-131]. Pls. 1-12. Praha. [In Czech with Russian summary at pp. 634-650, and English summary at pp. 651-665.]
- HECKER, R. F., 1957: Vvedenie v paleoekologiju [An introduction to palaeoecology]. 126 pp. 20 pls. Moskva. [In Russian; French edition: Bases de la Paléoécologie (transl. by R. ROGER), *Ann. Serv. d'Inform. Géol.* 44, Paris 1960.]

- HILL, DOROTHY, 1939: The Devonian rugose corals of Lilydale and Loyola, Victoria. *Proc. R. Soc. Victoria*. 51 (N.S.), Pt II, pp. 219–256. Pls. 13–16. Also *Univ. Queensl. Papers Dept. Geol.* 1: 12. Brisbane.
- 1956: Rugosa. *Treatise on Invertebrate Paleontology* (Ed. R. C. MOORE), Pt. F, pp. F233–F324. Kansas (Geol. Soc. Amer., New York).
- 1957: The sequence and distribution of Upper Palaeozoic coral faunas. *Austral. J. Sci.* 19, pp. 42–61. Sydney. Also *Univ. Queensl. Dept. Geol.*, N.S. 60.
- 1959(?): Distribution and sequence of Silurian coral faunas. *J. Proc. Roy. Soc. New South Wales* 92, pp. 151–173. Sydney. Also *Univ. Queensl. Dept. Geol.*, N.S. 70.
- HILL, DOROTHY and JONES, O. A., 1940: The corals of the Garra Beds, Molong District, New South Wales. *J. Proc. Roy. Soc. New South Wales* 74, pp. 175–208. Pls. 2–8. Sydney. Also *Univ. Queensl. Papers Dept. Geol.* 2: 3.
- HILL, DOROTHY and STUMM, E. C., 1956: Tabulata. *Treatise on Invertebrate Paleontology* (Ed. R. C. MOORE), Pt. F, pp. F444–F477. Kansas (Geol. Soc. Amer., New York).
- IVANOV, A. N. and MJAGKOVA, E. J., 1955: Fauna ordovika zapadnogo sklona srednego Urala [Ordovician fauna of the western slope of the Middle Urals]. *Akad. Nauk SSSR, Uralskij Filial, Trudy Gorno-Geol. Inst.* 23, pp. 9–75. Pls. 1–26. Moskva.
- JONES, O. A., 1941: The Devonian Tabulata of Douglas and Drummond Creeks, Clermont, Queensland. *Proc. Roy. Soc. Queensl.* 53, pp. 41–60. Pls. 1–3. Also *Univ. Queensl. Dept. Geol.*, N.S. 3. Brisbane.
- JONES, O. A. and HILL, DOROTHY, 1940: The Heliolitidae of Australia, with a discussion of the morphology and systematic position of the family. *Ibid.* Also *Univ. Queensl. Papers Dept. Geol.* 1: 14.
- KAPLUN, L. J., 1956: [Devon im nordöstlichen Balchasch-Land.] *Sovietskaja Geol.* 52, pp. 60–67. Moskva & Leningrad. [In Russian; not seen; abstract in *Zbl. Geol. Paläont.* 1960, II: 595.]
- KAPLUN, L. J. and RUKAVISHNIKOVA, T. B., 1958: [Silurian and Devonian boundary in the north-eastern Balkhash area.] *Izv. Akad. Nauk SSSR Ser. Geol.* 1958, 11, pp. 59–70. Moskva. [In Russian; not seen.]
- KELLER, B. M., KRYLOV, J. N. and NEGREJ, E. V., 1958: [The Palaeozoic in the western Balkhash area in the region of Mynaral.] *Ibid.* 1958: 10, pp. 56–71. Moskva. [In Russian; not seen.]
- KOMAR, V. A., 1957: [Devonian stratigraphy of the Rudnyy Altai.] — *Trudy Vsesojuzn. Aerogeol. Tresta.* 3, pp. 15–45. [In Russian; not seen; abstr. in *Zbl. Geol. u. Paläontol.* 1959, II: 783.]
