*Stratigraphy and Geological Correlation, Vol. 12, No. 4, 2004, pp. 321–330. Translated from Stratigrafiya. Geologicheskaya Korrelyatsiya, Vol. 12, No. 4, 2004, pp. 3–13.*


# Problems Related to the International (Standard) Stratigraphic Scale and Its Perfection

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Received January 14, 2004

**Abstract**—All the aspects of the International stratigraphic scale (ISS) versions prepared by the International Commission on Stratigraphy in 2000 and 2002 are analyzed to show their similarity with and differences from the General stratigraphic scale (GSC) accepted and used in Russia. It is shown that the Precambrian ISS based on chronometric data is unacceptable, because geological systems of the Precambrian, except for the Vendian, cannot be defined. As is substantiated, the boundary and ISS stratotypes are complimentary, and the former cannot substitute the latter. The idea of validating the Phanerozoic ISS units depending on approval or rejection of the Global Boundary Stratotype Section and Point (GSSP) is criticized. It is shown that placing the Holocene and Pleistocene into the Neogene System, as it is done in the ISC-2002, we come to elimination of the autonomous Quaternary System. The attitude of the Interdepartmental Stratigraphic Committee of Russia to the procedure of consideration and acceptation of important international resolutions concerning general stratigraphic aspects is formulated. Substantiation of stratigraphic boundaries for stages established in Russia is supposed to be a procedure aimed at ISS perfection.

**Key words:** International (Standard) stratigraphic scales of Precambrian and Phanerozoic, unit and boundary stratotypes, Global Boundary Stratotype Section and Point, Quaternary System.

The perfection of the International (standard) stratigraphic scale, the elaboration level of which reflects achievements in stratigraphy, is among the most important tasks of this science.

By the middle of 20th century, the ISS represented a sufficiently stable structure with succession and ranks of its subdivisions accepted worldwide, and its perfection progressed toward specification of stage boundaries and further detailing (definition of substages, zonal and infrazonal biostratigraphic units). At that time, ranks of some systems (Silurian, Permian) were under discussion, and new stages were introduced into some systems (Cambrian, Silurian, Devonian, Permian, Neogene). The specified position of stage boundaries precisely was regarded to be critical for reliable regional, interregional, and global stratigraphic correlations.

A long-term verification of the Silurian–Devonian boundary by the special committee of the International Commission on Stratigraphy (ICS) in 1960–1972 under the leadership of H.K. Erben (Germany) and then of A. Martinsson (Sweden) is a perfect example methodically correct work. It should be mentioned that specialists from 21 countries took part in these study and in field examination of boundary sections in Belgium, Germany, Czech Republic (Barrandien), Morocco, the United States (Nevada), and the USSR (Podolia, Salair). A serious book summarizing the study results includes descriptions of over 20 sections and brief characteristics of 13 faunal and floral groups. This was a real scientific substantiation of that boundary, which resulted in recognition of new Pridolian, Lochkovian, and Pragian stages of the systems (*The Silurian–Devonian Boundary*, 1977).

Of course, it is hardly possible now to substantiate all the debatable boundaries between the ISS units based on similar long-term and expensive researches. Nevertheless, the methodological approach should remain precisely the same, if we want to achieve desirable.

Unfortunately, further studies developed in line with a simplified scenario turned finely into selection and approval of the Global Boundary Stratotype Section and Point (GSSP).

In the 1980s, leaders of the International Commission on Stratigraphy commenced actions aimed at perfection of the International stratigraphic scale that was called global. In 1986, J. Cowie, W. Ziegler, A. Boucot, M. Basset, and J. Remane proposed a project of the Global stratigraphic scale with a stage as its lowest-rank unit for a wide discussion (Cowie *et al.*, 1986; Cowie, 1986). Their project included the rules of the GSSP selection and description (*Stratigraphic Code*, 1992, Appendix 2). Some comments of the Interdepartmental Stratigraphic Committee of the USSR to the Global scale were forwarded to the ICS.

At the 28th Session of the IGC in 1989, Cowie and Basset (1989) presented, as editors, a new version of

the Global stratigraphic scale added by geochronological and magnetostratigraphic data. In principle, the scale remained the same, although it was slightly modified.

Based on materials presented by all the commissions on systems and subdivisions of the Precambrian, the Stratigraphic Committee of Russia prepared and sent to the ICS circumstantial letters (of February, 1990, and of March, 1992) with comments to coincidences and differences between the ISS and GSS accepted in Russia. In his letter of May 12, 1993, J. Cowie informed that the GSS accepted in Russia would be most useful for the ISS perfection.

