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RANK OF STRATIGRAPHIC UNITS IN THE PRECAMBRIAN SCALE

Abstract. The paper proposes a system of ranks for the Precambrian stratigraphic units, which was accepted by the majority of the respective specialists of the USSR (adopted at the Second All-Union Meeting on General Problems of the Precambrian Subdivision — Ufa, 1990). The new hierarchical system enables to classify the Precambrian and Phanerozoic stratigraphic units from a common viewpoint and opens up further possibilities of improving the stratigraphic scale.

At the modern stage of geological studies in the territory of Eurasia, when the extensive Precambrian areas are being covered by detailed mapping, setting up a common hierarchical system of the general stratigraphic units (stratons) acquires not only an undoubted theoretical, but also a significant practical value. The general stratigraphic scale of the Precambrian used until recently was based on the principles of pragmatism, which resulted in a combination of stratons of different ranks and significance within a single succession (Решение..., 1979). Thus, as regards the principles of construction, the Precambrian scale of the USSR differed markedly from the type Phanerozoic scale, where the hierarchical principle of construction was strictly followed. At a definite stage of studies this approach was the only one possible. However, the lack of a common system of ranks for the Precambrian taxonomic units resulted in the fact that the stratigraphic columns in the official geological maps were compiled with a break, separately for the Phanerozoic and Precambrian. Therefore, the Precambrian/Cambrian boundary represented a line, separating different hierarchical systems in stratigraphy. Are such constructions justified? An ever deepening research into the Precambrian convinces one that stratigraphic studies on the Phanerozoic and Precambrian have common tasks and procedure. In fact, all the methods of stratigraphy developed and tested on the Phanerozoic material are also used in the Precambrian. A common methodological basis on the studies results in distinguishing lithostratigraphic, biostratigraphic, and climatostratigraphic stratons and the development of the corresponding specialized scales not only in the Phanerozoic, but also in the Precambrian. Common tasks and methods of the Phanerozoic and Precambrian stratigraphy open up new possibilities for using modern approaches in the periodization and classification of the oldest formations. For a long time, geological literature placed an emphasis on the names

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of stratigraphic units, rather than on the precise determination of their rank. As a result, the stratigraphic nomenclature abounds in stratigraphic units whose rank is either totally unknown, or established without the proper grounds. However, the rank of a straton determines its range and place in general or regional scales, and the name is protected only by the priority rule, which cannot retain non-valid stratoms. Rank of stratigraphic units should undoubtedly be based on tested periodization schemes. It is necessary to distinguish event and calendar periodization. Ranks of the Phanerozoic subdivisions are based on event periodization and, especially, on the analysis of evolutionary changes in skeletal organisms; this stimulates ever new paleontological studies. Many criteria on whose basis general stratoms were distinguished in the 19th century have lost or significantly changed their value; however, the Phanerozoic scale was not subject to any radical changes. Similar to the Phanerozoic scale, the standard stratigraphic scale of the Precambrian is based on the event periodization and systematizes the historical geological data, among them paleontological ones. Though the Precambrian paleontology is only making its first steps and the evolution character of the majority of ancient peculiar biotas has not yet been fully defined, the general principles and methods of biostratigraphic analysis retain their significance in the Precambrian.

A calendar periodization is based on geochronometric data. These data were not taken into account when the standard scale of the Phanerozoic was compiled, since they appeared much later. Repeated efforts have been made to use these materials for the subdivision of the Precambrian. In these cases the calendar periodization has often been opposed to the event one, as it is more objective and reliable.

Among such proposals which have gained a significant popularity is the "version of round numbers," envisaging a subdivision of the entire Precambrian history into periods lasting 100, 400, or 500 Ma (Боровиков and Спизарский, 1965; Goldich, 1968).

The simplicity and convenience of such a periodization and many other similar ones are quite obvious, though the initial principles have no historical geological sense. A great significance for the classification of general subdivision of the Precambrian can be acquired by a different analysis of geochronological data. On the basis of empirical materials, the duration limits of the main taxa, systems, and erathems are established in the Phanerozoic.

