

**PROCEEDINGS OF THE
27TH INTERNATIONAL
GEOLOGICAL CONGRESS
VOLUME 1
STRATIGRAPHY**

56-5053
I 61-1
1984(27)-1

**Proceedings of the
27th International Geological Congress
Moscow 4-14 August 1984**

Volume 1

STRATIGRAPHY

WVNU SCIENCE PRESS

**Utrecht, The Netherlands
1984**

VNU Science Press BV

P.O. Box 2073

3500 GB Utrecht

The Netherlands

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First published 1984

ISBN 90-6764-010-7 Volume I

ISBN 90-6764-009-3 set of 23 volumes

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Printed in Great Britain by J. W. Arrowsmith Ltd, Bristol

PREFACE

The leading scientists in the many different fields of geology were invited by the Organizing Committee to present a paper on a specific problem in present-day geological science at the 27th International Geological Congress. The published proceedings of the Congress consist of twenty-three volumes. Each volume is dedicated to a particular aspect of geology. Together the volumes contain all of the contributions presented at the Congress.

The Organizing Committee is pleased to acknowledge the efforts of all of the participating scientists in helping to produce these proceedings.

Professor N. A. BOGDANOV
General-Secretary of the
Organizing Committee

CONTENTS

Preface	v
Subdivisions of the International Stratigraphic Scale (state and perspectives) V.V. Menner	1
An overview of the measurement of geologic time and the paradox of geologic time scales J.D. Obradovich	11
Paleomagnetic scale for the Phanerozoic and magnetostratigraphic problems E.A. Molostovsky and A.N. Khramov	31
Graptolite zones and standard stratigraphic scale of the Silurian T.N. Koren and A.P. Karpinsky	47
Relation between the minuteness of a biostratigraphic unit and its geographic range M.S. Mesezhnikov	77
Neogene horizons and zones of Northeastern Asia (methods and details of correlation and refining) Yu.B. Gladenkov	89
Chronostratigraphical division of the Holocene L.K. Königsson	107
Stratigraphical boundaries and periodicity of evolution of a sedimentary basin (Baltic Silurian) D. Kaljo	119

Steps to a standard Silurian C.H. Holland	127
Middle Carboniferous of Eurasia (biogeographic differentiation, zonal scales) M.N. Solovieva	157
A standard for the Lower Triassic K.O. Rostovtsev and A.S. Dagis	173
Relations between biostratigraphy, magnetostratigraphy and event stratigraphy in the Jurassic and Cretaceous A. Hallam	189
Constraints provided by ecostratigraphic methods on correlation of strata and basin analysis, by means of fossils A.J. Boucot	213
Correlation of polyfacies sediments using historic- geological methods (on the unity of stratigraphy) V.S. Sorokin	219
The Vendian System and its position in the stratigraphic scale B.S. Gokolov	241
The Sinian and its position in geological time scale Xing Yusheng	271
Stage subdivision for the Permian of the USSR in the light of recent studies D.L. Stepanov	289
The Permian of Gondwanaland B. Runnegar	305

Mid-Palaeozoic palynology, facies and correlation 34.
J.B. Richardson

Palynological correlation
E.D. Zaklinskaya 367

SUBDIVISIONS OF THE INTERNATIONAL STRATIGRAPHIC SCALE (state and perspectives)

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A great number of extremely different stratigraphic subdivisions is used in geological practice. Their validity is proved by both the individual and the complex data. However, when compiling geological maps, only such units are used which are based on the geological age, and, therefore are called chronostratigraphic. The latter, due to greater or lesser isochroneity of their boundaries, show in maps the mode of character and position of mountain rocks and peculiarities of the geological history and structure of the region. Below are considered stratigraphic subdivisions of this group, and only those of interregional or global importance, as they determine the scale of the geological cartography.

Among such stratigraphic (chronostratigraphic) subdivisions there are some which have been long known and widely used in practice (while working in Phanerozoic deposits, for instance). They were recommended for the International use as far back as in 1881 at the 11-th International Geological Congress in Bologna, and subsequently approved in 1900 at the VIII International Geological Congress in Paris. These are the subdivisions which were included in all stratigraphic codes and reference-books of the most countries of the world (see Table: eratema (group) - era, system - period, division - otdel (series) - epoch, stage - age, zone (chronozone - chron). The name of the first category "group" did not become established in countries of the western hemisphere and, was not approved by the Paris Session of the Congress. That is why, H. Hedberg suggested in the sixties to substitute it by the term "eratema" that has been used at present in the International practice and is almost generally accepted.