J. Remane (Swiss), the new chairperson of the ICS elected at the 29th Session of the IGC continued the work of his predecessor. In 1998, the preliminary version of the International Stratigraphic Scale was published. It was approved by the Commission on the Geological Map of the World (CGMW) and by the International Union of Geological Sciences (IUGS) as it is evident from accompanying emblems (*International Stratigraphic Chart*, 1998).[1] J. Remane declared that the preliminary edition was prepared in cooperation with all subcommissions of the ICS and that the editorial working group included J. Dercourt and P. Bouysse, leaders of the CGMW, and A. Faure-Muret who took part in compiling the Geological Atlas of the World. Simultaneously, V.E. Khain, Yu.G. Leonov, and G.E. Grikurov, members of the CGMW bureau, reported that opinion of the CGMW plenary meeting was not unanimous at all. The Resolution of 1998 included suggestion to take into consideration the results of discussion at the General Assembly of the CGMW in further edition of the scale before its presentation at the 31st Session of the IGC in 2000.

The scale of 1998 met numerous objections of Russian stratigraphers. A new circumstantial letter, which summarized opinions of the ISC subcomissions, was sent after its approval at the enlarged ISC bureau, to J. Remane, A. Salvador (former chairperson of the International Subcommission on Stratigraphic Classification, ISSC), and to A. Riccardi, the editor of the second edition of the International Stratigraphic Guide and acting chairperson of the ISSC. The last two addressees informed that they do not also agree with some innovations in the scale. The letter was published in the "Resolutions of the Interdepartmental Committee" of 1999 and in official ISSC Circular (1999). The letter specially emphasized that the project of the International stratigraphic scale needed in discussion by national stratigraphic bodies. As is clear now, J. Remane was not going to follow this suggestion and presented at the 31st Session of the IGC (Rio de Janeiro, 2000) the International stratigraphic chart (colored and with explanatory notes) similar in principle to the version of 1998. Moreover, the presented version included some unsubstantiated renovations. The emblems of UNESCO and IUGS meant to confirm the status of the chart (*International Stratigraphic…*, 2000).

The International Stratigraphic Chart of 2000 (ISC-2000) was considered briefly by all the ISC commissions on Precambrian systems and subdivisions and twice at meetings of the ISC bureau in September of 2000 together with members of the Scientific–Editorial Council of the Ministry of Natural Resources and at its enlarged meeting in February of 2001with myself as a speaker (Zhamoida, 2003). After discussion of the International Stratigraphic Chart and received comments to it, the ISC Bureau approved the detailed resolution, which was forwarded to the Scientific–Editorial Council of the MNR. The resolution emphasized a significant similarity between the International Stratigraphic Chart and the General Stratigraphic Scale accepted in Russia as a statutory standard (*Stratigraphic Code*, 1992). Features in common were as follows: subdivision of the scale into three largest units, the Archean, Proterozoic, and Phanerozoic (they are termed as eonothems and acrothems in the ISC and Russian GSS, respectively) with close ages of lower boundaries accepted for two upper units; traditional systems, series (except for the Silurian, Carboniferous, and Permian), and stages (except for the Cambrian, Ordovician, and Upper Permian) accepted in the scale; similar letter indices for erathems, systems, and series (except for the Cambrian and Paleogene) and identical coloration of most subdivisions. For the first time, the official ISS includes the autonomous Paleogene and Neogene systems, Induan and Olenekian stages of the Triassic (both systems and stages used in the USSR since 1956 were approved by the ISC resolution) and all "Russian" Carboniferous and Lower Permian stages. At the same time, the International Stratigraphic Chart of 2000 contains several renovations, which do not appear to be sufficiently substantiated. The approval of some renovations can result in serious violations of traditional rules in geological mapping used by most national geological surveys and in international projects.

The resolution on the ISC-2000 was published in *Resolutions of the Interdepartmental Committee* of 2002 and in regular ISSC Circular (2001) and sent to the International Commission on Stratigraphy and to M.B. Cita (Italy), the current chairperson of the ISSC. Some Russian geologists accepted showy copies of the ISC-2000 accompanied by explanatory notes as the approved official international document. Therefore, several Russian journals published articles, where the statute of this chart was clarified and which included relevant resolutions of the Russian ISC (Zhamoida, 2000; Zhamoida and Prozorovskaya, 2001; Gladenkov, 2001).

Gladenkov (2002) represented officially the Russian ISC at the working meeting of the International Commission on Stratigraphy (Urbino, Italy, 2002) dedicated

[1] In Russian, the English word "chart" corresponds in the considered case to word "scale" (*Addendum to the Stratigraphic…*, 2000).

to the present problems and prospects of stratigraphy. He informed about reports of all chairpersons of subcommissions on systems (from the Cambrian to Quaternary) on the present-day knowledge of various systems and on plans for 2004–2006. It was decided at that meeting to prepare and distribute a new version of the International Stratigraphic Scale with recent data on subdivision and dating of ancient sections by 2004, i.e., by the 32nd Session of the IGC.

