Annales de la Société géologique de Belgique, T. 116 (fascicule 2), 1993, pp. 265-273 Octobre 1994

AMMONOID BIOSTRATIGRAPHY FOR THE PROPOSED MID-CARBONIFEROUS BOUNDARY STRATOTYPE, AKSU RIVER, SOUTH TIEN-SHAN, CENTRAL ASIA[1]

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(2 figures and 1 plate)

ABSTRACT. The studies of ammonoid succession in the Aksu section, proposed as a stratotype for the Mid-Carboniferous boundary, document the co-occurrence of *Isohomoceras* aff. *subglobosum* and *Proshumardites delepinei* in association with *Eumorphoceras* in the layer 2.3m above the bed bearing *Proshumardites delepinei* in association with *Zephyroceras* and 1.9m above the bed yielding *Proshumardites delepinei* alone. The latter interval is interpreted as spanning the boundary between the *Eumorphoceras* and *Homoceras* ammonoid zones. The important ammonoid index genus *Isohomoceras,* by which the boundary between *Eumorphoceras* and *Homoceras* Zones is recognized, precedes the conodont *Declingnathodus noduliferus* that marks the Mid-Carboniferous boundary. Two successive subzones defined by the range of *Isohomoceras subglobosum* and *Isohomoceras ventrosum* are established in the Aksu section.

KEY-WORDS: Ammonoids, Mid-Carboniferous boundary, biostratigraphy, Aksu section, stratotype.

RESUME. Biostratigraphie des Ammonoïdes dans la coupe proposée comme stratotype mi-Carbonifère de la rivière Aksu, sud Tien Shan, Asie centrale. Les études de successions d'ammonïdés dans la coupe d'Aksu, proposée comme un stratotype de la limite mi-Carbonifère, démontrent l'existence simultanée de *Isohomoceras* aff. *subglobosum* et de *Proshumardites delepinei* en association avec *Eumorphoceras* dans la couche située 2,3m au-dessus du banc portant *Proshumardites delepinei* en association avec *Zephyroceras* et 1,9m au-dessus du banc contenant *Proshumardites delepinei* seul. Ce dernier interval est interprété comme chevauchant la limite entre les Zones d'ammonoïdés *Isohomoceras* et *Homoceras.* L'important genre index d'ammonoïdés *Isohomoceras,* grâce auquel la limite entre les Zones *Eumorphoceras* et *Homoceras* est reconnue, précède le conodonte *Declingnathodus noduliferus* qui marque la limite mi-Carbonifère. Deux sous-zones successives, définies par l'extension de *Isohomoceras subglobosum* et *Isohomoceras ventrosum* sont établies dans la coupe d'Aksu.

MOTS-CLES: Ammonoïdés, limite mi-Carbonifère, biostratigraphie, coupe d'Aksu, stratotype.

1. INTRODUCTION

The Mid-Carboniferous Boundary has been studied extensively for many years. It is recognised by the appearance of the conodont *Declinognathodus noduliferus* and closely coincides with one of the most significant changes in Carboniferous ammonoid evolution. This change is marked by the boundary between the *Fayettevillea-Delepinoceras* and *Homoceras-Hudsonoceras* genus zones (Bogoslovskaya, 1982; Manger & Saunders, 1982; Saunders & Ramsbottom, 1982).

The search for a Mid-Carboniferous Boundary Stratotype has been the focus for international study since 1983, with the first proposal being that of Ar-

