Stratigraphy and Geological Correlation, Vol. 10, No. 6, 2002, pp. 531–546. Translated from Stratigrafiya. Geologicheskaya Korrelyatsiya, Vol. 10, No. 6, 2002, pp. 3–19.

Different Approaches to Perfection of the General Stratigraphic Scale

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Received June 19, 2001

Abstract—Different approaches (American and European) to perfection of the General stratigraphic scale (GSS) are discussed. Practice of the International Stratigraphic Commission that consists, according to recommendations of "International guides," in "hammering in the golden spikes" (GSSP) in rock sequences of monotonous lithology at the levels marked by changes in composition of fossil species (mainly conodonts), which are thought to be evolutionary and independent of the environmental influence, is criticized. Boundaries between series of the Devonian System and between the Permian and Triassic systems are considered as examples, and it is shown that such an approach to recognition of boundaries between major stratigraphic subdivisions violates the priority principle and eventually leads to destabilization and complete reorganization of the GSS. Principles used to specify the GSS are not only of the abstract theoretical interest, but they directly influence practice of geological mapping and other geological investigations.

Key words: General stratigraphic scale, correlation, Global boundary stratotype section and point, Devonian System, Permian System, Triassic System.

INTRODUCTION

The Russian Stratigraphic Code determines the General stratigraphic scale as "an integrity of general stratigraphic subdivisions (in their complete volumes without gaps and overlapping) arranged in their stratigraphic succession and hierarchical subordination" (*Stratigraficheskii kodeks...*, 1992, p. 22). It is believed that general stratigraphic subdivisions are potentially of planetary significance and can be used by geologists from different countries. Therefore, the scale composed of these units is also termed as the International stratigraphic scale (ISS). International stratigraphic and corresponding geochronological scales were elaborated in general more than a century ago and were approved at the Second session of the International Geological Congress in Bologna, Italy in 1981. Since that time, the International stratigraphic scale served as a basis for any geological researches. In opinion of Leonov (1973), it did not experience any substantial changes until the 1970s. All introduced changes and additions were insignificant and did not violate the general principle the scale is based on.

The second half of the 20th century and particularly the last decades were characterized by intense researches aimed at perfection of the general stratigraphic scale. The activity of the International Stratigraphic Commission whose purpose was to specify boundaries between geological systems, series, and stages also intensified. Many Soviet geologists were involved in different international projects. Simultaneously, investigations of precisely this period showed differences in approaches to solution of main stratigraphic problems. Two different concepts that appeared were conditionally termed the "American" and "European" ones (Zhamoida and Menner, 1974).

The "American" concept, as it is reflected in the American Stratigraphic Code and in the International Stratigraphic Guide (1976) translated into Russian under the name *Mezhdunarodnyi stratigraficheskii spravochnik* (1978), is based on the idea of multiple independent stratigraphic categories of different significance (lithostratigraphic, biostratigraphic, chronostratigraphic). It also assumes the artificial character of boundaries between units of the general stratigraphic (geochronological) scale, which should be distinguished in a continuous succession of preferably marine sediments. The priority principle obligatory for the scientific terminology is virtually ignored. Serious changes have not been introduced into the second edition of the guide (*International Stratigraphic...*, 1994; Zhamoida, 1996).

The "European" concept that is reflected in stratigraphic codes of the USSR and Russia (*Stratigraficheskii kodeks...*, 1977, 1992) considers stratigraphy as a single fundamental branch of geological sciences, but not as many *stratigraphies* independent from each other and based on different research methods. According to this concept, main stratigraphic subdivisions, including global, regional, and local ones, are of a geosystem nature, because they reflect certain stages in development of the geosphere as a whole and of its separate parts. Special stratigraphic units are established using special methods and are auxiliary to main subdivisions.

Many researchers (Zhamoida and Menner, 1974; Menner, 1978; Zhamoida and Moiseeva, 1980; Sokolov *et al.*, 1992) expressed a hope for the gradual convergence of the "American" and "European" concepts and elaboration of a common approach to main stratigraphic problems. The further events showed, however, that proposals of many European (including Russian) stratigraphers are ignored. Members of the Working group on editing of the International Stratigraphic Guide (including representatives of Australia and the USSR) who disagreed with views of its leaders lost opportunity to participate in this work, and the published guide reflects only one standpoint.

The further development of principles for selecting global stratotypes of boundaries between ISS units, which are formulated in the *International Stratigraphic Guide*, can be seen in *Guidelines for establishment of global chronostratigraphic standards* (Remane *et al.*, 1996). This brief *manifest of contemporary chronostratigraphy* contains some rightful provisions. It states that the priority should not be ignored completely, when selecting the boundary stratotypes,[1] and that other criteria, e.g., levels of particular events and others, should be used along with paleontological ones. These good intentions however disappear from solutions under the pressure of *interests* of the voting majority, but not of *scientific arguments.* It is absolutely clear that voting is not a scientific method of solving problems. Attempts to solve scientific problems by voting are based on the assumed artificial character of stratigraphic boundaries and *convenience principle.* According to Leonov (1973, p. 517), "the personal convenience meant here is usually inconvenient for others. It is apparent that common agreed principles cannot be elaborated for the international scale based on such approach."

Main drawbacks of mentioned guidelines consist in ignoring the European concept of stratigraphic classification that is based on a tremendous experience of European (including Russian) geologists and resolutions of international geological congresses, besides the neglecting of priority principle. All this played a negative role during elaboration of a new variant of the general stratigraphic (geochronological) scale that was presented at the last IGC session. Many points of this project appeared to be inappropriate for Russian geologists, as it can be partly seen from the Interdepartmental Stratigraphic Committee resolution adopted in 1999.

We do not intend in this paper to discuss once again the problem of the artificial character of boundaries between ISS units and persuade our opponents in fallibility of their views. This is impossible in view of the character of contemporary discussions. The aim of the paper is to demonstrate negative consequences that result from the modern practice to approve new boundaries between geological systems and their series based on recommendations of "international guides." We want as well to discuss the topical question: how should stratigraphers who are categorically against some novelties behave in order to protect the domestic stratigraphy from harm?

Any researcher who realizes the dialectics of scientific knowledge development should understand that extreme approaches could never serve as a basis for constructive solutions. Nobody amid adherents of the "natural" character of the ISS subdivisions do not consider the latter as corresponding to similar one-rank stages in development of lithosphere and biosphere. Otherwise, attempts (still unsuccessful) of radical reorganization of the geochronological scale based on major tectonic, biological, and other events would be less numerous. The contemporary geological science is not ready for such reorganization. Simultaneously, irregular patterns (and certain periodicity) of earth crust, hydrosphere, and atmosphere evolution represent the empirically established regularity.

Elaboration of the global stratigraphic scale developed spontaneously. Views on position of boundaries between stratigraphic subdivisions changed many times. Significance of events that substantiate boundaries between systems and series is far from being unambiguous. Moreover, boundaries between some series are undoubtedly more important in the historical–geological respect than boundaries between systems. These and many other facts allow the International stratigraphic scale to be considered as representing a *conditional* construction. Simultaneously, this conclusion has nothing to do with proposition to consider the geochronological scale as the *artificial* construction and with attempts to completely exclude the principle of "natural character" peculiar of stratigraphic subdivisions from stratigraphy, as it was done in the American and international stratigraphic codes. Considering the global stratigraphic scale as a conditional construction, G.P. Leonov simultaneously emphasized that "more or less complete correspondence of most subdivisions in the international scale to certain stages in geological development of separate regions is evident from the entire history of defining of these units, being out of doubts" (Leonov, 1973, p. 453).