The results of the ICS working meeting in Urbino are briefly presented in the article by F. Gradstein, the chairperson of the Commission, and J. Ogg, its general secretary (Gradstein and Ogg, 2002). The article is supplemented with the chart of the Overview of GSSP (compiled by Ogg) lacking letter designations of the International stratigraphic scale.[2] The Phanerozoic stages are accompanied by a brief and very incomplete characterization of their lower boundaries, sometimes with indication of the Principal correlative events, by the name and location of the GSSP, boundary status (approved or debatable), and reference publication (mostly from journal *Episodes*). Magnetostratigraphic data are shown for the lower boundaries of the Neogene stages and the Aptian, and the Ir-anomaly is shown at the Danian Stage base.

The principal difference of the Phanerozoic stratigraphic scale under consideration (ISC–2002) from previous versions consists in elimination of the Quaternary System as an autonomous system (period), because the Holocene and Pleistocene are included into the Neogene System.

## PRECAMBRIAN

The Precambrian portion of the International stratigraphic scale of 2002 is identical to that in the ISC-2000: boundaries of subdivisions are characterized here by the same approved Global Standards of Stratigraphic Ages (GSSA). In its structure, nomenclature of subdivisions, and boundary ages, the Proterozoic part of the new scale corresponds to the scale approved by the International Subcommission on Precambrian Stratigraphy (Plumb, 1991). Therefore, the former assessment of the Precambrian scale formulated in the resolution of the ISC Bureau of February 2, 2001 (*Resolutions of the Interdepartmental…*, 2002) remains valid and consists in the following:

(1) The ISC cannot accept the principle of the Precambrian scale constructing based chronometric data only, i.e., the refusal from the uniform approach to both the Precambrian and Phanerozoic, which is of essential importance. By the way, Professor H.D. Hedberg, the editor and, in fact, the author of the first International Stratigraphic Guide (1976) was an advocate of this concept.

(2) The general Precambrian stratigraphic scale elaborated by Russian stratigraphers and based on the complex study of type sections with recognition of specific geological formations and analysis of isotopic dates obtained by different methods demonstrated a high efficiency of the historical–geological approach to subdivision and correlation of Precambrian sequences. Therefore, the ISC recommends to use the Lower Precambrian stratigraphic scale approved at the 3rd All-Russian meeting (Apatity, 2000) and Upper Precambrian (Upper Proterozoic) scale approved at the 2nd All-Union meeting (Ufa, 1990) with specified isotopic dates for the Upper Riphean, Lower and Upper Vendian, and Cambrian lower boundaries published in *Addenda to the Stratigraphic Code of Russia* (2000). Both these scales were approved at enlarged meetings of the ISC Bureau and published (*Resolutions of the Interdepartmental…*, 1992, 2002; *Resolution of the 3rd All-Russian Meeting…* 2001).

(3) Recognition of geological systems in the Proterozoic is unacceptable except for the Vendian System that is comparable with the Neoproterozoic-III in the International Stratigraphic Chart. The stratotype of the Vendian System is comprehensively studied in the East European platform and its reference section in carbonate facies, in the Siberian platform.

According to recent data, the isotopic age of the Vendian and Upper Vendian lower boundaries is accepted to be at $600 \pm 10$ Ma and within the interval of 570–555 Ma, respectively (*Addenda to the Stratigraphic Code…*, 2000). Stratigraphic analogues of the Vendian are established in southern China, Australia, South Africa, Canada, and in the British Islands. The Vendian System is included in serial legends of State geological maps of Russia and widely used by geological mapping in Ukraine and Belarus (*The Vendian System*, 1985; Sokolov, 1997).

## UNIT AND BOUNDARY STRATOTYPES

Before going to analysis of the general Phanerozoic stratigraphic scale, we should dwell on the problem of relationship between a stratotype of subdivision in the general scale and the lower boundary stratotype of that subdivision (or limitotype). This issue was in detail considered in the report to the International Symposium "Upper Permian Stratotypes of the Volga Region" (Zhamoida, 1999), therefore I repeat here only some principal points.

In 1996, the ICS approved the statute of the Global Boundary Stratotype Section and Point (GSSP). Although the attitude of geologists to this concept is different (Naidin, 1998; Zhamoida, 1999; Gladenkov, 2001; and others), the proposed procedure of selecting the lower stage boundaries is approved by international stratigraphic bodies and consequently, is obligatory. Description of the procedure is given in the Addendum 2 to the Russian Stratigraphic Code of 1992 and in

[2] Let us conditionally term it as the ISC-2002.