1. *Manuscript received and accepted May 1994.*
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row Canyon, Nevada, USA (Lane *et al.*, 1985). Subsequently other sections were proposed, e.g., from Britain (Riley *et al.*, 1987), China (Li Xing xue *et al.*, 1987), the Donets Basin, Russia (Skipp *et al.*, 1989), and most recently Uzbekistan (Nigmadganov & Nemirovskaya, 1992). Of these proposals, the Subcommission on Carboniferous Stratigraphy (SCCS) has recently decided that only three should remain as candidates. These are: Aksu, Uzbekistan (Nigmadganov & Nemirovskaya, 1993); Arrow Canyon, Nevada, USA (Lane *et al.*, 1985) and Stonehead Beck, Great Britain (Riley *et al.*, 1987), one of which will be chosen as the global stratotype. The present paper adds knowledge to the ammonoid stratigraphy from the Aksu candidate section, Aksu River, South Tien-Shan, Uzbekistan, described previously in Nikolayeva & Nigmadganov (1992) and Nigmadganov & Nemirovskaya (1992). Ammonoids are abundant and numerous conodonts have been obtained from over twenty horizons, permitting a precise ammonoid and conodont zonation across the Mid-Carboniferous Boundary. The detailed ammonoid taxonomy is still in press (Nikolayeva, 1993), hence the species *Isohomoceras grandicostatum*, *I. notum* and *I. ventrosum*, referred to herein, are not strictly valid (*nomen nuda*) under the terms of the International Code of Zoological Nomenclature (ICZN), until the publication of the Nikolayeva paper.

Fig. 1.- Location map for proposed Mid-Carboniferous boundary stratotype on the left bank of the Aksu River, South-West Gissar, Tien-Chan, Central Asia.

2. STRATIGRAPHY

In Russia, and the other countries of the former Soviet Union, the majority of stratigraphers place the Mid-Carboniferous Boundary at the level between the Serpukhovian and Bashkirian stages. However, this interpretation is not stratigraphically consistent because the base of the Bashkirian Stage has been interpreted at several levels since it was established in 1934-6 (Semikhatova *et al.*, 1978). In the original description it corresponded to the boundary between the early Westphalian (*Brannerоceras-Gastrioceras* and *Diaboloceras genus* zones = G2 Zone of Bisat, 1924) and Namurian C (the upper part of the *Bilinguites-Cancelloceras* Genus Zone = G1 Zone of Bisat, 1924). Later the Namurian B (*Reticuloceras-Baskortoceras* Genus Zone = R1 and R2 zones of Bisat, 1924) as well as a part of the Namurian A (*Homoceras-Hudsonoceras* Genus Zone = H1 and H2 zones of Bisat, 1924) were also assigned to the Bashkirian Stage. Presently the base of the Bashkirian is taken at the boundary between the *Homoceras-Hudsonoceras* Genus Zone and the underlying *Fayetevillea-Delepinoceras* Genus Zone of Serpukhovian age. This position which is supported overwhelmingly in Russia, the Ukraine and Central Asia (Bogoslovskaya, 1982, Einor *et al.*, 1990, Nikolayeva & Nigmadganov, 1992, Nigmadganov & Nemirovskaya, 1992) corresponds, in Western Europe, to the boundary between the upper part of the *Eumorphoceras* Zone (E2) and the lower part of the *Homoceras* Zone (H1) of Arnsbergian and Chokierian age respectively.

The Aksu section is located in the Surchandarjinskaya region of Uzbekistan, on the south edge of the Surchantau Ridge, which represents a part of the South-West Gissar Mountains (Fig. 1). The outcrop lies on the left bank of the Aksu River, several km south of the village of Badava, at an approximate altitude of 2,300m.

The section exposes the Chodzhirbulakskaya (Badavinskaya) Series which contains grey limestones in its upper part. In the upper part, limestones are interbedded with mudstones, however, the mudstone intervals are usually unexposed. There are no visible erosional surfaces in the interval spanning the level of the ammonoid-based boundary (Fig. 2). Ammonoids are numerous in the limestones, particularly in the uppermost part of the section, where the ammonoids form coquinas. The ammonoid based-boundary lies within layer 4, approxi-

mately 11.8m above the base of the section which is described as follows;

Top

Layer 6. Limestones, dark-grey to black, with numerous shell debris and intact ammonoid conches, in some parts there are coquinas. 1.4m.

Layer 5 (mainly unexposed). Three beds (A, B, C) of dark-grey, fine-grained limestones 0.2-0.3m thick are exposed in the middle part. In exposures between these limestone beds, fissile to platy siliceous bands, silty mudstones and argilaceous limestones occur. 7.2m.

Layer 4. Limestones, dark-grey, fine-grained, massive with sparse siliceous nodules. Ammonoids occur in the top. 0.5m.