In his fundamental work on stratigraphy, Leonov managed to avoid extremities, "walked along the razor blade," and formulated principles of converting the International stratigraphic scale into the universal, stable, and sufficiently detailed system of geochronological classification. He suggested "(1) to consider the geochronological scale as a conditional construction, (2) to follow the regional–stratigraphic principle of determining the range and boundaries of its units based

[1] However, when determining ranges of ISS units, the authors likely mean preferential variants of new global boundary stratotypes rather than the priority principle or "historical method" that was certified in resolutions of the 8th International Geological Congress and in all classic works.

on relevant stratigraphic standards corresponding to particular regional stratigraphic units, and (3) to keep stable the ranges and boundary positions in the international scale based on the priority principle" (Leonov, 1973, p 526). If international geological organizations were following these recommendations, situation with the ISS would be different. Unfortunately, the International Stratigraphic Commission took another way, and as a result we have now what we have.

In order to retain the traditional regional–stratigraphic principle of establishing the unit boundaries, laborious researches are needed. One should pass, using correlation based on the principle of chronological interchangeability of certain indications (Meyen, 1989), from sections with hiatuses and sharp facies variations, which were used to establish the units originally, to other sections, where hiatuses are minimal or (in the ideal case) absent at all, and where indications of corresponding events are expressed in a different form. Precisely such sections are appropriate to select the GSSP.

Nevertheless, the International Stratigraphic Commission and its subcommissions recommend to "hammer in the golden spikes" in the parts of sections of uniform lithology, where successions of fossil species are allegedly independent on the environmental influence, being exclusively evolutionary. Such a way of searching for the "ideal" boundaries is widely used, although it strongly resembles an old anecdote about a person who searched for the purse under the lantern, because there is lighter, but not in the place of loss. Rock members, which fit the above requirement, are rare near traditional boundaries between systems and series, being more frequent in their middle parts. Accordingly, the newly selected levels appear to be substantially displaced relative to the former. An approval of such levels as corresponding to boundaries between major stratigraphic subdivisions results in a brute violation of the priority principle and, eventually, in destabilization and complete reorganization of the general stratigraphic scale (Karaulov, 1994).

Refusing to use the historical–geological method of establishing boundaries between major stratigraphic subdivisions of the ISS, we objectively meet the situation, when the number of features, which can potentially characterize a boundary, radically decreases. For the sake of the truth, it should be noted that the last achievements in development of non-paleontological methods, for instance, the Ir geochemical anomaly established across the Cretaceous–Paleogene boundary, a sharp decrease of $\delta^{13}C$ values across the Permian–Triassic boundary, or recognition of narrow paleomagnetic zones, clearly demonstrate their significance for precising the boundary levels (Remane *et al.*, 1996). Nevertheless, the leading role still belongs, as before, to paleontological criteria. The latter are often understood as the *first appearance* of a species selected arbitrarily (by agreement or voting) that actually means *the first occurrence level* of that species in a particular (stratotype) section. In the majority of sections, barren layers and members separate sediments bearing paleontological remains. To avoid the problem to what adjacent fossiliferous units such intervals should be referred, many researchers prefer to select the boundary stratotypes in condensed sections, which are extremely rare, having very low correlation potential based on fossil remains of some "ultrastratigraphic" groups only.

Conodonts, which were under keen attention in last decades, often to the detriment of other similarly important fossils, represent one of such fossil groups.[2] Conodont remains are found to characterize previously "barren" intervals in different marine sections composed of terrigenous, calcareous, and siliceous sediments—the fact of a positive significance for stratigraphy. On the other hand, the researchers who study conodonts consider them a priori as representing the *archistratigraphic* group and attribute a supreme role to the conodont zonal standards. Nevertheless, drawbacks of the stage stratigraphic scale of the Permian System that is based exclusively on conodonts and formal successive replacement of their species in a single phylogenetic lineage were recently discussed by Leven (2001). Traditional fossils such as ammonites, which served successfully before and serve now as a basis for subdivision of Paleozoic and, particularly, Cenozoic sequences, are ignored in this case.

As a result, practical geologists are deprived from opportunity to trace confidently boundaries of the ISS units and to show them in geological maps. Paleontological methods are undoubtedly decisive for the Phanerozoic stratigraphy. Nevertheless, if we really want to establish boundaries between major stratigraphic subdivisions of the global nature, we should take into consideration stages in development of the whole organic world, verifying our conclusions by other, first of all, lithological–formational methods, which allow the different-rank historical–geological stages to be objectively revealed.

There are many examples when methods adopted by international organizations for defining boundaries between major ISS units negatively influence practical geological investigations. We will consider here only some of them concerning those intervals of the stratigraphic scale, which we are better acquainted with from our experience. Before the pertinent discussion, let us consider the most general problem of positioning the Precambrian–Phanerozoic boundary.

[2] Conodonts are the multielement remains of circumoral apparatuses of ancient animals whose integral biological system, but not its disintegrated elements, is now under incipient deciphering only (e.g. Orchard and Rieber, 1998). Stratigraphically most informative are their paired elements Pa. At present, there is a tendency to define two types of conodont zonal scales based on pelagic and shallow-water forms.

ON THE CAMBRIAN LOWER BOUNDARY

The most important problem related to specification of boundaries between geological systems has always been and remains now the problem of the lower boundary of the Cambrian System (and of the entire Phanerozoic as well). We are not experts in this field and just can discuss some aspects concerning the method applied for the boundary establishing. The All-Union meeting held in Ufa in 1967 decided that, defining the lower boundary of the Cambrian System, geologists should take into consideration paleontological data first of all, regarding the appearance of skeletal fauna as the most important criterion. Similarly to members of the International Working Group on the Precambrian–Cambrian boundary, participants of that meeting considered it unnecessary to use the historical–geological criteria (Rozanov *et al.*, 1976). Searches for the global stratotype of this boundary lasted more than 30 years and ended with decision to select the necessary point in the Newfoundland section and to define it based on changes in ichnofossil assemblages (fossil traces of organisms of unclear taxonomic affinity); this appeared to be absolutely unacceptable for the Russian and many other stratigraphers (Rozanov *et al.*, 1997).

This could be expected, because the decision was made by voting under influence of researchers occupying key position in relevant international organizations who had their particular, not always scientific and purposeful interests. Discussing the problem of the boundary in question, Sokolov (1997, p. 5) wrote: "From my standpoint, it is defined now as a standard one quite accidentally at the base of the *Phycodes pedum* Zone of Newfoundland, thus being based on fossilized traces of unknown organism of a wide stratigraphic range. Of course, this boundary stratotype should be revised with due account for traditional biostratigraphic requirements, though the decision that *physical zone at the base of the Cambrian System should be reliably recognizable worldwide remains principally important.*"

From our point of view, the refusal from the historical–geological (regional-, event-, and eco-stratigraphic) criteria was premature and erroneous, because precisely the mass appearance of skeletal organisms at the base of the Tommotian Stage (Rozanov *et al.*, 1969) is the most important argument in favor of placing the considered boundary at this level from both the paleontological and historical–geological standpoints. From the last standpoint, a hiatus present at the base of most Tommotian sections only emphasizes the boundary significance and does not represent an obstacle for its approval as a lower boundary of the Phanerozoic, especially if we take into consideration the fact that there are sections where this hiatus is minimal or absent at all. In any case, only relevant resolutions of the Interdepartmental Stratigraphic Committee are appropriate for geologists who carry out investigations in the Siberian platform and other regions of Russia.