Another term that seems frequently a puzzle is a "division" substituting in the Slav language the word

"series". It was recommended as far back as at the Bologna Session of the Congress, which took into consideration that at that time the terms "series and suite" were always understood in the Slav-speaking countries as a lithostratigraphic term. In the Soviet Union and in Bulgaria this has remained up till now.

The case is more complicated by the term "zone" which was not discussed at the 11-nd Congress, and at the VIII-th Congress it was adopted as a unit of regional significance. As suggested by H. Hedberg, it was introduced as "chronozone" into the International stratigraphic guide-book instead of "zone", as a great number of zones and zonal scales based on remains of various groups of organisms can be recommended for the same interval of the stratigraphic scale, whereas the only one - approbated - chronozone can be included into the International scale. In this case, using the term "chronozone" one should bear in mind that there is not a single system for which a set and succession of chronozones could be considered strictly established, not speaking of their approval in the International plan. However, as units which are less than a stage, the subdivisions of the category "zone" or "chronozone" are very widely used in practice, frequently on a subglobal scale. That is why, the official legalization of this category is certain to be a matter of the nearest future. Soviet stratigraphers have already compiled zonal scales for the most systems that guarantee the subdivision of deposits of the entire USSR Territory into zones and lones.

We shall not dwell on such categories as Eonothema and Link, as the former, though being included into the International scale, is used extremely freely, and the latter has been accepted as yet by the "Stratigraphic Code of the USSR" alone. Therefore it will be more convenient to consider them below.

It was thought until recently that the accumulation time of the smallest of correlated subdivisions, namely a zone, determines the limit of accuracy of geological constructions (Messezhnikov, et al., 1979). However, already since the end of the last century, much larger and much more detailed subdivisions, though

having not been internationally approbated have been widely used in practice by geologists of various countries for subdivision of Precambrian or Quaternary deposits.

Geologists managed to realize the significance of such categories only during the last years owing to introduction of physical methods, especially the isotopic analysis, into practice of stratigraphic works. These methods enabled to establish the surprisingly long time of accumulation of Precambrian sediments, and short duration of Quaternary ones, for which geologists tried previously to use general Phanerozoic categories, but in a broader or narrower sense (Archean and Proterozoic group, Sinian system, the Valdai stage, etc.). This created many difficulties and lead to endless discussions. In order to avoid them, it is necessary to introduce new for the Precambrian larger categories, and, on the contrary, more detailed ones for the Quaternary. Unfortunately these ideas have not been understood by the majority of scientists and advance for them very slowly.

The largest stratigraphic categories already used in practice, but not codified yet are as follows: Precambrian, Archean, Proterozoic, Riphean, Aphebian, Guronian, Burzyanian and many others. At first the Archean and Proterozoic were considered groups, but now geologists try to call them Eones setting them equal to a much shorter Phanerozoic; though they do not obviously correspond to these categories and require introduction of other specific terms for them (see Table 1, section 1).

For instance, for the Precambrian as a whole, a term megathema (the largest) can be recommended, and in time megachron, as its duration exceeds 4 bil. years. Both these, and all the subsequent categories of rank 1-4, except for phytema, have no analogues among Phanerozoic subdivisions. It can be easily understood, as the Precambrian is by 8 times, and the Archean and Proterozoic almost by 4 times exceed the duration of the entire Phanerozoic that is a prototype of eonthema. For a rather long time researchers tried to regard these subdivisions as

large groups. This resulted in never-ending debates: what can the Riphean be regarded which is certain to be larger than a system and even larger than the Phanerozoic groups, and at the same time are the only subdivisions of the Proterozoic "group". Now scientists try to set them equal to the Paleozoic which they exceed almost by three times relative to duration of sediment accumulation. However, in order to avoid further endless discussions, it seems better to introduce a special category for them - acrotema, the name of which would emphasize vitality of attributed to it subdivisions. Noteworthy is that in the sixties the International Subcommittee on Precambrian stratigraphy proved uselessness and emptiness of these two terms. However, they not only withstood criticism, but after their elimination, link Phoenix, according to decision of the same Commission, revived in the former stratigraphic volume, but already as International stratigraphic subdivisions of the global value.