Layer 3. Limestones, dark-grey, fine-grained, fissile. 0.5m.

Layer 2. Limestones, grey, fine-grained, with sparse siliceous nodules, thick-bedded. Ammonoids are present in the top. 7.5m.

Layer 1. Limestones grey, fine-grained, interlayered by siliceous bands, platy. A bed with numerous ammonoids occurs in the middle part. 3.0 m.

Conodont distribution reported by Nikolayeva & Nigmadganov (1992) suggests that the appearance of *Declinoganthodus noduliferus* is within layer 5 (horizon u) 3.5m above the first occurence of *Isohomoceras* in layer 4.

3. AMMONOID BIOSTRATIGRAPHY

The boundary level between the *Fayettevillea-Delepinoceras* and the *Homoceras-Hudsonoceras* genus zones is marked by the mass extinction of highly developed and widespread ammonoid taxa. The former zone includes forty two ammonoid genera, while the latter only nineteen genera. Only eight genera survive through this boundary from below, and comprise persistant taxa, such as *Stenopronorites, Stenoglaphyrites* and *Proshumardites*, together with the final members of early Carboniferous families represented by *Eumorphoceras* and *Cathranoceras*. Highly developed taxa, typical of the early Carboniferous, such as *Girtyoceras* and *Delepinoceras*, were nearly extinct by the beginning of the Bashkirian. Domination of ammonoid assemblages by the Homoceratidae (*Isohomoceras, Homoceras* and *Parahomoceras*) occurs slightly above the Mid-Carboniferous Boundary. Several new genera from the *Ramositidae, Stenoglaphyritidae* and *Nomismoceratidae* enter somewhat later (Ruzencev & Bogoslovskaya, 1971, 1978).

Detailed study of the ammonoid sequence around the Mid-Carboniferous Boundary in the Tien-Shan sections (Nikolayeva, in press) has provided new and interesting information on the distribution of certain taxa. In the Aksu section, thirteen ammonoid species (Fig. 1) occur at eight levels across the *Fayettevillea-Delepinoceras* (=E2) and lower part of the *Homoceras-Hudsonoceras* (=H) genus zones. Only 1.9m of strata separate the horizons yielding assemblages representative of these genus zones.

Ammonoids typical of the *Fayettevillea-Delepinoceras* Genus Zone occur at three levels within layers 1 and 2 (the lower 10m of the section). The lowest level contains *Proshumardites delepinei* Schindewolf, *Glaphyrites* sp., and an indeterminate prolecanitid (sample 3/92). The second limestone layer containing ammonoids lies 5.5m above the first; it contains (sample 3/85) P. *delepinei* and *Zephyroceras donabile* Nikolayeva. The third level 1.4m above the second contains *P. delepinei* only (sample 3/82). This assemblage, which is typical of the *Fayettevillea-Delepinoceras* Genus Zone, can be compared with assemblages from the South Urals (Ruzhencev & Bogoslovskaya, 1971), Spain (Kullmann, 1962; Wagner-Gentis, 1963) and North Africa (Delépine, 1941; Pareyn, 1961).

The *Homoceras-Hudsonoceras* Genus Zone in this section falls into two successive, concurrent subzones; those of *Isohomoceras subglobosum* and *Isohomoceras ventrosum*. The lower subzone contains *Isohomoceras* sp., *I.* aff. *subglobosum*, *Eumorphoceras* sp., *Proshumardites delepinei* and *Glaphyrites* sp., showing their first occurrence 1.9m above the last ammnoids of the preceding genus zone (sample 3/75). The upper boundary of this subzone coincides with the lower boundary of the next ammonoid layer (layer 6).

Ammonoids of the *Isohomoceras ventrosum* Subzone enter 7.6m above the first occurrence of *Isohomoceras* in this section (layer 6). The assemblage of this subzone contains *Isohomoceras ventrosum* Nikolayeva, *I. grandicostatum* Nikolayeva, *I. notum* Nikolayeva, *Glyphiolobus sholakensis* Ruzhencev & Bogoslovskaya, *Cathranoceras badavense* Nikolayeva (samples 3/60, 3/62).