BOUNDARIES OF THE DEVONIAN SYSTEM AND ITS SERIES

The problem of the Devonian lower boundary has a long-lasting and very pictorial history considered in detail by Leonov (1973). A special committee of the IUGS Stratigraphic Commission that was organized in 1960 had to solve the problem of boundary separating the Silurian and Devonian systems. Since that time, several national and international programs of stratigraphic research across the Silurian–Devonian boundary deposits, which searched for a satisfactory solution of the boundary problem in continuous marine sequences, were accomplished in different countries (*Granitsa silura...*, 1971).

These investigations yielded new extensive materials, according to which the Silurian–Devonian boundary was placed at the first appearance level of *Monograptus uniformis*, the zonal graptolite form, between the Pridolian and Lochkovian stages of the Pragian syncline. This decision was approved at the Montreal session of the International Geological Congress in 1972. The GSSP of the boundary was established in the Klonk section 35 km southwest of Prague. It should be emphasized that in this case the boundary between stages, which were previously defined as formations, was selected to represent a boundary between major stratigraphic subdivisions of the ISS, i.e., the regional–stratigraphic principle has not been violated.

The selected boundary was accepted by the majority of stratigraphers. It is close to the traditional one (slightly higher than that accepted in England, slightly lower as compared with the level previously adopted in the USSR, and approximately corresponding the Belgian–German variant) and bears a certain historical–geological meaning (coincides with the beginning of one of the transgressive–regressive cycles and with a substantial biota renewal), being widely traceable based on several features, although significance of corresponding events is noticeably lower in comparison with some other Devonian boundary events.

Resolutions on series boundaries of the Devonian System, which were adopted by the International Subcommission of the Devonian Stratigraphy (SDS) organized in 1972, are more controversial. When selecting these boundaries, the subcommission neglected the regional–stratigraphic approach and proposed several occurrence levels of conodont species and subspecies as potential boundary stratotypes, though they do not correspond in most cases to significant historical–geological and biotic events and, consequently, have a low correlation potential.

Originally, the SDS proposed four levels, which may represent the lower boundary of the Middle Devonian: (1) the base of the *costatus costatus* conodont zone; (2) the base of the upper subzone of the *costatus patulus* Zone; (3) the base of the *costatus patulus* Zone; and (4) the first occurrence level of *Polygnathus dehiscens* and *Monograptus yukonensis*. In 1979, only two variants were left for selecting the Lower–Middle Devonian boundary: (1) the base of the *costatus patulus* Zone corresponding to the base of the Couvinian Stage in Ardennes; and (2) the base of the *costatus partitus* presumably corresponding to the base of the Lauch Beds in the Eifel Hills (Rzonsnitskaya, 1983). In the same year, resolution was voted to place the lower boundary of the Eifelian Stage and, correspondingly, of the Middle Devonian, at the first occurrence level of *Polygnathus costatus partitus*. This level is recorded 1.9 m below the lower boundary of the Lauch Beds in the Wetteldorf section of the Eifelian Mountains that represents a stratotype of the Eifelian Stage (Ziegler and Klapper, 1985).

Discussion of the problem of the Middle Devonian lower boundary showed, on the one hand, the invalidity of the extended *Eifelian* Stage adopted in the USSR and gave birth, on the other, to the problem of the lower stage of the Middle Devonian (*Nizhnii yarus...*, 1983) that is still waiting its solution. The problem is rooted in the fact that the boundary characterizing distinct changes in development of many groups of fossil organisms and almost a universal change of geological formations was considered in the USSR as a boundary between the lower and middle series of the Devonian System. In its new understanding, it turned out to be significantly below the base of the Eifelian Stage, and the base of the Eifelian Stage and Middle Devonian appeared to be indistinguishable and untraceable in the territory of Russia and adjacent regions of North Eurasia based on paleontological or historical–geological criteria.

At the same time, there are distinct boundaries related to paleogeographic and paleobiological events, which are easily traceable not only in the European stratotype sections, but worldwide as well. Johnson *et al.* (1985) compiled an eustatic curve that reflects alternation of major Devonian transgression and regressions in North America and West Europe. Similar curve was obtained by House (1985) when he studied evolutionary stages of Paleozoic ammonoids. Studying independently the Devonian history of the Uralian–Mongolian belt and adjacent regions of North Eurasia, one of us established several phases of considerable extension and reduction of Devonian sea basins related to eustatic sea-level fluctuations, which have been induced by tectonics (Karaulov, 1988; Karaulov and Gretschishnikova, 1997). Boundaries between largest transgressive–regressive cycles in the curves compiled for different continents coincide that implies their planetary character.

The International Symposium "Eustatic sea-level fluctuations during the Devonian" held in 1994 (*Sbornik tezisov...*, 1994) confirmed the validity of above conclusion. Consequently, the statement that distinct boundaries between stratigraphic units of different sections are controlled by local factors and cannot be traced in other regions is only partly true. Most significant historical–geological boundaries are related to global events and traceable almost worldwide. It should be kept in mind, however, that indications of these events can very differ in different-type sections (Karaulov, 1977).

Returning to the problem of the lower stage of the Middle Devonian, let us recollect that serious arguments in favor of placing the lower boundary of Middle Devonian at the base of either Couvinian (Rzhonsnitskaya, 1983) or Dalejian (Bogoslovskii, 1983) stages were proposed long ago at the initial stage of the discussion. This level is very close to the first of most important historical–geological boundaries mentioned above and to the traditional Lower–Middle Devonian boundary accepted in Russia. It is also not incidental that the Couvinian Stage that included then the Ierge Beds of graywackes was placed at the base of the Middle Devonian already in the first Devonian stratigraphic scales (Leonov, 1973, p. 268).

The subsequent stratigraphic practice showed, as it could be expected, the vainness of attempts to fix the lower boundary of the Middle Devonian in Russia at the level recommended by the SDS. According to the resolution of the Interdepartmental Stratigraphic Meeting dedicated to the Middle and Upper Paleozoic deposits of the Russian platform, the base of the Middle Devonian is placed at the base of the Kojva Horizon of the upper Emsian corresponding to the base of the *Zdimir pseudobaschkiricus–Megastrophia uralensis* brachiopod zone or to that of the standard *patulus* conodont zone (*Reshenie mezhvedomstvennogo...*, 1990). It is absolutely clear that all attempts to place the Lower–Middle Devonian boundary closer to the level approved by the SDS are futile and result in destabilization only. The boundary displacement from traditional level to the base of the *Zdimir pseudobaschkiricus–Megastrophia uralensis* Zone is unable to solve the problem as well, because the latter is situated one standard zone lower than the boundary recommended by the SDS, being far from the convenience of its tracing (Karaulov, 1994).

So, where is an exit from the situation? It is evidently unreasonable to go back to the problem of the Eifelian Stage lower boundary. Taking into consideration an appeal for opinions about rational division of some stages into substages (the SDS Newsletter no. 13) and obvious great significance of historical–geological criteria indicative of boundary events between stratigraphic units, we may suggest to subdivide the Emsian Stage, the lower boundary of which has not been defined so far, into the Zlichovian and Dalejian stages of the Czech stratigraphic scale. The SDS already uses Czech stage units in the general scale. The lower boundary of the Dalejian Stage corresponds to the base of the *Anarcestes* goniatite zone, is close to the base of standard *inversus* zone in the conodont zonation, and coincides with the boundary between distinct historical–geological stages. Precisely this level used to be regarded in the former USSR as corresponding to the lower boundary of the Middle Devonian.

Similarly intricate situation concerns the Middle–Upper Devonian boundary. Until now, this boundary in Russia was reliably placed at the base of the Pashyja Horizon and its age analogues (*Stratigrafiya SSSR...*, 1973) and correlated with the base of the Fromelen Beds, i.e., with the traditional boundary between the Givetian and Frasnian stages. The situation changed when the SDS decided to place the lower boundary of the Frasnian Stage and Upper Devonian at a considerably higher level (at the base of the standard *L. asymmetricus* conodont zone or in the middle of the *falsiovalis* Zone).