**Table 1.** Amount of Phanerozoic stages in the International Stratigraphic Charts of 2000 (2002) and their status according to the International Commission on Stratigraphy (Table 1, Gradstein and Ogg, 2002)

| GSSP / Geological systems | Number of stages in ISC-2000 and ISC-2002 | Number of approved GSSP, years of approval | | | Candidates for approval | Guide events at boundaries not defined |
|---|---|---|---|---|---|---|
| | | ISC-2000 | Added to ISC-2002 | Total number | | |
| Cenozoic | 18 | 8 / 1985–97 | – | 8 | 3 | 5 |
| Mesozoic | 30 | 2 / 1996–2000 | 4 / 2000–02 | 6 | 9 | 8 |
| Carboniferous–Permian | 16 | 3 / 1990–96 | 3 / 2001 | 6 | – | 4 (Carboniferous) |
| Silurian–Devonian | 15 | 15 / 1972, 1980–95 | – | 15 | – | – |

*Addenda to the Stratigraphic Code of Russia* (2000). At the same time, it is impossible to agree that the stage validity depends on the approved GSSP. According to this approach, almost all Mesozoic stages (except for the Aalenian and Bajocian) would be unofficial in the ISC-2000, although they are recognizable in practice more reliably than some Paleozoic stages with approved GSSPs. Moreover, despite urgent requests of the ISC, substantiated GSSPs for different intervals of the general scale are proposed very irregularly (Table 1), and this is likely not incidental.

The first International Stratigraphic Guide (1976) points to significance of the stratotype for chronostratigraphic (general) units. In the second edition of the International Stratigraphic Guide (1994), only the boundary stratotypes, i.e., the GSSPs are considered obligatory for general subdivisions. Nevertheless, A. Salvador, its editor considered the study of unit stratotypes desirable at least, understanding a universal significance of this procedure (ibid, p. 88).

Authors of the *Revised Guidelines for the Establishment of Global Chronostratigraphic Standards by the International Commission on Stratigraphy* (Remane *et al.*, 1996) are of a principally different opinion. In the sections entitled "Boundary-stratotypes instead of unit-stratotypes," they unequivocally state: "Chronostratigraphic units of the Phanerozoic Global Standard can only be defined through boundary stratotypes" and further: "The use of terms like holostratotype, parastratotype, etc. should therefore be avoided" (ibid, p. 78). Thus, according to the International Stratigraphic Guide (1994) and the guidelines mentioned above, the unit stratotypes of the General stratigraphic scale will turn into an exception in the geological practice.

Gladenkov (2001, p. 111) justly notes that the passion for "points" and "nails" in stratigraphy reduces to zero the analysis of the ISS stratigraphic units proper, actually belittling and even excluding the regional stratigraphy out of the "ISS perfection process." Meanwhile, the International (General) stratigraphic scale was itself constructed based on regional stratigraphy or, as was noted by Sokolov (1971, p. 160) is a "consequence of the purely regional synthesis."

Another important point is as follows. To select and substantiate in line with the accepted procedure, and to approve the GSSP is only half the work. The main objective is to establish this boundary in particular sections worldwide. Moreover, sediments corresponding to various units of the General stratigraphic scale should be correlated.

The International Stratigraphic Guide (1994) and leaders of the ICS (Remane *et al.*, 1996) recommend a wide application of non-biostratigraphic methods for GSSP selecting. The suggestion is correct. Nevertheless, despite doubtless achievements, the isotopic, magnetostratigraphic, geochemical, paleogeographic, and other methods are far from being self-sufficient for remote correlation. The recommendation to apply the sequence stratigraphy method when selecting the GSSP looks even stranger. Authors of the Guidelines themselves consider the biostratigraphic method as the main one for definition of boundaries between Phanerozoic units.

A stage, the stratotype of which materializes the corresponding interval of the scale, is the main stratigraphic unit in the General stratigraphic scale of the Phanerozoic. Boundaries between series and systems correspond to the stage boundaries. Specification of boundaries between stages is specification of boundaries between zones. The first question is therefore: which interval of the section should be included into the boundary stratotype? Is it enough to take one zone from each conjugate unit or should we take two–three zones from them for the reliability? What should we do if there are only two or three zones in the stage? In this

case, practically the entire stage, i.e., its stratotype, should be taken into account.

Another question concerns the so-called conjugation of successive zones. For the Phanerozoic, only successive changes in the fossil faunal (floral) assemblages (following the Hucksley's principle) or in continuous phylogenetic lineages enable a relative objectivity in selecting the events, which are important for recognition of any boundary stratotype, the GSSP inclusive. This approach precisely is recommended for the GSSP substantiation, although it is incompletely reasonable, because only two levels (base and top) but not the whole section (unit stratotype) are under consideration.

"Extracting" from the section the boundary layers only by selecting the GSSP, we encounter the other uncertainties. First, significance of several plant groups (macroflora, spore-pollen assemblages, charophytes) recedes, because boundaries of relevant units are frequently established based on changes in quantitative distribution of the same taxa (domination degree). The same is true of some freshwater fishes and benthic animals. Given these fossil groups useless, it will be naturally difficult to establish boundaries between the GSS units in continental sections. It should also be noted that recommendation to use solely sections composed of pelagic sediments when selecting the GSSP is disputable, particularly for the systems represented mostly by continental sediments, volcanogenic facies included. In general, using as many fossil groups as possible by characterization of any stratotypes (boundary stratotypes included), we get a highest efficiency of stratigraphic correlations.