The duration limits vary extensively and are not absolutely precise when applied to certain specific objects. At the same time, considering the trend towards increasing duration of taxa with growing age as well as an overall time range for subdivisions in the Precambrian scale, maximum values of the duration of such taxa as eonothem (>550 m.y.), erathem (340 m.y.), and system (85—90 m.y.) acquire greater significance when the ranks are determined. The durations of various taxa differ markedly and, apparently, can be used as control ones for the classification of the Precambrian units of the standard scale.

The stratigraphic codes now in force (Жамойда, 1988; North American ..., 1983) distinguish a whole hierarchical system of taxa, subordinate to a system (series, stages, etc.) in the Phanerozoic. They are not considered in the present paper, because they are as yet almost never used in the Precambrian. It should be noted that the Phanerozoic system of large taxa had practically not been extended to cover the Precambrian before the Second Meeting on General Problems of the Precambrian Subdivision (Ufa, 1990), and the rank of many general units of the Precambrian scale, adopted in the USSR, had not been determined (Пешенко ..., 1979).

Different ideas concerning this problem have been put forward in geological literature. Alongside with showing that it was reasonable to distinguish some general units adopted for the Phanerozoic (system, erathem, eonothem) in the Cryptozoic, notions of a specific Precambrian character have been developed and the necessity of specific units different from the Phanerozoic (phythems, protosystems) has been proven.

Introducing phythems Keller (Келлер, 1966) took into account the great significance of floristic remains in the Precambrian biotas. However, even in the Phanerozoic the role of terrestrial vegetation in stratigraphy cannot be ignored. The Cambrian/Precambrian boundary can hardly be called the most important one in the evolution of floras and it is by far less significant than the time of the appearance of terrestrial vegetation. On the other hand, in the Vendian phythem (Precambrian) (Келлер, 1966) the Ediacarian fauna has great significance.

Therefore, counterposition of the Phanerozoic systems to the Precambrian phythems is not quite justified. Besides, there are some doubts about the belonging of phythems and systems to taxa of the same rank. The investigators are not unanimous as to the rank of certain stratigraphic units of the standard scale of the Precambrian (Келлер, 1966; Меннер, 1977; Либрович, 1954; Жамойда, 1988; Glaessner, 1984; Cowie et al., 1989). Thus, for instance, the Riphean used to be distinguished as a group; then it was assigned to a system, and later, to eonothem (Шатский, 1963). All this shows that the definition of the rank of general subdivision of the Precambrian is a rather complicated task, which requires methodological developments. Attempts have been made at establishing the rank of stratigraphic units on the basis of the analysis of the cyclicity of sedimentary, climatic, or tectonic phenomena. Not negating the validity of such constructions, it should, however, be emphasized that they do not solve the problem, since the global extent of a number of cycles is doubtful, and the rank and significance of cycles remain poorly determined. Cyclic constructions disturb the unity of the standard stratigraphic scale (which, as was noted above, has been constructed proceeding from different principles) and result in the development of alternative models. The problem arises how to span a "bridge" from the Phanerozoic general stratigraphic units, whose rank is known, to the Precambrian strata of the standard scale, whose ranks are as yet poorly developed?

The Vendian phenomenon seems to offer us such a possibility. This unit is defined by the researchers as the terminal system of the Precambrian (Соколов and Федонкин, 1990). From the biostratigraphical viewpoint, the Vendian is a unique, undoubtedly Precambrian epoch of generation, evolution, and extinction of the most ancient macrobiota, which enables to compare this unit with the Phanerozoic stratigraphic units, whose rank has been determined. The Vendian biota is limited by paleontological boundaries, which are among the most distinct ones known on the Earth. The presence of nonskeletal fauna ensures a planetary traceability of the Vendian deposits (Glaessner, 1984).

From the viewpoint of historical geology, the Vendian is a large and quite independent stage of the evolution of the main structural elements of the Earth, the time of the emplacement of the ancient, and, sometimes, the most ancient platform mantle and the latest, youngest Precambrian molasses in fold areas of different ages.

The structure of the Vendian is rather complicated. On the area of the former USSR, two major units (lower and upper) are distinguished in the Vendian, which are traced over extensive areas. The Upper Vendian, in its turn, is subdivided into a number of regional stages (Вендская..., 1985).