When selecting the Middle–Upper Devonian boundary, the SDS used the formal criterion—the first occurrence level of some conodont species. By voting in 1982 (seven pro and three contra), it was decided to draw this boundary at the base of the *L. asymmetricus* Zone, where the first occurrence level of *Ancyrodella rotundiloba* is recorded (Ziegler and Klapper, 1985). The boundary stratotype problem was considered to be of a second priority in this case and its solution was postponed. Subsequent samplings across the selected boundary resulted in identifications of slightly different conodont assemblages suggesting different levels for the boundary, and there appeared a necessity to revise the zonal scale (Bultynck, 1986). Somewhat later, the GSSP was selected in the Montagne Noire section (southern France). The boundary point in this section is 50 cm below the base of the *L. asymmetricus* Zone, and authors of the relevant publication considered the situation at hands as exemplifying discrepancy between intentions and practice of elaborating the conodont biostratigraphic zonation (Sandberg *et al.*, 1988). When defining "standard zones" of the Upper Devonian afterward, specialists on conodonts concentrated attention on the *Palmatolepis* lineage and placed the Upper Devonian lower boundary inside the *falsiovalis* Zone.

Specialists on conodonts probably persuaded each other that they have selected at last the ideal Middle–Upper Devonian boundary. nevertheless, they can hardly persuade practical geologists that the boundary established in one–two unique successions is precisely a universal traceable level that separates the middle and upper series of the Devonian System. While the base of the *L. asymmetricus* Zone is more or less close to the base of the Sargaevo Horizon of the East-European platform and western Urals, the new "ideal boundary" appears to be inside the Kynov and Timan horizons and can be traced nowhere. One can hardly imagine another, more vivid example of the fallaciousness of the method accepted by the SDS and ISC for "specification" of boundaries between the major ISS units.

The raised problem of the Middle–Upper Devonian boundary compelled to carry out the comparative historical–geological analysis of structure of the upper Givetian–Frasnian sections in Eurasia and other continents (Karaulov, 1989a, 1989b). The results obtained showed that several approximately isochronous levels corresponding to the initial phases of extension and deepening of Devonian basins can be outlined and widely traced. Most significant among them is one level that coincides with the traditional Givetian–Frasnian boundary. Precisely this level occurring in the middle of the *varcus* Zone characterizes a sharp change in development of ammonoids, other faunal groups, and terrestrial flora. House (1985) who specially studied biotic events in evolution of Devonian ammonoids showed that the level in question marks the *Taghanic Event*. As mentioned above, this level coinciding with the traditional Middle–Upper Devonian boundary corresponds to one of two most significant falls in the sea-level curve (Johnson *et al.*, 1985; Karaulov and Gretschishnikova, 1997).

The Middle–Upper Devonian boundary, which occupied during many decades the base of the Fromelen Beds of the Frasnian Stage or the base of the Adorphian Stage, defines the first occurrence level of the ammonoid genus *Pharciceras* and archaeopterid flora. It also marks evolutionary changes in other groups of fossil organisms, coincides with the major historical–geological event, and should be kept at the traditional level. The SDS recommendation to displace this boundary, one of the most distinct and widely traceable traditional boundaries, represents a dangerous precedent of the priority principle violation and leads to destabilization of the stratigraphic nomenclature.

The idea to separate the upper part of the "new" Givetian Stage as the autonomous Fromelen Stage with subsequent probable recurring of the latter into the Upper Devonian can represent a solution of the problem (in line with the above-mentioned Newsletter no. 13). The Fromelen Stage includes the Fromelen Formation of Ardennes, Tailfer and de Roux formations of the northern flank of the Dinant synclinorium, Pashyija and Timan horizons of the East European platform, Altchedat and Izyly horizons of the Altai–Sayan folded region, and Saryn Horizon of the Omulevskii uplift (northeastern Russia). If these proposals will be rejected by the SDS, the Interdepartmental Stratigraphic Committee of Russia should independently make a decision concerning the boundaries of the Middle Devonian Series in this country.

The Devonian–Carboniferous boundary remained debatable for a long time. At present, it is placed at the base of the standard *sulcata* conodont zone that approximately coincides with the boundary between the *Wocklumeria* and *Gattendorphia* genus-zones. A substantially higher position of this boundary, as compared with that earlier accepted in the USSR, is pregnant with certain difficulties and raises a problem of separating the upper part of the "new" wider-range Famennian Stage as an autonomous subdivision. One of the possible names for the latter is the "Strunian Stage," the lower boundary of which coincides with basal levels of the goniatite *Climenia* and ostracod *hemisphaerica-triceratina* zones, being simultaneously close to the base of the *expansa* zone in conodont zonation. From the historical–geological viewpoint, this boundary corresponds to the initial stage of a great transgression. The higher part of the Famennian Stage that was previously referred to the basal Carboniferous is correlative with the following regional subdivisions: upper *Climenia* limestones and shales of Thuringia; Schistes de l'Epinette and Calcaire d'Etroeungt of the Dinant basin; Plava, Ozerki, Khovanskii, and Ziganskii horizons of the East European platform; basal and brachiopod beds of the Tarkhanka Formation of the Rudnyi Altai; and with other synchronous sequences (Karaulov and Gretschishnikova, 1988).

A LAME ATTEMPT TO DEFINE THE PERMIAN–TRIASSIC GSSP

As is known, the Permian–Triassic boundary layers were established in continental successions. Von Alberti (1834) began the Triassic in West Europe with the Buntsandstein (red beds) overlying the saliferous Zechstein, the upper subdivision of the "Peneen" System distinguished by Omalius d'Halloy in 1831. Seven years later, Murchison (1841) who defined the Permian System in Russia included in the latter, although with some doubts, continental red beds of the central Moscow syneclise, which have been later identified by Nikitin (1887) as the Tatarian Stage. For a long time, these deposits were considered as transitional between the Permian and Triassic Systems (Permotrias). Subsequently, it was shown that the lower part of the Nikitin's Tatarian Stage is of the Late Permian age, and now this name is retained for this interval, whereas the upper part (Vetluga and Yarensk groups, according to the contemporary nomenclature) turned out to be correlative with the Buntsandstein of the Lower Triassic (Lozovsky, 1997).

Later on, when marine standards of the Triassic were distinguished in the Tethyan realm, the base of the ammonite *Otoceras woodwardi* Zone defined in Himalayas was selected for the lower boundary of the system (Mojsisovich *et al.*, 1895). In the Boreal realm, the *Otoceras* fauna, which became known later, is represented by other species (*O. concavum* and *O. boreale*). The succession of boreal ammonites is divided in two zones, the first of which begins the Griesbachian Stage of the Lower Triassic in Canada (Tozer, 1967). In northeastern Russia, the lower *Otoceras concavum* Zone begins the Induan Stage (Kiparisova and Popov, 1956, 1964; Rostovtsev and Dagys, 1984), the lower one in the Triassic System of the ISS. The Triassic age of the *Otoceras* Beds is accepted by all specialists on ammonoids (Smith, 1932; Spath, 1935; Kiparisova and Popov, 1956, 1964; Kummel, 1957; Rostovtsev and Dagys, 1984; Shevyrev, 1986, 1990).