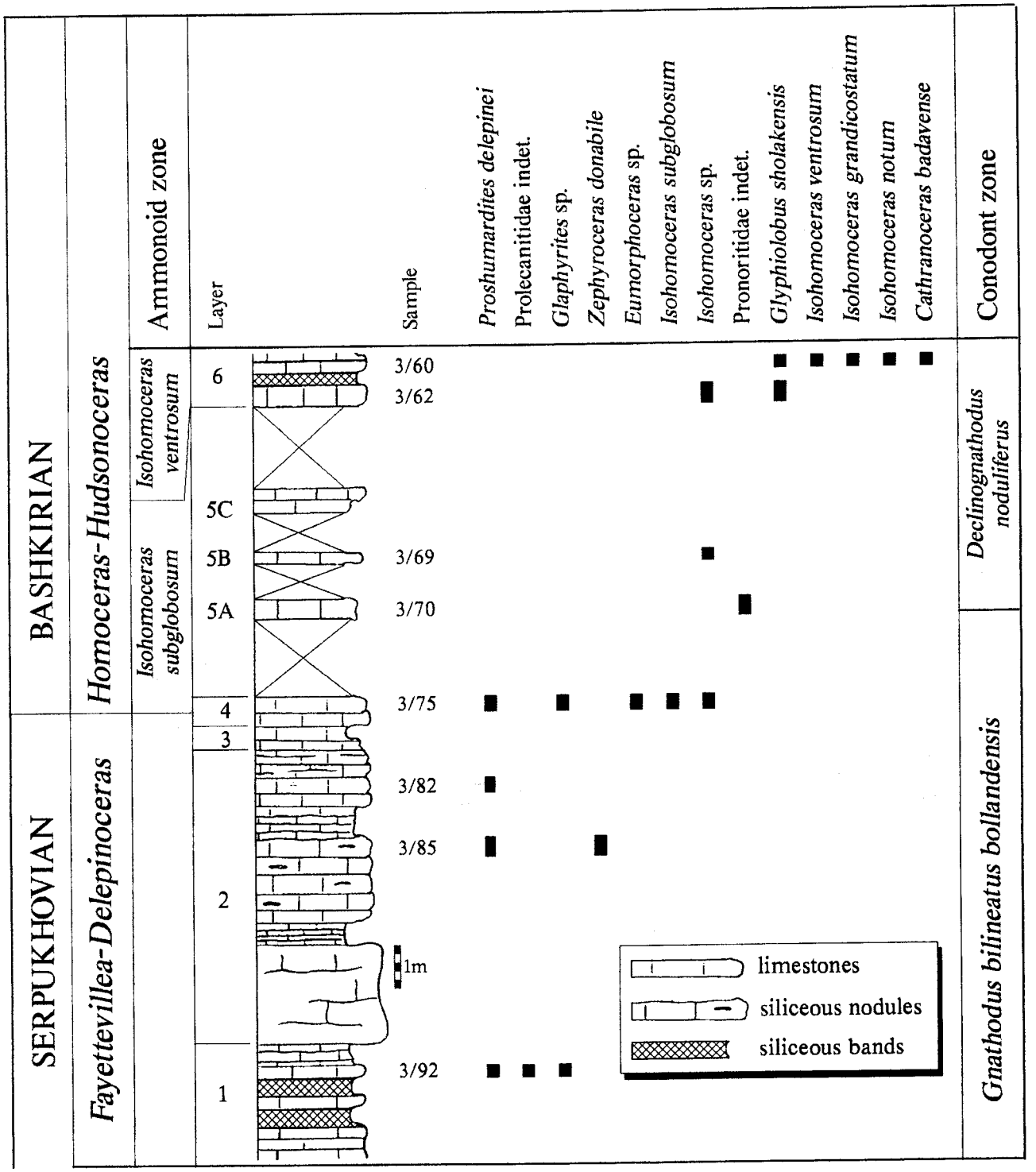

Fig. 2.- Ammonoid range across the Serpukhovian-Bashkirian boundary, Aksu section.