The idea to select a narrow interval for the boundary does not account for some phenomena such as, for instance, the appearance of species and genera at different stratigraphic levels in different regions. This phenomenon improperly stipulated is responsible for the notion of "transitional beds" and "time belt" in the Norwegian stratigraphic code (*Regler for Norsk Stratigrafisk Nomenclatur,* 1961).

When the stratotype is ignored, difficulties and even impossibility are unavoidable in tracing boundaries between the GSS units because of "sedimentological factors."

In condensed or lithologically uniform sections, boundaries between units, for example between stages, can be interpolated from more distinct marker horizons located below or above, i.e., beyond the boundary stratotype interval. In sections of most systems, there are the correlative levels of this kind recognizable in different continents. The same approach should be used in case of hiatuses, event though they are short, either within sediments of some GSS unit or, in particular, in the boundary intervals. Even if a boundary is reliably established in areas located far away from the boundary stratotype, it is always useful to define marker horizons (biostratigraphic ones included) to enhance validity of that boundary.

Neglecting the unit stratotype, we practically exclude applicability of rhythmostratigraphic methods (sensu lato), which are useful for intercontinental correlation, although to a lesser extent than some researchers believe. The same is true of the so-called event-stratigraphy method very popular now. In fact, stratigraphy since its appearance is completely based on registration of events, although mission of event-stratigraphy is to define those boundary events recorded in a section, which were much shorter than events recorded below and above in the succession. It is clear that this is hardly attainable in a narrow boundary interval desirable for the GSSP. Thus, the unit stratotype disavowal appears to be a great error as far at it concerns the Phanerozoic subdivisions of the general stratigraphic scale. The boundary stratotype is not an alternative to the unit stratotype of any kind, the GSS stratigraphic subdivisions included.

The unit and boundary stratotype are complementary notions. It seems that adherents of the unit stratotype denial are interested in the establishment and official approval of the GSSP rather than in possibility of practical tracing of given boundaries in particular intricate situations.

## PHANEROZOIC

I am in bewilderment why all the Cambrian stages became excluded from stratigraphic scales of 2000 and 2002, especially the "Russian" stages of the Lower and Middle Cambrian, which were included into the Global stratigraphic scale of 1989 (Cowie and Busset, 1989). In Russia, geologists use the scale of the Cambrian System recommended by the Stratigraphic Code (1992) with addition of the Upper Cambrian Batyrbaian Stage of 1997, which overlies the Aksaian Stage (*Resolutions of the Interdepartmental…*, 1997). The isotopic age of the Cambrian lower boundary in the ISC-2000, ISC-2002, and in the Russian scale is estimated to be 540 ± 5, 543.3, and 535 ± 1 Ma, respectively (*Addenda to the Stratigraphic…*, 2000).

In the scale of 2002, boundaries of the third (Middle Ordovician) and fifth (Upper Ordovician) yet unnamed stages are approved, in addition to the lower boundaries of the Tremadocian and Derrivilian stages officially approved for the ISC-2000. Such a situation and still "uncertain" status of the Derrivilian Stage are hardly admissible from the standpoint of the general stratigraphic scale.

Russian stratigraphers cannot accept subdivision of the Silurian System into four series as proposed in the ISC-2000, because this act violates traditions. The Silurian is subdivided in two series: the lower one including the Llandoveri and Wenlock and upper series consisting of the Ludlow and Přidoli. The proposed units termed as stages in the ISC-2000 are used in Russia in the substage rank.

All the stages of Devonian System have their lower boundaries approved; the Silurian–Devonian boundary was approved in 1972.

In the ISC-2000 and ISC-2002, the Carboniferous System is subdivided in two, the Mississippian and Pennsylvanian subsystems. The former corresponds to the traditional Lower Carboniferous (with Tournaisian, Visean, and Serpukhovian stages) and the latter can be subdivided in two series with ranges determined by stages of the East European scale: the lower series (middle series of the system) of the Bashkirian and Moscovian stages and the upper series of the Kasimovian and Gzhelian stages. In opinion of the ISC Commission on the Carboniferous System, the Tournaisian and Visean stages can be regarded in the rank of superstages divisible into stages (two in each) corresponding to well-substantiated regional units of the East European scale.

In the ISC-2002, only lower boundaries of the system and Pennsylvanian Subsystem (Bashkirian Stage) are considered as officially approved. As for the boundaries of four remaining "Russian" stages, it is stated there: "Guide event is undecided." The wording should alarm Russian stratigraphers who must undertake resolute actions for circumstantial argumentation to substantiate validity of these stages. This means the accomplishment of formal, though rather strict requirements for the GSSP approval.