It should be noted that the *Otoceras* fauna characterizes universally the lower parts of transgressive marine successions unconformably overlying various Permian and older horizons and beginning the Mesozoic historical–geological evolutionary stage. This is obvious in Boreal basins (e.g., in Spitsbergen, eastern Greenland, Arctic Canadian Archipelago, and eastern Verkhoyansk region; Tozer, 1967; Dagys *et al.*, 1986; Embry, 1991; and others) and less distinct in the Peri-Gondwanan regions (Shevyrev and Lozovsky, 1998).

In parallel with study of Triassic deposits, biostratigraphic investigations of Upper Permian marine sections were carried out. The Dorashamian Stage was defined as the terminal Permian unit in the Transcaucasia region (*Osnovnye cherty...*, 1984) and synchronous Changsingian Stage in China (Jin *et al.*, 1994); the latter is now included into the ISS. Until recently, most researchers placed the Permian–Triassic boundary at the base of the *Otoceras woodwardi* Zone and, correspondingly, at the top of the Dorashamian (Changsingian) *Paratirolites kittli* Zone, although the direct succession of both zones has never been observed.[3] Tozer (1988a, 1988b) was first to note that *Paratirolites* and *Otoceras* faunas are separated in space. He explained this phenomenon by a worldwide hiatus corresponding to either the terminal Permian (Dorashamian Age) or the initial Triassic (early Griesbachian time). Prior to the *Otoceras* fauna appearance, the diverse and abundant Paleozoic fauna dies off, and, in opinion of Tozer, this was a worldwide event in the history of oceans, because "*if the beds above the unconformity are obviously synchronous they are entirely suitable as a chronostratigraphic datum*" (Tozer, 1988b, p. 255).

In 1981, the special working group on definition of the global stratotype section and point of the Permian–Triassic boundary (PT GSSP) headed by E. Tozer was organized by the International Subcommission of Triassic Stratigraphy. None of the sections studied by that time met requirements for GSSP definition, because they lack continuous successions of marine deposits, and Tozer perfectly realized this. In 1984, first inquiries of the group members showed that the majority of them (16 of 18) tended to place the Permian–Triassic boundary at the base of the *Otoceras* Zone. The Guryul Ravine section in Kashmir (Nakazawa *et al.*, 1975) was considered as a possible stratotype, but its youngest Permian layers yield paleontological remains inadequate for a definite conclusion.

The situation considerably changed when data on conodont were involved into the biostratigraphic practice. Seeking for reasons, which may explain absence of sections showing the succession of the *Paratirolites* and *Otoceras* beds, some researchers assumed that they are partly or completely synchronous. Moreover, Kozur (1989) and Waterhouse (1976) suggested the Permian

[3] The *Rotodiscoceras–Pleuronodoceras* Zone is now regarded as terminal one in the ammonite scale of the Changsingian Stage. This zone overlies the *Paratirolites (Pseudotirolites)* Beds in China and the Transcaucasia region, where it was identified by Zakharov (1988) who correlated uppermost parts of the Dorashamian and Changsingian stages.

age for the *Otoceras* Beds. First data on conodonts from the Permian–Triassic boundary layers brought unexpected results that seemingly confirmed this assumption. Conodont finds were reported from the *Otoceras* Beds of Himalayas. Their forms were erroneously identified with species known from undoubtedly Upper Permian Dzhulfian–Dorashamian (=Wuchiapingian–Changsingian) beds (Bhatt and Arora, 1984; and others), but this was not confirmed later on (Orchard and Krystyn, 1998).

Trying to prove "synchronism" of the *Otoceras woodwardi* and *Paratirolites* zones, Sweet (1979) compared the Permian–Triassic boundary sections from Kashmir and Salt Range using the formal method of graphic correlation proposed by Shaw. The absurdity of such an approach was so evident that E. Tozer showed, using the same method, that both sections reveal a hiatus between the Permian and Triassic strata, which is diachronous, thus the idea of "synchronism" was fallacious (unpublished letter of 1989 to the members of the Triassic and Permian commissions). Nevertheless, the erroneous idea found a wide recognition among geologists, and the majority of "conodont" adherents became strong enough by that time to vote for pleasing decision. As early as in 1994, only two members of the Working Group on the Permian–Triassic boundary retained their initial opinion of 1984 on the prime significance of the *Otoceras* fauna, and 13 members considered the appearance of conodonts *Hindeodus parvus* as a criterion for defining this boundary. Among adherents of the conodont-based boundary, there appeared soon new members, e.g., Yu.D. Zakharov who defended not long ago the ammonite standard (Kozur *et al.*, 1996).

Chinese professor Yin (1985, 1993) who inherited the Tozer's post of the Chairperson of the aforementioned group suggested to establish the PT GSSP in the Meishan section (South China) situated at the southern slope of the eponymous mount in the Changsing County of Zheliang Province. This section is characterized by the continuous succession of marine sediments at the Permian–Triassic boundary. The section is described in detail in several works (Zhao *et al.*, 1981; Sheng *et al.*, 1984; Yin *et al.*, 1996; Shevyrev and Lozovsky, 1998). Its structure is shown in the figure.

Initially, Chinese researchers (Sheng *et al.*, 1984) were of opinion that the Permian–Triassic boundary should be placed at the base of Bed 25 (White Clay), immediately above which Triassic ammonites *Otoceras?* sp. and other forms appear in Bed 26 (Black Clay). These forms are accompanied by the Permian fossils, ammonites *Pseudogastrioceras* and brachiopods *Neowellerella* and *Crurithyris*, included (coexistence of mentioned taxa is known in the Triassic lower strata of other regions). Later on, the Permian–Triassic boundary was placed inside the thin (16 cm) Bed 27 that yielded the conodont species *Hindeodus parvus* representing a member of the "evolutionary morphogenetic lineage" *Hindeodus typicalis—H. latidentatus—H. parvus—Isarcicella turgida—I. isarica* (Kozur, 1990; Yin *et al.*, 1996). The decision formally meets requirements of the global stratotype section and point.

Later on, the above lineage was revised and subsequently regarded either as *Hindeodus latidentatus praeparvus—H. parvus erectus—Isarcicella turgida—I. staeschei—I. isarica* (Kozur, 1996), or as *Hideouts latidentatus—H. parvus erectus—Isarcicella staeschei—I. isarica*, an independent lateral lineage of which corresponds to *H. priscus—H. turgidus* (Wang, 1995, 1996). The final compromise lineage proposed immediately prior to voting for the boundary definition looks as follows: *Hideouts latidentatus—H. latidentatus praeparvus—H. parvus—Isarcicella isarica* (*Proposal...*, 1999). The uncertainty results, first of all, from the different understanding of stratigraphic range of *H. parvus*, the species first established by H. Kozur and Pyatakova in the basal *Claraia* beds where ammonites *Ophiceras* came from.[4] The taxonomic situation around this species is very puzzling (Wang, 1998). Known at present are six its morphotypes and subspecies (*Hideouts parvus erectus, H. parvus parvus, H. parvus anterodentatus, H. parvus meishanensis*, and others). Consequently, when defining the Permian–Triassic boundary, researchers should come to an agreement which form is most appropriate, otherwise, as Wang justly emphasized, we will have six (!) similar levels substantiated by each subspecies or morphotype. In his opinion, the way out of this situation is in a wide discussion of problems related to conodont biostratigraphy and in elaboration of the agreed resolution. We share his viewpoint completely.