Such a situation speaks of insufficiently worked out stratigraphy of Precambrian deposits for whose subdivisions different scales were repeatedly suggested: based on development of organic forms - Azoic, Eozoic, Proterozoic, etc.; or by stages of the Earth's surface development - Archean, Paleoproterozoic, Mesoproterozoic, Eonoproterozoic; or by stages of the processes of the Earth's crust formation: Protogeic, Mesogeic, etc. All these terms are certain to reveal reliably definite peculiarities of development of the Earth and its surface, but they are as yet substantiated not sufficiently enough. This does not allow to give preference to any of them. Therefore, at present we have to recommend for using the traditional subdivisions used in stratigraphy for a long time and well grouped into four categories (see Table 1, sect.1) which directly supplement the previously adopted International scale: megatema, acrotema, eonotema, and phytema.

The last category here is phytema established by B.M. Keller (1980) for Precambrian subdivisions which were previously regarded by him as analogous to systems, but identified by remains of the algal origin,

which determined the name of this category. However, the duration of accumulation of deposits of different phytoms increases, as a rule, by one order the time of accumulation of Phanerozoic system deposits (330 and 35-40 mln. years) and twice almost exceeds the duration of accumulation of the most Phanerozoic eratems, except Paleozoic. We should also bear in mind the fact that V.V. Drushchits and V.N. Shimansky as long ago as in 1965 proposed to regard Paleozoic as not one but as two eratems in conformity with the Caledonian and Hercynian cycles of orogenesis. It is likely more practical to single out such subdivisions as a special category such units as phytomas are not an exception, but a rule, on more ancient intervals of the stratigraphic scale too.

Finishing the analysis of categories of the largest stratigraphic subdivisions (introduction of new terms for the largest of them being necessary) we must remember those numerous difficulties arising in solution of the problems of the ranks of Riphean, Sinian, Proterozoic and even Archean due to a lack of such categories. I think that it is not expedient to repeat such errors only because of stinginess of geologists for new names.

Having analyzed the largest units of the stratigraphic scale, we shall pass to the most detailed subdivisions whose duration of accumulation does not exceed, as a rule, one million years, and is frequently measured by thousands and even hundreds of years. Until recently it was considered that such subdivisions are purely local, and they should not be included into international stratigraphic scales, as they lie already beyond the limits of accuracy of stratigraphic correlations. However, the data of the last decades speak of the reverse, and their importance proves more and more obvious. Many of them are mapped even in relatively small-scale maps and can be traced almost throughout the globe.

All these subdivisions are distinguished by means of paleoclimatic data pronounced both in the character of rocks of one or another interval, and in assemblages of organic remains recognized in them. The best worked

out scale of categories of such subdivisions was suggested by the Commission on Quaternary stratigraphy of International Stratigraphic Committee of the Soviet Union. The commission recommended to single out categories of five ranks, and if we consider the subdivisions used in practice, the number of such categories should increase to seven (see Table 1, sect. III).

The largest of these subdivisions is a division corresponding to Pleistocene s. str. By duration of accumulation of composing its deposits, it corresponds to a zone, or more correctly to a subzone of Phanerozoic deposits, or hyperclimatema of the climatostratigraphic scale by V. Zubakov. The Pleistocene is distinguished according to progressive cooling observed at that time both on the land and in the oceanic sediments.

The next after a division category - a link has been introduced into the stratigraphic code of the USSR. It corresponds to one large climatic cycle. In the Quaternary a link begins, as a rule with warm interglacial and is completed by well pronounced cooling and glaciation. In so doing the Interglacial is always warmer than the present moment. As for older Phanerozoic systems, no subdivisions equal to a link have been officially distinguished yet. If they were distinguished for analogous close by duration subdivisions, geologists commonly used the terms zone of bed. However, the duration of such subdivisions is much shorter than the present-day zones. Therefore, it would be more rationally for them to use different term derived from zone - zonula. The category following after a link is a Quaternary superstop or circle, or superclimatema of V. Zubakov scale under which either the entire warm, or the entire cold part of the link is meant. Cromerian, Likhvinian and Mikulino Interglacials, or Riss or Valdai glaciation are a typical example of snow subdivisions. Nevertheless, within each of these subdivisions, colder or warmer moments are distinguished that enable us to single out some colder and warmer steps. Dneprovian and Moskovian glaciations, or steps separated by the Odintsovo (Roslavl) in periglacial,

can be mentioned in the Riss circle. In deposits of the Emian interglacial preceding the Visla glaciation G. Voilard suggested to single out three subdivisions which are certain to be steps as well: these are true Emian deposits s. str. and overlying deposits of the climatic optima - Saint Germain I and Saint Germain II. Each of them is completed by deposits of drastic cooling during which the vegetation in West Europe acquired the tundra character with predominance of shrub-birch, willow and alder. An analogue of circles and steps in oceanic sediments are the so-called isotopic stages of Emiliani and Shakleton, or ortoclimatemas of V. Zubakov which are not only traced in Pleistocene sections of various oceans, but can also be distinguished in Eopleistocene and Pliocene deposits.