The Permian System of the ISC-2000 is proposed to be divided into three series. It should be noted that Russian stratigraphers repeatedly discussed a possibility of three-member subdivision as well. Names of the series (Cisuralian, Guadalupian, and Lopingian) violate traditional rules of the stratigraphic nomenclature, although they seem to be justified as eliminating the alternative reading. The lower system boundary only is approved in the ISC-2000, and thus, only the Asselian Stage is admitted. In 2001, the GSSPs of all three stages of Guadalupian series and, consequently, its basal boundary were approved. The International Subcommission on Permian Stratigraphy (ISPS) presented the lower boundary of the Lopingian Series for the approval. The Russian experts on Permian stratigraphy undertake intense actions to substantiate the remaining three "Russian" stages of the lower Cisuralian Series and to present them for the official approval. This issue is to be discussed at the General Symposium G-22.04 (32nd Session of the IGC) "Global Correlation of Cisuralian stages (Lower Permian)" with B.I. Chuvashov as one of conveners. Inasmuch as the Permian Period was a time of widespread continental sedimentation, the Interdepartmental Stratigraphic Committee of Russia suggests to approve officially two parallel scales for the Upper Permian (Guadalupian + Lopingian): the East European scale for the Biarmian and Notal realms and for other regions with continental Permian sediments, and the ISS version for the equatorial and Tethyan regions. The latter cannot practically be used in the other realms and regions.

This proposal was supported by participants of the International Symposium "Upper Permian Stratotypes of the Volga Region" (*Reports…*, 1999), Prof. B. Wardlow, the chairperson of the ISPS included. The scale proposed by the Interdepartmental Stratigraphic Committee can be accepted as the basic (main) one.

The recent finds of Roadian ammonoid and conodont assemblages in basal strata of the Kazanian Stage and Wordian conodonts found in Kazanian deposits of various regions of Russia (Novaya Zemlya, Verkhoyan'e, southern Primor'e, and others) offer an opportunity of direct correlation between the East European scale and ISC-2000.

All the Cretaceous, Jurassic, and Triassic stages of the international stratigraphic scale were accepted in Russia as official units and were always used in geological legends of various kind and in stratigraphic studies. Nowadays, they are in use as formerly in Russia and in all northern countries of the former USSR. In opinion of the Interdepartmental Stratigraphic Committee, it would be unreasonable and inadmissible to rename or replace the Mesozoic stages. As for the Mesozoic of the ISS, the Induan (Triassic lower boundary), Sinemurian, Aalenian, Bajocian, Cenomanian, and Maastrichtian stages are considered in it as officially approved.

The lower boundaries of the Paleogene (Danian Stage) and Neogene (Aquitainian Stage) systems are officially not approved. The Paleogene–Neogene scale used in Russia is identical to that of the ISC-2000.

## QUATERNARY SYSTEM

As is known, the Quaternary System of the Pleistocene and Holocene is broadly acknowledged, being in use since the first quarter of the 19th century. It is included in all international and regional (national) stratigraphic codes. The International Union for Quaternary Research (INQUA) with its Commission on Quaternary Stratigraphy exists since the 1930s.

In the former USSR, the Commission on Quaternary Research under the aegis of Academy of Sciences was formed in 1927 on initiative of academician V.I. Vernadskii. It was successively headed by academicians A.P. Pavlov, F.Yu. Levinson-Lessing, I.M. Gubkin, V.A. Obruchev, V.N. Sukachev, G.I. Garetskii, and A.L. Yanshin. Since organization of the Interdepartmental Stratigraphic Committee in 1955, the commission on the Quaternary System actively collaborated with this institution. In Russia, the Pleistocene was traditionally divided into the lower and upper subseries.

In 1995, the subseries were named by the ISC approval as Eopleistocene (corresponds to the lower Pleistocene or Calabrian of the European scale) and Neopleistocene (corresponds to the middle–upper Pleistocene of the European scale) (Table 2, *Resolu-*

**Table 2.** General stratigraphic scale of the Quaternary System (*Addenda to the Stratigraphic Code of Russia*, 1992, p. 23)

| General stratigraphic units | | | | | Principal geochronologic boundaries (Ma) | Geochronologic units | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| system | series | subseries | link | step | | period | epoch | phase | time | thermochron, cryochron |
| Quaternary | Holocene | | | | –0.01– | Quaternary | Holocene | | | |
| | Pleistocene | Neopleistocene | upper | forth | | | Pleistocene | Neopleistocene | late | late cryochron |
| | | | | third | | | | | | late thermochron |
| | | | | second | | | | | | early cryochron |
| | | | | first | | | | | | early thermochron |
| | | | middle | | | | | | middle | |
| | | | lower | | | | | | early | |
| | | Eopleistocene | upper | | | | | Eopleistocene | late | |
| | | | lower | | –1.8– | | | | early | |
| Neogene | Pliocene | Upper | | | | Neogene | Pliocene | | | |

*tions of the Interdepartmental…*, 1996; *Addenda to the Stratigraphic Code…*, 2000).

The Quaternary, as an autonomous system consisting of two series (Holocene, Pleistocene), was included into the ISC-2000 and discussed by Gradstein (2000). Nevertheless, in their article on scientific perspectives of stratigraphy, Gradstein and Ogg (2002) eliminated the Quaternary System from the chart and included Holocene and Pleistocene into the Neogene System without any reasoning. Their chart was reproduced in the ISSC Circular (2002) also without necessary comments.