The validity of evolutionary conodont lineages, which include *H. parvus* and its subspecies and morphotypes, was seriously criticized (Baud, 1996; Krystyn and Orchard, 1996; Orchard and Krystyn, 1998; Wang, 1998). As it was established in the Spiti section, *H. latidentatus* occurs above *H. parvus* and *Isarcicella staeschei* coexists with *H. parvus*, whereas *I. turgida* appears below the latter in the Changsing locality. Orchard and Krystyn (1998) do not consider *H. latidentatus* sensu stricto as representing an immediate predecessor of *H. parvus*, viewing the former as a representative of a separate lineage that begins with the Late Permian species *H. typicalis*. In their opinion, conodonts from younger layers formally referred to *H. latidentatus* should be identified with *H. praeparvus*. The first occurrence level of *H. parvus* in the middle of Bed 27 of the Meishan section is also doubted. Par example, Mei (1966), the well-known specialist in conodonts, revised the form from Bed 25 (previously determined as *H. latidentatus*) and identified it with *H. parvus*. Later on, Orchard referred this form to *H.* aff. *parvus*

[4] As Wang (1998) noted, two different forms were selected to represent the holotype, and the first of them should be evidently considered as valid. It differs from the form described under the same name from the *Otoceras* Beds of Kashmir (Matsuda, 1981) and naturally leading to confusion.

(Orchard and Krystyn, 1998). In the same bed, the form coexists with first *Neogondolella (Clarkina) meishanensis* and *N. (Cl.)* cf. *tulongensis* (Tian). Combination of shallow-water *Hindeodus* and deep-water *Neogondolella* forms allowed the mentioned authors to define "mixed" zones (*meishanensis–praeparvus* and *meishanensis–parvus*). Some researchers who prefer the first occurrence level of *parvus* forms for candidate of the Permian–Triassic boundary (Kozur, 1998; Wardlaw and Mei, 1998a; 1998b) consider these zones as successively replacing each other with time. Others (Orchard and Tozer, 1997; Krystyn and Orchard, 1996; Orchard and Krystyn, 1998) justly believe that different *Hindeodus* morphotypes (*praeparvus* and *parvus*) can appear, depending on the facies type, at different levels. On the one hand, they may be concurrent to first *N. meishanensis* species (Selong and Meishan? localities). On the other hand (Arctic Canada), *parvus* form appears slightly after the α datum of the *Neogondolella* evolution that marks the appearance of *N. meishanensis* and *N.* ex gr. *teilorae.* In general, major changes in the *Neogondolella* fauna are close to or coincide with (in mixed biofacies) the first appearance of ammonites representing the genus *Otoceras* and associated with conodonts *H. parvus* or *H. praeparvus*, and *each of the latter can serve as a marker of the Permian–Triassic boundary.* Baud (1996) expressed in fact the same standpoint. Recent data on conodont distribution in the continuous succession of Permian–Triassic boundary layers in the Dolomites confirm these relationships. *H. parvus* was previously established here in the uppermost part of the Tesero Oolitic Member above the *H. latidentatus* (=modern *Hindeodus praeparvus*) Zone, and corresponding event was regarded as marking the Permian–Triassic boundary (Kozur, 1989). In the neighboring section, this species is discovered at a significantly lower level, almost at the base of the above member (Nikora and Perri, 1999). These diachronous first-occurrence levels show that the indicated species is unsuitable for definition of the Permian–Triassic boundary.

Despite the aforesaid, the Subcommission of Triassic Stratigraphy absolutely ignored the problems of conodont biostratigraphy and carried out voting, in written form, questioning who agrees to place the PT GSSP at the base of Bed 27c of the Meishan section. The results of voting are published (Gaetani, 2000): 22 of 27 full members (81%; the group consists of 31 persons in total), voted pro and two contra, with one abstention. Maurizio Gaetani, the Chairperson of the subcommission was happy with the results of voting, because the PT GSSP is the first one accepted for the Triassic System. The voting results were supported by the ISC and approved by the IUGS in March of 2001. In August of 2001, a majestic monument was unveiled at site of the boundary stratotype in Meishan (Yin and Tong, 2001).

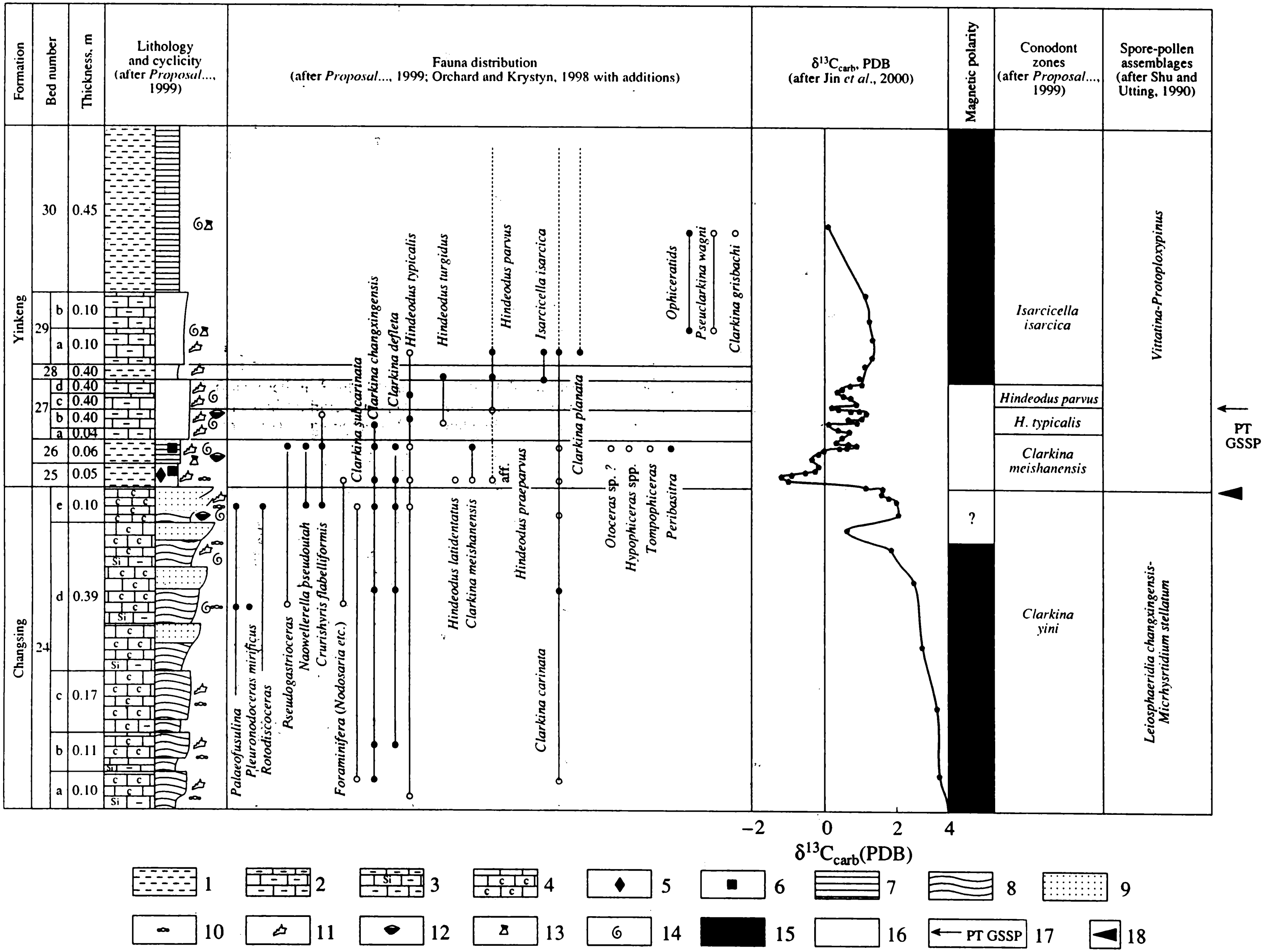
V.R. Lozovsky who took part in voting sent a separate opinion favoring the Meishan section, but indicating that the boundary in question should be placed at the base of Bed 25 in the lowermost Yinkeng Formation conformably overlying the Changsing Limestones. Below, we discuss arguments supporting this standpoint, which were partly mentioned elsewhere (Lozovsky, 1997; Shevyrev and Lozovsky, 1998).