This is not the end of detailed subdivision of Quaternary deposits. The maps of Quaternary deposits with ridges of terminal moraines, separate stages of degradations of the last continental glaciations are well known. Such ridges are well known in the North-West of our country, and in West Europe and North America. The general duration of the state of the last glacier retreat from our territory is estimated (by means of varved clays and C₁₄) only as 8 thous. years, and somewhat larger in America - 10 thous. years. Noteworthy is the fact that the moment of even such small (short) coolings and warmings which determined some of ice drifts, coincided rather precisely in time both in Eurasia and in North America, whereas the Holocene optimum was traced at the same time in our country, in North America and in sections of New Zealand. All these data speak of possibility of global tracing of even such detailed subdivisions which in the climatostratigraphic scale are given the category of nanoclimatemas.

In more ancient parts of the scale such detailed subdivisions are used much rarer and are not traced so widely yet. Thus, we can say that while subdividing the Upper Cretaceous scale of the south-eastern regions of the USA, the zones were used which had been distinguished by means of ammonite and inoceram remains.

It will be more expedient to regard them as "zonulas" for the time of accumulation of their sediments does not exceed 100-150 thous. years. In Upper Permian and Triassic deposits of the Soviet Union, as far back as in the fifties a number of sedimentation cycles was distinguished, the duration of their accumulation not exceeding the first hundreds of thousands. Similar subdivisions whose duration of accumulation does not exceed the first hundreds of thousands of years, were distinguished by V.S. Sorokin in the Upper Devonian of the Baltic region according to rhythmicity of sediment accumulation. We must not forget of rhythmically built flysh deposits the formation time of separate rhythms of which is traced over hundreds of kilometers, and, as now established, is not over some centuries.

The above examples show that already to-day the geologists in their works use subdivisions of detailed, very small categories not only in Quaternary deposits, but in older ones, and try to trace them in both the oceanic and the continental deposits. Physical methods ensure the correlation of some of them in sections of various continents.

The last works discrowned the myth of metachroneity of phenomena of glaciations on various continents; they took away the concepts of zones as of subglobal categories, and of the accuracy limit of stratigraphic constructions, and testify directly to rightfulness of further detailization of the stratigraphic scales up to the limits determined by practical needs. These are only perspectives yet, but their methodological aspect and possibility of realization are already clear, and everyday thorough work will always allow us to achieve the results we would like to have.

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TABLE 1. Scale of the categories of stratigraphic subdivisions

General basis	Rank	Categories of standard stratigraphic subdivisions		Examples
		Global/Interregional	Duration, min. y.	
Tectono-magmatic cycles	1	Megatem	4000	Precambrian
	2	Acrotem	2000	Archean, Proterozoic
	3	Enotem	1000	Aphabian, Carelian, Riphean
	4	Phytem	250 - 350	Karatavian, Paleozoic
	5	Eratem (Group)	64 - 150 (330)	Vendian, Mesozoic (Paleozoic)
	6	System	(1) 22 - 40 - 75	Devonian
	7	Series	3,5 - 15 - 30	Miocene
	8	Stage	1 - 6 - 18	Cenomanian
	9	Chronosone (Oppalsone)	0,7 - 1,5 - 6	Pailoceras planorbis
Evolution of organic life	10	Subsone Division	0,65 -- 1,1	Eopleistocene, Pleistocene
	11	Link	0,11 - 0,15 - 0,30	Q1, Q2
	12	Superstep	0,06 - 0,08 - 0,2	Riss, Valdai
	13	Step	0,012 - 0,02 - 0,04	Varta, St. Jermain
	14	"Step"	0,005 - 0,006 - 0,012	Degradations
	15	"Stadial"	0,001 - 0,003 - 0,005	Bogogovsky, Atlantic
	16	"Phasial" (Oscillation)	0,001	Allered
Fluctuations				
Eustatic-climatic				

(31/9) 4-R-11