4. CORRELATION

The *Isohomoceras subglobosum* Subzone correlates with the lower part of the *Homoceras coronatum* Subzone established in the South Urals at Sholak-say (Ruzhencev & Bogoslovskaya, 1978) and the *Isohomoceras subglobosum* Subzone (H1a) of Great Britain (Bisat, 1924, 1928, 1936; Ramsbottom, 1969; Riley *et al.*, 1987) and Belgium (Bouckaert, 1959,1961).

The *Isohomoceras ventrosum* Subzone correlates with the upper part of the *Homoceras coronatum* Subzone of the South Urals and the *Homoceras beyrichianum* (H1b) Subzone of Britain and Belgium. These Bashkirian zones cannot be so far accurately correlated with the Mid-Carboniferous Boundary deposits in China because the boundary section at Jingyan (Li Xing xue *et al.*, 1987) lacks ammonoids.

The *Isohomoceras subglobosum* and *I. ventrosum* subzones are notably younger than limestone D5 10, of the Donets Basin, which is reported to contain *Homoceras* sp. (Aisenverg *et al.*, 1985).

5. DISCUSSION

In the most complete succession described across the Mid-Carboniferous Boundary (Stonehead Beck in Britain, Riley *et al.*, 1987) the boundary is placed at the level showing the first occurrence of *Decinognathodus noduliferus* Zone conodonts. This level is approximately 9m above the first occurrence of *I. subglobosum*. The distance between the last ammonoids of the E2 Zone (*Nuculoceras nuculum* Subzone E2c) and the first H1a Subzone ammonoids is also approximately 9m. The separation of the last *Gnathodus bilineatus* Conodont Zone conodonts and the first *D. noduliferus* Conodont Zone conodonts is approximately 13m (Varker *et al.*, 1991). Nevertheless despite the separation of Upper Carboniferous faunas from Lower Carboniferous ones, the Stonehead Beck section shows the highest precision of correlation among all so far proposed stratotypes.

The Stonehead Beck section and the Aksu succession demonstrate the comparable degree of high resolution provided by the ammnonoid biostratigraphy. The first Bashkirian ammonoids appearing at Aksu correlate with the *Isohomoceras subglobosum* Subzone, which represents the lowest horizons within the *Homoceras* Zone. This is consistent with all known sections yielding ammonoids at this level. This is further corroborated by the co-occurence of *Isohomoceras* and *Eumorphoceras* in the basal bed of the Zone at Aksu.

The Stonehead Beck section shows the last Eumorphoceras in the E2c4 Marine Band horizon (this was omitted in error by Riley *et al.* 1987, N. Riley pers. comm. 1994) where it is associated with fauna typical of the uppermost *Eumorphoceras* Zone, such as *Nuculoceras nuculum* Bisat. The lowest assemblages from the *Homoceras* Zone are characterised by the presence of *Isohomoceras* only.

At Aksu, *Eumorphoceras* is associated with *Proshumardites delepinei* which appears already in the *Fayettevillea-Delepinoceras* Genus Zone, and these ammonoids co-occur with *Isohomoceras* cf. *subglobosum* at the base of the succeeding *Homoceras-Hudsonoceras* Genus Zone. The association of *Isohomoceras* and *P. delepinei* within the *Homoceras coronatum* Subzone in the South Urals was discussed by Ruzhencev & Bogoslovskaya (1978). The latter zone showing the simultaneous entry of *Isohomoceras* and *Homoceras* seems to correspond with the H1b Subzone of Britain.

The overlap of *Eumorphoceras* and *Isohomoceras* occurrences is confined to one bedding plane 10cm thick, which does not show any visible evidence of hard ground or non-sequence events. Specimens representing both genera were recovered from the same piece of rock, hence the co-occurrence is unlikely to be a result of crude sampling.

The Stonehead Beck section contains *Nuculoceras nuculum* in the E2c4 Marine band Horizon. *Nuculoceras* is also present in the Sholak-say section in the *Fayettevillea-Delepinoceras* Genus Zone (Layer 8), where it is associated with *Proshumardites delepinei*. The Aksu section lacks *Nuculoceras*, and this genus has not been yet recorded from any section in Central Asia.