This boundary is easily traceable and appropriate for mapping in South China. It is probably not incidental that Chinese researchers defined previously the Permian–Triassic boundary precisely here (Sheng *et al.*, 1984). The main Permian fauna, including fusulinids (genus *Paleofusulina*), Late Permian ammonoids of the *Rotodiscoceras–Pleuronodoceras* Zone (except for *Pseudogastrioceras* forms having wide stratigraphic range), and many Permian brachiopods, become extinct above Bed 24 although some representatives of the latter group cross the boundary under consideration.

Bed 26 is marked by the appearance of a new assemblage termed by Chinese researchers the *Hypophiceras* fauna (Yin *et al.*, 1996). It includes ammonoids *Otoceras?* sp., *Hypophiceras* cf. *martini* Trömpy, *H. changsingense* Wang, *Metophiceras* sp., *Pseudogastrioceras* sp., and *Tompophiceras* sp. Such a strange composition of the assemblage that includes typical Triassic and one Permian forms is a result, in opinion of Shevyrev (1999, 2000), of their erroneous determinations. From our viewpoint, ammonites determined as *Otoceras?* sp. and associated *Hypophiceras* and close genera rightfully occur at this level. Deposits enclosing this assemblage termed by Chinese scientists (Yin *et al.*, 1996, pp. 49–56) as the *Hypophiceras* fauna can be considered as an important biostratigraphic unit equivalent to the basal part of the *Otoceras woodwardi* Zone of the Spiti section, to the *O. concavum* Zone of boreal basins, and to *Hypophiceras* Zone of eastern Greenland, i.e., to *deposits traditionally regarded as oldest Lower Triassic layers.*[5]

The appearance of boreal *Otoceras* species in central areas of the Tethys is explained by penetration of cold waters from high latitudes, and this event was likely responsible for disappearance of many thermo-

[5] In the Boreal and Tethyan realms, biozonations of the *Otoceras* Beds are based on different *Otoceras* species. In the Boreal realm, this is the universally accepted Tozer's scale consisting of two, the *Otoceras concavum* and *O. boreale* zones. First of these species undoubtedly appears slightly earlier than *O. boreale*, and both species coexist in the middle part of the beds (Henderson and Baud, 1996), whereas only the latter occurs higher passing into the overlying *Ophiceras* Zone. Two zones (*O. latilobatum* and *O. woodwardi*) are defined also in the Tethyan realm.
Mutual correlation between the *Otoceras* zones of both realms is sufficiently reliable, substantiated by a similar evolutionary level of ammonites *Otoceras woodwardi* and *O. boreale*, which are close to each other in both the shell morphology and the lobe line structure. Thus, they can be considered as concurrent (Shevyrev and Lozovsky, 1998). Some researchers (Dagys, 1994; Shevyrev, 2000) believe the *Otoceras concavum* Zone is older than the *Otoceras woodwardi* Zone, whereas some others (Yin, 1993; Orchard and Krystyn, 1998; and others) regard them as synchronous. The latter standpoint well agrees with the data on conodonts published in the last work.



Characteristic features of the Meishan section (South China) where the Global Stratotype Section and Point of the Permian–Triassic boundary is selected: (1) clay; (2) clayey or silty, (3) dolomitized, and (4) organogenic–detrital limestones; (5) volcanogenic admixture; (6) β quartz; (7) horizontal, (8) wavy, and (9) graded bedding; (10) fusulinids; (11) conodonts; (12) brachiopods; (13) bivalve forms; (14) ammonoids; (15) normal and (16) reversed magnetic polarity; (17) approved and (18) proposed variants of Permian–Triassic boundary.

philic Permian organisms (Kozur, 1998). The paradoxical (at first sight) conclusion of Chinese authors on the Late Permian age of the above ammonite assemblage is based mainly on stratigraphic position of the host beds below the accepted boundary corresponding to the first appearance level of conodonts *Hindeodus parvus*, which associate with Permian brachiopods and bivalve forms, two of which are of the Permian age, and the third one represents a new subspecies (*Pteria ussurica variabilis* Chen et Lan) very close to Triassic *Claraia*.[6]

The boundary proposed in the Meishan section is marked also by changes in the conodont fauna used to substantiate the deep-water *Neogondolella* scale: the upper Changsingian *Clarkina yini* Zone is replaced here upward by the *Clarkina meishanensis* Zone (Orchard and Krystyn, 1998; Mei *et al.*, 1999). In the shallow-water zonation of *Hideouts* forms, the lower part of the *meishanensis* Zone corresponds to the *Hideouts praeparvus* Zone overlain by the *H. parvus Zone* mentioned above.[7] In addition to transitional layers of the Meishan section (Beds 25–28), the "mixed" *meishanensis–praeparvus* assemblage is characteristic of the *Otoceras concavum–Otoceras boreale* Zone in Arctic Canada, *Otoceras latilobatum* Zone in Selong, and *Otoceras woodwardi* Zone in Himalayas. These data confirm the ammonite-based correlation mentioned above. The positioning of boundary at the base of Bed 25 and equivalents that accounts for appearance of several forms, including shallow- and deep-water ones, is more reliable than that substantiated by species *H. parvus* only, because their range is understood by different researchers in a different manner, as mentioned above. The additional investigation of conodonts from the Meishan section resulted in discovery of two new *Hindeodus* species appearing in Bed 26 (Metcalfe *et al.*, 2001). These finds once more emphasize significance of the proposed boundary.

The spores–pollen assemblage from the uppermost part of the Changsing Formation of the Meishan section is not diverse (Quyang and Utting, 1990). It includes acritarchs of a wide stratigraphic range and miospores known from the Upper Permian deposits of China. Most interesting components of the assemblage are abundant remains of fungi *Tympanicysta stoschiana* Balme, the bloom of which (the so-called fungal spike) is registered worldwide at the Permian–Triassic boundary both in marine and terrestrial facies and represents an excellent global marker (Wood and Mangerud, 1994; Yaroshenko and Lozovsky, 1997; Lozovsky *et al.*, 2001).[8] The next *Vittatina–Protohaploxypinus* assemblage from overlying layers of the Meishan section (beginning from Bed 25) is of a mixed character because of diverse Late Permian taxa associated at this level with typical Early Triassic species. In general, it is very similar to the *Protohaploxypinus* assemblage from the basal part of the *Otoceras* Beds of eastern Greenland (Balme, 1980) and, to a less extent, to the basal Triassic spore–pollen assemblages of western Canada (Jansonius, 1962) and the Canadian Arctic Archipelago (Utting, 1989). It is considered as the early Griesbachian in age (Shu and Utting, 1990).

Both the *Otoceras* Beds of Arctic Canada (Ogg and Steiner, 1989) and layers yielding the mixed assemblage in China (Yin *et al.*, 1996) correspond in general to paleomagnetic zone N1T of normal polarity. The interval of reverse polarity begins approximately from the level of *Ophiceras* Beds. The normal polarity zone encloses a short-term event of the reverse polarity corresponding to the interval of Beds 25–27 in the Meishan section (Zhu and Lio, 1999) and traceable in oldest continental formations of China (Lozovsky *et al.*, 2001).