- KOVALEVSKY, O. P., 1956: Silurijskie tabulati i heliolitidy Centralnogo Kazakstana i ich stratigrafičeskoe značenie [Silurian Tabulata and Heliolitida from Central Kazakhstan and their stratigraphic significance.] (Avtoref. dissertacii.) [Cited in KRASILOVA, 1959; not seen.]
- KRASILOVA, I. N., 1959: Stratigrafija i pelecipodi verhnego silura i nižnego devona severo-vostočnogo Pribalchašč'a [Stratigraphy and Lamellibranchs of the Upper Silurian and Lower Devonian in the north-eastern part of the Balkhash area]. *Doklady Akad. Nauk SSSR.* 127, pp. 1081–1084. Moskva. [In Russian, English translation in *Doklady Acad. Sci. USSR. Earth Sci. Sect.* 127: 1–6, pp. 741–744. 1960. Publ. by the Amer. Geol. Inst., Washington.]
- LAFUSTE, J. G., 1958: Note on the structure and microstructure of *Thecia swinderniana* (Goldf.). *Geol. Mag.* 95, pp. 409–414. Pl. 10. London.
- LECOMPTE, M., 1939: Les Tabulés du Dévonien moyen et supérieur du bord Sud du Bassin de Dinant. *Mém. Mus. Roy. Hist. Nat. Belg.* 90, pp. 1–229. Pls. 1–23. Bruxelles.
- 1952: Madréporaires paléozoïques. *Traité de Paléontologie* (Ed. J. PIVETEAU), 1, pp. 419–538. Paris (Masson et C<sup>ie</sup>).

- LE MAITRE, DOROTHÉE, 1952: La faune du Dévonien inférieur et moyen de la Saoura et des abords de l'Erg el Djemel (Sud-Oranais). *Mat. Carte Géol. Algérie*, 1<sup>re</sup> Sér., Paléontologie, 12, pp. 1-171. Pls. 1-22. Lille.
- MARKOWSKIJ, B. P., 1960: Stratigraphie der devonischen Sedimente des europäischen Teiles der UdSSR. *Prager Arbeitstagung über die Stratigraphie des Silurs und des Devons (1958)*. *Ústř. Úst. Geol. Praha* (Ed. J. SVOBODA), pp. 375-392. 1 tab. Praha.
- NALIVKIN, D. W., 1960: Verschiedene Arten der Silur/Devon-Grenze im westlichen Teil der UdSSR. *Ibid.*, pp. 47-55.
- NICHOLSON, H. A., 1879: *On the structure and affinities of the "Tabulate Corals" of the Palaeozoic period*. Edinburgh & London (W. Blackwood & Sons). xii + 342 pp. 15 pls.
- NIKIFOROVA, OLGA I. and OBUT, A. M., 1960a: Parallelisierung des Silurs im europäischen Teil der UdSSR und in Mitteleuropa. *Prager Arbeitstagung über die Stratigraphie des Silurs und des Devons (1958)*. *Ústř. Úst. Geol. Praha* (Ed. J. SVOBODA), pp. 277-287. 1 tab. Praha.
- 1960b: Stratigraphy and paleogeography of the Silurian deposits in the USSR. *International Geol. Congr. XXI Sess. Rep. of Soviet Geologists*. Problem 7: Ordovician and Silurian stratigraphy and correlations (ed. Acad. Sci. USSR, Nat. Comm. Geol. USSR.). Pp. 22-32. Leningrad. [In Russian with English summary at pp. 28-32.]
- NORIN, E., 1935: A tentative correlation of the Palaeozoic sedimentary formations of the Eastern Tien-shan, Chinese Turkistan. *Geogr. Annaler. Spec. Vol. Dedicated to SVEN HEDIN*, pp. 185-196. Pls. 1-3.
- 1941: Geologic reconnaissances in the Chinese T'ien-shan. *Rep. Sci. Exp. N.W. Prov. China Sven Hedin. The Sino-Swed. Exp. III. Geology*: 6. xii + 229 pp. 23 pls. + pls. A-D. Stockholm.
- PHILIP, G. M., 1960a: The Middle Palaeozoic squamulate Favositids of Victoria. *Palaeontology* 3, pp. 186-207. Pls. 30-34. London.