The chart includes principal correlative events marking lower boundaries of the Holocene and three Pleistocene subseries. The Pleistocene lower boundary is dated at 1.806 Ma (the base of the Vrica sapropel beds in Italy) and the Holocene lower boundary at 0.1 Ma, i.e., as in Russia. There is a peculiar comment to the Neogene System: "The "Quaternary" (quotation marks as in original, A. Zh.) is traditionally considered to be the interval of oscillating climatic extremes (glacial and interglacial episodes) encompassing Holocene and "Pleistocene" (Gradstein and Ogg, 2002, p. 204).

The Interdepartmental Stratigraphic Committee of Russia and Commission on the Quaternary Research of the Russian Academy of Sciences could not agree with such the factual abolishment of the Quaternary as an autonomous geological system of the Cenozoic. The Commission on the Quaternary System of the ISC (S.M. Shik, B.A. Borisov, A.N. Alekseev, Yu.A. Lavrushin, E.P. Zarrina, V.D. Tarnogradskii) and bureau of the committee prepared a relevant letter signed by myself, which was forwarded to the ICS, ISSC, INQUA, and its Commission on the Quaternary Stratigraphy (*Resolutions of the Interdepartmental…*, 2003).

The long-term studies in Russia and other countries brought out clearly that in its geological history the Quaternary sharply differs from the Neogene and from older periods. Characteristic of the Quaternary period were recurrent continental glaciation in middle latitudes (these events have nor been recorded here since the Paleozoic) and alternation of pluvial and arid epochs in low latitudes. These peculiar features of the Quaternary determine a wide distribution of glacial sediments and loess-and-soil formations. These sediments and formations of a great practical significance

for ecology and engineering geology require application of specific methods by the study and geological survey. Quaternary sediments up to several hundreds meters thick are widespread in sedimentary cover of seas and ocean floor and cover the surface of continents. There are two kinds of geological maps used worldwide: of the Quaternary and pre-Quaternary sediments. Maps of the first kind usually depict data on age, genesis, and lithology of sediments, as it is important for practice.

The periodicity of glaciations offers an opportunity to apply climatostratigraphic methods for subdivision and correlation of Quaternary sediments. In combination with biostratigraphic methods (small mammals, landscape palynology, and others), this approach enables definition and mapping of subdivisions corresponding to very short time spans (around 100 k.y.) that is impossible for older, even Neogene sediments.

The appearance and development of the genus *Homo* is a unique feature of Quaternary period that stimulated development of archeological stratigraphic methods unsuitable for older periods of the Earth history. That is why Russian academician A.P. Pavlov proposed in 1919 the term "Anthropogene" for the Quaternary System.

The Quaternary System crowning the General (International) stratigraphic scale differs from others Phanerozoic systems so significantly that it turned into mission of the Quaternary geology, an autonomous complex scientific branch dealing with peculiar features of Quaternary sediments and operating with specific methods of their study. Among specific problems it is addressed to ecological (sensu lato) aspects of stratigraphy are most important. The program of the 32nd Session of the IGC includes General Symposium G 19: Quaternary Geology.

In conclusion, the letter of the ISC emphasizes the validity of the Quaternary System consisting of the Pleistocene and Holocene and attracts the ICS attention to potential difficulties we can meet by geological mapping and by comparison of new and former geological maps and other materials because of changes in the international stratigraphic scale.

In July 2003, I have received the reassuring letter (of July 1, 2003) from F. Gradstein, the chairperson of the ICS, in which he said: "As is usual in Stratigraphic Science, there is a distinction between formally approved and informal stratigraphic names. The ISC fully respects the use of the informal name Quaternary, and it is included in the official time scale at the official website of ICS. An exhaustive documentation of the history and current use of various Cenozoic terms will appear in the forthcoming book "The Geologic Time Scale" (Cambridge University Press) co-authored by 40 stratigraphers. The formal program of ICS does not suppress the name Quaternary. ICS hopes to be able to ratify the definitions of the Middle and Upper Pleistocene Boundaries, as well as the Holocene in the coming years.

It is unknown so far, what an "exhaustive documentation" will appear in a new book *The Geologic Time Scale*, but M.B. Cita, the chairperson of the ISSC considers the Gradstein's position as erroneous, and this may have unexpected consequences (her letter of July 8, 2003). She informed that INQUA is going to organize a new Commission on Stratigraphy, independent on the International Union of Geological Sciences and subordinate ISC.

## GENERAL INFERENCES

(1) It should be once more emphasized that universal documents like the International (General) stratigraphic scale and their changes must be discussed by national stratigraphic bodies, not only by leaders and by several members of ICS subcommissions.

(2) The ISC should officially determine, in coordination with the International Commission on the Geological Map of the World, the status of the proposed International stratigraphic scale, i.e., clearly indicate for what kind of geological works it is obligatory and for what kind is recommended only.