The Permian–Triassic boundary in the Meishan section coincides with two major events: the outburst of volcanic activity and replacement of the Late Permian regression by transgression. Some researchers relate the first event to the emplacement peak of traps in the Siberian platform. Wang (1996) defines at the same level also an important lithostratigraphic boundary—the replacement of carbonate sedimentation by the terrigenous–carbonate one. The level is also marked by the negative $\delta^{13}C$ anomaly that used to be explained by a sharp decrease in productivity of marine plankton and mass extinction of organisms.

Even if we leave aside the problem of age of the *Hypophiceras* ammonite fauna and diachronism of the first appearance level of *H. parvus*, any unbiased researcher can clearly see that the boundary between Beds 24 and 25 in the Meishan section marks the beginning of a rapid basin deepening and extensive transgression. It precisely corresponds to the main event boundary within a hiatus separating the undoubtedly Permian deposits from the Triassic strata in the stratotype regions. It separates major stages in development of litho- and biosphere and represents, from the historical–geological standpoint, the most suitable level for the boundary between these systems in the continuous section.

It should be particularly emphasized that the boundary in question is easily traceable in continental sections (*Granitsa permi...*, 1998; Lozovsky *et al.*, 2001). Correlation of continental and marine sections can be done using the basal part of the Tesero Oolitic Member in the Dolomites, where conodonts *Hindeodus praeparvus*, oldest Early Triassic spores–pollen assemblages, and megaspores *Otynisporites eotriasscus* Fugl. occur in association. Two latter associations are regis-

[6] The Triassic forms such as *Claraia* sp. and *Eumorphotis* sp. earlier reported from the same layers (Sheng et al., 1984) are not mentioned in subsequent works.

[7] Kozur (1998) terms it the complex *Clarkina meishanensis–Hindeodus latidentatus praeparvus* Zone.

[8] The negative $\delta^{13}C$ and $\delta^{18}O$ anomalies at the same level are explained by the Late Permian regression and subsequent oxidation of organic matter on the dried shelves. This event increased the CO_2 content in atmosphere and decreased the oxygen content in the ocean–atmosphere system, and both factors favored the mass development of fungi on land and in water basins

tered also at the bases of both the Vetluga Group of eastern Europe and the Buntsandstein of western Europe, the historical stratotype of the Triassic System in the last case. It should be noted as well that the indicated basal levels mark an important structural reorganization in both regions (Lozovsky, 1985).

According to guidelines for GSSP selection (Remane *et al.*, 1996), the priority should be given to the best candidate after discussion of several proposed continuous successions. Considering both variants of the Permian–Triassic boundary in the Meishan section (within Bed 27 that is voted by the majority and at the base of Bed 25 that is proposed here), we arrive at the conclusion that the second one is undoubtedly advantageous. However, the Subcommission on Triassic Stratigraphy did not discuss this variant at all. The hurry in voting not only deserves regret, but also gives birth to doubts in true motives of voting. It is quite clear that a single biostratigraphic criterion used to establish the boundary between systems and based on one evolutionary lineage of conodonts that is under doubts of many scientists, can lead and has already led to impossibility of its definition in many regions, especially when indications of traditional faunas such as ammonoids and historical–geological criteria are completely ignored. For instance, the boundary in question cannot be identified in the vast territory of northeastern Russia, where basal layers of the Lower Triassic transgressive cycle yield the *Otoceras* fauna but are lacking the "guide conodont forms."

Many researches showed that the Triassic continental sequences are as widespread as the Permian ones. The analysis of continental sections of the world (*Granitsa permi...*, 1998) revealed that they, like the marine sections, have a hiatus. In most cases, sequences above the hiatus begin with layers, which can be reliably correlated with the marine *Otoceras* Beds. The Early Triassic age of the layers is well established with the help of different correlation methods (ecotonic, palynological, paleomagnetic).

When the Permian–Triassic boundary is displaced at any higher level, as it happened in the Meishan section, it become completely lost, and this consequence was repeatedly predicted (Lozovsky, 1997, 1998; *Granitsa permi...*, 1998). The present-day situation caused by the resolution of Subcommission on Triassic Stratigraphy is as it was a century ago, when the Paleozoic–Mesozoic boundary strata were termed the "Permotrias." Such a situation is probably convenient for leaders of the International Stratigraphic Commission, but we cannot agree with their decision.

Ovations on occasion of the PT GSSP monument opening still continued, when many researchers abroad became aware of unpleasant consequences of the hasty and unreasoned resolution. Par example, the revision of the Changsing section in the north of the Sichuan Province of China, which is well correlative with the Meishan section based on several stratigraphic markers (White Clay, Black Clay, *Hypophiceras* fauna), showed that conodont species *Hindeodus parvus* occurs in the former five meters higher than in the latter. This led researchers to the conclusion that the Meishan section is possibly lacking a significant "pre-*parvus*" part (Metcalfe *et al.*, 2001). In this case, the established PT GSSP do not meat requirements of the International Stratigraphic Code!

In view of the discussed resolution on the Permian–Triassic boundary, it is necessary to revise the scope of the Griesbachian Stage, the traditional subdivision of the boreal Triassic in Arctic Canada, in which *H. parvus* has been identified for the first time. However, it is hardly possible to do because the accepted boundary does not mark any event (mass extinction, fungal peak, and others) or any physical surface, e.g., a level of sharp facies changes or that of magnetic polarity inversion (Baud, 2001).

CONCLUSION

The discussed examples show that principles used to precise the general stratigraphic scale are not only of the abstract–theoretical interest; they directly influence practice of geological mapping and other geological investigations. The problem is probably not crucial for some countries, but not for Russia with its vast territory insufficiently studied as yet in the geological aspect. For Russia where works on preparation of a new state geological map (Scale 1 : 200000) are in progress, this problem is of a primary importance. If boundaries of all cartographic units do not coincide with boundaries between stages, series, and systems of the general stratigraphic scale, one may ask what such scale is needed for and how it can be correlated with real boundaries and geological history of a particular region. All talks about the necessity of a global chronostratigraphic standard are ruined by geological practice that shows impossibility of tracing the "ideal" levels established in the unique section and based on the first appearance of voluntary (by agreement) selected fossil species.

We are not against the establishment of the Global Boundary Stratotype Sections and Points as one can conclude after reading this paper. The GSSR's are needed as peculiar markers separating intervals of the geological history. In practical geology, this is thought to be a function of the so-called Auxiliary Stratotype Points. However, we are categorically against the hasty "hammered in golden spikes" now common in practice of the International Stratigraphic Commission. The perfection of the general stratigraphic scale representing an idealized section of the upper part of the Earth's crust usable for correlation of particular stratigraphic sections is necessity beyond a doubt. We actively protest against attempts to radically reorganize the traditional scale by means of selecting fully artificial, incidental boundaries of a negligible correlative potential, to refuse the regional–stratigraphic principle used to establish range and boundaries of geological systems, series, and stages, and to ignore the priority principle that guards stability of the general scale.

In this connection, V.A. Krassilov rightfully said : "In practice, they try now to combine chronostratigraphic boundaries with geohistorical events, indications of which are used for correlation. A point stratotype established somewhere near the natural boundary is only a monument in honor of the International Stratigraphic Commission activity. If the sense of chronostratigraphic procedure is elaboration of universal standards, which could serve as a common language for stratigraphers, then such an artificial language resembles Esperanto that is unnecessary as one can see from the experience of international communication. Passion for Esperanto ended long ago because even the imperfect knowledge of a natural language is more useful for international communication than any artificial language" (Krassilov, 1997, p. 7).

In situation when international geological organizations persistently follow the concept accepted under press of country representatives occupying key position in these bodies and do not wish to take into consideration other approaches (a reflection of policy, but not of science), then national geological surveys should decide whether it is reasonable to follow all their resolutions.

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