- 1960b: Victorian Siluro-Devonian faunas and correlations. *Intern. Geol. Congr. Rep. 21st Sess. Norden 1960* 7, pp. 143-157. Copenhagen.
- PORFIRJEV, V. B., 1937: O nekotorych korallach iz gruppi Tabulata vostochnogo sklona Urala [On some corals of the group Tabulata from the eastern slope of the Urals.] *Mater. CNIGRI [Central Geol. Prosp. Inst.] Paleontol. Stratigr.* 1937: 3, pp. 22-34. Pls. 1-5. Leningrad & Moskva. [In Russian with English summary at p. 31.]
- REGNÉLL, G., 1941: On the Siluro-Devonian fauna of Chöl-tagh, Eastern T'ien-shan. I: Anthozoa. *Rep. Sci. Exp. N.W. Prov. China Sven Hedin. The Sino-Swed. Exp. V. Invertebrate Palaeontol.* 3. 64 pp. 12 pls. Stockholm. (Also in *Palaeontol. Sinica*, Nanking.)
- RSHONSNIZKAJA, MARIJA A., 1960: Die Korrelation der karbonatischen Sedimente des Unter- und Mitteldevons in der Sowjetunion und in Westeuropa. *Prager Arbeitstagung über die Stratigraphie des Silurs und des Devons (1958)*. *Ústř. Úst. Geol. Praha* (Ed. J. SVOBODA), pp. 123-138. Praha.
- SCHINDEWOLF, O. H., 1952: Korallen aus dem Oberkarbon (Namur) des oberschlesischen Steinkohlen-Beckens. *Akad. Wiss. Lit. Mainz. Abh. Math.-Naturw. Kl.*, Jg. 1952: 4, pp. 143-227. Pls. 1-2. Wiesbaden.
- 1959: Würmer und Korallen als Synöken. Zur Kenntnis der Systeme *Aspidosiphon/Heteropsammia* und *Hicetes/Pleurodictyum*. *Ibid.*, Jahrg. 1958: 6, pp. 259-327. 14 pls.
- SCHOUPPÉ, A. VON, 1951: Beitrag zur Kenntnis des Baues und der Untergliederung des Rugosen-Genus *Syringaxon* Lindström. *Sitzungsber. Österr. Akad. Wiss. Math.-naturw. Kl., Abt. I*, 160, pp. 207-216.

- 1954a: Korallen und Stromatoporen aus dem ef der Karnischen Alpen. *Neues Jb. Geol. u. Paläontol. Abh.* 99, pp. 379–450. Pls. 25–27. Stuttgart.
- 1954b: Revision der Tabulaten aus dem Palaeozoikum von Graz. Die Favositiden. *Mitt. Mus. Bergbau Geol. Techn. Landesmus. "Joanneum", Graz* 1954: 12. 40 pp. 2 pls. Graz.
- 1954c: Die Korallenfauna aus dem ef des Paläozoikums von Graz. *Mitt. Naturw. Ver. f. Steiermark.* 84, pp. 159–171. Pl. 2. Graz.
- SENKEVITCH, M. A., 1957: [Devonian flora in Central Kazakhstan.] *Izv. Akad. Nauk SSSR. Ser. Geol.* 1957: 3, pp. 3–18. Moskva. [In Russian; not seen; abstr. in *Zbl. Geol. u. Paläont.* 1959, II: 782.]
- SOKOLOV, B. S., 1948: Kommensalizm u favositid [Commensalism in favositids.] *Ibid.*, *Ser. Biol.* 1948: 1, pp. 101–110. Moskva. [In Russian; not seen.]
- 1951–1955. Tabulati paleozoja evropejskoj časti SSSR. [Palaeozoic Tabulata of the European part of USSR.] *Trud. Vses. Neft. Nauch.-Issled. Geol.-Raz. Inst. (VNIGRI) N.S. Leningrad & Moskva.* [In Russian.]
  - II. Silur Pribaltiki (Favositidi Llandoverskogo jarusa) [Silurian of the Baltic (Favositids of the Llandovery beds)]. *Ibid.*, 52. 1951. 200 pp. 37 pls. [SOKOLOV 1951.]