In my opinion, the ISS can be obligatory for all international geological projects, which are financially supported and headed by international scientific bodies. Inasmuch as national geological traditions substantiated by the practice are strong in some countries, the International stratigraphic scale can only be recommended for national or international projects, if international geological bodies do not participate in the latter.

(3) Subdivisions of the ISS (GSS) should have approved the unit stratotypes and the GSSPs, which should be considered as supplementing characteristics for each unit, not alternative notions. The phrase "Boundary stratotypes instead of unit stratotypes" should be excluded from the "Revised Guidelines" to establish the Global Boundary Stratotype Section and Point. The validity (official status) of ISS units cannot be considered as justified only after the approval of GSSPs (official, semiofficial, unofficial). The information on the approval of GSSPs should be published in official circulars of the ISC and its subcommissions in the journal *Episodes* and in International stratigraphic scales issued separately.

(4) In the International Stratigraphic Guide (1994) and ISC-2000, a stage is the lowest-rank unit. In the Russian scale, the lowest-rank unit is a zone, while a step is the smallest unit of the Quaternary System. If the stage remains the smallest unit in the official International stratigraphic scale, it would be desirable to have supplementary biostratigraphic zonations for each system, which must be substantiated by advanced data and approved as standard units. At any rate, the International stratigraphic scale should be supplemented by a chart with indication of two adjoining zones, the

boundary between which corresponds to the boundary between corresponding stages, as it is done long ago for the Jurassic System (*Resolution of Plenary…*, 1963).

(5) There is no officially approved priority principle in stratigraphy, therefore national stratigraphic guides and researchers consider it obligatory to a varying extent and some of them ignore it completely. The priority principle, sufficiently strict and simultaneously permitting necessary divergences should probably be accepted in stratigraphy. Sections 11 and 12 of the Russian Stratigraphic Code (1992) dedicated to the validity and priority of stratigraphic subdivisions can probably be a basis for elaboration of the principle.

(6) The special paragraph in resolutions of the national ISC of February 2, 2001 (*Resolutions of the Interdepartmental…*, 2002) states: "The stratigraphic survey of Russia reserves the right to follow Russian geological traditions in stratigraphy and national geological–cartographic practice and to ignore the ISC-2000 in the intervals, terminology, and nomenclature, which are insufficiently substantiated and inconsistent with mentioned traditions and practice."

This important decision approved by the ISC Bureau was completely included into the resolution that was forwarded to F. Gradstein in December of 2001 and published in the ISSC Circular (2001).

(7) Russian delegates to the so-called General symposia at the 32nd Session of the IGC in Florence (Italy, 2004) should report to participants on the concepts and comments to the ISC-2000, which are outlined above. The ISC Bureau will prepare a special report to the ICS and ISSC meetings.

(8) Russian stratigraphers face the very serious tasks aimed at perfection of the International (General) stratigraphic scale. To solve the tasks, they should undertake all efforts to get the official international approval of stages first defined in Russia. These are all the Cambrian (the Batyrbaian Stage stratotype is in Kazakhstan) and Permian stages, the Serpukhovian, Bashkirian, Kasimovian, and Gzhelian stages of the Carboniferous System, and the Olenekian Stage of the Triassic System. The urgent character of actions is primarily dictated by the potential priority loss, when the stages originally established in Russia will be replaced within various intervals of the general scale by new stages recognizable in other countries. Scientific activity in this direction is fundamental and of practical significance, because it is necessary to keep stability of the General stratigraphic scale that is accepted in Russia as a basis for all geologic-cartographic and other works. The preparation of necessary documents can be performed only in the course of planned scientific–research works with participation of specialists from Russian Academy of Sciences, Ministry of Natural Resources, and higher school under guidance of corresponding commissions of the Interdepartmental Stratigraphic Committee.

The ISC commissions on the Permian and Carboniferous Systems already worked successfully in that direction. As was mentioned, the problem of boundary stratotypes for the Lower Permian stages will be discussed at the 32nd Session of the IGC. The Commission on Cambrian Stratigraphy activated its work: a special meeting headed by A.Yu. Rozanov was organized in Novosibirsk. The work of the Commission on Triassic Stratigraphy aimed at substantiation of the Olenekian Stage official status should also be intensified. Although the lower boundary of the Induan Stage (Triassic System) is approved by the ICS in 2001, it is established in China, not in the stratotype area of Pakistan (*Episodes*, 2001). Zakharov *et al.* (2002) proposed the Triassic section of the Abrek Bay (southern Primor'e) as a candidate for the global stratotype of the Olenekian Stage lower boundary. Judging from presented materials, this boundary is sufficiently well substantiated.

Now, it is difficult to foresee a possibility to organize the state program of studies mentioned above. Nevertheless, after discussion of problems at the 32nd Session of the IGC, the program should be organized in order to get desirable results and to prepare required materials to the next IGC session.

Reviewers Yu.B. Gladenkov and V.A. Zakharov

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