In other approaches, Ediacarian corresponds to the Upper Vendian; and

Varangian, to the Lower Vendian (Glaessner, 1984). A unique organic kingdom, a complicated inner structure, and abrupt boundaries result in constructions where the Vendian is regarded as a double system or even erathem (Glaessner, 1984).

From the geochronological viewpoint, the duration of the Vendian, which is approximately equal to the largest Phanerozoic systems, is noteworthy. So this quite independent criterion can be considered in classifying the Precambrian subdivisions.

It is quite evident that the time range of the Vendian is not characteristic of the largest erathems, though it does not rule out the possibility of assigning the Vendian to double systems, exemplified by the Ordovician-Silurian stratigraphic unit (Phanerozoic). Nevertheless, it should be borne in mind that the time range of the smallest Cenozoic erathem is close to a number of system taxa, which makes unambiguous use of geochronological data difficult.

Attempts of establishing system categories in the Precambrian predating the definition of the Vendian are known from earlier works. An early and vivid attempt is the Precambrian Sinian system of Grabau (1922), which was comprised into the Paleozoic. Since then, the Sinian has been distinguished in China and in adjacent territories with such different ranges that it is difficult to regard the rank of the unit as reliably established. At one time, the Sinian as an interregional complex was also an object of mapping in the Precambrian of the USSR. Later, along with the advancement of the ideas of the Sinian as a system, certain viewpoints evolved, according to which the Sinian is a higher-rank straton, similar to the Riphean or the terminal erathem of the Precambrian (Шкала..., 1985).

Proceeding from the hierarchical belonging of the Vendian, one can determine the rank of such units of the general scale of the Precambrian as the Lower, Middle, and Upper Riphean. They were commonly assigned to protosystems or phytems (Келлер, 1966, 1980). Their duration is according to isotope data 350—400 Ma, which exceeds the time of emplacement of the Vendian system 3—4 times. All the three stratigraphic units of the Riphean have a complex structure.

Thus, for instance, in the Upper Riphean such units as Kipchak, Tangaur, and Tam'yan, are distinguished. This division has been accepted by the latest interdepartmental stratigraphic meetings on the Russian Platform and the Urals. In their duration of emplacement and event filling these interregional units are approaching system categories. All this enables to consider the Lower, Middle, and Upper Riphean not in the rank of systems, but in the rank of erathems, equal to their Phanerozoic equivalents.

A special problem is the terminal erathem of the Precambrian. The Vendian terminal system (Соколов and Федонкин, 1990) should crown the terminal Precambrian erathem. It cannot be placed under phytem categories, since it would comprise systems, distinguished on the basis of the distribution of both faunal and floristic assemblages.

The problem of the pre-Riphean erathems remains in fact open, though it is becoming clear that the traditional inclusion of the Archean as well as Proterozoic into the groups (erathems) is an absolutely groundless anachronism.

The next hierarchical level in the classification of the Precambrian taxa is held by eonothems, whose total duration can reach 1 b.y. Commonly, after Chadwick's research the Precambrian Cryptozoic eon was set off against the Phanerozoic eonothem (Хедберг, 1978), though they are not comparable either in event filling or the time of emplacement, which determines the belonging of the Cryptozoic to extra-rank units, such

as pre-Mesozoic, pre-Devonian, Precambrian, etc. Keller (Келлер, 1966) convincingly proved the belonging of the Riphean to the category of eonothems. The Upper Proterozoic also belongs to the units of the same rank. Sometimes, such an analogy causes perplexity, since, according to modern views, their ranges are not identical. However, this difference in range is not significant for the determination of the ranks of such units. It is known that the range of the Phanerozoic eonothem is also interpreted differently: the Vendian is either included or excluded. It has sometimes been suggested to join the Lower Triassic or other units to the Paleozoic erathem.