The Sholak-say section in the Urals lacks ammonoids in the basal part of the *Homoceras coronatum* Zone (Layers 11, 12, 13, ca. 0.7-0.8m). The preceding Layer 10 contains ammonoids indicating the *Fayettevillea-Delepinoceras* Genus Zone (Ruzhencev & Bogoslovskaya, 1971, 1978). Ammonoids occurring in the Layer 14 show the simultaneous appearance of *Isohomoceras* and *Homoceras*. This cooccurrence is comparable with that of the H1b Subzone in Britain, where the *Homoceras* Zone starts with *Isohomoceras* (H1a), whereas *Homoceras* enters later (Riley *et al.*, 1987). Therefore, the part of the Sholak-say section between the Layer 10 and Layer 14 lacking ammonoids may correllate with the *Isohomoceras subglobosum* Zone in Aksu section, where *Isohomoceras*, as in H1a Subzone in Britain, is not associated with *Homoceras*.

6. CONCLUSIONS

The section at the left bank of the Aksu River exhibits a continuous sedimentary succession within the interval of Mid-Carboniferous Boundary ammonoid zones: *Fayettevillea-Delepinoceras* and *Homoceras-Hudsonoceras.* It contains numerous ammonoids and conodonts permitting accurate biostratigraphy. Ammonoid data across the Mid-Carboniferous Boundary derived from this section supplements the ammonoid chronostratigraphy developed in other regions. The most important data include the presence of *Eumorphoceras* in the base of the *Homoceras* Zone. The sequence of ammonoids also shows that in the early part of the *Homoceras* Zone at Aksu *Isohomoceras* precedes *Homoceras* and *Declinognathodus noduliferus* and in this respect Aksu is consistent with the sequence in the British stratotype proposal at Stonehead Beck (Riley *et al.*, 1987). Furthermore, the precision of ammonoid control with a separation of only 1.9m between fauna characteristic of the *Fayettevillea-Delepinoceras* and *Homoceras-Hudsonoceras* zones is comparable only with Stonehead Beck.

7. ACKNOWLEDGMENTS

I am indebted to Dr. M. Bogoslovskaya for her informative discussions, Dr. I. Nigmadganov and Dr. T. Nemirovskaya for information on conodonts. Figures were completed in the Universität of Tübingen with the help of Prof. Dr. J. Kullmann and Dr. D. Korn, for which I am grateful. Special thanks are expressed to Prof. Barskov and Dr. N. Riley for their constructive criticism. I am also grateful to Dr. N. Riley for considerable revision of the English.

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PLATE 1

All specimens are held in the Paleontological Institute, Russian Academy of Sciences, coll. N. 4372.

1 (a,b). *Zephyroceras donabile* Nikolayeva
holotype 4372/400; x 1; level 3/75.

2 (a,b). *Eumorphoceras* sp.,
specimen 4372/399; x 3; level 3/75.

3 (a,b). *Proshumardites delepinei* Schindewolf,
specimen 4372/403; x 2; level 3/75.

4 (a,b).
5 *Isohomoceras* aff. *subglobosum* (Bisat)
specimens 4372/401, 4372/402; x 1; level 3/75.