  - III. Silur Pribaltiki (Favositidi Venlokskogo i Ludlovskogo jarusov) [Silurian of the Baltic (Favositids of the Wenlockian and Ludlovian beds)]. *Ibid.*, 58. 1952. 132 pp. 22 pls. [SOKOLOV 1952a.]
  - IV. Devon Russkoj platformi i zapadnogo Urala [Devonian of the Russian Platform and the Western Urals.] *Ibid.*, 62. 1952. 291 pp. 40 pls. [SOKOLOV 1952b.]
- Vvedenie v obščievoprosi sistematiki i istorii rasvitija tabulat [General introduction to the problem of the taxonomy and evolution of Tabulata.] *Ibid.*, 85. 1955. 528 pp. 90 pls. [SOKOLOV 1955.]
- SOSHKINA, E. D., 1952: Opredelitel devonskich četirechlučevich korallov sostavljen po materialam iz devona Urala, Timana, Armenii i centralnogo devonskogo polja Russkoj platformi [Determination of Devonian tetracorals based on material from the Devonian of the Urals, Timan, Armenia, and the central Devonian area of the Russian Platform]. *Trud. Paleontol. Inst. Akad. Nauk SSSR.* 39. 128 pp. 49 pls. Moskva. [In Russian.]
- SPASSKIJ, N. J., 1960: Stratigraphische Bedeutung der devonischen Tetrakorallen. *Prager Arbeitstagung über die Stratigraphie des Silurs und des Devons (1958). Ústř. Úst. Geol. Praha* (Ed. J. SVOBODA), pp. 455–467. Praha.
- STASIŃSKA, ANNA, 1958: Tabulata, Heliolitida et Chaetetida du Dévonien Moyen des Monts de Sainte-Croix. *Acta Palaeontol. Pol.* 3, pp. 161–240. Pls. 1–39. Warszawa.
- STENSIÖ, E., 1944: Contributions to the knowledge of the vertebrate fauna of the Silurian and Devonian of western Podolia. II. *K. Sv. Vet.-Akad., Arkiv f. Zool.* 35A: 9, pp. 1–83. Pls. 1–14. Stockholm.
- SUN, Y. C., 1948: Problems of the Palaeozoic stratigraphy of Yunnan. *The Nat. Peking Univ., Fiftieth Anniv. Papers Geol. Ser.*, pp. 1–26. 1 tab. Peking.
- TALENT, J. A., 1956: Siluro-Devonian brachiopods from Marble Creek, Thomson River, Victoria. *Proc. Roy. Soc. Victoria* 68, pp. 73–84. Pls. 8–10. Melbourne.
- WANG, H. C., 1948: The Middle Devonian rugose corals of Eastern Yunnan. *Contrib. Geol. Inst. Nat. Univ. Peking* 33, pp. 1–45. Pls. 1–5. Peiping.
- WEISSERMEL, W., 1939: Obersilurische und devonische Korallen, Stromatoporidae und Trepostome von der Prinzeninsel Antirovitha und aus Bithynien. *Abh. Preuss. Geol. Landesanst.*, N.F. 190, pp. 3–131. Pls. 1–15. Berlin.
- 1941: Favositen aus schiefbrigem Mittel- und Unter-Devon im Rheinischen Schiefergebirge. *Senckenbergiana* 23, pp. 177–182. Frankfurt a. M.

- 
- 1943a: Korallen aus meist kalkigem Oberdevon Ost-Thüringens. *Z. Deutsch. Geol. Ges.* 95, pp. 1-12. Pl. 1. Berlin.
- 1943b: Korallen von der Silur-Devon-Grenze aus West- und Mitteldeutschland. *Ibid.*, pp. 13-32. Pls. 2-3. Berlin.
- YUDICHEV, M. M., 1936: [Stratigraphy and tectonics of the pre-Palaeozoic formations of the northern and western slope of the Dzhungarskiy Ala-tau.] *Problems of Soviet Geology* 6: 11, pp. 938-951. Moskva. [In Russian.]