All these differences in opinions about the range of certain Phanerozoic stratigraphic units, inevitable in the stratigraphic practice, do not lead to changes in their rank. Study of stromatolites, which are developed in the Precambrian and Phanerozoic, has enabled to establish four Late Precambrian and three Phanerozoic stromatolite assemblages, which, possibly, indicates that the ranks of the Phanerozoic and Riphean are comparable. The pre-Riphean eonothems are exemplified by the Lower Proterozoic (Aphebian, Karelian) and the Upper Archean (Lopian).

Until the lower boundary of the Archean is drawn, its lower part should be assigned to extra-rank strata.

Such subdivisions of the Precambrian as Proterozoic and Archean were in the Soviet literature traditionally assigned to groups (erathems) and were compared with the corresponding Phanerozoic taxa (Либрович, 1954). It was commonly noted that such comparison was conditional, though these units reflected the initial interpretation of these terms common in Canada. However, an ever growing "wave" of geochronological data on different continents of the Earth, obtained using different methods, clearly shows that the duration of the Proterozoic approaches 2 b.y. Though the lower boundary of the Archean has never been drawn precisely, its duration is characterized by similar values. However approximate these dates may be, they nevertheless show clearly that the traditional understanding of the rank of the Proterozoic and Archean requires cardinal changes. In the review by Harland et al. (Шкала..., 1985) and also in some other works (Plumb and James, 1986; Cowie et al., 1989) the rank of these units is raised to eonothems.

Comparison of historical geological and geochronological data shows that the hierarchical scale of the Phanerozoic lacks units with such duration and should be supplemented from above by a new taxa, which we, following Menner (Меннер, 1977), assign to the category of acrothems.

Hierarchical system of Precambrian taxa

Acrothem (to 2 b.y.)	Eonothem (1—0.5 b.y.)	Erathem (to 0.3 b.y.)	System (to 0.1 b.y.)
Proterozoic	Phanerozoic	Cenozoic	Cretaceous
		Mesozoic	
	Upper Proterozoic	Paleozoic	Permian
Archean	Riphean	Upper Riphean (Neoproterozoic)	Cambrian
	Lower Proterozoic (Paleoproterozoic)	Middle Riphean	Vendian and others
	Upper Archean	Lower Riphean	(Kipchak, Tangaur)

A hierarchical system of the general Precambrian taxa (Table) has been developed for the draft of the Stratigraphic Code edited by Zhamoïda (Жамойда, 1988). Later, it was presented at the Stratigraphic Meeting on General Problems of the Precambrian Subdivision (Ufa, 1990); it was approved and entered as a part of the Stratigraphic Scale of the Precambrian adopted at the meeting. The new hierarchical system makes it possible to classify the Precambrian and Phanerozoic strata from a single viewpoint and opens up further possibilities of improving the stratigraphic scale. Determination of the rank of strata becomes a promising method of development both on the general and the regional scale of the Precambrian.

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EELKAMBRIUMI SKAALA ÜLDISTE STRATIGRAAFILISTE ÜKSUSTE KLASSIFITSEERIMISEST

Edusammud eelkambriumi uurimisel on kaasa toonud mitmete stratigraafiliste üksuste eristamise, mille klassifikatsiooniate üldskaalas pole määratletud. Artiklis on esitatud eelkambriumi skaala üksuste astmestik, mis on aktsepteeritud endisel NSV Liidu territooriumil erialaspetsialistide vastavateemalisel nõupidamisel (Ufaa, 1990). Uus hierarhiline süsteem lubab ühesugustelt lähtekohtadelt klassifitseerida nii eelkambriumi kui ka faneroosikumi põhiüksused ja võimaldab seega edaspidi täiustada üldist stratigraafilist skaalat.

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РАНГ ОБЩИХ СТРАТОНОВ ШКАЛЫ ДОКЕМБРИЯ

Прогресс в геологическом изучении дофанерозоя привёл к пополнению стратиграфической шкалы докембрия целым рядом стратонов, ранг которых не был установлен. В статье предложена система ранжирования стратиграфических подразделений докембрийской шкалы, которая была принята на совещании по общим вопросам расчленения докембрия (Уфа, 1990). Новая иерархическая система позволяет с единых позиций классифицировать стратоны докембрия и фанерозоя и открывает дальнейшие возможности совершенствования стратиграфической шкалы.