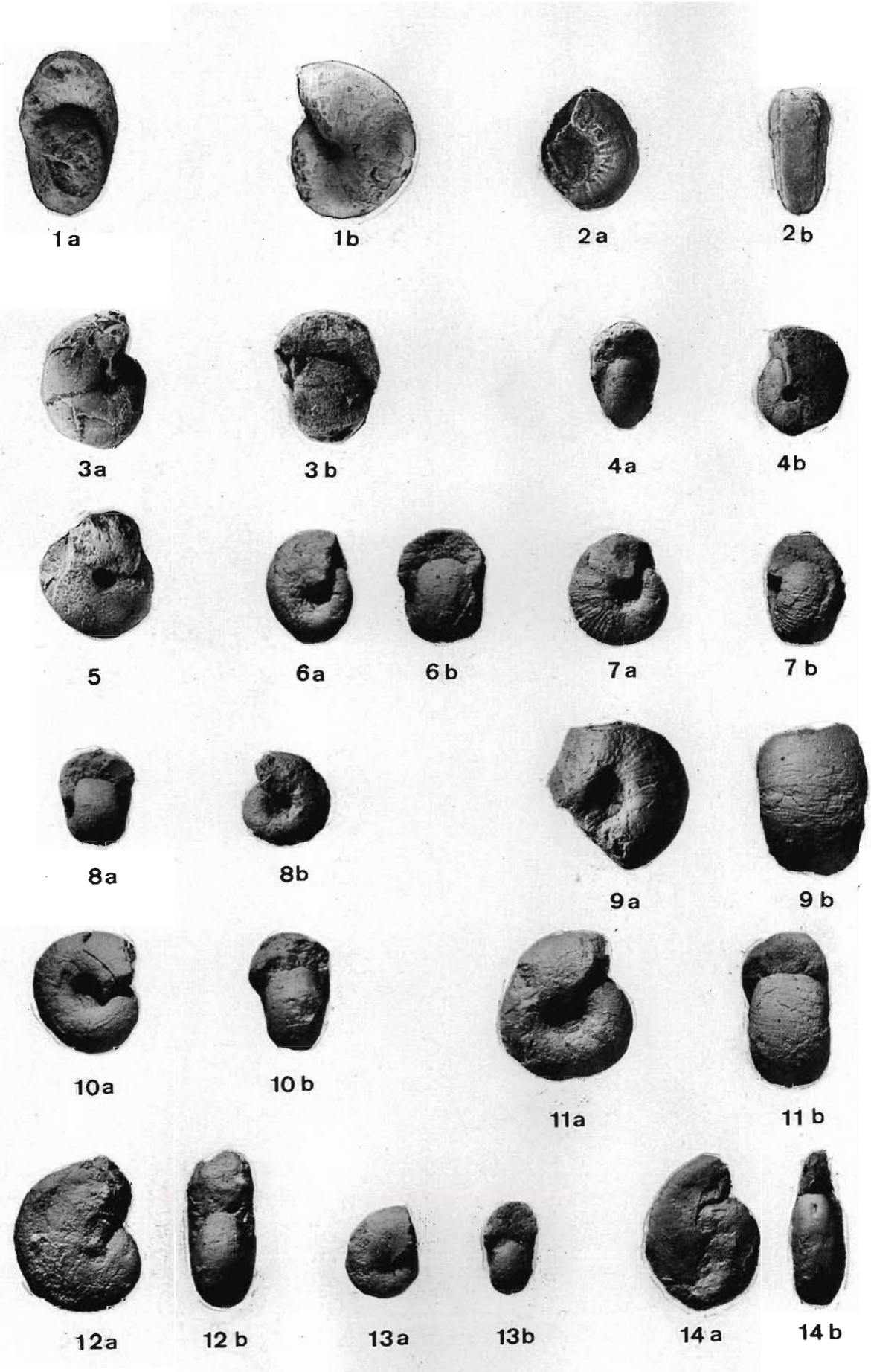
6 (a,b). *Isohomoceras grandicostatum* Nikolayeva
7 (a,b). specimens 4372/27; holotype 4372/26; x 2; level 3/60.

8 (a,b). *Isohomoceras ventrosum* Nikolayeva
9 (a,b). specimens 4372/11, 4372/10; x 2; level 3/60.

10 (a,b). *isohomoceras notum* Nikolayeva
11 (a,b). specimens 4372/176; 4372/176; x 2; level 3/60.

12 (a,b). *Glyphiolobus sholakensis* Ruzhencev & Bogoslovskaya
specimen 4372/42; x 2; level 3/60.

13 (a,b). *Cathranoceras badavense* Nikolayeva
14 (a,b). specimen 4372/2; holotype 4372/1; x 2; level 3/60.


1a
1b
2a
2b
3a
3b
4a
4b
5
6a
6b
7a
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8a
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9a
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10a
10b
11a
11b
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